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OPTIMIZATION OF DISPERSION TECHNIQUE FOR GRAPHENE / PEG NANOFLUID

ABDUL ALEEM [a], RASHMI WALVEKAR [a,*], ABDUL KHALIQ RASHEED[b], MOHAMMAD KHALID[b]

[a]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: rashmigangasa.walvekar@taylors.edu.my

[b]Graphene & Advanced 2D Materials Research Group (GAMRG), School of Science and Technology, Sunway University, No. 5, Jalan University, Bandar Sunway, 47500, Subang Jaya, Selangor DE, Malaysia

Abstract

The conventional coolant used in radiator such as water and ethylene glycol have insufficient heat transfer performance due to the presence of oxygen molecule in water that will lead to corrosion. Thus, to overcome the situation waterless coolant such as polyethylene glycol (PEG) dispersed with graphene nanoflakes is utilised and the various dispersion techniques have been used with single and combined effect to obtain the most stable dispersion. The various dispersion methods utilised are magnetic stirrer, homogenizer and ultrasonication. In order to obtain stable nanofluid, the configuration of magnetic stirred is set at higher speed which is 1500 RPM and the time of dispersion was varied from 30-90 min. Moreover, the homogenizer speed and sonication frequency were set to 25000 RPM and 37Hz, respectively. The dispersion time for homogenizer is varied from 5-15 min while for sonication 3-5 hours has been set. After obtaining the most stable samples from each effect, combined dispersion effect was studied by fixing the most stable configuration. The stability of the samples were obtained by visual observation for 14 days and further percentage reduction in absorbance was calculated using UV Vis spectrophotometer. Hence, 30 minutes of magnetic stirrer, 3 hours of sonication and 10 minutes of homogenization is more stable for single dispersion method and 3 hours of sonication with 10 minutes of homogenization for combine dispersion method.

COMPARISON BETWEEN COAGULATION-FLOCCULATION AND DIRECT FLOCCULATION TO TREAT PALM OIL MILL EFFLUENT (POME)

TEN KIAT. CHAN*, NURHAZWANI B. ISMAIL

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: ten_kiat@hotmail.com

Abstract

A study was carried out to compare the conventional coagulation-flocculation method with the direct flocculation method to treat Palm Oil Mill Effluent (POME). For the coagulation-flocculation method, the dosage of the Ferric Chloride coagulant was varied as well as the pH of the POME and flocculant dosage. For the direct flocculation method, the dosage of the Polyacrylamide flocculant was varied as well as the pH of the POME. The treated POME samples were analysed in terms of COD, TSS and Fe ions according to the standard methods. For the coagulation-flocculation method, the results show that the POME wastewater treated with the optimum coagulant dosage of 300 mg/L of ferric chloride at the optimal pH of pH8 with the optimum flocculant dosage of 50 mg/L of polyacrylamide shows a COD percentage removal of 54.5% and a TSS percentage removal of 75% as well as a iron content of 114.2 mg/L. For the direct flocculation method, the results show that the POME treated with the optimum flocculant dosage of 100 mg/L of polyacrylamide at the optimal pH of pH 4 show a COD percentage removal of 54.4% and a TSS percentage removal of 85% as well as an iron content of 62.234 mg/L.

Keywords: POME, coagulation, direct flocculation, ferric chloride, polyacrylamide

CONDUCTIVE POLYMER COMPOSITE FROM POLYLACTIC ACID FILLED WITH GRAPHENE

KIM LING CHEONG[1*], MING MENG PANG[1], SEONG CHUN KOAY[1], KIM YEOW TSHAI[2], FACHMI BUYS YOSE[3]

[1]School of Engineering, Faculty of Built Environment, Engineering, Technology & Design, Taylor's University Lakeside Campus, No. 1 Jalan Taylor's, 47500 Subang Jaya. Selangor, Malaysia.
[2]Department of Manufacturing and Materials Engineering, International Islamic University Malaysia (IIUM), Jalan Gombak, 53100 Kuala Lumpur, Malaysia.
[3]Faculty of Engineering, The University of Nottingham, 43500 Semenyih, Malaysia
*Corresponding Author: MingMeng.Pang@taylors.edu.my

Abstract

Conductive polymer composite (CPC) derived from renewable resource has always been the focal point of researchers. So far, polylactic acid (PLA) is the most promising candidate to replace the petroleum-based polymer to produce CPC with the addition of conductive filler. In this research study, PLA composites reinforced with two types of conductive filler such as graphene nanoplatelets (GNP) and expanded graphite (EG) were produced via melt blending. Tensile, electrical properties and morphology studies were investigated to reveal the influence of conductive fillers. PLA/GNP composite with addition of 7wt% GNP has successfully achieved conductive region ($\sim 10^4 \Omega$), however PLA/EG composite attained dissipative region ($\sim 10^8 \Omega$) at 12wt% EG. This is due to the larger surface area of the GNP (nano scale) as compared to EG (micro scale). Tensile strength and tensile modulus of PLA/GNP composite were greatly enhanced by the addition of 3wt% GNP. Further increment of GNP filler at 7 and 12wt% GNP attributed to week interfacial adhesion between GNP filler and PLA matrix, causing decrement in tensile strength and modulus. PLA/EG composite showed tensile modulus increase, yet tensile strength and elongation at break decreased with the addition of EG. This is proven that the poor mechanical properties of PLA/EG composite are attributed to the presence of void, filler pull out and discontinuity as shown in SEM micrographs. The overall results of this studies demonstrated that PLA/GNP composite was the most desirable composite to be used to form CPC as it obtained better overall effect performance on the tensile properties, electrical resistivity, and morphology studies compared to PLA/EG composite

Keywords: Conductive polymer composite; polylactic acid; expanded graphite; graphene nanoplatelets

HIBISCUS SABDARIFFA POWDER MANUFACTURED BY FREEZE DRYING FOR WASTEWATER APPLICATION

CHRISTINE OLGA BOBOI, NURHAZWANI ISMAIL*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: nurhazwani.ismail@taylors.edu.my

Abstract

In the industry, the preparation steps to prepare natural coagulants are very long and time consuming. Natural coagulants cannot be stored for too long as it effects the efficiency of the coagulant to treat wastewater. In this research, coagulation process is used to treat dye wastewater using *Hibiscus sabdariffa* seeds as a coagulant. The coagulants were prepared in two different methods, which were direct use of seeds (direct method) and *Hibiscus sabdariffa* seeds powder by freeze drying. There were four types of powder prepared with the condition of 20 wt% and 30 wt% feed concentration of freeze dryer where it undergo 24 hours and 65 hours of freeze drying time. All of the powder were analyzed based on its surface morphology, water activity (a_w) and solubility. In terms of surface morphology of each powder, all of the powder had irregular shapes and porous structures. As for a_w, powder of 20 wt% and 30 wt% with 24 hours freeze drying time had the lowest water activity value, which were 0.478 and 0.4587 respectively. For powder of 20 wt% and 30 wt% with freeze drying time of 65 hours had water activity value of 0.565 and 0.538 respectively. The solubility percentage of powder 20 wt% and 30 wt% with 24 hours drying time and 20 wt% and 30 wt% with 65 hours drying time were 57%, 44%, 40% and 47.2% respectively. Powder of 20 wt% feed concentration of freeze dryer with 24 hours freeze drying time is selected to be used as *Hibiscus sabdariffa* powder. The presence of protein in the selected powder had been confirmed using FTIR spectroscopy. Jar test was performed to compare the efficiency of the powder produced by freeze dryer with the *Hibiscus sabdariffa* seeds prepared using direct method. Using direct method can remove dye from 100 ppm of initial dye concentration with the removal percentage of 93.85% using 3000 mg/l coagulant dosage at pH 2. For *Hibiscus sabdariffa* powder, the powder was able to remove 99.20% of dye from the wastewater using 1500 mg/l at pH 2. It is found that the efficiency of *Hibiscus sabdariffa* powder as a coagulant is comparable with the direct method.

Keywords: *Hibiscus sabdariffa*, Freeze drying, Congo red, Natural Coagulant, Coagulation

PREPARATION OF POLYVINYL ALCOHOL WITH NATURAL HYDROXYAPATITE FROM WOLF HERRING FISH BONE AS BIO COMPOSITE

EDMUND DAVID*, SIEW WEI PHANG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: edmunddavid@sd.taylors.edu.my

Abstract

The focus of this work was to study the bio composite materials as a potential application in medical field. A theoretical study was carried out in the literature review where the focus was on various types of biomaterials mainly on composites of Polyvinyl Alcohol (PVA) and natural Hydroxyapatite (HAp). Natural hydroxyapatite was obtained from Whitefin Wolf Herring fish bones. The fish bones were cleaned, then calcinated at 800^{o}C for 4 hours and powdered to 200μm. Polyvinyl alcohol (PVA) samples were prepared with various ratios of Hydroxyapatite (0% HAP, 2.5% HAp, 5% HAp, 10% HAp, 20% HAp and 30% HAp) through the solution casting method. Fourier Transform Infrared Spectrometer (FTIR) was used to identify and verify the various functional group in the composite samples. Thermogravimetric Analyse (TGA) and universal tensile testing was done to measure the effect on amount of HAp in the bio composite samples based on its thermal stability and mechanical properties respectively. The major contribution by this work will be that bio composites of PVA/HAp were tested and characterised by using a wide scope of methods. For as in FTIR, the components bonding between them are detected, the composites thermal stability has been further improved when compared to that of pure PVA and finally mechanical properties of the bio composite has been strongly influenced as well.

Keywords: Hydroxyapatite, Polyvinyl Alcohol, Bio composite, Solution casting Characterization

DEVELOPMENT OF EGGSHELL/ CHITOSAN FILM

EDZMIERA SALFENA BINTI MOHD SUKRIE*, OH KAI SIANG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: edzmierasalfenamohdsukrie@sd.taylors.edu.my

Abstract

Water is fundamental to life on earth. As of late, water has become scarce in supply in many regions of the populated world. Greywater can be treated by recycling in individual houses as a means of conserving freshwater. Adsorption method is a treatment method that is mostly favored among other methods due to its rapidity, efficiency and convenience as well as its insensitivity towards toxic contaminants. Eggshell and chitosan have shown promising characteristics in terms of being good adsorbent materials. The porous structure of eggshell make for an effective green adsorbent. Meanwhile, chitosan exhibits exceptional properties such as high adsorption capacity, macromolecular structure, low-cost, non-toxicity etc. Eggshell is positively charged at pH 1-6 and is negatively charged at pH 6-9. Hence, it may act as a buffer. Moreover, chitosan is cationic in nature. The pH effect plays a vital factor in the capacity of eggshell/ chitosan film as the amino groups in chitosan are easier to cationize at low pH and they are able to adsorb the composition of greywater anions strongly by electrostatic attraction. Eggshell/ chitosan film are added into synthetic greywater sample and are agitated on an orbital shaker. Comparison between untreated and treated greywater solution that contains eggshell/ chitosan films of different eggshell concentrations is done based on parameters such as pH, turbidity, COD and TSS. Experimental results show that 0.5 wt% of eggshells in eggshell/ chitosan film is the optimal combination for effective synthetic greywater treatment. This indicates that the presence of more eggshells in the film will decrease the treatment efficiency.

Keywords: Greywater, treatment, eggshell, chitosan, adsorption

INVESTIGATION OF SUGAR PRODUCTION FROM UNWASHED SUGARCANE BAGASSE

DR.YOON LI WAN*, ISHRAK SHARIAR RAFI

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: liwan.yoon@taylors.edu.my

Abstract

Washing is an essential step to neutralise the pH of the deep eutectic solvent (DES) pretreated substrate prior to enzymatic hydrolysis. Elimination of washing stage could result in significant cost saving to produce bioethanol. This study aims to investigate the feasibility of applying unwashed DES-pretreated substrate for glucose analysis by finding a suitable DES producing high glucose content. Four different DES consisting of choline-chloride citric acid, choline-chloride glycerol, choline-chloride urea and choline-chloride malonic acid were used in pre-treating sugarcane bagasse. Chlorine-chloride malonic acid was chosen as the DES due its ability to produce the highest glucose concentration. To evaluate the feasibility of unwashed pretreated substrate, glucose production from enzymatic hydrolysis from both washed and unwashed pre-treated sugarcane bagasse was compared and evaluated. The washing step is proven to be non-essential as the glucose content measured by DNS method for the unwashed pretreated substrate (3.03mg/ml) has shown to be higher than the washed pretreated substrate (2.91 mg/ml). This study suggests that it is feasible to apply unwashed pre-treated substrate for bioethanol production which will further reduce the cost involved in the wastewater generation.

Keywords: bioethanol production, deep eutectic solvent, enzymatic hydrolysis, pretreatment, lignocellulosic biomass, washed substrate, unwashed substrate, glucose concentration.

PREPARATION AND CHARACTERIZATION OF RICE STRAW-BASED HANDMADE PAPERS:TEARING RESISTANCE, TENSILE PROPERTIES AND SURFACE MORPHOLOGY

SHI MIN LEE, JIUN HOR LOW*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: JiunHor.Low@taylors.edu.my

Abstract

The aim of this research is to replace wood fibre with rice straw fibre for the fabrication of handmade paper. Furthermore, different concentration of sodium hydroxide solution was used and the effect of sodium hydroxide concentration on the mechanical properties of rice straw-based paper is reported in the present study. The optimum point obtained from the tearing test was at 10% sodium hydroxide concentration whereas for the tensile test, Young's Modulus and elongation at break the optimum point obtained was at 15% sodium hydroxide concentration. The increment of tensile and tear strength is due to degree of delignification increase when sodium hydroxide increased as shown in the Fourier Transform Infrared (FTIR) test. However, a decreasing trend was observed when there is further increased of sodium hydroxide concentration. This is due to the degradation of cellulose occur which is observed by surface morphology, where fibrillation was observed on the rice straw fibres at 25% sodium hydroxide concentration due to the degradation of cellulose.

Keywords: Rice straw; non-wood fibres; handmade paper; sodium hydroxide concentration; lignin.

DEVELOPMENT OF BLOO MIMICKING FLUID FOR SURGICAL SIMULATION USING 3D PRINTED ANATOMICAL MODEL

LEE SZE HUI[1*], ANIS SUHAILA SHUIB[1], DAVID GERAINT HASSELL[1] AND MUHAMMAD IZZAT AHMAD SABRI[2]

[1]School of Engineering, Taylor's University, Malaysia
[2] Lönge Medikal Sdn. Bhd., Putra Science Park, Malaysia
*Corresponding Author: szehui.lee08@sd.taylors.edu.my

Abstract

Surgical simulation is a medical procedure performed by medical professionals to rehearse a complicated surgery or to train new surgeon by using a human anatomical model or cadaver instead of actual patient. Currently, the surgical simulation is done using 3D-printed anatomical model to physically simulate actual surgery on patient with water acting as a substitute for blood. However, the tactile feedback of blood mimic needs improvement and it is related to blood rheology. Blood mimicking fluid (BMF) or also known as blood analogue fluid is a type of fluid that has the physical properties of blood but not the hazards of it as human body fluids. Contrast agent is added to the fluid so that the flow could be viewed in medical imaging devices such as X-Ray, computed tomography angiogram (CTA) and magnetic resonance imaging (MRI). According to the literature, blood behave as shear thinning fluid, hence the non-Newtonian models of Power Law is chosen as a basis. An experiment is designed to develop a new blood mimic which consider the addition of contrast agent. In this research, samples of blood mimicking fluid are prepared by varying chemical compositions of xanthan gum, distilled water and glycerol at different ratios within a shear rate range of 0.1 to 245 s^{-1}. The contrast agent is added to evaluate the influence of contrast agent in the rheology of blood. Screening analysis is performed to determine the factor that has the most influence on the viscosity of the fluid developed. Since true blood has a viscosity range of 3.00-11.00 cP , the potential mimic fluid that was chosen has a chemical ratio of glycerol at 40 %v/v, water at 60% v/v and xanthan gum at 0.06% w/v, with a viscosity range of 3.09-25.20 cP. The addition of contrast agent to the mimic fluid shows a decrease in viscosity to a viscosity range of 2.68-12.80 cP.

Keywords: Blood Mimicking Fluid, Blood Analogue Fluid, Shear Thinning Fluid, Rheology, Non-Newtonian Fluid

GREYWATER TREATMENT USING EGGSHELL POWDER

JIA-E LIM, KAI SIANG OH*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: KaiSiang.Oh@taylors.edu.my

Abstract

In the present days, numerous number of people suffer from water scarcity. Greywater recycling is one of the possible solutions to this challenge as it is an alternative for water source that can be utilized at long term basis. Also, greywater can be used for non-potable purposes after treatment. In this project, eggshell is used to treat greywater as it is high porous and environmental-friendly which makes it a great green adsorbent. The treatment performance between calcined chicken eggshells and non-calcined chicken eggshells in removing total suspended solids (TSS), turbidity, chemical oxygen demand (COD), dye, oil and grease from the synthetic dark greywater are studied and compared. The chemical structure of the eggshells before and after calcination are observed using the Fourier-transform Infrared Spectroscopy (FTIR) and is found that the significant difference between non-calcined and calcined eggshells is that the peak at 3639cm^{-1} appears after calcination. The peak indicates the O-H bonding during the water adsorption by calcium oxide when the calcium carbonate breaks down into calcium oxide during calcination. The adsorption studies are conducted with various eggshell sizes of <500 µm, 500 µm, 600 µm, and 800 µm and dosages of 0.025 g/ml, 0.05 g/ml, 0.075 g/ml, and 0.1 g/ml. The most suitable size and dosage of the chicken eggshells used in the adsorption process is found to be the smallest size of <500 µm and highest dosage of 0.1 g/ml. The results show that the treatment performance of calcined eggshells is better than the non-calcined eggshells, with the removal efficiency achieved up to 97.2%.

Keywords: Greywater, eggshell, greywater recycling, adsorption, calcination.

PARTIAL PURIFICATION OF ANTHOCYANINS FROM *GARCINIA MANGOSTANA* PEELS USING AQUEOUS TWO-PHASE SYSTEM

Y. H. CHOW*, Z. T. L

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: YinHui.Chow@taylors.edu.my

Abstract

Aqueous two-phase system (ATPS) was employed in this studies for the extraction of anthocyanins from *Garcinia mangostana* Peels. The factors that affects the extraction efficiency of anthocyanins such as the type and concentration of salt, the concentration of ethanol and the crude load were studied. The optimum conditions for the recovery of anthocyanins was achieved in ATPS that composed of 20% (w/w) of ammonium sulphate, 24% (w/w) ethanol and 2.5% (w/w) *Garcinia mangostana* peels powder. Results showed that the anthocyanins can be simultaneously extracted from the *Garcinia mangostana* peel and partial purified in the ethanol-rich top phase with a yield of 90.69%, while 50.99% of sugar and 5.68% of protein were removed to the salt-rich bottom phase in one step. This study demonstrated that ATPS can serve as potential tool for the extraction and separation of natural pigments from plant sources.

Keywords: *Garcinia mangostana*, Aqueous two-phase system, Anthocyanins, Extraction, Purification.

TREATMENT OF TEXTILE WASTEWATER BY PHOTO FENTON PROCESS

MUSAB SAIF MUBARAK ALKIYUMI, RAJESH RAJASEKARAN*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: rajesh.rajasekaran@taylors.edu.my

Abstract

The flourishing of the textile industry has been causing an adverse result due to the significant amount of by-product textile wastewater. The main product is the dye that appears in different ways and chemical forms and carries toxic materials in most cases. In addition to the dyes, the use of detergent biocides as a part of manufacturing textiles constitutes the second hazard pollutants in the textile effluent. The textile effluent has to be treated to avoid environmental and health hazards which can be anywhere from destroying the ecosystem due to high acidity with high biological oxygen demand (BOD), chemical oxygen demand (COD), and creating the total suspended solids (TSS). The treatment of textile wastewater has been regulated by local governments and the United Nations by issuing and been standardized by relevant international organizations. Research has shown that several methodologies are being used to achieve the accepted environmental level of the textile pollutants in the textile effluent. In this report, photo Fenton is used to treating the textile wastewater collected from one of the local textile industries. Photo Fenton has proven that it is an effective method to treat textile wastewater. The basic principle of photo Fenton process is oxidizing organic and inorganic compounds (called pollutants) and degrade them such that they become easier to rid of them. The textile wastewater using photo-Fenton oxidation process was investigated using UV. The influence factors of the PH, Fe^{2+} concentration, H_2O_2 concentration were studied and determined at the optimum value to treat textile wastewater by photo fenton process. It is expected that the treatment of textile wastewater will result in a higher reduction of COD, normal pH range, reduction of toxicity level in order reach the level accepted by the standard of the health and environmental organizations.

Keywords: Textile, Wastewater, Photo Fenton.

OPTIMIZATION OF THE PURIFICATION OF POLYPHENOLS FROM DACRYODES ROSTRATA SEED EXTRACT USING SECONDARY STAGE AQUEOUS TWO PHASE SYSTEM (ATPS)

NASAR AL-MAHROUQI, TEE LEE HONG*, OH KAI SIANG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: LeeHong.Tee@taylors.edu.my

Abstract

The immunity of the human body is critical for being healthy. Indeed, it plays major role in living longer by preventing or healing from such diseases. One of the important pillars for well immune system is antioxidants. Under the environmental stress, oxidative stress occurs when reactive oxygen species (ROS) attack the cell molecules leading in poising DNA and RNA which then can result to cancer and cardiovascular. The significant of the antioxidants exists in stopping or preventing the cell damage caused by ROS. Due to the facts that the low concentration of the antioxidants and the high concentration of ROS results in oxidative stress and our bodies do not produce enough antioxidants, human diet like fruits, vegetables and grains are main source of antioxidant. One of these fruits is *Dacryodes Rostrata.* The antioxidants exists as polyphenols in *D. Rostrata* and it is found that its seed has the highest amount of them. The aim of this study is to extract the polyphenols form *D. Rostrata* seed using the Aqueous Two Phase System (ATPS). A conventional extraction (Solid-Liquid Extraction) is done to extract the polyphenols from *D. Rostrata* seed. Since the extract amount has impurities, first stage ATPS is done as purification method to purify the total phenolic content (TPC) and the total flavonoids content (TFC) by eliminating more of the total sugars content and the total protein content. The first part of this project is to conduct secondary stage of ATPE to enhance the purity of both TPC and TFC. The secondary stage ATPE has only parameter which is ammonium sulfate concentration. The other part is to add sodium chloride for first stage ATPE.

Keywords: Antioxidants, Polyphenols, Aqueous Two Phase System, *Dacryodes Rostrata.*

WATER RECLAMATION OF KLANG RIVER

NAVED AHMED*, DR. RAJESH RAJASEKARAN, DR. WAN YOKE KIN

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: navedahmed25894@gmail.com

Abstract

Water Scarcity is one of the great dangers that is looming on the current and future generation of human beings. Only around 3% of the water on the Earth's surface accounts for freshwater, of which two-thirds are stored away in frozen glaciers or are not currently available for usage. The available freshwater on Earth is under continuous threat by the economic activities of the humans coupled by the climate change. Many research and studies conducted indicates that the scarcity of water is destined to increase significantly over the next few decades which would challenge the food security, environmental sustainability, and economic development of the society. On of the main reasons for this situation is the heavy exploitation of the river resources in recent years. Rivers have always been one of the very important sources for the supply of freshwater. But due to the rapid growth in economy and urbanization most of the rivers around the world have become vulnerable to constant disposal of industrial, domestic and other wastes, which has seen a great rise in river pollution resulting in the serious damage of the ecosystem. Therefore, many rivers have lost its function as a resource which has extremely depreciated the urban ecosystem and the aquatic environment. Thus, it is very important to invest on effective techniques to manage the river water quality, especially given that the water scarcity is also looming large on the current generation of the human population. Malaysia also has its own problem of river pollution. The Klang River, which is one of the main rivers of Malaysia, has become polluted significantly and the situation is getting worse. Cleaning it up could reduce some of the stress on the water supply resources. One of the fourteen Grand Challenges is to 'provide access to clean water'. So getting the motivation from here this project was selected. This research is aimed to first find the pollution source of the river, and what is the level of pollution that currently exists in the Klang river. The treatment approach would be according to the level of pollution. The major challenge would be to make sure the quality of the Klang river water could be maintained after achieving it, so that the future generation does not have to spend on its treatment to use the water from it. The approach would be to collect some samples of water from the Klang river and perform tests on them to check whether they satisfy the water quality standards set by the Department of Environment (DOE) of Malaysia. There are a list of parameters on the Water Quality Index (WQI) table set by the DOE, which are aimed to be used in this research to check the quality of water. Through the study of other literature, it is expected that the main source of pollution are the non-point sources, i.e. the domestic wastes, because of which the water quality is diminishing in the Klang River.

Keywords: Water scarcity; water quality parameters; pollutants; river water quality; treatment

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PREPARATION AND CHARACTERIZATION OF PLASTIZED POLYLACTIC ACID FILLED WITH GRAPHENE

JIA L. NG[1], MING M. PANG[1,*], SEONG C. KOAY[1], TSHAI K. Y.[2], Y. F. BUYS[3]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
[2]Faculty of Engineering, University of Nottingham Malaysia Campus, Jalan Broga, 43500 Semenyih, Selangor, Malaysia
[3]Department of Manufacturing and Materials Engineering, International Islamic University Malaysia (IIUM), Jalan Gombak, 53100 Kuala Lumpur, Malaysia
*Corresponding Author: mingmeng.pang@taylors.edu.my

Abstract

Polylactic acid (PLA) was mixed with graphene nanoplatelets (GNP) ranged from 1 to 12 wt% by using melt blending method. A constant 10wt% coconut oil (CO) was used as a plasticizer which can enhance the flexibility and processability of polymers with fillers through improving interfacial interaction between PLA and GNP. The effects of GNP filler content and CO on the electrical, mechanical and morphological properties of polylactic acid (PLA) composites with GNP fillers were investigated. The mechanical results showed that the addition of GNP decreased the tensile strength and elongation at break but increased the tensile modulus of PLA/GNP composites. The addition of CO had improved the mechanical properties by increasing the elongation at break and decreasing both the tensile strength and tensile modulus of PLA/GNP composites. Meanwhile, the surface resistance of PLA/GNP composites was dropped by increasing the GNP content. The addition of CO did not affect the electrical properties. The adoption of electrical property was attained at high GNP content, at approximately 7wt% GNP filler content, which the surface resistivity dropped to conductive range of ~10^4 Ω. The presence of CO enhanced the interfacial adhesion between GNP and PLA matrix.

Keywords: Conductive polymer composite; Polylactic acid; Graphene nanoplatelets; Coconut oil.

PREPARATION AND EVALUATION OF LIGNIN FILLED WATERBORNE POLYURETHANE BIO-COMPOSITE FILMS: TENSILE PROPERTIES, DENSITY, THERMAL STABILITY AND SURFACE MORPHOLOGY

QI YUAN NG, JIUN HOR LOW*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: JiunHor.Low@taylors.edu.my

Abstract

Waterborne Polyurethane (WPU) is a green alternative to the conventional solvent borne polyurethane. However, the WPU is inferior in mechanical properties and thermal stability compared to its solvent borne counterparts. For this reason, the synergistic effect of lignin and WPU was investigated and reported in the present study. The lignin-WPU bio-composites films were prepared at different lignin content (0.5, 1.0, 1.5 and 2.0 wt%). The study revealed that the ultimate tensile strength of the fabricated bio-composite films decreases with increasing of lignin loading due to the weak interfacial adhesion between lignin and WPU, as evidenced by scanning electron microscopy analysis. The result reveals that the ultimate tensile strength of 2wt% lignin-WPU bio-composite film is 27.7% lower than pristine WPU film. Besides, the incorporation of 2 wt% lignin leads to the 50% increase in Young's modulus and 98% decrease in elongation at break of WPU bio-composites. Owing to the low-density and low-thermal stability nature of the lignin, the fabricated bio-composite film shows decrease trend for both density and thermal stability with the increasing of lignin loading. The density and the initial degradation temperature for the 2 wt% lignin-WPU bio-composite film is 0.7648 kg/m^3 and 285.59℃ respectively.

Keywords: Waterborne Polyurethane, Lignin, Bio-composite Film, Tensile Properties, Thermal Stability

DEVELOPMENT OF AN ULTRASONIC MICROMIXER

NIGEL YEOH EU-HAAN, DAVID GERAINT HASSELL*, ANIS SUHAILA SHUIB*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: david.hassell@taylors.edu.my, anissuhaila.shuib@taylors.edu.my

Abstract

This research was performed to evaluate the effects of ultrasonic agitation in a microchannel to benchmark emulsions such as milk. Milk was diluted due to its opacity and the rheology of diluted milk was studied. The velocity profile of the flow was also analysed using a particle image velocimertry (PIV) software, PIVLab. Images of the microchannel were captured using a light microscope and a smartphone. These tests were performed to ensure diluted milk exhibited a Newtonian behaviour as well as obey the velocity profile in a fully developed laminar flow. Using ultrasonication at 42 kHz, the flow behaviour of the microchannel was observed and analysed with PIV at respective on/off states. This was carried out with varying flowrates of 0.3, 0.4, and 0.5 ml/hr. However, no significant changes in flow behaviour could be found with visual observations as well as with PIV analysis. This outcome has been discussed in the paper.

Keywords: Microfludics, emulsions, ultrasound, particle image velocimetry (PIV)

OPTIMIZATION OF AQUEOUS TWO-PHASE EXTRACTION OF ANTHOCYANIN FROM *D. ROSTRATA* PEELS

NURASATIFAH KAHAR[1], LEE HONG TEE[1,*], YIN HUI CHOW[1]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: LeeHong.Tee@taylors.edu.my

Abstract

Anthocyanin is a natural pigment found in plants and fruits. *Dacryodes rostrata* is one of the indigenous fruits which contains high amount of anthocyanin in its peel. Aqueous Two-Phase Extraction (ATPE) is a powerful technique that is able to extract and purify anthocyanin in a single integrated step due to its high-water content, which generates low interfacial tension, resulting in the formation of the two phases and efficient separation and purification of biomolecules using low energy. This research aims to select ethanol-salt ATPS and to identify the ATPS system parameters that have a significant effect on the extraction and purification of anthocyanin from *D. rostrata* peel using 2^4 factorial design. The first part of the experiment was to screen out the ethanol-salt system based on the efficiency and partition behaviour of Total Anthocyanin Content (TAC). Sodium dihydrogen phosphate was chosen for the factorial screening as it has the most efficient TAC extraction. Each factor (concentration of ethanol, concentration of salt, concentration of crude load and mixing time) and their interaction were then analysed. The concentration of ethanol and the concentration of crude load are the single factors that was shows influence on the the partition coefficient and recovery of TAC and TPC, whereas the concentration of NaH_2PO_4 and mixing time is insignificant to the any responses. Results obtained also showed that the interaction between concentration of ethanol and NaH_2PO_4 is significant to partition coefficient and yield of TAC. The highest yield and partition coefficient can be achieved with high concentration of NaH_2PO_4 and ethanol, therefore this system is selected for optimization. Concentration of ethanol, salt and sample load shows significance and high contribution to the responses. On the other hand, mixing time was found insignificant and contributed the least effect on the responses. Therefore, mixing time is not selected for further optimization work.

Keywords: Anthocyanin, Antioxidant, Aqueous Two-Phase Extraction, Dacryodes rostrata, Response Surface Methodology

THE EFFECT OF ALKALINE AND SILANE TREATMENT ON COCONUT SHELL POWDER AND COIR FIBER SURFACES. CHARACTERIZATION BY FTIR, TGA, SEM.

PRIYA MARAPPAN*, MOHAMMED HOSSEINI FOULADI[1], SATESH NARAYANA NAMASIVAYAM[1], HUI LING CHOO[1], THAI KIAT ONG[2], RASHMI WALVEKAR[1]

[1]School of Engineering, Taylor's University, 47500 Subang Jaya, Selangor, Malaysia.

[2]Faculty of Engineering and Technology, Tunku Abdul Rahman University College,53100, Kuala Lumpur, Malaysia.

*Corresponding author: priya.marappan@sd.taylors.edu.my

Abstract

Natural fiber provides an alternative to the conventional synthetic fibers as reinforcing agent in the polymer composites. Such reinforcement improves the mechanical and thermal properties of the composite. Poor fiber-matrix interfacial adhesion may, however, reduce the physical and mechanical properties of the resulting composites due to the surface incompatibility between hydrophilic natural fibers and hydrophobic polymer. Chemical surface modification of the fiber improves the fibers' physical properties and the interfacial adhesion. The objective of this work was to modify coconut shell powder (CSP) and coconut coir fiber (CF) using 5wt% alkaline solution and 3wt% of 3-glycidoxypropyltrimethoxysilane coupling agent (GPTMS) solution and to study the effects of the treatment on the functional group changes, thermal properties, and morphologies of the fibers. FTIR studies demonstrated that the silyl parts of silane coupling agent efficiently grafted on CSP and CF. SEM images of treated CSPs and CFs further proves the efficiency of the silane treatment. CSPs and CFs has the potential to be used as reinforcing agent in polymer composites.

Keywords: coconut shell powder (CSP), coir fiber (CF), reinforcing agent, 3-glycidoxypropyltrimethoxysilane (GPTMS).

RESPONSE SURFACE METHODOLOGY OPTIMISATION OF THE EXTRACTION CONDITIONS AND MATHEMATICAL MODELLING OF THE EXTRACTION KINETICS OF ALOE-EMODIN IN *CASSIA ALATA*

Roger Suraj A/L Sebastian[1,*], and Dr. Chua Bee Lin[1]

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: rogersuraj.sebastian@sd.taylors.edu.my

Abstract

Cassia alata (L) is an medicinal plant which belongs to the family of fabaceae This research is performed to identify the optimum extraction condition of the Ultrasound Assisted Extraction (UAE) extraction method and to analyse the antioxidant activity of aloe-emodin. The main objective of the research to select oven drying temperature which will produces highest aloe-emodin yield, to identify ideal extraction condition of UAE by utilising the Response Surface Methodology (RSM), and to select the best fitted extraction kinetic model of aloe-emodin from *Cassia alata* at its optimum condition. Based on the results obtained from the research, as for the determination of the yield percentage of crude extract 60℃ oven drying temperature produces highest percenatge crude extract yield which have a value of 12 % compared to the oven drying temperature. Furthermore, 60℃ oven drying temperature records highest antioxidant activity of aloe-emodin with the value of 54.33 % compared to the other oven drying temperatures. Lastly, drying kinetic of 60℃ oven drying temperature were modelled and anaysed.

Keywords: Cassia alata, Aloe-emodin, Ultrasound Assisted Extraction (UAE), Oven drying temperature, Antioxidant Activity.

EVALUATION NON-NEWTONIAN MIXING IN MICROCHANNELS

SK. MD. NOOR E ALAM*, DAVID GERAINT HASSELL, ANIS SUHAILA SHUIB

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: anna_a_lee@web.abc.cd

Abstract

Numerical simulations were carried out to investigate the flow dynamics and mixing in serpentine microchannel. Both Newtonian and non-Newtonian fluid were studied and analysed. As an illustrative case study, non-Newtonian fluids with parameters n=0.2 and n=1.8 were considered. Cartesian equation was used to model the simulation software. Steady and Navier-Stokes equations were solved in flow and mixing analysis. All the simulations were performed in 'ANSYS 18.0 Academic'. Three Reynold numbers (Re=1, 50 and 100) were studied for Newtonian fluid and non-Newtonian fluids. Flow in serpentine channel of Newtonian fluid was parabolic and was symmetric. As for the flow of non-Newtonian fluids, the curves were different. For n=0.2, shear thinning effect was observed and for n=1.8 shear thickening effect was observed. All the curves for n=0.2 at three Reynold numbers used showed similar pattern, however there were some differences. Curves for n=1.8 at three Reynold numbers displayed parabolic patter similar to the Newtonian fluid, however with higher maximum velocity. Velocity in z-direction was observed for flows higher than Re=1 and n=1. This implies fluid mixing will be high under such conditions due to more cross-flow in the curvature of the serpentine channel.

Keywords: Mixing, Serpentine, Numerical Analysis, non-Newtonian, laminar

PHENOLIC COMPONENT AND ANTIOXIDANT ACTIVITY ANALYSES OF EXTRACTED PLUMERIA OBTUSA CONCENTRATE

W. S. TAN, R. NITHYANANDAM*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: Rajesh.Rajasekaran@taylors.edu.my

Abstract

This research is to study the phenolic compound recovery of *Plumeria Obtusa* (Frangipani flower) and comparing two extraction methods which are hot water extraction and ultrasonic-assisted extraction. Various extraction conditions are used including ethanol concentration (0-100% v/v), extraction time (10-60 minutes), extraction temperature (25-65^{o}C) and solid to solvent ratio (1:15 to 1:120). Ultrasonic-assisted extraction (UAE) is a more efficient method to extract antioxidant compounds out from plumeria obtusa compared to hot water extraction (HWE) in terms of yield and antioxidant activity of phenolic compounds with the highest values of 1180.06 mg GAE/100g DW, 2654.76 mg QE/100g DW and 163.99 μM Trolox/100g DW. Also, the optimum UAE condition for plumeria obtusa is performed under a temperature of 45^{o}C, 30 minutes extraction time, solid to solvent ratio 1:30 and ethanol concentration of 40%. Under this condition, the values reported are 745.83mg GAE/100g DW for TPC, 1967.33 mg QE/100g DW for TFC and 98.8 μM Trolox/100g DW for 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid (ABTS) scavenging. TPC and TFC were found to have good correlation with ABTS (0.710 & 0.614) under the influence of ethanol concentration. However, TPC and TFC showed low and negative correlation with ABTS under the influence of extraction temperature.

Keywords: *Plumeria Obtusa, Hot water extraction (HWE), Ultrasonic-assisted extraction (UAE),* Total phenolic content (TPC), Total flavonoid content (TFC), 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical-scavenging capacity.

DESIGN OF PROCESS CONTROL TO OPTIMIZE GLOVE CHLORINATION PROCESS

TIONG SHIN EN*, LEONG YIK TEENG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: martintiong95@gmail.com

Abstract

Chlorination is an approach in glove industry to produce powder-free latex glove with low protein levels. However, carry over protein that caused latex protein allergy due to inappropriate glove chlorination process had rose the concern among the end user mostly patient and medical personnel who has higher exposure to the risk. In this research study, design of process control for the chlorination system optimization will be conducted. Statistical analysis of data: ANOVA test and empirical modelling will be performed during the optimization process based on real time data.

ANOVA test were conducted via Minitab software by using the real time process data of three main factors; chlorine temperature (A), former temperature (B) and cooling tank temperature (C) to identify the most significant main effect of chlorination system. The selection of main factor will based on resulted highest P-value. For further investigation, the main effects and interactions graph will be plotted. For empirical modelling, System Identification Toolbox™ by MATLAB® are employed for generation of process model and disturbance model. Block diagram of three different process control schemes; Feedback control, Feedforward control and Feedback-Feedforward control are constructed and simulated via Simulink software. The performance analysis for each of the process control scheme is assessed based on simulated step response graph by comparing the transient response parameters such as settling time, t_s and overshoot. The main factor was identified to be the former temperature (B) with a P-value at 0.2777 which shows the most significant effect on the chlorination system. However, former temperature cannot be altered, hence, oven temperature which is correlated to former temperature will be considered as the main effect for empirical modelling. Process model and disturbance model were generated via System Identification Toolbox™ by MATLAB® based on real time data collected from the chlorination system. Based on the step response graph simulated from Simulink software using pre-determined process and disturbance model, the parameters; settling time, t_s for feedforward control, feedback control and feedback-feedforward control were 987.17 seconds, 481 seconds and 446.7 seconds while the overshoot percentage were 175.5%, 22.6% and 2% respectively. The simulation results showed that feedback-feedforward control had outperformed feedback and feedforward control in terms of the parameters. Feedback-feedforward demonstrated faster response time and lowest overshoot percentage. Hence, feedback-feedforward control has been selected as the best option to optimize the chlorination system.

Keywords: Powder-free gloves, Chlorination, Process control, Statistical Analysis of Data, ANOVA

EFFECT OF TEMPERATURE AND SONICATION TIME ON DESULPHURIZATION EFFICIENCY OF GROUND RUBBER TYRE UTILISING DEEP EUTECTIC SOLVENTS

UDYANEE J[1], RASHMI W.[1]*, RICKY SAPUTRA[1], KHALID M[2]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
[2]Graphene & Advanced 2D Materials Research Group (GAMRG), School of Science and Technology, Sunway University, 47500 Subang Jaya, Selangor, Malaysia

*Corresponding Author: rashmi.walvekar@gmail.com

Abstract

Deep Eutectic Solvents (DESs) are a devulcanization agent that is suggested to replace Ionic Liquids which are more economically costly and environmentally harmful. The purpose of this study is to study the effect of sonication time and temperature on the devulcanization process using DES. With a fixed rubber to DES mass ratio of 1:20, sonication time was varied to 10, 20, 30, 40, 50 and 60 minutes while the heating time was varied to 5, 15, 25, 35, 45, 55, and 60 minutes at 180℃. After carrying out FTIR and gel content analysis it was proven that the best conditions for devulcanization process is using sonication time of 60 minutes followed by heating at 180℃ for 55 minutes. This result was used to study the effect of zinc chloride in the devulcanization process by using three different zinc chloride mass ratios. By, analysing the samples using FTIR it was observed that the samples with zinc chloride underwent devulcanization successfully.

Keywords: Deep Eutectic Solvents, Devulcanization, Ground Tyre Rubber, Sonication Time

CENTRALISED CLEANING SOLUTION RECYCLING SYSTEM FOR GLOVE HAND-MOULD WASHING TANK

VENCY LAI, YIK T. LEONG*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: yikteeng.leong@taylors.edu.my

Abstract

Glove hand-mould washing tanks are frequently cleaned to remove the accumulated solids and replaced with new cleaning solution to ensure efficient hand-mould washing, resulting in increased freshwater consumption for cleaning and preparing new cleaning solution. This can be overcome by integrating a centralised hub for cleaning solution recycling in the process. Thus, this paper aims to determine the suitable solid-liquid separation equipment involved in the centralised hub and determine the optimum cleaning solution recycling flowrate to meet the maximum allowable suspended solids concentration in the washing tanks through the mathematical optimisation approach. Multiple solid-liquid separation equipment was listed as potential process unit involved in the centralised hub prior to performing optimisation on the mathematical model developed for the centralised recycling system embedded with solid-liquid separation equipment. Sensitivity analysis was conducted to study the effect of change on cleaning solution recycling ratio to determine the optimum recycling flowrate with minimum total annualised cost. The findings from this research showed the centralised recycling system embedded with a bag filter system and recycling ratio of 0.9 has the least total annualised cost and achieved approximately 39.6% reduction in both raw materials consumption, and 58.3% wastewater generation.

Keywords: Water minimisation, process integration, mathematical optimisation, glove industry.

ANTIFOAMING FOULING AND CHEMICAL CLEANING OF FORWARD OSMOSIS MEMBRANE

WINSTON L.K LIM[1]*, Y.K. WAN[1]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: winstonlikkhai.lim@sd.taylors.edu.my

Abstract

The fouling propensity of forward osmosis membrane in treating silicone-based antifoam-rich wastewater and the cleaning effectiveness by both physical and chemical cleaning were studied in bench scale experiments. Through 1-hour wastewater tests, it was found that rapid fouling of 55 – 57% fouling had occurred. The foulant consisted of both physically reversible and irreversible fouling. The physical cleaning, in reverse flush mode, had contributed 25 – 50% fouling reduction from the total fouling. By varying chemical cleaning period of 30 min – 4 hours, it was found that 30-min and 1-hour alkali and acid cleaning had less cleaning effect. Unexpectedly, 2-hour acid cleaning had instead, increased fouling percentage after 2-hour alkali cleaning. Nonetheless, the synergistic effect of alkali-acid cleanings had shown significant fouling reduction. It was found that 4-hour alkali cleaning and 2-hour acid cleaning showed the optimum results in terms of cleaning time and chemical usage without compromising membrane integrity. No correlation was found between cleaning efficiency and fouling severity. Therefore, few sets of alkali-acid cleanings have to be performed in order to reduce the fouling percentage to desired value.

Keywords: Forward osmosis, membrane fouling, membrane cleaning, wastewater, silicone-based antifoam

MICROSTRUCTURE CHARACTERIZATION AND MECHANICAL PROPERTIES STUDY FOR PVA-HYDROXYAPATITE COMPOSITE DERIVED FROM MACKEREL FISH BONE

HUI YING YOW, SIEW WEI PHANG*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: SiewWei.Phang@taylors.edu.my

Abstract

The aim of this work is to synthesize biocomposite scaffolds by embedding natural hydroxyapatite (HAp) particles derived from Mackerel fish bones in poly(vinyl alcohol) (PVA) as well as to characterise the properties of the composites. The composites of HAp and PVA have proven mechanical properties and osteoconductivity that allow it to be used as bone graft substitutes in BTE applications. In this work, mackerel fish bone is selected as the natural source to extract HAp because fish bone is inexpensive and does not provoke religious conflicts, while mackerel fish can be easily accessed in this region. To fabricate HAp/PVA composites scaffolds, the simple and inexpensive solution casting technique is selected. The HAp particles extracted from Mackerel fish bones are calcinated and grinded to produce <200 µm of particles. Pure PVA is plasticised by glycerol and water in 97 ºC for 1 hour. The HAp/PVA composites are prepared using solution-based technique varying HAp from 2.5 phr to 30 phr in thin films as it can successfully create uniform dispersion of HAp in the PVA blend. Fourier transform infrared absorption spectra (FTIR) and thermogravimetric analysis (TGA) have proved the interaction between PVA matrix and HAp particles are due to the strong intermolecular hydrogen bonding and $[HO]-Ca^{2+}-[OH]$ linkage. The results also show an improvement in mechanical properties of the composites with the increase in the loading of HAp particles to 5 phr to the resultant composites. Higher HAp contents in the composites such as 10, 20 and 30 phr resulted in agglomeration and deterioration of mechanical strength. By comparing the composites and human cancellous bones, the mechanical properties were similar. In conclusion, 2.5HAp/PVA and 5Hap/PVA composites with uniform microstructure and enhanced mechanical properties have the potential to act as an effective biomaterial for the replacement of human cancellous bones.

Keywords: Poly(vinyl alcohol), Hydroxyapatite, Solution Casting, Bone Tissue Engineering

PRELIMINARY STUDY ON COMPUTER NUMERICAL CONTROL MACHINABLE WAX FOR PROTOTYPING

L.W. ADRIAN CHUNG, W.J. KELVIN CHEW*, S.C. KOAY, S. RAMESH

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: kelvinwaijin.chew@taylors.edu.my

Abstract

The effects of the addition of polymer on the structure, hardness and machinability of the solid block of machinable wax were investigated. The samples were prepared through melting and molding. The results from the molding of the formulated machinable wax indicates that the increase in polymer content increased the flex and shrinkage in the wax block. The increase in polymer content also caused an increase in the surface roughness of the wax block. The hardness of the solid block formulated were determined using the Brinell Hardness Number acquired from the Gunt Universal Testing Machine. The hardness of the formulated wax block varied with the amount of polymer added into the wax mixture. It is found that the hardness of the wax block increases with the amount of low-density polyethylene added from 10 wt% to 50 wt%. The resulting data indicates that the addition of polyethylene into the mixture of paraffin wax elevates its hardness. The machinability of the formulated wax blocks was tested under computer numerical control machining. The 30 wt% formulation was best suited to manufacture the machinable wax which can be used in numerous prototyping applications.

Keywords: Machinable wax, Computer numerical control (CNC), Paraffin wax Low-density polyethylene, Prototyping.

REDUCTION THE NOISE LEVEL OF LOW-SUBSONIC-SPEED WINGS USING TRAILING EDGE SERRATION

BEH HENG YEW, ABDULKAREEM SH. MAHDI AL-OBAIDI, MOHAMMAD HOSSEINI FOULADI, SHAHROOZ EFTEKHARI

School of Engineering, Taylor's University Lakeside Campus, Malaysia

Abstract

This research paper aims to determine causes and effect of Aeroacoustics Noise Generation by the airfoil of an aircraft and effects of serrations on the trailing edge of an airfoil. A range of serration designs are tested to identify magnitude of reduction of noise and a conclusion will be reached on the best configuration. The research paper primarily achieves its objectives by utilizing both numerical analysis and Wind Tunnel Testing to identify and ascertain the impacts applying serrations yield in noise generation. Main findings ascertain that serrations act to reduce Aeroacoustics Noise Generation by increased surface area generated with the placement of serrations. This reduces magnitude of boundary layer condition area that forms on the top of the airfoil and delays the formation further from leading edge. This controlled boundary layer is shown to create pockets of near silent aeroacoustics close to the surface of the serrations and airfoil. However, due to limitations in compute power available for numerical analysis and lack of equipment necessary to properly map out noise generation areas of the airfoil in Wind Tunnel experimentation and detailed analysis of flow across serration tips in Numerical Analysis testing respectively, both data source are unable to validate each other as intended and thus an improved and final serrated airfoil design that truly blends the advantages of low Aeroacoustics noise generation and maintained flight performance will not be attainable currently.

IMPROVE OUTPUT CAPACITY OF A POWDER COATING LINE BY INTRODUCING INFRA-RED CURING AND OPTIMIZING SPRAY BOOTH TRANSFER EFFICIENCY

CHEE CHUN YIK*, FELICIA WONG, EDWIN CHUNG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: junychee@gmail.com

Abstract

In the powder coating industry, colored thermoplastic/thermoset polymer (powder) that sprayed onto parts are heated to melt and bind the onto surface for a durable finish. This process known as curing. Curing is accomplished by baking the coated parts for 10 minutes at a temperature of ≥200°C. Existing powder coating industry uses only one convection oven to function both pre-heating parts up to 200°C and another 10 minutes dwell at 200°C. Although it is easy to maintain a convection oven temperature using a thermostat, the efficiency of convection heating may not be the best. 3 weaknesses of convection heating are space requirement, dust contamination, and low heating power. This study examines the use of infra-red heating to eliminate the 3 weaknesses associated with convection heating. Solution to these 3 issues, an experimental result has validated the theoretical values. To compare the performance between convection heating and infra-red heating towards powder coat, a thermo sensing device call Datapaq Insight EasyTrack version 7.10 is used to examine temperature profiling within the oven. Two criteria quantifying the performance is extracted from the device are: pre-heat time, dwelling time. The software able to record temperature profile in time intervals and shows the gradient slope of pre-heat time taken. This device uses a thermal barrier to hang into oven and endure like other coated parts and its temperature is recorded across time to measure convection oven performance. The pre-heat slope across time manifests the pre-heat performance, the steeper the slope the faster the pre-heating of parts up to 200°C. This rapid pre-heating is explained possible by fundamental theory such as Stefan-Boltzmann constant, Planck's distribution, are used to understand the power of infra-red energy. These theories also explain the absorptivity specifically for powder coatings. These theory covers the wavelength spectrum that is most suitable for powder coatings to absorb. Controlling emissive power of Infra-red is equal to wavelength manipulation. Different infra-red wavelengths penetrate differently into powder coatings. Penetrating power of infra-red equates to the temperature to the power of 4. Heat loss by Infra-red radiation is proportional to power of 4 in operating temperature, $\boldsymbol{T^4}$. The higher the operating temperature, the higher the emissive power by the shorter emitted wavelengths (higher penetration). Gas-Catalytic Infra-red type is chosen as an emitter to compensate running together with convection oven. Gas-Catalytic Infra-red type is where a blackbody capable to glow in red after being heated and emit infra-red waves. The performance of infra-red heating is expected to be twice more efficient than convective heating especially in pre-heat stage. The temperature profile will manifest the weakness of convection in pre-heating from the slope of graph. Infra-red pre-heating slope is expected to be twice the steeper than convection pre-heating slope, meaning time taken to reach 200°C by infra-red is half from convection, double the heating efficiency. Implementation of Infra-red heating is to meet the goal of optimizing the output rate in powder coating line. If Infra-red heating can steepen the pre-heat slope better, the total time taken needed in oven is lesser. With total

heating time reduced, given the same long oven the parts now need to travel faster through entire oven and exit before overheating. This will allow the faster line speed resulting in higher output rate.

Keywords: Radiating intensity, wavelength, emissive power, blackbody, gas-catalytic infra-red, absorptivity, pre-heat, curing, dwelling, line speed

REMOVAL OF METHYL ORANGE AND METHYL VIOLET DYES FROM WASTEWATER BY USING CONDUCTING POLYMER AS AN ADSORBENT

CHEW ZE JIAN*, NORHABIBAH MOHAMAD

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: zejian96@gmail.com

Abstract

In this study, adsorption water treatment process was studied with the usage of polypyrrole (PPy) as the conducting polymer. The dyes which were to be removed from this experiment through adsorption are Methyl Orange (MO) and Methyl Violet (MV). The significances of the adsorption wastewater treatment were simplicity of design, low cost, high efficiency, easy availability, ease of operation and possesses ability to treat dyes in more concentrated form. The purpose of the research was to prepare PPy adsorbent by using synthesis process of polymerization for the removal of MO and MV dyes from wastewater. Also, this review was aimed to characterize the chemical structure and study the thermal, chemical and morphology of the conducting polymer adsorbent by Fourier-Transform Infrared Spectroscopy (FTIR) and Thermogravimetric analysis (TGA). Besides that, the aim of this research was also to analyse the effects of various parameters such as the contact time between the adsorbent in the dye solution and the movement condition of the treatment process (stirring or static) on the adsorption process for removal of dyes. At the end of the experiment, MO and MV were successfully removed with MO has the highest efficiency of 97% at stirring condition for 3 hours treatment with the polypyrrole conducting polymer.

Keywords: Adsorption, Polypyrrole, Methyl Orange, Methyl Violet, Conducting Polymer

REDUCTION OF COMPRESSOR SOUND IN AN AIR CONDITIONING UNIT

CHOO HANG SHENG, A/P DR. MOHAMMAD HOSSEINI*,

PROF. DR. SATESH,

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: Hosseini@taylors.edu.my

Abstract

The application of compressor is widely seen all over the world, such as household appliances, vehicle, industrial machinery, and especially in air conditioning system. This research focusses on the method to reduce the sound generated from the rotary compressor in air conditioning outdoor unit. The aim of this project is to design a soundproof cover and implement onto the compressor to reduce the noise propagated from it. Numerical analysis includes acoustic analysis by using ANSYS software-harmonic response. The setup of the simulation for geometry, meshing, boundary conditions are almost done but the results require more simulation to achieve. Experimental testing is carried out to measure the sound pressure level (SPL) of the compressor by using sound level meter. Since the prototype is still 3D printed and thus the experimental results will be obtained after it is manufactured and tested. The expected outcome is the result of SPL before and after modification at a certain higher frequency, for example at 12.5 kHz will be having a significant reduction and it will be verified with the standard allowable SPL value from OSHA. The experimental results will be compared to the simulation results in order to ensure the accuracy and also optimise the design of soundproof cover for future improvement.

Keywords: Compressor, Noise, Soundproof Cover, Sound Pressure Level (SPL)

THE RAPID PROTOTYPING OF BIO-INSPIRED TOPOGRAHIES BY DEVELOPING A MOULD USING A 3D PRINTER

DARWEN A/L T. BALAKRISHNAN, FELICIA WONG YEN MYAN*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: FeliciaYenMyan.Wong@taylors.edu.my

Abstract

Bio-inspired topographies are found in varieties of living organisms in the world. These surface topographies are considered special as it exhibits anti-fouling properties or in simple words, it displays self-cleaning properties [1-6]. A few examples of these organisms are shark riblet, lotus leaves, gecko's feet and etc. The process of recreating these surface topographies has been done in the form of photolithography and soft lithography. The cons of the processes are that it is expensive in terms of facilities and equipment & the materials and also limited to a small-scale production [7-8]. Hence, in this research, the aim was to see if 3D printing technology, that has been trending worldwide would be a sufficient alternative to create a mould consisting of these surface topographies that could be used for rapid prototyping. The sketch of the micro-structures was done in Solidworks software and then converted into 3D printable files which were loaded in the Ideamaker software. In that software, settings such as infill density were set and exported to the 3D printing machine via USB drive and the mould was printed. The Polydimethylsiloxane (PDMS) sheet was done by mixing silicone elastomer and the curing agent, and poured onto the 3D printed mould. The mould was then heated on a hot plate at 35°C to catalyse the reaction faster. The dried PDMS sheet was then peeled off and sent for characterisation using Laser Confocal Scanning Microscopy (LCSM). And based on the research done, it was found that, with the 3D printing technology, the micro-structures (surface topographies) can be produced (the mould), in a large manner depending on the requirement. This was proven when the PDMS sheet that was characterized under the LCSM showed the sizes of the micro-sized topographies were less than 400 microns. Also, it was discovered that there was there was discrepancy between the original file and the converted file. The resolution of the mould is to be kept at optimum to get it done at faster pace, the bigger the resolution, the more time is taken for the mould to be completed.

Keywords: Bio-inspired topographies, Micro-fabrication, Polydimethylsiloxane (PDMS), Rapid-prototyping, 3D Printing

STUDY OF LATTICE STRUCTURE FOR MECHANICAL STRENGTH ENHANCEMENTS OF TISSUE ENGINEERING SCAFFOLD

EUGENE KOO KENG YEEN*, YONG LENG CHUAN, CHOO HUI LENG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: anna_a_lee@web.abc.cd

Abstract

Applications and characterization of three dimensional lattice structures in tissue engineering is an industry in the medical field which is growing very vastly. The 3D scaffold should consist of the following characteristic as well interconnected pore networks, highly porus and have consistent and sufficient pore size for cell migration to take place. The very objective of the present study is to figure out the highest value of Young's Modulus and yet low density out of the three lattice structure which it being triangular, square and hexagonal prism. The test which are being carried out on the three lattice structures with some constant variables which each being relative density, equal base area with volume and equal length of each unit cells. It can be seen that the Young's Modulus is to be proportional to its relative density. Besides that, the shape of design of the triangular prism has shown to be the most promising shape compared to the other three which it being the square prism and also the hexagonal prism because it does have the highest value of Young's modulus with the lowest density. A stiffness to ratio or specific stiffness test have also been conducted in order to prove that the triangular prism is to the best as it has proven to have the highest value of Young's Modulus with the lowest density. However, the cubic prism shaped lattice structure has then showed that the Young's Modulus will be at the highest when then constraints of the same base area together with its height.

Keywords: Tissue Engineering, Scaffold, Lattice Structure, Young's Modulus

ONE-STOP PORTABLE FIXTURE FOR TIRE DIMENSION MEASUREMENT INSTRUMENTS

GILBERT LIM, DOUGLAS TONG*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: douglaskumtien.tong@taylors.edu.my

Abstract

The research details design concepts of additional accessories to attach to a fixture that is used to take measurements of conventional passenger car tires. The tire fixture is a device used to lift and freely rotate a car tire, allowing for measurements to be taken. Engineering design techniques were studied and implemented in this research. Several design concepts were drawn using 3D CAD software Solidworks and the aspects of designs were evaluated based on feasibility, manufacturability, cost and ergonomics. Of the more plausible designs, a linear motion ball bearing using the round shaft with guiderail is used. A mechanical arm part is designed to position the measuring instruments for easy reach and minimize required motions for taking measurements. ANSYS software is then used to simulate acting forces on the design parts that may result in failure.

Keywords: design, tire, fixture, measurements

DESIGN OPTIMISATION ON DEFAULT ONSHORE TALL WIND TURBINE TOWER

HOOI KOK PAN, MOHAMMAD HOSSEINI FOULADI*, SATESH NAMASIVAYAM

School of Engineering,
Taylor's University,
Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya,
Selangor DE, Malaysia
*Corresponding Author: Hosseini@taylors.edu.my

Abstract

The aim of this research study is to carry out design optimisation on onshore tall wind turbine at Kota Kinabalu, East Malaysia with height of 150 m from ground, by implementing an earthquake-proof mechanism in the system to reduce the impact of seismic activity in Malaysia. Hence, geometrical modelling of tall wind turbine was modelled through Computer Aided Design (CAD) Software, followed by detailed numerical simulation through ANSYS Numerical Simulation under Random Vibration Analysis to validate the innovated wind turbine tower based on the parameters such as, tower's maximum deformation, equivalent stresses, directional acceleration and its fatigue life during cyclic base excitation. Hence, both default and innovated wind turbine tower is simulated under the same boundary condition by referring to the seismic design spectral of Kota Kinabalu, East Malaysia based on Eurocode-8, and then comparing based on the stated parameters to evaluate the effectiveness of the optimised wind turbine tower over the default wind turbine tower. Moreover, it is found that the maximum deformation of the innovated wind turbine tower is lower compared to the default wind turbine tower with values of 0.053 m and 0.48 m respectively. Besides, the equivalent stresses imposed on the innovated wind turbine tower are lower compared to the default wind turbine tower with maximum equivalent stresses of $3.2669\,x\,10^7$ Pa and $4.7956\,x\,10^7$ Pa respectively. Furthermore, under the same cyclic base excitation, the innovated wind turbine tower shows a longer fatigue life of 9.6 months whereas, the default wind turbine tower shows a shorter fatigue life of 2.4 months. In addition, the innovated wind turbine tower exhibits lower directional acceleration than the default wind turbine tower with acceleration of 0.35 $\mathrm{m/s^2}$ and 1.10 $\mathrm{m/s^2}$ respectively.

Keywords: Innovated Wind Turbine Tower, Default Wind Turbine Tower, Directional Deformation, Fatigue-Life & Equivalent Stress

ENERGY ABSORPTION OF ADDITIVELY MANUFACTURED CELLULAR STRUCTURES

HUI LENG CHOO*, RASHEED HUSSAIN

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: HuiLeng.Choo@taylors.edu.my

Abstract

Recent developments in additive manufacturing (AM) techniques have led to advances in the design and fabrication of metallic cellular structures. Among cellular structures, triply periodic minimal surface (TPMS) structures are considered to be novel materials with lightweight and good energy absorption characteristics. This study investigated the compressive properties and the energy absorption characteristics of two types of periodic cellular structures, namely Primitive (P) and Diamond (D), with three different relative densities. For preliminary studies and cyclic compressive testing of the structures, samples were firstly manufactured using polylactic acid (PLA) via fused deposition modeling (FDM) process. The results of the manufactured samples revealed that the properties and deformation mechanisms strongly depend on the unit cell geometry. Compression testing shows that D structures display relatively uniform stress distribution across all lattice cells leading to collapse of the structure by shearing and brittle failure of individual struts. In contrast, the P structures experience a bend dominant behavior followed by brittle fracture at the struts of the bottom layer. P structures were found to have a higher stiffness and yield point as compared to the D structures while the D structures exhibit superior energy absorption capacity compared to the P structures with the same volume fraction. It was observed that energy absorption capacity of the structures increases with increasing relative densities. The total energy absorbed by D-5 structure up to 50% strain was found to be is 23% more than the energy absorbed by regular BCC polymer based cellular structures documented earlier with similar volume fraction and structure size. While the total energy absorbed by the P-5 structure up to 50% strain was 17% more than the energy absorbed by the cellular structures documented earlier. The cyclic compression of the PLA samples revealed that corresponding hysteresis stress-strain graphs are in good agreement with that of steel dampers previously researched. The results and findings of this study improved the current understanding of additively manufactured lattice structures which have the potential to be designed and manufactured for sophisticated, functional and lightweight components such as hysterical dampers in the future.

Keywords: Energy absorption, Cellular structures, Triply periodic minimal surface, Additive manufacturing, Selective laser melting

MECHANISM STUDIES OF STONE TRAPPINGS IN TIRE TREAD PATTERN GEOMETRY

KEJHAN MURALITHARAN*, KU PEI XUAN

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: kejhan.1695@gmail.com

Abstract

A study is carried out based on the performance of tire on the road. Research is based on the stone being trapped in tread tire blocks and the performance of the tire. Tire is and importance when it comes to driving. Life span of tire is being reduced based on stone trapping phenomena. Due to this, the life span is reduced tremendously although the performance of tire can be used longer if the trapped stone did not damage the tires. The average stone size is between 11.5-32.75mm. The diameter used in this case is 20mm. The total deformation and maximum stress being applied on the tire at static condition is simulated using Ansys Workbench. The fixed support is set on the tire and the platform to determine the simulation results. External forces have also been applied in the simulation of the tire performance. As for future work, comparison of thread depth of the tire is being compared under dynamic condition. Further research would be carried out based on the placement of the stone from horizontal to vertical. Besides that, the use of different diameter of stones to determine changes of the simulation results will also be carried out.

Keywords: Tire, tread depth, stone trapping, simulation of tire, tread pattern.

DESIGN AND MANUFACTURING OF CONTINUOUS FIBER FEEDER FOR FDM PROCESS

HUI LENG CHOO*, YE CHUAN LEW

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: HuiLeng.Choo@taylors.edu.my

Abstract

Mechanical strength of FDM products are lower than metal since it's material is limited to thermoplastic polymers. Composite materials had been developed to increase the strength of FDM product. An attempt has been made to produce continuous glass fibre reinforced polylactic acid composites by 3D printer. Multiple approaches were made to implement the continuous glass fibre into FDM machine and the results were discussed according to the printed parts. The printed CFR product strength was tested by conducting destructive tensile test and a 21.398% improvement in ultimate tensile stress was observed.

Keywords: FDM, Continuous Fibre, 3D printer

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Paper number 2ME14

THERMOELECTRIC CONVERSION EFFICIENCY OF COMMERCIALLY AVAILABLE THERMOELECTRIC MODULE FOR POWER GENERATION

LIM HAN WERN*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: anna_a_lee@web.abc.cd

Abstract

A project had been conducted on determining the conversion efficiency of commercially available TEM models. Using the equation acquired through derivation from various journals. Thermoelectric had been advancing in terms of research recently where the number of journals, paper and thesis have been increasing but no proper data had been provided on TEM models even by the manufacturers. This is due to the original purpose of manufacturing the product is for thermoelectric cooling – TEC which is uses the opposite effect of Seebeck which is the Peltier effect. All the TEM models purchase has the same dimension which is 40mm x 40mm x 4mm thus comparing the results is most accurate than having different sizes. The 4 models are SP1848-27145, TEC1-12703, TEC1-12706 and TEC1-12715. These are all commercially available to public which cost below RM20 each. A tester is built to imitate the scenario of implementing the TEM models for waste heat recovery process. Comparison of output energy produced will be compared with the temperature difference provided to see the pattern in the graph plotted from the data acquired through the experiment. The results will then show the thermoelectric efficiency figure of merit – ZT and the conversion efficiency. The thermal cycling will also show the reliability and performance of TEM while estimating the long-term use of TEM. All these results will help in looking having an estimation of the data generated during the implementation of TEM as a waste heat recovery for industrial uses.

Keywords: Thermoelectric Generator, Thermoelectric Module, Figure of Merit, Conversion efficiency, Thermal Cycling

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A NUMERICAL STUDY TO DETERMINE THE EFFECTS OF SURFACE INCLINES AND UNEVEN SURFACES ON ANTIFOULING PROPERTIES OF MICRO-SIZED TOPOGRAPHIES

MICHAEL LEANG

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia

Abstract

A study is made using flow simulation and Solidworks to determine the effects of surface inclines and uneven surfaces on antifouling properties of micro-sized topographies. The considered block of topography will be a 2mm by 3mm wide area with varying shapes and sizes of topographies etched on top. The block is placed in an 8mm by 8mm by 80mm flow tunnel in a flow simulation. The results in shear stress and flow velocity on the topographies are verified through comparison with both available data and experimental data collected during the control simulations.

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THE INFLUENCE OF AIR FILTER ON PRESSURE DROP INSIDE AN AUTOMOTIVE AIR CLEANER

NOR SAKINAH BINTI SEPUAN[a*], NOOR ZAFIRAH BINTI ABU BAKAR[a], NUR FADZILAH BINTI SHAIKH DAWOOD[b]

[a] School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
[b]PROTON Holdings, SDN BHD
*Corresponding Author: nsakinah.sepuan@gmail.com

Abstract

Air Intake System (AIS) and air filter provide major influence to channel good air quality into the car engine system. Good air quality has an effect on efficiency of internal combustion thus give benefits in term of social, economy and environmental. This research focused on the influence of air filter on the pressure drop inside an automotive air cleaner. The objectives of this research study are to develop a simulation model of airflow inside the current air box design without the air filter, to analyse the influence of air filter geometries inside the air cleaner and to investigate the correlation between different porosity levels of air filter on the pressured drop. The research was carried out via Computational Fluid Dynamics (CFD) simulation by using ANSYS Workbench 18.0 platform. The 3D model of the AIS was designed by using SolidWorks. The simulation was divided into two parts; the simulation on overall AIS without air filter and the simulation to study the influence of air filter on pressure drop inside air cleaner. Based on the analysis on actual AIS, it is known that the pressure drop increases at higher speed. For the analysis on air filter geometries, triangular filter shape gives lower pressure drop than the U-shape due to the velocity of air across the filter element. Lastly on the simulation for different porosity level at higher porosity, the pressure drop will be lower due to higher density of the filter paper that will restrict the movement of air across the filter element.

Keywords: Air Intake System (AIS), Computational Fluid Dynamics (CFD), air filter, porosity, pressure drop

PREPARATION AND CHARACTERIZATION OF A NEW CONDUCTING POLYMER FOR DYES REMOVAL IN WASTEWATER

NURUL FATHULLAH MOHAMMAD*, NORHABIBAH MOHAMAD

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: nurulexfathullah@hotmail.com

Abstract

A thorough investigation has been made to study the effect of Polypyrrole as well as Ferric Chloride Hexahydrate towards the removal of Methyl Orange and Methyl Violet dyes by adsorption process. The study used application of experimental methods such as Chemical Oxidative Polymerization to prepare the Polypyrrole based adsorbent as well as analytical methods by plotting a UV calibration curve graph based on the dyes treatment process in order to calculate the efficiency of dyes removal towards the adsorption process. Two processing parameters were tested, which were the effect of contact time ranging from ½ hour, 1 hour, 2 hours and 3 hours and motion condition during dyes treatment process which are either in static or stirring condition. Moreover, the yield obtained from the following dyes treatment process was taken to undergo characterization by using two instruments which are Fourier-transform Infrared Spectroscopy (FT-IR) and Thermogravimetric Analyzer (TGA). Based on the graphs plotted, it can be found that a stirring motion condition of contact time three hours delivers the best efficiency of 95.17% of dyes removed.

Keywords: Polypyrrole, Adsorption, Methyl Orange, Methyl Violet, Dyes Treatment, Fourier-transform Infrared Spectroscopy (FT-IR), Thermogravimetric Analyzer (TGA)

DESIGN AND ANALYSIS OF A MAGLEV VEHICLE

RASHVIN RAVINDRANATHAN, DOUGLAS TONG KUM TIEN*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: DouglasKumTien.Tong@taylors.edu.my

Abstract

Frictionless suspension systems that leverage on magnetic levitation (maglev) have started to gain popularity in the transportation field, especially through the implementation of maglev trains. Among the benefits of maglev technology are allowing high speed travel, reducing the energy consumption of a vehicle and producing minimal pollution. Despite these advantages, the technology has yet to be incorporated as a solution to congestion and environmental issues resulting from a surge in number of vehicles on roads in busy cities. Hence, the objective of this research paper is to design, analyze and investigate a feasible concept for a maglev-based personal rapid transit (PRT) as an alternative to both private and public transportations. Here, the effects of vehicle shape, size and drag force towards the vehicle's feasibility are considered. Furthermore, in order to conduct this research study, 2 numerical software, SolidWorks and ANSYS Fluent are primarily used for 3D designing and simulation purposes. From the results obtained, it can be verified that the chosen new design shows a reduction in both size and drag force acting on it compared to the current commercialized PRT design. Therefore, recognizing the potential of a maglev-based PRT system in providing a more convenient, safer, personalized, faster and eco-friendly experience to its users if adopted.

Keywords: Maglev, personal rapid transit, size, drag force, numerical software

NUMERICAL STUDY ON THE IMPROVEMENT OF FLOW DISTRIBUTION UNIFORMITY FOR MULTI-INLETS MINIATURE HYDROGEN BATTERY

RYAN CHEW EE SENG, MOHD. HARDIE HIDAYAT BIN MOHYI*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: hardie.hidayat@taylors.edu.my

Abstract

Polymer Electrolyte Membrane Fuel Cell (PEMFC) is a device capable of generating electricity through a chemical reaction between hydrogen and oxygen gases. The reaction produces water as the by-product. The reactants are distributed through a channel on the bipolar plates. The flow field designs on the bipolar plates influences the performance of the PEMFC. The flow field is necessary for the distribution of reactants, hydrogen and oxygen, and removal of reaction product, water, from the PEMFC. This numerical study focuses on the improvement of flow distribution uniformity for multi-inlet miniature hydrogen battery or Proton Exchange Membrane Fuel Cell (PEMFC), the computational fluid dynamics (CFD) approach is used. Seven different flow field designs are verified though the three-dimensional simulation. This numerical study aims to create geometry designs for the multi-inlet PEMFC for better water management. The results which are acquired from the simulation will be the pressure drop, the mass fraction of water and current density. The polarization curve shows the dual inlets and single outlet with three vertical channels produces a low reaction rate loss and high current density at low cell potential. With a low reaction rate loss, this means the PEMFC can start up fast. The dual inlet single channel outlet with vertical channels also has a low pressure drop. A low pressure drop prevents flooding from occurring which can affect the performance of the PEMFC.

Keywords: PEMFC, polarization curve, current density, flow uniformity, parallel flow fields

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DESIGN OPTIMIZATION FOR PRESSURE DROP IMPROVEMENT INSIDE AN AUTOMOTIVE AIR INTAKE SYSTEM

STEVEN KWAN[1], NOOR ZAFIRAH ABU BAKAR[1*], NUR FADZILAH BINTI SHAIKH DAWOOD[2]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500 Subang Jaya, Selangor DE, Malaysia
[2]Perusahaan Otomobil Nasional, HICOM Industrial Estate, Batu 3, 40918 Shah Alam, Selengor DE, Malaysia
*Corresponding Author: noorzafirah.abubakar@taylors.edu.my

Abstract

Air intake system provides clean air for the engine to 'breathe'. Dirty air from the environment is channelled through the snorkel and ducts of the intake system before it gets to the air filtering element where it gets filtered. The ducts where the air is channelled through consists of bends and changes in diameter which result in pressure drop. Pressure drop inside the system has negative effects on the performance of the engine. Therefore, this research aims to develop a simulation model of the airflow inside the current air intake system of a Proton Iriz 1.3L using Computational Fluid Dynamics (CFD), identify the overall pressure drop, validate the model with actual data provided, and propose improvements to the current design and comparing it with the current actual results. To achieve these objectives, three-dimensional parts of the air intake system were created and assembled together in SolidWorks to form the air intake system. The air intake system model was imported onto ANSYS Fluent and mesh independency check was conducted. The simulation was carried out by inputting the necessary boundary conditions and turbulence model onto Fluent. The simulation model was conducted under ambient air and intake system wall temperature of 25°C with three mass air flow rates which depends on the speed of the engine at 2000 rpm, 4000 rpm, and 5500 rpm. The fluid flow characteristics and pressure contours from the results were studied and it is concluded when the engine speed increases, the overall pressure drop in the system will increase and the highest magnitude of pressure drop was found at 5500 rpm, therefore, at this engine speed, the improvement of pressure drop will be the most significant. The region which contains the highest pressure drop relative to the inlet pressure is the zip tube. The results obtained were then validated with actual experiment data and design improvement was made to the current geometry by the addition of guide vanes into the air box interior to reduce its overall pressure drop by up to 28.4% at 5500 rpm.

Keywords: Automotive, air intake system, CFD, pressure drop, optimization

PREPARATION & CHARACTERIZATION OF WOOD PLASTIC COMPOSITE FROM POST-USED STYROFOAM & COCONUT SHELL

SUBHRAMANI THANGAMUTHU[1], SEONG CHUN KOAY[1]*, CHAN MING YENG,[2] ONG THAI KIAT[3], PANG MING MENG[1]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor Darul Ehsan, Malaysia.
[2]Centre of Engineering Programmes, HELP College of Arts and Technology, 6.01, Level 1-7, Kompleks Metro Pudu, 1 Jalan Metro Pudu 2, Fraser Business Park, 55200 Kuala Lumpur, Malaysia

[3]Faculty of Engineering and Technology, Tunku Abdul Rahman University College,
Jalan Genting Kelang, Setapak, 53300 Kuala Lumpur, Malaysia.

*Corresponding Author: SeongChun.Koay@taylors.edu.my

Abstract

Styrofoam is widely used as packaging materials for furniture or electronic goods and container for food. Generally, the Styrofoam is non-biodegradable, not always being recycled and most of it are sent to landfills which causes many environmental issues. This research is proposed to prepare the wood plastic composite (WPC) from recycled polystyrene (rPS) from Styrofoam and coconut shell (CS) using melt compounding and compression moulding technique. This research is to study effect of filler content on processing torque, flexural, and morphological properties of rPS/CS composites. The results show that the flexural modulus of rPS/CS composite increases when the filler content increases, but the flexural strength decreases. Furthermore, the higher the CSP filler content, the lower the stabilization torque of rPS/CS composites. Besides that, the interfacial bonding of the unmodified rPS/CS is shown through the scanning electron microscope. Overall, rPS/CS composites with 30 phr filler content to be the optimum. Hence, this rPS/CS composite with further modifications can be a potential WPC in near future.

Keywords: Wood plastic composites, coconut shell, post-used Styrofoam.

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IMPROVING THE AERODYNAMIC EFFICIENCY OF WINGS USING TRAILING EDGE SERRATION AT LOW SUBSONIC SPEEDS

SUFI ZUHAIR BIN AZMI, AND ABDULKAREEM SH. MAHDI AL-OBAIDI

School of Engineering, Taylor's University, 47500 Subang Jaya, Selangor, Malaysia

Abstract

This research focuses on the issue of aerodynamics of wings on an aircraft, and how to improve it. The aim of this research topic is to study the effects of trailing edge serrations and how it affects the aerodynamic flow of a wing based on the coefficients of lift and drag. The inspiration of testing and applying trailing edge serrations towards modern day aircrafts comes from studying the flight patterns of birds. With birds varying from shapes and sizes, their fight pattern differs from one another, which is where the difference of serration configurations can be studied. Studies will be conducted by comparing these different types of serration configurations together with a clean non-serrated wing. The comparisons between a clean trailing edge wing and a serrated trailing edge wing will be done by undergoing two simulations, first being a numerical simulation. Through numerical simulations a number of serration configurations are tested, and through that, their respective coefficients as well as flight patterns are identified. Base on the numerical results, the different types of configurations are narrowed down, and study them experimentally through wind tunnel experiments to obtain more precise and accurate results. Both the numerical and experimental data will then be compared with publish data for validation. From the results obtained, the configuration of serration will be integrated to a newly design wing, resulting with an aerodynamic characteristic, such as aerodynamic efficiency. Theoretical and experimental data suggest that trailing serattions will indeed improve the aerodynamic efficiency of the wings due to an increase amount of surface area, therefore increase the amount of lift force.

Keywords: Aerodynamics, serrations, configuration, aircraft wing, numerical and experimental simulation

DESIGN AND SIMULATION OF COMFORT AUTOMOTIVE SEAT

ZHE Y. TAN, MOHD F. BIN ALADDIN*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: MohdFarid.Aladdin@taylors.edu.my

Abstract

The aim of this research paper will be study and research on current technologies applied for the seat design for comfort aspects. Other than looking into current technologies focusing on comfort of the seats, this paper will be focusing on the back rest part of the seat for comfortable development. Factors that will be affecting the back rest comfort will be analyse and study such as postures and material of the seat. Using effective methods such as enhancing new design and modification to standard seat structure to allow adjustable components for occupant in aspects of safety and dynamic comfort. Whereas the parameter will be obtained using Computer Aided Engineering (CAE) as there will be various natural frequencies that will affect the resonance of seat and the occupants. In this paper, several expected outcomes will be predicted. The relationship between vibration natural frequency and human body relationship will be study through. Other than that, research will be done and will be used to decide material used in the design.

Keywords: Vehicle features, Seat design, Comfort seat, Safety features, Ergonomics.

EURECA 2018 – Conference Paper
Paper number 2ME24

NUMERICAL STUDY ON THE IMPROVEMENTS OF FLOW DISTRIBUTION UNIFORMITY FOR MULTI-INLETS FULL SIZE HYDROGEN BATTERY

WAN NUR FARIEES FITRIE WAN RAMLI[1], HARDIE MOHYI[2]

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: wannurfarieesfitriewanramli@sd.taylors.edu.my

Abstract

This project is to improve the flow distribution in the multi-inlet parallel configuration of full-size Proton Exchange Membrane Fuel Cell (PEMFC). PEMFC is a one of the promising alternatives for the the fossil fuel as fossil fuel is expected to run out in the future. PEMFC also considered as a clean energy as its products are electrical charge, water and heat. The reactants flow in the channel of parallel configuration of PEMFC need to be improved. In other to have an efficient flow in the cell, the flow must have a low pressure drop along the cell channels. By having a low pressure drop, the rate of reaction of the reactants would increase. The purpose of this project is to produce a parallel configuration design of PEMFC that has the high performances. The main challenge in this project is to model and improve the model of PEMFC until the objective to produce a high-performance parallel configuration PEMFC is achieved The parallel configuration of PEMFC will be designed by using SOLIDWORKS software. After that, the design will undergo the simulation by using the ANSYS Workbench 18.0. All the simulation data regarding to the pressure drop will be collected and tabulated. The data will be analyzed. If any part of the design that can be improved, the design will be modified. It will run simulation once again. The process continue until the best performance of design is obtained or there is no more improvement can be made.

Keywords: Proton Exchange Membrane Fuel Cell (PEMFC), pressure drop, velocity distribution, current density, parallel configuration

EFFECT OF INFILL PARAMETERS ON THE MECHANICAL PROPERTIES OF 3D-PRINTED POLY LACTIC ACID (PLA)

YEO KWONG SHEANG, LIM JOON HOONG*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: JoonHoong.Lim@taylors.edu.my

Abstract

A study had been carried out to focus on the effect of infill density and pattern on the tensile properties of 3D-printed Poly Lactic Acid (PLA). The selected infill densities were 60%, 80% and 100% while the infill pattern that will be taken into study was grid, triangle and honeycomb. The specimen was subjected to tensile test to obtain a stress strain curve and further calculation and analysis was carried out to identify the mechanical properties of various infill parameters. From the results, grid infill pattern had the highest ultimate tensile strength with decent printing time and material consumption because of its short side wall. In comparison, triangle proved to be the best solution in terms of time over strength because it not only had the shortest printing time, but the rigidity of the shape itself mean the shape will not deform underload. In the other hand, the nature shape of honeycomb lead to its low material consumption and flexibility which was suitable to be used when cost played an important role during printing process. Lastly, the tensile strength was proportional to the infill density since more materials were present inside the specimen to hold it together when tension was applied.

Keywords: 3D printing, infill density, infill pattern, PLA, tensile properties

REAL-TIME POWER MONITORING AND OPTIMIZATION OF IOT MONITORING SYSTEM FOR ENVIRONMENT SENSING

DIONG HAN WEN[1], TEH AUN SHIH[2]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor, Malaysia
[2]School of Engineering,
hanwen.diong@sd.taylors.edu.my, aunshih.teh@taylors.edu.my

Abstract

This project focuses on the study of power utilisation of an IoT environmental monitoring system. One of the main factors that impedes the deployment of environmental monitoring systems as vast ubiquitous sensors is due to the power needs of each sensor node. In urban areas, sensor nodes can be directly tethered to electrical conduits but for implementation in areas such as agricultural plantations, the method of having wired sensors is not commercially viable. Hence, current strategies focus on integrating battery modules and in some instances energy harvesters to enable such sensor nodes to be self-reliant. An environment monitoring system enables one to maximize the prospect of one's crops and provide the capability for early detection of possible issues, such as onset of diseases and external vectors (eg. insects and fungi). An environment monitoring system needs not only to monitor specific information continuously but to also communicate the information to a user usually through wireless transmission. Such information can provide a farmer/crop owner with critical real-time data of the ambient conditions and of the status of their crops so that they are able to act accordingly if any situation arises. Typical information being monitored include temperature, relative humidity, soil moisture, ambient gas conditions etc. In this study, the author performs the analytical study of the monitoring system's power consumption and energy usage to determine its power utilization. The motivation behind this project apart from the study of power utilisation is to optimise the power utilisation of the system to enable continuous independent monitoring without human intervention for a few years. Once the power consumption and energy usage of individual components are known, optimisation is carried out by developing power saving code and implementing it to the monitoring system's main code to maximize power efficiency. Experimental results show that the energy usage of the components decrease as the sampling intervals are increased. However, if the sampling interval is too long, it will have an impact on the monitoring system's data relevancy. The grand challenge addressed in this project is to "Restore and Improve Urban Infrastructure" whereby a continuous monitoring system enables infrastructures in agriculture to continually function with lower maintenance, lesser need for human intervention and with increase in crop yields.

Keywords: Environment monitoring system, Power optimisation, Power utilisation

EXPERIMENTAL DEVELOPMENT AND CHARACTERIZATION OF AN ECONOMICAL FBG INTERROGATOR MODULE

WAI LOON KOH, GHAFOUR AMOUZAD MAHDIRAJI*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: Ghafour.AmouzadMahdiraji@taylors.edu.my

Abstract

Fibre Bragg Grating (FBG) fibre optic sensors have been widely implemented in the structural health monitoring (SHM) of buildings and physical structures. Fibre optic-based monitoring system has been constantly growing in terms of interrogation techniques that were introduced in SHM for better performance and reliability in monitoring the condition of physical structures. However, most of the interrogation techniques have high manufacturing cost due to high accuracy and complexity in design. Thus, a low cost FBG interrogator module implementing a low complexity interrogation technique, wavelength matching which has an interrogation range of 1530 nm – 1565 nm was fabricated in this study. The relationship between temperature and wavelength shift in the FBG sensors was investigated whereby a temperature of 23^{o}C to 50^{o}C were tested in this study. The interrogator fabricated recorded a sensitivity of 51 pm – 110 pm wavelength shift by every 1^{o}C – 2^{o}C change in temperature at 1549 nm – 1551 nm interrogation range. The developed interrogator is also tested for mechanical load and found a sensitivity of around 6.18kg, which is as equal as 1^{o}C in applied temperature. A cost analysis is also studied in this study showing that the proposed interrogator can be fabricated with about 5 times lower than the commercial interrogator. With the above-mentioned sensitivity, the proposed interrogator would be very suitable for SHM applications.

Keywords: Structural Health Monitoring, Fiber Bragg Gratings, FBG Interrogator, Wavelength Matching.

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INVESTIGATION OF MIRCROWAVE MICROSTRIP SENSOR FOR DETERMINATION OF NPK NUTRIENT CONTENTS OF FERTILIZER

LOO JIAN ANN[1], MUN HOU KIT[1]* and YOU KOK YEOW[2]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
[2]Faculty of Engineering, University Teknologi Malaysia, Skudai, 81310 Johor, Malaysia
*Corresponding Author: HouKit.Mun@taylors.edu.my

Abstract

The mixing ratio control of the Nitrogen, Phosphorus, and Potassium (NPK) with the other chemical content can directly affect the growth of the crops and the national Gross Domestic Product (GDP) of Malaysia. To overcome the challenge of maintaining a sustainable supply-demand chain by reproducing the crops under mass harvesting, the fertilizer manufacturer should investigate the amount of NPK chemical added in the fertilizer for optimum yield of crops. The microwave sensor on several applications have shown several advantages such as easy to fabricate, cost-friendly and high sensitivity with low return loss and high insertion loss. Hence, the microwave sensing technique is introduced for determination of NPK nutrient content in fertilizer in this paper. The NPK nutrient content of the fertilizer was measured by the shifting of the resonant frequency change of dielectric constant of the sensor between loaded condition (with sample) to unloaded condition (without sample/free space condition). The simulation result for the modified ring sensor has 2.45 GHz operating resonant frequency, high return loss (-42.26 dB) and low insertion loss (-0.083 dB).

Keywords: microstrip, wide-ring sensor, resonant frequency, return loss, insertion loss, NPK fertilizer

INTERNET OF THINGS BASED ARCHITECTURE FOR ADDICTIVE MANUFACTURING INTERFACE

NORHIJAZI AHMAD*, PHANG SWEE KING.

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: hijazi.ahmad92@gmail.com

Abstract

The paper discuss about the current challenges facing while managing multiple additive manufacturing unit without a proper system. The whole printing process is time consuming as it is require human interaction and presents to carry out the whole process. The current system does not conserve energy usage as the manufacturing unit must be control physically. Concurrently, managing a whole lot of 3-D printer is troublesome and difficult. For example, which printer to use, which printer need to rest and to monitor the printer's printing progress. This process has shown a big flaw in the system as it requires a lot of physical interaction between the machine and human. As of today, there are a little to none for a 3D printer managing system. The printer technically still requires human monitorization and they must manually feed the file via external drives (SD Card, Pen-drive, Thumb-drive, etc.).The research purpose is to design a solution to almost-zero physical interaction to additive manufacturing units. Then, to monitor the whole system in real-time manner via various sensing units and interpretation through intelligent network. Also, to optimize the printing sequence and station on printer network with multiple manufacturing unit. The solution proposed is by using the saturated IoT technologies. Webserver will be used to create a webpage to upload the file, approval, and check the printing status. A server will be used to store the files, slicing software, files queuing system and to store temporary information of the manufacturing units' status. A camera will be used as a sensor to track the project progress visually. At the end of the research, user will be able to upload the files and ask for approval by online, which eliminates the travelling time. The files is then will be queue to a specific manufacturing unit to print out by the algorithm set on the cloud server. Then, the manufacturing unit will send importance data to the server such as time estimation, progress percentage and the extruder's temperature. Finally, the cloud server will notify the user if there is any issues risen, completion and a reminder to take the project out from the printer.

Keywords: Additive manufacturing units, 3D printing, Online Printing, Printer Managements, Cloud Printing, Printing Networking, IoT Printer, Printing Monitoring, Heat Monitor.

MORE NATURAL SUNLIGHT TO THE HOME

YI KHAI PHANG[1], G. A. MAHDIRAJI[1]*, C. V. ARAVIND[1], F. R. M. ADIKAN[2]

[1]School of Engineering, Taylor's University, Taylor's Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
[2]Integrated lightwave research group, Department of Electrical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
*Corresponding Author: Ghafour.AmouzadMahdiraji@taylors.edu.my

Abstract

Natural sunlight has lots of benefits for the body. Example of such benefits are increase of vitamin D, setting of circadian rhythm, increase protection against cancer, protection against some heart disease and lower blood pressure, improving brain function, and etc. Having natural sunlight to the home and offices is highly desired to receive the sunlight while doing daily jobs. With the advances in optical fiber manufacturing technology, optical fibers have shown to be the best option with higher efficiency for transferring lights from one point to another point. In most reports, plastic optical fibers have been selected due to lower costs or otherwise, for higher performance, a large-core optical fiber with conventional structure, which include a silica core, silica cladding and polymer coating, have been used. In conventional structure optical fibers, the light only travels from the fiber core area, thus, part of the fiber area, which is the cladding, is not used for light transmission. In addition, fabrication of optical fibers with large core area is very costly. This paper investigates performance of different optical fibers in transferring sunlight to the home. A new structure of optical fiber has been proposed, fabricated and examined in this study. Performance of the proposed optical fiber has been compared with two conventional structure optical fibers. Furthermore, a new type of sunlight concentrator apparatus making up of Fresnel lenses equipped with a new and economic silica optical fiber was designed to reduce the payback period of the system significantly as well as to save the consumption of energy by transmitting natural light indoors which reduces the need of converting electrical energy into light energy using light bulbs. It is shown that with the use of proposed optical fiber, the sunlight transmission efficiency can be improved while the fabrication costs can be reduced by about 7 times.

Keywords: Optical fiber, PV system, solar energy

ADAPTABLE OPEN SPACE PARKING DETECTION SYSTEM

SAM T.W. YEE *, WEI JEN CHEW

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: yeethongwah.sam@sd.taylors.edu.my

Abstract

Car park monitoring systems can be divided into sensor- and vision-based approaches. Sensor-based approach is the conventional method and can be found in indoor car parks where the commonly used sensors are ultrasonic sensors and magnetic sensors. Sensor-based systems require installations and maintenance of the sensors at each of the parking lots and the costs increase as per increase in parking space. On the other hand, vision-based systems use cameras instead of sensors to monitor the parking lots. In this paper, a vision-based open space parking detection system was proposed. The proposed system uses a low-cost camera made with Raspberry Pi Zero W and a camera module to capture snapshots of the car park and send them to a host computer to be processed. The system consists of two main stages which begin with the image processing stage where the received snapshot went through various image processing such as colour segmentation, dilations, noise filtering and then proceed to the final stage where the occupancy of each parking lot will be determined by a fine tuned convolutional neural network (CNN). The results obtained show that the proposed system was able to determine the occupancy of the detected parking lots with a percentage error of 3.15%. In terms of adaptability, the success rate of the detection of parking lot locations for plus-sign type parking lots was 91.38%, for open-rectangle type the success rate was 81.82%, while for the closed-rectangle type the success rate was 60%.

Keywords: Parking system, image processing, convolutional neural network.

ENERGY EFFICIENT PROGRAMS FOR COMMERCIAL BUILDING

THEN YIH SHYONG, REYNATO ANDAL GAMBOA

Electrical & Electronic Engineering, School of Engineering
Taylor's University

Abstract

Taylor's University has been heavily using energy in its day-to-day operations. The 3-month's electricity bill showed a monthly bill of RM 533,532.65, RM 485,764.17 and RM 516,351.65 for May 2017 to July 2017 respectively. The bill is believed to be a significant portion of Taylor's University's monthly operating cost and the significance is much evident on the peak demand where, on average, it is estimated about 20% of the monthly bill. Therefore, this project seeks to conduct an energy audit of Taylor's University and assess the prevailing condition of energy consumption patterns of Taylor's University facilities to identify energy wastes and cost-saving opportunities. A perfect balance between the load and the supply in real time is essential to improve the energy efficiency of the electricity system. The frequent change of both supply and demand levels is the challenge behind it. Thus, it is essential to analyze the energy consumption at the use stage. The objective of the research is to assess the impact of cost and energy efficiency of current energy consumption. The research is conducted by collecting past electricity bills and conducting a survey of illumination level and room temperature. The data collected will be used to perform retrofit and cost-benefit analysis. In this paper, room temperature, lighting retrofit, and cost-benefit analysis are accessed and discussed.

A SIMPLE SEMI EMPIRICAL MODEL FOR FORCED CONVECTION CONDENSATION ON HORIZONTAL INTEGRAL-FIN TUBE

Z.H. ONG, NAMASIVAYAM. S, BRIGGS. A, SIVANESAN. S

Faculty of Built Environment, Engineering Technology & Design, Taylor's University
Lakeside Campus, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
david.ong828@gmail.com

Abstract

A new simple semi empirical model for forced convection condensation on integral fin tube will be presented in this paper. The experimental data and existing model from previous research will be added into this new model for validation and testing purpose. This model should be able to cover the condensation of steam and ethylene glycol on a set of five fin tubes had constant fin height, thickness and root diameter of 1.6, 0.25 and 12.7 mm respectively while fin spacing was varied from 0.25 to 2.0 mm. The correlations from this new model will be tested with a range of vapour velocities up to 62 m/s for steam and 22 m/s for ethylene glycol and produced an average percentage difference of never more than 17%. Indeed, the new semi empirical model should be able to predict a majority of 867 data points to within ±25% in normal spreadsheet.

Keywords: Condensation, Fin tube, Heat transfer, Semi Empirical Model, Steam, Ethylene Glycol

1. Introduction

Condensation heat transfer has generally been the essential component in a wide range of engineering applications such as refrigeration, air conditioning and power generation [12]. During condensation, gas is cooled and compressed into saturation limit where gas phase changes physically into liquid phase. Condensation heat-transfer occurs on a solid surface and can be categorized into two different categories i.e. filmwise and dropwise. Film wise condensation occurs when steam condenses on a wet-able surface in

Nomenclature

b	Fin spacing at fin tip	s	fin spacing at fin root
C_1	Constants in Equations in 3.12 and 3.33	t	Fin thickness at fin tip
C_2	Constants in Equations in 3.12 and 3.33	U_v	Free steam velocity
C_3	Constants in Equation in 3.12	$\overline{U}_{\text{tip}}$	Effective vapour velocity at fin tip
d	Smooth tube diameter or fin root diameter of finned tube	$\overline{U}_{\text{root}}$	Effective vapour velocity at fin root
d_o	Fin tip diameter of finned tube	$\overline{U}_{\text{flank}}$	Effective vapour velocity at fin flank
f_f	Flooding proportion at fin flank	**Greek Symbols**	
f_s	Flooding proportion at fin root	ρ	Density of condensate
g	Specific force of gravity	ρ_v	Density of vapour
h	Fin height	$\mathcal{E}$	Heat-transfer enhancement ratio
h_{fg}	Specific enthalpy of evaporation	ϕ_f	Condensate retention angle
$\bar{h}$	average convection coefficient	σ	Surface Tention
k	Thermal conductivity of condensate	ξ	Active surface area enhancement for fin tube
Nu	Vapour-side Nusselt number	ψ	See equation 3.9
Q	Total heat transfer rate	ΔT	Temperature difference across the condensate film
q	Heat flux on outside of test tube		
q_{tip}	Heat flux to fin tip	**Abbreviations**	
q_{flank}	Heat flux to fin flank	*calc*	calculated
q_{root}	Heat flux to fin root	*exp*	experimental

which a condensate film is formed resulting in low heat-transfer. In contrast, dropwise condensation happens on a non wet-able surface where steam condenses and forms droplets. These droplets grow in size and fall due to gravitational force. Theoretically, vapour-side, heat-transfer coefficients are much higher for dropwise condensation than for filmwise but dropwise condensation is difficult to maintain for long periods because it contains higher density than filmwise that tend to drop away into liquid form while filmwise remains. Due to the fact that it is easier to maintain and achieved through a wide range of fluids, condensers are designed to operate under filmwise conditions. However, there are some cases where both manners can occur on different parts of the same surface such as in a horizontal fin tube condensation. The condensate film is formed on the upper surface with sufficient vapour velocity becoming thicker and heavier which is likely to slip to the bottom surface of the fin tube where the condensate accumulates and becomes droplets, hence both dropwise and filmwise condensation method occurs.

The idea of fin tubes in enhancing the heat transfer coefficient with additional area available for heat-transfer [10,11] by thinning the condensate film due to pressure difference from the surface tension has been well

documented. Up to the date, there is yet a simpler model to predict heat-transfer coefficient for forced-convection condensation on integral-fin tube adequately in empirical method. This could be done with simple theory of Nusselt's number that expressed according to fin dimensions and specific empirical constants. This could be a new model with lesser degree of complexity and which is able to cover a wider range of testing fluids. It could also be further applied to predict heat transfer analysis in a more practical way.

2. Objective

There is yet a simple model to predict heat transfer coefficient for forced convection condensation on integral fin tube adequately in empirical method. This is possible to be done by utilizing the simple theory of Nusselt number that is equivalent to the fraction of heat flux to temperature difference that determine from experiment. There are several proposed models for predicting heat transfer coefficient for forced convection condensation on integral fin-tubes was found in high complexity and less practical to analyze the outcome in numerically. A simplified semi empirical forced convection model can be proposed by using the empirical correlation approach of Nusselt number that expressed empirically with fin dimensions accordingly together with specific empirical constants that is able to predict an adequate Nusselt number in normal spreadsheet. The objective of this project is to develop a simple semi empirical model for forced-convection condensation on horizontal integral fin tube. The mathematical solution from this model should comply with the theory of condensation heat-transfer on fin tube and existing experiment data from previous research. In order to clarify the capability of this model, the effects of vapour velocity on condensation at integral-fin tube should be accounted for in the final results that providing a similar or better trend to that produced by Namasivayam [1] model. The final results from this model should be measured in dimensionless quantity to accommodate the result agreements in between experimental and theoretical. At the end of current investigation, a simple semi empirical model for forced-convection condensation of steam and ethylene glycol on integral fin tubes will be presented that specifically covered the five fin tubes with fin root diameter, height and thickness of 12.70, 1.60 and 0.25 mm respectively and various fin spacing from 0.25 to 2.00 mm. This semi empirical model should be able to predict a majority of 867 data points to a correlation within $\pm 25\%$ in common spreadsheet.

3. Methodology

The procedures for developing a simple semi-empirical model for forced-convection condensation on integral fin tube are summarized as the diagram shown below.

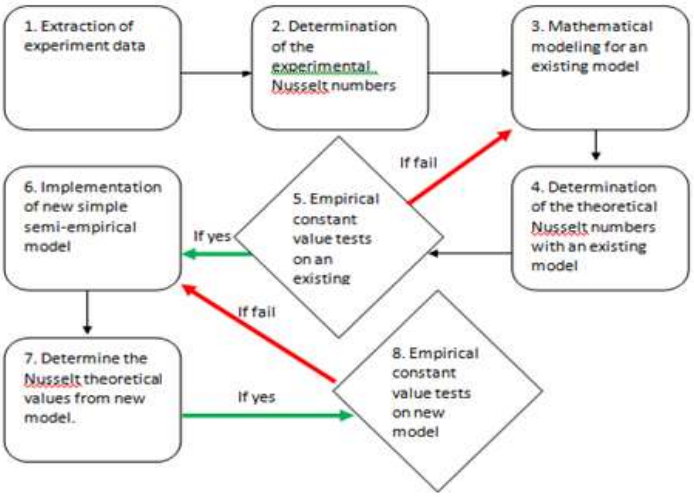

Figure 3.1: Flow chart of current investigation.

The temperature differences and heat fluxes measured experimentally at three different testing fluids by Namasivayam. S & Briggs [2,3,4] were extracted in a series of numerical data points that consist of 867 individual data points can be applied into relevant heat-transfer equations. To provide agreement between theoretical and experimental for condensation on fin tube, Nusselt numbers will be introduced to correlate both results in terms of appropriate dimensionless parameters. For experimental approach, a series of data points for heat fluxes and vapour-side, temperature differences from Namasivayam & Briggs [2,3,4] were applied in Nusselt number for forced convection on the circular cylindrical object which is expressed below.

$$Nu_{exp} = \frac{\bar{h}d}{k} \tag{3.1}$$

Where,

$\bar{h}$ is average convection coefficient.

d is fin root diameter

k is thermal conductivity of condensate

Consider the experiment conditions, a fluid of velocity and temperature flows over a circular cylindrical object where the tube surface is assumed to be uniform temperature, T_s and $T_s \neq T_\infty$, the average convection coefficient, $\bar{h}$ is expressed as,

$$\bar{h} = \frac{q}{\Delta T} \tag{3.2}$$

Where,

q is heat flux

ΔT is vapour-side temperature difference

Then the dimensionless parameter for experiment forced-convection condensation on integral-fin tube Nu_{exp} is,

$$Nu_{exp} = \frac{qd}{k\Delta T} \tag{3.3}$$

In equation above, the values of Nu_{exp} obtained will be compared to the theoretical values, Nu_{calc} from Namasivayam [1] and is expressed below.

$$Nu_{calc} = \left(Nu_{g\sigma}^{n} + Nu_{u}^{n}\right)^{\frac{1}{n}} \tag{3.4}$$

Where free-convection condensation on integral fin tubes by Rose [5] used as presented below.

$$Nu_{g\sigma} = (\varepsilon).Nu_{smooth} \tag{3.5}$$

And

$$\varepsilon = \left[\begin{array}{l} \dfrac{d_0}{d}\dfrac{t}{b+t}\left\{\dfrac{d}{d_0} + \dfrac{0.143\sigma d}{0.728^4\,\tilde{p}gt^3}\right\}^{0.25} \\ + \left(\dfrac{\phi_f}{\pi}\right)\dfrac{1-f_f}{\cos\beta}\left\{\dfrac{{d_0}^2 - d^2}{2d(b+t)}\right\}\left\{\dfrac{\left(\dfrac{0.943}{0.728}\right)^4\dfrac{d}{h_v} + }{\dfrac{0.143\sigma d}{0.728^4\,\tilde{\rho}gh^3}}\right\}^{0.25} \\ + \left(\dfrac{\phi_f}{\pi}\right)(1-f_s)2.97\dfrac{s}{b+t}\left\{\dfrac{(\xi(\phi_f))^3}{0.728^4} + \dfrac{0.143\sigma d}{0.728^4\,\tilde{\rho}gs^3}\right\}^{0.25} \end{array} \right] \tag{3.6}$$

Where,

$$\xi(\phi_f) = 0.874 + 0.1991\times10^{-2}\phi_f - 0.2642\times10^{-1}{\phi_f}^2 + 0.5530\times10^{-2}{\phi_f}^3 - 0.1363\times10^{-2}{\phi_f}^4 \tag{3.7}$$

And flooding angle by Honda et al. [6],

$$\phi_f = \cos^{-1}\left(\frac{4\sigma}{\rho gsd_o}(1-\psi) - 1\right) \text{ for } s < 2h \tag{3.8}$$

Where,

$$\psi = K\left(\frac{\rho_v {U_v}^2}{\rho gs}\right)^m \tag{3.9}$$

And Nu_{smooth} is found from the Nusselt [7] model as follows.

$$Nu_{\text{smooth}} = 0.728\left[\frac{\rho(\rho-\rho_{\text{v}})gh_{\text{fg}}d^3}{\mu k\Delta T}\right]^{0.25} \tag{3.10}$$

Equation 3.10 as shown above represents the free convection condition in the model where vapour velocities are neglected. Conversely for forced convection condition, the equation included the effect of vapour velocities and is shown below in equation (3.11).

$$Nu_{\text{u}} = \frac{qd}{k\Delta T} = \frac{Q}{\pi(s+t)k\Delta T} \tag{3.11}$$

Where,

$$Q = C_1\pi d_{\text{o}}tq_{\text{tip}} + \frac{\phi_{\text{f}}}{\pi}\left(C_2(1-f_{\text{f}})\frac{\pi\left(d_{\text{o}}{}^2-d^2\right)}{2}q_{\text{flank}} + C_3(1-f_{\text{s}})\pi bdq_{\text{root}}\right) \tag{3.12}$$

Equation (3.12) above indicated the heat transfer rate to the whole fin tube with the concern of heat flux, flooding angle and the proportion in each condensation area.

For the fin flank flooding proportion by Rose [5],

$$f_{\text{f}} = \frac{1-\tan(\beta/2)}{1+\tan(\beta/2)}\cdot\frac{2\sigma\cos(\beta)\tan(\phi_{\text{f}}/2)}{\rho gdh\phi_{\text{f}}} \tag{3.13}$$

and the fin root flooding proportion Rose [5],

$$f_{\text{s}} = \frac{1-\tan(\beta/2)}{1+\tan(\beta/2)}\cdot\frac{4\sigma\tan(\phi_{\text{f}}/2)}{\rho gds\phi_{\text{f}}} \tag{3.14}$$

For heat flux on fin tip evaluated by Shekriladze and Gomelauri [8],

$$q_{\text{tip}} = \left[\frac{0.9^2\rho k^2\Delta T^2\overline{U}_{\text{tip}}}{\mu d_{\text{o}}}\right]^{\frac{1}{2}} \tag{3.15}$$

In the present case for the fin tip, since $\overline{U}_{\text{tip}} = U_{\infty}$

For heat flux on fin root evaluated by Shekriladze and Gomelauri [8],

$$q_{\text{root}} = \left[\frac{\rho k^2\Delta T^2\beta(\phi_f)\overline{U}_{\text{root}}}{\mu d}\right]^{\frac{1}{2}} \tag{3.17}$$

where,

$$(\phi_{f\,\text{f}}) = 1.4177+0.0172\ \phi_{f\,\text{f}} - 0.0477\ \phi_{f\,\text{f}}{}^2 \tag{3.18}$$

and the effective vapour velocity at fin root $\overline{U}_{\text{root}}$ is,

$$\overline{U}_{\text{root}} = U_{\infty}\left(1-\exp\left(-\left(\frac{s}{h}\right)\right)\right) \tag{3.19}$$

in this case, $\overline{U}_{\text{root}} \to U_{\infty}$ for large values of *s/h* and $\overline{U}_{\text{root}} \to 0$ for small values of s/*h*.

For heat flux on fin flank by Shekriladze and Gomelauri [8],

$$q_{\text{flank}} = \left[\frac{2\rho k^2 \Delta T^2 \overline{U}_{\text{flank}}}{\mu d_{\text{o}} \phi_{\text{f}}}\right]^{\frac{1}{2}} \tag{3.20}$$

For this case,

$$\overline{U}_{\text{flank}} = \left(\overline{U}_{\text{tip}} + \overline{U}_{\text{root}}\right)/2 \tag{3.21}$$

Figure 3.2 to 3.4 compare the Namasivayam [1] model to the experiment data of Namasivayam & Briggs [2], [3] and [4]. In overall, the correlations presented produced fair agreement that manage to maintain most of the data points to within ±25% for all three testing fluid predicted by Namasivayam [1] model with percentage differences of 24% for steam at atmospheric pressure, 55% for steam at low pressure and 23% for ethylene glycol at low pressure. All three comparisons above are also summarized in Table 3.1 were using the suggested empirical constant values C_1 = 1 and C_2 = C_3 = 0.41 in equation 3.12 by Namasivayam [1].

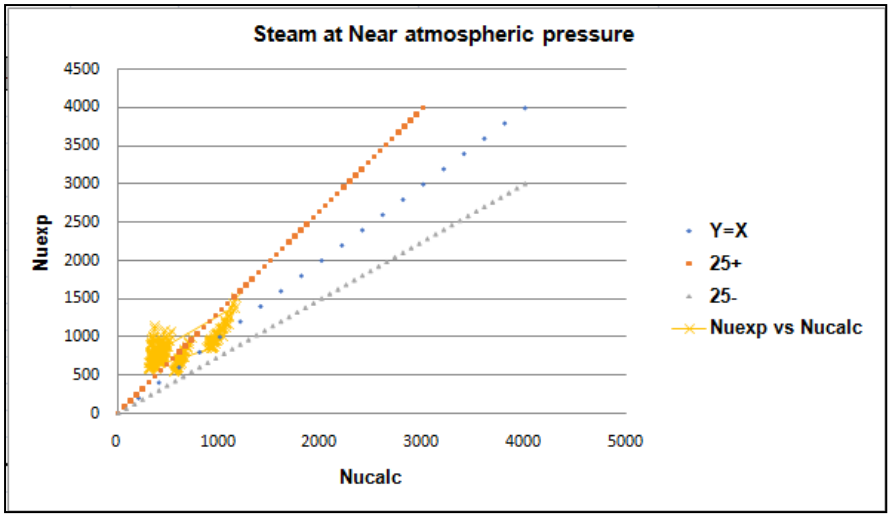

Figure 3.2 Comparison of the experiment data with Namasivayam [1] model for Steam at Atmospheric Pressure – Experimental vs Theoretical Nusselt Numbers with $C_1 = 1$ and $C_2 = C_3 = 0.41$

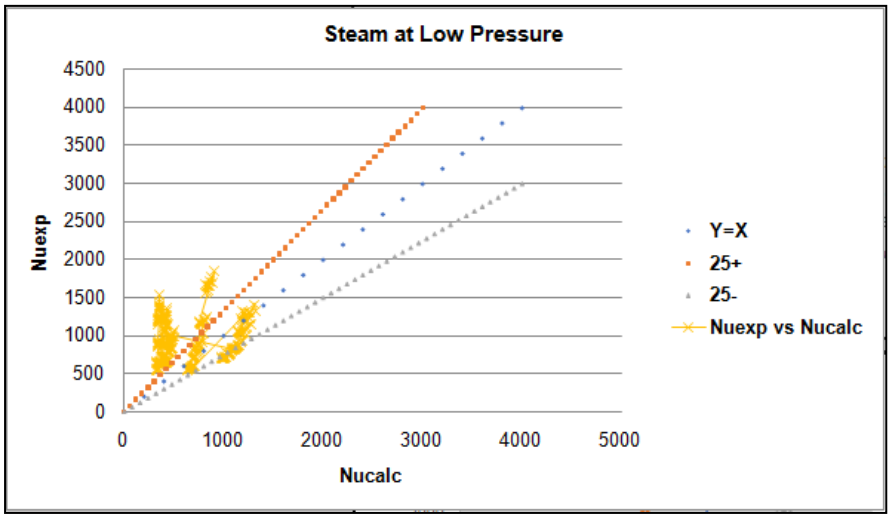

Figure 3.3 Comparison of the experiment data with Namasivayam [1] model for Steam at Low Pressure – Experimental vs Theoretical Nusselt Numbers with $C_1 = 1$ and $C_2 = C_3 = 0.41$

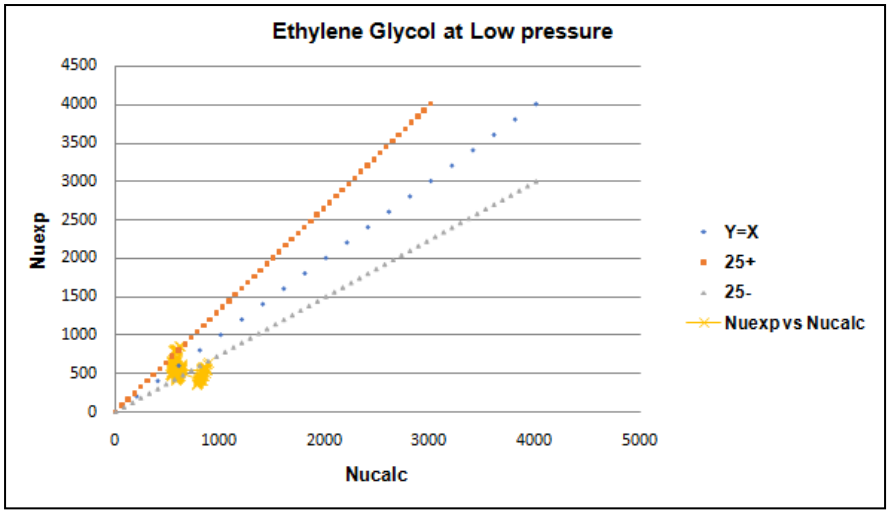

Figure 3.4 Comparison of the experiment data with Namasivayam [1] model for Ethylene Glycol at Low Pressure – Experimental vs Theoretical Nusselt Numbers with $C_1 = 1$ and $C_2 = C_3 = 0.41$

Table 3.1: Summarize of empirical constant values C_1, C_2 and C_3 by Namasivayam [1] against the overall percentage difference for the empirical correlations at all three different tests.

Steam at atmospheric pressure			
C1	C2	C3	Overall % Difference
1	0.41	0.41	23.8
Steam at low pressure			
C1	C2	C3	Overall % Difference
1	0.41	0.41	54.83
Ethylene glycol at low pressure			
C1	C2	C3	Overall % Difference
1	0.41	0.41	22.66

The equation 3.12 from Namasivayam [1] model was tested in a series of numerical trials to determine the new optimum values of C_1, C_2 and C_3 that could enhance the correlation between Nu_{exp} and Nu_{calc}. These enhancements were determined for all three testing fluids are shown below in Figure 3.5 to 3.7 and the new values for C_1, C_2 and C_3 are also listed in Table 3.2

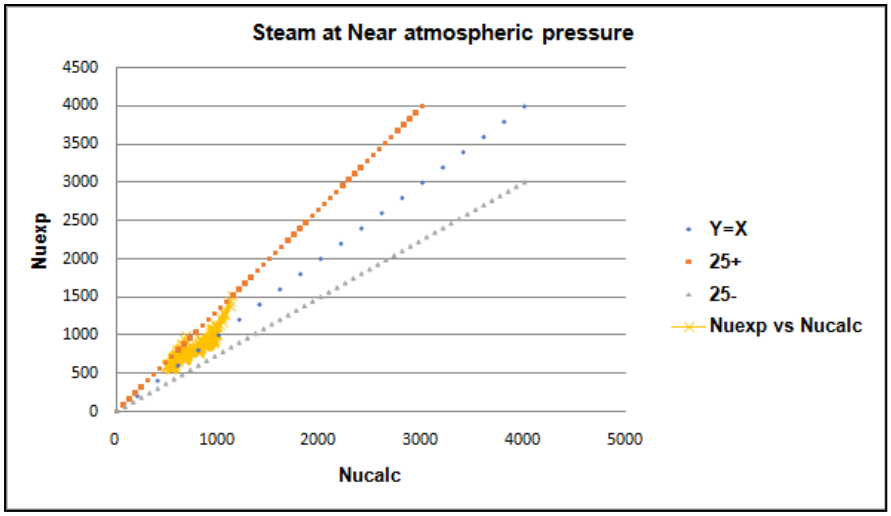

Figure 3.5 Comparison of the experiment data with Namasivayam [1] model for Steam at Atmospheric Pressure – Experimental vs Theoretical Nusselt Numbers with C_1 = 0.4, C_2 = 4 and C_3 = 1.81

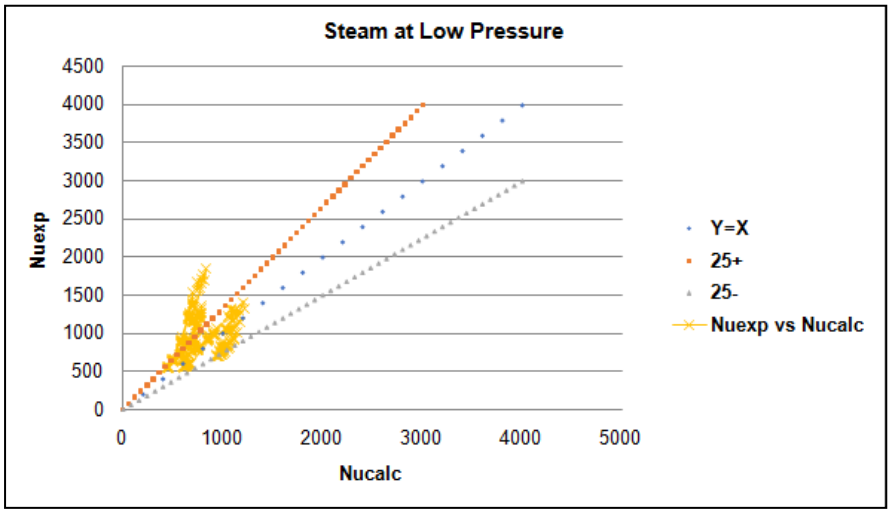

Figure 3.6 Comparison of the experiment data with Namasivayam [1] model for Steam at Low Pressure – Experimental vs Theoretical Nusselt Numbers with C_1 = 0.53, C_2 = 2.17 and C_3 = 2.44

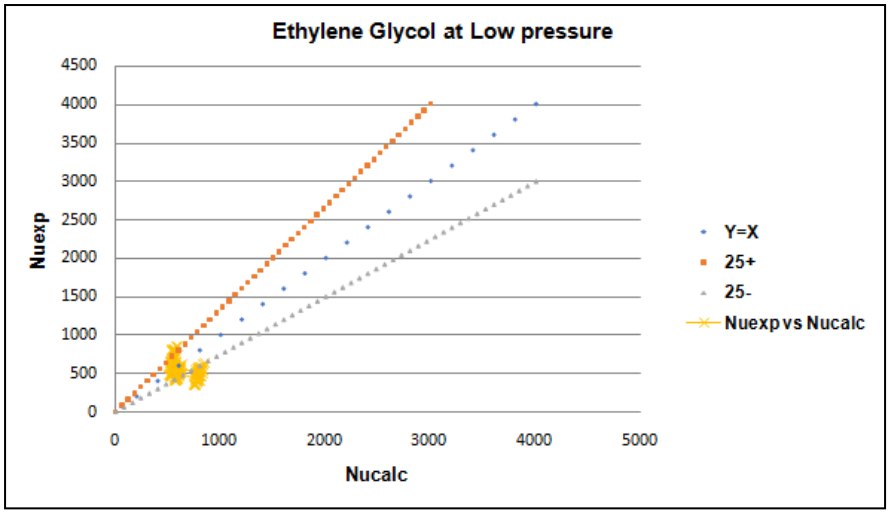

Figure 3.7 Comparison of the experiment data with Namasivayam [1] model for Ethylene Glycol at Low Pressure – Experimental vs Theoretical Nusselt Numbers with $C_1 = 0.04$, $C_2 = 0.77$ and $C_3 = 0.06$

Table 3.2: Summarize of new empirical constant values C_1, C_2 and C_3 against the overall percentage difference for the empirical correlations at all three different tests.

Steam at atmospheric pressure			
C1	C2	C3	Overall % Difference
0.4	4	1.81	8.17
Steam at low pressure			
C1	C2	C3	Overall % Difference
0.53	2.17	2.44	26.78
Ethylene glycol at low pressure			
C1	C2	C3	Overall % Difference
0.04	0.77	0.06	21.88

It is interesting to note that the suggested C_1, C_2 and C_3 values (see table 3.1) by Namasivayam [1] are identical for all three testing fluid experiments however, the new C values (see table 3.2) were vary for each testing fluid when corresponded to the new correlation. This can be explained by different thermophysical properties induced by different test fluid that require specific magnitudes to support the correlations. The new empirical constant values for C_1, C_2 and C_3 in Table 3.2 produced a promising improvement by enhancing the percentage differences of 23.8% to 8.2% for steam at near atmospheric pressure. The percentage differences were also improved from 55% to 27% and 23% to 22% for steam and ethylene glycol at low pressure respectively.

The semi-empirical model with empirical constants had successfully predicted the fin tube condensation in a realistic result where both experimental and theoretical values are stay within the desire agreement but it was found higher

complexity to predict the Nusselt numbers where more than 30 over variables are needed to observe at instant during the empirical constant value tests. This could be solved by a simpler model that able to predict such results in overall conditions. The empirical correlation by Hilpert [9] for forced-convection condensation on a cylindrical object could be the solutions to the matters above which is widely used for Pr ≥ 0.7 and is expressed below.

$$\overline{Nu}_D \equiv \frac{\bar{h}D}{k} = CRe_D^m Pr^{1/3} \quad (3.22)$$

For current investigation, the values for C and m are 0.027 and 0.805 respectively that calculated with the experiment data by Namasivayam & Briggs [2], [3] and [4]. To ensure a similar outcome as produced by Namasivayam [1] model, the equation 3.22 was rearranged and applied to the equation 3.12 for forced-convection condensation on integral-fin tube,

$$Nu_{calc} = CRe_D^{4/5} Pr^{1/3} = \frac{Q}{\pi(s+t)k\Delta T} \quad (3.23)$$

It was noticed that the C value in equation 3.23 should be follow as listed in Table 3.3.

Table 3.3 Constants of equation 5.1 for the circular cylinder in cross flow by Hilpert [5]

Re_D	C	m
0.4 - 4	0.989	0.330
4 – 40	0.911	0.3835
40 – 4000	0.683	0.466
4000 – 40,000	0.193	0.618
40,000 – 400,000	0.027	0.805

However the value is not capable to maintain a good correlation for Nu_{calc} against Nu_{exp} and should be further extended to fit the required correlations. The constant C in equation 3.33 should be rearranged by using the variables that are practical and mutually existed in theory and experiment elements. The variables should be able to produce values that compromised theoretical and experimental Nusselt numbers. For current investigation, fin spacing and height were proposed to be the numerators to fin thickness providing the appropriate dimensionless parameter in theoretical Nusselt numbers, Nu_{calc}. Finally, a new simple semi-empirical model for forced-convection condensation on integral fin tube is presented below.

$$Nu_{calc} = C_1\left(\frac{s}{t}\right) + C_2\left(\frac{h}{t}\right)Re^{4/5}Pr^{1/3} \quad (3.33)$$

4. Results and Discussions

Empirical constants C_1 and C_2 in equation 3.33 were tested in a series of numerical combinations that able to produce best correlations for three different testing fluids in between Nu_{calc} and Nu_{exp}. The optimum values for C_1 obtained are vary (Refer to Table 3.4 to 3.6) and C_2 is 0.01 that found empirically from the experiment data by Namasivayam & Briggs [2],[3] and [4] that covered five different fin spacing of fin tubes condensed in steam and ethylene glycol with a range of vapour velocity. The C_1 was determined in a wide range of values and this can be explained by the cause of various combinations from vapour velocity, fin spacing and thermophysical properties that acquire different empirical constant magnitude to produce correlations adequately in between theoretical and experimental Nusselt numbers. Both values of C_1 and C_2 were tested that corresponded to various fin geometries, vapour velocities, fluid properties, heat fluxes and vapour-side temperature difference with a total of 867 data points.

Table 3.4: The optimum C_1 values in steam @ near atmospheric pressure

Fin spacing (mm)	Vapor velocity (m/s)	C_1
1	2.4	3.06
	4.9	2.01
	7.5	1.65
	10.4	1.51
1.5	2.4	2.14
	4.9	1.38
	7.5	1.12
	10.4	0.98
2.0	2.4	1.81
	4.9	1.11
	7.5	0.86
	10.4	0.71

0.25	2.4	20.17
	4.9	12.20
	7.5	8.66
	10.4	6.20
0.25	2.4	6.20
	4.9	3.94
	7.5	3.01
	10.4	2.46

Table 3.5: The optimum C_1 values in steam @ low pressure

Fin spacing (mm)	Vapor velocity (m/s)	C_1
1	14.7	0.5
	19.7	0.46
	30.5	0.45
	45.9	0.44
	62.3	0.4
1.5	14.7	0.39
	19.7	0.35
	30.5	0.3
	45.9	0.26
	62.3	0.24
2.0	14.7	0.3

	30.5	0.2
	45.9	0.16
	62.3	0.14
0.25	14.7	2.67
	30.5	1.62
	45.9	1.24
	55.6	1.32
	62.3	1.44
0.5	14.7	1.03
	30.5	0.74
	34.5	0.8
	45.9	0.86
	62.3	0.96

Table 3.6: The optimum C_1 values in ethylene glycol @ low pressure

Fin spacing (mm)	Vapor velocity (m/s)	C_1
1	10.5	0.37
	14.3	0.33
	17.9	0.3
	22.1	0.28
1.5	10.5	0.23

	14.3	0.2
	17.9	0.18
	22.1	0.16
2.0	10.5	0.17
	14.3	0.14
	17.9	0.13
	22.1	0.11
0.25	10.5	1.18
	14.3	1.05
	17.9	1.02
	22.1	0.96
0.5	10.5	0.78
	14.3	0.7
	17.9	0.67
	22.1	0.68

In table 3.7, the percentage differences produced by this new model show good improvement compare to that those produced by Namasivayam [1] model which has a 2.3 % for steam at atmospheric pressure, 11 % for steam at low pressure and 7 % for ethylene glycol at low pressure. Figure 3.8 compares the atmospheric pressure steam data to the present model. All the data points are at almost completely staying within the margin of ± 25%. The correlation for these data points produced by present model was seen even better when compared to that produced by Namasivayam [1] model (Refer to Figure 3.2). A similar result can be seen in Figure 3.9 for steam at low pressure data produced by present model. The correlations produced by present model have improved drastically to an excellent agreement data (see Figure 3.3 for comparison) with completely all the data points staying within ±25%. Figure 3.10 compares the ethylene glycol data produced by Namasivayam & Briggs [3] to present model. A similar agreement to steam at low pressure data can be seen that all the data points are staying within ±25%.

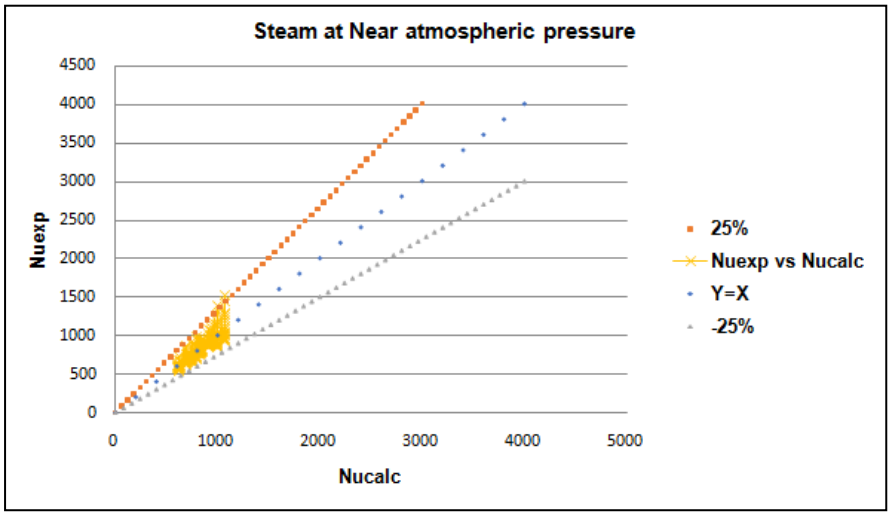

Figure 3.8 Comparison of the experiment data with present model for Steam at Atmospheric Pressure – Experimental vs Theoretical Nusselt Numbers with optimum values of C_1 and C_2.

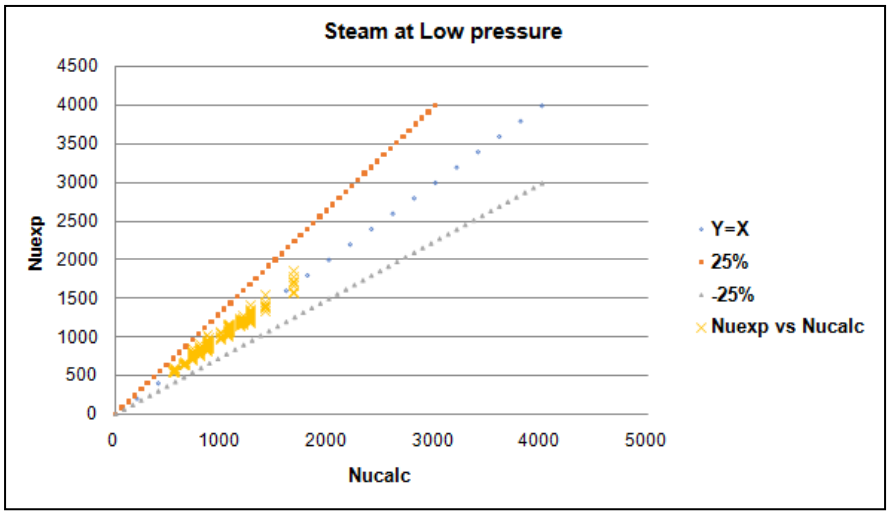

Figure 3.9 Comparison of the experiment data with present model for Steam at Low Pressure – Experimental vs Theoretical Nusselt Numbers with optimum values of C_1 and C_2

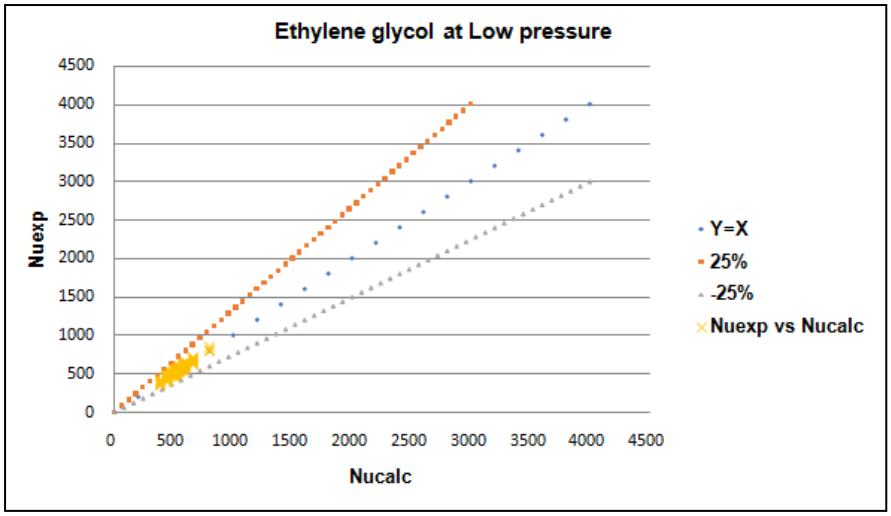

Figure 3.10 Comparison of the experiment data with present model for Ethylene Glycol at Low Pressure – Experimental vs Theoretical Nusselt Numbers with optimum values of C_1 and C_2

Table 3.7: The overall percentage differences with empirical constants for present model

Steam at atmospheric pressure		
C1	C2	Overall % Difference
Vary, refer to Table 5.2	0.01	2.3
Steam at low pressure		
C1	C2	Overall % Difference
Vary, refer to Table 5.3	0.01	11
Ethylene glycol at low pressure		
C1	C2	Overall % Difference
Vary, refer to Table 5.4	0.01	7

5. Conclusion:

The experimental data by Namasivayam & Briggs [2],[3] and [4] had successfully validated in the complex semi empirical model of Namasivayam [1]. The

empirical constants in Namasivayam [1] model were being tested and verified with the selected experimental data that specifically covered a set of five different geometry fin tubes to maintain a correlation within a margin of ±25% and an average percentage difference of never more than 34%. Indeed, the mechanisms for forced-convection condensation on integral-fin tube analysis are understood that able to develop a simpler semi-empirical model for similar heat-transfer analysis.

A new simple semi empirical model for forced convection condensation of steam and ethylene glycol on integral fin tube is presented. The model combined the empirical solutions by Hilpert [9] and dimensionless elements from fin dimensions in order to produce a series of adequate theoretical Nusselt numbers. The optimum empirical constant values in the model produced a correlation to within ±25% and an average percentage difference 7% for fin tubes with various fin spacing of 0.25, 0.5, 1.0, 1.5 and 2.0 mm and a constant fin root diameter, height and thickness of 12.7, 1.6 and 0.25 mm respectively.

This present model has predicted a limited database which is mainly focus on producing better correlation with lesser heat-transfer equations that additional data are still required for more accurate prediction outcome. Besides, the predicted correlations from the model were not independently where still requiring the support from Namasivayam [1] model and the empirical constant C_1 values were found in a wide range which is not practical as expected on predicting the theoretical Nusselt numbers. The semi-empirical model presented could be improved, and the next step might be attempting to include the effects of vapour velocities directly in the present model with wider range of existing experiment data.

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INVESTIGATION OF CHEMICAL PRETREATMENT ON RUBBER WOOD SAWDUST BIOCHAR ON DCFC PERFORMANCE

L.K. PALNIANDY[1], L.W. YOON*, W.Y.WONG[2]

1School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: LiWan.Yoon@taylors.edu.my
2Fuel Cell Institute, Universiti Kebangsaan Malaysia, 43600 UKM Bangi,
Selangor, Malaysia.

Abstract

Direct carbon fuel cell is a promising technology for power generation in future. Using woody biomass as the fuel source for DCFC creates reproducible renewable sources and easy application. In this context, the paper focuses on chemically pre-treated rubber wood biochar as the fuel source. The rubber wood biomass was pre-treated with acid and alkali separately. Both sample were further subjected to pyrolysis at 850°C at the heating rate of 10°C/min with duration of one hour. DCFC performance investigation were done via DCFC fuel cell at 850°C for both pre-treated pyrolyzed sample. Fuel properties were investigated for its proximate analysis by TGA and functional group studies via FTIR. DCFC performance shows that acid pre-treated rubber wood obtained higher power density, 0.4120 mW/cm^2, compared to alkali pre-treated rubber wood which shows only 0.1288 mW/cm^2. Higher fixed carbon, presence of oxygen functional group, low moisture and volatile content in acid pre-treated biochar shows better electrochemical activity compared to alkaline pre-treated biochar. This study shows that acid pre-treated biochar shows higher electrochemical performance, however, further studies on lowering the temperature of DCFC is in need.

Keywords: Direct carbon fuel cell, biomass pre-treatment, pyrolysis, power density, current density

1. Introduction

The current electricity production is mainly via natural gas, coal, crude oil, petroleum products and hydropower. These sources are mostly classified as non-renewable energy, with continuous supply is unsustainable. Extensive research in the use of renewable sources has increased in recently. Current technology on

energy production via combustion based power plants and fossil fuel has created negative environmental impact with the emission of carbon dioxide, causing depletion of ozone layer and acid rain [1]. Thus, in recent years, many discussion and research has focused on reducing the negative impact on climate changes. However, this remain as a big concern in world scenario. An alternative to a clean energy with a high efficiency system is in need.

Fuel cell technology is one of the systems that works as an electrochemical device which converts the chemical energy directly into electrical energy. In combustion based power plants, the heat energy that was converted to mechanical energy and subsequently to electrical energy. As compared to fuel cell, a complex conversion is applied for the production of energy from combustion and this has resulted in a reduced efficiency of its system [2] besides causing environmental pollution [1]. As such, fuel cells become as an alternative system with only conversion from chemical energy to electrical energy.

Fuel cells that works in higher temperature range are solid oxide fuel cell, molten carbonate fuel cell and direct carbon fuel cell. Direct carbon fuel cell produces higher electrical efficiency of 70 – 90% compared to the other two fuel cell, which are lower than 65% efficiency. DCFC utilizes carbon rich solid as the fuel source such as charcoal or carbon source derived from any carbon rich substance such as biomass. This is an added advantage to ease the fuel preparation compared to the tedious steps in preparation of fuel source for molten carbonate fuel cell. However, the disadvantage of the DCFC is the relatively faster rate of material corrosion and degradation of the cell [1], [3]. Among all, DCFC possess the highest electrical efficiencies with 70% - 90%.

Direct carbon fuel cell is still at its infancy state. Challenges rely on this advance technology require in depth study for its commercial application. This technology has been tested mainly for commercial carbon black and it shows high efficiency and remains the clean fuel for DCFC [4], [5]. However, commercial carbon black is not feasible to be utilized as the solid fuel for the DCFC because it is not economically viable. Alternatively, this challenge can be overcome by using the biomass char.

The presence of impurities in the use of the carbon rich fuel source affects the performance of DCFC., as supported by other researchers [6], [7]. Thus, ash free carbon sources are favourable for DCFC. Ash free carbon source could be produced by first pre-treating the biomass prior to pyrolysis. In this study, the effect of the chemical pre-treatment on rubber wood for the application of DCFC will be investigated.. The correlation of the biochar properties on DCFC performance will be explored.

2. Materials and methods

Experiments were conducted by using rubber wood as the fuel source. Rubber wood biomass was subjected to washing using distilled water for removal of any other residual contaminants. Then, it is dried in oven (UN75, Memmert USA) at 110°C for 24 hours for moisture removal. The dried biomass was grinded by using grinder (JK-SG-160, KGC Scientific) and sieved into smaller particle lesser than 500µm using sieve shaker (RX-812-1, Tyler).

2.1. Biochar Production

The rubber wood (RW) was pre-treated with acid and alkali prior to biochar production. For alkali treatment, rubber wood was treated with 0.5 M sodium hydroxide at 122°C under ambient pressure for one hour. As for the acid treatment, sample was treated with 2 M hydrochloric acid at 122°C under ambient pressure for one hour [8]. The treated biomass and untreated RW (control) was pyrolyzed by using split tube furnace (HST 12/400, Carbolite) at 850°C at 10°C/min for one hour under nitrogen flowrate of 150 ml/min. The pre-treated samples are named as RWacid and RWalkali respectively.

2.2. Carbonaceous fuel characterization

Proximate analysis of the RWacid and RWalkali were conducted via thermogravimetric analyser (TGA8000, Perkin Elmer). The analysis was carried out from room temperature to 110°C under Nitrogen gas flow and was hold for 20 minutes. Then, the temperature was ramp from 110°C to 950°C and was hold for 20 minutes. Gas were switched to air flow at 950°C and were hold for another 20 minutes [9].

The presence of oxygen-functional group was analysed by using the Fourier transform infrared (FTIR) (Spectrum100, Perkin Elmer) transmission analysis. The samples were analysed by using the attenuated total reflection (ATR) accessory from 4000 cm^{-1} to 650 cm^{-1} at resolution of 4 cm^{-1} [10]

2.3. DCFC Performance evaluation

Direct carbon fuel cell used in this study is the button cell design [11]. Silver wire is used as current collector. Both anode and cathode alumina tube will be connected by using mechanical compression. Gas inlet on the top of anode will be feed with nitrogen flow at 200 ml/min and cathode will be feed with air flow at 200 ml/min. The fuel cell chamber was operated at 850°C at the heating rate of 10°C/min for holding period of 2 hours. Prior of heating, anode flow will be flowed to remove any residual gas inside the chamber. Upon reaching the target temperature, open circuit voltage (OCV) test and voltage-current density characteristic were measured at the scan rate of 1 mV/s by using a potentiostat (Gamry, Interface 1000E). The internal resistance was tested at high frequency of 1kHz [12], [13].

3. Results and Discussion

4.3.1. Proximate Analysis

Proximate analysis of treated and untreated RW is shown in Table 1. Pretreated rubber wood sample with chemical treatment produced a much lower moisture content (0.1 % for RW acid and 0.3 % for RW alkali) compared to untreated biochar of having 14.2 %. However, not much differences were observed for volatile content, as in the range of 17.9 % to 22.3 %. Chemical pretreatment aids in producing higher fixed carbon content compared to untreated biochar. Higher fixed carbon may contributed from further disintegration of the volatile fractions into smaller molecular weight [14]. Based on the result, ash content for the alkaline treated rubber wood samples shows 7.0 % compared to RW acid (approximate to 0%). RW acid shows a better demineralization effect compared

to the alkali application in the pretreatment technique. This supports by study on using oak sawdust which produced lowered ash content in acid pre-treated. The substantial reduced via nitric acid, removed the alkaline earth metals, such as ferric oxide and calcium oxide, thus, reduced the ash content [15].

Table 1. Proximate analysis of pretreated rubber wood samples (wt%).

Sample	Moisture	Volatile	Ash	Fixed Carbon
Untreated RW	14.2	21.8	2.1	62
RW Acid	0.1	17.9	-	82
RW Alkali	0.3	22.3	7.0	70.5

Figure 1 shows the FTIR spectra for both chemically treated RW and untreated RW. There is obvious peak observation in RW acid compared to the untreated and alkali treated RW. Prominent peak were observed at the area of 1134 cm^{-1} to 1000 cm^{-1} shows larger in RW acid than RW850 and RW alkali. It possibly represent the symmetric C-O stretching, for cellulose, hemicellulose and lignin, shows that acid treatment change the surface characteristic of the biochar. It shows that Peak at 1433 cm^{-1} (aromatic C=C) observed for untreated sample and RW acid, while a smaller peak at RW alkali, shows the lignin carbohydrate. Peaks were present at the range of 874 cm^{-1} for RW acid and untreated compared to small intensity peak, shows C-H groups.

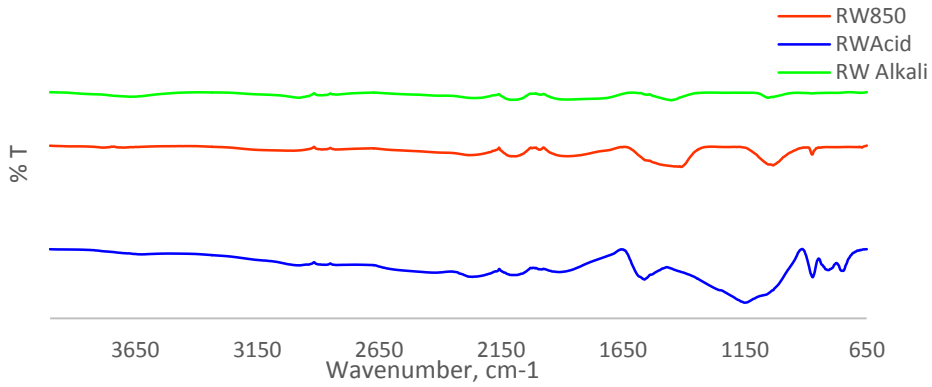


Figure 1: FTIR spectra for rubber wood derived biochar

Study has shown that oxygen surface functional groups able to provide a better electrochemical performance that is claimed to act as the reactive sites for the anode reaction [16]. The active sites that aids in a better electrochemical activity are the carbon atom that connects with the oxygen containing functional groups, such as, alkyl chains or it presences on the surface atoms with dangling bonds [17].

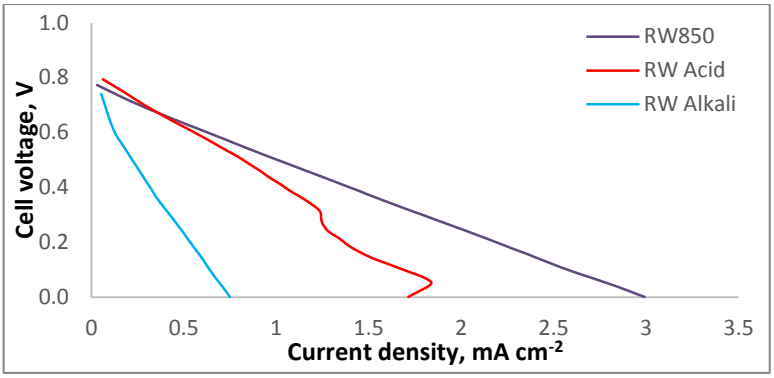


Fig. 1. Effect of untreated and chemically pre-treated of the rubber wood biochar on i-V curves at 850°C.

DCFC performance test were carried out by using solid carbon fuel contacting the anode side of the button cell. Initial voltage test shows that acid pretreated biochar produces higher open circuit voltage, 0.83 V compared to the alkaline pre treated biochar, shows only 0.74 V and untreated RW shows 0.77 V. Fig. 1 presents the I-V curves of untreated rubber wood, pre-treated with alkali and acid at 850°C. The graph shows a rapid decrease from the initial OCP value which contributed by fast consumption of the fuel and affected by activation resistance as reported by Li et al. [5]. Activation polarisation are active at the lower current densities for both samples, as this shows sluggish electrode kinetics.

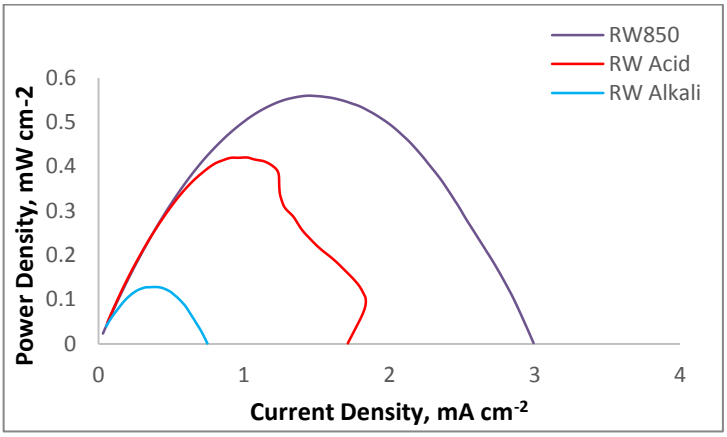
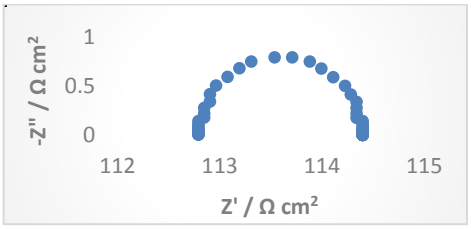


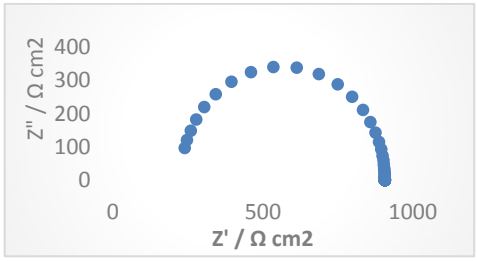
Fig. 2. Effect of untreated and chemically pre-treated of the rubber wood biochar on i-P curves at 850°C.

I-P curve shows a better electrochemical activity for acid treated rubber wood samples, with 0.4192 mW/cm^2 and only 0.1288 mW/cm^2 for alkaline treated sample. Alkaline treated sample shows a rapid fall of power density, which assumes that the lack of activation sites for the oxidation to took place. This further explains that, the alkaline pre-treated biochar having high ash content compared to the acid pre-treated biochar, which contributes high impurities in the sample [12]. Thus, electrochemical activity enhanced with presence of lower ash So, this supports the necessities of the pre-treatment technique on the removal of the impurities in the solid fuels. On the contrary, high power density for acid

treated sample supports a better electrochemical of solid fuel to the anode reaction.



(a)



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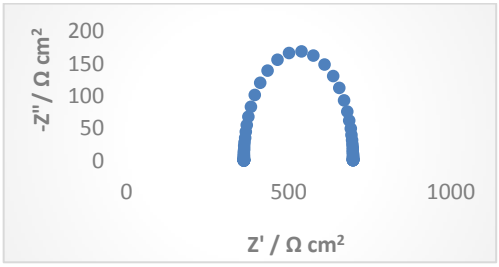

Fig. (c) **ɨdance spectra for (a) RW Acid (b) RW850 (c) RW Alkali in DCFC at 850°C.**

Resistance of the cell were characterized by impedance spectra. Fig 3 shows the impedance spectra for the untreated rubberwood biochar and treated with acid, alkali respectively. It measured that the polarization resistance value for RW acid is smaller, 2.762 Ω cm^2. However, the polarization resistance for the RW alkali show much larger of 587.2 Ω cm^2 which shows that the presence of the activation resistance and concentration resistance that occurs during the cell reaction mechanism [18].

5. Conclusions

This study shows that acid pretreatment gaves a better physicochemical modification compared to untreated biochar and alkali treated biochar. However, higher power density were acquired during the DCFC performance,

shows 0.57 mW/cm^2 compared to acid treated biochar of 0.47 mW/cm^2. This study shows that alkali treatment for woody type biomass is not suitable for increasing the oxygen surface group and lowering the ash content. Its conclude that untreated rubber wood is sufficient in the application of DCFC as further chemical treatment is only lowering the electrochemical activity and increasing the cost of production.

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THERMAL CONDUCTIVITY PROPERTY OF NAPHTHENIC-BASED MINERAL OIL, PALM OIL MINERAL ESTER (POME) AND ITS MIXTURES

DANIAL AMININ BIN ZAIRIN, RASHMI GANGASA WALVEKAR*

School of Engineering, Taylor's University, Taylor's Lakeside Campus,
No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: anna_a_lee@web.abc.cd

Abstract

An investigation has been made to study the thermal conductivity of naphthenic-based mineral oil, palm oil methyl ester (POME) and its mixtures. Mineral oil and POME was mixed to produce blend oils with weight ratio (mineral oil:POME) of 70:30, 80:20 and 90:10. The blend oils were prepared by homogenizing process for 10 minutes. Thermal conductivity analyser was utilized to measure the thermal conductivity. Results indicated that thermal conductivity increases as temperature increases. Mineral oil resulted in highest thermal conductivity at 80 °C. Blend oil with 80 wt.% mineral oil and 20 wt.% POME resulted in highest thermal conductivity in room temperature. There were no significant difference in thermal conductivity for blend oils as temperature elevates.

Keywords: Transformer Oil, Mineral Oil, Vegetable Oil, Palm Oil Methyl Ester, Blend Oil

6. Introduction

Transformer is one of the most essential electrical components as it serves a vital link in distributing electricity to the consumers [1]. Known to be high-cost component and has direct effect on network operation, location, oil contents and toxic material, any interruption on the working of transformer would reduce the reliability of the power system [2-4]. Nowadays, there is a continuous expansion in urbanization and thus, more power and electricity are needed. Transformers have been pushed to its limits to meet the demand of power and electricity One of the suspects that causes transformer failure is the overheating and thermal stress. Overheating and thermal stress hold about 32% of causes on transformer failures [5].

Coolant is essential for heavy machinery operations where it deals with heat and transformers are no different. Transformer oil, which is mostly made up of mineral oil, is used as coolant and to provide insulation to all immersed electrical components for decades due to their thermal insulation traits [5]. However, transformers have evolved to satisfy the current power demands. Hence, mineral oils should evolve to ensure the operation of transformer remains optimum, efficient and, most importantly, safe. Even though it is used as coolant, insulation and able to function at high temperatures, mineral oil, in nature, has poor thermal properties, which is the current challenge [6].

In the recent years, there have been environmental concerns on the use of mineral oil that has poor biodegradability in electrical systems where spills and leaks are likely to occur. Besides, due to limitation sources of mineral oils, sustainable production of transformer oil is being discussed since it is acknowledged that mineral oils are produced from petroleum products. Vegetable oils are thought to be suitable alternative to counter these environmental concerns. They have been number of investigations being performed on vegetable oils for providing as alternative to transformer mineral oil [7]. Vegetable oils have properties like high thermal conductivity, high dielectric properties, high biodegradable, high flash and fire points and it is considered more environmentally friendly fluids [8-9]. However, the drawback is that it is prone to oxidation, making them unstable due to its high unsaturated fatty acid content, which in turn, affect the physiochemical and dielectric properties of vegetable oils [10]. Mixtures of mineral oil and vegetable oil are being investigated to study its physiochemical and dielectric properties in order to reduce mineral oil usages and improve its performance [11-13].

The objective of this paper is to study the effects of different mixtures of mineral oil and vegetable oil on thermal conductivity. In this investigation, naphthenic-based mineral oil and palm oil methyl ester (POME) are used to prepare blend oils with different ratio. The blend oil weight ratio (mineral oil to POME) that are being investigated are 70:30, 80:20 and 90:10.

7. Methodology

Naphthenic-based mineral oil and palm oil methyl ester (POME) were obtained from Apar Industries Limited, India and ExcelVite, Malaysia, respectively. Mineral oil and POME were mixed using homogenizer for 10 minutes. Table 1 below displays the samples with different blend oil ratios. Thermal conductivity of the nanofluids was measured using Thermal Conductivity Analyzer (KD2 Pro Decagon Devices Inc, Pullman, USA) at temperature range between room temperature and 80 °C.

Table 1. Samples with different blend oil ratios

Sample	1	2	3	4	5
Mineral Oil (wt.%)	100	90	80	70	0
POME (wt.%)	0	10	20	30	100

8. Results and Discussion

The thermal conductivity of mineral oil, palm oil methyl ester (POME) and blend oils with respect to temperature is displayed on Figure 1 below. All samples resulted in similar trend; thermal conductivity enhances as temperature elevates.

In mineral oil, thermal conductivity increases as temperature increases. However, there is a drop of thermal conductivity at 40 °C due to natural behaviour of mineral oil [14]. POME showed similar trend to mineral oil where thermal conductivity enhances as temperature elevates. However, thermal conductivity of POME drops at 80 °C due to its unsaturated fatty acid content [15].

Blend oils resulted in similar thermal conductivity trend as temperature elevates. However, at room temperature, blend oil with 80 wt.% mineral oil and 20 wt.% POME resulted the highest thermal conductivity of 0.118 W/mK among the other oils. Nevertheless, thermal conductivity of blend oils resulted in no significant difference as temperature increases. In the long run, mineral oil resulted in the highest thermal conductivity of 0.248 W/mK at 80 °C.

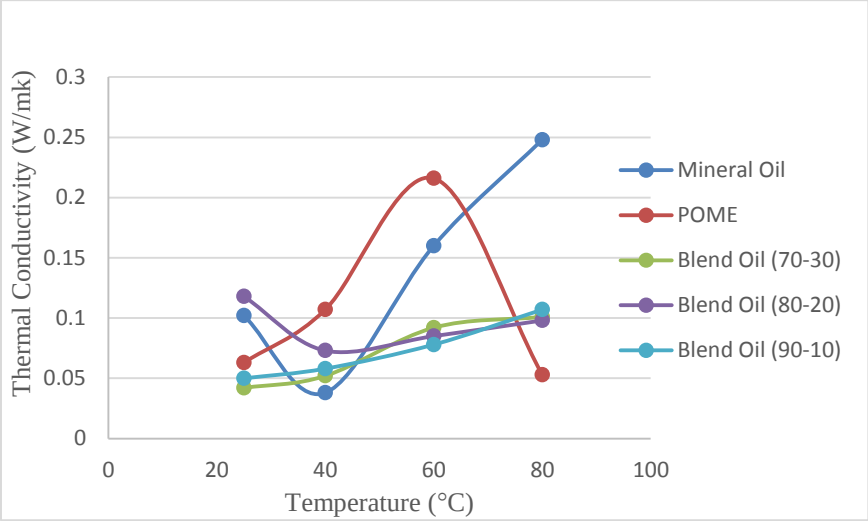

Figure 1. Thermal conductivity on mineral oil, palm oil methyl ester (POME) and blend oils with different ratios

9. Conclusions

Some concluding observations from the investigation are given below.

- Mineral oil, palm oil methyl ester (POME) and blend oils showed similar trend where thermal conductivity increases as temperature elevates.
- There were drops of thermal conductivity as temperature elevates due to nature and content of the respective oils.
- Mineral oil resulted in the highest thermal conductivity of 0.248 W/mK at 80 °C. However, in room temperature, blend oil with ratio of 80 wt.% mineral oil and 20 wt.% POME resulted in the highest thermal conductivity of 0.118 W/mK.
- Thermal conductivity of blend oils resulted in no significant difference as temperature elevates.

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TECHO-ECONOMIC ANALYSIS FOR THE PRODUCTION OF TITANIUM DIOXIDE NANOPARTICLE PRODUCED BY LIQUID-PHASE SYNTHESIS METHOD

RISTI RAGADHITA, ASEP BAYU DANI NANDIYANTO*, AHMAD CHANDRA MAULANA, ROSI OKTIANI, AJENG SUKMAFITRI, AMIR MACHMUD, EKA SURACHMAN

Departemen Kimia, Universitas Pendidikan Indonesia,
No. 229 Setiabudhi Street, 40154, Bandung, West Java, Indonesia
*Corresponding Author: nandiyanto@upi.edu

Abstract

Titanium dioxide (TiO2) is one of the most used and popular materials due to its excellent performance. This makes the demands for the production of TiO2 increasing recently. Therefore, there is a need for the feasibility study for generating industries for the production of TiO2 especially in the developing countries. This study aimed to evaluate the prospect for the production of titanium dioxide nanoparticles in practical uses. This study was done to confirm whether the large-scale production of TiO2 is profitable or not. As a model of the synthesis method for fabricating TiO2, the liquid-phase synthesis involving the hydrolysis of titanium isopropoxide with nitric acid was used. The evaluation was done using two types of feasibility studies: engineering analysis and economic evaluation. The estimation of the project was also completed with the project. calculation from ideal conditions to the worst cases of production by adding several parameters: raw materials, sales, utilities, labor, and external conditions (i.e., taxes and subsidiaries). The engineering analysis gave information the potential large-scale production since the process can be done using current available technology and inexpensive apparatuses. The economic evaluation based on various economic evaluation parameters (such as gross profit margin, break-even point, payback period, etc) showed the potential profitability for the All evaluation parameters gave positive points. The project also used relatively inexpensive total cost of purchased equipment. Although further developments must be also added especially regarding the additional strategies to boost the profit to attract the investors, this study provides a great promise for the possible fabrication of TiO2 in developing countries.

Keywords: Titanium Dioxide Nanoparticles, Economic evaluation, Feasibility study.

1. Introduction

Titanium Dioxide (TiO_2) is one of the most important transition metals that have been widely studied and recently used for many technologies and applications. The wide applications of TiO_2 are used to for pigment, paint, toothpaste,

cosmetics, electronics, and also photocatalyst at present [1-3]. TiO_2 exists in three crystal structure that include are anatase, rutile, and brookite. Anatase-phased TiO2 has a crystalline structure that establishes in the tetragonal system with bypiramidal system. This material is applied for cosmetics, especially for sun protection. Rutile-phased TiO_2 also has a crystalline structure that corresponds to the tetragonal system with prismatic system. Rutile is used for paint, plastics, coating, and also cosmetics. The brookite-phased TiO_2 has a crystalline structure with orthorombic system. Its crystalline polymorphic forms make it suitable for several technological applications due to its chemical stability and low toxicity [4].

Researches on TiO_2 nanoparticles production have been reported [4]. TiO_2 nanoparticles have been synthesized by various methods such as aerosol process, sol-gel method, inert gas condensation, and hydrotermal process [7,8-14]. In the aerosol process, high-purity TiO_2 nanoparticles are produced using a simple process. However, the high temperature setting when applying this process leads to the problems in the cost of production. Sol-gel method involves many steps of processes. For some cases, it also uses expensive chemicals. In the case of the inert gas condensation process, the process needs expensive cost of production due to the use of sophisticated apparatuses such as ultrahigh vacuum. Hydrothermal process can produce particles in the relatively low-temperature range (less than 300^oC). However, to get better materials, the additional processes and safety for handling the system are still required. Among the types of processes, the liquid-phase synthesis is the best. The liquid-phase synthesis method can allow the obtainment of high surface area and highly crystalline of product. The process is simple, uses fast reaction with relatively simple apparatuses, and is prospective to form high purity of products by additional simple treatments [14].

To evaluate the production of TiO_2 nanoparticles, the present study adopted a synthesis method from literature [14]. This method was evaluated from two perspectives: engineering and economic evaluation. To support the economic evaluation in this study, several economic evaluation parameters were calculated:

(i) gross profit margin (GPM; to predict the rough analysis of the economic condition),

(ii) internal rate return (IRR; to ensure the condition of economic),

(iii) payback period (PBP; to estimate the possibility for the year of profit),

(iv) cumulative net present value (CNPV; to predict the condition of the project as a function of year of production),

(v) break-even point (BEP; to get the minimum requirement of the production capacity),

(vi) profitability index (PI, to obtain information about the profit).

To support the analysis, several information was adopted, such as data for chemical price, utilizing components, and specifications for apparatuses. The data is then calculated to get the feasibility study for generating industry for the fabricating of TiO_2 in developing countries such as Indonesia. In addition, this feasibility study is important because this helps the decision whether the scaling up process is prospective or not. This study also gives suggestion how to optimize the project to give benefit to the economic growth. The successful production can

create several aspects relating to the socio-economic condition, including reducing poverty [15,16]. In short, building and developing this project can create employment opportunities that has direct impact to reducing poverty. Additional opportunities obtained from the presence of this project are also found in the cash flow generation. The cash flow can be generated from workers, distributors, sellers, and even the surrounding community (e.g. housing, restaurant, etc).

Since the present study is the first analysis in the feasibility study, all calculations were done in the specific conditions. The additional variables were added to the calculation, such as labor condition[17], raw materials, product (sales), utility, [18] as well as the external condition including environmental uncertainty (e.g. such as competition in the production and sales, tax from the government, and subsidiary from the government) [19]. However, for scaling up process, further analyses must be done to predict the realistic condition for the development of the project. We believe that the present analysis will drive further investigation for the large-scale production of the TiO_2 material in developing countries.

2. Theoretical Synthesis of TiO_2 Nanoparticles

The production of TiO_2 was adopted and improved from literature [14,20]. In short, synthesis of TiO_2 nanoparticles in this project was done using the liquid-phase synthesis method based on the use of titanyl nitrate and glycine. Titanyl nitrate was prepared by reaction of titanyl hydroxide ($TiO(OH)_2$) obtained by hydrolysis of titanyl isopropoxide with nitric acid. Systematic process used in this study is shown in Fig. 1.

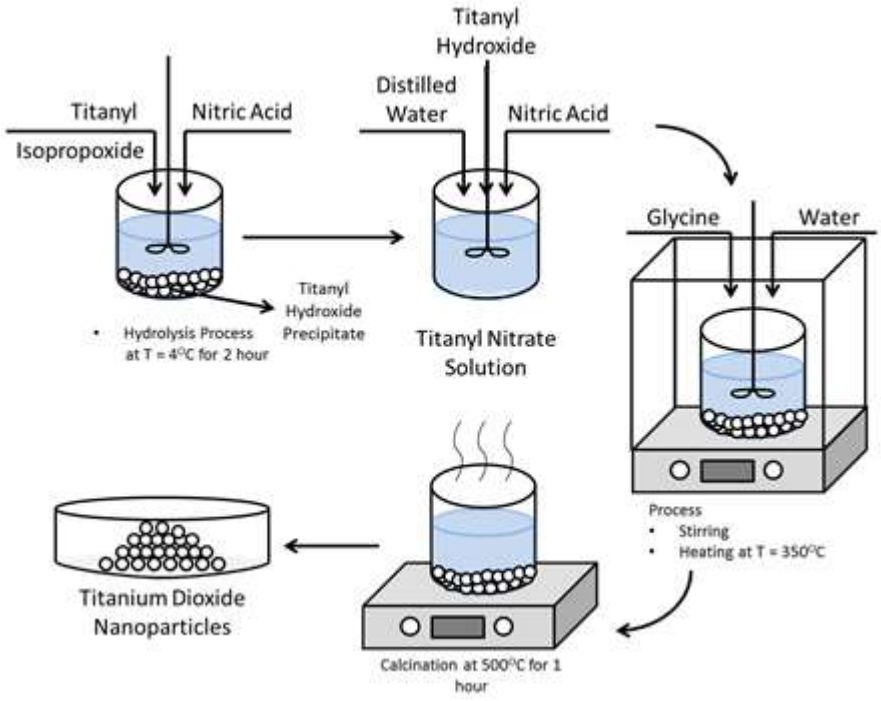

Figure 1. Schematic representation of the liquid-phase process

The process is described as follows: initially, the titanylnitrate [$TiO(NO_3)_2$] precursor is synthesized by reaction of titanyl hydroxide [$TiO(OH)_2$]. Titanyl

hydroxide is obtained from the hydrolysis of titanium isopropoxide [Ti(i-OPr)$_4$] with nitric acid. Hydrolysis was controlled under ice-cold condition (4°C) with stirring for 2 hours until a white titanyl hydroxide precipitate was produced. The precipitate was mixed with distilled water and then dissolved in nitric acid to obtain a titanyl nitrate solution. This mixed solution was used as a precursor for the synthesis of TiO_2 nanoparticles. The precursor was then mixed with glycine in water and heated in a furnace to 550°C under stirring condition. The solution was dehydrated to produce titania [7,14,20]. During the process, the following reactions occur [14,20]:

- Hydrolysis

$$Ti(C_3H_7O)_4\,(s) + 3H_2O\,(aq) \rightarrow TiO(OH)_2\,(s) + 4C_3H_7OH\,(aq) \quad (1)$$

- Nitration

$$TiO(OH)_2\,(s) + 2HNO_3\,(aq) \rightarrow TiO(NO3)_2\,(aq) + 2H_2O\,(aq) \quad (2)$$

- Synthesis

$$9TiO(NO_3)_2\,(aq) + 10C_2H_5O_2N\,(aq) \rightarrow 9TiO_2(s) + 14N_2\,(g) + 20CO_2\,(g) + 25H_2O\,(g) \quad (3)$$

3. Method

The present method used for the analysis data of price, utilizing components, and specifications for apparatuses that were taken based on available online shopping web such as alibaba. All data are then calculated by a simple mathematical analysis to get several economic evaluation parameters, including GPM, IRR, PBP, CNPV, BEP, and PI sales to investment. The economic evaluation parameters were calculated based on the literature [18]. In short, the calculation was obtained using the following formulas:

(1) GPM was calculated by substracting sales and raw material cost

(2) IRR was from the following equations: $NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$ where *Ct* and *Co* are the net cash inflow during the *t* period and the total investment costs, respectively. *r* is the discount rate. *t* is time (as year)

(3) PBP is the length of time required to recover the cost of an investment. The simplest way to obtain PBP is gained from the CNPV curve. The value of PBP was determined by understanding the time when value of CNPV/TIC reaches zero for the first time.

(4) CNPV is the values gained from the net present value (NPV) at a specific time. In short, the CNPV was obtained by adding the value of NPV from the beginning of the project. The NPV was calculated by multiplying cash flow with discount factor.

(5) BEP was calculated by dividing fixed cost and profit.

(6) PI was estimated by dividing CNPV and total investment cost or sales, corresponding the PI types of profit to investment or profit to sales, respectively.

Then, when evaluating economic feasibility various conditions are tested such as changes in raw material, sales capacity, labor, interest rates, etc.

4. Results and Discussion

4.1. Energy and Mass Balance Analysisis

Based on the process as shown in Fig. 1, the amount of product was calculated stoichiometrically based on 40 L of titanyl tetra isopropoxide (TTIP). Several assumptions were made:

- All compositions of chemicals, such as titanium isopropoxide, nitric acid, titanyl nitrite and glycine used for the produce TiO_2 nanoparticle were calculated based on literature [14,21].
- Conversion rate for the titanium hidroxide formation process was 90%.
- Conversion rate for the TiO_2 nanoparticle formation process was 90%.
- All products are anatase-type TiO_2 nanoparticles.
- Losses obtained due to the mechanical process, including purification, drying, calcination, and product collection were 10%.

Based on the above calculation, to produce 38 kg of TiO_2, the process needs 40 L of titanyl tetraisopropoxide, 48 L of nitric acid, and 16 kg of glycine. And, water required for the process was at least 4 L. This calculation was then used for further analysis for the scaling up process.

4.2. Economic Evaluation

To analyze the economic perspective in this study, assumptions were made:

- The calculation for the economic condition used IDR (Indonesian currency). Then, the value was converted to USD with a fix currency of 1 USD = 10,000 IDR.
- All prices used based on commercially available materials gained in available online market. In short, the price of titanyl isopropoxide, nitric acid, glycine and TiO_2 nanoparticles were 5 USD/L; 4 USD/L; 1 USD/kg; and 16 USD/kg respectively.
- All materials used in the production were estimated based on the stoichiometrical calculation.
- The process neglected other supporting fees (e.g. instrumentation, plant start-up, electrical-related component).
- The total investment cost (TIC) was calculated based on the Lang Factor [18]. The result from the Lang Factor showed that the TIC was about four times of the total equipment cost.
- The process was done under purchased land. Therefore, the land was calculated as the initial cost (at the beginning of the plant construction) and recovered/regained after the project (at the end of the project).
- For calculating depreciation, direct-type depreciation was used [18].
- One cycle in the production to convert titanium isopropoxide into TiO_2 nanoparticles needs 2 hours of production

- One-year project is 300 days and the rest of the days are used for cleaning and setting up the process.
- Basic electricity cost is 0.15 USD / kWh.
- The total wage/labor was assumed with a fixed value of 8 USD/day.
- The discounted rate and the income tax were 15, and 10% annually, respectively.
- The length of the project operation was 20 years.

4.2.1. Ideal Condition

Figure 2 presents the CNPV curve with various economic evaluation parameters under ideal conditions. The result confirmed that the conversion of titanyl isopropoxide to TiO_2 nanoparticles are promising. The engineering analysis confirmed that the preparation can be scaled up using current available technology and inexpensive apparatuses. The economic evaluation also showed the prospective results since the values of economic parameters are positive (see the insert table in Fig. 2). However, regarding the PBP, the project needs about more than 10 years.

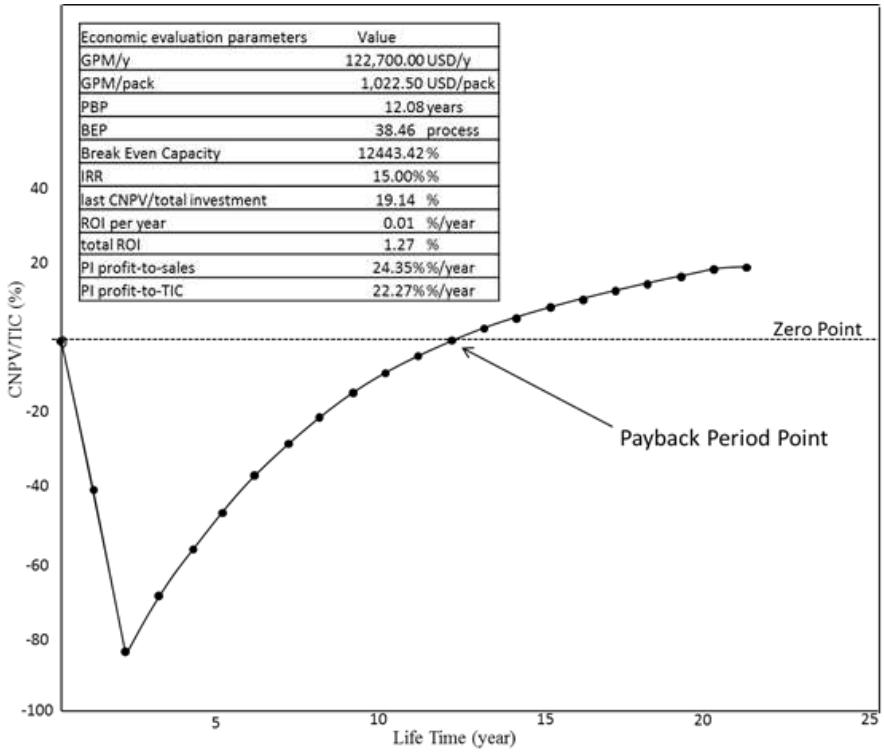

Fig. 2. Ideal condition for CNPV under various economic evaluation parameters

4.2.2. Effects of raw material (i.e. titanyl isopropoxide, nitric acid, and glysine), product sales, labor, and utility

Initially, the analysis was to evaluate the effect of raw material prices and sales on GPM (see Fig. 3). The calculation result was obtained by subtracting the cost of the product sales (revenue; how many product can be sold) with the initial cost of the raw materials [17]. Sales had a positive impact with GPM values, while raw material has opposite correlations. It means that generating more sales will be profitable on the project, while the increase in raw material prices had a negative impact on the project. Based on the analysis in the raw materials, the impacts of nitric acid and glycine on the GPM were almost similar. The most influential parameters in the raw materials is titanil isopropoxide.

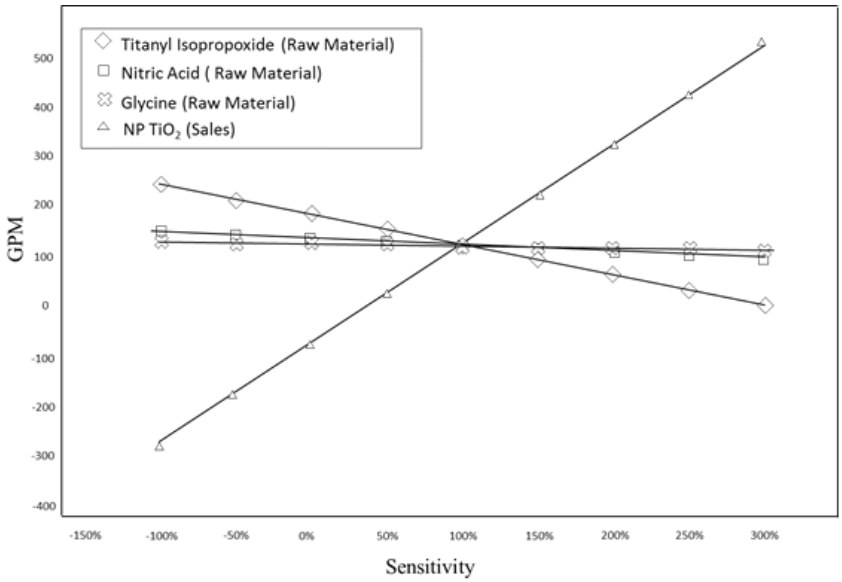

Fig 3. Raw materials (i.e. titanyl isopropoxide, nitric acid, and glysine) and sales cost on the GPM.

To confirm other factors in addition to the raw materials and sales, analysis of PI was conducted (see Figs. 4 and 5). These figures combined the evaluation of PI based on sales, raw materials, labor and utilities. An exponential curve for the sales in the PI analysis was obtained. The change in the PI values was obtained, confirming that sales had a direct impact on the profit. However, a significant increase in sales prices did not give impacts to the obtainment of profit because an increase in sales will be followed to changes in variable costs. Therefore, the sales price must be optimized to get optimal value. In the case of raw material, the PI was a linier curve. This informs that the raw material has a direct impact to the change of PI. Regarding the labor and utility costs, increases in these parameters seem to give no significant effect on the PI in comparison with sales conditions and raw materials. In short, we can conclude that the higher production price has a direct impact on the more profit. However, this production cost must be optimized with raw materials, labor, and utilities for sustaining the project. Based on this analysis, the most dominant factor is sales and then followed by price of raw materials, labor parameter, and utility cost.

BEP analysis (see Fig. 6) was conducted to ascertain the effects of sales, labor costs, raw materials, and utilities on the profit. Analysis was carried out using

variations of -100 to 300% of the predicted value. To provide a perception of project feasibility, the analysis was determined by the indication in the dotted and clear area for the infeasibility and feasibility of the project, respectively. The analysis results showed that the increases in sales have a good relation with the decreases in the BEP value. On the contrary, the labor condition, price of raw materials, and cost of utilities had the opposite correlations. To clarify the impact of these parameters on BEP, evaluations were also done in a certain range (between -100 and 300% of the predicted value).

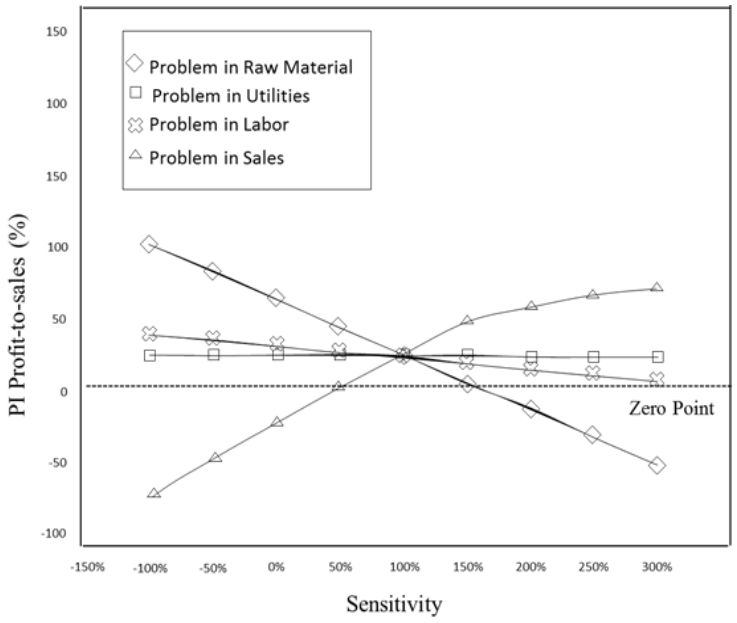

Fig. 4. PI profit to sales as a function of sales, raw materials, utility, and labor. The term problem in the figure is the variation of a specific parameter

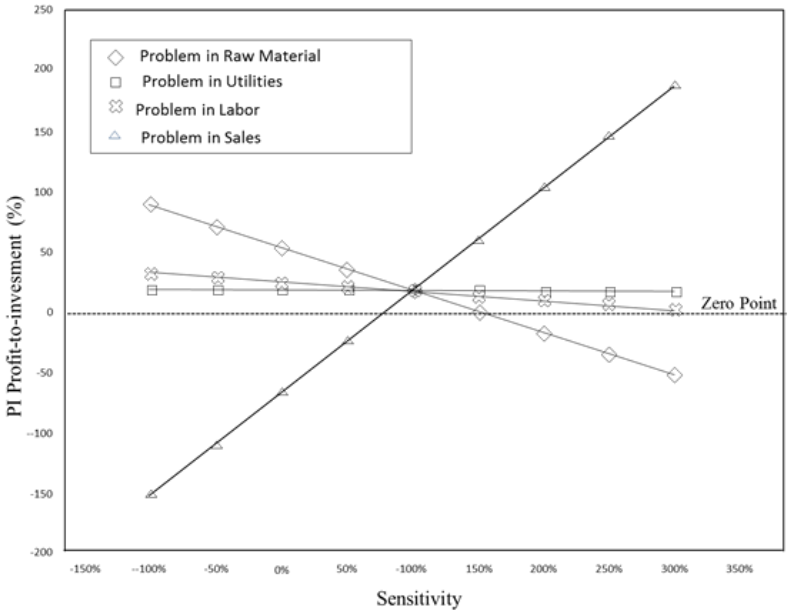

Fig. 5. PI profit to investment as a function of sales, raw materials, utility, and labor. The term problem in the figure is the variation of a specific parameter

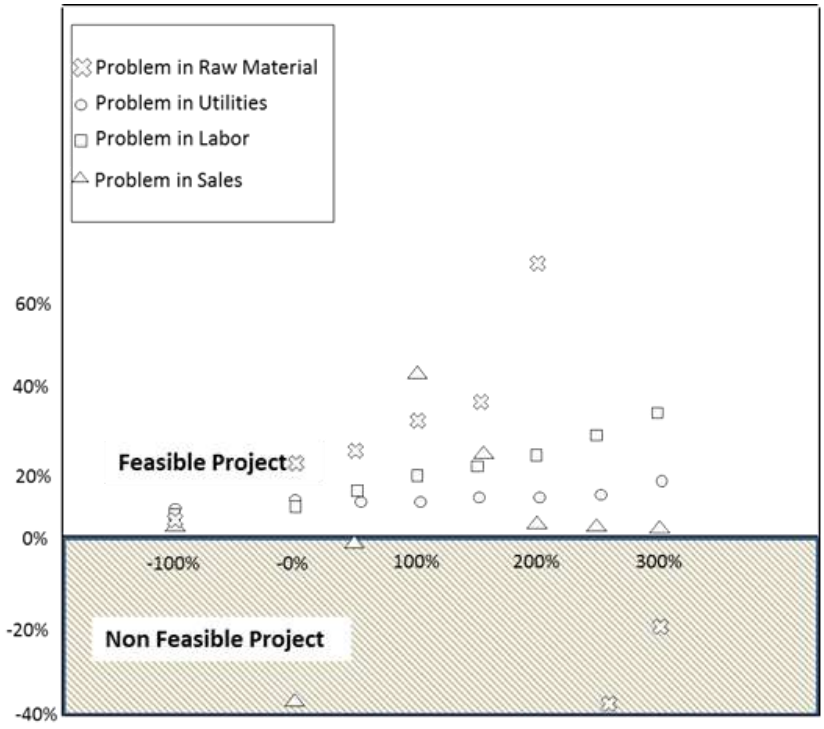

Fig. 6. BEP as a function of sales, labor, raw materials, and utility. The term problem in the figure is the variation of a specific parameter

CNPV analysis based on changes in variable costs is shown in Fig. 7. The analysis results showed that variable costs play an important role in project profitability, in which a decrease in variable costs directly affects to the high value of the final CNPV. In short, when using lower variable costs, the project would be effective to generate more profits. However, regarding the cases in increasing variable costs, the project will be useless and the profit will reduce. The maximum value for varying the costs to sustain the project must be less than 100% of the predicted value. Then, when using production of more than 100% of variable costs, the minimum PBP cannot be gained. Indeed, this will create an unprofitable project.

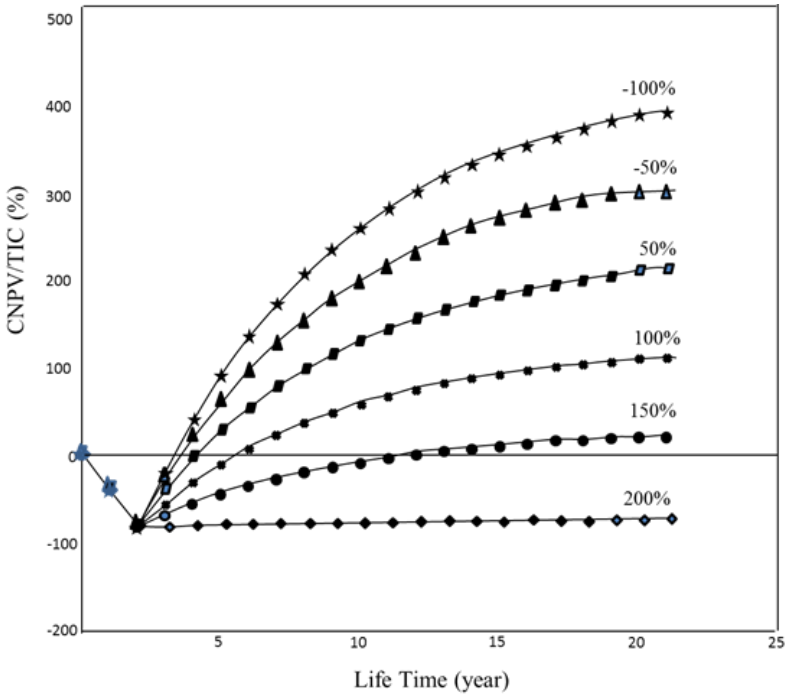

Fig. 7. CNPV curve under various variable costs.

4.2.3. Effect of Production Capacity

To get the minimum production capacity requirements, the calculation must be done through the CNPV analysis as presented in Fig. 8. CNPV analysis is used to predict in detail whether the project starts to get benefit or not. This also estimates PBP of the projects. The results showed that capacity plays an important role in project profitability. Reducing the production capacity will directly affect the final CNPV value and also affect PBP values. The minimum production capacity to maintain the project must be more than 50% of the predicted value. If the production capacity is less than the minimum production capacity (less than 50%of the predicted value), it will create the unprofitable project.

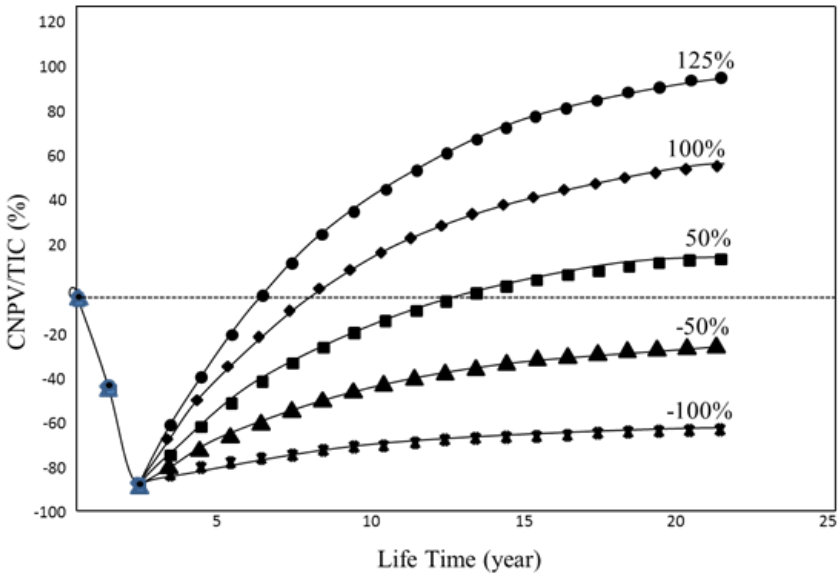

Fig. 8. CNPV curve under various production capacities.

4.2.4. Impact of External Condition

In addition, internal factors (conditions of raw materials, utilities, labor, and sales costs) can affect the success of a project, there are external factors that can affect a project. One of the most influential external factors is the economic condition of a country where the project is implemented. This is related to the financial costs or other imposed factor on the project. The impact of domestic economic conditions can also take the form of taxes from the government itself. To get the correlation of the external condition, the present study used the most speculative values between -100% and +150% of the predicted value based on literature [22] for the worst case in Indonesia. The negative value shows the subsidiary from the government, whether positive is the information for the change in the tax.

Figure 9 presents the curve of CNPV under various tax costs. PBP was obtained with tax variations. As shown in the picture, the initial conditions (calculated from beginning (0 year) to the end of the project (2 years)) of the CNPV curve under various tax costs were identical. This is because these years of productions is related to the construction of a project. No tax can be applied. Indeed, the effect of tax on CNPV can be obtained after the project is established (from two years). When the tax costs added to the project increase, the project profits would decrease. This is related to the PBP. Based on the analysis of PBP, the maximum tax cost for obtaining BEP (the position at which either a profit or a loss on the project) was 50% of the predicted value. Changes in taxes to more than 50% create a failure in the project.

Investigation about the governmental subsidiary cash for the project was also done. For example, when the government provides an additional fee of 50% of the predicted value (displayed as -50% in the graph), it will create more profit in the project. It was found that the additional subsidiary gave to the additional cash flow in the company. However, we found that the subsidiary did not give too much impact on the project because PBP was around 5 years.

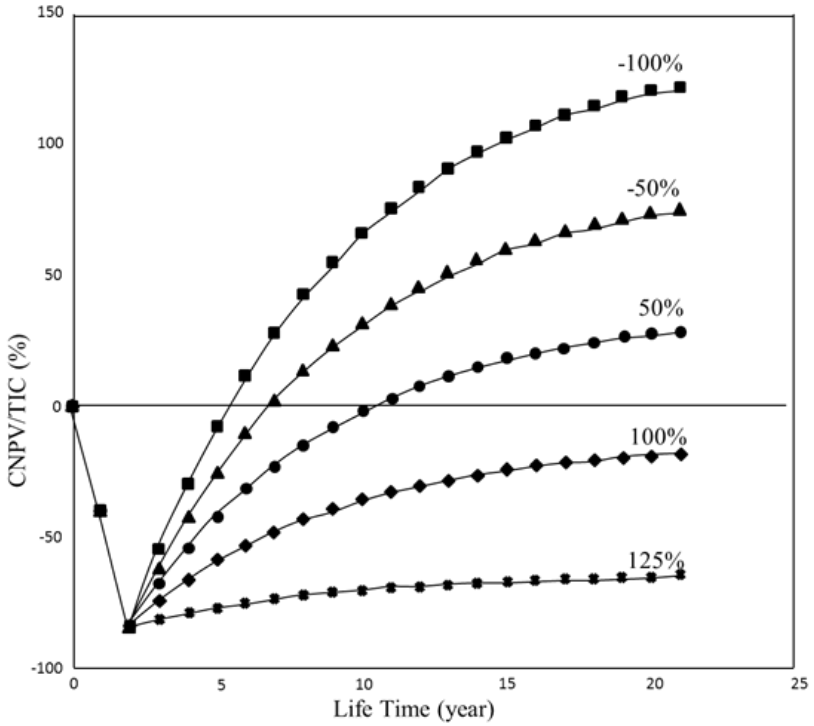

Fig. 9. CNPV curve as a function of project life time of the project with various taxes.

5. Discussion

5.1. Results from Engineering Perspective

The engineering point of view showed the possibility in the scaling up process. This is because the scaling up process can be implemented using commercially available and inexpensive apparatuses. Further, by calculating projects with 1200 processing cycles per year, the suggested scheme is prospective to produce about 12 tons of TiO_2 by consuming consume 12 tons of titanyl nitrate per year. Furthermore, an analysis of the total cost of equipment per batch of reactor that can consume 40 L of titanyl nitrate requires a total equipment purchase cost of USD 4.9350. Adding Lang Factor to the calculation, TIC must be less than USD 244000. This value is relatively economical and the project requires less investment funds. In the ideal condition, projects can reach 1200 processing cycles per year, which can allow the production of TiO_2 products of about 12 tons per year. Adding calculation for 20 years of project life time, the results showed that the whole project can generate 240 tons of product in the ideal condition.

5.2. Results from Economic Analysis

Based on the above analysis, the project under ideal conditions is feasible. However, when there are changes in economic conditions, the project is only

beneficial in certain economic conditions. All analyses were compared with the condition of Indonesian bank and currency[23].

In short, if the project is carried out in a specific situation that is beyond the certain economic conditions, the project will be lost. Detailed descriptions of specific conditions based on the above analysis are described as follows:

- The project can still be profitable if the increases in the cost of raw material is less than 150% of the estimated raw material cost. Based on the analysis in the raw materials, the impacts of nitric acid and glycine on the GPM were almost similar. The most influential parameters in the raw materials is titanil isopropoxide.
- To sustain the project, product sales must be done as higher as possible. However, the increasing sales must be still optimized due to its correlation to the other costs. When there is a condition for reducing the sales, the sales must be still higher than 50% of the estimated value. Otherwise, the project will be failure. This is because the minimum cost for production cannot be fulfilled if the sales is too low.
- Regarding labor cost, the increases in this value will create less profit. Labor has less impact to the profit. This is is confirmed by the stability of the project although the maximum labor cost reaches the value of 300% of the estimated labor cost. However, for some cases, the labor cost can be lowered by applying automation technology as alternative to use of labor.
- There is no problem with the utility cost since it gives less impact to the project. In general, even there is an increase in the utility cost of up to 300% of the estimated utility cost, the project can be still profitable.
- Tax has a great effect on the project profitability. The tax must be less than 50% of the estimated tax value.
- Subsidiary from government gives improvement in the sustainability of the project. But, the subsidiary has less impact compared to tax.

In addition to economic prospect, a project feasibility analysis also needs to be carried out. In this project, GPM and BEP showed the positive value. However, other economic parameters such as PBP, ROI, IRR, PI, and CNPV final showed the opposite value giving a negative perspective from the investors. This perspective is based on Indonesian capital market standards. PBP analysis showed that investment will be profitable after more than 12 years. When compared with PBP's capital market standard, the results show an uncompetitive condition.

In the analysis of other economic parameters, it is found that ROI analysis showed around 0.01%. It seemed that the analysis has a negative impact on the sustainability of the project. This ROI analysis implies that 100 USD investment funds generate additional benefits that are not attractive compared to bank and capital market interest of 0.01 USD. So, long-term investment is not attractive to investors. Based on the ROI analysis, the results showed that the cost for sustaining the project is relatively high. For this reason, further analyses must be done for confirming the present results.

Regarding the final CNPV, the value is high enough for the project with 20 years of life time. But, when adding annual calculation, the CNPV value is relatively low. This result is also strengthened by the fact for the condition with

relatively less value for PI. Certainly, this typical long-term investment will give unattractive perspective for investors. Another parameter that is considered is IRR. This value shows 15% for 20 years of life time of the project. This value provides a relatively low yield of 0.75% per year. This IRR value shows that this project is not promising.

6. Conclusion

Based on the results of the analysis, the TiO_2 nanoparticles project is prospective if we viewed from a technical point of view. The economic perspective shows unattractive results for investors. As a consequence, to sustain the project, financial supports must be considered. This can come from government or industrial social responsibility. In addition to the need of this project especially for giving socio-economic impact to the country, there is an additional concern regarding the environmental issue. The process to produce TiO_2 involves the non-biodegradable materials, creating the requirements for the additional careful waste treatments.

7. Acknowledgements

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TEMPERATURE ON THE EFFECTIVENESS OF ARDUINO-BASED PORTABLE SPECTROPHOTOMETER WITH WHITE LIGHT-EMITTING DIODE (LED) AS A LIGHT SOURCE FOR ANALYZING SOLUTION CONCENTRATION

AJENG SUKMAFITRI[1], ASEP BAYU DANI NANDIYANTO[1,*], ROSI OKTIANI[1], RISTI RAGADHITA[1], ADE GAFAR ABDULLAH[2]

[1]Department Kimia, Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudi no 229, Bandung 40154, Indonesia
[2]Department Teknik Elektro, Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudi no 229, Bandung 40154, Indonesia
*Corresponding Author: nandiyanto@upi.edu

Abstract

The aim of this study was to evaluate the effects of temperature on the measuring ability of Arduino-based portable spectrophotometer in analyzing solution concentration. In the experimental procedure, curcumin solution (as a model of dye) was put into the present spectrophotometer instrument consisting of a single white light-emmiting-diode (LED) as a light source, a light sensor, a thermometer, a heater, and arduino electronic card as an acquisition system. The temperature of the curcumin solution was varied from 20 to 50°C, which is an ample variation for understanding the effect of temperature on the measurement analysis in the spectrophotometer. The results showed that portable spectrophotometers were effective as a concentration analyser due to its successfulness in measuring and distinguishing different concentrations in the sample. When there is a change in the temperature, analysis measurement showed the ability in this apparatus to distinguish different analyses. Analysis result for samples that heated with higher temperature still can be accepted. However, when higher temperature is used, solution has less fluid density and the possibility for the decomposition of material must be concerned.

Keywords: Temperature, Spectrophotometer, Turmeric, Concentration, Arduino

1. Introduction

Spectrophotometer is one of the tools that can be used in many purposes [1]. One of the potential applications from the spectrophotometer is for analyzingconcentration in the sample. For example, Davis et al. [2] reported the use of spectrophotometer for analyzingblue bromothymol. Other studies utilized this apparatus system for determining iron in river water samples [3] and even chromate in drinking water [4].

Although the spectrophotometer is highly used for many applications, the use of this apparatus met problems for being used in developing countries, especially

for the availability of standard UV-Visible spectrophotometer that can be classified as a sophisticated apparatus due to its high price [1]. To address these limitations, many researchers have tried to find out the problem solvers [1,2].

However, the current available reports showed the potential design of cost-effective spectrophotometer without consideration of the environmental condition during the analysis. One of the most important environmental conditions that must be concerned is temperature.Temperature is a quantity value that relates to the process for giving heat or cold to the material [5]. Temperature can affect the properties of substances and devices [6-8].

Here, the purpose of this study was to evaluate the effect of temperature on the effectiveness of spectrophotometer for analyzing solution concentration. As a model of spectrophotometer, we used Arduino-based portable spectrophotometer, which was design in our previous studies [1]. This type of spectrophotometer was selected because of its simplicity, portability that can be used regardless place and time, cost-effective design that is fit for developing countries, and effectiveness for being used in analyzing solution concentration.

In short of the experimental procedure used, curcumin was diluted in an aqueous solution with different concentrations. This solution was then heated at a specific temperature, and its concentration was analyzed using the present spectrophotometer. In this study, the temperature is limited to 50°C since the higher concentration will not be used in most applications of spectrophotometer. Indeed, higher temperature will give impacts on the decomposition of material.

2. Experimental Method

2.1. Preparation of curcumin for analyzing the solution concentration

To test the effectiveness of a portable spectrophotometer, measurement of the concentration of the solution was carried out by analyzing the curcumin solution whose concentration and temperature were made vary. In conducting this test, curcumin solution was made from turmeric (*Curcuma Longa*, purchased in Bandung, Indonesia).

In short, the turmeric was washed, thinly cut (1x1cm in sizes), dried at 70°C, and saw-milled. Detailed information for the saw milling apparatus is explained in previous literature [9]. Then, the powder obtained from saw-milling apparatus is then extracted using our method shown in our previous study [10,11].The extracted curcumin was then diluted in an ultrapure water. In addition, to confirm the chemical composition of turmeric, fourier transform infra red (FTIR-4600, Jasco, Japan) was also used.

2.2. Design of Arduino-based portable spectrophotometer

Fig. 1 shows an illustration of the Arduino-based portable spectrophotometer based on our previous report [1]. The present portable spectrophotometer consisted of several components: luxmeter as a measuring instrument for the light intensity transmitted from the light sensor, a cuvette as a reactor to containcurcumin solution for being analyzed, white LED as a light source, and LED driver. The spectrophotometer was assembled in an acrylic box with length,

width, and height dimensions of 200, 130, 150 mm, respectively. The total mass of this portable spectrophotometer is around 1 kg.

In this tool, the white light from the LED is emitted and focused by insulating the room and giving a hole in the part to be passed by light. The light is emitted into the solution in the cuvette, and the translucent light will be detected by the sensor so that it is readable by the luxmeter. The measurement results are shown by luxmeter in the form of light intensity.

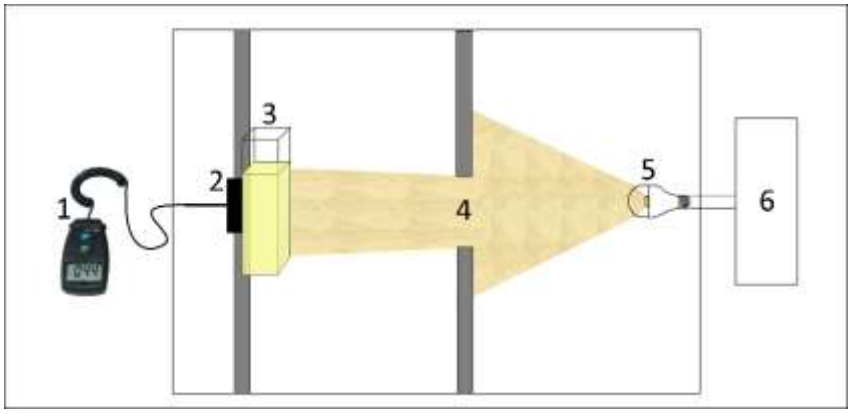

Fig. 1. Illustration of components in a portable spectrophotometer, (1) Luxmeter, (2) The light intensity sensor, (3) Cuvette with Solution, (4) Hole for focusing light beam, (5) White LED, and (6) LED Driver.

2.3. Experimental procedure for the analysis of curcumin concentration at various temperatures

To analyze the concentration of curcumin, the diluted curcumin with a specific concentration was heated at a specific temperature. The concentration of curcumin was varied from 0 to 100 ppm. Then, the temperature was varied from room temperature to 50°C. The heated solution was then put into the cuvette inside the spectrophotometer as shown in Fig. 1. To ensure the effectiveness of the present spectrophotometer, a standard UV-Visible spectrometer (Jenway, US) was also used.

3. Results and Discussion

3.1. Characterization of turmeric

To ensure the purity of the extracted curcumin solution, FTIR characterization was carried out. Fig. 2 shows the results of FTIR analysis of curcumin. Several peaks were detected, which confirmed the detection of chemical bonds in the material. The peaks are in a good agreement with the curcumin material as shown in previous literature [10,11].

In general, several peaks were detected. The peak at around 3030 cm^{-1} indicated the presence of CH aromatic bonds, which is correspond to turmeric that has 2 benzene aromatic rings. Other peaks at 1650 cm^{-1} was detected, which is a

peak for C=O bonding. Peaks at 2962 cm^{-1} in the FTIR analysis indicated a C-H bonding. FTIR wavenumber at 3650 cm^{-1} is an O-H related peak, confirming that the curcumin can be dissolved in water. Peak at 1540 cm^{-1} is a C-O group.

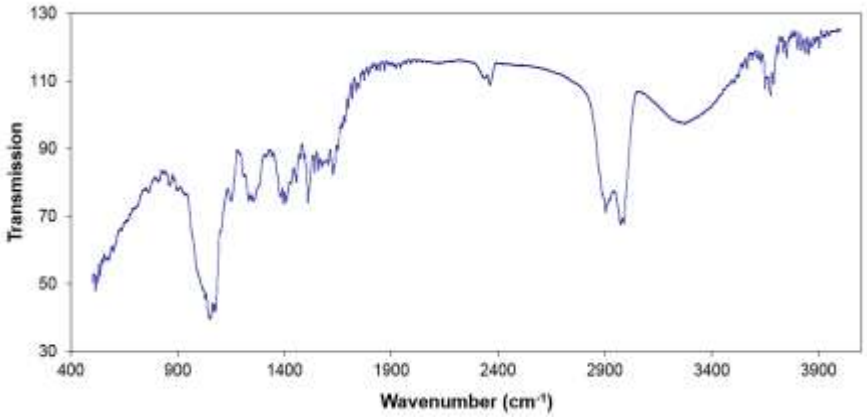

Fig. 2. FTIR analysis result of curcumin

3.2. Analysis curcumin solution using a standard UV-Visible spectrophotometer

Prior to the analysis of curcumin solution using the present spectrophotometer, physical observation of the curcumin solution with different concentrations is shown in Fig. 3. The difference color and turbidity was obtained. The less amount of curcumin in the solution has a correlation to the more transparent solution. On the contrary, the higher concentration can result higher turbidity. This result will create difference in the light transmission, which can give advantages for the analysis of spectrophotometer.

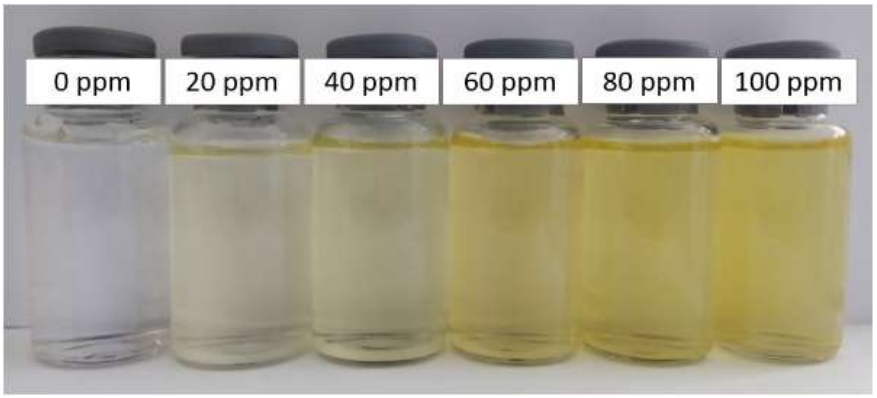

Fig. 3. Photograph image of curcumin diluted in ultrapure water at various concentrations from 0 to 100 ppm.

The standard UV-Visible spectrophotometer result of curcumin at specific concentration is presented in Figs. 4 and 5. Fig. 4 shows the UV-Visible spectrophotometer results of curcumin solution at 25°C, whereas Fig. 5 shows the analysis for solution heated at 50°C. The figures detected the absorbance of the samples at different concentrations. From the figures, it can be detected that the main peak of the curcumin solution is at a wavelength of 283 nm. Then, the more concentration will give the more peak intensities.

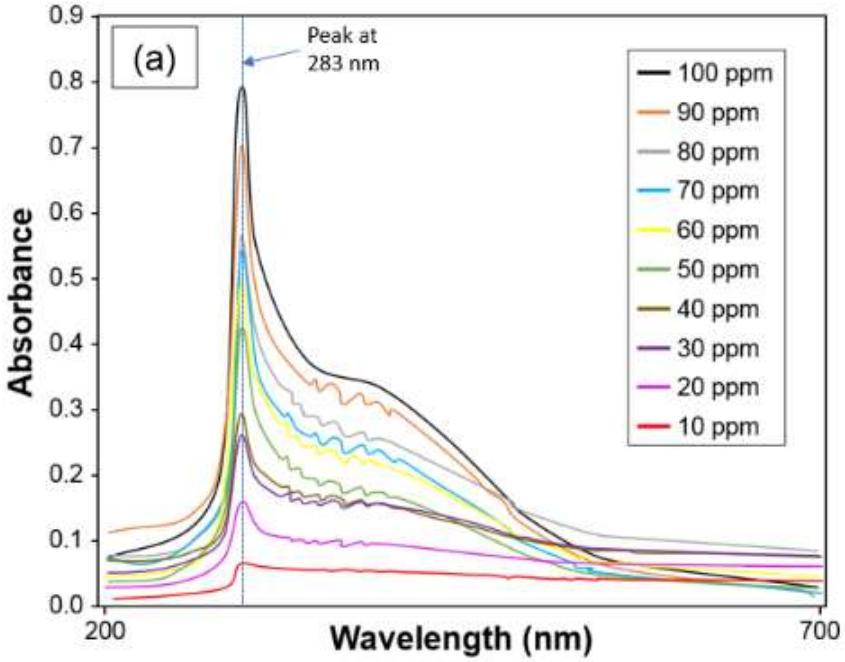

Fig. 4. Standard UV-Vis analysis results of curcumin solution at room temperature (25°C).

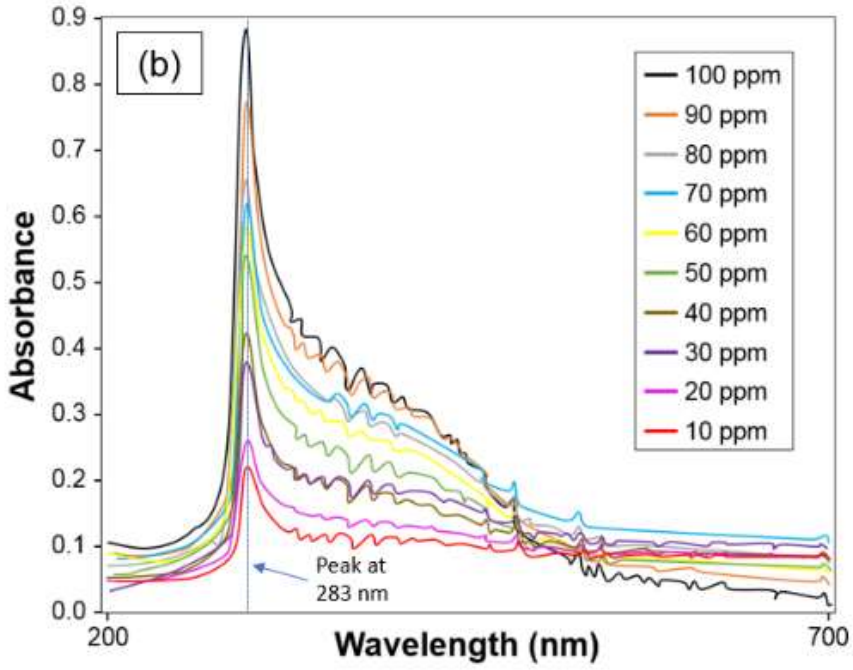

Fig. 5. Standard UV-Vis analysis results of curcumin solution heated at 50°C.

Absorbance at both temperatures shows different results for each concentration. The figure confirmed the increases in absorbance intensity for both types of samples. The increasing was in a good correlation to the increases in concentration from 0 to 100 ppm. At sample heated at temperature of 25°C, the lowest absorbance was at 0 ppm at 0.102 and the highest concentration at 100 ppm was 0.785.

This condition was also found not only for the sample heated at a temperature of 25°C but also for that of 50°C. After raising the heating temperature to 50°C, the absorbance increased. The lowest absorbance was 0.116 at a concentration of 0 ppm and the highest was 0.884 at a concentration of 100 ppm.

The change in temperature from 25°C to 50°C affected the properties of the curcumin solution. This is confirmed by the detection of the results gained from UV-Visible spectrophotometer analysis. For samples with concentration of 0 ppm (ultrapure water) and heated at temperatures of 25 and 50°C, the absorbances of curcumin solution were 0.102 and 0.116, respectively. Then, the absorbances increased with increasing the concentrations, and all trends showed that the higher heating temperature (50°C) will always result higher peak intensities compared with room temperature. The change of this absorbance indicates that increasing temperature can affect its absorbance value, which is due to the existence of the change in the viscosity and the density of the molecules in the curcumin solution.

3.3. Evaluation of portable spectrophotometer as an effect of temperature

Measurement of curcumin solution with a concentration of between 0 and 100 ppm was carried out using a portable spectrophotometer (Fig. 6). Fig. 6 shows curves of the relationship between the concentration of curcumin solution and the intensity of light. Changes in the light intensity of the analyzed solution were obtained. In the figure, there are several lines that each point is given a different symbol. The line shows the results of measuring curcumin solution at various temperatures, that are temperatures of 25, 30, 40, and 50°C that are corresponding to Figs. 6(a), (b), (c), and (d), respectively. Overall results showed a decrease in light intensity when increasing concentration. The light intensity obtained decreased from 562 to 444 lux.

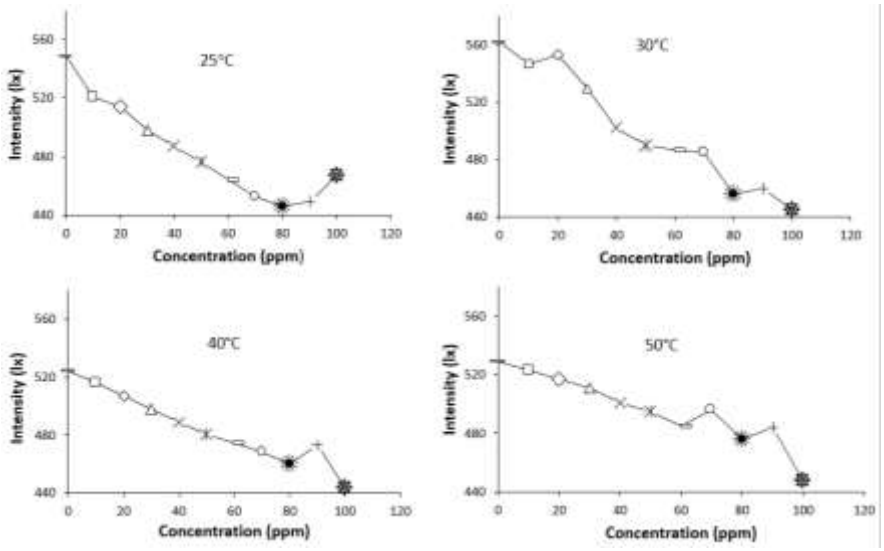

Fig. 6. Effect of concentration of curcumin solutionon the intensity of light obtained from the Arduino-based spectrophotometer at various temperatures: (a) 25, (b) 30, (c) 40, and (d) 50°C.

Similar trend for the correlation of concentration and light intensity was found. The higher concentration of curcumin is used, the less light will be transmitted. The main reason is because some lights are absorbed by the curcumin solution.

The phenomena is in a good agreement with the facts in the realistic condition. If the solution contained high concentration, the solution will have more molecules that can be hit by the light. When the light passes through the solution, some lights are blocked and absorbed by molecules. Because less light can get through, this condition causes the visual appearance of solution to get darker. Indeed, when we added the sensor in the solution, less light can be detected.

For sample heated at the temperature of 25°C, the intensity of the light decreases with increasing temperature. However, there is an increase in the

intensity after the concentration is more than 90 ppm. The hysteresis condition was also found for samples heated at 30, 40 and 50°C. This condition happened due to the existence of coagulation phenomenon of curcumin since the maximum solubility of curcumin is 100 ppm.

Based on the figure, the result showed that there is a decrease in light intensity when increasing the temperature. However, the fluctuation of the intensity is not much as shown in the standard UV-Visible spectrophotometer (See Figs. 4 and 5). This confirmed that the present spectrophotometer is more stable than the standard UV-Visible spectrophotometer.

To confirm the hysteresis in the UV-Vis spectrophotometer, Fig. 7 shows the relationship between the temperature of the curcumin solution and the light intensity. To clarify the discussion, figure was equipped with several lines that are corresponding to the specific concentration. The concentration was varied from 0 to 100 ppm. The overall results showed that the light intensity increased at 30°C and decreases at 40°C.

Changes in detection of light intensities in this measurement occur because of the influence of temperature changes in the curcumin solution. When the heat is applied to the solution, the process of molecule movements (namely diffusion) happens more rapidly and the molecules can spread out or mix with other molecules more quickly in the solution. This makes the fact that when light passes through the solution, more interaction between light and molecules happen. This contact, indeed, disturbs the light travels. In short, the higher temperature used, the smaller the density of the molecules in the curcumin solution can be obtained. Thus, the number light absorbed are less.

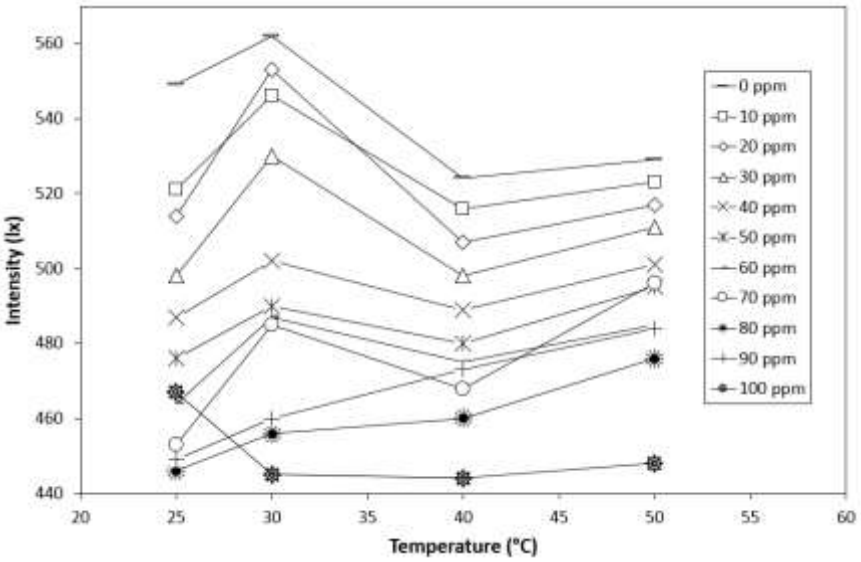

Fig. 7. Graph of the temperature of the curcumin solution to the intensity obtained from the Arduino-based portable spectrophotometer with a concentration of curcumin solution of 0-100 ppm.

Table 1 shows the comparison analysis results of samples characterized by the present portable spectrophotometer and the standard UV-vis spectro. Data for the present portable spectrophotometer was calibrated based on previous reports [1]. The result showed that the present method is effective to be used for concentration analyzer since this spectrophotometer is prospective for measuring the solution of curcumin with a concentration of up to 100 ppm and at high temperatures reaching 50°C. Although the standard UV-vis spectrophotometer shows good result, the high cost for the apparatus still becomes problems. But, the use of the present spectrophotometer is relatively good for rough analysis.

Table 1. Comparison between portable spectrophotometer and standard UV-Visible spectrophotometer. Data was validated and calculated based on previous references [1].

Curcumin Concentration (ppm)	Portable Spectrophotometer				Standard UV-Visible Spectro.
	25°C	**30°C**	**40°C**	**50°C**	**25°C**
0	0	0	0	0	8.31
10	7.12	7.46	7.05	7.15	4.83
20	20.08	21.60	19.81	20.20	16.50
30	32.43	34.51	32.43	33.28	30.11
40	43.9	*45.25**	44.08	*45.16**	*34.83**
50	52.92	54.48	53.36	*55.03**	54.00
60	*66.94**	*70.75***	*68.76**	*70.42**	63.58
70	66.92	71.65	69.14	73.27	69.97
80	78.85	80.39	81.01	83.48	*73.72**
90	89.26	91.45	94.03	96.22	91.50
100	98.03	*93.41**	93.20	*94.04**	103.17

Note: *error obtained more than 5 ppm, **error obtained more than 10 ppm

4. Conclusion

The existence of this study has shown how the Arduino-based portable spectrophotometer works to measure light intensity in the analysis of curcumin solution samples. Based on the research, the Arduino-based portable spectrophotometer is effective for analyzing curcumin solution samples with different concentrations even in high temperature conditions. Although the present study is effective to analyze the samples heated with higher temperature, several problems must be considered, including the change in the fluid density and viscosity, as well as the possibility for the decomposition of material.

5. Acknowledgements

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EXISTENCE OF ALUM ON THE EFFECTIVENESS OF EXTRACTED MIANA LEAVES ON BATIK COLORING

ROSI OKTIANI[1], RISTI RAGADHITA[1], ASEP BAYU DANI NANDIYANTO[1,*], AJENG SUKMAFITRI[1], ROSENA SHINTABELLA[1], ISMA WIDIATY[2]

[1]Departemen Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi no 229, Bandung 40154, Indonesia

[2]Departemen Pendidikan Kesejahteraan Keluarga, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi no 229, Bandung 40154, Indonesia

*Corresponding Author: nandiyanto@upi.edu

Abstract

The purpose of this study was to investigate the effect of existence of alum on batik coloring application. As a model of batik coloring agent, miana leaves extract was used. In short of the experimental procedure, extracted miana leaves were dipped into the cotton fabrics that were initially soaked into the alum solution. To understand the effects of alum on the coloring phenomena on fabrics, the process was completed with the analysis of various pH conditions. The experimental results revealed that existence of alum was effective for binding extracted miana leaves into the fabrics, confirmed using several characterization analyses. The main idea for the successful coloration is due to the existence of aluminum ion (Al^{3+}) that is from the dissolution of alum (i.e. Al^{3+} ions). Al^{3+} ions then easily penetrate to the deepest position in the fabric fibers. The penetrated ions react with the extracted miana leaves to form large-size complex salt. As a consequence, dye could not be removed easily from the fabric fibers. Therefore, understanding the existence of alum has the potential to be applied in the batik industry to improve the natural dye coloration.

Keywords: Alum, Batik, Miana leaves extract, Natural dye

1 Introduction

Coloring batik is one of the important parameters in creating beautiful batik artworks. To color batik, it is not difficult since the process is putting only coloring agent into the fabric material. The batik coloring agent can be obtained easily in commercially available markets and stores in Indonesia, and even it can be obtained from the companies that sell batik materials and tools. One of the most used dyes for coloring agent is chemical-based dyes (known as textile dyes). Although these chemicals are largely available in various colors, problems in the waste management are found since they cannot be easily decomposed.

To against this condition, natural dyes are typically used as one of the alternative coloring agent because the material is largely available, environmental

friendly, and inexpensive [1, 2]. Natural dyes are usually obtained from extracts of parts of plant, such as bark, leaves, roots, fruit, seeds, and flowers that contain tannins, flavonoids, and quinonoids [3, 4]. Each plant and/or the part of plant can produce different types of colors [4]. The color produced by natural dyes is also softer, shinier, and calmer for eyes [2]. Since the natural dyes were extracted from the parts of plant, they are environmental friendly and harmless [2]. Examples of the plants and/or the parts of plant that can be used for the sources of natural dyes are rosella petals (*Hibiscus sabdariffa L*) for producing red, orange, purple and blue colors, mangosteen peel for creating red color; teak leaf extract for getting blue (at high pH) and red colors (at low pH); Kesumba seed extract for providing yellow and red colors; and secang wood extract (*Caesalpinia Sappan L*) for giving red color[4].

Although the natural dyes can be used for altering the use of chemicals, they have limitations in the number of colors. This makes them to be less practical [5]. One of the methods for solving the problems is using the fixation process [2]. The fixation process or commonly called the mordanting process can be done in three ways, namely pre-mordanting (before coloring), simultaneously mordanting (by mixing fixation agents with natural dyes), and post-mordanting (after coloring) [2]. Various types of fixation agents can be used, such as iron sulphate[6, 7], alum, aluminium sulphate[2], aluminium potassium sulfate, iron sulphate, copper sulphate, stannous chloride[8], natrium sulphate, magnesium sulphate, [9], and tin chloride[10]. Although above chemicals can be used for the fixation process, they must be used in the specific steps in the fixation process. According to Gupta et al. [10], increasing color sharpness with the post-mordanting method gives good results when using copper or iron sulphate, while the pre-mordanting method should be done using tin chloride or alum. Although the methods are effective for improving the number of colors gained from natural dyes, applications of the methods in the realistic conditions in Indonesia are still limited.

This study aims to investigate the effect of the existence of alum on batik coloring application with miana leaf extract (*Coleus atropurpureus [L] Benth*) as a model of tannin source). Understanding this study will be potential for further developments in batik industries in Indonesia, in which this will become the most important engineering aspect in this study.

The main idea for the use of miana leaf extract is because this part of plant is largely available in tropical countries such as Indonesia, while, until now, the use of miana leaves as the source of natural dyes is still rare. Marpaung et al. [11] reported that the miana leaves have flavonoids, tannins, triterpenoids, steroids, and essential oils. Specifically, for tannin, this compound is the most important chemical because the phenolic hydroxyl groups of tannins can form crosslinking with various types of fibers [12]. The use of tannin as natural dyes is effective to be applied to fabric fibers that have low affinity [13].

In the experiment, to extract dyes from miana leaves, we used combinations of drying, grinding, and maceration process. Drying and grinding process is used to make the miana leaves to be easily stored and used whenever they are needed. Combinations of drying, grinding, and maceration were used to solve the current problems in the traditional batik industry. The traditional batik industry typically implemented multistep processes for extracting natural dyes. In short, the traditional batik industries get the dyes using the following procedures: soaking a certain amount of parts of plants in water for several days, which is followed by

immersing the cloth into the soaked parts of plants in 1-3 days. This makes the production process less efficient.

To improve colors gained from miana leaf extract, alum is used as a fixation agent. Alum is one of the most-used fixation agents [6, 7]. In this study, alum was used in the pre-mordanting step. To understand the effect of alum on the coloring phenomena on the fabrics, the process was completed with various pH conditions. To identify the compounds in miana leaf that acts as a coloring agent, UV-Visible (UV-Vis) spectrophotometry and Fourier transform infrared (FTIR) analysis were carried out. To determine the morphology of the fabrics after going through the coloring as well as washing processes, analysis using a scanning electron microscope (SEM) was conducted. Based on the results of the analysis, tannin from extracted miana leaves is effectively binding aluminium ions (Al^{3+}), forming large complex compounds to make the natural dyes trapped in the fabric fibers.

2. Experimental Method

Miana leaves (obtained from Bandung, Indonesia) were sliced into small sizes and then dried. Dried Miana leaves were ground and mashed to get powders with a specific size using our grinding apparatuses[14, 15]. The powder was then put into the maceration method with soaking time of 24 hours. The maceration was carried out using ethanol 95% as a solvent. Detailed maceration apparatuses were explained in our previous studies [16-18]. The product was filtered and then evaporated for 90 minutes with a rotary evaporator to get the extracted dyes.

The extracted dyes were diluted with solvent and put with the fabrics (obtained from Bandung, Indonesia), in which this step is named as the coloring process. Prior to adding into the coloring process, the fabrics were fixated with alum. For a standard comparison, some fabrics are put into the coloring process without alum fixation. In the case of fabrics that fixated by alum, fabrics were soaked in alum solution (1 wt%) for 10 minutes. Next, the soaked fabrics were dried in room temperature overnight. Fabrics with alum fixation and without alum fixations were then soaked in extracted miana leaves for 1, 2, and 3 hours.

To determine the effect of immersion time on the structural properties of the chemical compounds in the fabrics, an FTIR (FTIR-4600, Jasco Corp., Japan) was used.

To investigate the effects of pH and the type of solvent on the chemical composition as well as the color produced from Miana leaf extract, miana leaf extract that was dissolved in different pH values (from 3 to 7). Then, the dissolved extracts were tested using a UV Visible spectrophotometry (Vis mini 1240, Shimadzu Corp, Japan). In addition, for gaining solutions with pH of 3, 4, and 7, acetic acid (Bratachem, Indonesia) were used. For obtaining the pH of 5, ethanol (95%, Bratachem, Indonesia) was used.

To determine the morphology of the fabric fiber before and after the coloring process, samples with various soaking processes were tested using a SEM (JSM-6360LA; JEOL Ltd., Japan).

3 Results and Discussion

Figure 1 presents the photograph image of samples after additional extracted miana leaves. The figure showed different colors for the fabrics. Initial fabrics were white, whereas after additional extracted miana leaves resulted in the yellowish green colored fabrics.

The sharpness of the color was affected by several factors as shown in Figure 1. The factors investigated in this study were the existence of alum fixation and soaking time of fabrics. Fig. 1(1) shows the initial fabrics. Figs. 1(a1), (a2), and (a3) are the fabrics with the alum fixation process that were soaked at 1, 2, and 3 hours. Figs. 1(b1), (b2), and (b3) are the fabrics without alum fixation process that were soaked at 1, 2, and 3 hours.

Experimental results showed that soaking for 3 hours is the most optimum condition for coloring process. The different colors obtained with the process with 2 and 3 hours were not significant, and further longer soaking processes did not bring more effects on the coloring process. For this reason, we limited the observation of soaking time to 3 hours. In addition, fabrics that were fixated in the pre-mordanting step had better coloring sharpness in comparison with that without alum fixation process.

In the case of sample for getting pH of 5, ethanol was used. Then, to understand the effects of pH on the coloring process, acetic acid was used to get pH of 3 and 4. To get pH of 7, more water dilution to the ethanol solvent was used. The photograph image of the dyes produced with various pH conditions is inserted in the left-bottom of the Fig. 1.

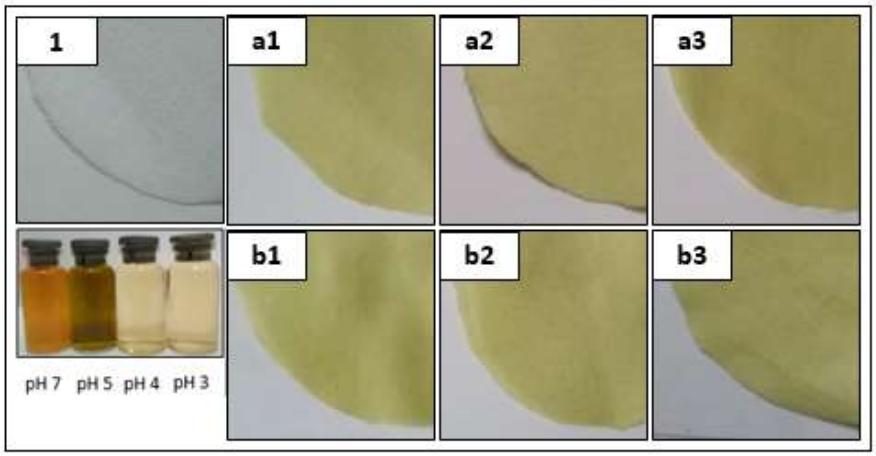

Fig.1. The photograph image of fabric after additional extracted miana leaves. Fig. (1) is the sample before the coloring process. Fig. (a) is the samples that are dyed and fixated by alum with soaking time (1, 2, 3) 1, 2, and 3 hours, respectively. Fig. (b) is the samples that are dyed without alum fixation with soaking time (1, 2, 3) 1, 2, and 3 hours, respectively. The insert image in the bottom left is the extracted miana leaves with various pH conditions.

Extracted miana leaves could be used as natural dyes because it had chemical content that produced color and could be bound to fabric fibers. Figure 2 is the result of FTIR analysis on colored fabrics with extracted miana leaves with various soaking times. To ensure the effect of soaking time, FTIR curves were

classified as the top, the middle, and the bottom for the sample that was soaked for 1, 2 and 3 hours with alum fixation, respectively.

The appearance of the extracted miana leaves using 95% of ethanol is shown in the paneled image in the bottom left in Fig. 2. The results showed several peaks were identified, in which this is in a good agreement with the tannin-related components. For example, from the results of the analysis in accordance with the results of FTIR analysis on tannins [19], there were peaks at wavenumbers of 1040 and 1115 cm^{-1}, indicating participation of –CO and –CH groups. Also, peaks in the wavenumbers of 1370-1380 cm^{-1} indicated the –OH and –CH -related groups, informing that the produced extract solution can be dissolved in water and ethanol. Detailed information about the peak in the FTIR is shown in Table 1.

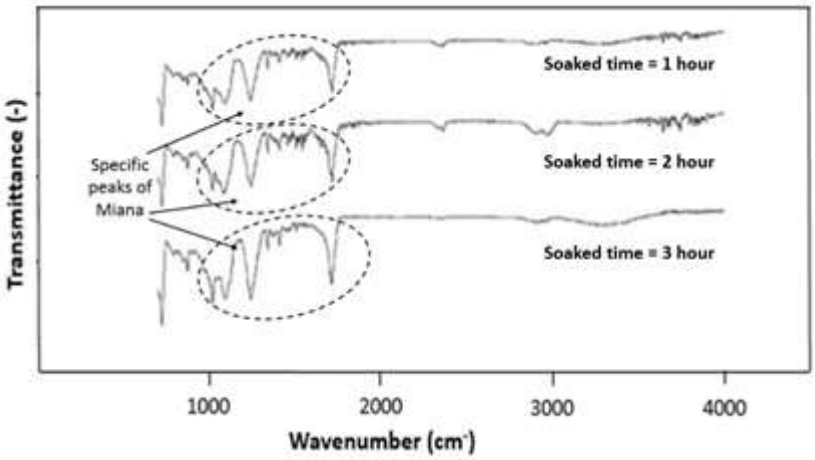

Fig. 2. The FTIR analysis of alum-fixated fabrics with various soaked times.

Table 1. Functional group of Miana leaf extract in FTIR.

Functional Group	Wavenumber (obtained from experiment) (cm^{-1})	Wavenumber (from references) (cm^{-1})
=CH (alkena)	996	995-710
C-O alcohol	1239	1050-1260
C-H (at CH_3)	1337	1300-1475
C-H (at CH_2)	1412	1300-1475
C=C	1717	1620-1680
C-H aliphatic	2911	2800-3000

Fig. 3 is the UV-Vis spectrophotometric analysis of the extracted miana leaves in various pH conditions. The detailed information about the correlation of peaks with the potential compound in the solution is shown in Table 2. Several peaks were obtained, especially at wavelength of 250, 350, and 650 nm. This confirms the potential extracted solution for producing different colors and chemical compounds. Indeed, this informs that producing a specific color has a correlation to the additional treatment, such as controlling pH solution.

The differences in the pH conditions caused different peaks appeared in the UV-Visible spectrophotometry analysis (see Fig. 3), in which these results are in a good agreement with the changes in colors (see Fig. 1). Using four pH

conditions, all samples have the same highest peak at wavelengths of 265-268 nm, in which this peak corresponds to flavonoids [20]. The results showed a major peak at the wavelength 400 nm, which is identified tannin compounds in extracted miana leaves.

At the sample using pH of 5, a slight different result was obtained. There are three different peaks at wavelengths of 411, 536, and 608-665 nm, corresponding to auron, anthocyanidin, and condensed groups, respectively (see Table 2) [20-22]. These compounds, makes different types of color on different pH conditions. Also, these compounds are used to make green color.

The changes in color are due to the change of tannin stability. At the pH condition of 3, tannins will form oxonium or stable flavillium salts. At higher pH condition, oxonium in the solution will be hydrolyzed, producing pseudobasa components, in which this component can undergo tautometrics and there is an equilibrium condition between keto- and enol-form [23].

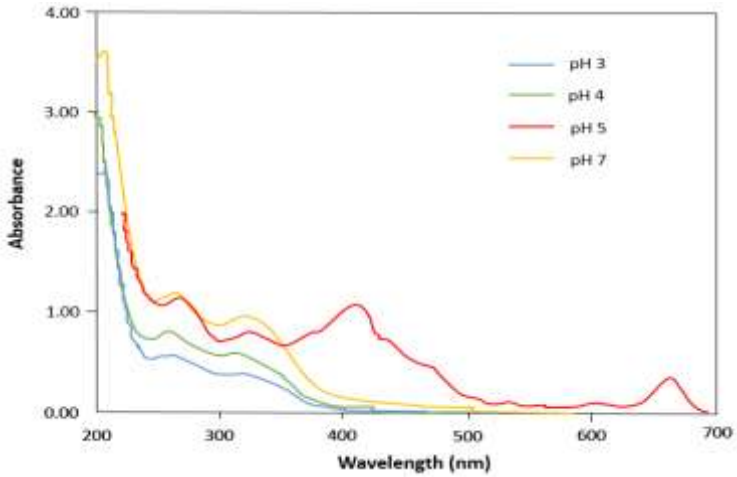

Fig. 3. The results of UV Visible spectrophotometry analysis of extracted miana leaves in various pH conditions.

Table 2. Visible spectrum of miana leaf extract in various pH conditions.

pH	Peak	Compound
3	207	ellagic acid
	265	flavonoid
	314	flavon
4	265	flavonoid
	315	flavon
	671	condensed group
5	268	flavonoid
	327	flavon
	411	auron
	536	antosianidin
	608	condensed group
	665	condensed group
7	208	ellagic acid
	265	flavonoid
	321	flavon

The examination of the coloring fabrics was carried out using a washing method using a detergent (see SEM images in Figs. 4 and 5). The results of this analysis were analyzed by SEM at 50x (Fig. 4) and 2000x magnification (Fig. 5). The result showed the patch of the tannin extract on the surface of the fabrics.

Figure 4 shows the SEM images of the samples after dipped into extracted miana leaves. Comparison of samples before and after the washing process (using detergent) was to obtain the effect of alum fixation on the fabrics. The result showed no different in the SEM observation.

Since low magnification of SEM images in Fig. 4 was not clear enough to confirm the patch of tannin color (from extracted miana leaves), analysis using high-magnified SEM image is important (Fig. 5). As shown in these figures, the patch of material (which was identified as a complex of tannin) was clearly obtained when using high magnification of SEM images (Fig. 5). We found that the additional alum fixation had the impact to the more patched materials on the surface of fabrics. The larger components attached to the fabrics confirmed that the coloring agents cannot enter and penetrate into the deepest position in the fabrics. Indeed, this results in the release of this component after several times of washing process. However, when using the fixation process, the small components were produced, making them to penetrate into inside of the fabrics.

Based on the above results, the existence of alum was effective for binding tannin (gained from extracted miana leaves). This was confirmed by several characterization analyses shown in the above. The main idea for the successful coloration is due to the existence of aluminum ions (Al^{3+}) that are from the dissolution of alum. Al^{3+} ions then easily penetrate to the deepest position in the fabric fibers. The penetrated ions react with the extracted miana leaves to form large-size complex salt that is bound inside the fabric fibers. The large complex was confirmed by the existence of attached material into the fabrics (see SEM

images in Fig. 5). As a consequence, dye could not be removed easily from the fabric fibers.

Based on the above results, understanding the existence of alum has the potential to be applied in the batik industry to improve the natural dye coloration. However, further analyses must be done to improve the coloring batik.

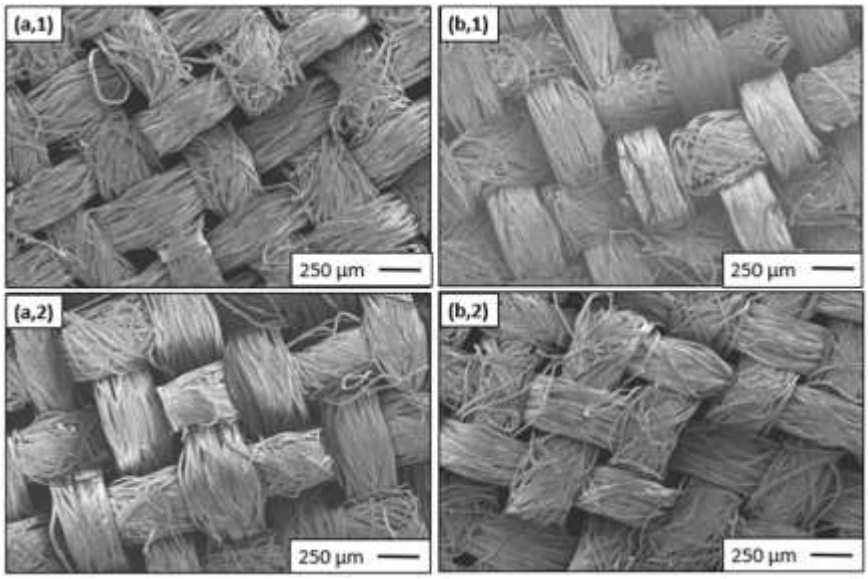

Fig. 4. The results of low-magnified SEM analysis of samples with various fixations of alum. Figures (a, 1) and (b, 1) are the samples without and with alum fixation before washing process. Figures (a, 2) and (b, 2) are the samples without and with alum fixation after washing process.

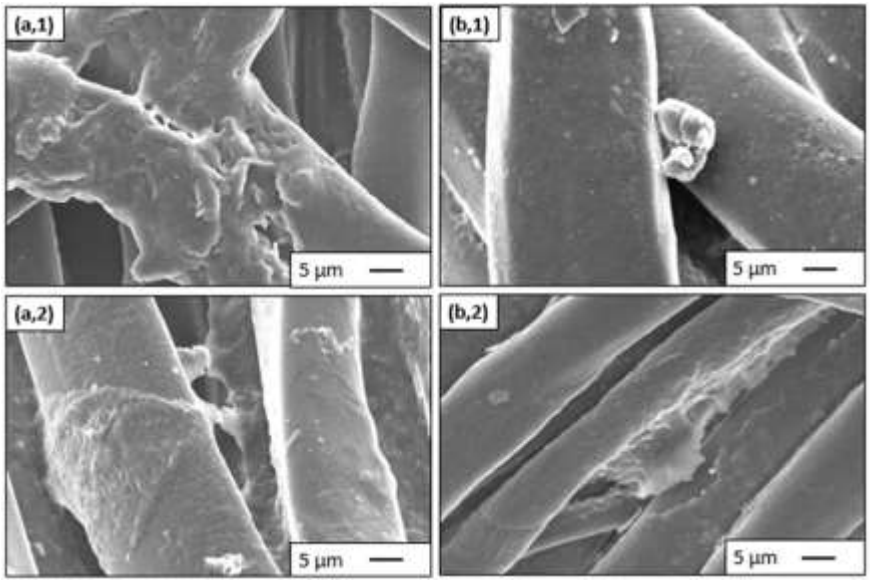

Fig. 1. The results of high-magnified SEM analysis of fabrics under various fixations of alum. Figures (a, 1) and (b, 1) are samples without and with alum fixation before washing process. Figures (a, 2) and (b,2) are samples without and with alum fixation after washing.

4. Conclusion

The investigation of the effect of existence of alum on batik coloring application was presented in this study. As a model of batik coloring agent, miana leaf extract was used. The experimental results showed that existence of alum is effective for binding extracted miana leaves on the fabrics, which was confirmed using several characterization analyses. Control of the coloring phenomena can be achieved by controlling pH condition. Some parameters must be considered to make better penetration of alum.

5. Acknowledgements

This study acknowledged RISTEK DIKTI for Grant-in-aid Penelitian Terapan Unggulan Perguruan Tinggi (PTUPT) and Penelitian Unggulan Strategies Nasional (PUSN).

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REDUCTION OF WELDING POROSITY RATE IN MANUAL BUTT JOINT WELDING PROCESS IN A BOILER MANUFACTURING COMPANY

NEMY H. CHAVEZ AND RYAN JEFFREY P. CURBANO
Graduate School of Engineering, Lyceum of the Philippines University, Capitol Site, Batangas City, Philippines

Abstract

The main objective of this study was to reduce the welding porosity rate in manual butt joint welding process in a boiler manufacturing company. The researcher used the applied method of research. The research was carried out on application of Lean Six Sigma method. The goals of this were to improve product excellence to no greater than 3.4 defects per million opportunities and assist businesses make leaner industrial processes. The participants of the study were a team from the company and the researcher of this study. It was found out that the highest number of defects is the welding porosity. The porosity defect was given the highest priority of the study based on the Pareto Chart since it was the top percentage. The goal was to reduce welding porosity defect from 68 to 45 parts per million (PPM) or 33% improvement by January 2018. The porosity was mainly caused by no preventive maintenance schedule; Design of Experiment (DOE) on parameters was performed 2 years ago, no formal certification for welders, and no supplier selection specification. The team's roadmap to develop the process was through Define, Measure, analyze, Improve and Control (DMAIC) principle. Preventive maintenance/ calibration for all welding machine was completed immediately. The result of DOE on all machines was used. The welders were retrained and updated the control plan. The incoming inspection of all materials was instantly achieved. It was concluded that after the application of DMAIC approach, the quantity of porosity defects wit`h 68 PPM was reduced to 41 PPM. The sigma level of the porosity defect was improved from 4.57 to 4.71. The recommended contingent measures were confirmed effective. The team must make sure the implementation of the countermeasures will constantly develop the welding procedure.

Keywords: Welding Porosity Rate, Lean Six Sigma, DMAIC, DPMO, Manual Butt Joint Welding Process

1. Introduction

In the modern age of globalization, businesses are implementing innovative tools and methods to create products to survive in today's stiff competition. Like for instance, in the case of manufacturing of boilers, currently, there has been high foreign competition among them. Additionally, the most

discouraging concern encountered by companies now is how to distribute their products or materials rapidly at little cost and good quality. The application of lean six sigma methods (LSS) is one promising technique for addressing this problem. The goals of LLS method is to improve product excellence to no greater than 3.4 defects per million opportunities and assist businesses make leaner industrial processes. It also has provided important enhancements and efficient at firms as varied as General Electric Co., Dell Inc., Xerox Corp., and Johnson & Johnson.

The purposes of LSS technique are to recognize and diminish non-value added activities or waste which "has become the most popular business strategy for deploying continuous improvement (CI) in manufacturing and service sectors, as well as in the public sector" through continuous development. The research objective of a cable industry that accomplished applications of LSS was enhancing the quality of good by means of gathering of facts about defective product, analysis of data utilizing failure mode and effect analysis (FMEA) and provision of solution (Arnheiter & Maleyeff, 2005). The effect to the firm was performance development and production waste reduction through a production enhancement approaches using LSS that is DMAIC cycle (define, measure, analyze, improve).

In order to manage with the market fluctuations and growing customer demands, there is no uncertainty that the manufacturing business are challenged, pressured and observed to apply developments in their procedures and perform better. One of the most significant ideas that help industries to compete is implementing LSS philosophy. Some of the lean production and six sigma tools used were problem solving tools such as Pareto Analysis, Process Capability Analysis, 5-Why's Technique, and Project Charter.

Defect means nonconformity of a product or service to its specification. One of the disadvantages of having welding defects is lesser efficiency and productivity wherein additional waste is manufactured which can increase project expenses. This results to customer dissatisfaction. Operators of welding projects also need a high level of skill and training.

The welding defects include porosity, lack of fusion, under cut, excess penetration, concavity, offset, filler, incomplete penetration, and tungsten inclusion. Among the butt joint manual welding process**,** welding porosity rate has the maximum amount of defects with a PPM of 68. It exists when there is insufficient gas shielding and moisture, for example, from incorrectly stored electrodes or fluxes, humid shielding gas or leaks in water-cooled welding torches. By using LSS technique, the defect was minimized and product excellence was confirmed. The target weld porosity rate that needs to be reduced on January 2018 was 33 %.

The research was carried out on application of LSS method in the manual welding process in a boiler manufacturing company to reduce porosity rate.

Objectives of the Study

The main objective of this study was to reduce the welding porosity rate in manual butt joint welding process in a boiler manufacturing company.

More specifically, this study was guided by the following objectives: to define current condition of welding defects, to measure the porosity rate in terms of Control Chart of Porosity, Process Capability Analysis and Sigma Level; to analyze the root cause of porosity rate using 'why why' analysis, to reduce the porosity rate by developing Maintenance Plan Schedule, Welder performance qualification process, Control Chart, Process Capability Analysis, Histogram

and Sigma Level; and, to recommend control plan to sustain the proposed improvement.

2. **Literature Review**

This presented the summary of conceptual literature and related studies to the research that gave enough support to the study.

"Lean Six Sigma enables a company to improve both process cycle duration (efficiency and timeliness) and process quality (defect reduction). LSS deploys data and statistical analysis to expose the root cause of variation that results in inadequate process outputs" (Gupta et al., 2013).

A Butt Weld is the most common kind of joint engaged in the manufacture of welded pipeline systems and a circumferential butt welded joint. A butt joint is the best commonly used way of connecting pipe to itself, fittings, flanges, Valves, and other machine. This welding method is usually used in conditions where an excellent weld preferred, and the weld by X-ray precisely should be examined.

Gas tungsten arc welding (GTAW) is one of the several welding procedures that the term itself self-discusses the distinct attribute of GTAW from some other welding methods. It is also called as Tungsten Inert Gas (TIG). This is a manual method, therefore it involves a great deal of ability from the welder, but this process is difficult associated to shielded metal arc welding (SMAW)**.**

Porosity is weld metal contamination in the form of a trapped gas. Shielding gases or gases released as a result of the torch being applied to treated metal are absorbed into the molten metal and released as solidification takes place.

In welds, incompletely fused spots, called lack of fusion, persist. A weld can lack union with the parent metal or with a previous weld bead. With this, an adhesion joint is formed, which can be rather strong in certain cases. It is much like a brazed joint or joint formed in metallization.

Undercut is defined as a groove melted into the base metal adjacent the weld toe, or weld root, and left unfilled by weld metal. Excess penetration burning through – is more of a problem with thin sheet as a higher level of skill is needed to balance heat input and torch traverse when welding thin metal.

Concave weld beads are particularly prevalent when welding in vertical-down applications and are simply the result of working against gravity. It is difficult to keep the weld pool in the joint in this position, so the weld tends to be thinner at the throat. A good remedy is to adjust the welding parameters to a lower setting so the weld pool is less fluid and more able to fill in the joint. If a concave weld bead appears in the flat or horizontal position, it is typically the result of too high of voltage, too slow of wire feed speed or too fast of travel speed. Hence, there is a need to reduce these factors accordingly.

Offset a situation where base materials creating a butt or corner joint have moved out of alignment or position. This is sometimes called "misalignment." Insufficient Fill or Under Fill- is where the weld surface is below the adjacent surfaces of the base metal.

Defect counts are often considered as measurements of quality of manufactured goods. However, the number of undiscovered errors is the most important defect count. Defect counts can be used as indicators of procedure's quality. One should avoid supposing simple causal relations. Defect counts can offer valuable information but have to be presented with carefulness (Wijgers, 2000)

A specification is required which is evidently specified, for instance about the needed features in the design of somewhat.

Radiography (x-ray) is one of the most significant and widely recognized of all the non-destructive inspection approaches used to define the reliability of the welds.

Six Sigma is a business management strategy that was initially developed by Motorola in the 1980s, which is used by many Fortune 500 companies. It is used primarily to identify and rectify errors and defect in a manufacturing or business process. The Six Sigma system uses a number of quality methods and tools that are used by Six Sigma trained professionals within the organization. The DMAIC problem-solving method can be used to help with any issue that arises, usually by those professionals in the organization who have reached green belt level (Murray, 2016).

The DMAIC problem-solving technique is a roadmap that can be employed for any projects or quality enhancements that requires to be completed. The term DMAIC stands for the five key phases in the method: Define, Measure, Analyze, Improve, and Control.

In Six Sigma, describing the problem or project objectives is significant. The more precise the problem is described the better the opportunity of obtaining measurements and then effectively solving the problem or finishing the project. The meaning should define the problem correctly with numeric illustration. For example, "damaged finished goods from the production line have increased 17 percent in the last three months". The description of the issue or project should not be indefinite for instance "quality has fallen." The scope of the problem, or project should be distinct in addition to the business procedures involved as part of the definition phase.

3. Method

The researcher used the applied method of research. Applied research refers to scientific study and research that seeks to solve practical problems. Applied research is used to find solutions to everyday problems, and develop innovative technologies. The researcher reduced the welding defects by applying lean and DMAIC Methodology.

DMAIC approach was used. Various problem solving tools such as Pareto analysis, process mapping, project charter, control charts, process capability, sigma level, 5 Why analysis, Design of experiments, histogram and others were utilized in this method. Minitab software version 17 and JMP Statistical Software were utilized by the researcher to assist in studying the data gathered.

4. Results and Discussion

1. Current Condition of Welding Defects

The study concentrated first in defining the quality problem. The problem was in the manual butt joint welding process according to Engr De Guzman. The firm provided the researcher a copy of defects from April 2017 to January 2018 from manual welding. The weld rejection rate for manual welding process had the maximum percentage of defect as compared to automatic welding.

Figure 2 presents the Pareto Chart of Defects in the Manual Butt Joint Welding Process that was made using the Minitab software version 17.

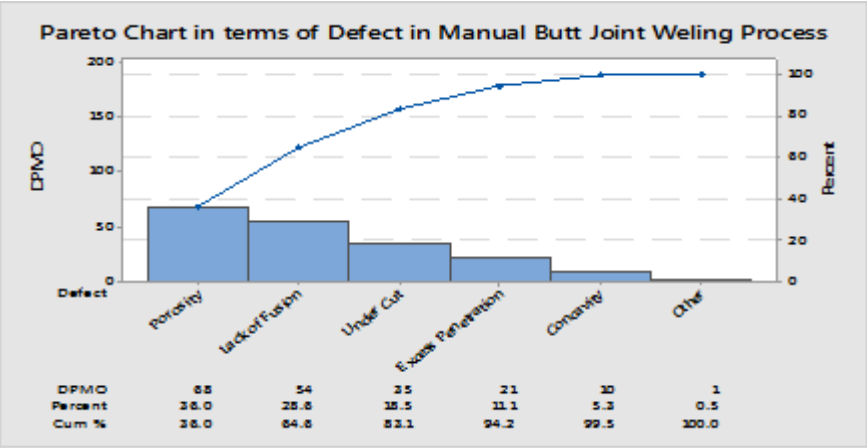


Figure 2. Pareto Chart of Defects in the Manual Butt Joint Welding Process

igure 3 indicates the process mapping or standard operating procedure.

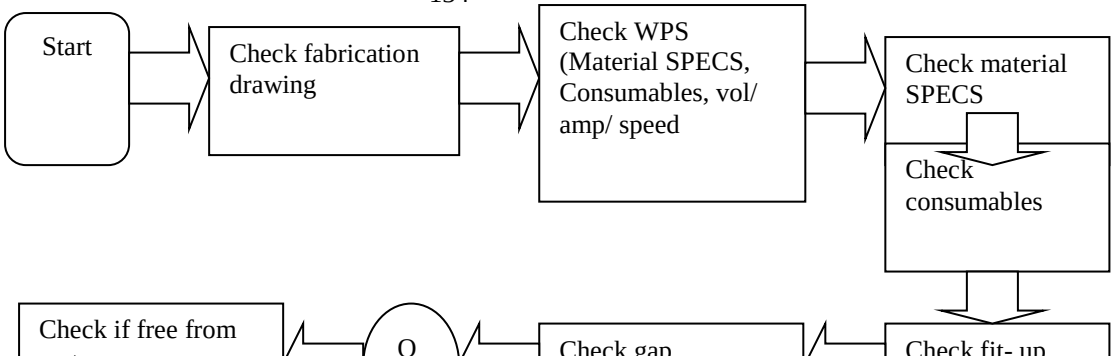


Figure 3. Process Mapping

Table 2, shows the Project Charter to summarize the findings of the Define phase of the project.

Table 2.
Project Charter

Project Title: Minimization of Welding Porosity Rate

Problem & Opportunity Statement

- The average welding porosity defects is 68 defect per million from April 2017- August 2017.

Goal Statement

- To reduce welding prosity defect per million from 68 DPM to 45 DPM or 33 % improvement by January 2018.

Project Scope

- This study will be accomplished by developing the procedure with the application of Lean Six Sigma Methodology concentrating on the manual butt joint welding process.

Project Plan

• Phase	Timeline
• Define	9/1/2017
• Measure	9/1/2017
• Analyze	9/1/2017
• Improve	September- January 2018
• Control	2/1/2018

Team Composition

• Function	Name	Designation
• Project Leader	Salde G. Tasarreglo	(Department Manager- Manufacturing)
• Team Member	Remedios Dimapasok	(Manager PPS)
• Team Member	Sarah T. Valenzuela	(Senior Engineer- Manufacturing)
• Team Member	Dealyn De Guzman	(Supervisor PPS- Estimating)
• Team Member	Jerica Anora	(E- Coil Group Shop D- Supervisor)
• Internal Member	Geronimo C. Ducusin	(Quality Assurance Manager)
External Member	Chavez, Nemy H.	Researcher

2. Measure of Porosity Rate

In the measure phase various tests were showed. The researcher utilized Control Chart and Sigma Level. Using Minitab software version 17, the Process Capability of the process was also determined.

2.1 Control Chart of Porosity
2.2 Process Capability Analysis
2.3 Sigma Level

3.1 Root Cause Analysis

This part was where the researcher collected data to investigate the root source of the problem. This is to conclude a cause and effect relationship. The researcher examined the process using 5 why analysis.

Table 5 shows the Why – Why Analysis- the reason for having porosity defects was due to the machine used.

Table 5
Why – Why Analysis

Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Validation Tool	Validation	Conclusion
	Wrong parameter used	Machine is not calibrated	No PM schedule	Production want machine run 24/ 7	Maximize output	Check machine performance logsheet	Found that PM is performed	Not True Cause
				No person assign to do PM	Headcount reduction	Check organization chart	There is person assigned to do PM	Not True Cause
				There is no system in place for PM	PM is not priority of the company	Check if there is PM recall schedule	There is no PM schedule	True Cause
		There is no standard parameter recipe	Parameters are not optimized	Qualification is not updated	DOE is not performed	Check if DOE on parameters is performed	Last data was 2 years ago	True Cause
Porosity	Welder is not skilled	Welder is not qualified	There is no training & qualification process	Management want immediate output after hire of welder	Management have to meet quota	Check production planning	Output is always above set target	Not True Cause
	Poor quality of work	Welder not focus in product	Welder focus on quantity of output	Welder is paid per piece	Pay per piece is the company design	Check with HR how they are paid	Welders are paid daily	Not True Cause
			Welder has no quality background	Hired welder has no experience on quality	Welders have no prior practice	Check background of welder	Hired welders have no formal certification	True Cause
	Poor quality of materials	Materials from supplier is not properly checked	There is no clear qualification/ checking of materials	Material supplier are not selected properly	There is no supplier selection process	Check purchasing department the supplier selection specifications	There is no supplier selection specification	True Cause

3.2 Verification Root Cause (DOE)

Design of experiment is used to find cause-and-effect relationships. This information is needed to manage process inputs in order to optimize the output. The objective of DOE is to minimize the porosity and know the best setting of parameters to be used in the welding process.

Table 6 tabulates the objective of the experiment that was to minimize porosity.

Table 6.
Screening Design

Y Response:		
Porosity	Goal: Minimize	Lower Limit: 0
X Factors/Variables		
	Low Setting	High Setting
X1 = Current, Amp	70	170
X2 = Voltage, Volt	6	17
X3 = Travel, mm/min	90	110

Table 7 shows that low and high setting of three factors was ran in JMP statistical software with randomization.

Table 7.
Experimental Run Design

Run No.	Pattern	Current, Amp	Voltage, Volt	Travel, mm/min	Porosity
1	+ + -	170	17	80	•
2	- + +	70	17	110	•
3	+ + +	170	17	110	•
4	+ - -	170	6	80	•
5	- - +	70	6	110	•
6	+ - +	170	6	110	•
7	- + -	70	17	80	•
8	- - -	70	6	80	•

Table 8 reveals the summary of fit.

Table 8.
Summary of Fit

Summary of Fit	
RSquare	0.997581
RSquare Adj.	0.983067
Root Mean Square Error	1.767767
Mean of Response	17.625
Observations (or Sum of Wgts)	8

Table 9 illustrates the parameter estimates.

Table 9.
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	17.625	0.625	28.20	0.0226
Current, Amp (70, 170)	-8.125	0.625	-13.00	0.0489
Voltage, Volt (6, 17)	-8.875	0.625	-14.20	0.0448
Travel, mm/min (80, 110)	3.625	0.625	5.80	0.1087
Current * Voltage	1.375	0.625	2.20	0.2716
Current * Travel	-1.125	0.625	-1.80	0.3228
Voltage * Travel	0.125	0.625	0.20	0.8746

Porosity = 17.625 + (-8.125 x Current) + (-8.875 x Voltage) + (3.625 x Travel) + (1.375 x Current * Voltage) + (-1.125 x Current x Travel) + (0.125 x Voltage x Travel).

Table 10 demonstrates the effect tests.

Table 10.
Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Current, Amp (70, 170)	1	1	528.12500	169.0000	0.0489
Voltage, Volt (6, 17)	1	1	630.12500	201.6400	0.0448
Travel, mm/min (80, 110)	1	1	105.12500	33.6400	0.1087
Current * Voltage	1	1	15.12500	4.8400	0.2716
Current * Travel	1	1	10.12500	3.2400	0.3228
Voltage * Travel	1	1	0.12500	0.0400	0.8743

Figure 7 reveals the interaction plot.

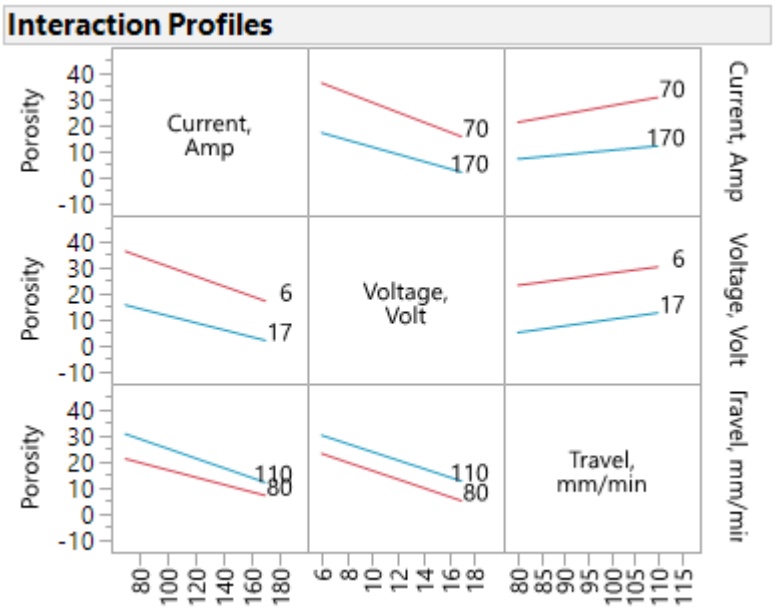


Figure 7. Interaction Plot

4. Improve Phase

The objective of this phase was to offer courses of actions to the problems recognized. This encompassed brainstorming for solutions, tests and assessment of the results. The team shared ideas and explained with each other in order to discover countermeasures in minimizing the welding porosity rate.

4.1 Maintenance Plan Schedule

Table 11 demonstrates the maintenance plan schedule.

Table 11.
Maintenance Plan Schedule

Service Time	Items Need to be Checked & Serviced	Person/s Involved
Daily Prior production	Gas Flow Power	Welding Operator
Note: The operator will test run the machine.		
Semi- annually	Welding Machine	Welding Operator
Every 3 months	Reconditioning of machine head which is part of machine	Welding Operator

4.2 Qualification Process for Welder's Performance

Figure 10 illustrates the details of the performance qualification processes initiated to take quality development in welder skill area.

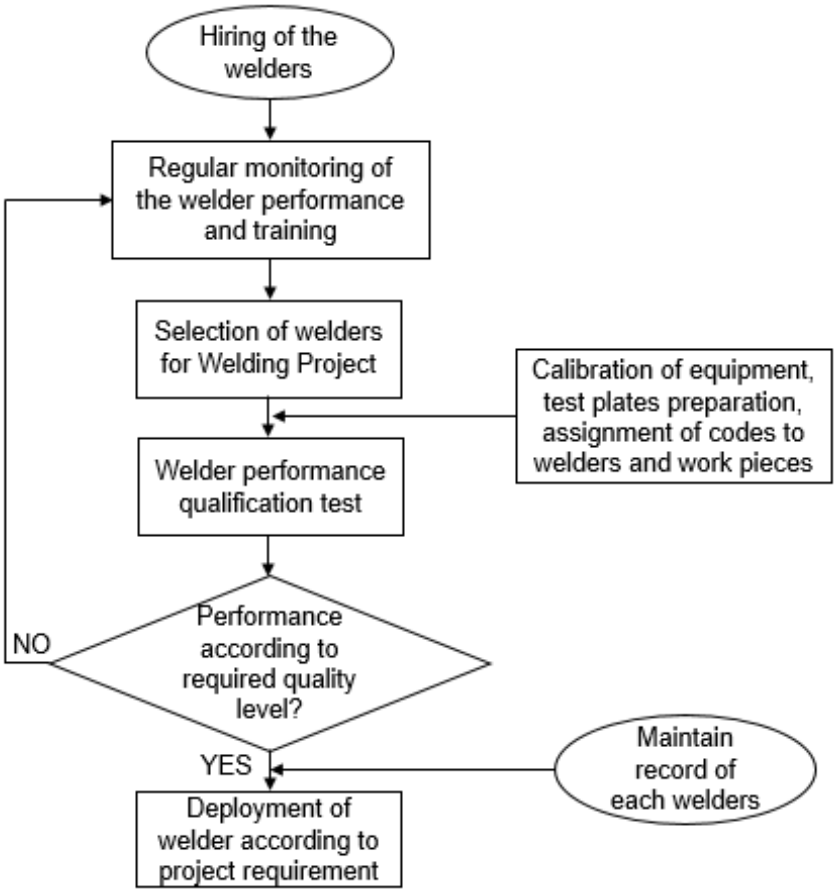


Figure 10. **Welder Performance Qualification Process**

4.3 Control Chart

Process Capability Analysis
Histogram
Sigma Level

Figure 11 indicates the C Chart after Improvement.

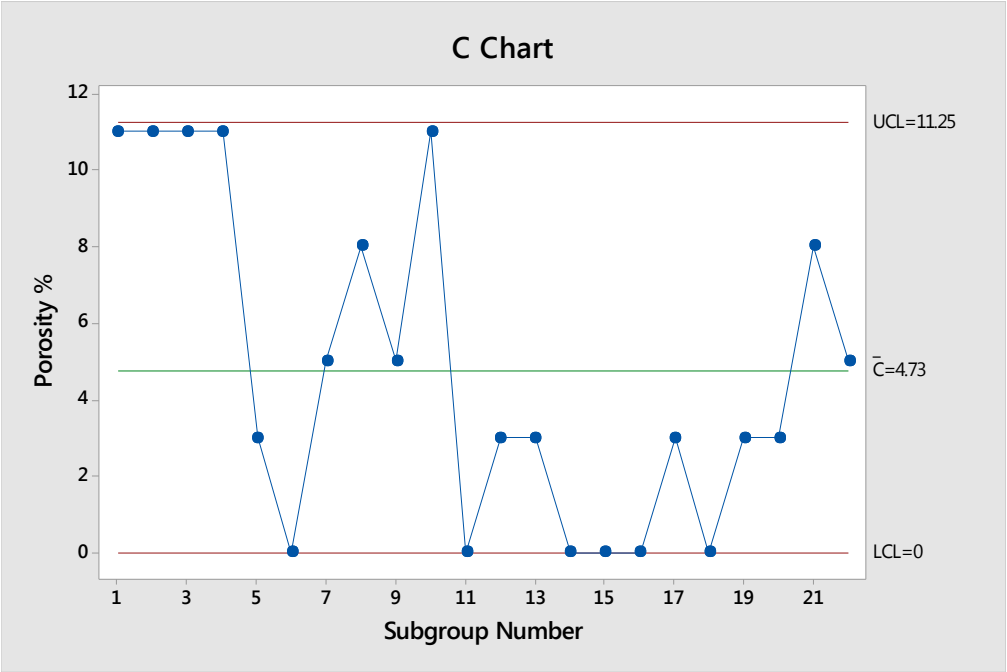


Figure 11. C Chart after Improvement

Figure 12 shows the Pareto chart of defects before and after the improvement.

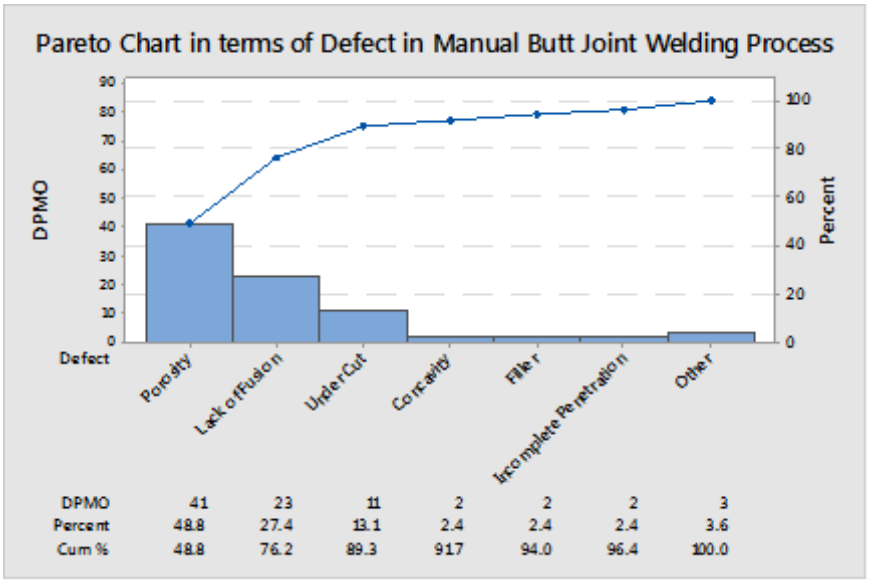
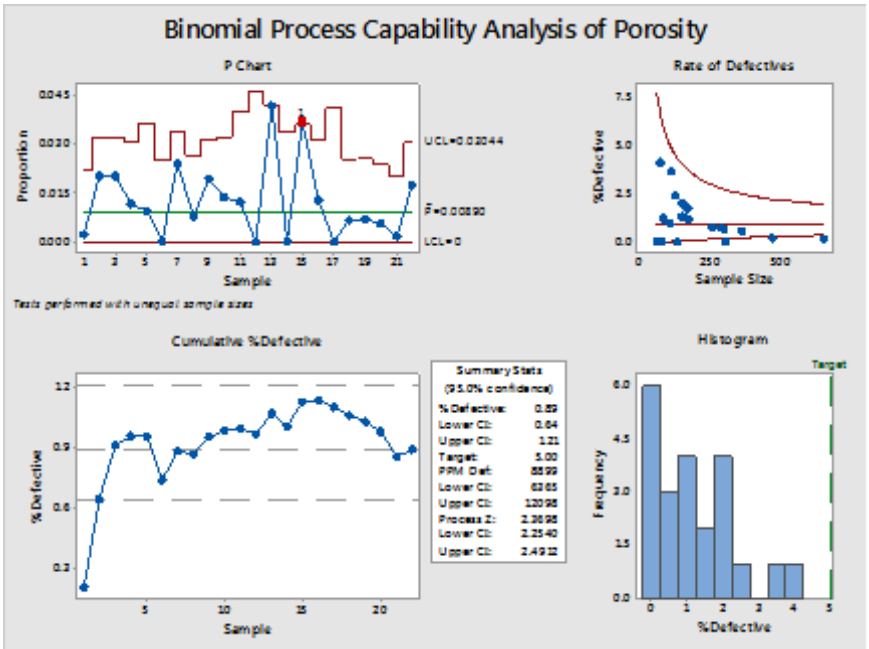


Figure 12. Pareto Chart of Defects before and After Improvement

Figure 13 displays the process capability before and after improvement.



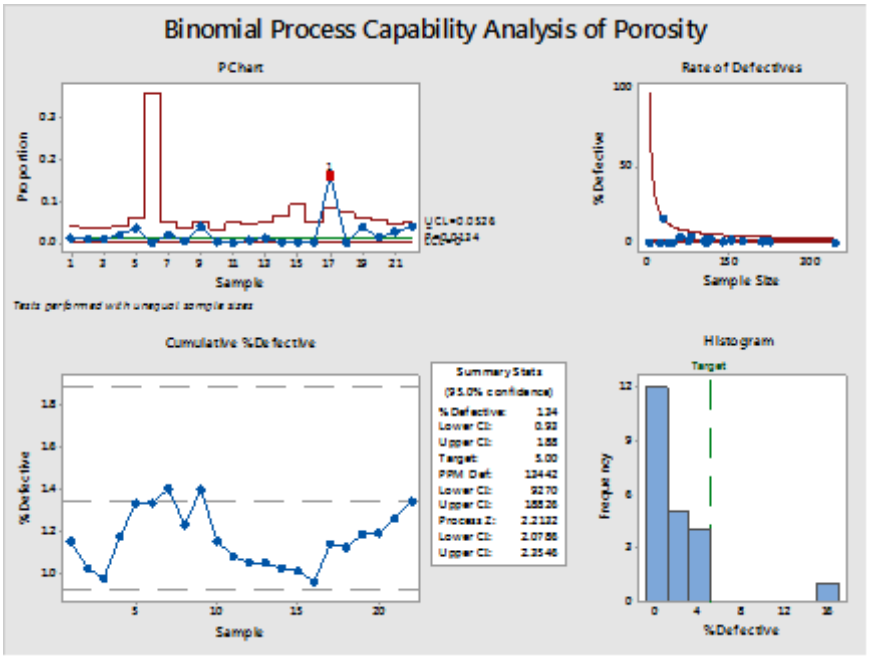


Figure 13. Process Capability of Defects before and After Improvement

Table 12 shows the process sigma after improvement.

Table 12.
Process Sigma After Improvement

Process Capability	Metrics
Number of defect opportunities per unit	9
Number of units processed	6950
Total number of defects made (include defects made and later fixed)	41
Defects Per Opportunity	0.00066
Yield	99.934%
Process Sigma	4.71

Table 13 demonstrates the improved six sigma project control plan for welding process to make sure the constant and to efficiently apply the control measures.

Table 13.
Project Control Plan

Sub Process	Measurement Method	Who Measures
Qualification of Welder Selection of WPS & Welders	Radiography Results	Radiography lab test reports HRD/ Welding School NDE Level- III Personnel
Qualification of WPS	Mechanical and Radiography Results	Approved Laboratory NDE Level- III & Client
Welding Execution	Visual & Radiography Results	Welding Engineer, NDE Level- II & III
Machine Maintenance/ Calibration	Job start checklist is PM/ calibration overdue is my material have QA seal	Welder, supervisor or foreman/ leadman, welding section manager, QA
Selection of Consumable	Chemical & Mechanical Results	Internal Inspector, Testing Lab & QA

5. Conclusions

1. The porosity defect was given the highest priority of the study based on the Pareto Chart since it was the top percentage.
2. The C chart after improvement shows that the number of defects was stable and in control. Since most of the bars of the histogram after improvement are in the left of the target value the process is capable. The sigma level of the porosity's defect was improved from 4.57 to 4.71.
3. The porosity was mainly caused by no preventive maintenance schedule; Design of Experiment (DOE) on parameters performed two (2) years ago, no formal certification for welders, and no supplier selection specification.
4. The researcher was able to develop a maintenance plan schedule and welder performance qualification process to` reduce the porosity rate. The decrease of the welding porosity rate was realized all throughout the procedure with observations in the Control phase. It was concluded that after the application of DMAIC approach, the quantity of porosity defects with 68 PPM was reduced to 41 PPM in manual butt joint welding process.
5. The researcher was able to recommend control plan to sustain the proposed improvement.

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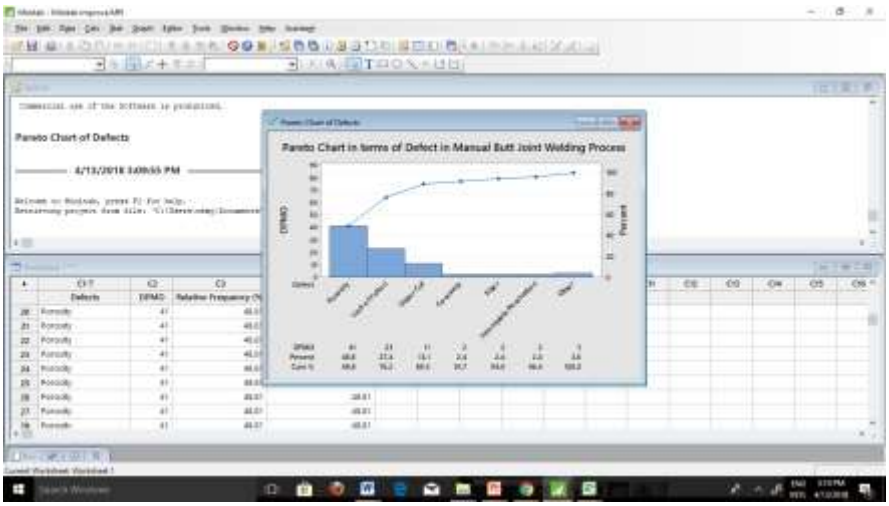
Appendix G

Pareto Chart in Terms of Defect in Manual Butt Joint Welding Process After Improvement



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CUSTOMER'S VIEW ON BUDGETLANE'S MARKETING STRATEGY TOWARDS SERVICE IMPROVEMENT

DIMAANO, JESTHER A., NAVARES, NEIL PATRICK C., SANGILAN, LLANIEL PRINCESS L., TAMAYO, EARL PHILIP B. AND DIPASUPIL, MARIA CECILIA S.

College of Engineering, Lyceum of the Philippines University, Capitol Site, Batangas City, Philippines

Abstract

This study aimed to improve the marketing strategy of BudgetLane Supermarket, Batangas based on the customer's view towards service improvement using descriptive method of research. More specifically this study aimed to: describe the profile of respondents as to age, gender, civil status, proximity from the BudgetLane and lastly monthly income; determine the different marketing strategy used by BudgetLane; identify the strengths and weaknesses of the marketing strategy of BudgetLane, Batangas as perceive by the customers; identify the needed improvement of the company in terms of marketing program and services rendered; determine the level of satisfaction of the respondents in terms of BudgetLane's product; determine the difference of responses on the level of satisfaction in BudgetLane's product according to profile; test the significance difference on the level of satisfaction in Budgetlane's product when grouped according to profile; and, proposed an action plan to enhance the marketing strategy of BudgetLane. The study concluded that majority of the respondents belonged to the 21-25 age bracket, female married and their proximity from BudgetLane is 6-8 kilometers, with a monthly income of 11 000 – 15000 php. Majority of the respondents visit BudgetLane thrice or 3 times a week. Majority of the respondents have never seen advertisements about BudgetLane, for those who answered yes to having seen advertisements of BudgetLane, majority have answered that they have never seen advertisements such as online and on television, seldom heard on radio, seldom seen in magazine/newspaper and outdoor/transit and never seen in direct mails, catalogues and leaflets. With regards to promotional Pricing, BudgetLane seldom offers, markdowns, loss leaders and bundle pricing. In terms of Point purchase displays, BudgetLane seldom has speed bumps, dump bins and free samples. With regards to loyalty programs, they never offer customers discount cards, seldom offer coupons and promo codes and they never have raffles. Majority of the respondents always purchase items or products on sale promotions offered by BudgetLane, Discount promos, items with freebies, bundle sales and often offers Buy1 get1 deal and holiday sale. Noted that there is significant difference exists on the level of satisfaction in BudgetLanes product when respondents are grouped according to age and monthly income. Therefore the null-hypothesis is rejected. Strategies are proposed to enhance the marketing strategy of

Budgetlane to enhance customer satisfaction. Also, a plan of action is proposed for implementation and evaluation.

Keywords: marketing strategy, BudgetLane, advertisements, promotional sales

1. Introduction

Marketing strategy speaks to a key component of achievement for associations. Executing a compelling technique is similarly as vital as conceptualizing and making it (Saif and Aimin, 2016). It has the essential objective of expanding deals and accomplishing a maintainable upper hand (Cook, 2008). Promoting procedure is the aftereffect of a fastidious market investigation that arrangement with the examination of the vital starting circumstance of an organization and the plan, assessment and determination of market-situated techniques that add to the objectives of the organization and its showcasing goals (Homburg, 2009).

A decent advertising methodology focused on items and administrations of the general population well and on how is the way to get them. (www.business.qld.gov.au).

Promoting should fill in as a scaffold amongst items and shoppers, as a critical device that pitch items to business sectors by assessing purchasers' needs and inclinations and trying endeavours to satisfy those necessities and inclinations trying to profit by seizing piece of the pie of imported products. Making beneficial development could likewise mean looking for subsequent to cutting the expenses of creation or market separation through bundle, plan or increased the value of items that will draw in purchasers to purchase local items rather than imported merchandise. There is in any case, some proof that organizations delivering sustenance items will profit by development later on. This can be founded on the actualities that amid our immediate contact with Budget Lane in Batangas, it was noted that their generation innovation is all around cutting edge, which could bring down their generation expenses and increment efficiency additionally organizations require is a showcasing division and deals work force trying to help deals in the nearby market, make new markets by presenting new items and outlines by means of item separation and expansion, and make a marking picture that will draw in trades too. In this paper it was contend that advertising is an imperative office in accomplishing this. Development systems every organization should set objectives or make a vital arrangement keeping in mind the end goal to develop in the market. From the macroeconomic hypothesis that characterizes that the principle explanation behind an association's presence is to make benefit (www.eujournal.org).

A company’s marketing strategy ought to be founded on advertise needs. Filipino customers are winding up more cost touchy and are progressively searching for advancements to adapt up to the rising costs of merchandise. Nielsen's investigation demonstrated that 15 percent of shoppers will change to an alternate store to show signs of improvement limited time special (a 3-point increment from 2009), and just 70 percent said they will shop at a similar store they generally disparage, contrasted with 82% out of 2008. Filipino customers are the most drastically averse to do "top-up" shopping contrasted with customers in other Southeast Asian nations. All things considered, they influence 1 "to top up" shopping trip a month, interestingly, customers in

Singapore and Indonesia enrolled 8 and 7 trips separately. With regards to primary shopping trips, Filipino customers all things considered will make around 2 trips per month 30 percent of purchasers in the Philippines do their principle shopping once per week, another third does it once every fortnight and 25 percent does it once per month (ABS-CBN News, 2012). There must be a comprehension of changing buyer needs and input into this procedure with the goal that a business can turn out to be better and better at fulfilling these necessities. The excellence of Spending Path is that it covers a great mass market with a comprehensively based general interest, giving comment. To do this includes conversing with clients to discover what they need pretty much of. An assortment of statistical surveying strategies is frequently utilized.

This research aims to enhance the marketing strategy of BudgetLane Supermarket in Batangas, City. It is known as importer and distributor of quality household products, importing from countries around the world. It also brings a fresh perspective to houseware industry. With experience in branding and design coupled with expertise in the Philippine market, BudgetLane was able to create products that suit its customers' needs.

BudgetLane is one of the leading supermarkets in the city of Batangas since it was established on 2010. It has developed individuals to end up marketing advantages by offering some incentive added administration to its clients as far as effectiveness, respectability, low cost and guaranteeing irreplaceable after deals consumer loyalty. BudgetLane imagines itself to be the most favoured store and to set up a branch in each real town and city in the nation.

The researchers observed that in BudgetLane Batangas branch, lacks marketing program such as advertisements. Also, customers are not aware of what BudgetLane's sales promotional offers. They only know it once they visit the store.

As residence living in Batangas City, the researchers consider themselves as consumers of BudgetLane Supermarket. In their observation, BudgetLane has huge success in their field. Customers go to the store very often and they shop in large quantities. The researchers want to know the reason behind this success by getting the customers' point of view towards the marketing strategy of the establishment.

As customers, the researchers observe things. It is to their observation that customers of BudgetLane purchase their groceries by bundles, through jeepneys or trucks. They become curious on what marketing strategy the store uses for them to be this effective and productive.

The researchers also conduct observations and interview to determine the current marketing strategy of BudgetLane, Batangas. The given information was treated with confidentiality for the safety of the management against their competitors.

2. Conceptual Framework

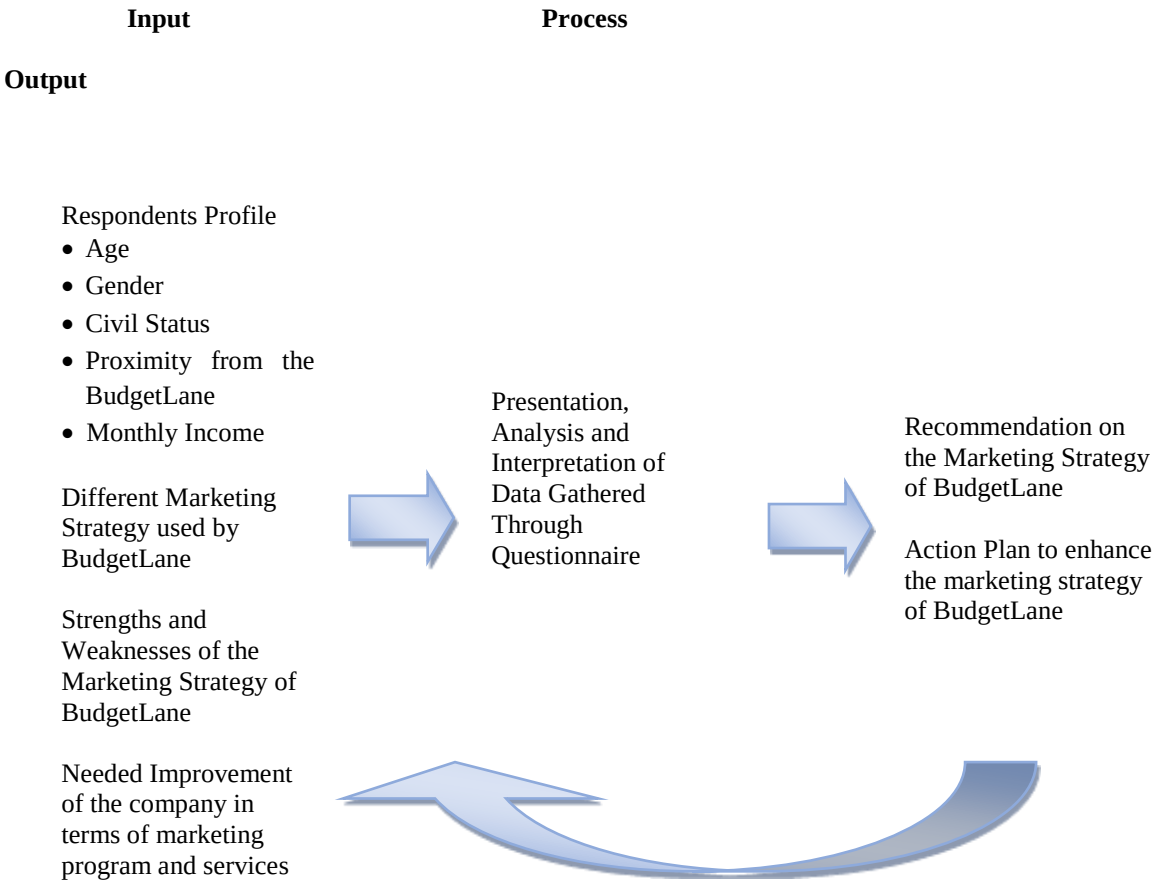

Figure 1.1 Conceptual Paradigms

Figure1.1 shows the conceptual paradigm of the study. The input focused on the data that were acquired from the questionnaire. The process pertained to the data collection and analysis using Analysis of Variance (ANOVA). Based from the

data interpretation, the researchers formulate recommendation on the Marketing Strategy of BudgetLane, Batangas,

The study involves the concept about the profile of the respondents in terms of age, gender, civil status, proximity from the BudgetLane and lastly monthly income.

Industrial Engineers faced with uncertain and sometimes chaotic environments in which to function. The traditional roles of an engineer are to design, develop, and streamline a manufacturing process for products are still valued and relevant. However, the need for an engineer to participate in the process of developing a marketing strategy, the schedule and resources required, and the goal of satisfying the customer, has become paramount to achieving the success of the enterprise. When these endeavors were included in the functions of an engineer, management of "engineering" takes on a new dimension (Krishen, K., 1993). Industrial engineers help businesses minimize inventory costs, control inventory management and conduct quality assurance activities to help businesses keep their customer bases satisfied (www.bls.gov).

As future Industrial Engineers, the researchers decided to assess the marketing strategy of BudgetLane, Batangas for good marketing strategy educates customers to make better choices about the store's products and services. Increasing the customer's awareness about the stores products and services is one of the objectives of this research. This study will benefit the store itself, the researchers, the customers and the future researchers. This study aims to amend the store's strategy if the external market changes due to a new competitor, or if the products substantially change. Also, to make the most of the store's marketing investment, keep the marketing focused and measure and improve sales results.

3. Literature Review

BudgetLane, Batangas is a supermarket which creates individuals to end up advantages for the organization that leads the organization to be a resource for the group by offering some incentive added administration to its clients regarding effectiveness, uprightness, low cost and guaranteeing imperative after-deals consumer loyalty.

Marketing Strategy

Marketing is a procedure of arranging which includes recognizing, foreseeing and fulfilling shopper needs. It begins with a comprehension of what individuals need, whereupon a thought can be produced. Many individuals have thoughts yet few get them going, from the thought comes an arrangement and after that a procedure of creation and statistical surveying, from which will come the item which purchasers need, at a value they will pay. This isn't the finish of the procedure. At the point when an organization creates items, it needs to achieve its clients not simply to advise them about the item and influence them to get one, yet additionally to make a method for dispersing the item to them. For an organization to succeed it must have the capacity to do this superior to anything some other contending organization. Be that as it may, this isn't the finish of the procedure (consumerpsychologist.com).

Keeping in mind the end goal to represent the estimation of advertising methodology and the procedure of usage a point by point writing audit was performed. The meta-examination reveals two particular yet related highlights to advertising technique content: promoting procedure choices and showcasing methodology choice usage. The writing likewise proposes there is a relationship of showcasing technique, and promoting blend components on authoritative execution, and underlines a further need to perform theoretical and experimental investigations. The inventiveness and estimation of the audit lies in the way that showcasing system has been examined both as far as its results and as a procedure that does not yield acceptable outcomes without compelling execution (Saif & Aimin, 2016).

Sana, et al. (2014) communicated that a long time money related and social goals have been seen as fighting, however insightful experts underline that this two orientation may join in particular conditions. Associations have a place with bunches where they develop their activities. Right when the social goals of the gatherings are related to the major focuses of the association, supporting a social reason could make fiscal favourable circumstances, for this circumstance corporate liberality and financial specialists' premium take a comparable heading. Cause-related showcasing is an advertising idea that increased more enthusiasm for the most recent three decades and epitomizes how social and financial destinations are accomplished in a key way in advancing efforts. Inquiries about in business and non-benefit associations uncover that reason related advertising efforts support the development of piece of the overall industry and deals, and help at enhancing brands picture. An ever increasing number of organizations and non-benefit associations discover cause-related showcasing as a key device appropriate for building long haul relations to the clients, for expanding brand mindfulness, for picking up a social capable corporative picture, for supporting neighbourhood group or for delivering change in maintaining causes at worldwide or global level. The investigation examinations the meanings of cause-related advertising the nearness and development of the idea in the scholastic writing, and promoting terms that are associated all the more regularly to this idea. Near to non-benefit advertising idea, cause-related showcasing picked up a bigger enthusiasm for writing. On the opposite side, corporate magnanimity is as yet an idea that additions more enthusiasm than cause-related advertising in scholastic writing, being a more cooperative path utilized by organizations in joint effort to non-benefit associations. Tided to cause-related promoting idea writing audit uncovers ideas as: buyer conduct, mark picture and corporate social duty being all the more frequently dissected. The notability of the shopper point of view, in scholastic research underlines the key and strategy part of cause-related promoting that must be considered in building relations to the clients for organizations.

With the widely use of internet, identified marketing strategies are the use of social media; video tutorials; blogging; search engine optimization; leverage influencers, building a great magnet; use of Facebook ads with re-targeting; use LinkedIn the right way; create an affiliate program; and the use of Email marketing sequences (https://www.entrepreneur.com/article/299335). Most of these strategies can be less expensive and can reach more customers however with the proximity of the store and taking into account the target market a tradition marketing strategies should also be considered. The use of signages; flyers and

brochure; billboards; face to face interactions; print ads; salespeople; and word of mouth can be also found effective and cannot be considered dead.

Strengths and Weaknesses of Marketing Strategy

There are a few zones inside a system where breaking down qualities and shortcomings is basic. By deeply understanding the correct way to deal with a promoting procedure, can give an input on how to build up an extensive evaluation on how an organization can enhance its marketing strategy (http://smallbusiness.chron.com).

Competitive Analysis. With the use of SWOT examination the organization will be able to surpass its competitors. The qualities of item offering, conveyance system and client benefit levels are contrasted with those of the opposition to figure out where qualities and shortcomings are. This kind of assessment is basic in figuring out which parts of the advertising design should be enhanced, and it likewise builds up an approach to gauge execution for issues, for example, client benefit since it gives a comment from loyal consumer levels.

Personnel Utilization. The qualities and shortcomings of how to use staff is another components in showcasing methodology. Work force qualities incorporate a refreshed range of abilities, a staff level that is prepared to do productively, performing assignments and the accessibility of outside temporary workers that can improve staff's capacities. For instance, pick transportation accomplices due to their aptitude in working with worldwide traditions and performing regulatory delivery errands that staff that is not productive. Weaknesses in work force usage incorporate absence of qualified faculty in key positions and a wasteful utilization of staff. For instance, may have a completely staffed distribution center to deliver items however need enough items to dispatch because of generation delays (http://smallbusiness.chron.com).

Location. In showcasing technique that is endeavouring to move item to the end client, area can be either a quality or a shortcoming. Putting conveyance organize along an indistinguishable courses from principle shipping bearer can make a strategic preferred standpoint in delivery and accepting item in an auspicious way. When need to make transportation arranges just to get item to and from a principle shipping center, at that point will be not able inspire item to advertise as fast as opposition.

Financial Resources. Achieving a wide target gathering of people with a showcasing methodology requires cash and in addition work force assets. In basic terms, budgetary assets can be a quality or a shortcoming relying upon amount accessible. On the off chance that organization is constrained in the monetary assets it can focus on an advertising procedure, at that point some bit of arrangement will endure. The accessibility of sufficient monetary assets turns into a quality that enables to be more aggressive in the commercial center (http://smallbusiness.chron.com).

Strengths, alludes to an organization's upper hands and unmistakable skills that is important thing in the organization to do extremely well. A few cases of qualities include: Strong employee attitudes, excellent client benefit, large piece of the overall industry, personal associations with clients, leadership in item advancement, highly productive, minimal effort fabricating, and high respectability.

Weaknesses are the imperatives that block an organization's accomplishment a specific goal, what the organization does not do well. Sample is running of the mill organization shortcomings may be: Inadequate meaning of client for item/advertise improvement, confusing administration approaches, too many levels of detailing in the authorities structure, limited item accessibility, lack of inclusion from top administration in building up another administration and lack of quantities objective (http://frog-dog).

Customers View

Customer fulfilment studies are a decent approach to assemble key data about how well organization has met client desires, how organization's execution contrasts and the opposition, and how could an organization's procedure be enhanced to better serve the client's needs.

Client is characterized as any individual who gets what is delivered by the individual or association that has esteem. Client desires are constantly expanding. Brand faithfulness is a relic of days gone by. Clients search out items and makers that are best ready to fulfil their prerequisites. An item does not should be appraised most astounding by clients on all measurements, just on those they believe are critical.

4. Methods

The research used the elucidating technique as it expects to depict and clarify the showcasing system utilized by BudgetLane, Batangas. Enlightening Exploration is an announcement of issues as they are at give the specialist having no power over factor. It might be portrayed as just the endeavour to decide, depict or distinguish what is. In its prominent configuration, engaging examination is utilized to portray attributes as well as conduct of test population (Ethridge, 2008).

Data Analysis

The data gathered were tallied and tabulated and interpreted. Different statistical tools were used to interpret the quantitative data. To test the significant difference in the level of satisfaction on the quality of BudgetLane's product Analysis of Variance (ANOVA) and Independent Sample T-Test was utilized. ANOVA is a collection of statistical models used to analyze the differences among group means and their associated procedures. ANOVA is used to test differences between two or more means (www.statisticssolutions.com). This includes frequency, percentage and weighted mean. While Independent Sample T -Test is used to determine whether there is a statistically significant difference between the means of two unrelated groups like age, sex, civil status, proximity from BudgetLane and monthly income.

5. Results and Discussion

Table 1
Percentage Distribution of the Respondents' Profile

Profile Variables	Frequency	Percentage (%)

Age		
15-20	23	8.00
21-25	69	24.10
26-30	59	20.60
31-35	31	10.80
36-40	47	16.40
41 and above	57	19.90
Sex		
Male	129	45.10
Female	157	54.90
Civil Status		
Single	127	44.40
Married	150	52.40
Separated	5	1.70
Widowed	4	1.40
Proximity from the BudgetLane		
0-2 kilometers	38	13.30
3-5 kilometers	63	22.00
6-8 kilometers	78	27.30
9-11 kilometers	57	19.90
12 or more	49	17.10
	1	0.30
Monthly Income		
5 thousand pesos below	61	21.30
6-10 thousand pesos	58	20.30
11-15 thousand pesos	90	31.50
16-20 thousand pesos	53	18.50
21 thousand and above	23	8.00
Table 1 continuation…		
How many times a week do usually visit BudgetLane?		
Once	63	22.00
Twice	77	26.90
Thrice	82	28.70
4-5 times	41	14.30
6-7 times	9	3.10
During special occasion	12	4.20
	2	0.70

Table 1 presents the percentage distribution of the respondent's profile. It was observed that majority of the respondents belonged to the 21-25 years old age bracket or 24.10%, it was followed by 26-30 years old (20.60%) and 41 and above years old age bracket (19. 9%). Data also shows that majority of the respondents are female (54.90%), followed by male (45.10%). In terms of civil status, 150 or 52.40% are married, followed by single with a total of 44.40%.

With regards to the respondent's proximity to BudgetLane, majority (27.30%) are 6.8 kilometers away from BudgetLane, followed by 3-5 kilometers with a total of 63 or 22%, and 57 or 19.90 % are 9-11 kilometers from BudgetLane.

In terms of Monthly Income, 90 or 31.50% of the respondents has a monthly income of 11,000-15,000 Php. It was followed by respondents with a monthly income of 5,000 Php and below (21.30%) and 6,000-10,000 Php (20.30%).

Having the largest percentage in times a customer visited Budgetlane is “thrice a week” with 28.70%, followed by twice a week (26.90%) and once a week with 22%.

Profile variables are used to discuss the percentage distribution of the respondent profile. Results show that majority of the respondents are in the 21-25 age bracket, married, female and the proximity from BudgetLane is 6-8 kilometers, with a monthly income of 11000-15000, and many of the respondents visits the store, 3x a week. Based on the results, it can be said that mostly female with jobs and have a certain monthly income mostly visit the store. It can also be said that most of the respondent are giving effort to travel to BudgetLane considering the highest percentage of proximity is 6-8 kilometers.

Filipino customers are additionally ending up more cost touchy and are progressively searching for advancements to adapt up to the rising costs of products, Nielsen's examination demonstrated that 15 percent of purchasers will change to an alternate store to show signs of improvement limited time special (a 3-point increment from 2009), and just 70 percent said they will shop at a similar store they generally disparage, contrasted with 82% out of 2008. Filipino customers are the least extent liable to do "top-up" shopping contrasted with customers in other Southeast Asia nations. All things considered, they influence 1 "to top up" shopping trip a month, conversely, customers in Singapore and Indonesia enrolled 8 and 7 trips separately. With regards to principle shopping trips, Filipino customers by and large will make around 2 trips per month 30 percent of purchasers in the Philippines do their fundamental shopping once per week; another third does it once every fortnight and 25 percent does it once per month (ABS-CBN News, 2012).

"Most Filipinos take this must-do movement in their walk and even get satisfaction from the action which might be seen by numerous shoppers in different nations as a task, "she included. The review directed from October to December 2010, demonstrated that ladies remain the primary customers in Philippine families at 67 percent. Yet, it likewise uncovered that a developing number of Filipino men are bringing up the assignment with the level of Filipino male primary customers tripling to 33 percent toward the finish of 2010 from 2006. The figure “placed the Filipino males as the second most likely to be the main grocery shopper for their households on the South-East Asian region, trailing Malaysia at 36 percent,” Nielsen said.

Table 2
Marketing Strategy of BudgetLane, Batangas

Indicators	Frequency	Percentage (%)	Rank
Are advertisements about BudgetLane visible?			
Always	3	1.0	
Often	22	7.70	

Sometimes	26	9.10	
Seldom	6	2.10	
Never	228	79.70	
If yes, what location is commonly seen?			
Online *(Facebook, Yahoo, etc.)*			**1**
Always	1	.30	
Often	6	2.10	
Sometimes	11	3.80	
Seldom	1	.30	
Never	38	13.30	
Television			**3**
Always	1	.30	
Often	13	4.50	
Sometimes	7	2.40	
Seldom	4	1.40	
Never	32	11.20	
Radio			**5**
Always	3	1	
Often	13	4.50	
Sometimes	20	7.00	
Seldom	21	7.30	
Magazine or Newspaper			**3**
Always	3	1	
Often	10	3.50	
Sometimes	10	3.50	
Seldom	32	11.90	
Outdoor and transit			**2**
Always	2	.70	
Often	9	3.10	
Sometimes	11	3.80	
Seldom	35	12.20	
Direct mail, catalogues & leaflets			**4**
Always	2	.70	
Often	2	.70	

Table 2 continuation…

Sometimes	14	4.90	
Seldom	10	3.50	
Never	29	10.10	
What kind of sales promotion techniques does BudgetLane offer?			
Promotional Pricing			
Markdowns			**2**
Always	14	4.90	
Often	30	10.50	
Sometimes	79	27.60	
Seldom	118	41.30	
Never	45	15.70	

Loss Leaders			**1**
Always	9	3.10	
Often	27	9.40	
Sometimes	83	29.00	
Seldom	126	44.10	
Never	41	14.30	
Bundle Pricing			**3**
Always	8	2.80	
Often	12	4.20	
Sometimes	110	38.50	
Seldom	112	39.20	
Point-of-Purchase Displays			
Speed Bumps			**2**
Always	3	1.00	
Often	15	5.20	
Sometimes	104	36.40	
Seldom	131	45.80	
Never	33	11.50	
Dump Bins			**1**
Always	2	.70	
Often	20	7.00	
Sometimes	104	36.40	
Seldom	133	46.50	
Never	27	9.40	
Free Samples			**3**
Always	12	4.20	
Often	28	0	
Sometimes	94	32.90	
Seldom	111	38.80	
Never	41	14.30	
Loyalty Programs			
Discount Cards			**1**
Always	9	3.10	
Often	13	4.50	
Sometimes	43	15.00	
Seldom	100	35.00	
Never	121	42.30	

Table 2 continuation…

Coupon Codes and Promo Codes			**3**
Always	9	3.10	
Often	16	5.60	
Sometimes	55	19.20	
Seldom	104	36.40	
Never	102	35.70	
Raffles			**2**
Always	8	2.80	
Often	13	4.50	
Sometimes	34	11.90	
Seldom	115	40.20	

Never	116	40.60	
Purchase items/products on sales promotion offered by BudgetLane?			
Always	92	32.20	
Often	86	30.10	
Sometimes	48	16.80	
Seldom	16	5.60	
Never	44	15.40	
If yes, what kind of promo are those?			
Discount Promos *(10% off, 25% off, 50% off, etc.)*			**3**
Always	88	30.80	
Often	80	28.00	
Sometimes	55	19.20	
Seldom	17	5.90	
Never	7	2.40	
Items with Freebies			**2**
Always	90	31.50	
Often	81	28.30	
Sometimes	50	17.50	
Seldom	19	6.60	
Never	7	2.40	
Bundle sale			**1**
Always	99	34.60	
Often	72	25.20	
Sometimes	53	18.50	
Seldom	15	5.20	
Never	8	2.80	
Buy one, get one deal; Buy 3 for a price of 1 deal			**4**
Always	84	29.40	
Often	88	30.80	
Sometimes	50	17.50	
Seldom	9	3.10	
Never	16	5.60	
Holiday Sale			**5**
Always	80	28.00	
Often	83	35.70	
Sometimes	46	16.10	
Table 2 continuation…			
Seldom	13	4.50	
Never	6	2.10	

Results show that customers "never" see advertisements about BudgetLane with a percentage of 79.70% and a frequency of 228, followed by "sometimes" with 9.10% or 26. "Always" has the lowest percentage of 1% or 3 respondents, followed by seldom with 2.10% or 6.

For those who commonly see advertisements of BudgetLane, in terms of online, 13.30% or 38 answered never followed by often with 2.10% or 6. Having the lowest percentage of 0.30% is always tied with seldom.

With regards to television, never has the highest percentage of 11.20% or frequency of 32, followed by often with 13 or 4.50%. Always has the lowest percentage of 0.30%, followed by seldom with 1.40% or 4 respondents.

In radio, seldom has the highest with 7.30% or 21 while always has the lowest with 10% or frequency of 3.

In terms of magazines and newspapers, it was observed that seldom ranks first with 12.20% or 35, while the lowest is always with percentage of 0.70% or 2.

In outdoor and transit, it was obtained that the highest is seldom with 35 or 12.20% while always has the lowest percentage of 3.10% or 9.

With regards to catalogues etc., it was observed that never has the highest percentage of 10.10% or 29, while the lowest are always and often with 0.70% or 2.

In terms of sales promotional techniques, results show that markdowns are seldom offered by BudgetLane with a frequency of 118 or 41.30%, followed by never with 15.70%.

It was also observed that with regards to loss leaders, BudgetLane seldom offers with a frequency of 126 or 44.10%, followed by never with 41 or 14.30%.

In bundle pricing, it was observed that the store seldom offer with 126 or 44.10%, followed by sometimes with 110 or 38.56.

When it comes to point of purchase display, it turns out that BudgetLane seldom offers speed bumps with 131 or 45.80%, followed by sometimes with 104 or 36.40%.

With regards to dump bins, it was observed that with the highest percentage of 46.50%

In free samples, it was obtained that the store seldom offers with 111 or 38.80%, followed by sometimes with 94 or 32.90%.

In terms of loyalty programs, it was observed that in discount cards, Budgetlane never offers with 121 or 42.30%, followed by seldom with 100 or 35%.

When it comes to Promo codes, the store seldom offers with 104 or 36.70%, followed by never with 102 or 36%.

While in terms of raffles, it was observed that they never offer with a frequency of 116 or 40.60%, followed by seldom with 115 or 40.20%.

For those who answered yes, results show that customers always purchase during sales promotion with 92 or 32.20%.

In terms of discount promos, it was observed that “always has the highest percentage with 30.80%. Never has the lowest with 2.40% or frequency of 7.

With regards to Items with freebies, it was obtained that always has the highest with 31.50% or 90 while never has the lowest with 2.40% or 7 respondents.

In bundle sale, results show that 34.60% or 90 respondents always purchase while never has the lowest percentage of 2.80%.

In terms of Buy 1 get 1, it was shown that always has the highest percentage of 24.90% or 84 respondents while seldom has the lowest with 3.10% or 9 respondents

With regards to holiday sale, always ranks first with 80 or 24.40% while never has the lowest percentage of 2.10% or 6 respondents.

Indicators target to determine marketing strategy of BudgetLane, to know if customers see advertisement of BudgetLane, to identify if they of promotional sales and to determine of customers patronize their promos if they have any.

Although the BudgetLane provides advertisements in terms of online, Television, Radio, Magazine/newspaper, outdoor and transit and direct mail, catalogues, leaflets. Based on the majority of the result, it can be said that customers are not aware of the advertisements released by the supermarket.

When it comes to promotional sales, it is just like the situation in terms of advertisement. The store used promotional sales techniques and they offer promos for their customers. Customers only know what promos are offered once they visit the store. Based on the results, it can be said that the look of awareness of customers in terms of their promos is due to the store short comings in their advertisements.

Promoting technique speaks to a key component of achievement for associations. Executing a viable advertising technique is similarly as imperative as conceptualizing and making it. Through showcasing methodology execution firms utilize rare assets through promoting capacities with a specific end goal to accomplish the set objectives and targets. Keeping in mind the end goal to represent the estimation of promoting methodology and the procedure of execution a point by point writing audit was performed. The meta-investigation reveals two unmistakable however related highlights to advertising system content: promoting methodology choices and showcasing procedure choice execution. The writing likewise proposes there is a relationship of promoting procedure, and showcasing blend components on authoritative execution, and underlines a further need to perform applied and observational examinations. The creativity and estimation of the audit lies in the way that promoting technique has been investigated both regarding its results and as a procedure that does not yield tasteful outcomes without viable execution (Saif & Aimin, 2016).

Table 3
Strengths of the Marketing Strategy of BudgetLane as Perceived by the Customers

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Their advertisements are informative and interesting.	3.27	Moderately Agree	2
2. All items on promo/discount are valid as I check out to the counter.	3.15	Moderately Agree	3
3. Signages of products on promo/discount and as well as, products which are not on promo/discount are clear and visible.	3.13	Moderately Agree	4
4. Employees are very accommodating and kind.	3.60	Agree	1
Composite Mean	**3.29**	**Moderately Agree**	

Legend: 4.50 – 5.00 = Strongly Agree; 3.50 – 4.49 = Agree; 2.50 – 3.49 = Moderately Agree; 1.50 – 2.49 = Disagree; 1.00 – 1.49 = Strongly Disagree

The table 3 presents the strengths and weaknesses of the marketing strategy of BudgetLane as perceived by the customers. Obtaining the highest mean is "employees are very kind and accommodating "(3.60 WM), followed by "their advertisements are informative and interesting" with weighted mean of 3.27, and "all items on promo/ discounts are as I check out the counter" (3.15 MW).

Having the lowest mean is "some products on promotional sales are expired", (1.98 WM), followed by "allowing other customers to suddenly appear and join the line midway (2.52 WM), and "long period of time waiting due to queuing of customers with a weighted mean of 2.76

The indicators are used to identify the strength and weakness of the Marketing Strategy of BudgetLane in the customers' perspective. Results show that their strength is that their employees are kind and accommodating while their weakness is that some products during promotional sales are expired. Based on the results, it can be said that the store is very good in their accommodation but they need improvement in terms of their inventory.

There are several areas within a marketing strategy where analyzing strengths and weaknesses are critical. By understanding this approach to a marketing strategy, develop a comprehensive analysis of how a company can improve its standing in the marketplace (http://smallbusiness.chron.com).

Strengths, alludes to an organization's upper hands and unmistakable skills that is the thing that the organization does extremely well. A few cases of qualities include: Strong employee attitudes, Excellent client benefit, Large piece of the overall industry, Personal associations with clients, Leadership in item advancement, Highly productive, Minimal effort fabricating, High respectability.

Table 4

Weaknesses of the Marketing Strategy of BudgetLane as Perceived by the Customers

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Slow service on promotional sales due to insufficient number of employees.	2.90	Moderately Agree	1
2. Allowing other customers to suddenly appear and join the line midway.	2.55	Moderately Agree	3
3. Some products during promotional sales are expired.	2.51	Moderately Agree	4
4. Long period of time waiting due to unorganized queuing of customers.	2.76	Moderately Agree	2
Composite Mean	**2.68**	**Moderately Agree**	

Legend: 4.50 – 5.00 = Strongly Agree; 3.50 – 4.49 = Agree; 2.50 – 3.49 = Moderately Agree; 1.50 – 2.49 = Disagree; 1.00 – 1.49 = Strongly Disagree

Table shows the weaknesses in the Marketing Strategy of BudgetLane as Perceived by Customers. It was observed that respondents "moderately agree" that BudgetLane has "slow service on promotional sales due to insufficient number of employees" ranks first with the weighted mean of 2.90. Results also show that with lowest mean of 2.51, respondents moderately agree that "some products during promotional sales are expired" ranking last.

Weaknesses are the imperatives that block an organization's accomplishment a specific key way at the end of the day, what the organization does not do well. Run of the mill organization shortcomings may be: Inadequate meaning of client for item/advertise improvement, confusing administration approaches, too many levels of detailing in the authorities structure, limited item accessibility, lack of inclusion from top administration in building up another administration and lack of quantitative objective (http://frog-dog).

Table 5
Improvement in Marketing Program and Services

Indicators	Weighted Mean	Verbal Interpretation	Rank
Advertisement			
1. BudgetLane advertisements should capture best qualities of their products and services.	3.38	Moderately Agree	1
2. Budgetlane advertisements should convince to buy their products.	3.34	Moderately Agree	2
Composite Mean	**3.36**	**Moderately Agree**	
Services			
1. Service Representatives should be well trained.	3.71	Agree	4
2. Service Representatives should be well supervised.	3.78	Agree	2.5

3. Service Representatives should adhere to professional standards.	3.81	Agree	1

Table 5 continuation…

4. Service Representatives should act in the best interest of the customers	3.78	Agree	2.5
Composite Mean	**3.77**	**Agree**	
Customer Satisfaction			
1. I'm satisfied with the products of BudgetLane.	3.70	Agree	3
2. I was accommodated by customer service.	3.15	Moderately Agree	6
3. All problems have been resolved to my satisfaction.	3.51	Agree	4
4. Budgetlane products are better than other supermarkets.	3.49	Moderately Agree	5
5. BudgetLane advertisements should capture best qualities of their products and services.	4.12	Agree	1
6. Budgetlane advertisements should convince customers to buy their products.	4.05	Agree	2
Composite Mean	**3.67**	**Agree**	

Legend: 4.50 – 5.00 = Strongly Agree; 3.50 – 4.49 = Agree; 2.50 – 3.49 = Moderately Agree; 1.50 – 2.49 = Disagree; 1.00 – 1.49 = Strongly Disagree

Table 5 shows the Improvement in Marketing Program and services of BudgetLane, Batangas. It was found out that in terms of advertisement, "BudgetLane advertisements capture best qualities of their products and services" first and has 3.38 weighted mean, followed by "BudgetLane convince to buy their products"(3.34 WM).

With regards to services, it was observed that" service representatives adheres professionals standards" has the highest mean with 3.81 WM, followed by " service representatives are well supervised" and "service representatives act in my best interest" that are tied with a mean 3.78 WM. Having the lowest mean is "service representatives are well trained" with 3.70

In terms of customer satisfaction, obtaining the highest mean with 4.12 is "BudgetLane advertisements capture best qualities of their products and services", followed by "Budgetlane convince to buy their products." (4.05WM)

Having the lowest mean with 3.15 is "Contacted customer service", followed by "BudgetLane products are better than other supermarkets" with a mean of 3.49

Indicators purpose is to discuss the improvement in Marketing Program and services with regards to Advertisement, services and customers satisfaction.

Majority of the respondents agree that the marketing program and services of BudgetLane are effective. Based on the results, it can be said that BudgetLane needs to improve in their marketing program in terms of advertisement and customers' satisfaction.

As a result of intangible, multifaceted nature of many services, it may be harder to evaluate service quality than goods. Because customers cannot be separated from service delivery - process. Thus, most scholars were on the view that it as a major determinant to measure the customer satisfaction and some time as a determinant of customer loyalty too (Pathmini, M.G.S., et al., 2014).

Table 6
Level of Satisfaction in BudgetLane's Products & Services

Indicators	Weighted Mean	Verbal Interpretation	Rank
Overall Quality	3.88	Satisfied	2
Value	3.81	Satisfied	5
Usage Experience	3.84	Satisfied	4
After Purchase Service *(warranty, customer service etc.)*	3.90	Satisfied	1
Overall Quality	3.86	Satisfied	3
Composite Mean	**3.86**	Satisfied	

Legend: 4.50 – 5.00 = Very Satisfied; 3.50 – 4.49 = Satisfied; 2.50 – 3.49 = Moderately Satisfied; 1.50 – 2.49 = Slightly Dissatisfied; 1.00 – 1.49 = Moderately Dissatisfied

The table shows the level of satisfaction in BudgetLane's products. It was observed that "After purchase" ranks first with a total mean of 3.90, followed by "overall quality with 3.88.Having the lowest is "value" with a weighted mean of 3.81, followed by "usage experience" with 3.84.
The purpose of indicators is to determine level of satisfaction in BudgetLane's Products and services in terms of overall quality, value, usage experience, after purchase service and overall quality. Overall, customers are satisfied with the result, it can be said that BudgetLane is doing a great job in maintaining their clients satisfied.
Also, definitions of service quality revolve around the idea that it is the result of the comparison that customers make between their expectations about a service and their perception of the way the service has been performed (Pathmini, M.G.S., et al., 2014).

Table 7
Difference of Responses on the Level of Satisfaction in BudgetLane's Product When Grouped According to Profile

Profile Variables	F-value	p-value	Interpretation
Age	2.776	0.018	Significant
Gender	0.478	0.633	Not Significant
Civil Status	2.517	0.058	Not Significant
Proximity from the BudgetLane	0.015	1.000	Not Significant
Monthly Income	3.156	0.015	Significant
Frequency of Visit	1.979	0.069	Not Significant

Legend: Significant at p-value < 0.05

Based from the result, only age (0.018) and monthly income (0.015) shows significant difference on the satisfaction of the product in BudgetLane since the computed p-values were less than 0.05 alpha levels. Thus, the null hypothesis of the study under these variables is rejected. This means that the satisfaction of the

customers varies as to age and income. In addition, from the Post Hoc conducted it was found out that 21 to 25 years old and those who have monthly income of 11,000 to 15,000 have higher satisfaction level.
Only one in 10 consumers in the Philippines "quite dislike "grocery shopping the report added. Marge Martinez, Nielsen's associate director for retailer services in the Philippines, said grocery shopping is a way for Filipino consumers to "entertain themselves and spend time with their families" (ABS-CBN News, 2012).

6. Conclusions

1. Majority of the respondents belonged to the 21-25 age bracket, female married and their proximity from BudgetLane is 6-8 kilometers, with a monthly income of 11 000 – 15000 php. Majority of the respondents visit BudgetLane thrice or 3 times a week.
2. Majority of the respondents have agreed that BudgetLane always uses sales promotion such as discount promos, items with freebies, bundle sale as marketing strategy. They also offer Buy 1 get 1 deal and holiday sale at times.
3. Majority of the respondents moderately agree that greatest strength of the marketing strategy of Budgetlane is its very kind and accommodating employees.
4. Respondents moderately agree that BudgetLane presently have weaknesses in the marketing strategy such as; slow service on promotional sales due to insufficient number of employees, allowing other customers to suddenly appear and join the line midway, some products during promotional sales are expired, long period of time waiting due to unorganized queuing of customers.
5. Respondents moderately agree that BudgetLane advertisement should capture the best quality of their products and services.
   Majority of the respondents agree that several representatives should adhere to professional standards.
6. Respondents are satisfied with BudgetLane's products and services, specifically with after service (warranty, customer service etc.) obtaining the highest rank.
7. A significant difference exists on the level of satisfaction in BudgetLane's product when respondents are grouped according to age and monthly income. Therefore the null-hypothesis is rejected.
8. Plan of Action is proposed for implementation and evaluation.

7. Proposed Action Plan

Listed Proposed Action Plan to Enhance the Marketing Strategy of BudgetLane, Batangas is based on the mixed traditional and application of technology and innovations.

Plans, Programs, and Activities (PPA)	Strategies	Performance Indicators	Responsibility	Time Frame	Budget Requirements
Marketing Plan	• Hire marketing experts to create a plan that would create awareness among people from all walks of life about the products and services of BudgetLane. • Intensive Marketing Campaign on the internet and social media (Facebook, Twitter, Instagram, etc.) about certain promotions and product offerings. • Use of Billboards, leaflets, magazines & newspapers, direct mail, catalogues, outdoor and transit and radios in events/sale/product Promotions of BudgetLane.	Awareness of the customer to the BudgetLane's Marketing Program. Customers' are attracted and maintained.	Marketing Department of BudgetLane, Batangas Cooperative Members, Managers and Board of Directors,	3 Months 6 Months 3 months	P 13, 000 (Salary per month of marketing expert) P 10, 000 (Facebook, Twitter, Instagram) P 25, 000 (Billboards, Leaflets, magazines and newspapers)
Marketing Program Review and Assessment	Creation of Evaluation Team composed of Cooperative Members, Managers and Board of Directors to review the guidelines and Marketing Program, specifically to:	Problems Identified and solutions recommended to encourage customer's loyalty	Marketing Department of BudgetLane, Batangas Cooperative	2 Months	P 24,000 (Salary of Staffs per month)

Plans, Programs, and Activities (PPA)	**Strategies**	**Performance Indicators**	**Responsibility**	**Time Frame**	**Budget Requirements**
	1. Identify problems that discouraged customer's loyalty.	Programs offered by BudgetLane shall be utilized and availed by customers Established a long range plan as a result of a complete review of processes including developing and reviewing alternatives	Managers and Board of Directors,	1 Month	P 5,000 (Survey Questionnaires, Transportation)
	2. Review the applicability of current list of programs that can be implemented and recommend possible inclusion of new marketing strategy addressing the needs of the customers.			2 Weeks	P 5,000 (Printing, Token, Transportation)
	3. Assess the procedure and time involved from planning up to the release of funds to improve and strengthen the strategies for a timely and effective implementation of projects.			2 Weeks	P 5,000 (Printing, materials, Food, Transportation)
	4. Review existing marketing program and determine the reasonable advertisements that is needed to attract the customers for recommendation to the Marketing Department.			2 Weeks	P 5,000 (Printing, materials, Food, Transportation)

7. Recommendation

1. BudgetLane should enhance their advertisements online and in television to capture the interest of all ages. They should also post additional tarpaulins around Batangas City.
2. BudgetLane should increase their sales promotion techniques. In terms of promotional pricing, they should increase loss leader pricing which helps make up for the losses on highlighted products. In terms of point-of-purchasing, they should display more dump bins which is a great attention grabber and are ideal height to prompt consumers to take advantage of a deal. In terms of loyalty programs, BudgetLane should offer discount cards. This could quickly draw people into the store. They should also maintain and enhance offering sales promotion such as discount promos, items with freebies, bundle sale, etc.
3. BudgetLane should increase their employees' productivity to cope up with the service expected by the customers. Employees should implement strict rules and regulation on the counter to avoid sudden appearance of the customers on the line midway.
4. BudgetLane should create an Inventory Management System. Through this, the company itself can keep track if an item is out of stock and is already not consumable by a customer. Promoting a product reflects how the company would establish its reliability and trust to customers, and the company should never overlook this.
5. The BudgetLane needs Digital advertising; Digital advertising as turned into a noteworthy segment of current advertising methodologies. Regardless of whether your business is B2B or B2C, by actualizing computerized commercials accurately, you'll have the capacity to effectively develop your online nearness, and eventually encourage more changes and deals. Presently like never before, advanced promotions enable your organization to have greater deceivability all through a significantly more extensive group of onlookers. When promoting via web-based networking media, it's vital to revive your imaginative frequently so it is significant thus that clients aren't seeing a similar post more than once.
6. Employees of the company need seminars and training in order to obtain an organized work for a project. Through this, not only it will enhance the skills of the employees, but also strengthen unity and communication althrough out the project implementation. A good team work also defines a good production.
7. BudgetLane should maintain and enhance their customer satisfaction when it comes to products and services by implementing the said techniques that the researchers proposed.
8. The proposed action plan is recommended to enhance the marketing strategy of BudgetLane, Batangas may be applicable and assessed thereafter.
9. Future researchers may conduct the same study using other variables and larger sample size. They can also use IE Principles such as Project Management which is the utilization of information, aptitudes, instruments, and systems to extend exercises to meet the project requirements.

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Appendix A

STATISTICAL OUTPUT

Frequencies

Statistics

		age	sex	Cs	prox	mi	Tvbl	bl1
N	Valid	286	286	286	286	285	286	285
	Missing	0	0	0	0	1	0	1

Statistics

		bla	blb	Blc	bld	Ble	blf
N	Valid	286	286	286	286	286	286
	Missing	0	0	0	0	0	0

Frequency Table

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	23	8.0	8.0	8.0
	2.00	69	24.1	24.1	32.2
	3.00	59	20.6	20.6	52.8
	4.00	31	10.8	10.8	63.6
	5.00	47	16.4	16.4	80.1
	6.00	57	19.9	19.9	100.0
	Total	286	100.0	100.0	

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
pp1	286	1.00	5.00	3.5245	1.03505
pp2	286	1.00	5.00	3.5699	.95532

pp3	286	1.00	5.00	3.6014	.89552
Valid N (listwise)	286				

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MCU BASED PROTECTION SUIT FOR HUMAN FALL DETECTION WITH GPS LOCATOR

JOY MELEIN J. ARELLANO, BRANDON CARLO C. LORENZO, RYANN RAFAEL B. RAZON, EXEKIEL ANTHONY M. VERGARA, *EVELYN L. DE CASTRO

College of Engineering, Lyceum of the Philippines University,
LIMA Campus, Cuta, Batangas City, Philippines
*Corresponding Author: eldecastro@lpubatangas.edu.ph

Abstract

Accidental falls are inevitable. Falls are generally caused by a combination of factors that threaten one's ability to do his/her everyday routine and activities safely and securely. As humans mature, they will be exposed to more illnesses and physical problems. Some of them are stroke, muscle weakness, arthritis, cardiovascular and neurological disorders, and balance difficulties. The people that suffer from more than one of the said conditions at the same time are likely to have greater chance of falling. The proponents had come up with a prototype which will be a contribution and an advancement in the assistive technology. This project focused on the development of a system for fall detection where it will prevent people from getting intrinsic fall related injuries. It consists of different types of sensors that will be used for measuring the body's orientation and acceleration, which are located inside the inflatable vest. A module called microcontroller unit (MCU), is used to handle the processes. Protection suit is used to catch a person, protect him/her, and to lessen the force when hit on any hard surface. Inflation unit is for the deployment of the protection suit when the system pre-detects a fall. Global Positioning System (GPS) is for locating the place of fall, and Global Systems for Mobile Communications (GSM) technology for notifying registered relatives/family members about the fall.

Keywords: MCU, GSM, GPS, Assistive Technology, Human Fall

1. Introduction

Today, technologies and innovations are emerging fast and continuously. It improves the quality of life, making things simpler, better and faster. There are just many existing technologies, but still scientists and engineers continuously make ways to innovate and develop. Some technologies can be used for entertainment, but mostly serve as a great help and assistance to human, like assistive devices. Assistive and protective devices such as airbag for cars, arise to protect people from accidents. The importance of these devices is that these are not only contributors to technology, but is also a really helpful device in saving lives and preventing serious and fatal injuries.

Injuries have its intrinsic and extrinsic factors. Intrinsic factors are caused internally i.e. the human body such as loss of balance, while extrinsic factors are caused externally, and some examples are human error, hazardous equipment and environment.[1] The motivation of this research is to address the intrinsic factors in human falls.

Falls are generally caused by a combination of factors that threaten one's ability to do his/her everyday routine and activities safely and securely. As humans mature, they will be exposed to more illnesses and physical problems. Some of them are stroke, muscle weakness, arthritis, cardiovascular and

neurological disorders, and balance difficulties. The people that suffer from more than one of the said conditions at the same time are likely to have greater chance of falling.

Another risk factor is aging. As the human body ages, the bones and muscles become fragile and the regeneration abilities decrease dramatically. Bones are being more exposed to fractures as they become weaker, thus they become more severe and fatal when one slips or falls. "Globally, falls are a major public health problem. An estimated 646, 000 fatal falls occur each year, making it the second leading cause of unintentional injury death, after road traffic injuries. Over 80% of fall-related fatalities occur in low- and middle-income countries, with regions of the Western Pacific and South East Asia accounting for 60% of these deaths", according to World Health Organization. [2]

The proponents conducted an interview to three medical professionals. A Physical Therapist, Nurse and a Medical Doctor. According to the physical therapist, "the geriatric population are prone to falls due to some physiological changes such as decrease muscle mass and decrease strength. Balance and coordination are also deteriorating as we age thus resulting to fall if external challenges were encountered such as perturbations, wet floor surfaces and uneven terrain". Legarejos, A.(2017, May 10). Online Interview. Women and people who suffers from Alzheimer's disease are more prone to have accidental falls. Head is the most fatal part of the body while the pelvis is the most common one. Usually the elderly, our grandparents fall when they are about to sit so the pelvis is the part that is injured during fall, and this is according to the medical doctor. Reyes, C. (2017, June 3). Personal Interview.

The three professionals agreed that the age affects the body itself. The cells lose its ability to reproduce and regenerate more. Unused hormones make the organs brittle especially the bones. The most fatal part of the body likely to be injured is the head while the most frequent is the pelvis/hip. The interviewees said that it would be practical, useful and innovative if it will exist in market and delightfully said to the proponents that he will recommend the prototype if someday it will be released in the market. Vergara, E. (2017, June 3). Personal Interview.

This project focused on the development of a system for fall detection where it will prevent people from getting intrinsic fall related injuries. It consists of different types of sensors that will be used for measuring the body's orientation and acceleration, which are located inside the inflatable vest. A module called microcontroller unit (MCU), is used to handle the processes. Protection suit is used to catch a person, protect him/her, and to lessen the force when hit on any hard surface. Inflation unit is for the deployment of the protection suit when the system pre-detects a fall. Global Positioning System (GPS) is for locating the place of fall, and Global Systems for Mobile Communications (GSM) technology for notifying someone about the fall.

The proponents have used a protection suit that is wearable and comfortable to use to prevent the user from suffocation when it inflates.

This protection suit is exclusive for the people who have disorders and diseases who are prone to falls. Also, it is not recommended for physical activities with various and fast movements like exercising, for it can confuse the system as a real fall and trigger the protection suit to inflate even though it should not really be considered as a fall. Another limitation is the voice record cannot be heard from a far, because it is only a 0.5watt speaker. The inflatable vest may pop when a high pressure Carbon Dioxide cartridge is used than its limit. SIM808 for its GPS feature is limited to function within indoor places.

In summary, the proponents had come up with a prototype which will be a contribution and an advancement in the assistive technology with its purpose of protecting the elderly and those with disorders, disabilities and illnesses, from injuries caused by falls and for decreasing the severity and mortality of it.

2. Materials and Methods

2.1 Design Process

Embedded system is a large system which is built by combining the computer hardware and software, with a purpose of performing specific functions. Figure 1 shows the process of the embedded system design. It presents the sequential procedure and the basis in developing the designed project.

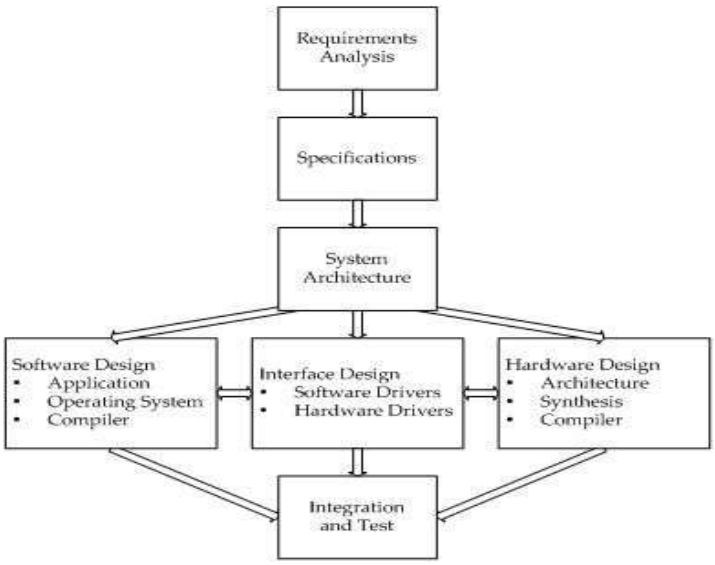


Fig. 1. Embedded System Design Process

In the requirements analysis phase, the proponents have determined the needs and conditions to meet for the development of the design project.

In the requirement's specification phase, the proponents have identified those requirements that the design must satisfy for it to be successful.

In the system architecture phase, the proponents have combined the software and the computer hardware, which is made possible because of Arduino IDE, operating system and compiler to convert the source code to a machine code for the communication of the software and hardware, and lastly with the use of software and hardware drivers.

2.2 Hardware Design

2.2.1Morphological Chart

Morphological chart was used as a technique in design to capture the necessary product's functionality and explore alternative means and combinations of achieving the desired functionality.[26]

Table 1. Morphological Chart for the Design of the Prototype

	Function	Means				
		1	2	3	4	5
1	Inflation Gas to the Protection Suit	Sodium Azide & Potassium Nitrate	Helium	Carbon Dioxide	Hydrogen	x
2	Sensors that will detect free fall	Accelerometer	Camera	Approximity	x	x
3	Sensors that will detect change in orientation/rotational velocity	Gyroscope	Camera	Approximity	x	
4	Triggering Device(inflation)	Solenoid Valve	Servo motor	DC Motor	x	x
5	Communication module	RF	GSM	Bluetooth	Wi-Fi	x
6	Locator Module	GPS	IPS	WPS	x	x
7	Microcontroller	Arduino	Raspberry Pi	AdaFruit	x	x
8	Cartidge	Refillable	Disposable	x	x	x

For each element of product function, there may be a number of possible solutions. The chart enables these solutions to be expressed and provides a structure for considering alternative combinations. This can enable the early consideration of the product 'architecture' through the generation and consideration of different combinations of 'sub-solutions' that have not previously been identified. When used appropriately, it can help to encourage a user driven approach to the generation of potential solution.[25] Morphological chart also helped the proponents visualize the materials that will help to assemble the best possible outcome of the project.

As shown in Table 1, the following are the means per function chosen by the proponents and the explanation why it was chosen:

1. Carbon Dioxide - the proponents have decided to use this gas, for it is the commonly used gas for inflation.
2. Accelerometer - to easily detect the sudden acceleration (value suddenly increased), instead of camera and proximity that will require calculation of the distance of the user to the ground
3. Gyroscope - to easily detect the user's changes in orientation, unlike the camera and proximity that will also require some calculations to know if the angle has changed.
4. DC Motor - so that the CO_2 will be released when a human fall is detected. It will twist the knob to open the valve of the inflator. Solenoid valves (Plastic) were not used for it cannot take the pressure of the CO_2

Cartridge.

5. GSM - it is easier to send an SMS rather than connect to a Bluetooth or Wi-Fi just to communicate, and lastly, RF is expensive.
6. GPS - it is commonly used to track location. GPS is for outdoor places, while IPS is for indoor which will not be suitable for the proposed design, and WPS may be expensive and hard to implement.
7. Arduino - it is the commonly used microcontroller for it is an open source. It is cheaper and practical to use than Raspberry Pi and Adafruit.
8. Disposable - It is the commonly used cartridge in the market. Refillable cartridges are only available in 12g used in airsoft guns.

2.2.2 System Block Diagram

A system block diagram is a diagram that shows the interactions, inputs received, and outputs produced by all the components used in the project.

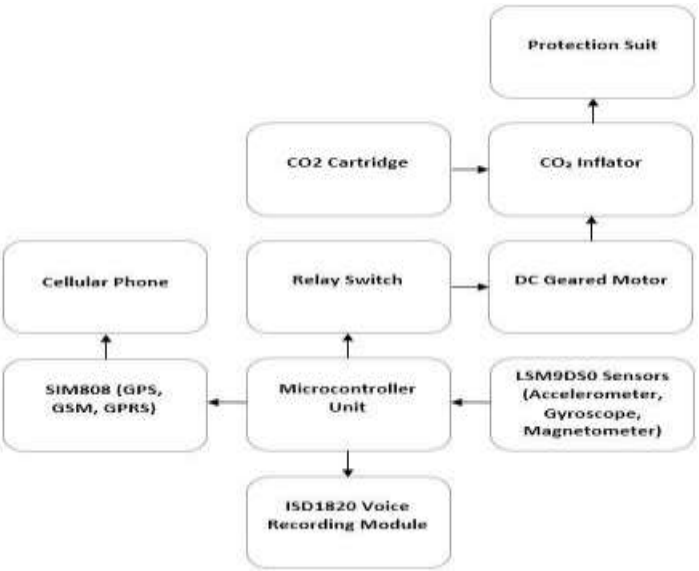


Fig. 2. System Block Diagram

Figure 2 shows the inputs, processes, and outputs made by each board or modules. As shown, the Microcontroller unit accepts values from LSM9DS0 and processes it. If those values met the set conditions, the Microcontroller Unit will send a signal to the relay switch which will close the circuit to supply power to the DC geared motor for twisting the knob and open the valve of the CO_2 Inflator to begin the protection suit inflation, ISD1820 voice recording module which will play the voice record, and SIM808 which will locate the place of fall and send an SMS notification with the coordinates.

2.2.3 Hardware Components

The figures presented are the components needed for the design together with their designated functions.

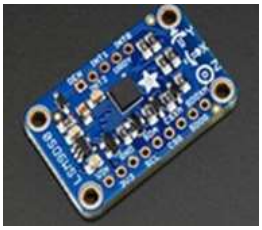


Fig. 3. Accelerometer / Magnetometer / Gyroscope Temp 9-DOF Breakout Board LSM9DS0 Adafruit

Figure 3 shows the board used by the proponents to measure the acceleration, orientation and direction of the user. When values of the accelerometer and gyroscope sensors exceeded the threshold values set, or when it detected a sudden acceleration and a change in orientation of the user, then the system will consider it as a fall, and then the inflation will now begin.

Fig. 4. Arduino Mega 2560 R3

Figure 4 shows the microcontroller used by the proponents as the main controller of their design project. It will accept all the values from LSM9DS0 Board (Accelerometer, Gyroscope, Magnetometer). When those values exceeded the threshold values set, Mega will begin to send a signal '1' to the Relay Switch, to the Voice Recording Module to play the voice record, and a signal for the SIM808 (GPS and GMS) to locate the place of the fall and send an SMS with its coordinates and a message notifying about the fall.

Fig. 5. SIM808 Module GSM/GPRS/GPS

The module shown in Figure 5 was used by the proponents to locate the place of fall by using its GSM feature, as well as the GSM feature which was used to send an SMS notification about the fall and its

coordinates to one or more phone numbers (which can be set at the program) of the relatives of the user.

Fig. 6. ISD1820 Voice Recording Module

The proponents used the module shown in Figure 6 to produce a voice seeking for help when there is a fall detection. It will play the 10-second voice record (or lower but not higher than 10 seconds, depending on the length of

the voice record.).

Fig. 7. DC Geared Motor

Figure 7 shows the device that was used in the design project to twist the knob to open the valve when a human fall is detected. The Relay Switch is the device responsible for closing the circuit, so that the motor will be supplied.

Figure 8. Relay Switch

Figure 8 shows the relay switch that was used by the proponents for the system to be able to electrically control the DC Motor. When a fall is detected and the MCU sends a signal to the Relay Switch, it will finally give the power supply needed by the DC motor to inflate the protection

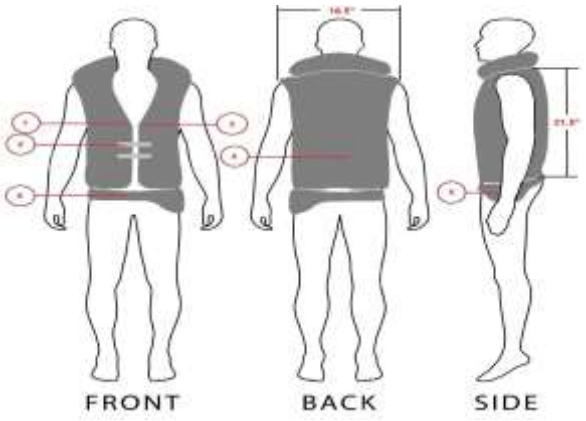
suit.

Fig. 9. CO_2Inflator

Figure 9 shows the valve used to store the CO_2 gas until its knob and valve is twisted and opened by the DC Geared Motor. If its knob and valve are twisted and opened, it will start releasing the CO_2 gas from the CO_2cartridge.

Fig. 10. CO_2Cartridges

Figure 10 shows the gas selected by the proponents for the inflation of the protection suit. These weigh 16 grams. It is then inserted into a CO_2 inflator with an opener, and when the CO_2 cartridge already has holes on it, the valve will be kept closed until a fall is detected and the DC geared motor twists the knob and opens it.



2.3 Overall design of the Protection Suit

Figure 11. Protection Suit Design

Figure 11 shows the protection suit designed by the proponents. Dimensions are given and numbered to indicate what materials are placed in that specific position.

1. LSM9DS0 Sensors (Accelerometer, Gyroscope, Magnetometer)
2. Adjustable Velcro straps
3. Speaker
4. Connecting air hose
5. Arduino Mega (MCU), DC Geared Motor, CO_2 Inflator and Cartridge, SIM808 Module, ISD1820 Voice Recording Module, Relay Switch and Power Supplies
6. Belt bag

2.4 Software Design

2.4.1 Flowchart of Fall Detection System

The flowchart explains the algorithm, workflow or process, of the proponents' design project showing the steps as boxes of various kinds, and their order by connecting them with arrows.

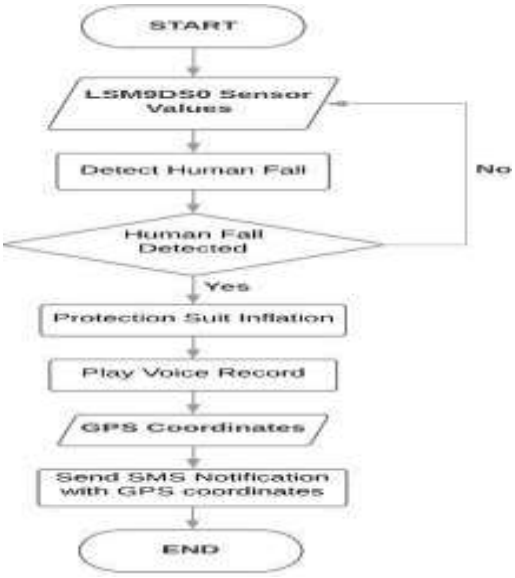


Fig. 12. Flowchart of Fall Detection System

As shown in figure 12, the system starts to get sensor values and processes it to determine a human fall. If a human fall is detected, the protection suit will inflate, the voice record will be played, the system will start to get GPS coordinates and lastly send an SMS notification with those coordinates. If no human fall is detected, then it will continue to get and process sensor values.

2.5 Interface Design

Interface design refers to the required drivers to run the software and hardware features of the design.

Software Drivers

1. DFRobot_sim808.h Library
   This library was included and used in the program to let the SIM808 perform its major functionalities which are to get GPS data and send text messages.
2. Wire.h Library
   This library allows one to communicate with I2C / TWI devices.
3. SPI.h Library
   This library allows one to communicate with SPI devices, with the Arduino as the master device.
4. SoftwareSerial.h Library
   The SoftwareSerial library has been developed to allow serial communication on other digital pins of the Arduino, using software to replicate the functionality.
5. Adafruit_LSM9DS0.h Library
   This library was included and used in the program to let the LSM9DS0 sensors perform its major functionalities such as detecting changes in acceleration and orientation
6. Adafruit_Sensor.h Library

A contract that every driver signs to make sure it plays well with other unified sensor drivers and programs that make use of the system. Anything that inherits from Adafruit_Sensor can obscure away almost all of its technical particularities, and instead present this common facade.

Hardware Drivers

1. Arduino Mega 2560 driver for Arduino
   The Arduino Mega 2560 driver is necessary for the computer to recognize and run the program written to the Arduino IDE.
2. Arduino Serial Monitor Driver
   The Arduino Serial Monitor Driver is necessary for the computer to display outputs dependent on the program written to the Arduino IDE. With the serial monitor, the proponents could see and verify the outputs if they are correct.

3. Experiments

3.1 Powering an LED based on Sensors - Adafruit LSM9DS0 Board

The LSM9DS0 is a versatile, motion-sensing system-in-a-chip. It houses a 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer – nine degrees of freedom (9DOF) in a single IC. Each sensor in the LSM9DS0 supports a wide range of…ranges: the accelerometer scale can be set to ± 2, 4, 6, 8, or 16 g, the gyroscope supports ± 245, 500, and 2000 °/s, and the magnetometer has full-scale ranges of ± 2, 4, 8, or 12 gauss. The objectives of the experiment are;

- To compare the LSM9DS0 values with the sample threshold values
- To determine which combination of values will trigger and change the status of an LED

Threshold values for: Accelerometer: <10 (when a person starts falling, the acceleration decreases from 1 g to around 0.5 g (perfect free fall (9.8) is never achieved) [44], Gyroscope: >50, Angle (Θ) > 145

Table 2. Accelerometer, Gyroscope and Θ values

Test No	Accelerometer value	Gyroscope value	Angle (Θ)	LED Status
1	9.23	41.46	147.23°	LOW/OFF
2	10.87	59.31	101.67°	LOW/OFF
3	10.38	47.92	117.32°	LOW/OFF
4	8.65	74.75	130.58°	LOW/OFF
5	7.94	62.23	152.74°	HIGH/ON

Table 2 shows that the LED Status is only ‘HIGH/ON’ if all the accelerometer, gyroscope, and Θ values met the set parameters, if not, then the LED status is ‘LOW/OFF’. ‘HIGH/ON’ indicates that the LED will light, and ‘LOW/OFF’ will not.

3.2 Getting GPS Data and send it through GSM - SIM808 Module GSM/GPRS/GPS

SIM808 module is a complete Quad-Band GSM/GPRS module which combines GPS technology for satellite navigation. The compact design which integrated GPRS and GPS in a SMT package will significantly save both time and costs for customers to develop GPS enabled applications. Featuring an industry-standard interface and GPS function, it allows variable assets to be tracked seamlessly at any location and anytime with signal coverage. The objectives of the experiment are;

- To get GPS Data through GPS feature of SIM808
- To know the GPS status when it comes to indoor and outdoor places
- To send an SMS with GPS Data through GSM feature of SIM808

Table 3. GPS, GSM and SMS Functionality

Test No.	Location	GPS Status	Coordinates	GSM Status	SMS Status
1	Indoor	Unavailable	N/A	Available	Sent
2	Outdoor (Rizal Ave Ext.)	Available	13°45'24.5", 121°03'07.1"	Available	Sent
3	Outdoor (Catalina Vill., Lipa)	Available	13°56'49.4", 121°07'54.5"	Available	Sent
4	Outdoor (LIMA Campus)	Available	13°44'38.58", 121°03'15.6"	Available	Sent
5	Outdoor (Cuta, Batangas City)	Available	13°44'45.6", 121°03'08.9"	Available	Sent

Table 3 shows that the accuracy of the GPS feature of SIM808 module depends on the location. Usually, GPS Status will be 'Available' for outdoors, and 'Unavailable' for indoors. It also shows that the status of the GSM feature of SIM808 module is 'Available' whether it is indoor or outdoor, and that it is able to send an SMS anywhere.

3. Controlling the DC Geared Motor to twist the knob of the CO_2 inflator using Relay Switch

DC Geared Motors can be defined as an extension of DC motor. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction.

At the first sight, the external structure of a DC geared motor looks as a straight expansion over the simple DC ones. The lateral view of the motor shows the outer protrudes of the gear head. A nut is placed near the shaft which helps in mounting the motor to the other parts of the assembly. Also, an internally threaded hole is there on the shaft to allow attachments or extensions such as wheel to be attached to the motor. The objective of the experiment is to;

- To control the DC Geared Motor to be able to twist the knob of the CO_2 inflator using Arduino UNO and Relay Switch

Table 4. DC Geared Motor Functionality

Test No	Relay Switch Status	Motor Status	CO_2 Inflator Knob after 1s	Motor Status after 1s	CO_2 Inflator Knob after 1s
1	1 (HIGH)	Spinning	Open	Not Spinning	Open
2	0 (LOW)	Not Spinning	Closed	Spinning	Open

Table 4 shows the status of Relay Switch, Motor and CO_2 Inflator Knob initially and after a few seconds. The status of the motor depends on the initial status of the relay switch, whether it will spin or not. The first test shows that when the relay switch status is 'high', the motor will spin and open the inflator knob, and the motor will stop spinning after one second. The second test shows that when the relay switch status is 'low', the motor will not spin, but will spin and be able to open the inflator knob after one second.

3.5 Automatic Inflation using LSM9DS0 and DC Motor

Inflation is the process of expansion of air in a closed space. It can be used in different things in life hot air balloon, air bed etc. Inflation can save lives. It can be used as an instrument to save a person from falling and make someone float. But in this experiment, LSM9DS0 sensors (accelerometer, gyroscope and magnetometer), CO_2 inflator and cartridge, and a DC motor will be used to inflate a vest automatically. The objectives of the experiment are;

- To be able to inflate a vest automatically using LSM9DS0 sensors and a DC motor to twist the CO_2Inflator knob.
- To determine the time in milliseconds it takes to activate the automatic inflation system.

Acceleration must be less than 9ms, orientation values must be more than 40 and angle must be 30-45° / 145-160° to activate the inflation.

Table 5. Automatic Inflation

Test No	Acceleration(ms^2)	Orientation	Angle	Time before inflation (ms)	Inflated (Inflation Status)
1	8.654	63. 217	46.5°	.357	YES
2	8.081	55.108	148.1 °	.421	YES
3	9.274	50	90.78 °	-na	NO
4	10.567	48.07	88.31 °	-na	NO
5	8.014	47.115	48.91 °	.471	YES
6	7.479	39.42	70.21 °	-na	NO

Table 5 shows that when at least one parameter among the three condition was not met, the DC motor will not twist the CO_2 inflator knob, but when all of the set parameters are met, automatic inflation will begin. It also shows the time before the inflation starts. 'YES' means that an inflation has occurred for the conditions are met, and 'NO' means that no inflation has occurred.

4. Results and Discussion

4.1 Hardware Development

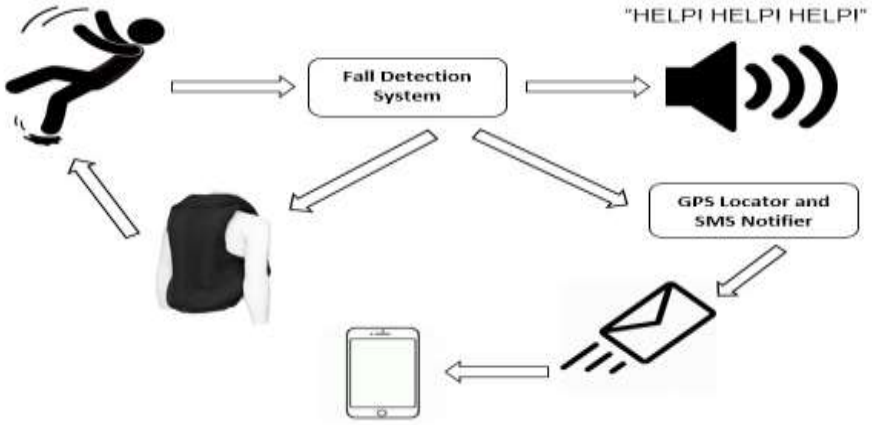


Fig. 13. Operational Design of the Project

Figure 13 shows the operational design of the project. When a human fall occur, fall detection system will trigger all the major functions such as the protection suit inflation, voice record playing, GPS Locator and SMS Notifier.

Fig. 14. Protection Suit (Front)

Fig. 15. Protection Suit (Back)

Shown in Figures 14-15 shows the protection suit itself with the inflatable vest inside it.

Figures 16-17 shows the different components located inside the belt bag. It consists of the Microcontroller Unit (Arduino Mega), the main controller of the system, SIM808 module for GPS and GSM, Voice Recording Module and Speaker for the "help me" feature, and the Relay Switch for controlling the DC geared motor for inflation.

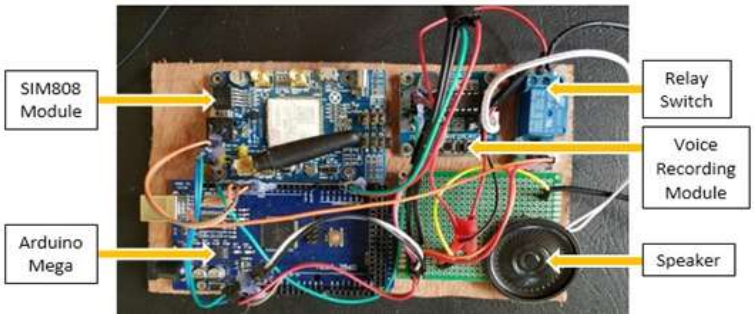


Fig. 16. Components inside the Belt Bag

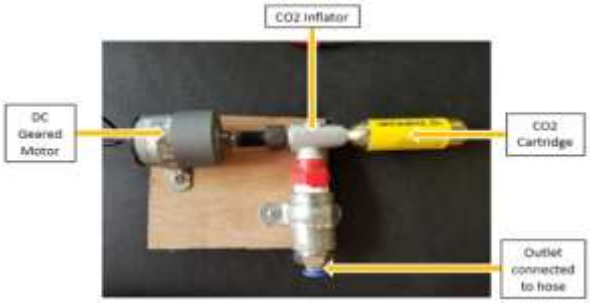


Fig. 17. Components inside the Belt Bag

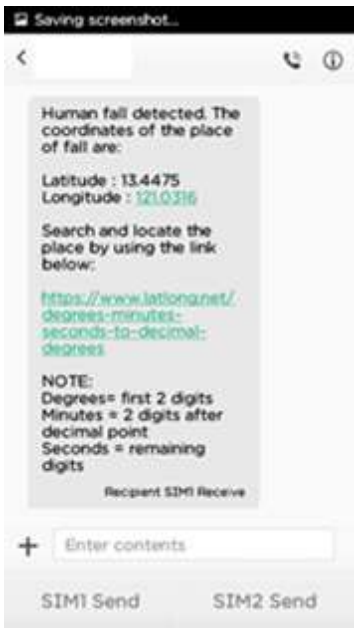


Fig. 18. SMS Notification

The proponents included an SMS notification feature to their design which will notify a relative when a fall occurs, GPS coordinates(latitude, longitude) are sent as well with a link and a note on how to use those coordinates for conversion and to locate the place of fall, as shown in Figure 18.

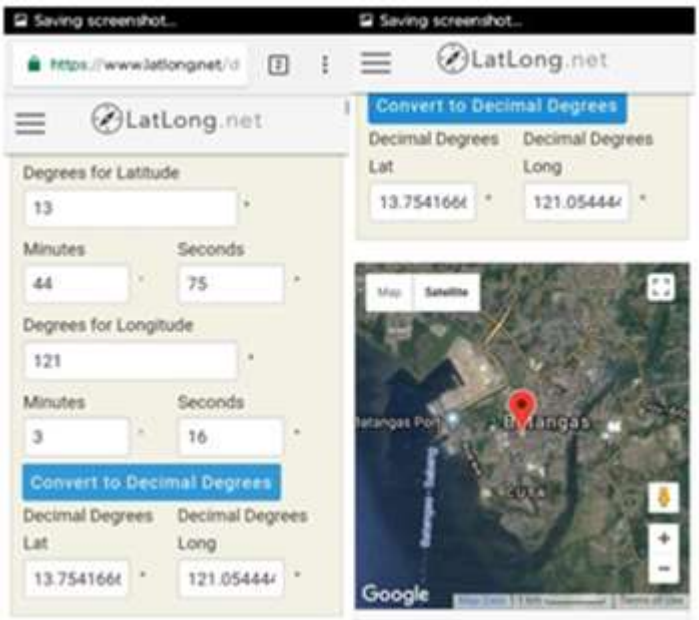


Fig. 19. GPS Coordinates Conversion and Map Viewing

As shown in Figure 19, the link given in figure 18 was used to convert the GPS coordinates(latitude, longitude) to decimal form and locate those coordinates. The red pointer in the map indicates the location where the fall occurred.

5. Conclusions

The design project aimed to develop an "MCU Based Protection Suit for Human Fall Detection with GPS Locator". It was designed to protect those that are prone to falls such as people with disabilities, diseases, and especially the elderly. After documenting and building the prototype of the system, the proponents concluded the following:

1. The proponents have been able to determine the causes and effects of fall-related injuries and fatalities by reading articles and studies about it, by researching about fall detection and collecting useful information from other research. The proponents also conducted interviews from professionals in the medical field about falls in the elderly.
2. The proponents were able to know the sensors that can detect sudden acceleration and change in orientation, as well as the GPS for navigation and the GSM for SMS notification, and their operations by reading books and surfing the internet. The proponents applied these learnings by using them as a guide in building the prototype.
3. With the use of microcontroller, different boards and modules combined with software, and the knowledge gained and information gathered from existing designs that are related to their research, the proponents were able to design an MCU Based Protection Suit for Human Fall Detection with GPS Locator which they based on the engineering requirements.
4. MCU Based Protection Suit for Human Fall Detection with GPS Locator functioned well for it met the desired functionality after the unit testing, integration testing, acceptance testing and evaluation.

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IMPACT OF FACILITIES ON PRODUCTIVITY AND CUSTOMER SATISFACTION: BASIS FOR IMPROVEMENT IN LAYOUT DESIGN IN VIAJEROS CORNER CAFE

ABRENICA, MARC ABRENICA M., CARANDANG, ANGELOU M., ILLESCAS, JODRELL C., SORIAGA, ANNFRED G., TAVUL, JOANNE HELDA, BELEN, RICA MAE W. AND DIPASUPIL, MARIA CECILIA S.

College of Engineering, Lyceum of the Philippines University, Capitol Site, Batangas City, Philippines

Abstract

The main objective of the study was to assess of the impact of facilities design on productivity and customer satisfaction in Viajeros Corner Café (VCC). More specifically to; describe the profile of respondents as to: age, sex, customer or employee, academic background, length of service; determine the impact of shop design & facilities in VCC; asses the customer satisfaction about facilities layout; determine the common productivity challenge in kitchen design; determine an ideal kitchen design; test the significant difference in the customer satisfaction from shop design and facilities when grouped according to profile; recommend an action plan by proposing an ideal facility layout design. The researchers used descriptive method of research wherein the quantitative data were gathered using a survey questionnaire which used Slovin's formula having an ideal and common marginal error of 5% to get the 147 customers and 4 workers respondents. The researchers found out that and was able to describe the profile of respondents according to age, sex, whether they are customer or employee; their academic background and the employees' length of service. For VCC, there are identified different facilities design that impacts the customer satisfaction and are ranked as first - entertainment; second- total ambiance of the place/shop and third - interior decoration. The only unsatisfactory result encountered as a facility error is the availability of parking. The assessment of the customer satisfaction with regards to facilities layout resulted as satisfactory were ventilation, arrangement of chairs and tables, good ambiance and lighting. Spacing of aisle is neither satisfactory nor unsatisfactory. The researchers also determined the effects of the facilities design and layout on the employees which resulted as satisfactory on kitchen layout in effect on their good productivity. While when it comes to common productivity challenge in kitchen design and facilities, the employees are neither satisfied nor not satisfied therefore there is neutral among the challenges and the employees. Testing the significant difference in the customer satisfaction from shop design and facilities when grouped according to profile resulted in a significant difference on customer's age. The researchers also conduct observations and interview to determine the current facilities layout in Viajeros Corner Café. The given information was treated with confidentiality for the said café. Given the result and findings, as the basis of the researchers to give their design recommendation.

Keywords: Facilities design, Productivity, Customer Satisfaction

1. Introduction

There is overwhelming evidence to support the idea that productivity of staff is significantly affected by facilities design. The British Institute of Facilities Management defines this as: The processes that maintain and develop an organization's services to support and improve the effectiveness of its primary activities. Viajeros Corner Café aims to learn and develop this with means to be able to partake to this role in our society.

There has been a great deal of research exploring the relationship between facilities design and productivity. Taking a closer look at how facilities layout links with productivity, there are many little-known aspects that contribute to the productive workplace.

As well as having the potential to directly improve productivity; facilities design influences several other areas of employees' lives that together contribute to the overall output of a company. Research by Sodexo revealed that facilities management can help to enhance social interaction among colleagues and increase ease of efficiency in day-to-day tasks. This shows that good practice is crucial for employees to be able to work in a motivated, focused and effective manner.

It is clear that facilities managers have an important part to play in improving productivity, including deciding on the best products and solutions to introduce into the work environment. As part of their critical decision-making role, seeking out products and solutions intended to boost employee productivity is key. (Rexel, 2015) Moreover, it is known that one of the goals of corporate culture is to retain and satisfy both the current and past customers.

Customer satisfaction is considered to be a key element for a company's success in the market; a leading criterion in determining the quality of service or product to the customers; and it is also crucial for organizational survival. Results of customer satisfaction measurements provide significant information for modern management processes and a warning signal about future business results. This enables an understanding of how customers perceive the organization, i.e., whether its performance meets their expectations, identifies priorities for improvement, benchmarks the performance of the organisation against other organisations and increases profits through improved customer loyalty.

As of 2017, Viajeros Corner Café still struggles to increase their numbers of customer considering that customer satisfaction is part of the key element for the café's success and development. With low-level of customers, staff productivity can deal great effect to the Café's development. The impact of facilities layout is being considered in this study.

Viajeros Corner Café (VCC) was first established in 2015, located in National Highway San Jose Batangas. The original concept was a Travel & Tours Office and Payment Center. The concept was patterned to the travel agency business. Initially offering snacks and promotes their travel and tours business. Few months after, they reintroduce their business into a café and focus on selling various delicious meals, i.e., pasta, burgers, pastries also beverages including coffee drinks, cocktails, punch and hot beverages. It became common luxury spot for the

people in their area and for by passers. The Corner Café delivers comfort and relaxation, entertainment, research purpose, and can be a good socialization to local customers. 2 years now into the business, the Corner Café aims for the betterment and reach to achieve their goal.

The researcher, being industrial engineering student that studied Facilities Planning and Design deemed it necessary to assess the impact of facilities layout on productivity of staff granted by the Viajeros Corner Café (VCC) and proposes strategies to improve the system layout of their facilities. Identifying the suitability of present facilities design of the corner café and correlating it to the satisfactory of customer is also an object of this research. In doing so, an action plan can then be considered to increase the productivity utilization for the betterment of the operational and customer service.

Problems in Facilities

While gathering the survey questionnaire the researchers determine the problem on facilities on VCC encountered by the customers through oral interview and observation. These are the lack of sufficient signage or road visibility, insufficient parking space for the customers who brought car on the café, and the major problem for the customers that is having a narrow aisle space on the dining area going to cashier as well as comfort room. The researchers focus on these problems and find conclusions and recommendations in this study.

2. Conceptual Framework

Figure1.1 shows the conceptual paradigm of the study. The input focused on the data that were acquired from the questionnaire. The process pertained to the data collection and analysis using Analysis of Variance (ANOVA). Based from the data interpretation, the researchers formulate recommendation on facilities to be improved on Viajeros Corner Café.

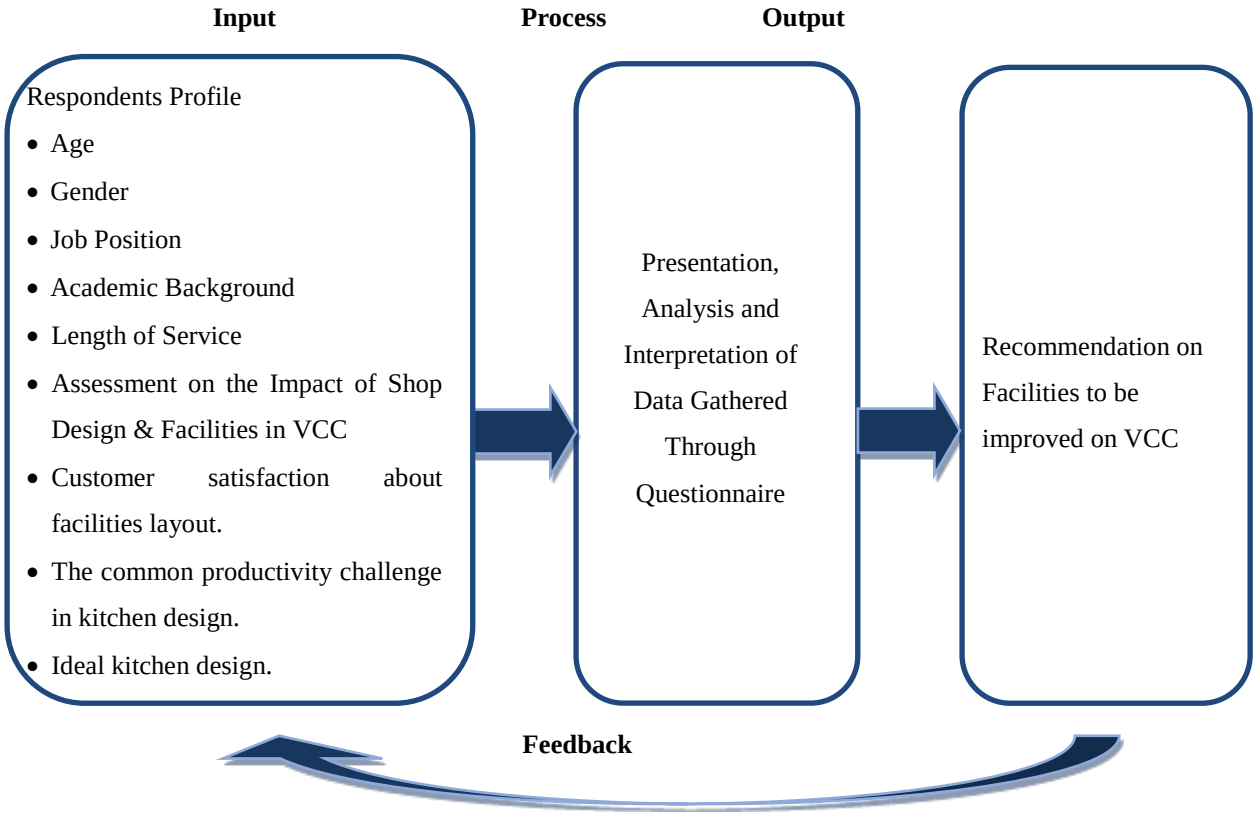


Figure 1.1 Conceptual Paradigm

3. Literature Review

Facility Management

The International Facility Management Association (IFMA) defines facility management as a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology. From this definition, we understand facility management to be the coordination of a facility's operations meant to make the organization as a whole more effective at what it does.

Facilities on Workers Productivity

The workplace environment has a direct impact towards the employees' productivity both positively and negatively. If the workplace environment can arrange in a better way it will contribute to increase the productivity of the employees. But on the other ground when the arrangement of office environment is not up to a standard it will decrease the employees' productivity. Better

outcomes and increased productivity is assumed to be the result of better workplace environment. Better physical environment of workplace will boost the employees and ultimately improve their productivity.

Facilities on Customer Satisfaction

Customer satisfaction can be defined in terms of meeting the expectations of the customers, in terms of parameters associated with satisfaction (Malik & Ghaffor, 2012). Companies win or lose based on what percentage of their customers they can keep. Success is largely about the retention of customers. In today's restaurant market an entrepreneur has to be innovative and stand out from what market has to offer, and to be able to do so have to provide not only good products and service, but also a unique dinning environment to contribute to the overall customer satisfaction (Liu & Jang, 2009a).

Physical environment of the restaurant has a great influence on the image of the restaurant and can act positively or negatively for the customer perception of the restaurant image, but the physical environment is not significant in the customer perceived value. Physical surrounding has to be maintained throughout the time and changed or improved according to the customer's wants and the restaurant image to keep up with the trends on the current market (Ryu, Lee, & Kim, 2010).

The facilities management has a range of duties with several organizational goals in mind one of these include boosting productivity. There has been a great deal of research exploring the relationship between facility management and productivity. As the International Facility Management Association (IFMA) says, FM is "a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology" (International Facility Management Association, 2011). In other words, it is the practice of coordinating the physical workplace with the people and work of an organization: it integrates the principles of business administration, architecture, behavior and engineering science (Pitt, Tucker, 2008).

Layout design of restaurants is planned to be a resource for professional hospitality, architectural and interior designers, architectural students and professional designers which are dealing with design projects. Although professional designers, who wish to know more about the food service design process, should beginning with design principles and layout design. To realize the best physical arrangement of layout design, designer must think about the type of the restaurant and important factors of the layout and choose the most acceptable layout for each restaurant. The best method for improving the space organization and quality is connecting and placing the functions in terms of acceptable layout design in restaurant plan. Several advantages of layout design are gained from a correctly planned and designed organization for both users and staffs. As a result, professional designers realize that layout design is as important as other factors in designs like interior design. In fact, the professionals make efforts to creating an appropriate restaurant layout.

A cross sectional survey was conducted to assess the impact of kitchen layout on employees' productivity. A purposive sampling technique was used to select 90 respondents from three (3) company kitchens in the Takoradi Metropolis of Ghana. The samples included all kitchen staff irrespective of their gender, age and position.

The proximity of the serving point to the guest seat should be proportional. Therefore, it is important to emphasize on the proximity between kitchen and dining area. According to the observation and preferences of costumers, there is a proper proximity between kitchen and dining area. If this proximity increase or decreases, this can cause some disadvantages. If the proximities become too short or too close to each other, this creates uncomfortable situation for both costumers and staff. For example, if kitchen in the restaurant is too close to the dining area, this can make costumer an unpleasant situation, like the smell of food, heat, noise and crowd. On the other hand, if the proximity of these functions becomes too long, again can cause some other issues like, ordering and service problem (cold & late food that make costumer unsatisfied), make staff tired, flow problem and crowd. Therefore, a proper proximity can make both costumer and staff satisfy, which can change according to some factors like urban area, location, weather, type of restaurants, kind of food, number of costumers, traffic etc. (Almanza & Kotschevar, 2007).

Gagić et al. (2013) identified four dimensions of restaurant quality: Food quality, service quality, physical environment and price fairness. Canny (2014) used three dimensions to measure dining experience: Food quality, service quality and physical environment. Saraiva et al. (2011) developed a study to measure customer satisfaction using the following dimensions: Menu, price, waiting time, staff service, hygiene quality and the internal and external environment. Surapranata and Iskandar (2013) evaluated the service quality of a family restaurant in Indonesia using the SERVQUAL dimensions, i.e. tangibles, reliability, responsiveness, assurance and empathy.

Physical interior environment are one of the major issue that have been continuously debated and discussed in order to create a better design and attraction to the users according to McCabe & Kennedy (2008). The physical environment encompasses both architectural elements such as physical layout, furniture, and equipment and visual sensory elements such as color, texture, and lighting. These two aspects, in conjunction with ambient factors, create the interior environment. (Bitner M. J., 2008). In an upscale restaurant, for example, patrons expect well-prepared food and attentive service, but they also expect comfortable seating, mood-setting lighting, pleasant or luxurious décor, soothing music, and an opportunity for social interaction. In these situations, the emotional components of the service setting become more important and can strongly influence the consumer's ultimate assessment of the quality of the service as a whole. (Jiang, 2008).

Layout design is basically the arrangement of machines or workstations at production floor to provide smooth movement of resources such as raw materials and workers. An effective layout design is important for good manufacturing of products or delivery of services (Drira et al., 2007).

Flow line is a layout that designs according to the sequences of process that need to be performed in order to produce a product. Usually, in a flow line, all jobs are processed by the same set of machines in linear fashion, from the first to last stage and one machine performs all the processing for each stage (Kurz and Askin, 2007). Therefore, each product type will have its own line and it is usually designed to produce a large number of outputs. The major concern in designing a flow line is to evenly distribute the total work of the line into relating workstations so that the bottleneck can be eliminated to improve the layout

efficiency. Apart from that, optimal workers' distribution plan is also important for the increased flow-line throughput and managed workload (Neubert and Savino, 2009). The latest researches on flow-line layout show the usage of simulated annealing-based approach (Arumugam et al., 2007; Laha and Chakraborty, 2010) and genetic algorithm (Besbes et al., 2010) in optimising the layout.

Researchers also gathered insights that helped them identify ways to design workplaces that would make people feel better about going to work every day, and not just to do their assigned work but really strive for a job well done.

According to study that is done in restaurant industry, important drivers for customer experience are people or employees that interact with customers, core service, more exactly the food that is served to the customer and physical environment of the restaurant (Walter, Edvardsson, & Öström, 2010).

As part of the study, as Heragu (2009) stated that personnel decisions impact design of support departments such as parking lot, restrooms (RRs), locker rooms, and cafeteria. Governmental regulations and company policy specify these support departments.

According to research of Alisha Desai, 2011 specific design choices support cafés ultimate goal of customer satisfaction. Atmosphere is of central concern. Depending on location and the target population, color, lighting, and music are manipulated. As customers desire comfort when settling down in cafés, the implementation of lounge chairs is beneficial. On the other hand, some prefer more rigid seating as they intend to focus on work. Therefore, a mix of furniture that can accommodate for different customer's wants and needs proves most successful. To account for privacy the visual accessibility and acoustic of the space should be considered. Finally, designers can meet the goal of creating a sense of belongingness by taking into account the elements of hominess and stimulation. The goals of cafés can most easily be met through detailed design layouts. The layout and design of the kitchen is based on efficiency of product flow through the food service system (Rodgers, 2007). Poor kitchen layout can limit the number of individuals who can work efficiently. It may require time-consuming trips to distant storage areas to obtain food items or dishes. If the layout of the kitchen is too spread out, the minimum staff needed to operate each station may increase.

Kitchen generally located between storage and dining area. Kitchen itself is divided into different sub areas like storage (dry storage and cold storage or refrigerator), preparation area, ware-washing area, cooking and final preparation, fabrication area each of these areas should be designed carefully according to the requirements in the menu (Arora, 2007). One of the key for designing a successful restaurant is to minimize the cross between customers flow pattern. Generally, flow patterns are available for customers, staffs, tableware, food and services and it should be considered in first steps of design programming. The flow planning also should be considered in entrance and parking area as well. "An important goal of VE (Value Engineering) is to optimize flow in terms of proximity, volume, speed and direction" (Durocher, 2010).

4. Methods

The data gathered were tallied and treated with set of statistical tools. The tools included frequency distribution, weighted mean and were tested using one way ANOVA which were used based on the objectives of the study. Weighted Mean was the over-all average of the responses of perceptions of the respondents. In the study, this was used to determine the assessments on customer satisfaction and workers' productivity on VCC's facilities design assessments using a five point scale with 1 as lowest to 5 as highest. ANOVA was used to determine significant difference in the assessment of company's workers toward the impact of facilities on productivity and customer satisfaction according to profile variables. One-Way ANOVA was used because there was just one categorical factor.

5. Results and Discussion

Table 1.1

Percentage Distribution of the Customers' Profile

Profile Variables	Frequency	Percentage (%)
Age		
16 – 20	35	23.80
21 – 25	53	36.10
26 – 30	22	15.00
31 – 35	7	4.80
36 – 40	10	6.80
41 – 45	16	10.90
46 – 50	3	2.00
51 and above	1	0.70
Gender		
Male	61	41.50
Female	86	58.50
Professional Background		
College Undergraduate	69	46.90
Bachelor's Degree	52	35.40
Master's Degree	18	12.20
Vocational (2yr. course)	8	5.40

Table 1.1 shows the percentage distribution of the customers' profile according to age, gender, professional or educational background.

In the age profile it reveals that most of the customers going to VCC range from ages 21-25 (36.10%) and for ages 51 and above, having the least percentage (0.70%) who visits VCC. In gender profile it shows the different results for male and female; female having higher percentage than male. It only means that female having 58.50% percentage have a lot of time to visits VCC rather than male who only got 41.50% of the population. For the professional background category, there are four choices. It seems that the highest population who pays to visit VCC comes from the college undergraduate having 46.90% which is almost half of the population in VCC. Having the least population (5.40%) who visits VCC comes from who take up vocational courses.

Table 1.2

Percentage Distribution of the Employees Profile

Profile Variables	Frequency	Percentage (%)
Age		
21-25	2	50.00
36-40	1	25.00
51 and above	1	25.00
Gender		
Male	2	50.00
Female	2	50.00
Professional Background		
College Undergraduate	3	75.00
Bachelor's Degree	1	25.00
Job Position/Title		
Chef	1	25.00
Assistant Cook	1	25.00
Service Crew	1	25.00
Cashier	1	25.00
Length of Service		
0 – 6 months	2	50.00
7 – 12 months	2	50.00

Table 1.2 shows the results of percentage distribution of the employees' profile of VCC according to age, gender, professional background, job position/title, length of service. Profile age shows the gradual representation of age differences ranging 21-25, 36-40, and 50 above years of age. Sex shows the equal or balance number of employees for male and female. Professional background shows the gradual differences of college undergraduate and bachelor's degree.

The result indicates three or 75% of the workers are college undergraduate and the remaining 25% have a bachelor's degree. The employees' job position/title shows equal or balance for each job positions. Their length of service shows a divided rating of employee respondents to VCC with 50% working from 0-2months and 50% working from 7-12 month. Age ranging from 21-25 have the highest percentage rating of VCC workers at 50%. Employees if VCC have a balance rate in accordance to sex; two females and two males.

Table 2

Impact of Shop Design & Facilities

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Signage or road visibility	2.83	Neither	7
2. Parking	2.46	Unsatisfactory	9
Continuation of Table 2			
3. Menu boards outside the shop	2.75	Neither	8
4. Cleanliness of the surroundings and within the shop	3.75	Satisfactory	4
5. Floor plans like wait stations, bar setups, and table configurations	3.54	Satisfactory	6
6. Interior Decorations	3.84	Satisfactory	3
7. Bathroom	3.67	Satisfactory	5
8. Entertainment	4.27	Satisfactory	1
9. Total ambiance of the place/shop	3.97	Satisfactory	2
Composite Mean	3.45	Neither	

Legend: 4.50 – 5.00 = Very Satisfactory; 3.50 – 4.00 = Satisfactory; 2.50 – 3.49 = Neither; 1.50 – 2.49 = Unsatisfactory; 1.00 – 1.49 = Very Unsatisfactory

A result on table 2 presents the impact on shop design and facilities as neither satisfactory nor unsatisfactory observed in its composite mean (3.45). This was observed as when its composite mean range between 2.50 to 3.49.

Nine indicators were utilized in determining the impact of shop design and facilities as per road visibility, parking, menu boards, cleanliness, floor plans, interior décor, comfort rooms, entertainment, and total ambiance of the café.

Entertainment is ranking first on satisfactory to impact on facilities with weighted mean on 4.27. Rank 2, the impact of facilities design was the total ambiance of the café. This was followed by the interior décor in rank 3. There were indicators that the facilities design was unsatisfactory particularly for parking. Two indicators were neither satisfactory nor unsatisfactory particularly for road visibility.

Heragu (2009) stated that personnel decisions impact design of support departments such as parking lot, restrooms (RRs), locker rooms, and cafeteria. Governmental regulations and company policy specify these support departments. For example, local, state, and federal government regulations may dictate the location of parking lots, fire exits, and location and number of RRs. Productivity and cost considerations may dictate whether or not cafeteria services is provided. Although a company may incur more fixed costs as a result of providing cafeteria service due to increased heating and maintenance, it may increase productivity because workers dine as the same place and have a chance to talk about work-related problems. (Facilities Design, Third Edition, Sunderesh S. Heragu, June 19, 2008)

Table 3

Customer Satisfaction

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Ventilation	3.89	Satisfactory	2
2. Arrangement of chairs and tables	3.81	Satisfactory	3
3. Spacing of aisle	3.39	Neither	4
4. Good ambiance and lighting	4.14	Satisfactory	1
Composite Mean	3.81	Satisfactory	

Legend: 4.50 – 5.00 = Very Satisfactory; 3.50 – 4.00 = Satisfactory; 2.50 – 3.49 = Neither; 1.50 – 2.49 = Unsatisfactory; 1.00 – 1.49 = Very Unsatisfactory

Table 3 indicates a verbal interpretation for customer satisfaction as satisfactory with a composite mean of 3.81. In all the four indicators, majority of the customer satisfaction interpretation were satisfactory, giving only uninterrupted as neither satisfactory nor unsatisfactory, particularly for the spacing of aisle.

The indicators utilized for the customer satisfaction are ventilation, arrangement of chairs and tables, spacing o aisle, and good ambiance and lighting.

According to research of Alisha Desai, 2011 specific design choices support cafés ultimate goal of customer satisfaction. Atmosphere is of central concern. Depending on location and the target population, color, lighting, and music are manipulated. As customers desire comfort when settling down in cafés, the implementation of lounge chairs is beneficial. On the other hand, some prefer more rigid seating as they intend to focus on work. Therefore, a mix of furniture that can accommodate for different customer's wants and needs proves most successful. To account for privacy the visual accessibility and acoustic of the space should be considered. Finally, designers can meet the goal of creating a sense of belongingness by taking into account the

elements of hominess and stimulation. The goals of cafés can most easily be met through detailed design layouts.

Table 4

Common Productivity Challenge in Kitchen Design and Facilities

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Kitchen layout	4.00	Satisfactory	1
2. Production equipment	3.50	Satisfactory	4.5
3. Organization in the workplace	3.25	Neither	6
4. Use of space	3.75	Satisfactory	2.5
5. Counter space	3.50	Satisfactory	4.5
6. Aisle space	2.50	Neither	7
7. Storage facilities	3.75	Satisfactory	2.5
Over – all Composite Mean	3.46	Neither	

Legend: 4.50 – 5.00 = Very Satisfactory; 3.50 – 4.00 = Satisfactory; 2.50 – 3.49 = Neither; 1.50 – 2.49 = Unsatisfactory; 1.00 – 1.49 = Very Unsatisfactory

The result shows in table 5 that the common productivity challenge in kitchen design and facilities is neither satisfactory nor unsatisfactory since its over-all composite mean is 3.46. In all seven indicators, majority of the common productivity challenge were satisfactory.

The indicators for the productivity challenge in kitchen design and facilities are kitchen layout, production equipment; organization in the workplace, use of space, counter space, aisle space, and storage facilities.

The layout and design of the kitchen is based on efficiency of product flow through the food service system (Rodgers, 2007). Poor kitchen layout can limit the number of individuals who can work efficiently. It may require time-consuming trips to distant storage areas to obtain food items or dishes. If the layout of the kitchen is too spread out, the minimum staff needed to operate each station may increase.

Table 5

Ideal Kitchen Design and Facilities Layout

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. All work surfaces and storage areas required to produce an item should be located close together.	4.00	Agree	2
2. Ergonomic kitchen design layout, it means carefully placing every piece of the kitchen with comfort and effectiveness in mind.	3.50	Agree	6
3. The cleaning and washing section of the kitchen should			
Continuation of Table 5…			
be located near the kitchen entrance so servers can quickly drop off dirty dishes and near the storage area so chefs can quickly find clean dishes.	3.25	Undecided	7
4. The storage area can be in a split into non-food storage, cold storage, and dry storage.	3.75	Agree	4.5
5. The food preparation area has sinks for washing areas, cutting areas, and mixing areas.	3.75	Agree	4.5
6. The meal cooking area should be near the front of the kitchen next to the service area.	4.00	Agree	2
7. Service area needs to be located at the very front of the kitchen, just after the meal cooking area, to shorten the time and distance between completed meals and customers.	4.00	Agree	2
8. Island style layout. The island-style layout places the ovens, ranges, fryers, grills, and other principle cooking equipment together in one module at the center of the kitchen, while other sections of the kitchen are placed on	2.75	Undecided	10

the perimeter walls in the proper order to preserve a circular flow (any section can be the "island" depending on what best suits your needs). This layout is very open and promotes communication and supervision, while leaving plenty of open floor space for easy cleaning. 9. Zone style layout. The zone-style layout has the kitchen set up in blocks with the major equipment located along the walls. Again, the sections follow the proper order for increased flow, *Continuation of Table 5…*			
giving you a dishwashing block, a storage block, a food prep block, etc. Communication and supervision are not difficult in this layout because the center of the space is completely open. 10. Assembly line layout. The assembly-line configuration is ideal for kitchens that need to serve a large quantity of people quickly, like cafeterias or correctional facilities.	3.00	Undecided	8.5
	3.00	Undecided	8.5
Composite Mean	3.50	Agree	

Legend: 4.50 – 5.00 = Strongly Agree; 3.50 – 4.00 = Agree; 2.50 – 3.49 = Undecided; 1.50 – 2.49 = Disagree; 1.00 – 1.49 = Strongly Disagree

As seen from the table, the respondents' assessments to their ideal facilities design shows majority on agreeing in reforming the facilities layout indicated with a composite mean of 3.50. This was observed since the average weighted mean ranges from 3.50-4.00.

Indicators were utilized to determine the effects of the facilities design and layout on the productivity of workers. Some are; work surfaces and storage areas required to produce an item should be located close together; the meal cooking area should be near the front of the kitchen next to the service,

Among the items presented, the cooking area being near the front of the kitchen next to the service area, service area needing to be located at the very front of the kitchen, and all work surfaces and storage areas required to produce an item being located close together, were given the highest assessment of 4.00 and verbally interpreted as agree.

Kitchen generally located between storage and dining area. Kitchen itself is divided into different sub areas like storage (dry storage and cold storage or refrigerator), preparation area, ware-washing area, cooking and final preparation, fabrication area each of these areas should be designed carefully according to the requirements in the menu (Arora, 2007).

One of the key for designing a successful restaurant is to minimize the cross between customers flow pattern. Generally, flow patterns are available for customers, staffs, tableware, food and services and it should be considered in first steps of design programming. The flow planning also should be considered in entrance and parking area as well. "An important goal of VE (Value Engineering) is to optimize flow in terms of proximity, volume, speed and direction" (Durocher, 2010).

Table 6

Difference of Responses on the Impact of Shop Design & Facilities and Customer Satisfaction when Grouped According to Customer Profile

	Impact of Shop Design & Facilities			**Customer Satisfaction**		
Profile Variables	F-value	p-value	I	F-value	p-value	I
Age	2.182	0.039	S	3.436	0.002	S
Sex	0.090	0.929	NS	1.608	0.110	NS
Professional Background	1.868	0.138	NS	1.505	0.216	NS

Legend: Significant at p-value < 0.05

Based from the result in table 4 showing the difference of responses on the impact of shop design as well as the satisfaction of the customer, there was significant difference observed on age (0.039) and (0.002). This was observed since the obtained p-values were less than 0.5 alpha levels. This only means that the impact of design varies as to the age bracket and it was found out that those whose age range was 16 to 20 years old have higher impact on the design and facilities while those who are 21 to 25 years have higher level of satisfaction.

Age, sex, and professional background were indicated in showing the difference of responses on the impact of shop design and satisfaction of customers.

In the study about Interior Design in Restaurants as a Factor Influencing Customer Satisfaction by Marija PECOTIĆ1, Vanda BAZDAN1, Jasminka SAMARDŽIJA the results of the study further indicate that the facilities layout of the restaurant is important factor for customers' satisfaction. According to the result there was a significant difference observed on age based on the interior design in restaurant with a p value of 0.03. In addition, the result also shows that there is significant difference by the customer satisfaction in interior design of a restaurant with a p value of 0.02

6. Conclusions

1. The researcher was able to describe the profile of respondents according to age, sex, whether they are customer or employee, their academic background, the employees' length of service. From the gathered data, most of the customers' age in VCC ranges from 16 to 25 years old and ages 20 to 25 of range for workers. There were more female customers than male. Most of the customer respondents were of college undergraduate followed by bachelor's degree same as for the workers having bachelor's degree. All of the respondents had less than a year of experience.
2. For Viajeros Corner Café, there are different facilities design encountered that impact the customer satisfaction. These facilities design are ranked; 1) entertainment; 2) total ambiance of the place/shop; 3) interior decoration. The only unsatisfactory result encountered as a facility error is the availability of parking.
3. The assessment of the customer satisfaction with regards to facilities layout resulted as satisfactory were ventilation, arrangement of chairs and tables, good ambiance and lighting. Spacing of aisle is neither satisfactory nor unsatisfactory.
4. The researcher determines the effects of the facilities design and layout on the employees which resulted as satisfactory on kitchen layout in effect on their good productivity. For the employees resulting on neither satisfactory nor unsatisfactory on the facilities' aisle space hinders their productivity of work.
5. The researchers determine that the employees neither satisfied nor not satisfied when it comes to common productivity challenge in kitchen design and facilities therefore there is neutral among the challenges and the employees.
6. Testing the significant difference in the customer satisfaction from shop design and facilities when grouped according to profile resulted in a significant difference on customer's age.

7. Recommendation

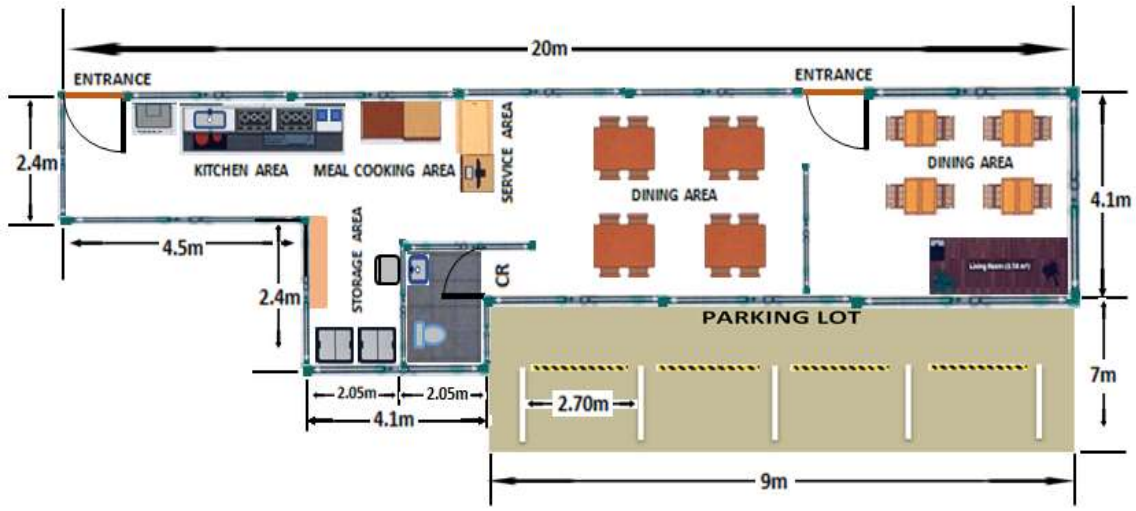
Sequence of the ideal layout was based from the results of the survey questionnaire conducted from the employees. According to them, they prefer the work surfaces and storage area to be close together. The meal cooking area and service area are preferred to be in front of the kitchen.

From this, the researchers proposed in changing the facilities layout and give the employees a better impact on their productivity in order to deliver a good quality of customer satisfaction.

The sequence of the ideal layout would be easier and more convenient for the employees that would optimize their productivity. The kitchen area will now be placed further back next to the back door followed by the meal cooking area. The meal cooking area will serve as the preparation of orders after the food is cooked. Behind the kitchen and meal cooking area is the storage area where all ingredients needed for each order is placed and more convenient for the cook. In front of the meal cooking area is the service area. Placing both areas closely together would lessen time preparation of orders to deliver to the customers table.

Three main areas (kitchen, meal cooking area, and service area) are placed closely together were the result of the employees' survey and the researchers' action to improve the employees' impact on their productivity.

Proposed Facilities Layout



LEGEND:

- Oven Stove
- Stove
- Sink
- Meal Table
- Refrigerator
- Freezers
- Dining Table
- Haging Cabinet
- Computer Table
- Parking Area
- Music Room

In light of the examination on cafe layout design, a wider area can also be looked into in other to derive a consolidated and well-designed café. Other various categories of a successful cafe design from the researchers' point of view i.e. lighting design, color selection, sound and acoustic design, heating, cooling and ventilation design, material design, outdoor space design also need investigation. The listed categories can be analyzed one after the other in order to active the result in terms of general principal of cafe design. In the ideal layout as you can see it emphasize the uniform process from the kitchen area till the end service area.

1. The researchers recommend on giving more attention on their target market specifically on male customers and those age range of 26 and above.
2. It would be useful for the Viajeros Corners Café to put more effort in finding out their customer preferences and expectations when it comes to designing the interior and exterior design of their café. Moreover, to redevelop their parking area specified for customers.
3. Considering on the result of customer satisfaction with regards to facilities layout. The researchers recommend that VCC should consider on planning

their systematic layout by minimizing their consumption of space for the customer.

4. The study recommends that the kitchen staff be more educated on the concept of their kitchen layout and the associated benefits to boost their productivity.
5. Keep on developing the efficiency in the kitchen despite the fact that the Customer confronted challenges still it won't influence, on the grounds that would result the greater part of the clients' response in absence of neutral point.
6. The study illustrated that there was, indeed, significant difference in customer satisfaction from shop design and facilities of different ages. Viajeros Corner Café should ascertain which shop design and facility factors are most responsible for creating return business and seek ways for improvements.
7. The researchers proposed an ideal sequence of facility layout to be able to meet the standard wants of the customers wants that have faced the challenges. All work surfaces and storage areas required to produce an item should be located close together. The meal cooking area should be near the front of the kitchen next to the service area. Service area needs to be located at the very front of the kitchen, just after the meal cooking area, to shorten the time and distance between completed meals and customers.
8. One of the future possibilities for the research is to determine through observation combined with self-reported measurements the effect of interior design on the amount of time customer spend in a restaurant. It would also be interesting to determine the impact of the facilities design factors on the first-time customers, and to investigate if the effect on a customer decreases after a number of visits. Such further research would determine if and how often should the facilities design factors be changed through time to increase competitiveness on the market.

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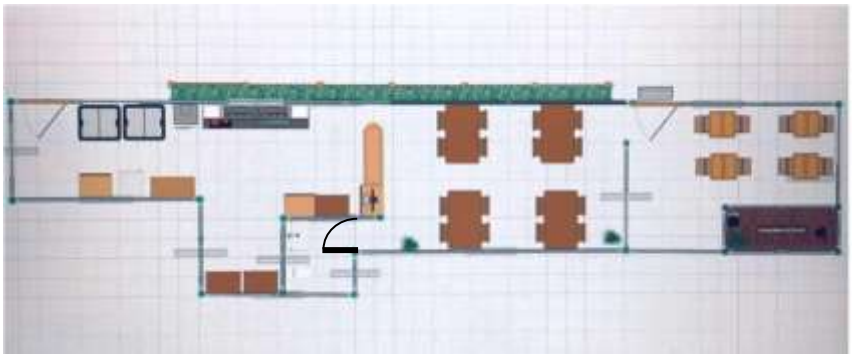
Appendix A

Current Facilities Layout



Appendix B

Statistical Output

Frequencies

Statistics

		age	gender	background
N	Valid	147	147	147
	Missing	0	0	0

Frequency Table

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	35	23.8	23.8	23.8
	2.00	53	36.1	36.1	59.9
	3.00	22	15.0	15.0	74.8
	4.00	7	4.8	4.8	79.6
	5.00	10	6.8	6.8	86.4
	6.00	16	10.9	10.9	97.3
	7.00	3	2.0	2.0	99.3
	8.00	1	.7	.7	100.0
	Total	147	100.0	100.0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	61	41.5	41.5	41.5
	2.00	86	58.5	58.5	100.0
	Total	147	100.0	100.0	

Background

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	69	46.9	46.9	46.9
	2.00	52	35.4	35.4	82.3
	3.00	18	12.2	12.2	94.6
	4.00	8	5.4	5.4	100.0
	Total	147	100.0	100.0	

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
i1	147	1.00	5.00	2.8299	1.07509
i2	147	1.00	5.00	2.4626	1.13035
i3	147	1.00	5.00	2.7483	1.26515
i4	147	1.00	5.00	3.7483	.83456
i5	147	1.00	5.00	3.5442	.75154
i6	147	1.00	5.00	3.8367	1.02062
i7	147	1.00	5.00	3.6735	1.06091
i8	147	2.00	5.00	4.2721	.80714
i9	147	2.00	5.00	3.9728	.97183
impact	147	2.11	4.78	3.4543	.53823
Valid N (listwise)	147				

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
cs1	147	1.00	5.00	3.8912	1.11115
cs2	147	2.00	5.00	3.8095	.85475
cs3	147	1.00	5.00	3.3878	1.03002
cs4	147	1.00	5.00	4.1361	.97671
satisfaction	147	2.00	5.00	3.8061	.80335
Valid N (listwise)	147				

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
impact	1.00	35	3.5175	.44194	.07470	3.3656	3.6693
	2.00	53	3.5178	.52792	.07252	3.3723	3.6633

	3.00	22	3.5303	.45092	.09614	3.3304	3.7302
	4.00	7	3.4127	.71063	.26859	2.7555	4.0699
	5.00	10	3.3667	.65640	.20757	2.8971	3.8362
	6.00	16	3.2986	.61225	.15306	2.9724	3.6249
	7.00	3	2.5556	.29397	.16973	1.8253	3.2858
	8.00	1	2.5556	.	.	.	.
	Total	147	3.4543	.53823	.04439	3.3665	3.5420
	1.00	35	3.8643	.76539	.12937	3.6014	4.1272
	2.00	53	3.8491	.85392	.11730	3.6137	4.0844
	3.00	22	4.1136	.72673	.15494	3.7914	4.4359
	4.00	7	4.4286	.37401	.14136	4.0827	4.7745
satisfaction	5.00	10	3.1250	.82706	.26154	2.5334	3.7166
	6.00	16	3.4531	.53400	.13350	3.1686	3.7377
	7.00	3	3.0000	.25000	.14434	2.3790	3.6210
	8.00	1	3.2500	.	.	.	.
	Total	147	3.8061	.80335	.06626	3.6752	3.9371

Descriptives

		Minimum	Maximum
	1.00	2.78	4.78
	2.00	2.44	4.78
	3.00	2.56	4.33
	4.00	2.22	4.67
impact	5.00	2.11	4.22
	6.00	2.44	4.78
	7.00	2.33	2.89
	8.00	2.56	2.56
	Total	2.11	4.78
	1.00	2.50	5.00
satisfaction	2.00	2.00	5.00

	3.00	2.50	5.00
	4.00	4.00	5.00
	5.00	2.00	4.25
	6.00	2.75	4.25
	7.00	2.75	3.25
	8.00	3.25	3.25
	Total	2.00	5.00

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
impact	Between Groups	4.188	7	.598	2.182	.039
	Within Groups	38.106	139	.274		
	Total	42.294	146			
satisfaction	Between Groups	13.900	7	1.986	3.436	.002
	Within Groups	80.324	139	.578		
	Total	94.224	146			

T-Test

Group Statistics

	gender	N	Mean	Std. Deviation	Std. Error Mean
impact	1.00	61	3.4590	.50122	.06418
	2.00	86	3.4509	.56588	.06102
satisfaction	1.00	61	3.6803	.86498	.11075
	2.00	86	3.8953	.74898	.08077

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
impact	Equal variances assumed	1.254	.265	.090	145

satisfaction	Equal variances not assumed			.092	137.944
	Equal variances assumed	4.019	.047	-1.608	145
	Equal variances not assumed			-1.569	117.358

Independent Samples Test

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
impact	Equal variances assumed	.929	.00811	.09040
	Equal variances not assumed	.927	.00811	.08855
satisfaction	Equal variances assumed	.110	-.21502	.13375
	Equal variances not assumed	.119	-.21502	.13707

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
impact	Equal variances assumed	-.17057	.18679
	Equal variances not assumed	-.16699	.18321
satisfaction	Equal variances assumed	-.47938	.04934
	Equal variances not assumed	-.48647	.05643

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
impact	1.00	69	3.4895	.52922	.06371	3.3624	3.6167
	2.00	52	3.5171	.53667	.07442	3.3677	3.6665

	3.00	18	3.2654	.60396	.14235	2.9651	3.5658
	4.00	8	3.1667	.33068	.11691	2.8902	3.4431
	Total	147	3.4543	.53823	.04439	3.3665	3.5420
	1.00	69	3.8442	.81360	.09795	3.6488	4.0397
	2.00	52	3.9038	.79544	.11031	3.6824	4.1253
satisfaction	3.00	18	3.5139	.71985	.16967	3.1559	3.8719
	4.00	8	3.5000	.86603	.30619	2.7760	4.2240
	Total	147	3.8061	.80335	.06626	3.6752	3.9371

Descriptives

		Minimum	Maximum
	1.00	2.22	4.78
	2.00	2.11	4.67
impact	3.00	2.33	4.44
	4.00	2.56	3.56
	Total	2.11	4.78
	1.00	2.00	5.00
	2.00	2.00	5.00
satisfaction	3.00	2.50	4.75
	4.00	2.50	4.75
	Total	2.00	5.00

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	1.595	3	.532	1.868	.138
impact	Within Groups	40.700	143	.285		
	Total	42.294	146			
	Between Groups	2.884	3	.961	1.505	.216
satisfaction	Within Groups	91.341	143	.639		
	Total	94.224	146			

Post Hoc Tests

Multiple Comparisons

Scheffe

Dependent Variable	(I) background	(J) background	Mean Difference (I-J)	Std. Error	Sig.
impact	1.00	2.00	-.02756	.09797	.994
		3.00	.22410	.14120	.474
		4.00	.32287	.19925	.456
	2.00	1.00	.02756	.09797	.994
		3.00	.25166	.14589	.399
		4.00	.35043	.20261	.396
	3.00	1.00	-.22410	.14120	.474
		2.00	-.25166	.14589	.399
		4.00	.09877	.22669	.979
	4.00	1.00	-.32287	.19925	.456
		2.00	-.35043	.20261	.396
		3.00	-.09877	.22669	.979
satisfaction	1.00	2.00	-.05964	.14677	.983
		3.00	.33031	.21153	.489
		4.00	.34420	.29850	.722
	2.00	1.00	.05964	.14677	.983
		3.00	.38996	.21856	.368
		4.00	.40385	.30352	.622
	3.00	1.00	-.33031	.21153	.489
		2.00	-.38996	.21856	.368
		4.00	.01389	.33960	1.000
	4.00	1.00	-.34420	.29850	.722
		2.00	-.40385	.30352	.622
		3.00	-.01389	.33960	1.000

Multiple Comparisons

Scheffe

Dependent Variable	(I) background	(J) background	95% Confidence Interval	
			Lower Bound	Upper Bound
impact	1.00	2.00	-.3047	.2496
		3.00	-.1754	.6236
		4.00	-.2408	.8866
	2.00	1.00	-.2496	.3047
		3.00	-.1611	.6644
		4.00	-.2228	.9236
	3.00	1.00	-.6236	.1754
		2.00	-.6644	.1611
		4.00	-.5426	.7401
	4.00	1.00	-.8866	.2408
		2.00	-.9236	.2228
		3.00	-.7401	.5426
satisfaction	1.00	2.00	-.4749	.3556
		3.00	-.2681	.9287
		4.00	-.5003	1.1887
	2.00	1.00	-.3556	.4749
		3.00	-.2284	1.0083
		4.00	-.4548	1.2625
	3.00	1.00	-.9287	.2681
		2.00	-1.0083	.2284
		4.00	-.9469	.9746
	4.00	1.00	-1.1887	.5003
		2.00	-1.2625	.4548
		3.00	-.9746	.9469

Homogeneous Subsets

Impact

Scheffe

background	N	Subset for alpha = 0.05
		1
4.00	8	3.1667
3.00	18	3.2654
1.00	69	3.4895
2.00	52	3.5171
Sig.		.263

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 18.667.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

satisfaction

Scheffe

background	N	Subset for alpha = 0.05
		1
4.00	8	3.5000
3.00	18	3.5139
1.00	69	3.8442
2.00	52	3.9038
Sig.		.499

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 18.667.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Frequencies

Statistics

		age	gender	background	job	length
N	Valid	4	4	4	4	4
	Missing	0	0	0	0	0

Frequency Table

age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	2	50.0	50.0	50.0
	5.00	1	25.0	25.0	75.0
	8.00	1	25.0	25.0	100.0
	Total	4	100.0	100.0	

gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	2	50.0	50.0	50.0
	2.00	2	50.0	50.0	100.0
	Total	4	100.0	100.0	

background

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	3	75.0	75.0	75.0
	2.00	1	25.0	25.0	100.0

	Total	4	100.0	100.0	

job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	1	25.0	25.0	25.0
	2.00	1	25.0	25.0	50.0
	3.00	1	25.0	25.0	75.0
	4.00	1	25.0	25.0	100.0
	Total	4	100.0	100.0	

length

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	2	50.0	50.0	50.0
	2.00	2	50.0	50.0	100.0
	Total	4	100.0	100.0	

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
cp1	4	4.00	4.00	4.0000	.00000
cp2	4	3.00	4.00	3.5000	.57735
cp3	4	3.00	4.00	3.2500	.50000
cp4	4	3.00	4.00	3.7500	.50000
cp5	4	2.00	4.00	3.5000	1.00000
cp6	4	2.00	3.00	2.5000	.57735
cp7	4	3.00	5.00	3.7500	.95743
cptotal	4	3.29	3.71	3.4643	.17976
Valid N (listwise)	4				

DESCRIPTIVES VARIABLES=i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 total
STATISTICS=MEAN STDDEV MIN MAX.

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
i1	4	4.00	4.00	4.0000	.00000
i2	4	3.00	4.00	3.5000	.57735
i3	4	3.00	4.00	3.2500	.50000
i4	4	3.00	4.00	3.7500	.50000
i5	4	3.00	4.00	3.7500	.50000
i6	4	4.00	4.00	4.0000	.00000
i7	4	4.00	4.00	4.0000	.00000
i8	4	2.00	3.00	2.7500	.50000
i9	4	3.00	3.00	3.0000	.00000
i10	4	3.00	3.00	3.0000	.00000
itotal	4	3.30	3.70	3.5000	.16330
Valid N (listwise)	4				

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QUEEN CLEANER DISHWASHING LIQUID

DEL RIO, FRANCIS T., LESCANO, JEROME D., MAQUIMOT, NORIELYN I., SANTORCE, MARY JEAN N., SIMBULAN, AILEEN F., LOMIO, PAULINE ISABELLE A., ABACAN, REINA LEE A., AND CHAVEZ, NEMY H.

College of Engineering, Lyceum of the Philippines University, Capitol Site, Batangas City, Philippines

ABSTRACT

The objective of this feasibility Study were to provide insights about forming a sustainable project for the adopted community of Lyceum of the Philippines University (LPU)- Batangas and to engage the students to a useful activity which is to acquire a transfer of technology from the output of Engineering Department of the said school to the Sotero H. Laurel (SHL) Restoration Village at Barangay Sico, San Jose, Batangas City.

The proponents named the product as "QCD" that stands for Queen Cleaner Dishwashing liquid, since the company aimed to be the company that can supply quality and affordable dish washing liquid in the province and to give the public an impression of queen-like standard product because of its high or excellent cleaning ability. The Queen cleaner Dishwashing Liquid (QCD) has similar characteristics with existing similar items. A teaspoon of QCD liquid can eliminate grease and bacteria in dishes, glass and kitchen utensils. Queen Cleaner Dishwashing liquid can also be used as hand sanitizer. A great amount of QCD can be an alternative solution in washing and removing dirt to clothes. Dishwashing liquid is consumable so the need for demand will continuously increasing. The products will be first distributed to the residence of the Village, Fast Food Restaurants in Batangas City, to LPU Canteens and Dormitory.

The firm shall produce dish washing liquid by mixing all the raw materials such as water, surfactants, degreaser,
antibac, water softener, thickener, foam booster, preservatives, scent, and colorant, through the use of mixing machine. The minimum capacity of the production in the company is 942 bottles of 250 ml and 2,320 bottles of 1 liter and the rated capacity is 2,356 liters.

The firm's total investment is Php 245,000.00. This capital will directly come from the LPU Management.
The initial investment has increased to Php 554,118.06 resulting to continuous profit of the business.

In addition, the business can generate additional revenue from its current economic slump. One of the major goals of putting up the business is to provide employments to the people living there, which have the skills and competencies in creating the product. Putting up the business in the Village can help the jobless get back on their feet and get their own living.

The cooperative which is established at SHL Restoration Village and currently operating is more than willing to manage the proposed project if it is given to them.

The researchers recommend this proposed project for those who want to establish the related business. The company sees a potential of this product in the market if the quality will be maintained and the price will be competitive compare to other existing dishwashing liquid.

Keywords: QCD, transfer of technology, sustainable project, surfactants

1. Introduction

This study aimed to provide insights and useful information about forming a livelihood project for the adopted community of Lyceum of the Philippines University (LPU) Batangas and to engage the students to a useful activity which is to acquire and perform a technology transfer or the application of technology from the output of Engineering Department of LPU Batangas to the SHL Restoration Village at Barangay Sico, San Jose, Batangas City.

With this study the residence of SHL Restoration Village, customers and researchers will be a beneficiary. The residence of SHL Restoration Village will gain an idea on how to operate the business. Users of the product will have an awareness of the initiative of the company to produce quality product to satisfy their needs.

The proponents believed that manufacturing and marketing of dish washing liquid is a good project since it is a basic need of almost every households, restaurants, canteens and other establishments.

Different cleaning agent plays an important role in everyday living of individuals as it lessen the difficulty and effort of tough cleaning process especially on household chores.

Dishwashing liquid also known as dishwashing soap and dish soap, is a detergent used to assist in dish washing. It is a highly-foaming mixture of surfactants with low skin irritation, and is primarily used for hand washing of glasses, plates, cutlery, and cooking utensils in a sink or bowl and sometimes use for hand washing.

Dishwashing liquid is one of the most common cleaning products consumed everyday as it is present and use for washing plates, glass, and other kitchen utensils. Application of technology in manufacturing of these products will result to increase volumes in productivity, reduction of labor costs, and improves labor productivity. Dishwashing liquid is consumable so the need for demand will continuously increasing.

The primary reason for the application of effective dishwashing liquid is to destroy those disease organisms which may be present on equipment or utensils after cleaning, and thus prevent the transfer of such organisms to the ultimate consumer that an ordinary soap cannot do.

The company proposed a product named “QCD” which stands for Queen Cleaner Dish washing liquid, an effective ,lemon scented dish washing soap that kills bacteria and germs in dishes,sink and other areas in the kitchen.In addition, proper sanitizing of dishes by using QCD may prevent spoilage of foods and prevent the interference of microorganisms in various industrial processes which depend on pure cultures. This study uses descriptive type of method that describe characteristics of the product being studied.

This product considered a good market since the product is easy to produce with low costs,production and a good management system will be the key for its success. The company’s location site will be at Barangay Sico, San Jose Batangas City and the products will be first distributed to the residence of SHL Restoration Village, Fast Food Restaurants in Batangas City and to LPU Canteens and Dormitory. The distribution of the products to grocery stores and convenient stores included to the company’s future plans.

This project feasibility was done to analyze and understand all the aspects regarding the product. At the end of the study, the researchers assessed if the proposed product will be feasible and marketable. Also the researchers determined all the production and marketing aspect of the product.

2. Methods

This research utilized the quantitative descriptive method of research. Quantitative methods emphasize on objective measurements and numerical analysis of data collected through polls, questionnaires or surveys. Quantitative research focuses on gathering numerical data and generalizing it across groups

of people. The purpose of quantitative descriptive studies is to find interrelationships between variables.

In designing a quantitative research study, descriptive is used to gather, analyze, and interpret the results. The subjects are generally measured once; the purpose is to only create relations between variables; and, the study may contain an example people of hundreds or thousands of topics to make sure that a legal estimation of a general association between variables has been gained are the rules in a descriptive study.

3. Results and Discussion

Market Feasibility

Market study covers the project's profitability by meeting the unsatisfied customer demand. The price of the dish washing liquid covers cost of production and promotion. Market feasibility speaks of market possibility of the product. Three Queens Manufacturing determines the possible demand and supply for the interviews and questionnaires.

There are certain factors affecting the market that may or may not be difficult to quantify or predict. These factors include demand, supply and price. The competitors, change in the economic status, income changes, population growth, and price can affect the demand.

The market aimed to established the product and its size, price to be sold, the supply situation and the nature of competition in the market, the nature and growth of the total demand for the product.

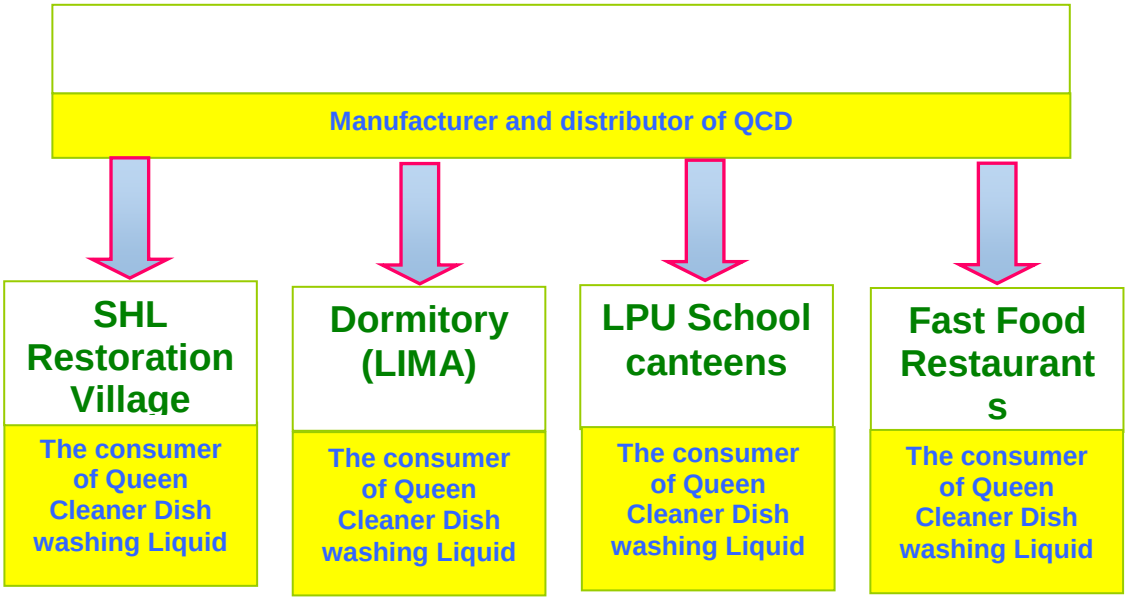

Figure 1 Channel of Distribution

Figure 1 shows the channel of distribution from the manufacturing company down to its consumer the SHL Restoration Village, dormitory at LIMA campus, school canteens of LPU Batangas and selected fast food restaurants in Batangas City. The proponents used this to be their guide to assure that they are following the procedures and the flow of distributions.

DEMAND

The proponents collected necessary information through survey. Based on the results dish washing liquid is highly consumable, therefore the demand for

dish washing is high. This shows that it is necessity for every household and for people who are in food and catering industry such as canteens, dormitory and home kitchens.

Technical Feasibility

This includes the plant layout, location map, building and facilities, machineries and equipment. This chapter will also consider the process flow of the product with its description, the production schedule, the labor requirements and other relevant things to consider.

The firm shall produce dish washing liquid by mixing all the raw materials such as water, surfactants, degreaser, antibac, water softener, thickener, foam booster, preservatives, scent, and colorant, through the use of mixing machine. By the use of machine the production meets the required consistency of mixing process and efficiency. The plant promotes cleanliness to assure safety and health of the workers and the quality of dish washing liquid to be produced.

Figure 2 The Product - Queen Cleaner Dishwashing Liquid

Figure 2 shows the Queen Cleaner Dishwashing liquid. It is made up from mixed ingredients such as powdered surfactants, gel surfactants, degreaser, foam booster, preservative, antibac, water softener, colorant and lemon scent. This also contains thickener and water.

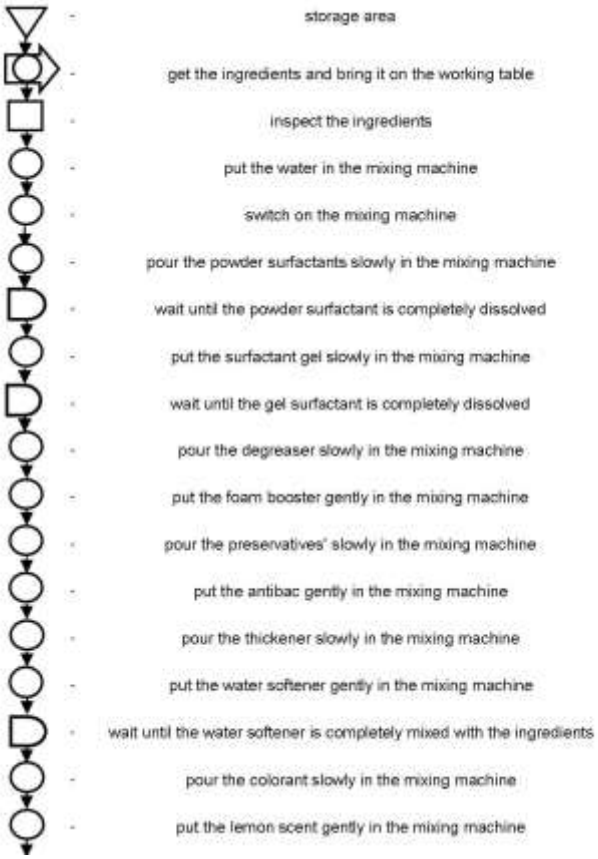

Figure 3 Manufacturing Processes

Figure 3 shows the manufacturing processes of dishwashing liquid in sequence with its corresponding symbols.

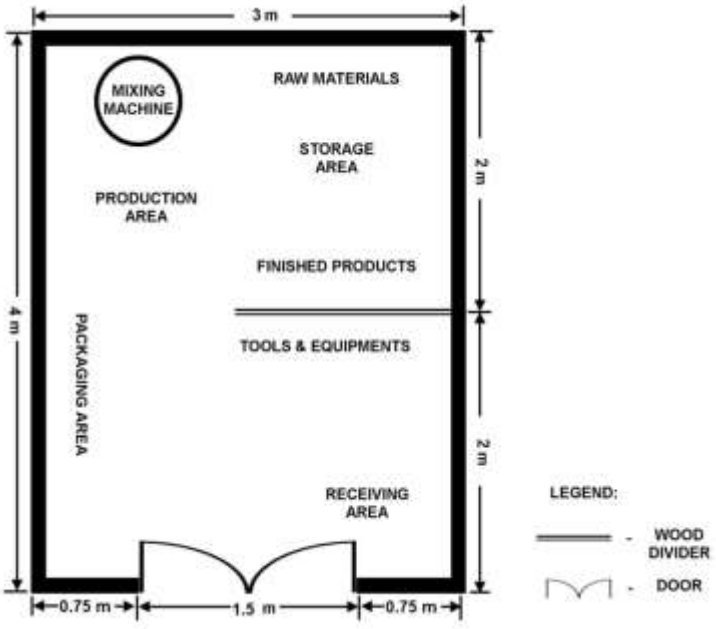

Figure 4 Plant Layout

Figure 4 illustrates the plant layout. It is composed of the following areas: machine area, storage area, and packaging area.

Financial Feasibility

Financial study identifies the expense in the production, the cost in establishing the project itself, the things that are needed to be considered in the business are the cost of raw materials, building, machinery and equipment, furniture's and cash.

The firm's total investment is Php 245,000.00. This capital will directly come from the LPU Management.

Financial Study covers the gross amount of the total project cost to be used, the financial statement and the source of capital . It also includes the depreciation, break-even point, net income statement, operating profit and the payback period.

Table 1
Projected Income Statement

	2015	2016	2017	2018	2019
Sales (250ml)	31, 095. 42	31,980.90	33,582.30	35,259.06	37,020.60
Less: Cost of Good Sold	12,078.60	12,320.17	12,566.58	12,817.91	13,074.27
Gross Income	19, 016.82	19,660.73	2,105.72	22,441.15	23,946.33
Sales (1L)	229,703.20	235,039.20	246, 801.60	259,144.00	272,112.80
Less: Cost of Good Sold	66,896.00	68,233.92	69,598.60	70,990.57	72,410.38
Gross Income	162,807.20	166,805.28	1,772.03	188,153.43	199,702.42
TOTAL GROSS INCOME	181,824.02	186,466.01	198,218.72	210,594.58	223,648.75
Less: Operating Expense					
Salaries & Allowances	98,800.00	100,776.00	102,791.52	104,847.35	106,944.30
Office Supplies	594.00	605.88	617.99	630.36	642.96
Transportation Expense	6000.00	6060.00	6,120.60	6,181.81	6,243.62
Contigency Expense	3000.00	3060.00	3,121.20	3,183.62	3,247.30
Permits	3,887.50	3,926.38	3,965.64	4,005.30	4,045.35
Utilities	14,602.00	9,201.60	9,385.63	9,573.34	9,764.81
Janitorial Expense	430.00	434.30	438.64	443.03	447.46
Pre-operating Expense	620.00	-	-	-	-
Dep- Prod. Equipment	360.00	360.00	360.00	360.00	360.00
Delivery Expense	5,760.00	5,817.60	5,875.78	5,934.53	5,993.88
Dep- Other Equipment	46.80	46.80	46.80	46.80	46.80
Safety Equipment	3,017.00	3,047.17	3,077.64	3,108.42	3,139.50
Dep- Furniture	73.80	73.80	73.80	73.80	73.80

Dep- Building	1164.00	1164.00	1164.00	1164.00	1164.00
TOTAL EXPENSES:	138,355.10	134,573.53	137,039.25	139,552.36	142,113.78
Net Income:	43,468.92	51,892.48	61,179.47	71,042.22	81,534.97

Table 1 shows the Income Statement of the company. This includes the sales, the expenses incurred and the net income for the given period. This indicates whether the company is earning or not. As shown in the table, the company's net income is continuously increasing.

Table 2
Cash Flow Statement

	2015	**2016**	**2017**	**2018**	**2019**
Cash Inflows					
Cash Sales	260,798.62	267,020.10	280,383.90	294,403.00	309,133.40
Cash Out Flows					
Building & Constructing	19,400.00	-	-	-	-
Production Equipment	8000.00	-	-	-	-
Delivery Vehicle	5,760.00	5,817.60	5,875.78	5,934.53	5,993.88
Furniture Expense	820.00	-	-	-	-
Safety Equipment	3,017	3,047.17	3,077.64	3,108.42	3,139.50
Other Equipment	260.00	-	-	-	-
Office Supplies	594.00	605.88	617.99	630.36	642.96
Contingency	3000.00	3060.00	3,121.20	3,183.62	3,247.30
Permits & Licenses	3,887.50	3,926.38	3,965.64	4,005.30	4,045.35
Direct Materials	61,440.00	62,668.80	63.922.18	65,200.62	66,504.63
Indirect Materials	17,534.60	17,885.29	18,242.10	18,607.86	18,980.01
Direct labor	98,800.00	100,776.00	102,791.52	104,847.35	106,944.30
Indirect Labor					
Utilities	14,602.00	9,201.60	9,385.63	9,573.34	9,764.81
Janitorial Expense	430.00	434.30	438.64	443.02	447.46
Pre-operating Expense	620.00	-	-	-	-
Transportation Expense	6000.00	6060.00	6,120.60	6,181.81	6,243.62
TOTAL CASH OUTFLOWS	244,165.10	213,483.02	217,559.82	221,716.24	225,953.83
Net Cash Flow	16,663.52	53,537.08	62,824.08	72,686.76	83,179.57

Add: Cash Investment Beginning	245,000.00	261,633.52	315,170.60	377,994.68	450,681.44
Cash Ending	261,633.52	315,170.60	377,994.68	450,681.44	533,861.01

Table 2 presents the statement of cash flow of the company for 2015-2019. This statement requires the preparation of the statement of cash activities of the company, cash inflows including the sales of the product and cash outflows including used to acquire machinery, equipment, property and other expenses that is necessary to operate the enterprise.

Table 3
Projected Balance Sheet

ASSETS	2015	2016	2017	2018	2019
Cash	261,633.52	315,170.60	377,994.68	450,681.44	533,861.01
Total Current Asset	261,633.52	315,170.60	377,994.68	450,681.44	533,861.01
Property Equipment					
Building	19,400.00	19,400.00	19,400.00	19,400.00	19,400.00
Production Equipment	8000.00	8000.00	8000.00	8000.00	8000.00
Furniture	820.00	820.00	820.00	820.00	820.00
Other Equipment	260.00	260.00	260.00	260.00	260.00
Less: Accumulated Depreciation	1,644.60	3,289.20	4,933.80	6,578.40	8,223.00
Total Property & Equipment	26,835.40	25,190.80	28,480.00	21,901.60	20,257.00
Total Assets	288,468.92	340,361.40	401,540.87	472,583.09	554,118.06
Current Liability					
Owners Equity	288,468.92	340,361.40	401,540.87	472,583.09	554,118.06

Table 3 shows the statement of balance sheet of the company. This indicates projected picture of the company's financial position from 2015-2019. Balance sheet includes the declaration of assets of the company containing the current assets such as cash and its inventory and the non-current assets such as its property, machineries and other equipment acquired less its accumulated depreciation. As counterpart of the assets gained, balance sheet also contains the liabilities or the obligations of the company from other organization such as taxes payable and the owner's equity to make it balance. The company does not have any liabilities, therefore total current asset will be equate to total owners equity.

Socio-Economic Feasibility

The manufacturing of dishwashing liquid improved the creativity of the Filipinos and helps boost their morale by competing with other business. In addition, the business can generate additional revenue from its current economic slump. Here, the products can be substitute for the existing dishwashing liquid which is more affordable. It also creates additional supply to the field of its related product.

This chapter also includes the social responsibilities of the firm in the environment, consumers, government and in the community.

One of the major goals of putting up the business is to have the transfer of technology to SHL Restoration Village, to provide employment to the people living there, who have the skills and competencies in creating the product. Putting up the business in the Restoration Village can help the jobless get back on their feet and get their own living.

Management Feasibility

It represents the supervision of process before and during the actual operation such as project, so with people involved in the production and operation. Also, management study gives the organizations description such as its type of ownership, organizational structure with the duties and responsibilities of each personnel, business policy. This also includes how many laborers are needed in the company.

The organizational and management considerations of the proposed project are presented in the section of this paper. It includes the discussion of the basic consideration in forming the organization, the form of ownership, organizational chart, officers and key personnel and the project schedule.

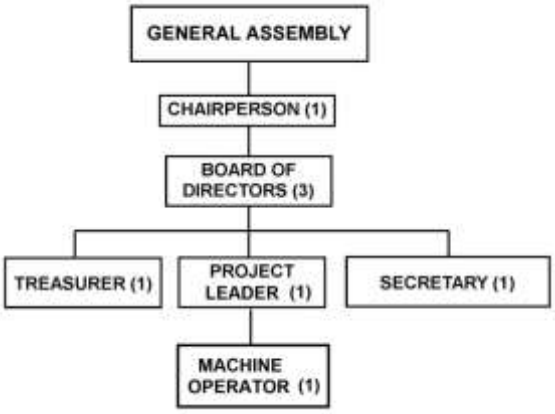

Figure 5
Organizational Chart of the Company

Figure 5 illustrates the organizational chart of the company. The company adopts a cooperative form of ownership, therefore the general assembly is in the top position since the whole body will make decisions democratically followed by the Chairperson, Board of Directors, Treasurer, Secretary and the Project Leader. The Project Leader supervises the machine operator. This is a line organizational structure since it has a specific line of command. This kind of structure allows easy decision-making.

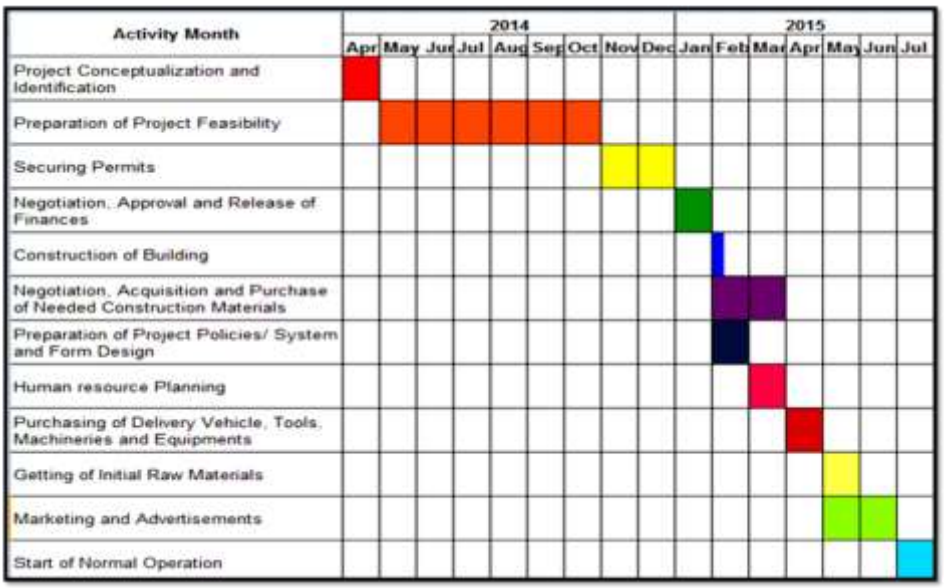

Figure 6
Gantt Chart

Figure 6 shows the Gantt chart of the following timetable of activities that will serve as a guideline for the study completion from the preparation to start the normal operation of the company.

4. Conclusions

The main purpose of the company is to provide a sustainable livelihood to the residence of SHL Restoration Village by producing a quality dish washing liquid to its target market.

The researchers got the actual orders of SHL Restoration Village residents, LPU school canteens and dormitory, and the fast food restaurants in Batangas City. The company can supply 942 of 250 ml bottles and 2320 bottles of 1 liter pack of Queen Cleaner Dishwashing Liquid in the first year of operation. The initial investment has increased from Php 245,000.00 to Php 554,118.06resulting to continuous profit the business.

Queen Cleaner Dishwashing liquid is essential to people especially those who deal with food related industry since they used dishes and kitchen utensils. Every household used dish washing liquid in washing and removing dirt to dishes, spoon and utensils.

This study will serve as a reference for researchers who are conducting research study related to the project. The researchers gathered information through survey to determine the demand of the product.

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Appendix B

Arithmetic Straight Line: Yc = a + Yi – 1

Where:

Yc = initial value (1st year)

Yn = final value (last year)

N = number of years

Yi = value for the year past

HISTORICAL VALUES

	Step 1					Step 2		
	Y	**a**	**+**	**Yi-1**	**=**	**Yc**	**Y-YC**	
2009-2010	9826							-
2010-2011	10062	17	+	9,826	=	9,843	219	47,961
2011-2012	9491	17	+	9,843	=	9,860	-369	136,161
2012-2013	9877	17	+	9,860	=	9,877	0	0

Projected Values

Year	A	+	Yi-1		YC
2013-2014	17	+	9,977	=	9,894
2014-2015	17	+	9894	=	9,911
2015-2016	17	+	9911	=	9,928
2016-2017	17	+	9928	=	9,945
2017-2018	17	+	9945	=	9,962

Appendix C

C1 Queen Cleaner Dish Washing Liquid Production Equipment

Equipment	Quantity	Unit Price	Cost
Mixing machine	1 set	Php 8000.00	Php 8000.00
TOTAL			**Php 8000.00**

C2 Queen Cleaner Dish Washing Liquid
Other Equipment Cost

Particulars	Quantity	Unit Price (Php)	Cost (Php)
Fluorescent light	1 pc	260.00	260.00
TOTAL			**260.00**

Source: SM Department Store)

C3 Queen Cleaner Dish Washing Liquid
Safety Equipment Cost

Equipment	Quantity	Unit Price(Php)	Cost (Php)
Working gloves	4 pairs	25.75	103.00
Hair net	6 pcs	5.00	30.00
Face Mask	192 pcs	6.00	1152.00
Apron	4 pcs	26.75	107.00
First Aid Kit	1 set	125.00	125.00
`Fire Extinguisher	1 unit	1500 .00	1500.00
TOTAL			**3017.00**

C 4 Queen Cleaner Dish Washing Liquid
Delivery Expense

Particulars	Cost per Month (Php)	Expenses (Php)
Transportation fees	Php 480.00	5760.00
TOTAL		**5760.00**

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RAIN H_20 DISPENSER : DEVELOPMENT OF A RAIN FILTRATION SYSTEM INCORPORATING SOLAR POWER AND AUTOMATED SCREENING THROUGH MICROCONTROLLER TECHNOLOGY FOR THE AETA COMMUNITY IN BATANGAS, PHILIPPINES

ENGR. LEAH Q. SANTOS*, ENGR. JESTONI M. ASI, RHOXIE THERESSES V. ARCIAGA, DIO-MEL D. MAYUGA, MARLON T. OLAES, REMSON A. OLIVEROS, PAUL ANGELO E. PORTUGUEZ

Department of Engineering, Lyceum of the Philippines University – Cavite, Governor's Drive, General Trias City, Cavite, 4107, Philippines
*Corresponding Author: leahquiritsantos@gmail.com

Abstract

This study aims to develop a combination of rain filtration, and mechatronic-controlled dispensing system powered by solar energy, that could reach out people who are isolated from clean water systems, and provide them with an additional source of reliable drinking water that utilizes rain and other usual sources of water (e.g. wells, etc.). The researchers decided to move forward about this study to contribute something beneficial for an affected area, particularly, the Aeta Community in Rosario, Batangas that is proven affected by the Community Outreach and Service Learning Department in Lyceum of the Philippines University - Cavite. Through the RainH2O Technology, and as the result of this study, their usual water sources, stored rain and well-water, can now be processed into a more reliable, laboratory-validated, and potable drinking water that could be dispensed at warm, cold, and hot temperatures.

Keywords: Rain Water, Solar Power, Filtration, System Automation, Dispenser, Potable Water.

1. Introduction

Water, a quintessential factor of living that everyone probably knows about, has been used for numerous reasons; most importantly, for drinking. "91% of the world now has access to Drinking Water, but One-Third doesn't have proper sanitation: It is no exaggeration to say that drinking water has been the lifeblood of civilization. Yet for so many residing in the underdeveloped parts of the world, it's a precious supply that's been endangered due to unsuitable or nonexistent sanitation systems." (Cara, 2015). Although clean and reliable water can be available for most people, admonish that there are people who are still and only relying with water from rivers, wells, and even rain due to water scarcity and

deprivation, not even thinking twice to consume these untreated waters, and that it could affect their health, and even their lives.

From the stated water sources above, the researchers thought of the most probable one that can mainly be utilized for drinking and that would be better and safer to sanitize. The Climate of the Philippines is tropical and maritime. It is characterized by relatively high temperature, high humidity and also known as a country for abundant rainfall (Climate Reselient: Philippines Aquaculture Portal, n.d.), because of this, the researchers thought about mainly employing rainwater itself; also opening up another idea that will enable the users to produce potable water even from their naturally stored and harvested waters (e.g.wells, rainwater).

The scope of this study only revolves around the development of a Rain Filtration and Dispensing system. The project incorporate solar panels as the main charger of the battery with the aid of a charge controller and an inverter to power the system properly. Arduino Microcontroller technology is utilized for the control system. An automated screening device is installed on top of the project that utilizes an IR sensor, servo motor, and a wiper to be able to prevent foreign objects from getting into the system. The flow of water from the tanks to the 6-stage filtration system is assisted by a pump to provide a faster flow. Filtrated water is directed into a dispenser that can finally be dispensed either in a normal, hot, or cold temperature. Backup reservoir is also available, to process stored waters, whenever there is no rain. Weather related issues will not be discussed.

2. Methodology

This chapter presents a reliable data about the project thesis' research and construction methods. Resulting from the initial compilation of project-related data and studies of water filtration, into its actual construction, application, and testing; create the RainH2O Dispenser, and produce a validated potable water output from rain and stored waters for the Aeta Community in Rosario, Batangas.

2.1. Research Design

The Research Designs used in this study are Experimental and Review Methodologies. These designs were most suitable for this engineering project for it helped the researchers on gathering data to be able to arrive at the desired output, which is a clean and potable water. The elements that contrived the RainH20 Dispenser came from typical and feasible sources in the market, constructing mechatronic systems that will make the project study possible. The project's ability to filtrate rain and stored water is the main focus of the project, to make it potable as safe as possible, with respect to the equipment's quality and capability.

In scientific studies, experimental design is the gold standard of research designs. This methodology relies on random assignment and laboratory controls to ensure the most valid, reliable results. Although researchers recognize that correlation does not mean causation, experimental designs produce the strongest, most valid results (Hall, 2017).

This study, the RainH_2O Dispenser: Development of a Rain Filtration System Incorporating Solar Power and Automated Screening through Microcontroller Technology for the Aeta Community in Rosario, Batangas, Philippines, requires Experimental Methodology for its possible health impacts to the beneficiaries. It includes input water testing, to know its properties and what actions are to be made to remove the unwanted substances, and scrutinizing the output water, to perceive the results of the clean potable water produced from the filtration system itself, existing inside the machine. These procedures are done in a service laboratory equipped to perform tests on water. On the other hand, the Review research design is also used since this project is a development of past project studies. References are used in order to be informed on recommendations and facts made by the previous researchers.

The research designs chosen for this study helped the researchers to attain the stated objectives, and also, to provide reliability and validity. Furthermore, be able to create an approach to lend a hand to other people in a small, but helpful way, through lessening those communities who are deprived of having clean potable water, through this project.

2.1.1. System Model

The researchers have used spiral model for the project since it is usually used and favored for large projects. Since spiral model introduce a high amount of risk analysis, avoidance of risk is also enhanced or increased. The system process can also be controlled by using this model since every part or process of the machine can be tested and evaluated separately. Once a prototype is made for a certain process of the machine, it can be tested immediately. Once the desired output was not obtained, changes or improvement could be made in the prototype until a desired output was produced. In order for the reader to be informed how spiral model works, the researchers put up a diagram of spiral modelling.

In relation to the Project, the RainH_2O Dispenser, one of the most beneficial processes included in the spiral model is Risk Analysis. For every process of the project, like the automated screening process, risk analysis takes place until an operational prototype is created. This analysis takes place in every system process of the project, like the piping and filtration system. The materials and components for the automated screening process can also be tested immediately after the software is created and developed for the microcontroller. This helps the researchers take a conventional control towards the phases of development of the machine. Spiral model also introduces a faster implementation of changes in the prototype, making it suitable not only for the researchers but also for the users of the machine themselves. Troubleshooting of software and hardware components will be present in each process of the machine in order for the researchers to find alternate solutions for a risk that might be encountered. These solutions will be suggested and implemented by the researchers until the desired output is produced and the chance of risk is reduced. The researchers will divide the development of the RainH2O Dispenser into parts that can be tested separately. Risky parts can be started or developed earlier for the researchers to have a better risk management for the project.

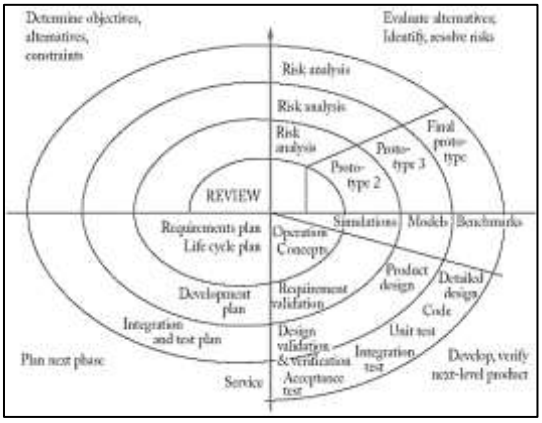


Figure 1. The Spiral Model (math.bas.bg)

2.1. 2. Process Flow

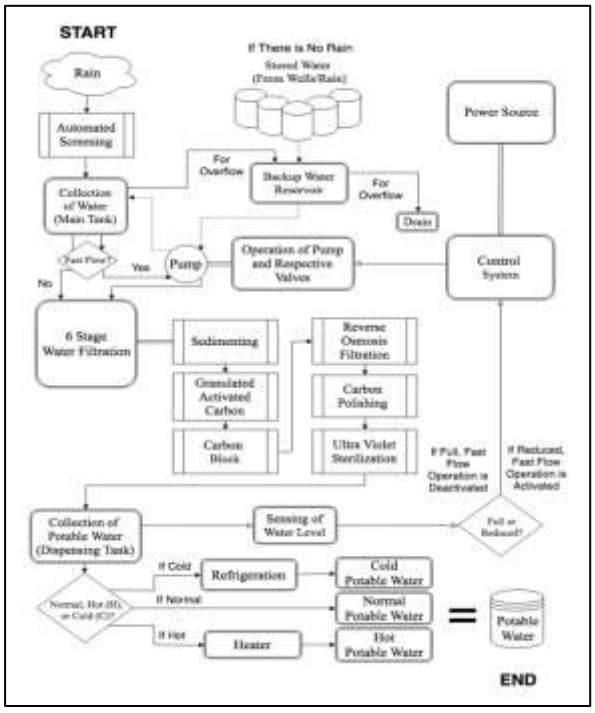
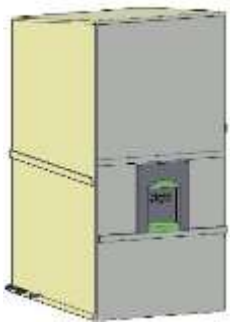


Figure 2. Overall Process Flow Chart

The Process basically start from obtaining rain water/stored water as the main project input. The input will initially be screened automatically from foreign-macro objects, and prevent it from getting into the main tank. When the main tank is filled-up with water, it can now be ran through the filtration system by the use of pump, aided by free flow due to gravity to achieve successful and faster filtration process. The filtration includes 6 stage filters: Sediment, GAC, Carbon Block, Reverse Osmosis, Post Carbon Polishing Filter and finally, through an Ultraviolet Light, for sterilization. After the water has been fully-filtered, it will now be stored in the dispensing tank, ready for dispensing the potable water output. The output can either be normal, hot, or cold that is done by the water dispenser's refrigeration system. When the dispensing tank reduces, it will be sensed by a sensor and will send a signal to the Control System that will now decide what action is to be done, based on the programmed conditions. When it is reduced, it will be refilled through the fast flow operation, by the pump until it is enough for dispensing, then followed by the continuous non-fast flow operation, to further fill-up the filtration containers, save time for filtration, and conserve energy for the pump. When there is no rain, and the main tank is empty, stored waters can be put into the backup reservoir that will be pumped to the main tank for screening, and again run through the same cycle. The electricity for the whole project is supplied by the Main Power Source (Power House).

(a) RainH_2O Dispenser Screening System Dispenser

(b) Additional Rain Catchment Device beside RainH_2O



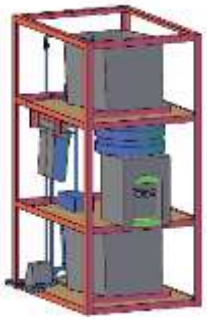


Figure 3. Actual RainH_2O Dispenser Perspective View [Cropped Gallon is Optional]

2.1.3. Power House and Electronic Control System Design

The Power House is composed of the Solar Panels, Solar Charger Controller, Batteries, and an Inverter.

2.1.3.1. Total Energy Consumption

Total energy (watt-Hour) is the sum of appliances/components power consumption (watt) multiply by hour use.

Table 1. Total Energy Consumption Table

Load	Quantity	Power Consumption(watts)	Average use (Hours)	Energy Consumption (watt-Hours)
Water Dispenser	1	450	3	1350
Water pump 1	1	30	5	150
Water pump 2	1	69	5	345
UV light	1	10	5	50
Arduino Uno 1	1	1	24	24
Arduino Uno 2	1	1	24	24
Solenoid Valves	3	12	1	36
Motor Shield	1	3	5	15
Servo Motor 1	1	5.4	0.5	2.7
Servo Motor 2	1	5.4	0.5	2.7
Relay	8	0.75	24	108
Water level sensor	2	10	1	20
IR sensor	1	0.1	24	2.4
RTC module	1	0.75	24	18
TOTAL ENERGY CONSUMPTION:				2147.8

2.1.3.2. Sizing of Battery Computation

Battery loss: 0.9

Total Energy: 2147.8 Watt-Hour

$$\text{Energy} = 2147.8 \,/\, Battery\ loss$$
$$= 2147.8 \,/0.9$$
$$\text{Energy} = 2386.44\ Watt - Hour$$

Depth of Discharge (DoD): 60% = 0.6

$$\text{Energy} = 2386.44/\ DoD$$
$$= 2386.44/\ 0.6$$
$$\text{Energy} = 3977.4\ Watt - Hour$$

Solar Setup voltage: 12V

$$\text{Energy} = 3977.4\ Watt - Hour\ /\ Setup\ voltage$$
$$= 3977.4\ Watt - Hour\ /\ 12V$$
$$= 331.45\ Ampere\text{-}Hour$$
$$= 331.5\ Ampere\text{-}Hour$$

Battery capacity = 332 AH

Battery capacity ≈ 300AH
Number of Battery: 2
Battery capacity = 300AH/ *no. of battery*
= 300AH/ 2
Battery capacity = 150AH

Total Battery AH Capacity: 150AH
Quantity: 2 Pcs VRLA Battery (12V)

2.1.3.3.Sizing of Solar Panel Computation

Total Energy: 2147.8 Watt-Hour
Factor Loss: 1.3
Energy $= 2147.8\ x\ factor\ loss$
= 2792.14 Watt-Hour

Effective Sun Hours in Rosario Batangas: 5.5 Hours
Energy = 2792.14 Watt-Hour / *effective sun hours*
= 2792.14 Watt-Hour / *5.5 hour*
= 507.67 Watt
Power ≈ 450 Watt

Number of Solar Panel: 3
Power = 450 Watt / 3
Power = 150 Watt

Total Watt power of PV capacity: 150 watt
Quantity: 3 Pcs Polycrystalline Solar Panel

2.1.3.4. Sizing of Solar Charge Controller (SCC) Computation

Solar panel watt power: 450 watt
Solar Setup voltage: 12V
Solar panel watt power = 450 watt / *Solar Setup voltage*
= 450 watt / *12V*
= 37.5 Ampere

Safety Margin: 1.25
SCC Amps = 37.5 Ampere *x safety margin*
= 37.5 Ampere *x 1.25*
= 46.875 Ampere
SCC Max Amps ≈ 60A
Total SCC Amps: 60A MPPT Solar Charge Controller

2.1.3.5. Sizing of Inverter Computation

Appliances/components with 220v AC supply.

Table 2. Power Consumption (Load with Motor) Table

Load with Motor	Power Consumption (Watts)
Water Dispenser	450
Water pump 1	30
Water pump 2	69
Servo motor	5.4
TOTAL POWER W/ MOTOR:	524.4

Safety margin for surge power: Multiply by Two (2)
Total power w/ motor = 524.4 watt *x safety margin*
Total power w/ motor = 1048.8 watt

Table 3. Power Consumption (Load without Motor) Table

Load without Motor	Power Consumption (Watts)
UV light	10
TOTAL POWER W/O MOTOR:	10

Safety margin: add 30% ~ 0.3
Total power w/o motor = 10 watt + *(0.3) Load*
= 10 watt + *(0.3)(10)*
Total power w/o motor = 13 watt

Total Inverter Watt Capacity = Total Power w/ Motor + Total Power w/o Motor
= 1048.8 watt + 13 watt
= 1061.8 watt = 1kw

Total Inverter Watt Capacity: 1KW Pure Sine-Wave Inverter (220v AC)

2.1.3.6. The Solar Panel Actual System

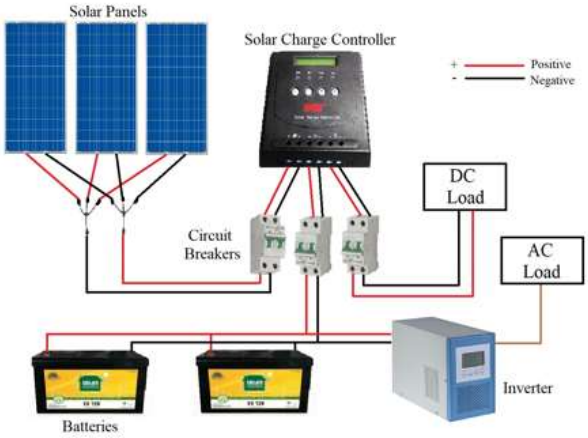


Figure 4. Solar Panel Actual System

In the diagram above, it shows the whole connection of the solar-power system, from the solar panels to the inverter. Solar panels will be used to gather energy from the sun and will then be converted into a usable power supply. As computed, three 150 watt solar panels will be used to sustain the required energy for the project to work.

The energy that will be gained from the panels will be directed to a solar charge controller. The Charge controller will control the charge that will enter into the battery because an uncontrolled charging/excessive amount of charge that will enter the battery will cause overcharging that will decrease the lifespan of the

battery or can even destroy it. The charge controller has regulated 12VDC supply that can be used for DC loads. Two 150AH batteries connected in parallel will be used to supply the dispenser, pump, and other electronic components.

A 1KW inverter is used to convert power coming from the battery from DC into AC, to power up the dispenser, UV light, and pump. Circuit breakers are used to maintain an acceptable level of power that will enter into a certain device just like the charge controller, and to protect it from possible surges of power coming from the panel. Surge of power resulting from huge amounts of collected energy from the sun will damage the charge controller if it is not prevented.

3. Results and Discussion

All system components were in good condition and properly functioning; tested separately, and when established together as a whole system. As a complete running system, the input (water from rain/well) has been successfully processed, provided that the output water has been tested safe enough for microbial factors. Power has been tested effective and sufficient to run the system for the specified operating time. The Piping and Control system worked accordingly, and transferred water properly based on the process flow conditions. The Filtration has been proven tested and working by submitting an input and output sample to JEFCOR Laboratories by performing a microbial testing (total coliform which resulted to a total coliform <1.1). The Dispenser can be filled up to its maximum storage (1000 mL) for 20-50 minutes when fully empty, and can give sufficient amount of potable water (cleaner water than their usual source of drinking), providing a total of at least 13500 mL for its whole operation time (5 hours) per one day, good enough for a simple prototype that will provide an additional source of reliable drinking water.

3.1. PH Testing (Via Litmus Paper)

The researchers utilized red litmus papers to be able to obtain the water's output ph level. The red litmus paper turns to Blue when there's a difference in the pH level, having more base (Alkali) to its properties, and stays at its red color when there is no difference in the pH level (Acidic), having more acid to its properties. Testing accumulated one litmus paper per one trial, performing five trials for each samples.

Table 4. PH Testing for specific Water Samples using Red Litmus Paper

Water Sample	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Unfiltered Rain	Red	Red	Red	Red	Red
Unfiltered Deep Well	Blue	Blue	Blue	Blue	Blue
Unfiltered Mixture of Rain and Deep Well	Blue	Blue	Blue	Blue	Blue
Filtered Rain	Blue	Blue	Blue	Blue	Blue
Filtered Deep Well	Blue	Blue	Blue	Blue	Blue
Filtered Mixture of Rain and Deep Well	Blue	Blue	Blue	Blue	Blue

Table 5. PH Testing Results (Based on Table 4.7)

Water Sample	Red Count (Acidic)	Acidic Output Percentage	Blue Count Alkali (Blue)	Alkali Output Percentage
Unfiltered	5/15	33.33%	10/15	66.67%
Filtered	0/15	0%	15/15	100%

For Table 4 and Table 5, it can immediately be observed that all input waters that have been processed by the RainH2O Filtration System has turned 100% of the acidic and basic inputs into a balanced basic (alkali) output.

The RainH2O Water Outputs are more of a base than of acidic contents. According to research, An Admin of Alkaline Water Filter Experts states that, "Alkaline water is water with a higher pH level. Since it has a higher level of pH, it helps neutralize the pH level in your body from all the acidic food and drinks that you have consumed throughout the day. An alkalized body has a stronger immune system and can help regenerate damaged cells, making you more resistant from diseases and less prone to fatigue. Also, oxygen absorption is more efficient; this is essential for your health." Therefore, from the PH Testing performed and showed at Tables 4 and 5, the 100% basic/alkali output of the RainH2O System can be said to be reliable, PH-healthy, and safe to drink.

3.2. Actual Prototype Testing

Table 6. Summary of Actual Testing

SUMMARY OF TESTING	
Tank Capacities	
Dispenser Capacity	1000 mL (per 22 min)
Main Tank Capacity	100 L
Bottom Reservoir Capacity	100 L
Processing Time	
Pumping and Filtrating	28.5 sec
Refilling the Dispensing Tank (Instal*)	22 min (47 min*)
Refilling the Main Tank (Initial*)	5 min (10 min*)
1 Complete Process Waiting Time (Initial*)	27 min (57 min*)
Total Time Dispensing all Stored Water	5 Hours
System Flowrate	
Filtered Water	1.07 mL/s
Waste Water	6.52 mL/s
Main Tank Refilling Water	102.01 mL/s
Dispensed Water	44.42 mL/s
Battery Data	
Charging Time (Solar Panel)	8 Hours +
Charging Time (Outlet)	6 Hours +
Actual Hours to Drain 100% Battery (at Full Load)	10 Hours +

Table 7. Actual Processing Time Data

Process No.	Process Description	Time				
		Trial 1	Trial 2	Trial 3	Average	RND
1'	Pumping and Filtration	26.38 sec	26.80 sec	26.71 sec	26.63 sec	27 sec
2'	Fill Up the Dispenser (Initially)	46 min 31.87 sec	44 min 57.47 sec	47 min 55.14 sec	46 min 28.16 sec	47 min
3'	Refilling the Main Tank (Initially)	9 min 18.21 sec	9 min 20.09 sec	9 min 36.12 sec	9 min 25.02 sec	10 min
Time to Start up the System (For Initial Installation Only)		56 min 16.46 sec	54 min 44.36 sec	57 min 54.97 sec	56 min 18.59 sec	**57 min**
Process No.	Process Description	Time				
		Trial 1	Trial 2	Trial 3	Average	RND
1	Pumping and Filtration	28.19 sec	30.27 sec	30.14 sec	29.53 sec	30 sec
2	Refilling the Dispenser After Emptying	21 min 31.84 sec	21 min 39.82 sec	21 min 47.24 sec	21 min 39.63 sec	22 min
3	Refilling the Main Tank Again	4 min 13.07 sec	4 min 10.4f6 sec	4 min 24.04 sec	4 min 15.86 sec	5 min
Time of 1 Complete Process (1, 4, 5) for 1 Full Dispenser "Waiting Time"		26 min 13.10 sec	26 min 20.55 sec	26 min 41.42 sec	26 min 25.02 sec	**27 min**
TOTAL OVER-ALL PROCESSING TIME						
Total Time to Process all 100 Liters on Main Tank Continuously (Filled the Dispenser 5 more times) (Time at Process No. 2) x 5		1 HR 48 MIN	1 hr 48 MIN	1 HR 49 MIN	1 HR 48 MIN	**2 HRS (x2)**
Total Time to Refill the Emptied Main Tank from Backup Tank		30 MIN	27 MIN	28 MIN	27 MIN	**28 MIN**
TOTAL TIME TO PROCESS ALL 200 L OF WATER		**5 HOURS APPROXIMATE**				

3.2. Microbial Testing

(a) Input Water (Unfiltered: Rain and Deep Well)

(b) Filtered Water

Figure 5. Microbial Testing

Based on the previously shown laboratory certifications, it can be observed that a huge difference has been made by the RainH2O filtration system. From having a total coliform of > 23 for both Stored Rain Water and Deep Well Waters, processed to a < 1.1 count of Total Coliform. According to Angelo (2011), having a total coliform count result of less than 0 or 1.1 contributes to the factors that can be analyzed and to be considered safe for Human Consummation.

"THE Davao City Water District (DCWD) said that Cabantian water is safe to drink based on the results of the monthly biological tests of samples. In July, the Cabantian reservoir water passed the microbiological test proving that samples from the Cabantian Reservoir 1 on July 17 had less than 1.1 total coliform, less than 1.1 fecal coliform, less than 1 heterotrophic plate count (HPC) and 0.87 chlorine residual. A sample collected on July 3, from the old Cabantian reservoir passed the microbiological test with less than 1.1 total coliform and fecal coliform, 40 HPC and 0.49 chlorine residual. Based on published documents, total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is probably environmental." (CAÑEDO, 2017).

Most results that have passed by accredited water testing laboratories show that its total coliform count is less than 1.1, and can be considered safe. Furthermore, JEFCOR Laboratories also remarked the RainH2O Water Output as "PASSED". Therefore it is very pleasing to conclude that the project's processed output is potable, and safer than the users' current drinking sources; made it more fit to drink than usual, having the water input pass through a 6 Stage Water Filtration Drinking System, is quite satisfying.

4. Conclusions

A solar powered system like this was made to eliminate the cost of paying electric bills, through the use of Solar Panels, 12V Batteries (150 AH), 60A Solar Charge Controller, and a 1KW Power Inverter, and the automation applied in the system, using infrared IR sensor obstacle avoidance module and a programmed motor, was designed to remove the hassle of manually doing the things that causes delays in the system just like of having any obstruction in the screen that will result to slow moving of the flow of water. The users no longer need to manually pick up the objects that blocks the passage of the water at the top of the project. The project also gives user awareness of the remaining charge in the battery that can be seen in the charge controller as well as in the inverter. The solar charge controller also displays the amount of power obtained by the solar panels and will display a fully charged status when charging from the sun is completely done. As for safety purposes, only maintenance and person who knows and instructed about solar panels are allowed to operate the solar power system. An IR sensor could successfully recognize the obstacles blocking the catchment area, therefore allowing the wiping system to operate.

This project, Rain$H_2$0 dispenser, aims to aid the insufficiency of clean water in the Aeta Community in Rosario, Batangas, Philippines by means of utilizing the renewable resources, such as water, from the environment. It is being done by the application of 6-Stage Filtration System, consisting of the following: Sediment Filter, Granulated Activated Carbon Filter, Carbon Block Filter, Reverse Osmosis, Carbon Polishing Filter, and an Ultra Violet Light, and dispensing systems, with simple vapor-compression refrigeration cycle for a hot, normal, or cold output. Catchment areas and tanks are established to serve as storage of water supply through the incorporation of a simple PVC piping system and solenoid valves. Testing of input and output water was done in order to assure its accuracy and its ability to produce clean water where the samples were brought to the Jefcor Laboratory, a government recognized water testing laboratory and through the PH Test, by means of Litmus Paper, where it showed 100% alkalinity on all trials done. The reading for the water output Total Coliform is <1.1 MPN/100mL where it passed and was based on the <1.1 PNSDW Standard for Drinking water. On the other hand, the average output flowrate of the filtration and piping system are 1.07 and 102.01 ml/s respectively.

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OPTIMUM EFFECT OF BLADE ATTACHMENT LOCATION FROM THE CENTER OF STRAIGHT VERTICAL AXIS WIND TURBINE USING AIRFOIL

THOMAS JOSEPH I. PINGAD, LENARD RYAN H. GUEVARRA, JASEM C. HERNANDEZ, RIZAL M. MOSQUERA

Mechanical Engineering Department, College of Engineering
University of Perpetual Help System DALTA Calamba Campus
Paciano Rizal, Calamba City, Laguna, Philippines

ABSTRACT

The goal of this study is to find the ideal distance from the central panel and pitch angle of the airfoil blade that had the most efficiency in capturing energy from the wind using a straight blade vertical axis wind turbine with central panel. The research's aim is also to find the blade positions with respect to the orientation of the central panel that would yield the optimum efficiency of the straight vertical axis wind turbine.

Field test shows satisfactory influence of the distance of the airfoil blade to the central panel while observing it's orientation with respect to the position of the central panel simultaneously varying the pitch angle. The study shows that at fixed size of the airfoil, its distance from the central panel influence the performance of the wind turbine.

Model result shows satisfactory performance of the straight vertical axis wind turbine with central panel with airfoil blade located at 22cm from the center and the pitch angle 0o. Both model and prototype self-start at the wind velocity of 6 m/s with an average efficiency of 23.28%.

1. Introduction

Despite minimal use of wind energy in the Philippines, potential is strong (Elliott, D. et al., 2001). A wind mapping survey estimated that the Philippines could potentially generate 70,000 MW from the available wind resource. The survey identified 47 provinces, with the potential to generate at least 1,000 MW each. Average wind power density across the country is estimated at $31\frac{\mathrm{W}}{\mathrm{m}^2}$ (Elliott, D. et al., 2001). The wind resource is greatest in the north and north-east of the country. Areas that face east towards the coast from Luzon to Samar also represent good-to-excellent wind resources for utility-scale, and excellent wind resources for village-scale, applications. Less potential exists in the south and south-west of the archipelago. Existing use of wind generation includes a 10 kW stand-alone system that provides electricity to 25 households. Batangas province has a 25 kW stand-alone system with six different loads (Lee, Z. H., 2013). A 3 kW wind-diesel system is also in use for a telecommunications relay station. A 25 MW wind farm was inaugurated in June 2005 at Bangui Bay, Ilocos Norte,

Philippines(Montenegro Pinto, C. E. 2013) which is the first wind farm to be fully operational in the country, and the largest in South-East Asia.

In the latest data from the Global Wind Energy Council (GWEC), the Philippines' wind power contribution was 216 Mega Watts (Martinot, E., 2006), for 2014, 2015, and 2016, only 0.049898% of the global contribution; while China leading the contribution leaderboards by contributing 168,690 Mega Watts, 38.96% of the total global contribution.

Airfoil Form for Straight Vertical Axis Wind Turbine

In the recent study of Tizon et al. (2015), the most recorded high power coefficient is the asymmetric blade design with central panel attached with 5˚ pitch angle giving 21.36 % power coefficient at 38% tip speed ratio. The set-up self-starts at 6 m/s. The more the blade is open (toe out pitch angle) and far from the center panel the more it rotates, because the central panel pushes the wind to the drag or lift part of the blade that gives the wind turbine the force to rotate.

The main concept of this study was to know the optimum effect of blade attachment locations of Straight Vertical Axis Wind Turbine using Airfoil blades with central panel, on the power output by varying which among the attachment location of the airfoil blades have a high efficiency of the vertical axis wind turbine.

Thickness in Percent Chord Analysis

The airfoil may be placed in such a way that the leading and trailing edges lie on the same horizontal line. And then find the chord length, which is the length of the line joining the leading and trailing edges. Find the maximum thickness of the blade using the formula: % Chord Thickness = (thickness of blade/Chord length) x (100). According to the study conducted by Rey, M. et al., 2016, an airfoil with thickness of 24% thick based on chord length is the most efficient. With this findings and adopting this kind of wind turbine, this study also uses the % thickness based on chord length.

2. Methods

There are two kinds of Wind Turbines: The vertical axis wind turbine and the horizontal axis wind turbine. The focus of this study is on the vertical axis wind turbine, which has 2 types of wind turbines: The Savonius type wind turbine and the Darrieus type wind turbine. The Savonius type is a drag-type device which looks like an "S" shape from the cross section and has high torque however, it has relatively low speed. The Da rrieus types are lift type turbines which uses the lift force generated by the wind to create a rotation; a concept used in aerodynamic flight. By combining the 2 types into a new breed of wind turbines which combines both lift and drag, the new breed of vertical axis wind turbines can rotate in any direction of the wind. Past studies have shown this study to be possible. This study focuses on how to increase the efficiency of the Straight Vertical Axis Wind Turbine (SVAWT) by varying the blade locations from the center with the corresponding pitch angle to capture the most wind so the turbine generates more electricity.

Operational Procedure for the Testing Model:

1. The testing model had adopted the previous study of Gibe et al., (2016) that uses asymmetric airfoil with 24% thickness based on chord length with 260mm long and 300mm high.

2 The Testing model will also be adopting the base panel testing assembly in the ME Laboratory of the University of Perpetual Help Calamba Campus

3 The testing model essential design is to provide the spoke where the airfoil is attached which was designed to have 762mm (30in.) in radius, with

center hole of 30mm and radial hole with the distance of 100mm from the first testing hole, and 40mm intervals for every subsequent holes outwards.

4 Fabricated the SVAWT spoke using a transparent acrylic material for ease of measuring the pitch angle when varied during the test.

5 Double checked the measurements to comply with project designs.

6 Made the necessary adjustments and polishes of fabricated parts.

7 Assembled the SVAWT testing model.

Testing Procedure:

1 Checked testing area to ensure safety. The wind turbine should have been connected to the shaft properly. The blades should have been attached to the base panel assembly of the wind turbine firmly and to the generator.

2 The testing machine was checked to be on good condition having the desirable wind velocity output.

3 Prepare the following measuring instruments:

3.1 Digital Tachometer

3.2 Digital Anemometer

3.3 Spring balance

3.4 Steel Tape measure

4 The wind velocity was measured on the fan and duct system 1m away from the outlet using the anemometer, where the wind velocity was captured before it hits the wind turbine.

5 The wind velocity was measured 1m between the fan and the testing model, where the output wind of the fan will directly hit the turbine.

6 The torque was measured by placing the spring balance on the hole of the acrylic spoke of the blade and pulling the spring balance. Measure the radius from the central axis to spring balance attachment.

7 The angular velocity in RPM was measured using the digital tachometer pointing it to the central shaft of the wind turbines which was provided with the reflecting sticker.

Design of SVAWT Prototype

The researcher takes note of performance of the wind turbine with the highest efficiency setting in terms of airfoil blade location and pitch angle setting of SVAWT testing model.

Using the findings from the result of the model testing, compute for the parameters of the design of the prototype via Dynamic Similitude.

Use the computed parameters form dynamic similitude in drawing the prototype design.

Material Selection of Prototype

For the prototype of the airfoils, it has been decided to use GI metal sheets in its fabrication. GI metal sheets are made to withstand harsh weather. Since the airfoils are installed in the outside condition, it would experience changes in climate. It should resist heavy rains and strong winds, and metal expansion due to heat. Round bars will support the lining of the airfoil to prevent deformation. For the prototype base, a 3mm steel plates and angle bars were the choice. They

were welded together into sturdy base that would withstand the moment formed by the air on the SVAWT.

A 200 Watts generator was fitted on the base due to the fact that the SVAWT prototype was designed to have a capacity of 200 Watts. It's fitted via cylindrical shaft with a bearing connecting it onto the base and into the generator.

Evaluation Procedure

In testing, the researchers used the fan and ducts system. By designating the distance of the fan and ducts system to the wind turbine, it should be assured that the wind turbine is in steady position and avoid the wiggling movement. As the fan and ducts system blew its wind, the wind velocity that will hit the blade of the wind turbine is measured using the anemometer. At first, the speed of the rotation was increasing because it started from rest, in that situation; tachometer is used to measure the angular speed (revolutions per minute). Assuring that the rpm is stable and does not increase or decrease rapidly, the rpm was recorded simultaneously with the air velocity.

This testing procedure was done several times in different blade locations. The results of the tests were graphed for the analysis of finding the optimum location of the blades of the straight vertical axis wind turbine.

The torque of the setup was measured using the spring balance and the angular velocity was measured using the tachometer for every test. The power produced by the testing model was calculated by using the formula: $W = 2\pi TN$, where T is the torque and N is the RPM of the wind turbine. The results was encoded in Microsoft excel and plotted the graph of both the RPM and the power versus the pitch angle. Using a line graph, it was analyzed and found out the "peak" performance of the testing model. Since the power produced is dependent on the RPM output, the "peak" of the graph was to be considered the most efficient or of optimum performance.

Ideal Blade Distance and Pitch Angle

In order to determine the ideal blade distance and pitch angle of the Straight Vertical Axis Wind Turbine, the researchers conducted and experiment in order to determine the distance of the airfoil blade from the central panel and what to what pitch angle to be toe out or toe in airfoil set-up.

Blade Distance

To determine the blade distance, the researchers used the testing model that had 7 holes, each corresponding to an equal distance of 40mm. Each hole has an interval of 4 centimeters, with the first hole having a distance of 10 centimeters from the center of the central panel.

Pitch Angle

Following the testing of the blade distance in the testing model, each airfoil hole attachment had a corresponding guide 5 centimeters above and below. This guide was had an arc of 30 degrees divided into 7 sections with corresponding angles, starting from 15 degree toe out to 15 degree toe in with 0 degree as its neutral point. While testing the ideal distance of the airfoil from the central panel, the pitch angle was also varied to determine the ideal blade distance and pitch angle that would yield the optimum efficiency.

In order to determine which parameter to choose for the prototype, the efficiency had to be determined. In order to determine the efficiency, the researchers used the formula:

$$\frac{output}{input} x100 \ = \ efficiency.$$

Output power being the power produced by the straight vertical axis wind turbine, which can be defined as the generator power:

$$Electrical\ Power(EP) \ = \ 2\pi TN.$$

Where:

T – Electrical torque produced by the electric field of the generator

N – Angular velocity of the generator

Π – 3.1416

Input power is the kinetic power generated by the wind and is determined by:

$$Air\ power(P) \ = \ \frac{1}{2}(Swept\ Area)(Density\ of\ air)(v_{air}^3)$$

Where:

ν – Air velocity

Self-starting capability vs. Efficiency

To determine which parameter of the prototype will yield its self-starting capability that have the best efficiency using the formula:

$$e = \ \frac{Electrical\ Power}{Air\ Power} x100\%$$

Model to Prototype Similitude

Designing the prototype was done using the similitude principle. By determining the dynamic similitude using the ratio of the power of the prototype and model to the ratio of their area as follows:

$$\frac{Power\ of\ Prototype}{Power\ of\ model} = \ \frac{Area\ of\ prototype}{Area\ of\ model}$$

3. Results

Pitch Angle versus Angular Velocity Laboratory Test Result

The Figure 3.1 shows the trend of the model wind turbine angular velocity output. The trend shows that after the 4th hole location, there is a decrease in RPM as the airfoil moves away from the central panel indicating the loss of pressure between the surfaces of the airfoil while rotating.

Model Laboratory Test Results

The results in testing the model to find the optimum effect of blade attachment location from the center of straight vertical axis wind turbine with central panel using airfoil are illustrated below in tables and figures.

Table 3.1 Model Test Results at Different Locations, -15^{o}Pitch Angle

Blade Location & Pitch Angle	Distance from Center (m)	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m2)	Wind Power (W)	Efficiency (%)
1st, -15 o	0.10	6	2.50	0.0	N	N	0.4	0.00	0.03	3.89	0.00
2nd, -15 o	0.14	6	2.50	0.0	N	N	0.4	0.00	0.06	7.78	0.00
3rd, -15 o	0.18	6	2.04	29.1	Y	N	0.4	1.22	0.10	12.96	9.41
4th, -15 o	0.22	6	2.22	36.8	Y	N	0.4	1.54	0.15	19.44	7.92
5th, -15 o	0.26	6	2.19	47.4	Y	N	0.4	1.98	0.21	27.22	7.28
6th, -15 o	0.30	6	2.50	52.1	Y	N	0.4	2.18	0.28	36.29	6.01
7th, -15 o	0.34	6	2.43	54.2	N	N	0.4	2.27	0.36	46.66	4.87

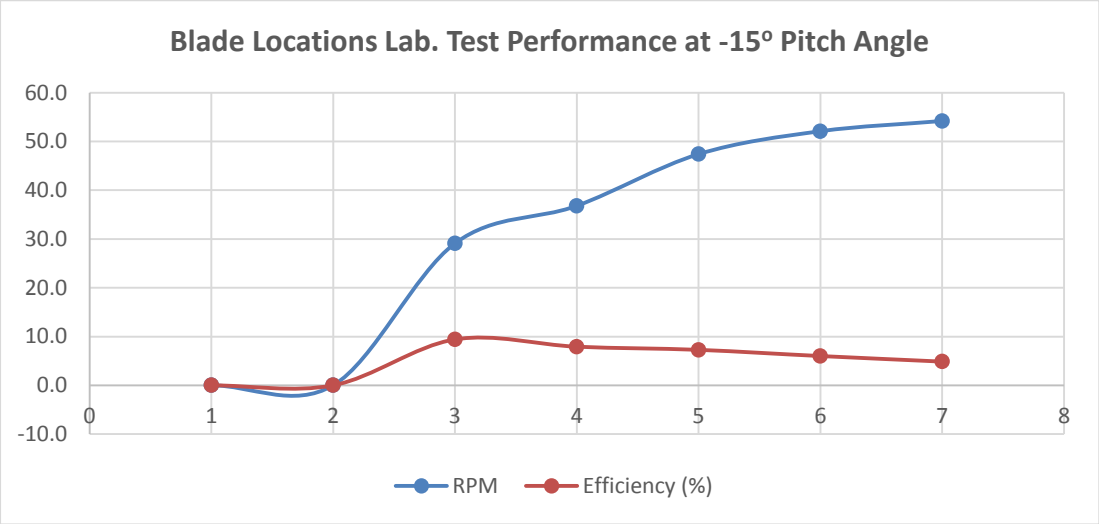

Figure 3.1 RPM and Efficiency Comparative Performance at – 15°

Table 3.1 and its corresponding graph Figure 3.1 shows that the turbine self-started at attachment location #3. It also yielded highest efficiency with increasing angular velocity.

Table 3.2 Model Test Results at Different Locations, -10^{o} Pitch Angle

Blade Location & Pitch Angle	Distance from Center	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m^2)	Wind Power (W)	Efficiency (%)
1st, -10 ^{o}	0.10	6	2.5	0	N	N	0.4	0.00	0.03	4.71	0.00
2nd, -10 ^{o}	0.14	6	2.5	0	N	N	0.4	0.00	0.06	9.23	0.00
3rd, -10 ^{o}	0.18	6	1.79	72.4	Y	N	0.4	3.03	0.10	15.26	19.86
4th, -10 ^{o}	0.22	6	2.35	92.6	Y	N	0.4	3.88	0.15	22.80	17.00
5th, -10 ^{o}	0.26	6	1.59	78.4	Y	N	0.4	3.28	0.21	31.85	10.31
6th, -10 ^{o}	0.30	6	2.51	74.3	Y	N	0.4	3.11	0.28	42.40	7.34
7th, -10 ^{o}	0.34	6	2.27	84.9	Y	N	0.4	3.55	0.36	54.46	6.53

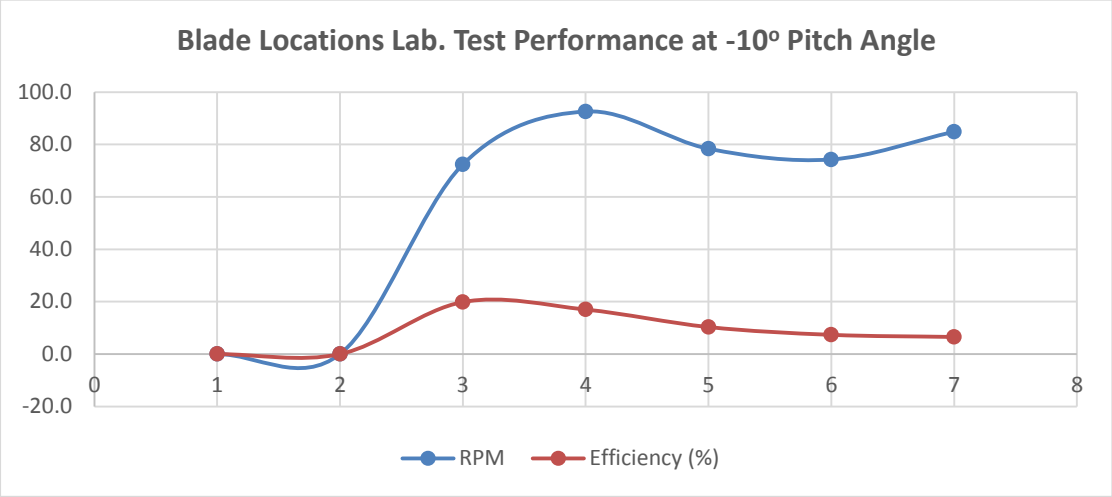

Figure 3.2 RPM and Efficiency Comparative Performance at – 10º

Table 3.2 and Figure 3.2 show the wind turbine self-stars at location #3 with highest efficiency, but at location #4 has the highest angular velocity.

Table 3.3 Model Test Results at Different Locations, -5º Pitch Angle

Blade Location & Pitch Angle	Distance from Center (m)	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m^2)	Wind Power (W)	Efficiency (%)
1st, -5 º	0.1	6	2.50	0.0	N	N	0.4	0.00	0.03	4.71	0.00
2nd, -5 º	0.14	6	2.50	0.0	N	N	0.4	0.00	0.06	9.23	0.00
3rd, -5 º	0.18	6	1.85	78.4	Y	N	0.4	3.28	0.10	15.26	21.50
4th, -5 º	0.22	6	2.19	120.7	Y	Y	0.4	5.05	0.15	22.80	22.16
5th, -5 º	0.26	6	1.68	85.2	Y	N	0.4	3.57	0.21	31.85	11.20
6th, -5 º	0.3	6	1.85	104.6	Y	N	0.4	4.38	0.28	42.40	10.33
7th, -5 º	0.34	6	1.88	107.7	Y	N	0.4	4.51	0.36	54.46	8.28

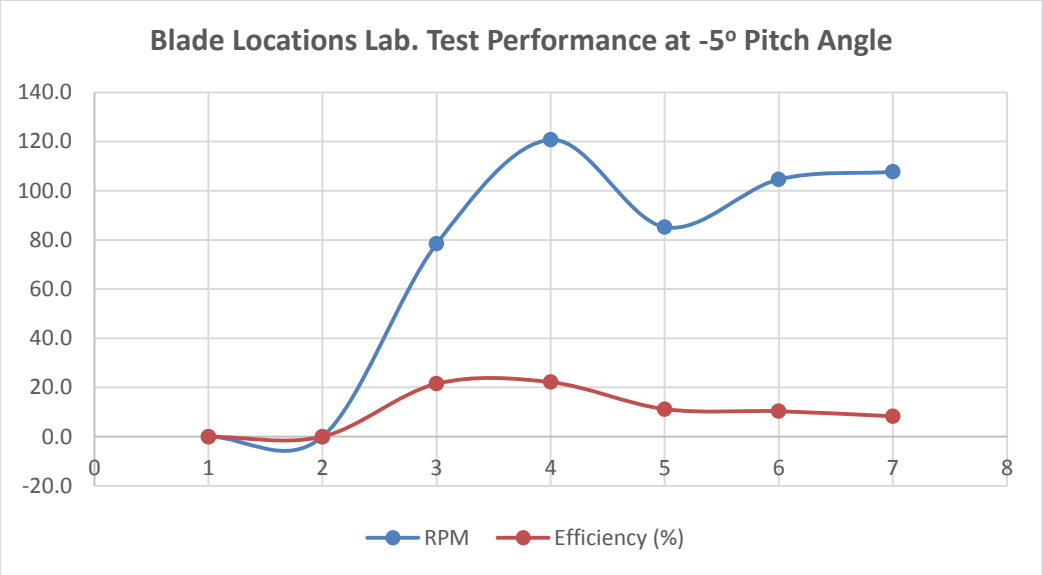

Figure 3.3 RPM and Efficiency Comparative Performance at –5º

Table 3.3 and Figure 3.3 show that the wind turbine self-starts when airfoil was located at attachment #3 also having the highest efficiency but attachment #4 has the highest angular velocity.

Table 3.4 Model Test Results at Different Locations, 0º Pitch Angle

Blade Location & Pitch Angle	Distance from Center (m)	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m^2)	Wind Power (W)	Efficiency (%)
1st, 0 º	0.10	6	2.50	0.0	N	N	0.4	0.00	0.03	4.71	0.00
2nd, 0 º	0.14	6	2.50	0.0	N	N	0.4	0.00	0.06	9.23	0.00
3rd, 0 º	0.18	6	1.90	78.3	Y	N	0.4	3.28	0.10	15.26	21.48
4th, 0 º	0.22	6	2.57	124.4	Y	Y	0.4	5.21	0.15	22.80	22.84
5th, 0 º	0.26	6	1.56	101.2	Y	N	0.4	4.24	0.21	31.85	13.30
6th, 0 º	0.30	6	1.90	110.3	Y	N	0.4	4.62	0.28	42.40	10.89
7th, 0 º	0.34	6	1.74	113.2	Y	N	0.4	4.74	0.36	54.46	8.70

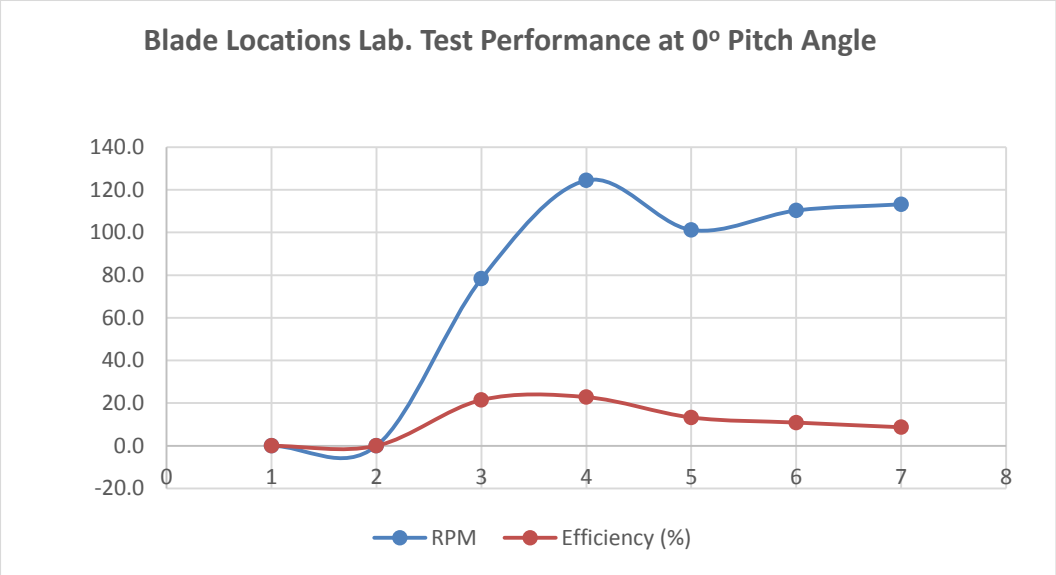

Figure 3.4 RPM and Efficiency Comparative Performance at 0°

Table 3.4 and Figure 3.4 show the wind turbine to start at attachment location #3 but at attachment location #4 yields the highest efficiency and angular velocity.

Table 3.5 Model Test Results at Different Locations, 5° Pitch Angle

Blade Location & Pitch Angle	Distance from Center	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m^2)	Wind Power (W)	Efficiency (%)
1st, 5°	0.10	6	2.50	0.0	N	N	0.4	0.00	0.03	4.71	0.00
2nd, 5°	0.14	6	1.45	43.6	N	N	0.4	1.83	0.06	9.23	19.77
3rd, 5°	0.18	6	2.09	79.3	Y	N	0.4	3.32	0.10	15.26	21.75
4th, 5°	0.22	6	2.51	120.5	Y	Y	0.4	5.04	0.15	22.80	22.13
5th, 5°	0.26	6	1.53	100.6	Y	N	0.4	4.21	0.21	31.85	13.23
6th, 5°	0.30	6	1.90	102.2	Y	N	0.4	4.28	0.28	42.40	10.09
7th, 5°	0.34	6	2.40	89.3	Y	N	0.4	3.74	0.36	54.46	6.87

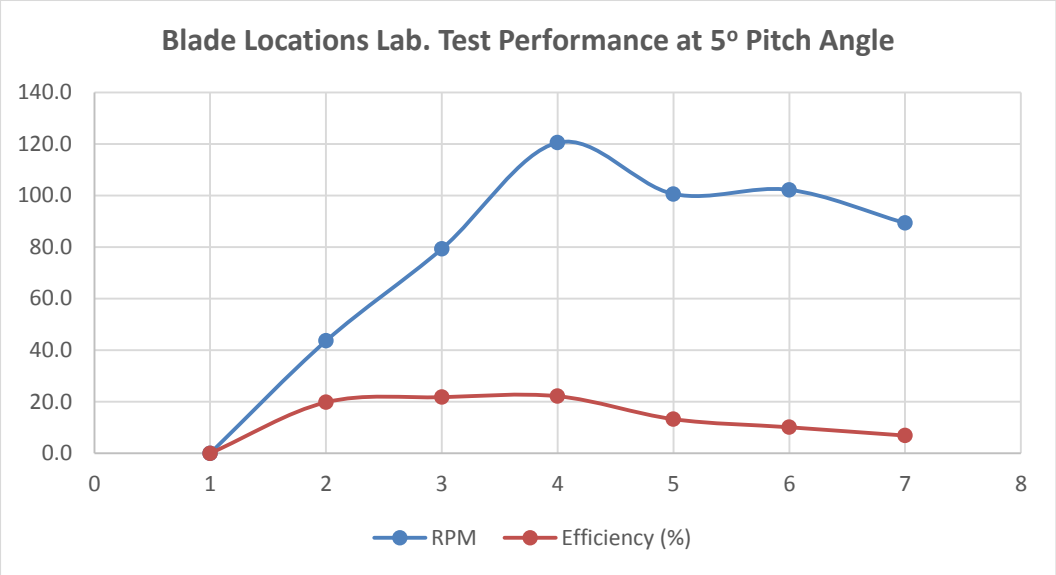

Figure 3.5 RPM and Efficiency Comparative Performance at 5º

Table 3.5 and figure 3.5 has almost the same behavior with the previous table and figure but it self-starts at attachment location #2.

Table 3.6 Model Test Results at Different Locations, 10º Pitch Angle

Blade Location & Pitch Angle	Distance from Center (m)	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m^2)	Wind Power (W)	Efficiency (%)
1st,10 º	0.10	6	2.50	0.00	N	N	0.40	0.00	0.03	4.71	0.00
2nd,10 º	0.14	6	1.56	45.40	N	N	0.40	1.90	0.06	9.23	20.59
3rd.10 º	0.18	6	2.27	79.70	Y	N	0.40	3.34	0.10	15.26	21.86
4th,10 º	0.22	6	2.52	110.40	Y	N	0.40	4.62	0.15	22.80	20.27
5th,10 º	0.26	6	1.44	87.80	Y	N	0.40	3.68	0.21	31.85	11.54
6th,10 º	0.30	6	1.91	92.70	Y	N	0.40	3.88	0.28	42.40	9.15
7th,10 º	0.34	6	2.52	26.80	Y	N	0.40	1.12	0.36	54.46	2.06

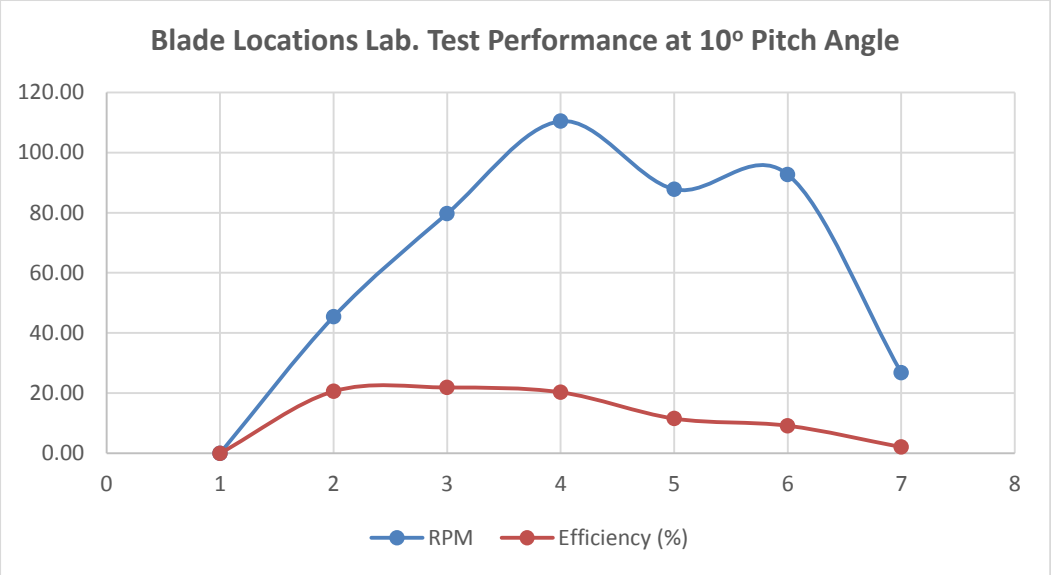

Figure 3.6 RPM and Efficiency Comparative Performance at 10°

Table 3.6 and Figure 3.6 also self-starts at attachment location # 2, yields the highest efficiency at attachment location #3 but angular velocity is highest at attachment location #4.

Table 3.7 Model Test Results at Different Locations, 15° Pitch Angle

Blade Location & Pitch Angle	Distance from Center (m)	Ave. Wind Speed (m/s)	Wind Speed After (m/s)	RPM	Self-Starting?	Light?	Torque (N-m)	Power (W)	Sweep Area (m^2)	Wind Power (W)	Efficiency (%)
1st, 15 °	0.10	6.00	2.50	0.00	N	N	0.40	0.00	0.03	4.71	0.00
2nd, 15 °	0.14	6.00	1.91	49.50	Y	N	0.40	2.07	0.06	9.23	22.44
3rd, 15 °	0.18	6.00	2.14	81.20	Y	N	0.40	3.40	0.10	15.26	22.27
4th, 15 °	0.22	6.00	1.98	100.30	Y	N	0.40	4.20	0.15	22.80	18.42
5th, 15 °	0.26	6.00	1.68	84.60	Y	N	0.40	3.54	0.21	31.85	11.12
6th, 15 °	0.30	6.00	2.09	30.20	N	N	0.40	1.26	0.28	42.40	2.98
7th, 15 °	0.34	6.00	3.20	16.90	Y	N	0.40	0.71	0.36	54.46	1.30

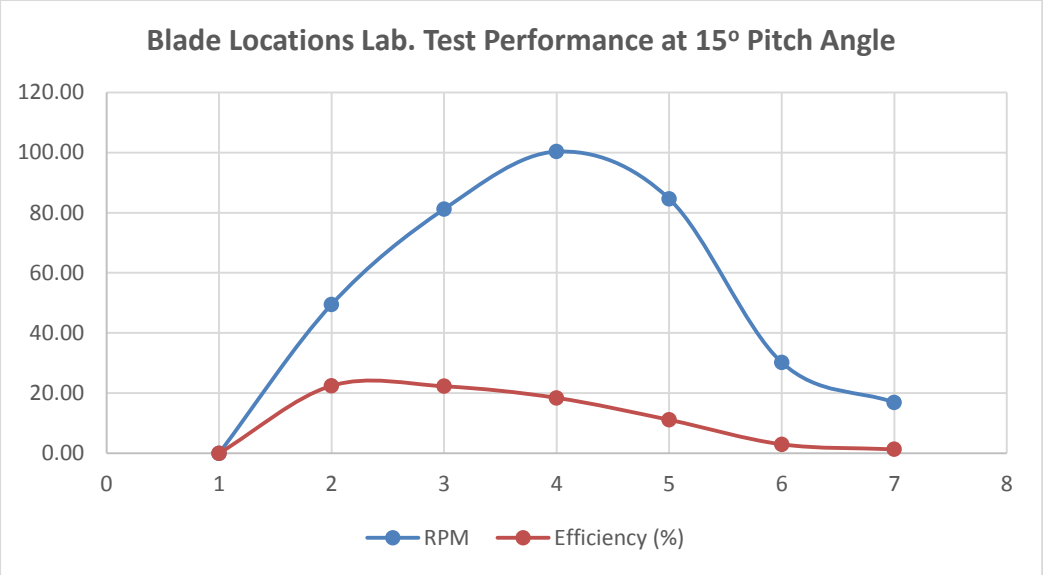

Figure 3.7 RPM and Efficiency Comparative Performance at 15°

Table 3.7 and Figure 3.7 shows the wind turbine self-starts at attachment location #2 and corresponds to highest efficiency but the angular velocity yield the highest at attachment location #4.

The tables and figures above showed the trend of the model test results. The trend shows that after the 4th attachment location, it showed a decrease in angular velocity as the airfoil moves away from the central panel indicating the loss of pressure is too great to self-start and rotate the straight vertical axis wind turbine.

Airfoil Blade Location Distance and Pitch Angle

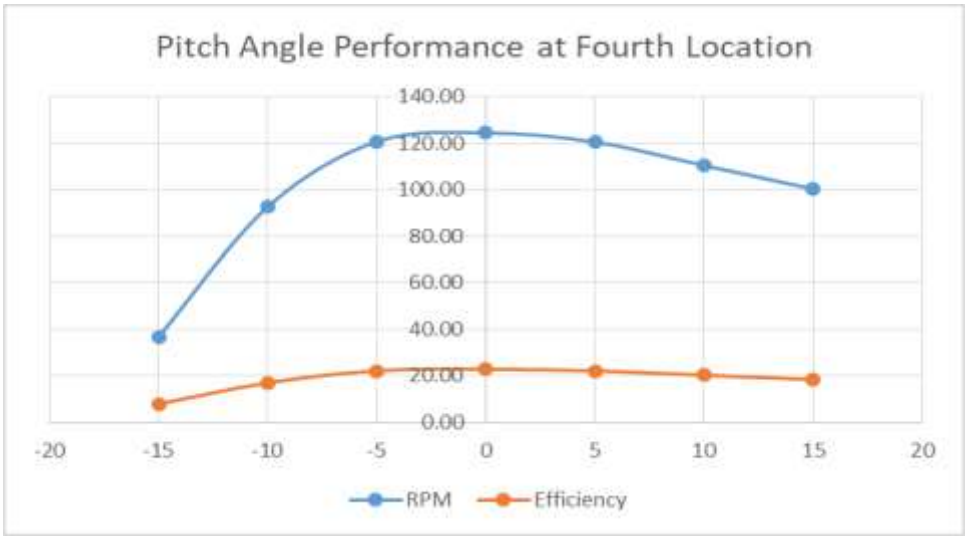

Figure 3.8 Pitch Angle Performances at Location #4 of the Airfoil Blade

The researchers have acquired the following results for the Ideal blade distance and pitch angle of the straight vertical axis wind turbine from the results of the model testing. The results are as follows based on the setting of 22cm (location #4) from the center with 0^o pitch angle (see Figure 4.8). It was selected that the optimal pitch angle which yields maximum angular velocity is at 0^o

Blade Distance and Pitch Angle

The configuration result from the testing of the wind turbine model that the distance from the central panel of the airfoil is to be 22cm and the pitch angle of 5 degrees toe in to yield an optimum efficiency as shown in figure 3.6.

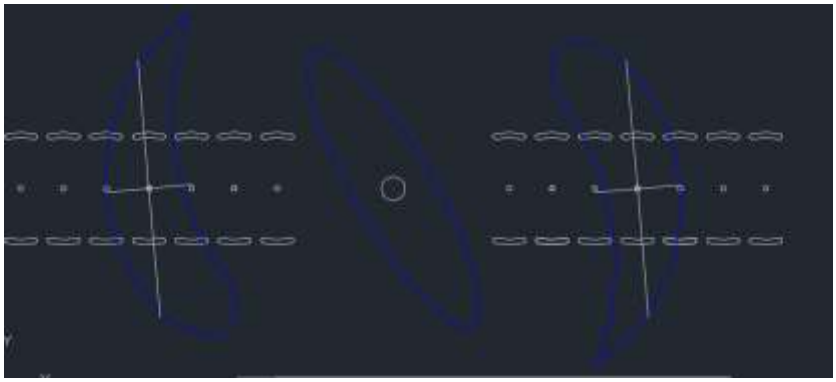

Figure 3.9 ACAD drawing of the prototype showing the hole holder location and the pitch angle of the airfoil wit optimum performance.

Figure 3.10 The actual assembly of Figure 3.9

4. Discussions

Blade Distance

The optimal blade distance of the testing model of the straight vertical axis wind turbine was determined which is at the 4^{th} hole for both the laboratory testing and the field testing. This hole holder has a distance of 22cm from the center of the central panel.

Pitch Angle

The optimal pitch angle of the testing model of the straight vertical axis wind turbine was determined by conducting the testing simultaneously with

the testing for the ideal distance of the airfoil to the central panel. There were 2 pitch angles to choose from, 0 degree angle for the laboratory testing, and 5 degree toe in for the field testing. It was determined that the 5 degree toe in was used because the prototype would yield similar results due to being tested in the field with natural air.

Self-start vs. Efficiency

It was established in the results that all the efficiencies that exceeded 20% efficiency were all labeled as self-starting. This was due to the wind having enough kinetic energy to compensate for the torque needed by the straight vertical axis wind turbine where the central panel helped a lot.

Model to Prototype Similitude

The prototype was established using similitude principle from the testing model. Both the Testing model and Prototype have over 24% efficiency and self-starts the wind turbine.

5. FINDINGS

The laboratory and field testing in finding for the optimum effect of blade attachment location from the center of straight vertical axis wind turbine using airfoil yielded the following results. The setting of the airfoil of the straight vertical axis wind turbine was found to be 0.65m from the center, which means it has 1.3m diameter. The airfoils have 5 degree toe in. The height of the Straight Vertical Axis Wind Turbine is 1.2m. This is designed to garner 200 watts at the wind velocity of 10 m/s.

In this study, the researchers have tested on wind speed with the average of 5.14m/s for the prototype. This wind speed is producing 70 watts with the max efficiency of 23.28% for a prototype dimension of 1.2 m high and 1.3 m diameter with the sweep area, of 1.327m^2.

6. CONCLUSIONS

An investigation have been made in finding the effect of the attachment distance of the airfoil location to the central panel for a straight vertical axis wind turbine and have found the ideal blade distance from the central panel that had the most efficiency in capturing the wind energy from the air. It is to be at 0.65m from the center when the height of the central panel is at 1.2m. at 0^o pitch angle.

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DESIGN AND DEVELOPMENT OF PORTABLE VERTICAL AXISWIND TURBINE

CYRILL A. FUENTES, JOHN LOUIE G. RABINO, MOHAMED D. TALIB RAHMAT, JOHN REYNER O. BECINA*, FAVIS JOSEPH C. BALINADO, PECE

College of Engineering and Computer Studies, Lyceum of the Philippines University – Laguna
Km. 54, Nat'l Hi-way, Makiling, Calamba City, Laguna, Philippines
*Corresponding Author: johnreyner.becina@yahoo.com

Abstract

Electrical energy demand has been continuously increasing. It provides people the energy needed to supply power for appliances and machines. However, there are some ways to have an alternative source of electricity; one is by using the wind's power. Wind energy is a type of renewable energy that utilizes the kinetic force of the wind in order to generate electricity. With the use of wind turbines, it captures the force of the wind and converts it to electricity by using a generator. The commonly used wind turbines are huge and installed in a specific area where the wind is strong, so upon the recommendations of others, the researchers thought of an idea making it light weight and portable. This project will focus on the design and development of portable wind turbine using vertical axis blades instead of horizontal-axis blades to harness better wind that would serve as the main mechanism to convert the mechanical movement of the wind turbine to electrical power.

Keywords: generator, mechanism, wind turbine, kinetic force, next keyword

1. Introduction

1.1. Background of the Study

Electricity provides energy needed to supply power for appliances and machines. The demand in electricity grows rapidly every year and this is where this research takes place. The main function of the research is to have an alternative source of electricity, which will mainly focus on the conservation of power consumption and eventually will make the electric bills smaller. The project harnesses the energy from the wind. It converts the wind's kinetic energy to electrical energy. The project does this "one turn at a time" by reducing the customers' carbon footprint. The principle behind the energy conversion is the nature's wind. With the increasing interest and demand in wind energy generation, there are more and more wind energy systems installed all over the globe. There is a report that 12% of the energy is generated through wind turbines by 2020.

Wind energy is a type of renewable energy that sustains the kinetic force of the wind in order to generate electricity. With the use of wind turbines, it captures the force of the wind and converts it to electricity by using a generator. The first ever wind turbine used for electricity production was in Glasgow, Scotland and it's built by Professor James Blyth in July 1887. However, the design was for manual operation only so, Charles F. Bush from Ohio first developed a wind turbine that is automatically-operated. Today, wind-powered generators are used everywhere for alternative source of energy, especially in this modern era where gadgets are everywhere. So, we thought of an idea to create a wind turbine generator for battery charging.

Today, wind turbines have to compete with many other energy sources. It is therefore important that the turbines be cost effective. The project needs to meet any load requirements and produce energy at a minimum cost per peso of investment.

The renewable energy is considered as a new technology and an alternating energy source to be used instead of fossil fuel; its continuous rising cost and due to growing concern to reduce the effects of climate change, such as global warming, generated by extensive and deliberate use of fossil fuels, mainly in the electric power generating plants and transport. Global warming will continue unless dependence on fossil is reduced, thus the wind power has a key role in reducing greenhouse gas emissions.

1.2. Statement of the Problem

Power loss usually happens in some places so, storing and conserving energy is the solution for this. Harnessing electrical energy from the wind's kinetic energy is the main target. This is for the benefit of our environment by lessening carbon footprint by means of green energy production and energy conservation. Large wind turbines are usually used in this, which are very space consuming and needs a specific location in order to work. So, existing research recommendations are to minimize the space occupied and make it light weight that can function not just only in a specific location.
With this, the researchers undertook the study to address the following problems:

- How to construct a system that would harness electrical energy from wind energy?
- How to make the system's output voltage significantly equal to 5 volts?
- How to measure the efficiency of the charging process?

1.3. Objectives

General Objective
The main objective of this study is to develop and conduct a performance testing of a portable vertical axis wind turbine using a three phase alternator generator to act as portable charging device.

Specific Objectives

- To design a portable vertical axis wind turbine that charges mobile devices by the process of converting wind energy into useful electricity
- To fabricate a rotating blade using PLA plastic
- To conduct performance testing of the device
- To determine the parameters of the wind turbine

1.4. Significance of the Study

There are certain procedures and reminders in order for this product to guarantee the satisfaction of the target users. First, collection of all the materials needed should be done for the production of the portable vertical axis wind turbine. Next, installation ofportable vertical axis wind turbine in any place or moving object that has strong wind density to harness wind kinetic energy must be done. After the installation of the wind turbine, the design of the grid and the circuit connections should be made which will be connected to the load where the harness energy will be stored and managed.

This study will be beneficial to the following:

Future Researchers: This study will serve as a basis for future enhancement of the project or any study related.

Lyceum of the Philippines – Laguna: This may help the school, including the students and staff of LPU-L conserve energy using the wind's kinetic energy as an alternative power source that can be used in their activities in the campus.

Environment - This prototype will be eco-friendly as it uses renewable energy to operate and does not give off any waste materials during its operation.

Philippine Community - This study will not only be helpful to the locals of Calamba, Laguna but also to the people of the Philippines as it will be very useful especially in emergency situations.

1.5. Scope and Limitations

The scope of the study is for the charging as a renewable source of energy on the highest possible peak and any moving open vehicles. The study will include the different parts of a wind turbine and how they work. It is focused on the wind turbine used as a source for renewable energy for research. The study is not suitable on places that has low wind kinetic energy and especially on lower floor of a building. The device does not act as a power bank; it will only charge electronic devices if the turbine spins and met the specific speed that can produce the charging voltage.

2. REVIEW OF RELATED LITERATURE

This study was done to optimize the aerodynamic and structural design efficiency of horizontal-axis wind turbines (HAWTs) rotors, which is a multi-disciplinary task involving conflicting requirements on maximum performance, minimum loads and minimum noise.

The optimum design should not be restricted to aerodynamic performance. Their key objective is to have a prototype design with minimum cost of energy. This leads to the development of a multi-disciplinary design method for the direct shape design of HAWT rotors. The method was based on numerical optimizations, where the objective was minimum cost of energy and multiple constraints were allowed. They designed a 1.5 MW stall regulated rotor to be used as to demonstrate the capabilities of the design method. They concluded that load constraints and cost estimations were important for the applicability of the optimization results. Their design method was based on numerical optimizations and several calculation models including aerodynamic, structural, time domain aero elastic, and extreme loads calculation along with the estimation of aerodynamic noise.

With traditional airfoil characteristics and blade structure, shape optimization of the rotor reduced cost of energy compared to a rotor of the same size. The change in rotor shape resulted in maximum allowable strains on more than 80% of the blade. A reduction in energy yield was counterbalanced by a larger load reduction. The cost of energy was thereby reduced by 3.5%. This is a proof of the control of important loads. Optimum specific power was found to 460 W/m2 which is lower than that of modern Danish wind turbines. The variation in the cost of energy with specific power was however found to be small. With the use of traditional airfoils, there is no easy way to gain a substantial reduction in the cost of energy.

Optimum airfoil characteristics showed that the airfoil sections should have a relative high maximum lift on the entire blade including the tip region, resulting in a decrease in energy cost by 7%.

3. METHODOLOGY

This chapter aims to present the research process. The discussion of the conceptual and theoretical framework of the study that are based on the findings presented in the literature reviewed in the previous chapter. The research methods and procedures used in developing the study were presented in this chapter.

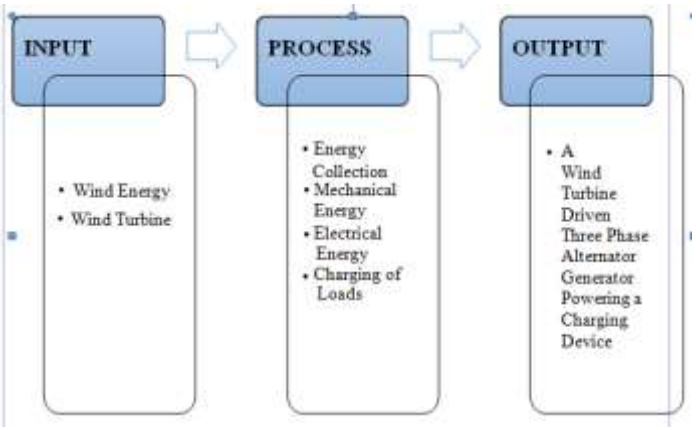


Table 1: IPO Chart

Table 1 show the IPO chart which shows what would be the input, process and the output of this system

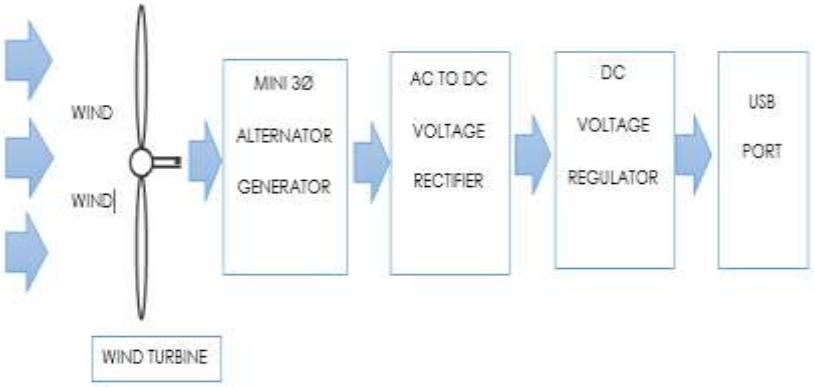


Figure 1. System Block Diagram

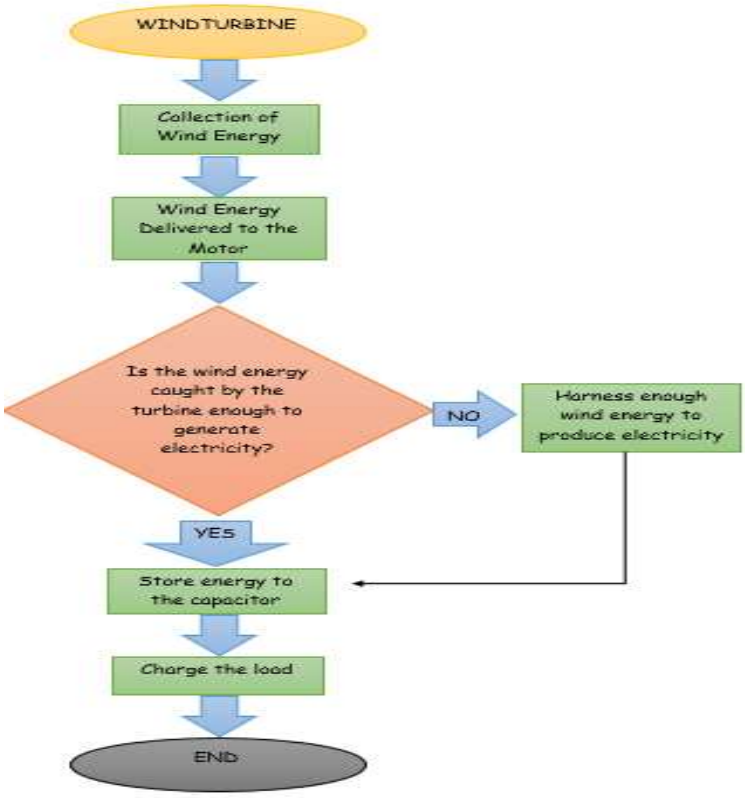


Figure 2. Flow Chart

4. DATA AND SIMULATION RESULTS

This test shows the output voltages it can produce per speed level in the electric fan. Based on the pictures below, only the 2nd and the 3rd can produce the charging voltage needed which is 2.16V.

Level	Voltage Output
3	0 – 5V
2	0 – 3V
1	0 – 2V

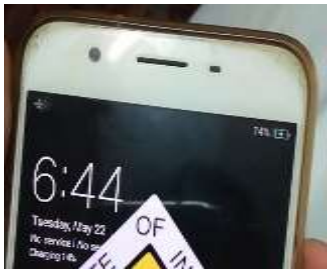
3rd level

2nd level

1st level

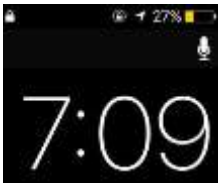
Android

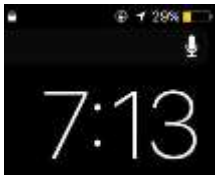
It takes 5-7 minutes to charge up a percent in android devices



Apple

It takes 2 minutes to charge up a percent in Apple devices.





5. CONCLUSION

Based through tests and simulations, the researchers conclude that by using the mini three phase alternator generator, AC voltage is produced. The AC voltage produced is now converted to DC voltage by the use of voltage rectifier. The charging voltage is constant 5V and using voltage rectifier is not enough so the researchers used voltage regulator to have constant 5V output.

According to the data, the researchers gathered for electronic devices to be charged the minimum voltage required is 2.16V, which is the output of the voltage rectifier. It is also the current needed to charge electronic devices using voltage regulator.

The researchers conclude that they are able to design a portable vertical wind axis wind turbine that charges electronic devices by the process of converting wind energy into useful electricity. It is a fabricated a rotating blade using PLA plastic as the material. The proponents conducted a performance testing that determines the parameters of the wind turbine. Its consistency just depends on the wind density and the type of motor used.

6. RECOMMENDATION

The wind turbine industry is a fast growing one where constant research is needed in order to maximize the efficiency of wind turbines, as there is in need of more reliable renewable energy sources. For the future researchers who may want to conduct field testing of this device, they should consider the height and weight of their prototype. The researchers recommend the following information for the refinement of this study.

1. The group recommends to use a high current motor/generator to harness more electrical energy
2. Lessen the friction loss
3. Lessen the weight of the turbine
4. Use a capacitor bank as a load

7. ACKNOWLEDGEMENTS

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DESIGN AND IMPLEMENTATION OF THE PROPOSED TWO – STOREY HOSANNA GREAT COMMISSION FELLOWSHIP CHURCH USING INSULATED CONCRETE FORM AS WALL IN BARANGAY BUBUYAN, CALAMBA CITY LAGUNA

R M. Bobadilla* J.A. C. Centeno, R.C. M. Montecer, V.X. R. Perez
Civil Engineering Department, Lyceum of the Philippines University – Laguna
Corresponding email: *ricbobadilla@yahoo.com

Abstract

This design project is entitled Design and Implementation of a Two – Storey Hosanna Great Commision Church Using Insulated Concrete Form as Exterior Wall at Barangay Bubuyan, Calamba City, Laguna. Its aims to design the complete structural and architectural plans for the said church using Staad Pro., Staad RCDC, Autocad, and Revit with the emphasis on the design of its structural members such as footings, columns, beams, and floor slabs. The application of Insulated Concrete Forms (ICFs) as exterior walls of the church is the innovative approach of the proponents.

This project also aims to gain the workability of the design based on the standard codes and law at economical cost. In order to provide an economical cost, the estimates of the materials, labor, and other costs to be incurred in the completion of the design project are also needed. This study is a developmental research since this project is more on instructional design and evaluation process which also involves production of knowledge. In the design procedure, the proponents used flowchart which uses symbols to define relationship. The designs of structural components used are the following: the foundation used is shallow foundation, the column design is 350mm x 350mm, the beam design is 300mm x 350mm and the slab thickness is 150mm. The estimated construction cost using ICF is Php 1,758,674.19, while the conventional CHB cost is Php 1,696,108.41. After attaining the results and conclusions, the proponents recommended to design the church as a green building and whole structure using ICF, the future designer must provide electrical and plumbing plan.

Keywords: Insulated Concrete Forms, Design, Implementation, STAAD Pro, STAAD RCDC, Autocad, Revit, Flowchart, Structural Components

1. Introduction

As time goes by, most structures are already adapting the concept of modernization and retaining its traditional design. As technology innovates, the people adapt the development and apply it to help the world to become a better place. In the construction industry, change is constant and improvements are needed to satisfy the fast-changing environment to ensure the capability of constructing structures to provide a durable and environmental responsible structure.

Since innovation is part of the fast-changing environment, many opportunities and improvements are given and applied in the industry. One of the innovation used in most countries is the Insulated Concrete Form (ICF). It has many advantages for the clients and contractors because Insulated Concrete Form structures are much more comfortable, quiet, and energy-efficient than those built with traditional construction methods.[20] These are also permanent, sandwich-type of forms, on which concrete is poured between two layers. These forms can undertake the place of masonry, wood, or concrete and can provide insulation. [21]

In structural designing, considering the basic requirements is needed in order to produce an effective output. The working or economic life of the structure should be specified and the fundamental requirements should be: to ensure the safety of the people around the building, to verify the capacity of the structure if it is adequate and sound, and if the structure is restorable.

Engineers constantly consider the structural and architectural conditions of a structure. In order to construct a building, there are codes that should be considered. In Europe, the engineers used the standard EN Eurocodes in order to construct the desired structures. There are also different codes used in USA such as ACI 318 (Building Code Requirements for Structural Concrete), ANSI/AISC 360 (Specification for Structural Steel Buildings), AISI S100 (North American Specification for the Design of Cold-Formed Steel Structural Members) and etc. while in the Philippines, NSCP 2010 (National Structural Code of the Philippines) is used. The purpose of all the codes is to provide a basis for strength, stability and safety of structures and a basis of the whole works in the field of civil engineering.[1]

In the Philippines, the architectural and structural designs of churches nowadays are mostly the result of influences of different cultures. There are churches, buildings and other structures that have been built because of the desire to innovate and help achieve the goals of the general population.[2] Churches such as Paoay Church, Iglesia Ni Cristo, Jesus Is Lord Church and many other churches manifest aesthetic appearance and so do buildings like San Miguel Corporation Building, The Mind Museum, The Cultural Center of the Philippines, among others, but Civil Engineers do not focus on physical appearance instead they focus on structural designing. The scrupulous structural design of the buildings is the most important to consider in construction because there are calamities such as flood, hurricanes, tornadoes, and earthquakes that may happen anytime. The design of the churches and other structures in the country follows National Structural Code of the Philippines (NSCP) to ensure the durability and avoid causing damage for the safety of the population.

The population is the reason why these churches and other structures are built. The population of Philippines may have different religion such as Roman Catholic, Born Again, Jehovah's Witnesses, Iglesia Ni Cristo, Islam and many more which make the structures significant because it uniquely satisfies the needs and wants of its inhabitants. On the other hand, Laguna is the third largest province in CALABARZON and still developing over the year. One of the major

contributors of the development in the province is Calamba City which is one of the top ten (10) richest cities in the Philippines according to the latest 2014 Annual Financial Report of the Commission of Audit (COA). In line with these, the job opportunities affect the population growth of the city and therefore, it causes numerous culture and beliefs. In Barangay Bubuyan, Calamba City, Laguna, there are different religions including Hosanna Great Commission Fellowship Inc. (HGCF), a Born Again Christian Church.

The religious organization originated in Cabuyao Laguna and is brought by Bishop Benito Batiao in Barangay Bubuyan, Calamba City, Laguna. Due to the growth of the population, the head of the organization decided to improve the needs of the people in the community since the current environment of the church does not give satisfactory to the community because the services are only held on the garage of the current pastor. The members are also experiencing some inappropriate environmental factors such as noise disturbance, weather, air pollution that may cause danger to the health of the community, and safety. The proponents are planning to improve the current location into an adequate environment, provide complete sets of church facilities, and to make sure the people feel the solemnity in the place.

Based on the cited circumstances, the proponents propose a two-storey Hosanna Great Commission Fellowship Inc. (HGCF) church that will use Insulated Concrete Forms (ICFs) as exterior walls to help the organization have their envisioned place where the participants can hold their activities such as youth services, cell groups, bible studies, seminars and many more. Also, the organization and the proponents will be the beneficiary of the project and the proponents want to practice and apply the knowledge they have learn through the years of taking Civil Engineering such as drafting plans, design processes, applying theories, computation using different programs such as STAAD.

2. Methodology

This chapter contains the methods and procedures of the design project including research design, the participants of the study, the design tools, and the design procedure of the proposed two-storey church.

3.Results and Discussion

3.1 Footing Design

The design given by Staad RCDC is shown in Table 2. The footing size is given based on the parameters stated in NSCP 2015. Since the concrete type to be used in the design is Class A, Grade C25 is selected and according to NSCP 2015, the yield strength of the reinforcement should be 415 Mpa. The proponents used shallow/pad footing because shallow foundation is widely used to spread the loads of the structure over a large area of soil.[6] Since the proponents do not have a soil bearing test, pad footing is suitable because the proponents assume that the site location has a low soil bearing capacity. The footing designed by the Staad RCDC meets all the parameters needed such as design for shear, punching, bending for a good and most economical design.

Table 2. Footing Dimension and Properties

Grp. No.	Footing Mark	Column Mark	Footing Type	Material Property	Column Size (mm)	Footing Size (LxBxD) (mm)
1	FC1	C1	Pad	C25 : Fy415	350 x 350	3350 x 3350 x 300
2	FC2	C2	Pad	C25 : Fy415	350 x 350	3350 x 3350 x 300
3	FC3	C3	Pad	C25 : Fy415	350 x 350	2900 x 2900 x 300
4	FC4	C4	Pad	C25 : Fy415	350 x 350	2900 x 2900 x 300
5	FC5	C5	Pad	C25 : Fy415	350 x 350	3000 x 3000 x 300
6	FC6	C6	Pad	C25 : Fy415	350 x 350	2900 x 2900 x 300
7	FC7	C7	Pad	C25 : Fy415	350 x 350	3600 x 3600 x 300
8	FC8	C8	Pad	C25 : Fy415	350 x 350	3500 x 3500 x 300

3.2 Column Design

Table 3. Column Dimension

Column Number	Dimension
C1	350 X 350
C2	350 X 350
C3	350 X 350
C4	350 X 350
C5	350 X 350
C6	350 X 350
C7	350 X 350
C8	350 X 350

Columns should have 4 main bars, one at each corner of minimum size 12 mm and minimum spacing of 12 cm.[7] Based on NSCP 2015 Section 708.2.3.9, the nominal width of column should not be less than 300 mm. The proponents used these parameters in STAAD RCDC to generate the properties of column needed in the structure. The load combinations used in the design is the basic combination and the footing design meets all the consideration such as slenderness ratio, shear, stability index and other in order to make the column stable.

3.3 Beam Design

Table 4. Beam Design and Properties

GRP	Beam	Type	Size (mm)	Material
G1	B1	Dctl	300 x 350	C25:Fy415
G2	B2	Dctl	300 x 350	C25:Fy415
G3	B3	Dctl	300 x 350	C25:Fy415
G4	B4	Dctl	300 x 350	C25:Fy415
G5	B5	Dctl	300 x 350	C25:Fy415
	B6	Dctl	300 x 350	C25:Fy415
	B7	Dctl	300 x 350	C25:Fy415
G6	B8	Dctl	300 x 350	C25:Fy415
	B9	Dctl	300 x 350	C25:Fy415
	B10	Dctl	300 x 350	C25:Fy415

Beams must be integrated design around tops of doors and windows connected to columns that are designed to withstand deflection since exorbitant deflections are unsatisfactory in building construction, as they can cause cracking of plaster and can cause jamming of entryways and windows.[7] Based on the NSCP 2015 Section 708.2.3.9, the nominal width of beams shall not be less than 150 mm. Since the concrete to be used in the design is Class A, the concrete grade should be C25. The yield strength of the reinforcement used in the design is 415 MPa. The proponents used the following data in STAAD RCDC in order to design beams that will carry the loads considered. The result dimensions given by STAAD RCDC are provided in table 4.

3.4 Slab Design

Table 5. Slab Thickness and Properties

No	Slab	Thickness (mm)	Conc Grade	Steel Grade
1	S1	115	C25	Fy415
2	S2	115	C25	Fy415
3	S3	115	C25	Fy415

The class of concrete that is used in the design is also Class A where that concrete grade is C25 and the yield strength of the reinforcement selected is also 415 Mpa. Concrete slabs also deflect and it should be supported by beams that are also supported by columns.[8] In line with this, the proponents used STAAD RCDC and considered all the parameters needed in order to design an acceptable results providing the number and spacing of reinforcement needed. The thickness of the slab is computed by the perimeter of the slab divided by 180.

Minimum slab thickness:

$$t_{min} = P/180 = 20/180 = 0.1111 \approx \mathbf{0.115\ mm}$$

4. Application of Insulated Concrete Forms as

Exterior Wall in the Church

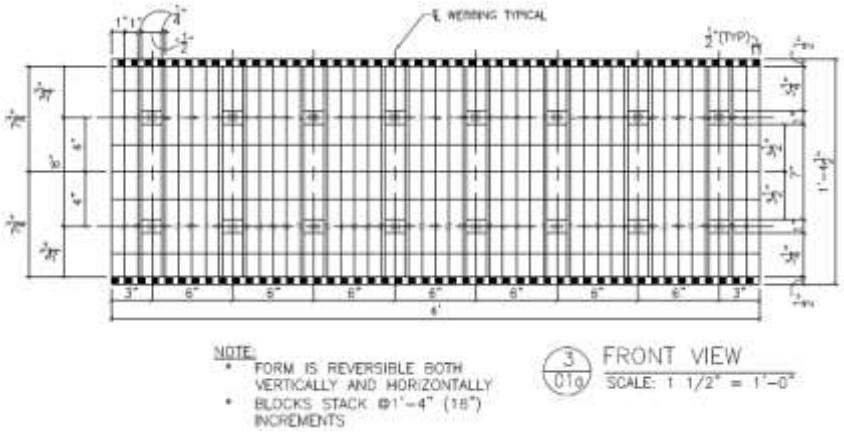
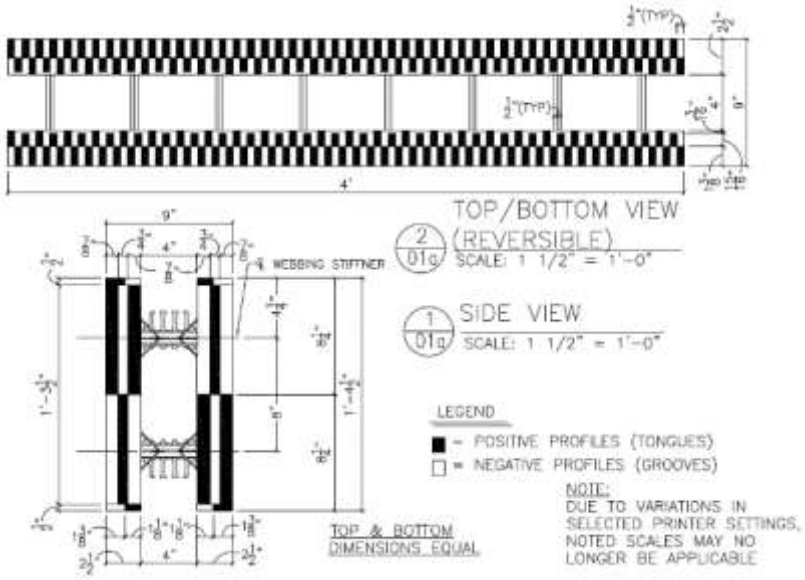


Figure 2. ICF Details



The proponents' innovative approach in the project is the usage of Insulated Concrete Form (ICF) as exterior wall for the church because of the advantages it provides for its users. Aside from providing a good insulation, it offers durability, cost efficiency, and many more that causes a high customer satisfaction which is

suitable in the community of Hosanna Great Commission Fellowship (HGCF) Church. Shown in the Figure 2 is the ICF with its details and specifications.

5. Estimates of ICF and CHB

Based on the estimated cost of the construction using ICF and CHB, the construction price of ICF is more expensive than CHB. The total costs using ICF is Php 1,758,674.19 and the CHB costs Php 1,696,108.41. On the other side, based on the projected duration of ICF and CHB, the estimated construction days using ICF is faster than CHB. Construction using ICF has 79 days duration while CHB has a 84 days of construction.

Using ICF for the labor cost provides fewer manpower because the installation is easy, fast, and simple to understand. ICF can save money in labor cost.[9] Based on the estimated labor cost of ICF, the projected labor cost is Php 1,470.00 because the construction duration is 8 days faster than CHB. CHB labor cost is Php 7,875.00 and the construction duration is 12 days.

The proponents selected ICF as a replacement in CHB walls although the price is more expensive because innovation needs investment. ICF has more benefits and advantages than CHB as stated in the design analysis of the study.

6. Conclusions

- After using the STAAD PRO and STAAD RCDC for structural designing of the Hosanna Great Commission Fellowship Inc. the proponents come up with the data needed. For the footing sizes, there are two (2) footings with a 3350mm x 3350mm x 300mm, three (3) 2900mm x 2900mm x 300mm, a 3000mm x 3000mm x 300mm, a 3600mm x 3600mm x 300mm and a 3500 x 3500 x 300mm footing design that passed in the STAAD RCDC software. The dimension for the eight columns is 350mm x 350mm, this dimension is selected because this is the most economical dimension for the structure. 115mm slab thickness is used which passed RCDC design. All the reinforcements used in the structure are the #10 and #16 bars. The result of the design exhibited by the data gathered is applicable since it is all tested and passed the STAAD PRO and STAAD RCDC application.

- The application of Insulated Concrete Form (ICF) as exterior wall of the church will give a high satisfaction to the beneficiary of the project because of its advantages, compare to the usage of the conventional Concrete Hollow Block (CHB).

- Based on the calculated estimates of the two materials, CHB is cheaper than ICF. The cost of ICF is negligible because of its feature that a CHB does not have. The total construction cost using ICF is Php 1,758,674.19 while CHB is Php 1,696,108.41. Using CHB as a wall will take about 12

days for the construction of the wall and 84 days in overall construction while four (4) days for the ICF wall and 79 days for its overall construction.

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DESIGN AND IMPLEMENTATION OF TWO-STOREY APARTMENT BUILDING LOCATED IN BRGY. SAN ISIDRO NORTE, STO. TOMAS BATANGAS USING AUTOCLAVED AERATED CONCRETE

R M. Bobadilla* J.A. C. Centeno, R.C. M. Montecer, V.X. R. Perez

Civil Engineering Department, Lyceum of the Philippines University – Laguna
Corresponding email: *ricbobadilla@yahoo.com

Abstract

This study proposes a two-storey apartment and commercial building located at San Isidro Norte, Sto. Tomas, Batangas City in which the complete architectural, structural, and sanitary plans were presented. It also includes the structural analysis computations and the estimates needed for the establishment of the project. This project is designed based on the specifications and standards set by the authorities and the government, such as the National Building Code of the Philippines (NBCP), Fire Code of the Philippines, National Structural Code of the Philippines (NSCP), etc. In this project, the researchers proposed Autoclaved Aerated Concrete (ACC) as the prime material of the walls instead of Concrete Hollow Block (CHB). It is a material that was just introduced in the Philippines in 2016 by LiteCrete Philippines and was used in different countries such as Europe and Malaysia. AAC has been known and is proven to be a more economical and workable material than most conventional building blocks such as Concrete Hollow Blocks (CHB).

Keywords: Apartment, Autoclaved Aerated Concrete, Concrete Hollow Blocks, Concrete Hollow Blocks, National Structural Code of the Philippines, National Building Code of the Philippines, Fire Code of the Philippines

Abbreviations

NBCP	National Building Code of the Philippines
NSCP	National Structural Code of the Philippines
STAAD	Structural Analysis and Design
ASEAN	Association of Southeast Asian Nations
AAC	Autoclaved Aerated Concrete
CBH	Concrete Hollow Block
ACI	American Concrete Institute

1. Introduction

One of the priority bases of the human essential necessities is to have a proper shelter. A building that will provide a sense of security, privacy, protection against natural threat, and a place to rest such as residential buildings. It comes from different forms based on social status, housing affordability and availability. Those who cannot attain to have their own house with the high price of land; they prefer to rent apartments based on their budget. Living in apartments is also necessary for students, professionals and workers that needed a place to stay temporarily.

In the Philippines, 31% of the population cannot afford proper shelter with 104.3 million estimated total populations of the Philippines. This number was based on the projection of Population's (POPCEN) at 100.9 million counts in 2015. This makes the country the 13th largest in the world and second biggest in the Association of Southeast Asian Nations (ASEAN) region [1]. As the population continuously increases, the demand for affordable house relatively increases.

With the rapid growth of the population in the country, demand in affordable housing has been increasing. It is a necessity that is not available to most people. Construction of apartment has come to trend as a solution to serve many people in a limited area. Most people cannot bear the cost of constructing an independent house because of the area value increases indefinitely due to industrial development. Due to this urbanization, factory and other work establishments are built in some rural areas. Work opportunity often obliges employees to leave their houses and seek affordable housing, which is near their work areas. To comply with this demand, apartment and lodge house business had shown up.

Apartment construction appears to show big numbers in 2013 with the growing demand of rental housing. Residential building construction recorded the 72.77% of the total new construction projects. It accumulates by 11.55% to 23,815 from 21,360 during the same period of 2013, attributed to the increase of apartment construction and rose by 5.6 percent [1].

Based on statistics, Residential constructions grew by 2.7 percent to 25,670 of 2017 first quarter from 24,988 reported during the same period of 2016. The Construction of other residential and apartment/accessoria with increases of 116.7 percent and 73.1 percent respectively were the drivers of growth in residential constructions. However, decrements in the number of residential construction were observed in residential condominiums (-50.0%), duplex/quadruplex (-41.2%) and single-type houses (-2.1%). [4] In the second quarter of 2017, the number of residential building constructions declined by 11.7 percent to 26,827 from 30,366 reported during the same period of 2016. All types of residential constructions except duplex/quadruplex showed decrements in number as follows: residential condominiums (45.7%), apartment/accessoria (19.9%), other residential constructions (12.8%), and single-type houses (11.0%) [2].

In line with the situations stated, the proponents proposed a project a Two-Storey Apartment Building located at Brgy. San Isidro Norte, Sto. Tomas, Batangas. The area is situated in a rural place 700 m away from St. Padre Pio National Shrine. It is accessible by Sto. Tomas-Lipa Road. Brgy. San Isidro Norte is being populated with near establishments where there are workers or students that needed a place

to rent. Because of unavailability of renting occupancy in the area, the client wants an apartment to be built. The building consist of three commercial spaces and two studio type apartment on the ground floor, and six studio type apartment on the second floor. It features the standard corridor apartment design and used Autoclaved Aerated Concrete (AAC) than the conventional concrete hollow block in the design for a new method for the wall system of the structure. AAC is a type of lightweight concrete that is produced with microscopic air bubbles of hydrogen gas that is formed by adding aluminum powder to the cement mix and it also has heat and cold insulating properties [3].

The proponents wanted to pursue this project to lessen the increasing demand on affordable housing in the area with an innovative approach that contributes in improving structures in response to the environment which will include conservation of energy, durability, sound and thermal insulation, and to use a material that has a minimal load effect to the structure.They also pursue this project in order to provide a safe building plan for the beneficiary and the people who will live in the apartment.

Methodology

2.1 Research Design

This project adopts the developmental method of research. Developmental method is a systematic study of designing and developing of products and projects that must meet the standards of effectiveness and uniformity. This method focuses on the analysis of the development of a design and evaluates its processes. In this project, the proponents aimed to develop a design that will be implemented. Developmental method of research suits the demand of this project since it requires analyzation to develop a design and its processes. The process of project development is thoroughly analyzed to be able to design the structural and architectural plan of a two-storey apartment building.

2.2 Design Analysis

One of the primary considerations in improving stability and economic structural design is the performance of the construction materials for the wall system. Autoclaved Aerated Concrete in comparison with Concrete Hollow Blocks is shown in the table below.

Table 1. Comparison of Properties

DESCRIPTION	CHB	AAC
Size	0.2m x 0.4 x 0.09m	0.2m x0.49m x 0.09m
Raw Materials	Sand, cement, gravel	Sand, cement, tension fibers
Dry density	+2000 kg/ m3	900
Working density		
Heat insulation	No	Yes, 5 times more insulation
Compressive Strength	Varies	400-500 psi
Sound Insulation	Good	better
Total Installation Cost	Typical	10% lower cost
Installation Time	Typical	2-3x faster
Fire Resistance	2 hrs	Over 4hrs
Steel Reinforced	Yes	yes
Steel Reinforced		
Water Absorption	Normal	Low water absorption
Compressive Strength		

Autoclaved Aerated Concrete, a modern green building material for wall system have the virtues of energy saving and environmental protection than the conventional concrete hollow blocks. The material characteristics were analyzed. As shown in the table, AAC has an excellent quality, performance and environmental coordination. The performance of AAC has higher extent than CHB.

In durability, AAC has less risk of cracking because of its high resistance. It is light in weight but strong enough to carry floor loads. Unlike CHB, it easily breaks. The strength of AAC (as IS: 2185-Part III) and its ability to carry loads is impressive that its 4 inches thick block can replace the 5 inches thick block of CHB.

In workability, it saves time in construction. The laborers can easily transport AAC on their work area, and reduces its installation time. It minimizes its rendering time. It has more workability than CHB. It can be easily sawn and grind into any size and shape without breakage.

In durability, AAC has less risk of cracking because of its high resistance. It is light in weight but strong enough to carry floor loads. Unlike CHB, it easily sawn and grind into any size and shape without breakage.

Table 2. Electricity Cost for AAC

Appliances	Unit	Kilowatt	Usage (Hrs/Month)	KWH per Month
Television	8	0.3	15	36
Lights	20	0.07	140	196
Refrigerator	3	1.2	250	900
Microwave Oven	5	1	15	75
Rice Cooker	5	1	40	200
Electric Fan	10	0.07	50	35
Water Dispenser	4	1	20	80
Flat Iron	4	1.1	8	35.2
			Total KWH/Month	1557.2
Components	Total KWH/Month		Price (Php)	Amount (Php)
Generation	1557.2		5.6352	8, 775.13
Transmission	1557.2		0.9664	1,504.87
System Loss	1557.2		0.5781	900.23
			Monthly Electricity Cost	11,180.217
	Estimated Annual Electricity Cost			**134,162.61**

Table 3. Electricity Cost for CHB

Appliances	Unit	Kilowatt	Usage (Hrs/Month)	KWH per Month
Television	8	0.3	15	36
Lights	20	0.07	140	196
Refrigerator	3	1.2	300	1080
Microwave Oven	5	1	15	75
Rice Cooker	5	1	40	200
Electric Fan	10	0.07	224	156.8
Water Dispenser	4	1	20	80
Flat Iron	4	1.1	8	35.2
			Total KWH/Month	1859
Components	Total KWH/Month		Price (Php)	Amount (Php)
Generation	1859		5.6352	10,475.84
Transmission	1859		0.9664	1,796.54
System Loss	1859		0.5781	1074.69
			Monthly Electricity Cost	13,347.068
	Estimated Annual Electricity Cost			**160,164.815**

AAC is environment friendly. Some independent laboratories conducted tests that show it is non-toxic and non-polluting. The material itself is recyclable. It is energy saving material because it reduces energy consumption due to its insulation property. Considering that the AAC has thermal insulation properties, the use of the common appliances has been reduced. As shown in table 4 and 5, the monthly energy consumption of CHB is higher than the consumption using AAC. The estimated annual electricity cost of AAC is Php134, 162.61 while the estimated annual electricity cost of CHB is Php160,164.815.

3. Results and Discussion

3.1Structural Design

This chapter discusses the results generated from the software that are used in designing the Two-Storey Apartment Building which are STAAD Pro V8i SS6,

STAAD RCDC, AutoCAD 2016 and Microsoft Excel and the design parameters, structural codes used in the proposed Two-Storey Apartment Building in accordance to the National Structural Code of the Philippines (NSCP) 2015 and the American Concrete Institute (ACI) Code. Minimum design loads are considered based from the NSCP 2015, as well as the seismic and wind considerations.

3.2 Design Criteria

The standard parameters used in designing the proposed project to have an economical and suitable design.

Compressive Strength	28 MPa
Unit Weight of Concrete	24 kN/m^3
Yield Strength	415 MPa
Modulus of Elasticity for Slab, Ebs	24870 MPa
Modulus of Elasticity for Beam, Ebb	24870 MPa
Density of Autoclaved Aerated Concrete	900 kg/m^3
Compressive Block Deep	0.85
Capacity Reduction Factor, Φ	0.90
Soil Data	100 kPa
Soil Bearing Capacity Increase for Earthquake	33%
Soil Bearing Capacity Increase for Wind	33%
Concrete Cover, in contact with ground	75mm
Concrete Cover, exposed to weather	40mm
Concrete Cover, for Slab	20mm
Footing Minimum Depth	175mm

3.3 Loads and Codes

In the software that was used for the structural plan, STAAD Pro V8i, the considerations of different load combinations were a dead load combination, live load combination, earthquake load combination along X and Z, and wind load combination along X and Z direction for the safety design of the project.

3.4 Calculations Files from Program

The final report generated from the STAAD project for design calculation consists of 638 pages as generated for all slabs, beams, columns and footings, and hence, the proponents gave some specific results of that report. As shown below are the different results for beams, columns, and footings using Autoclaved Aerated Concrete and Concrete Hollow Blocks, as well as for slab and roof beam, since it has the same results for both materials, the proponents only provided one result. For complete results you can see it in the CD provided. As the analysis progresses in STAAD Pro V8i SS6, it resulted to have no error and met all the design parameters required in the design of the structure, and for the analysis is the designing of the structure where it will be imported to STAAD RCDC.

3.5 Sections

In footing, the researchers used pad footing because it is the most used and most economical type of footing for residential and commercial buildings. The sections in Tables 12 and 13 generated through computation by analyzing the results from

STAAD RCDC. It shows the comparison of the required sections for AAC and CHB by following the parameters based on NSCP 2015, where it is clearly shown that the use AAC generates smaller sections than CHB. Therefore, the use of AAC as structural wall system shows an economical design for the footing of this structure where it will result to have a smaller foundation cost.

Based on the results generated from STAAD RCDC, the structural analysis and design using Autoclaved Aerated Concrete in comparison with Concrete Hollow Blocks, shows that the section of beam 20 and 21 on second floor from Table 18 and Table 19 had a difference of 150mm by 200mm. The data generated by STAAD RCDC, the section of beam 20 and 21 of AAC were 250mm by 300mm and for CHB was 400mm by 500mm. There are no differences in the section of other beams and columns. The design limits of the structural members were based on NSCP 2015.

In slab, the researchers used two-way slab for the basic floor and commercial. They also used one-way slab for the balconies, based on the ratio of the span lengths of a floor slab in the two principal horizontal directions. The computation of the slab thickness is based on NSCP 2015. They also used flat slab for the roof since it is commonly used in apartments.

3.6 Total Quantity of Reinforcement

The structural analysis and design for the Two-Storey Apartment Building was a stable and economical structure using AAC based on the specified minimum section and the reinforcing bars. The program generates the smallest section with the least quantity of reinforcements. Based on the results from the STAAD RCDC, there are no difference in the section of the columns aside from the footings and some of the beams particularly on the second floor. It is visible from the tables above that the required quantity and diameter bar size of reinforcements for footing, beam and slab were least using AAC than CHB.

3.7 Estimates and Gantt chart

Based on Gantt chart under item 9, the installation of AAC is convenient and fast. It does not require a lot of manpower, and labor cost is reduced. Unlike the conventional CHB, AAC is not hollowed so the volume of mortar to be used is lesser. The quantity of material used in construction is reduced as well as the construction cost. Also, AAC has already an insulating material that helps reduce cooling and heating cost. It is fire resistant and low in water absorption. It also reduces the foundation cost since the sections of structural members are smaller in the design using AAC than CHB as shown in the tables for the total estimated cost of construction. There is also a reduction in cost for reinforcements using AAC. It is shown in Table 4 and table 5 that the total estimated construction cost is comparatively lower if the AAC is used as the wall system. The total estimated cost for AAC is 40 % lesser than the estimated cost for CHB. As shown in table 3, the total estimated cost using AAC is Php4, 533,203 while the total estimated cost using CHB is Php4, 717,977.

4. Conclusions

In designing this project, several conditions are considered in order to produce a plan for a two-storey residential apartment building. In seeking for an innovative material, Autoclaved Aerated Concrete (AAC) is compared to conventional concrete hollow blocks. With the result of the comparison, an economical design for the building has been made possible.

Autoclaved Aerated Concrete, one of the innovative green construction material known for its lightweight and durability. Considering the impressive capabilities of this construction material, the study proposed to design a Two-Storey Apartment Building using Autoclaved Aerated Concrete, wherein, it has been compared to the conventional Concrete Hollow Blocks. Thereon, it is discovered that AAC is lighter than the conventional Concrete Hollow Blocks wherein the calculated section for the structural members such as beam, column, and footing have smaller dimensions, lesser quantities of reinforcement and smaller diameter size required. Thus, resulting in a lower cost for the needed concrete and reinforcement. The smaller section of the footing in accordance with the Autoclaved Aerated Concrete shows an adequate design of foundation to avoid the adjoin of substructures.

In accordance with the installation time and labor cost, structures with AAC wall are installed in a short period of time than the structures in the conventional CHB wall. Since it is a lightweight material, it is easier for the laborer to lift the material and work fast. The AAC only requires lesser steel bars, minimal amount of filler and minimal thickness of plaster than of CHB.

The cost of AAC per piece is more expensive compared to the conventional concrete hollow block for the wall system, but if one wants to promote green living to help to conserve energy, it is considered because of its thermal insulated material, and to have a sound insulated material that helps prevent noise disturbance since the nature of residential and commercial buildings is a busy place. Then the cost is negligible. Considering the total cost for this project, it is shown in the estimated total cost of AAC that it is lesser by 12 % than CHB.

With all the results and conditions above, the use of Autoclaved Aerated Concrete is deemed more suitable for the design of this project for its energy efficiency and cost effectiveness. The material helps minimize the rise of temperature and lessen the disruption of rights and privacy of other occupants with the micro air bubbles in AAC that provides sound insulation. Since, Autoclaved Aerated Concrete is a light weight material, it produces lighter loads for the load bearing members and transfers load to the footing and bearing capacity of the structure which results results have a smaller section for the members, saves time of construction, reduces labor cost, and reduces the reinforcements needed for the concrete works.

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DESIGN AND IMPLEMENTATION OF FOUR-STOREY MULTI-PURPOSE BUILDING IN SANTIAGO, MALVAR, BATANGAS USING TITANIUM DIOXIDE AS CONCRETE ADDITIVE

R M. BOBADILLA* J.A. C. CENTENO, R.C. M. MONTECER, V.X. R. PEREZ

Civil Engineering Department, Lyceum of the Philippines University – Laguna
Corresponding email: *ricbobadilla@yahoo.com

Abstract

The primary concern of this thesis is to produce a structure that prioritizes safety and quality. By following the standards stated in National Structural Code of the Philippines 2015 (NSCP) and National Building Code of the Philippines (NBCP) with the aid of software modeling tools, STAAD Pro V8i and STAAD Reinforced Concrete Designer (RCDC), the proponents are able to provide a complete and detailed plan for structural members such as footing, columns, beams, floor, and roof slabs. To evaluate the result, parameters from NSCP 2015 are directly inputted to STAAD Pro V8i and analyzed the structural adequacy of the whole structure. STAAD Pro V8i is a software created by Bently that can run analysis on structural frames and components using different structural codes from around the world. Although STAAD Pro V8i does not have NSCP 2015 as one of the structural code built in the program, the analysis used ASCI 318 as alternative structural code. With no difference between the content of ASCI 318 and NSCP 2015, the data gathered is accurate and reliable with respect to NSCP 2015. Results of the analysis will be then imported to STAAD RCDC, a software that goes hand in hand with STAAD Pro V8i for reinforced concrete design. The output is presented in a way structural plans are being presented in an actual blueprint. The dimensions of the structural members are provided as well as the diameter of the reinforcing bars with spacing between them provided. Aside from analyzing structural integrity of the design structure using softwares, this study also aims to present the use of Titanium Dioxide(TIO2) a material that can be used as concrete additive to increase the compressive strength of concrete while reducing the cost. TIO2 also adds self cleaning and waterproof property to concrete.

Keywords: Architectural, Structural, STAAD Pro V8i, STAAD RCDC, NSCP 2015, NBCP, Autocad

1. Introduction

In the Philippines, there is a growing demand for dormitories and apartments in both urban and rural areas. Apartments are specialized for residential purposes. Each floor contains several units that has its own bathroom, kitchen, living room, and bedroom. Dormitory on the otherhand usually containes multiple single or double-deck bed to accommodate several individuals for bedspacing. These dormitories are

often occupied by university students, factory workers, and even professionals who requires greater accessibility to schools and workplaces. [4] Thus, the researchers propose a project study that focuses on the design of a four-storey multipurpose building for partial fulfilment of the requirement of BS in Civil Engineering program. The structure contains five customizable commercial units, eight residential dormitory units, and a penthouse. It is designed using materials that comply or even exceed the standard set by the National Structural Code of the Philippines (NSCP 2015) and National Building Code of the Philippines (NBCP) using Structural Analysis and Design Pro v8i (STAAD Pro v8i) software to run simulations and computer analysis to enhance structural computations. Moreover, the proponents used concrete additive titanium dioxide (TIO2) as concrete additive to increase the strength of concrete and to lower the cost of the material. [16] Concrete stamps and floor hardener are also considered as alternative to tiles for flooring to reduce the cost of material. The researchers aimed to design a structure that highly emphasizes the quality of the structure while using value engineering to ensure that the cost is not being compromised.

2. Conceptual Framework

The researchers used the IPO Chart for their framework. IPO stands for Input-Process-Output a framework which utilizes the usage of testing ones hypothesis and evaluating the outcome and conduct a viable adjustment in the procedure conducted if

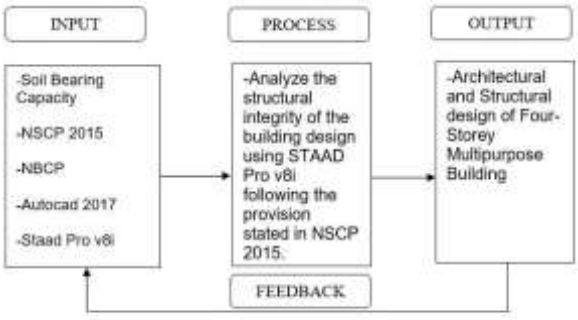


Figure 1. Research Paradigm

needed to attain the desired outcome.

NSCP 2015 is the primary reference book for all the design provision for structural members of the building. Tools such as Autocad and Staad Pro v8i are primarily used for creating computer designs and simulations. Meanwhile, simplified construction estimate was used as reference for quantity takeoff.

Input box contains the necessary tools and building codes for structural and architectural design. Process involves using STAAD Pro v8i software to analyze the structural integrity of the structure with respect to provisions on NSCP 2015. Output box contains both architectural and structural plan for the structure. Finally, a feedback is needed to know if the output satisfies the condition stated in the input.

3. Objectives of the Study

The design project aims to make a complete architectural and structural building design of a four- storey multipurpose building to be built in Santiago, Malvar, Batangas.

Specifically, it aims to:
1. Design a complete architectural and structural plan for a four-storey multipurpose building emphasizing the design of the following parameters:
1.1 Footing
1.2 Columns
1.3 Beams
1.4 Floor and Roof Slabs
1.5 Walls
2. Analyze the structural integrity of the four-storey multipurpose building based on the cited parameters by using computer softwares and computational analysis to calculate for the load capacities.
3. Estimate the materials, labor, and other cost to be incurred in the completion of the design project.
4. Compare the cost benefit of the design using conventional and with titanium dioxide as concrete additive.

4. Methodology

4.1 Research Design

Developmental research is used for presenting data in this study. Developmental research is used to anticipate the efficiency and effectivity of a product or system by using software modeling tools and techniques. It can also identify new principles, development and evaluation of a design.
Developmental research techniques enhance the educational aspect of the research by enhancing individual and organizational performance, therefore, it is a must for the growth of technology.

4.2 Data Analysis

4.2.1 Input

In order to create a structural design that met the
standards stated on the structural code, the proponents primarily used the NSCP 2015 as the basis of all the parameters in load combination design. The parameters for foundation, columns, beams, and slabs are then inputted into Staad Pro v8i and proceeded with computational analysis to acquire information on how these civilworks are designed based on their dimensions and spacings of rebars and concrete.
Autocad is used to create details and schedule for civil works based on the result provided by Staad Pro v8i. It is also the tool for floorplans and 3D drawings. For architectural elements such as distance from one element to another and spacing of rooms and units, National Building Code of the Philippines together with Planners and Designer Handbook by Max B. Fajardo Jr. is used as the main reference.

4.3 Process

The parameters to be used in designing the structural phase of the four-storey multi-purpose building relies with the given values design loads as stated in the National Structural Code of the Philippines 2015 for Volume 1: For Buildings, Towers, and Other Vertical Structures.

Dead Load
The values for dead load are based mainly with the Section 204 of the National Structural Code of the Philippines 2015. Table 204-2 (Minimum Design Dead Loads) of NSCP 2015 is the main reference for these values and all minimum design loads are considered in the design. The floor dead loads are as follows:

- 3.6 KN/m2 - weight of 150 mm slab
- 1.1 KN/m2 – floor finish; ceramic or quarry tiles
- 0.1 KN/m2 - gypsum board ceiling
- 0.1 KN/m2 – mechanical/electrical/plumbing fixtures

For the roof slab loads, 4.9 KN/m2 is used if tiles will be used but since tiles is absent in the design for the roof slab, a value of 1.1 KN/m2 will be deducted resulting in a total of 3.8 KN/m2 of load for the roof slab.
The values used for the CHB load are also in accordance with the codes provided in the Minimum Design Loads of NSCP 2015. The uniform load applied to beams due to the weight of CHB is 2.63 KN/m2 per 1- meter height of wall while the load of the plaster for every face of walls is 0.24 KN/m2 per 1-meter height of wall. For the 2.8 meters' height of floor, a total of 8.71 KN/m2 of CHB load is used.
The values of dead loads are in accordance with the section 204 of the National Structural Code of the Philippines 2015. Table 204-2 (Minimum Design Dead Loads) of NSCP 2015 was used for the parameters of dead loads in the simulation in STAAD Pro v8i.

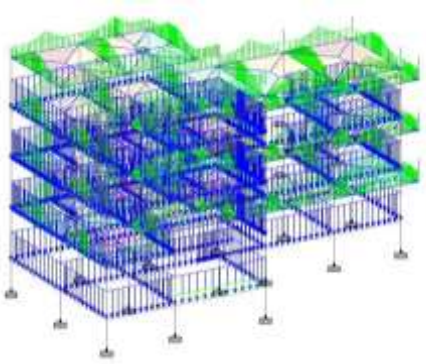


Fig. 2 Dead Load

Live Loads
The values for dead load are based mainly with the Section 205 of the National Structural Code of the Philippines 2015; all values will be based depending on the intended use or occupancy of the building. Table 205-1 of (Minimum Design Dead Loads) of NSCP 2015 is the main reference for these values and all minimum design loads are considered in the design. The use or occupancy to be considered for design of the building is for residential use with values of 1.90 KN/m2 for the

basic floor area and 2.94 KN/m2 for the exterior balconies. The building will use water tanks as source of the supply of water for the occupants, two water tanks will be used and are considered as live loads. The load for each tank is 21 KN/m2, therefore a total of 42 KN/m2 is used for the total load for the two tanks.

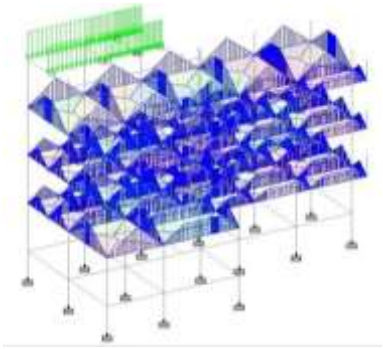


Fig 3. Live Load

Soil Bearing Capacity

The values for the soil bearing capacity are based mainly on the provided by existing soil bearing analysis of Municipality of Malvar, Batangas specifically at Barangay Santiago. The soil investigation provided a value of 144 KN/m2. For the full specifications of the soil analysis of the location, see appendices.

Wind Load

The values for wind load are based mainly in accordance with the Section 207 of the National Structural Code of the Philippines 2015. This section is the reference for the needed values in the STAAD Simulation. The zone which the project site is located provides a Category III Building which is having a wind speed of 240 kilometers per hour.

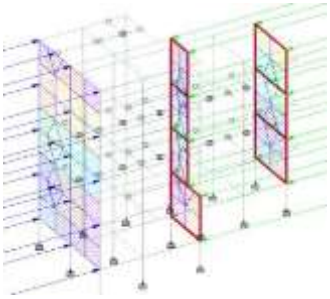


Fig 4.1 Wind Load X

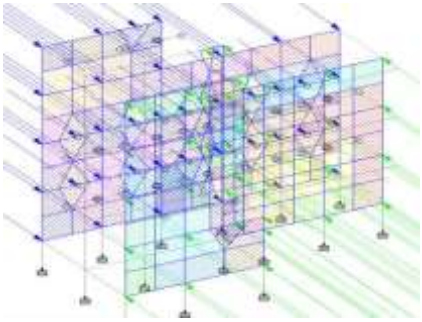


Fig 4.2 Wind Load Z

Seismic Load

The values for seismic load are based mainly in accordance with the Section 208 of the National Structural Code of the Philippines 2015. This section is the reference for the needed values in the STAAD Simulation. The following values are used as the seismic parameters:

0.4 – Zone
1.0 – Importance Factor
8.5 – Rw in X direction
8.5 – Rw in Y direction
4.0 – Soil profile type
1.0 – Near source factor NA
1.0 Near source factor NV

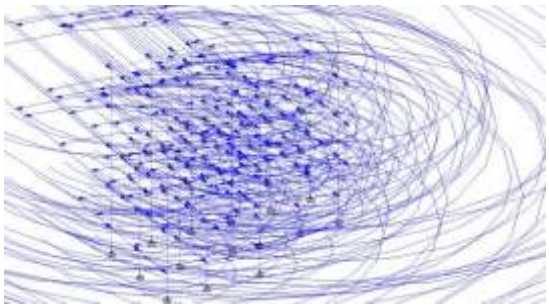
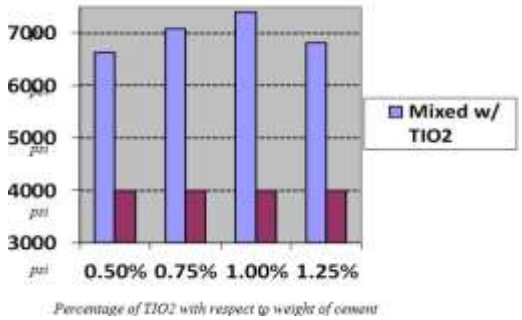


Fig. 5 Seismic Load

Titanium Dioxide as Concrete Additive

In the study of Sorathiya et al, their tests show a dramatic increase in compressive strength of concrete when titanium dioxide was mixed depending on the corresponding proportion of TIO2 to the weight of cement used in the mix. In the tests, the researchers used M – 20 concrete mix which is equivalent with Class AA mix, and



used different percentages of TIO2.

Fig. 6 Increase of compressive strength due to presence of TIO2

4.4 Output

Cost Analysis

The proponents came up with the Class C concrete mix added with titanium dioxide in a percentage of 0.75% of the total weight of cement to be used in the construction. This mix will result in a compressive strength relatively higher than a Class C mix without TIO2 that has a 2000 psi of strength. When a Class C is mixed with 0.75% of TIO2, its strength is increased up to 3538psi, relatively greater in compressive strength compared with a conventional Class C concrete mix.

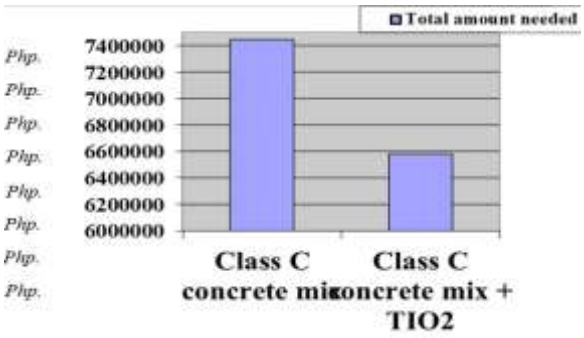


Fig.7 Budget Estimation of project build using Class C mixture + TIO2 vs. Class C Standard

In figure 7, the budget estimation of the project is shown when using a Class A concrete mix and when using a Class C concrete mix added with a TIO2 (0.75% of the cement weight) in the building's structural members and typical slabs. First bar shows an estimated cost of Php 7,466,035.11 using a plain Class C concrete mix in the building's structural members and typical slabs. A projected amount of Php6,580,385.91 is shown in the second bar when using the mix of Class C added with 0.75% TIO2 in the construction of the building. Using the modified mix versus the conventional mix without TIO2 gives a large difference in cost with a projected less amount of Php. 885,649.20 which can be used for contingency or for other relevant use in the benefit of the owner. For the whole estimation details when using Class C mix concrete and Class C mix concrete with TIO2 as concrete additive, see Appendices.

5. Results and Discussion

Design of Structural Elements

A. Footing Design

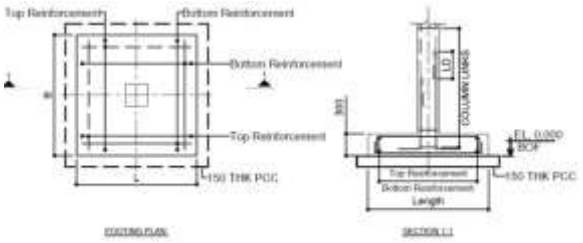


Fig.8 Footing Design

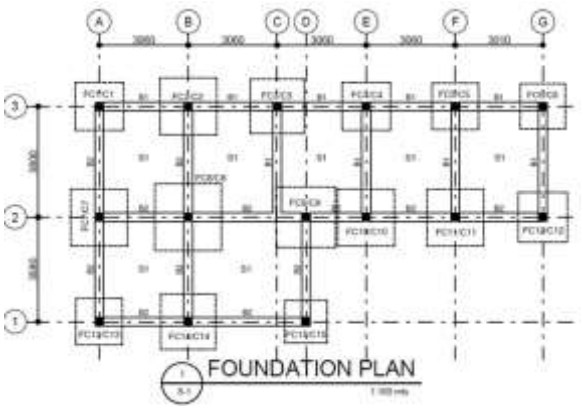


Fig.9 Foundation Plan

Fig.9.2 2nd and 3rd Floor Framing Plan

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*******************************************************************************

FLOOR DIAPHRAGM     UNIT - KN   METE
---------------     ---------------

 NO.  TYPE        FL. LEVEL      FL. WT     CENTRE OF MASS      MASTER JOINT NO.
                                             X        Z

  1   RIGID          1.800       524.22     8.409    7.763          258
  2   RIGID          5.000       686.29     8.859    7.952          259
  3   RIGID          8.200       684.59     8.857    7.939          260
  4   RIGID         11.400       620.50     8.651    8.072          261
  5   RIGID         14.600       343.77     5.050    8.644          262

*******************************************************************************


191. DEFINE UBC LOAD
192. ZONE 0.4 I 1 RWX 8.5 RWZ 8.5 STYP 4 CT 0.0731 NA 1 NV 1
193. REFERENCE LOAD Y
```

Fig.10 Rigid Floor Diaphragm

This figure shows the result of rigid floor diaphragm analysis on STAAD Pro v8i. The assumption is that every floor slab is rigid to come up with the computation of total weight per floor level. The result shows the total weight per floor level as well as giving the coordinates of the center of mass for each floor. The result shows an accurate representation of floor weight in a sense that it conforms the design of the building structure since the area of the roof top is a lot smaller with respect to other floor levels.

```
VERTICAL STRUCTURAL IRREGULARITIES : SOFT STORY CHECK - ASCE/SEI 7-05
-------- ---------- --------------

STORY          FL. LEVEL IN METE          S T A T U S
-----          -----------------          -----------
                                          X          Z

  1                 1.80                 OK         OK
  2                 5.00                 OK         OK
  3                 8.20                 OK         OK
  4                11.40                 OK         OK
  5                14.60                 OK         OK

NOTE : NO SOFT STOREY IS DETECTED.


*********************************************************
*                                                       *
*  X  DIRECTION : Ta =  0.546 Tb =  0.552 Tuser =  0.000 *
*  T =  0.592, LOAD FACTOR =  1.000                     *
* UBC TYPE = 97                                         *
* UBC FACTOR V = 0.1272 W       2888.00 =     367.31 KN  *
*                                                       *
*********************************************************
```

Fig.11 Soft-Storey Check

The table above shows the result of soft – storey check on STAAD Pro V8i. Soft Storey is amethod of determining any irregularities in structure that may fail if earthquake occurs. The result aboves proves that the structure passes soft-storey check which implies that the structure is structurally safe.

STORY	HEIGHT (METE)	LOAD	AVG. DISP(CM) X	AVG. DISP(CM) Z	DRIFT(CM) X	DRIFT(CM) Z	RATIO	STATUS
BASE=	0.00						ALLOW. DRIFT = L / 238	
1	0.00	5	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		6	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		7	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		8	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		9	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		10	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		11	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		12	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
2	1.80	5	0.1278	0.0029	0.1278	0.0029	L / 1408	PASS
		6	-0.0017	0.1391	0.0017	0.1391	L / 1294	PASS
		7	-0.1301	0.0027	0.1301	0.0027	L / 1383	PASS
		8	-0.0006	-0.1334	0.0006	0.1334	L / 1349	PASS
		9	0.1281	0.0023	0.1281	0.0023	L / 1405	PASS
		10	-0.0014	0.1384	0.0014	0.1384	L / 1301	PASS
		11	-0.1298	0.0021	0.1298	0.0021	L / 1387	PASS
		12	-0.0003	-0.1341	0.0003	0.1341	L / 1343	PASS
3	5.00	5	0.7224	0.0427	0.5946	0.0398	L / 538	PASS

< PAGE 11 Ends Here >

DXF IMPORT OF THESIS 4 STOREY.DXF -- PAGE NO. 12

		6	-0.0162	0.8132	0.0145	0.6741	L / 474	PASS
		7	-0.7559	0.0521	0.6258	0.0493	L / 511	PASS
		8	-0.0173	-0.7184	0.0167	0.5850	L / 547	PASS
		9	0.7265	0.0314	0.5984	0.0292	L / 535	PASS
		10	-0.0121	0.8019	0.0107	0.6635	L / 482	PASS
		11	-0.7516	0.0408	0.6200	0.0387	L / 514	PASS
		12	-0.0132	-0.7297	0.0129	0.5956	L / 537	PASS
4	8.20	5	1.2907	0.1691	0.5683	0.1264	L / 563	PASS
		6	-0.0031	1.5473	0.0131	0.7341	L / 436	PASS
		7	-1.3135	0.1849	0.5575	0.1328	L / 574	PASS
		8	-0.0196	-1.1933	0.0023	0.4749	L / 674	PASS
		9	1.2936	0.1270	0.5671	0.0956	L / 564	PASS
		10	-0.0002	1.5052	0.0119	0.7033	L / 455	PASS
		11	-1.3106	0.1428	0.5587	0.1020	L / 573	PASS
		12	-0.0160	-1.2353	0.0035	0.5057	L / 633	PASS
5	11.40	5	1.6956	0.3016	0.4049	0.1325	L / 790	PASS
		6	0.0194	2.1141	0.0225	0.5669	L / 564	PASS
		7	-1.7104	0.3046	0.3970	0.1195	L / 806	PASS
		8	-0.0343	-1.5082	0.0146	0.3149	L / 1016	PASS
		9	1.6976	0.2295	0.4040	0.1025	L / 792	PASS
		10	0.0214	2.0421	0.0217	0.5369	L / 596	PASS
		11	-1.7084	0.2323	0.3978	0.0895	L / 804	PASS
		12	-0.0322	-1.5802	0.0155	0.3449	L / 928	PASS
6	14.60	5	2.0605	0.4520	0.3649	0.1505	L / 877	PASS
		6	0.1112	2.6857	0.0918	0.5716	L / 560	PASS
		7	-1.9909	0.1483	0.2805	0.1561	L / 1141	PASS
		8	-0.0416	-2.0854	0.0073	0.5772	L / 554	PASS
		9	2.0527	0.3807	0.3552	0.1512	L / 901	PASS

< PAGE 12 Ends Here >

DXF IMPORT OF THESIS 4 STOREY.DXF -- PAGE NO. 13

STORY	HEIGHT (METE)	LOAD	AVG. DISP(CM) X	AVG. DISP(CM) Z	DRIFT(CM) X	DRIFT(CM) Z	RATIO	STATUS
BASE=	0.00						ALLOW. DRIFT = L / 238	
		10	0.1035	2.6144	0.0820	0.5724	L / 559	PASS
		11	-1.9986	0.0770	0.2902	0.1553	L / 1102	PASS
		12	-0.0493	-2.1567	0.0171	0.5765	L / 555	PASS

Fig.12 Storey Drift Check

The table above shows the result on storey drift check. Storey drift is the horizontal displacement of structural components due to lateral loads such as earthquake and wind. According to NSCP 2015, the maximum allowable drift for 15 storey and below is said

to be L/238. The results show that all structural member passed the drift check; this implies that the building is structurally safe against lateral movement.

CENTRE OF RIGIDITY UNIT - METE

DIAPHRAM	FL. LEVEL	X-COORDINATE	Z-COORDINATE
1	1.800	8.578	7.934
2	5.000	8.531	7.913
3	8.200	8.461	7.851
4	11.400	8.409	7.809
5	14.600	6.560	8.041

Fig.13 Center of Rigidity Check

This table shows the center of rigidity of the structure for each floor levels. Center of rigidity is a point at a particular storey as the location of application of lateral load at that point will not produce rotation of that storey. This implies that the coordinates given above is a point in which the structure is most rigid.

6. Conclusion

Based on the following findings and in relation to the objectives, the following conclusions were made.

- Class C concrete mixture with 0.75% of titanium dioxide (TIO2) of cement weight yields 3500 psi of compressive strength which is also the same as the compressive strength of a standard Class A concrete. This will also provide our concrete self- cleaning property as well as waterproofing capability. This leads to a huge amount of money that can be saved for the construction of reinforced concrete projects.
- The safe and economical footing design that is used for this study is isolated footing. The depth of footing according to the soil analysis gathered is 1.5m-2.0m. The proponents decided to use 1.8m for safety purposes. Majority of footings are having the dimension of 2.1m x 2.1m x 0.3m as their length, breadth, and thickness respectively. The largest footing has a dimension of 2.6m x 2.6m x 0.3m, this footing carries the largest load throughout the whole structure
- To have a stable building frame, STAAD softwares come up with a column design having the dimension of 300mm x 300mm all throughout the building structure. The reinforcement required for an economical design is 4 - 20mm diameter rebar per column from base to the top of the column. Stirrups are spaced 300mm on center. Class C concrete mixture with 0.75% of TIO2 of cement weight is required for columns.
- The design of high load bearing beams (B1) are 400mm depth and 300mm width for the structure presented in this study to be rigid and stable. The main reinforcement to be used for B1 are 4 – 20mm diameter rebar while stirrups with the diameter of 10mm are spaced 130mm on center. Furthermore, 300mm depth and 250mm width beams (B2) are being used to support walls in the bathroom areas of the apartments as well as the

ends of the cantilever slabs located on the residential floors. The main reinforcement requirement for B2 are 4-16mm diameter rebar and stirrup requirement is 10mm diameter rebar spaced at 100mm on center. Class C concrete mixture with 0.75% of TIO2 of cement weight is required for beams.

- The design of ground slabs and suspended slabs used in this study is in accordance to the minimum rebar diameter of 10mm spaced at 300mm on center on both span. The thickness for the said slabs are 150mm in all floor levels. This is in accordance to the NSCP 2015. Class C concrete mixture with 0.75% of TIO2 of cement weight is used for slab since it is the most practical in terms of slab-beam monolithic design.
- For the outer walls of the structure, the researchers used 6" hollow blocks, due to a need for a thicker material since it is exposed to weather. Hollow blocks with the size of 4" will be used as internal partition for the building for economical purposes since it is the thinnest hollow block size in NSCP 2015.
- The cost of the whole project with the inclusion of material, labor, and other cost is estimated to be at Php 6,580,385.91 This amount considers contingency cost of 10% for both material and labor. Contractors' profit is considered at 6% of total cost of material, labor, and other cost.
- The estimated time for the project is 7 months from excavation to wrapping up. The proponents used the said time frame based on the construction duration of the same sized project. The structural member's dimensions and parameters stated above is adequate enough to resist up to magnitude 8.4 earthquake with respect to parameters stated in NSCP 2015. It is also the highest possible earthquake that can hit the Philippines. With this, the proponents therefore conclude that the design presented in this thesis study passes all standards that is imposed on structural buildings on the Philippines up to date.

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DESIGN AND IMPLEMENTATION OF A PROPOSED TWO-STOREY BARANGAY HEALTH CENTER WITH RAINWATER HARVESTER SYSTEM AT BARANGAY LAUREL, TANAUAN CITY, BATANGAS

RICARDO M. BOBADILLA*, C.E. BALAGTAS, R.G. RECIO, J.A. RAMILO, G.C. REIG

Civil Engineering Department, Lyceum of the Philippines University - Laguna
Km. 54 Makiling Calamba City of Laguna, Philippines
*Corresponding Author: ricbobadilla@yahoo.com

Abstract

The proponents proposed to design a two-storey Barangay Health Center in Barangay Laurel, Tanauan City that has a rainwater harvester to collect rainwater and store it in a cistern for future use. The design provided by the researchers used both steel (for roof trusses) and concrete (for other members) materials to fulfill the desired safe and economical design of the barangay health center. The structural integrity of the building was assured by designing the project using STAAD (for columns, beams, trusses) and manual computations (for floor slabs, footing, sanitary lines and rainwater harvesting system). The researchers included a design of a rainwater harvesting system to provide back-up emergency supply of water for water closets, lessen the cost in water consumption and help conserve water as well. The proponents used standards and codes from American Institute of Steel Construction (AISC), National Structural Code of the Philippines (NSCP) 2015, American Concrete Institute (ACI), National Building Code of the Philippines (NBCP), Uniform Building Code (UBC), Uniform Plumbing Code (UPC) and American Society of Plumbing Engineers (ASPE) in designing the project and was also assessed by applying different load factors such as seismic load, wind load, dead load and live load. For the design project to be implemented, the demand of the beneficiary was addressed by the researchers. The minimum possible design was used in the project without compromising the structural integrity to achieve the most economical and safest design of the building.

Keywords: Rainwater Harvester, Cistern, STAAD, Load Factors, Structural Integrity

1. Introduction

Health problems in rural areas may be more serious by the time they are diagnosed. People in rural areas have higher rates of having chronic disease than people in urban areas. They also have higher rates of getting certain types of cancer, from exposure to chemicals used in farming and other works alike.

One of the primary needs of a health center is water. But water is not regularly supplied in rural areas especially during summer season, and modern society forgot that

roofs could be efficient and convenient water collection surfaces. Due to this reason, the proponents designed a rainwater harvesting system to help resolve the problem.

The Rainwater harvesting is used primarily to describe a strategy designed to collect roof precipitation for irrigation of the landscape, reducing the need for supplemental water or storing it in a cistern for future use.

Cistern systems date back several thousand years. In its simplest form, a cistern system collects rainwater that falls on a roof so that the collected water can be used at a later time.

The proponents proposed to design the health center of Brgy. Laurel, Tanauan City, Batangas. The need for this structure comes from two sources, the lack of health center in the area and the remote location of the barangay. The design project aimed to meet the requirements imposed by the beneficiary and would be structurally safe, economical and innovative.

2. Conceptual Framework

The researchers used conceptual framework to develop a possible methodology to present a means of presiding the project design.

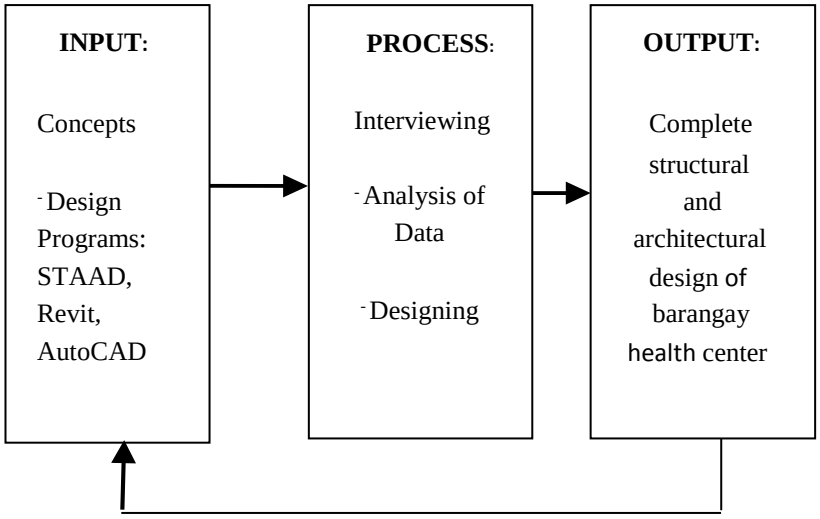


Figure 1. Conceptual Framework

The study started by collecting necessary data by interviewing the barangay council. The gathered information was used to assess the requirements provided for the health center. After collecting the data, the researchers started to design the structural and architectural plan of the health center with the aid of software, specifically STAAD and AutoCAD, giving emphasis on the different parameters especially the footing, columns, beams, floor slabs, walls, roof and sanitary line. After that, the cistern capacity and the power of the pump, for the transferring of water from the cistern to the water closets, was designed and computed manually. The proponents then analyzed the structural integrity of the building based on the said parameters to assure the community of its safeness. Lastly, the researchers estimated the total cost of the proposed project

based on the materials, labor, and other cost to be incurred in the completion of the design.

3. Objectives of the Study

The design project aimed to propose a structural and architectural design of the barangay health center with rain water harvesting system at Barangay Laurel, Tanauan City, Batangas.

Specifically, it sought to:

3.1. Design the complete structural and architectural plan of the barangay health center in Barangay Laurel, Tanauan City, Batangas with the emphasis on the following parameters:

- **3.1.1.** Footings,
- **3.1.2.** Columns,
- **3.1.3.** Beams,
- **3.1.4.** Floor Slabs,
- **3.1.5.** Walls,
- **3.1.6.** Roof,
- **3.1.7.** Sanitary Line, and
- **3.1.8.** Rainwater Harvester System;

3.2. Analyze the structural integrity of proposed design of barangay health center based on the above listed parameters; and

3.3. Estimate the material, labor, and other cost to be incurred in the completion of the design project

4. Methodology

Research Design

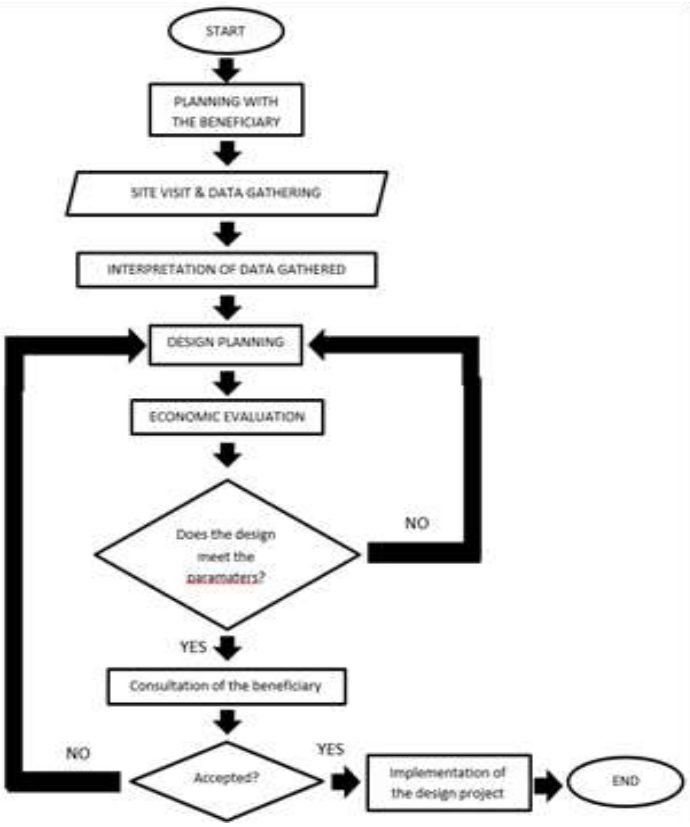
The proponents used developmental research design for the process of designing a two-storey health center. It is a systematic study of designing, developing, and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness. It involves situations in which the product- development process is analyzed and described, and the final product is evaluated.

Participants of the Study

The participants for this design project were Hon. Danilo L. Vargas, the Chairman of Barangay Laurel, Tanauan City; Dr. Ricardo M. Bobadilla, the proponents' project design adviser; Engr. Marlou Mico R. Malabuyoc, the proponents' technical adviser; and the researchers.

The proponents gathered information by visiting the target site and made a layout design presented to the barangay council. The researchers also consulted the beneficiary on the requirements that must be imposed. On the other hand, Engr.

Flow Chart



5. Result and Discussion

Footing

Based on the computations, the researchers came up with the dimensions of the footing. The researchers used isolated square footing. The footing has the length and width of 1500 mm, thickness of 400mm and depth of -1.5m from NGL (Natural Grade Line). The top and bottom bars have the same number of reinforcements, longitudinal and transverse have six and five pieces of 20 mm diameter bar, respectively.

Columns

Based on the computations, with the aid of STAAD, the researchers came up with the dimensions of the column. The researcher used rectangular columns. There are two types of columns used in the design, column 1 and column 2 with legends C-1 and C-2, respectively. C-1 and C-2 columns have dimensions 350 mm x 350 mm and 300 mm x 300 mm respectively, and reinforcement grade 60 with specific reinforcements of twelve

pieces of 16 mm diameter. Ties are 12 mm diameter. Spaced 2 at 50 mm, 4 at 100 mm and the rest at 200 mm.

Beams

In the design, the researchers divided the beam into two types, namely second floor beam and the typical roof beam which are both double layered. All of the specifications for both second floor beam and the roof beam were analyzed and designed using STAAD. For the second floor beam, there are three types used, B-1 (Beam 1) B-2 (Beam 2) B-3 (Beam 3). B-1 has base of 300 mm and height 500 mm. The exterior support, midspan and interior support has a top reinforcements of three pieces of 20 mm diameter bar while the bottom reinforcements of two pieces of 20 mm diameter bar. B-2 has base of 300 mm and 400 mm height, the exterior support, midspan and interior support have a top reinforcements of two pieces of 20 mm diameter bar and bottom reinforcements with two pieces of 20 mm diameter bar. Lastly, B-3 having a base of 300 mm and height of 500 mm has an exterior support, midspan and interior support with a top reinforcement of four pieces of 20 mm diameter bar and bottom reinforcement with two pieces of 20 mm diameter bar.

Roof

The roof truss design of the structure was divided into three sections, Truss-1, Truss-2 and Truss 3. All of the members used in the design have four members, specifically, the top bar, bottom bar, the web member and the gusset plate. For Truss-1, the top bar has a dimension of 2L – 100 x 100 x 10 mm, bottom bar with dimensions of 2L – 50 x 50 x 10 mm, web member with dimension of 2L – 75 x 75 x 10 mm and gusset plate with 10 mm thickness.

For Truss-2, the top bar has a dimension of 2L – 75 x 75 x 10 mm, bottom bar with dimensions of 2L – 50 x 50 x 10 mm, web member with dimensions of 2L – 75 x 75 x 10 mm and gusset plate with 10 mm thickness.

For Truss-3, top has a dimension of 2L – 75 x 75 x 10 mm, bottom bar with dimension of 2L – 50 x 50 x10 mm, web member with dimension of 2L – 75 x 75 x 10 mm and gusset plate with 10 mm thickness. All of the dimensions were computed using STAAD and followed the standards using NSCP 2015.

Floor Slab

The design has two types of slab, the one-way slab and the two-way slab. Slab – on – grade has a thickness of 200 mm: 125 mm for the slab and 75 mm for the concrete cover. The suspended slab has a thickness of 125 mm which is the minimum requirements for two-way slab based on NSCP 2015 (see table 3 for reinforcement details). All slabs have 20 mm concrete cover.

6. Conclusions

1. The researchers have successfully designed the Proposed Two-Storey Barangay Health Center With Rainwater Harvester System at Barangay Laurel, Tanauan City, Batangas. The researchers conclude that the dimensions of the said parameters can withstand all loads applied.
   1.1. The footing with the length and width of 1500 mm, thickness of 400 mm and depth of -1.5m from NGL.

1.2. For external and interior column, the dimensions are 350 mm x 350 mm and 300 mm x 300 mm respectively.
1.3. The beam has a base of 300 mm and height 500 mm for second floor beam, and base of 300 mm and 400 mm height for the typical roof beam.
1.4. For the floor slab, the design includes slab-on-grade thickness of 125 mm and suspended slab thickness 125 mm.
1.5. For the walls of the building, 150 mm CHB is used for the exterior walls and 100 mm CHB is used for interior walls.
1.6. For the roof design, the researchers use hipped roof since it is more suitable for the design of rain water harvesting cistern.
1.7. For sanitary line, the researchers design both sewage and water line of the barangay health center.
1.8. The researchers use one horsepower water pump to transfer the water to the water closet.

2. The design provided by the researchers use both steel and concrete materials to assure the structural integrity of the building with the aid of the standard codes from American Institute of Steel Construction (AISC), National Structural Code of the Philippines (NSCP) 2015, American Concrete Institute (ACI), National Building Code of the Philippines (NBCP), Uniform Building Code (UBC), Uniform Plumbing Code (UPC) and American Society of Plumbing Engineers (ASPE) in designing the project and also by applying different load factors such as seismic load, wind load, dead load and live load.

3. The proposed two-storey barangay health center is estimated to cost a total of Php 2,214,330.57 in which the total material cost of the project is Php 1,565,178.20 wherein 35% of the material cost is the labor cost at Php 649,152.37.

7. Recommendation

With the data accumulated and presented in this structural project, and the project focuses only in the structural, architectural, plumbing design and budget estimation, the researchers recommend to the beneficiary to have an experienced professional for a thorough evaluation and design of mechanical, electrical and fire protection of the building since its not part of the expertise of the proponents. The project design includes an innovation that collects and uses rainwater as a substitute for flushing of toilet and cleaning, but it is recommended to the future researchers to have a detailed design of water treatment of the collected rainwater to be used in other non-potable purposes and not just for toilet flushing. It is also recommended to the future researchers to have a design for solar powered pump to make the RHS work from renewable energy and to distribute the treated water free of charge, so that it can always be used since it is free and not only to be used as emergency supply during water shortage.

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DESIGN AND IMPLEMENTATION OF THE PROPOSED FOUR-STOREY HIGH SCHOOL BUILDING IN LYCEUM OF THE PHILIPPINES UNIVERSITY-LAGUNA USING LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

GLENN CHRISTOPHER J. LAMBINO, RICA MEL L. LINATOC, JAMES MATTHEW P. LUMBRES

Lyceum of the Philippines University – Laguna
Dr. Ricardo Bobadilla Program Chair, Civil Engineering Department, Lyceum of the Philippines University – Laguna
Corresponding Authors: glennchristopherlambino@gmail.com[1], ranlinatoc@gmail.com[2], jamesmatthewlumbres@gmail.com[3]

Abstract

Availability of rooms such as classrooms is one of the major problems arising in schools today because of the implementation of K-12 in the Philippines that results to rapid growth of student population in schools. In this project, the group of Civil Engineering students were given the opportunity of the administration of Lyceum of the Philippines University-Laguna to provide the design of the Four-Storey High School Building in the said location. The project will decongest the classrooms of the main private school building and will give a convenient learning facility for the high school students and teachers. As an innovation, the group used the requirements of Leadership in Energy and Environmental Design for Schools New Construction and Major Renovations 2009 (LEED) to be eco-friendly and to have a better market among the competitors in the Region as well. The special functions of the building are a podium, roof deck, and a mezzanine. The building is wind and earthquake resistant. The design will be utilized in the computer softwares such as Staad v8i and STAAD RCDC. The total cost of the project is said to be roughly around Php 150, 945, 345.97.

Keywords: K-12, design, building, decongest, LEED, computer softwares

1. Introduction

Building construction became one of the largest industries today because of the growth of economy linked to the rapid urbanization of the world. Since the twentieth century, building construction has greatly evolved and still continues to innovate. School building construction may face various problems in different aspects that need wide range of construction knowledge, skills, and techniques. Different schools from different countries differ in design and construction approach depending on its climate, culture and beliefs. These kinds of problems are in same case to some schools in the Philippines. Since frequent earthquakes also occur, restoration of structures that are damaged is another dilemma. But, the biggest problem of schools in the Philippines today, according to one of the articles of Sunstar Bacolod, is the overcrowded classrooms because of the implementation of K-12. [34] This problem arises most especially in public schools where some perform classes in places like gymnasiums, fields and even under a tree. Some schools also instigated night

shift classes in order to accommodate their students. Due to the implementation of K–12 in the Philippines, the College Schools, specifically LPU–Laguna, doesn't have much enrollees for the 1st year and 2nd year level during this School Year. On 2022, the grade 12 students will now reach 5th year college, if enrolled in Engineering program, and the 5year level in College will be completed. The LPU–Laguna marketing committee expects to accommodate 4,000 students during this time. This is the anticipated number of enrollees for High School Department for a 5–year study of the LPU–Laguna marketing committee. On 2022, Junior High School will have 814 enrolees, and Senior High School will have 1,629 enrollees, for a total of 2443 enrollees. Since the existing buildings of LPU–Laguna is intended to cater college students only, the anticipated 2443 students might have a severe problem in classroom accommodation. Before this big problem of insufficiency of classrooms occurs, LPU-Laguna planned to construct a four-storey high school building in the campus vicinity on 2020 that will be designed by the researchers. This initiative will not only help the researchers to have their subject building but also help the institution economically by providing LEED certified plans that will be used in the future implementation. This will also strengthen the student administration relationship in the campus by applying the core values of LPU-Laguna, efforts of administration, and knowledge of the researchers.

2. Methodology

In this chapter, the researchers discussed the research design that has been used in the study. Also, this chapter described the participants of the project, design or research gathering tools, data gathering procedures, and design standards. It answered how the researchers gathered the data and obtained the needed information to make the study reliable.

3. Results and Discussion

3.1 Leadership in Energy and Environmental Design (2009) for Schools New Constructions and Major Renovations Design

3.1.1 LEED Standards

Table 1. Summary of LEED Achievements

Achieved LEED Requirements	Considered Parameters	Equivalent Point/s	Cost
SS Prerequisite 1: Construction Activity Pollution Prevention Required	Provision of gravel bedding and silt fence polyethylene and often watering of ground	0	₱16,042.42
SS Prerequisite 2: Environmental Site Assessment Required	No past land use	0	₱0.00
SS Credit 1: Site Selection	30m away from a wetland and is not a habitat for endangered species	1	₱0.00
SS Credit 4.1: Alternative Transportation–Public	61.69m away from the road	4	₱0.00

Transportation Access			
SS Credit 4.4: Alternative Transportation – Parking Capacity	Sharing of parking facility of LPU-Laguna	2	₱0.00
SS Credit 5.1: Site Development – Protect or Restore Habitat	Planting of bermuda grass that will cover 20% of the total area	1	₱166,666.67
SS Credit 5.2: Site Development – Maximize Open Space	Provision of soccer field	1	₱0.00
SS Credit 10: Joint Use of Facilities	Inviting St.Frances Cabrini Medical Center and food stalls to be used for non-school events	1	₱0.00
WE Prerequisite 1: Water Use Reduction	Installation of non-flushing urinals that can save up to 40% of water consumption	0	₱55,922.40
WE Credit 1: Water Efficient Landscaping	Use of 100 pots snake plant for landscaping	4	₱25,870.00

WE Credit 3: Water Use Reduction	Installation of non-flushing urinals that can save up to 40% of water consumption	4	(already included in WE Prerequisite 1)
EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems	Making sure that the general contractor is accredited by the PCAB	0	₱0.00
EA Prerequisite 2: Minimum Energy Performance	Installation of 25 Solar Panels with 325 Watts/Hr each	0	₱389,925.00
EA Prerequisite 3: Fundamental Refrigerant Management	Installation of non-chlorofluorocarbon emitting refrigerants in the proposed building	0	Will depend on the appliances that will be installed in the future.
EA Credit 2: On-site Renewable Energy	Installation of 25 Solar Panels with 325 Watts/Hr each	7	(already included in the EA Prerequisite 2)
EA Credit 3: Enhanced Commissioning	Making sure that the general contractor is	2	₱0.00

\

	accredited by the PCAB		
EA Credit 6: Green Power	Installation of 49 Solar Panels with 15,750 Watts each	2	(already included in EA Credit 2)
MR Prerequisite 1: Storage and Collection of Recyclables	Provision of trash bins	0	₱71,361.00
MR Credit 2: Construction Waste Management	Storing of 75% of the construction wastes for future use	2	₱0.00
MR Credit 5: Regional Materials	Getting the Redi Mix Concrete, Inc. to be the supplier of ready-mix concrete	2	₱0.00
MR Credit 6: Rapidly Renewable Materials	Using of armchairs with wheatboard and installation of sound absorption cotton wool in the podium.	1	₱7,434,372.8
ID Credit 2: LEED Accredited Professional	Hiring of 1 LEED professional	1	Labor Cost

ID Credit 3: The School as a Teaching Tool	Add a topic in one of the subject of high school that talks about LEED	1	₱0.00
RP Credit 1: Regional Priority	*WE Prerequisite*	4	*WE Prerequisite*
TOTAL		40 Points	₱8,534,522.69

3.2. Architectural Design

3.2.1. Codes

Table 2. Summary of NBCP Met Requirements

Code	Considered Parameters
Section 104: General Building Requirements	The contractor must ensure the safety and requirements that will meet the functional requirements of the building.
Section 301: Building Permits	It is the responsibility of the contractor to secure the necessary permits.
Section 401: Types of Construction	Type V: Fire Resistive Building
Section 701: Occupancy Classified	Group C: Education and Recreation
Section 704: Location of Property	The site has a direct access to a public space yard.
Section 805: Ceiling Heights	Minimum floor height is 2.9m
Section 806: Size and Dimensions of Rooms	The least dimension of kitchen is 7.95 while the bathroom has 6.8
Section 807: Air Space	The minimum air space per student is 3.886 cu.m.

Summary of NBCP Met Requirements

Requirements in Determining the Size of Rooms	
Section 1207: Stairs, Exits, and Occupant Loads	There are three exits per floor and two exits for the Mezzanine.
Section 1212: Fire Extinguishing System	There is a fire-extinguishing system installed in the proposed building.
Section 1214: Motion Picture Projection Rooms	The distance of the two exits in the Mezzanine is 29.58m from each other.
Section 1901: General Rule	The STAAD results are properly documented by the researchers.

3.3 Loads and Codes

3.3.1 Dead Load

In accordance with the Section 204 of the National Structural Code of the Philippines 2015, dead load consists of all the material's weight and fixed equipment in the building. In this chapter, the dead loads are computed based on the values listed on Table 204-2 (Minimum Design Dead Loads) of NSCP 2015. These loads were utilized as an input in Staad v8i.

Table 3. Dead Loads Considered

Dead Load		
1. Slab Weight	Thickness of Slab = 200mm	4.8 kPa
2. Wall	A. Thickness of CHB for external walls = 8"	4.07 kN/m
	B. Thickness of CHB for internal walls = 6"	3.11 kN/m
	C. Interior partitions = 4"	1 kPa
3. Floor Finish	Ceramic finish on stone-concrete fill	1.53 kPa

3.3.1 Live Loads

In accordance with the Section 205 of the National Structural Code of the Philippines 2015, live load depends on the intended use or occupancy of the building. In this chapter, the live loads are computed based on the values listed on Table 205-1 of (Minimum Design Dead Loads) of NSCP 2015. These loads were utilized as an input in Staad v8i.

Table 4. Live Loads Considered

Live Load		
1. Schools	A. Classrooms	1.9 kPa
	B. Corridors above the ground	3.8 kPa
	C. Ground Floor Corridors	4.8 kPa
2. Assembly Areas	Stage Areas	7.2 kPa

3.3.1 Wind Load

In accordance with the Section 207 of the National Structural Code of the Philippines 2015, wind load depends on the location of the site. These loads were utilized as an input in Staad v8i.

Table 5. Wind Loads Parameter

Wind Load	
1.Category	IV
2. Wind Speed	250 mph

3.3.1 Seismic Load

In accordance with the Section 208 of the National Structural Code of the Philippines 2015, seismic load depends on the location of the site. These loads were utilized as an input in Staad v8i.

Table 6. Seismic Loads Parameter

Seismic Load	
Z	0.4
I	1

RWx	8.5
RWz	8.5
STYP	4
NA	1.2
NV	1.2
CT	1.2

3.3.1 Factored Loads

As defined in NSCP 2015 Section 203.3.1 where the load and resistance factor are used, structures and all portions thereof shall resist the most critical effects from the following combinations of factored loads:

U = 1.2D + 1.6L

U = 1.2D + 0.5L + 1.6Wx

U = 1.2D + 0.5L + 1.6Wz

U = 1.2D + 0.5L + 1.6Ex

U = 1.2D + 0.5L + 1.6Ez

Where:

D=Dead Load

L=Live Load

W=Wind Load

E=Earthquake Load

3.4 Structural Design

3.4.1 STAAD Framing Plan

Frames that were designed in AutoCAD will be transferred to Staad v8i for analysis. These frames will then be given properties and applied by loads.

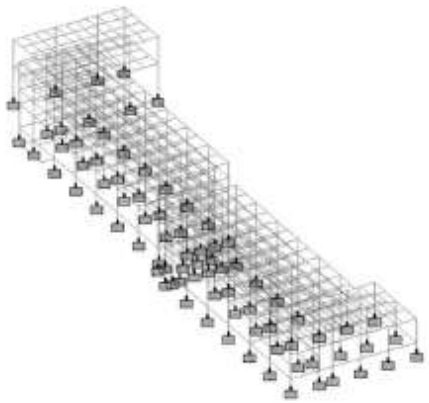

Figure 1. STAAD Framing Plan

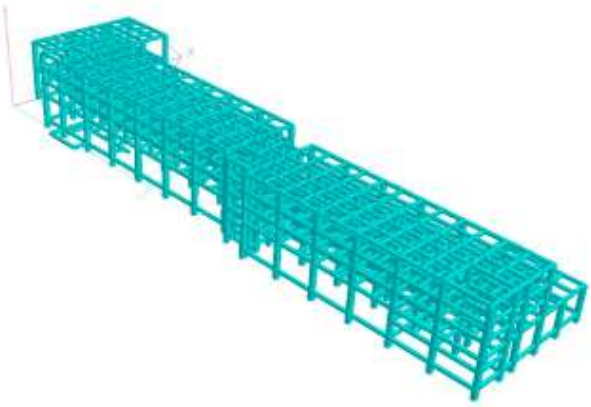

Figure 2. STAAD3D Framing Plan

3.4.2 Footing Design

Since the site is at LPU-Laguna, 120kPa for the soil bearing capacity and 20mm for the settlement were used. These values were based on the study of Marlou Malabuyoc. Just like what Braja Das said, the footings are spread footing since the foundations are shallow.

4. Conclusions

- The aim of the design project is to be able to design a structure for the proposed Four-Story High School Building with a rood deck located at Lyceum of the Philippines University-Laguna in Brgy. Makiling, Calamba, Laguna. The researchers were able to come up with the design using STAAD v8i and STAAD RCDC for the structural members such as footings, columns, beams, girders and slabs. For Gantt Chart and estimates, MS excel was used.
- The design of the project comprises the minimum requirements of the National Building Code of the Philippines and the National Structural Code of the Philippines 2015. The building is design to be structurally safe and eco-friendly but at a low cost.
- In addition, the building is not just structurally safe but energy and environmental innovative as well by meeting the requirements of Leadership in Energy and Environmental Design for School New Construction and Major Renovations 2009. The building is qualified for LEED Accreditation for being able to reach 40 points in their pointing system.
- Following LEED requirements, the building will conserve water consumption up to 40%, prevent the reaction of chlorofluorocarbon in the atmosphere, and decrease the electricity expenditure up to 35%.
- The total cost of the project is said to be roughly around Php 168,387,582.64 with a total estimated number of 160 construction days.

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DESIGN AND IMPLEMENTATION OF THE PROPOSED STUDENT ACTIVITY CENTER USING PLASWALL BUILDING SYSTEM AS EXTERIOR WALLS IN LYCEUM OF THE PHILIPPINES UNIVERSITY - LAGUNA

R M. Bobadilla* K.M. M. Baybay, H.J. N. Sarmiento, B.L. N. Villegas
Civil Engineering Department, Lyceum of the Philippines University – Laguna
Corresponding email: *ricbobadilla@yahoo.com

ABSTRACT

Nowadays, there is a need of activity center especially in the universities like Lyceum of the Philippines University-Laguna (LPU-Laguna). The researchers proposed a design of Student Activity Center using Plaswall Building System as exterior walls in LPU-Laguna to implement it in the near future. The design project aims to design the complete structural and architectural design of the Student Activity Center with the emphasis on the following structural member: footing, column, beam, slab, wall, and roofing. Also, to determine the cost-benefit analysis of using Plaswall Building System as exterior walls and to estimate the material, labor, and other cost to be incurred in the completion of the design project. For the architectural and structural plan, AutoCAD and Revit is used. STAAD Pro and STAAD RCDC for the design analysis. For the material and labor cost estimates, MS Excel is used and MS Project 2016 for the project schedule.

The project is successfully designed by the researchers. It is designed to resists live load, dead load, earthquake load, and wind loads. The results are gathered from the analysis of the structural member. The footing to be use is pad footing. The column is square or rectangular. The beam to be use is simply supported and it has also an intermediate beam. The type of slab is two-way. Lastly is the wall, in the exterior wall, Plaswall is to be use while concrete hollow blocks in the interior wall. There is the use of Plaswall Building System because it is eco-friendly and cost effective than using concrete hollow blocks. Also, the researchers, determined the types and dimensions of footing, column, beam, slab, wall, and roofing. It is more economical because of the costs and duration is faster compared when concrete hollow blocks is used in the construction.

Keywords: *Plaswall Building System, Concrete Hollow Block*

1. INTRODUCTION

University is an educational institution intended for teaching and examination of students of advanced learning, consulting degrees in various faculties, and often embodying colleges and similar institutions. The goal of universities is to educate and to enhance the knowledge of all the students to prepare them on the challenges they will meet in the future. Universities put the students to a higher degree of learning by providing a full freedom to develop the students' capabilities in handling activities and also to have the opportunity to conduct seminars and events.

With the growth of achievement and learning of students, school facilities such as libraries, audio visual rooms, multimedia rooms, laboratories, and so on have a great impact on student outcomes. One of the facilities that a university needs is the student activity center. A student activity center can play a vital role in the university to widen on-campus learning. It is an establishment mostly founded in universities where students gather for their activities like school events, organizational meetings, student gathering, leisure time, and other school activities.

Lyceum of the Philippines University – Laguna (LPU-L) is a university of higher education located in Km. 54, Brgy. Makiling, Calamba City, Laguna. It was formerly known as Lyceum Institute of Technology and was established in January 18, 2000. The university consist of three buildings which is the Jose P. Laurel (JPL) Building, Paciencia H. Laurel (PHL) Building, and Culinary Building (CB) and a Gymnasium. As of 2017, LPU-L community is

continuously increasing due to the implementation of K to 12 program. Every year there is an increase of enrollees especially high school students which results to the lack of rooms and other facilities.

Student organizations are conducting their seminars in the library due to the lack of Audiovisual Room. College events are held in school lobby that sometimes causes distraction on classes. The researchers propose a student activity center in Lyceum of the Philippines University – Laguna due to the need of such facility and this could serve as the campus living room for students. The student's gathering or school events will no longer be held in the lobby that distracts classes during class hours. The student activity center will not only help the university where the events can be held but also the student councils in different colleges will have their respective offices for their organizational meetings and activities. They can also develop their leadership abilities by joining in student organizations. Also, it can provide an atmosphere for a common life and cultivated social program for the students, faculty, and alumni of the university.

The researchers think of the alternative materials that can be used in the construction of the student activity center. This alternative could provide a cost-effective and durable construction at the same time. In the construction industry, there are many modernizations developed by many engineers. In building construction's modernization, many contractors developed a sustainable, cost-effective, and faster method of construction. This modernization is usually cast off in wall panels. One of the examples is the Plaswall Building System, which is commonly used in residential houses and commercial buildings.

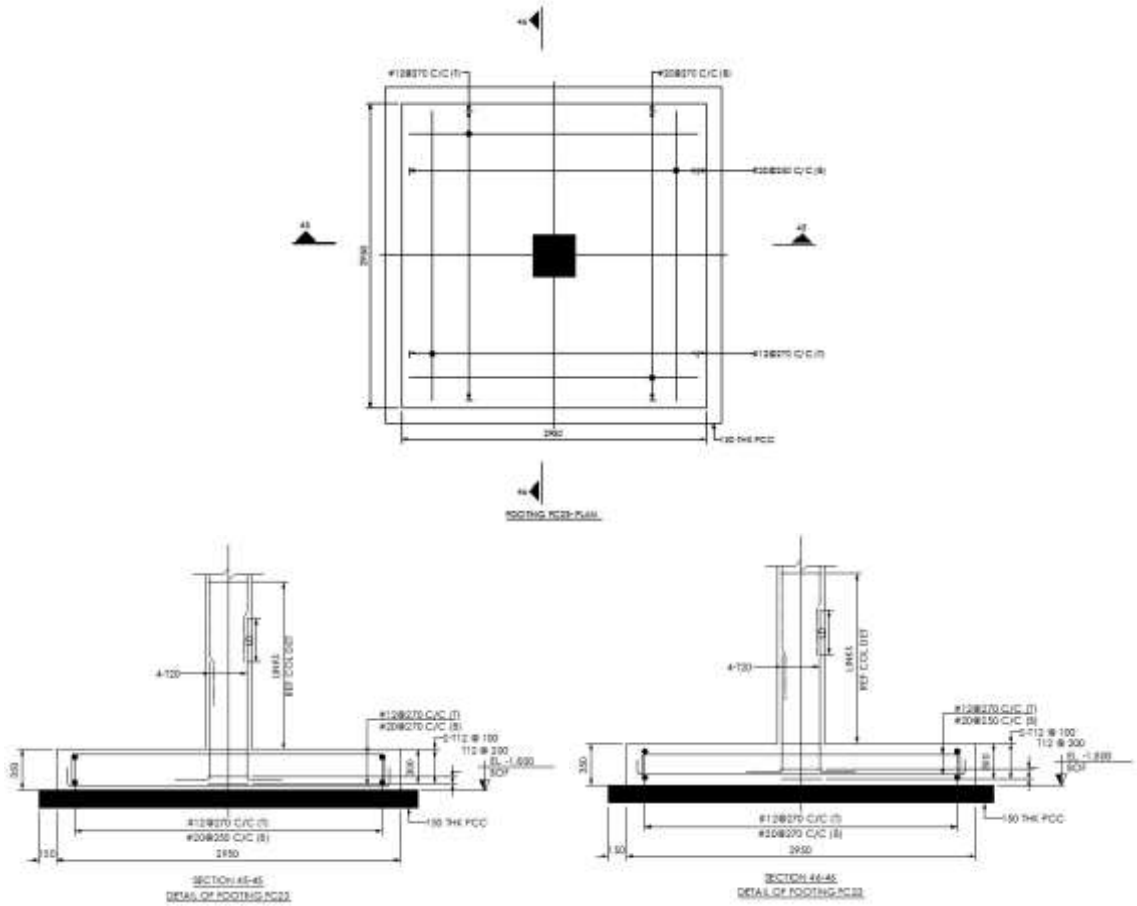
There are many construction companies in the Philippines that are using Plaswall building system. Plaswall is an exclusive fibrocement that requires a substitute to concrete hollow blocks usually used in the construction industry. It makes a complete load-bearing wall with a complete concentrated surface. It also needs lower experienced manpower to construct high-class concrete structure. This kind of system is applicable to apply in constructing residential houses, schools, high-rise buildings, and countryside structures. The application of this material is a new system of developed performance, cost-effective, faster construction, and lessening of wastes. It is also made to be ecofriendly and as time passes by, these old materials, manpower, and energy rates in our time stands to rise. [1]

Furthermore, the researchers proposed a design project that will be using Plaswall Building System to lessen the time of construction, the number of manpower, and the project to be cost-effective. It is a newly developed material that is now widely used in some parts of the country which is an alternative to Concrete Hollow Block (CHB). Also, this kind of building system has many advantages. It is also applicable for any constructions like residential houses and commercial buildings.

2. RESULTS AND DISCUSSION

Design of Structural Elements

A. Footing Design



SCHEDULE OF FOOTING

FOOTING NUMBERS	COLUMN NUMBERS	FOOTING TYPE	FOOTING DIMENSION					FOOTING REINFORCEMENT				REMARKS
								BOTTOM		TOP		
			STEP	L	B	D1	D2	ALONG B	ALONG L	ALONG B	ALONG L	
FC25	C25	Pad	-	3300	3300	700	-	#20@270 C/C	#20@270 C/C	#12@130 C/C	#12@130 C/C	-
FC26	C26	Pad	-	2400	2400	300	-	#12@130 C/C	#12@135 C/C	#12@300 C/C	#12@300 C/C	-
FC27	C27	Pad	-	2350	2350	300	-	#12@135 C/C	#12@150 C/C	#12@295 C/C	#12@295 C/C	-
FC28	C28	Pad	-	2350	2350	300	-	#12@135 C/C	#12@150 C/C	#12@295 C/C	#12@295 C/C	-
FC29	C29	Pad	-	2400	2400	300	-	#12@130 C/C	#12@135 C/C	#12@300 C/C	#12@300 C/C	-
FC30	C30	Pad	-	3300	3300	700	-	#20@270 C/C	#20@270 C/C	#12@130 C/C	#12@130 C/C	-
FC31	C31	Pad	-	3400	3400	425	-	#20@265 C/C	#20@245 C/C	#12@215 C/C	#12@215 C/C	-
FC32	C32	Pad	-	2600	2600	325	-	#20@260 C/C	#12@105 C/C	#12@290 C/C	#12@290 C/C	-
FC33	C33	Pad	-	3350	3350	400	-	#20@240 C/C	#20@225 C/C	#12@225 C/C	#12@225 C/C	-
FC34	C34	Pad	-	3500	3500	600	-	#20@235 C/C	#20@235 C/C	#12@110 C/C	#12@110 C/C	-
FC35	C35	Pad	-	3500	3500	600	-	#20@235 C/C	#20@235 C/C	#12@110 C/C	#12@110 C/C	-
FC36	C36	Pad	-	3600	3600	600	-	#20@225 C/C	#20@225 C/C	#12@110 C/C	#12@110 C/C	-
FC37	C37	Pad	-	3000	3000	350	-	#20@250 C/C	#20@250 C/C	#12@250 C/C	#12@250 C/C	-
FC38	C38	Pad	-	3100	3100	400	-	#20@250 C/C	#12@100 C/C	#12@225 C/C	#12@225 C/C	-
FC39	C39	Pad	-	3000	3000	350	-	#20@250 C/C	#20@250 C/C	#12@250 C/C	#12@250 C/C	-
FC40	C40	Pad	-	3600	3600	600	-	#20@225 C/C	#20@225 C/C	#12@110 C/C	#12@110 C/C	-
FC41	C41	Pad	-	3100	3100	700	-	#20@265 C/C	#20@260 C/C	#12@130 C/C	#12@130 C/C	-
FC42	C42	Pad	-	2950	2950	325	-	#20@270 C/C	#12@100 C/C	#12@270 C/C	#12@270 C/C	-
FC43	C43	Pad	-	2950	2950	325	-	#20@270 C/C	#12@100 C/C	#12@270 C/C	#12@270 C/C	-
FC44	C44	Pad	-	3100	3100	700	-	#20@265 C/C	#20@260 C/C	#12@130 C/C	#12@130 C/C	-

Table 1 shows the sample schedule of footing of the structure. It shows the footing member, column member, the type of footing to be used, the footing dimensions, and the footing reinforcement.

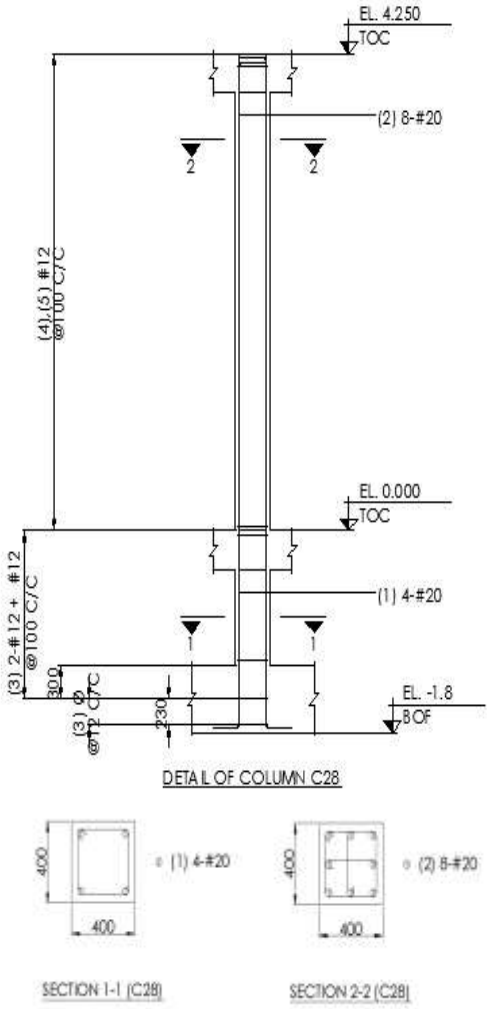


Figure 2. Sample Column Section

Figure 2 shows the column section which has the representation of the reinforcement. The type of column to be used is the rectangular column. It is given that the result is a square or rectangular column because of the size or dimensions. Based on the gathered related literature from The Constructor: Civil Engineering Home, square or rectangular traditional for any structure and based on length, short column, and long column if length and width ratio is greater than 12.

Beam

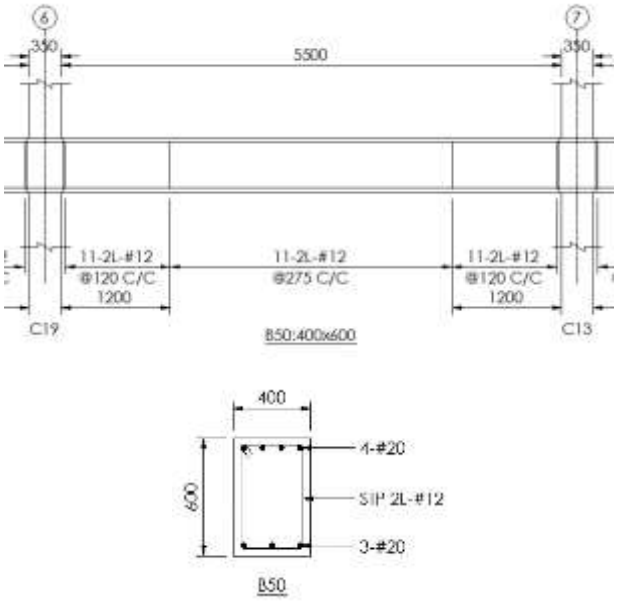


Figure 3. Sample Beam Section

Figure 3 shows the beam section and its reinforcements. The type of beam to be used is simply supported beam and it has an intermediate beam. Based on the gathered related literature from Baig and Ammar, simply supported beam is a beam that has supports near its ends, which restrain it against vertical and horizontal movement.

Wall

The wall to be used in the design project is Plaswall in exterior walls and concrete hollow blocks in the interior walls. The Plaswall is fire resistant, a noise insulator, and has a flexural strength is 3 MPa while CHB has only 0.45 MPa. Plaswall also do not required plastering and curing unlike the CHB. Moreover, the compressive strength of the Plaswall is C25 grade of the concrete while in CHB it has only 3.50 MPa.

Cost-benefit Analysis

The researchers have a summary of the budget estimation of the Proposed Student Activity Center using Plaswall Building System as exterior walls compared to the concrete hollow blocks. During the interview, Mr. Crisostomo Malabuyoc stated that there is no given budget for the said project. The researchers estimated that the project will cost up to Php 16,426,060.62 using Plaswall Building System while Php 16,772,959.35 using concrete hollow blocks. The cost estimation listed below includes the costs for the General Requirements, Earthworks, Concrete Works, Masonry Works, Formworks, Architectural Works, MEFPS, Metal Reinforcement, and the cost of using Plaswall as exterior walls. The table below consists of detailed computation of labor and material cost of each equipment. The basis of costing for the general requirements and earthworks were from the design project entitled "Design of Two-Storey Cultural Center Localizing Bubble Deck System" since they had almost the same floor areas and number of floors. The cost of materials such as cement, sand, gravel, and reinforcement bars were based from magkano.com and

LKG Group of Companies. For the Plaswall panel, the researchers had a contact with the Sterling Construction and Development.

3. Conclusion

The researchers have successfully designed the Proposed Student Activity Center using Plaswall Building System as exterior walls in Lyceum of the Philippines University-Laguna. The building will provide the needs of the students for an activity center. It will help the students to have an office for each department in the university and it will serve as the campus living room.

The Student Activity Center is designed to resists live load, dead load, earthquake load, and wind loads with the structural design based on the codes under NBCP and NSCP. Also, the researchers, determined the types and dimensions of footing, column, beam, slab, wall, and roofing. For the footing, pad footing is used. Moreover, rectangular for the column, and simply supported for the beam, were determined. The slab used is a two-way slab and for the wall, it is concluded that Plaswall as exterior walls is a load bearing wall so it contributes to strength of the structure.

The overall cost of the project until its completion using Plaswall Building System is Php 16,426,060.62 while Php 16,772,959.35 in using CHB. The researchers conclude that Plaswall is more economical than using the concrete hollow blocks and the duration is faster compared to the conventional. The use of Plaswall Building System is eco-friendly and cost effective than using CHB. The project is set to start in June 2018.

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DESIGN AND DEVELOPMENT OF A PC-BASED IR FRAME MULTITOUCH TABLE USING TUIO FRAMEWORK AT THE COLLEGE OF ENGINEERING AND COMPUTER STUDIES IN LPU-LAGUNA

CARLENE JOY A. BREGANZA[1], FRANCES CAMIL C. ILAGAN[1], MICO G. MEDIALDIA[1], KAYE CRISTINE M. TOLENTINO[1]
FAVIS JOSEPH BALINADO[2]

College of Engineering and Computer Studies, Lyceum of the Philippines Unversity - Laguna Km.54 Nat'l Hi-way, Makiling Calamba City, Laguna, Philippines
*Corresponding Author: micjing_14@yahoo.com

Abstract

This paper intends to create a multitouch table that expands for institutional implementation which is then able to interact through various applications involving university concerns. This study specifies the College of Engineering and Computer Studies as the recipient of the system application. To achieve these aims, the construction of the table includes an Infrared (IR) LED frame with acrylic glass which serves as the interface of the multitouch table. Other peripherals such as projector and camera are necessary in order for the system to establish. The light detected by the camera from the IR LED frame is processed in the computer. The communication between these devices are commanded by the TUIO protocol which requires both a client and a tracker application to interpret the results and provide the corresponding actions based upon the gathered data. The program runs under Windows 10 on an Intel Core 2 Duo microprocessor and is written using HTML, C++, Php+MySQL. In the aggregation of the matching procedures, multitouch table using personal computer is developed.

Keywords: *Multitouch Table; Microprocessor, CCV (Community Core Vision); TUIO (Tangible User Interface)*

1. INTRODUCTION

1.1 Background of the Study

Advanced living through high-end technological improvements have captured people's interest on continuing on throughout the day. In that case, we tend to engage ourselves on utilizing its optimum benefits. This is proved starting with the use of the simplest form of device up to the most complex machine we are dealt with every day. Various projects had come into place which verified the inevitable rise in the technological matters.

Smart glass interface is one of the most innovative ideas which the technology had been reinventing in the present time. It has evolved from integrating existing electronic displays into mirrors for an easier use featuring an interactive relation between the user and the machine [1]. Mostly, these mirrors are enhanced further in which several functions are interlaced in it. Some systems were made for the purpose of convenience and improved security represented by the basic automation of selected devices [2]. Moreover, it has the principal ability as being WiFi-supported in order to gain access to a wider address for a better service of functions including News and Weather updates.

Gadgets have been essential for use in personal and other purposes which provide us even on making a living. Through time, touch screen technology has taken place as a display screen which is sensitive with touch interferences [3]. Also, the existence of this serves as replacement for other hardware components. In relation to that, it has delivered ease to the people. Today, studies are made for implementing the use of this technology on boundless possibilities. It was first collaborated on simple devices such as phones. Through time, there has been development of touch panels which are used for interfacing the source command to the device. The primary purpose of this is to eliminate other computer peripherals such as keyboard and mouse. Aside from the decreased power consumption, this has as well as delivered innovation and convenience and elimination of external devices [4].

Various ways are opted for implementing touch panels namely resistive, capacitive, surface acoustic waves and infrared. All of these have discussions on the advantages and disadvantages of each [5]. Smartphones and tablets that are widely-used are distinguished by the hardware which supported its specifications. The area for improving the touch-screen technology has increased through other algorithms as well as the physical parameters of the devices [6]. Lately, the existence of a bigger touch-screen device has appealed to the people for refining the use on certain applications. A number of public malls have implemented these touch panels for the people to search particular stores and gain information about some specifics. This has provided ease and convenience to the user as well as avoided getting lost yet significantly saved up time. Another application that it has addressed is the profile assistance on museums and other establishments. Most importantly, it has aided for educational purposes and entertainment. Aside from all the technology and innovation that it has presented, the purpose of the Multitouch table kept on being developed by expanding its applications [7].

1.2 Statement of the Problem

In this fast-paced world we had developed for ourselves, people tend to always find the easy way on almost everything. This has led into the development of machines and devices which aim to support this kind of necessity. Later on, touch screen mechanism was interfaced on mirrors and was further linked on table-wide surfaces. Multitouch tables have a wider display which make it more accurate than a normal LCD monitor to detect the coordinates of the point where the finger met the surface [8].

Previous researches had worked on using different specifications. Existing multitouch tables that are available at the market are very costly, that is why it is not highly implemented for other beneficial use [9]. Commonly, only those who can afford are able to buy such products that are mostly subjected for entertainment alone. This is the main reason why not everybody is able to interact with these. The use of these devices must not be limited on these applications rather be expanded for other assistances as well.

Lyceum of the Philippines University-Laguna (LPU-L) is one of the universities which supports the use of improved technology on various applications. It has implemented some examples of devices which are products of the advanced science such as the Closed-Circuit Television (CCTV) for enhanced security. Another is the fingerprint-based attendance system for the employees; as well as the advancement on the LPU-L network such as the student portal and mrooms. Although all of these are being applied, some concerns are resurfacing which have relations to unmodernized processes. One of them is the unawareness

of some students on announcements and activities that the school has high regards of; while others are the unfamiliarity of their student identification profiles. Considering that there is an existing eLearning Portal for the LPU students as well as the official page for the LPU Laguna available online, this study is designed for the offline access. Hence, the use of a readily-available machine is helpful for these situations.

Consequently, multitouch tables are expensive for implementation. The mechanism of these existing touch-screen devices is commonly restricted for personal use and entertainment. These are only made as the Human Machine Interface (HMI) for computers while eliminating the keyboard and mouse. Hence, this study aims to develop one that is cost-efficient. Also through this, it would be possible to interlace the applications of the multitouch tables for other purposes starting with education.

1.3 Objectives of the Study

General Objective

The goal of this research is to develop a Multi-Touch Table using Raspberry Pi 3. This is then capable of being touched on multiple points at the same time. This prototype would be tested for implementation at the College of Engineering and Computer Studies (COECS). This would serve as an assistance for the LPU students with regards of the information that they need.

Specific Objectives

1. To identify the system requirements for hardware and software specifications which are to address the following considerations:
   - Input/Output specifications
   - Power requirements
   - Functional features of the system
   - Physical components for system development

2. To program a PC to perform the specific functions as follow:
   - To make use of the Infrared LED Sensor for data acquisition.
   - To implement the use of Community Core Vision (CCV) and Tangible User Interface (TUIO) for the surface technology.
   - To create a program using HTML, CCS, JAVASCRIPT, PHP programming language and My Structured Query Language **(**MYSQL) for website development.

3. To assemble and test the prototype based on the following:
   - Functionality
   - Accuracy
   - Speed
   - Reliability

4. To identify statistical analysis tool to determine the validity of the data and results.

2. REVIEW OF RELATED LITERATURE

A novel algorithm for the detection of multiple points of contact on an imaging touch surface. The algorithm used is Java programming language for the achievement of detecting multiple fingertip blobs for the experiments conducted. In addition, the algorithm presented is a variation of color conversion, procuring the digital image, and counting algorithm. After doing several trials, the error rate was found to be 1 out of 12 making the algorithm 92% accurate. Two techniques used in implementing image touch screen are Frustrated Total Internal Reflection (FTIR) and Diffused Illumination (DI) using a web camera instead of an infrared (IR) camera and using an acrylic sheet instead of tracing paper as a diffuser. Imaging multi-touch screens is reading the inputs from the several frames and then arranging a logical pattern by using the input. The device should perform this process intelligently to avoid overlooking inputs. Imaging touch-screens is flexible having no constraints in size, opposing to functionality where touch screens excel. Multi-touch algorithms are also used to detect objects on the surface and can take any actions depending on the object detected. [9]

A system is designed to attain a solution on problems encountered by an infrared multi-touch screen hardware system through the use of ARM7 processor. The ARM7 processor serves as the driver of infrared emission tube while an I2C bus serves as the receiver of information from infrared tubes. This is intended for the multi-touch point identification. The system is able to improve point accuracy, reduced response time and locate point coordination. [10]

Touch panel is a multi-touch scheme that detects touch through linear array of modulated light receivers which uses modulated infrared (IR) sensors and IR Light Emitting Diode (LED) to create a series of invisible light beams crossing the screen. This optical sensor allows data to be captured and be processed using computer vision techniques making it practical and applicable in installation in real-world. The prototype is believed to be an effective proof of a new conceptualized approach on multi-touch sensing for a thin display. The researchers also tried on expanding the sensing area to cover the entire display. The importance of the project it is a profitable, adaptive, affordable and a feasible solution for the purpose of the Interactive Education. [11]

A slim and wide multi-touch table top interface with two IR cameras and two mirrors is presented. For the identification of touch and drag operations, the system used a combined method of Frustrated Total Internal Reflection (FTIR) and Laser Light Plane (LLP). The system can be used in various application such as electronic Menu and puzzle games. In this paper, the system was applied to a puzzle matching game which shows the feasibility and the efficiency of the proposed system through the use of the combined method. In addition, the combined method is expandable and has accurate touch recognition. [12]

An automated touch sensing in the mouse tapered beam test using Raspberry Pi is conducted in this study. A capacitive touch sensor was used to detect footsteps on top of the beam using layer of conductive paint. The results were processed and stored in the Raspberry Pi. With the use of this method, compared to a ‘gold standard’ manual video scoring, a 96.2% sensitivity is achieved. [13]

To test what will be the results of interaction device when performed in a control task process, two conditions, 4K-resolution 55” screen with a 21” touch screen and 4K-resolution 55” screen with keyboard/mouse, were given to be

differentiated. Using touch screen resulted in faster data entry but slower times for detection and navigation because of the additional user action needed to direct the right detail display when touch screen is used. Touch screen allocates evidences some advantages for data entry but needing some additional step when it comes to navigation. [14]

3. METHODOLOGY

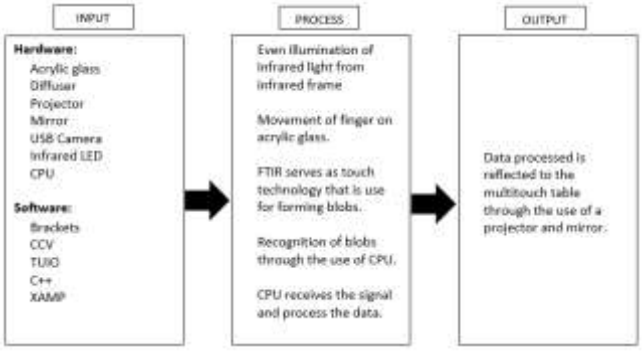

Figure 1. IPO Chart.

Input

To be able to develop a multitouch table, different hardware and software are needed. An acrylic glass with diffuser and IR LED serves as the surface touching interface. Recognition of touch is performed by a USB camera. Data processing will be done by the CPU, which will be projected back to the surface touch interface through the use of mirror. This will be done using software such as, CCV, TUIO, Php, and C++.

Process

The process involves an IR frame multitouch table using TUIO framework. The input of the system will be the movement of fingers across the surface touch interface. This will cause the FTIR to produce blobs based on the disturbance cause by surface touching. The blobs will be recognized by the USB camera which will be sent to the CPU as data. The data gathered will be processed through the use of CPU.

Output

The input and process of the system resulted to an output. The output is the data processed by the processor. The use of TUIO framework allows the encoding of data from the USB camera to be transferred as a decoded data back to the processor. This will be reflected back to the surface touch interface through the use of projector and mirror.

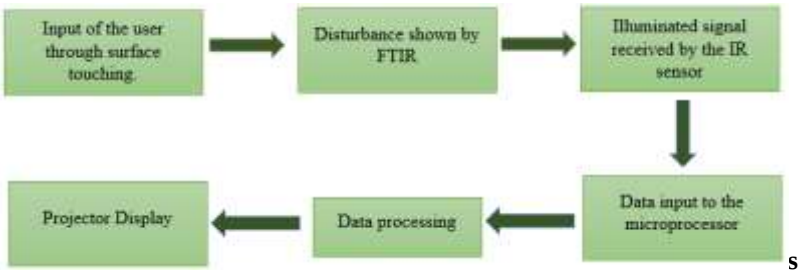

Figure 2. Conceptual Framework.

The conceptual framework involves the interruption on the surface surrounded by the IR Frame which produces an illuminated blob caused by the Frustrated Total Internal Reflection (FTIR). The signal is in the form of the coordinates which is interpreted by the TUIO API. This data would be processed by the use of the CPU. The data acquired is processed in the CPU. This contains programs which were developed and run in the module. Depending upon the command of the processor, it would send off information which would be displayed using the projector. The output is then displayed on the acrylic glass interface.

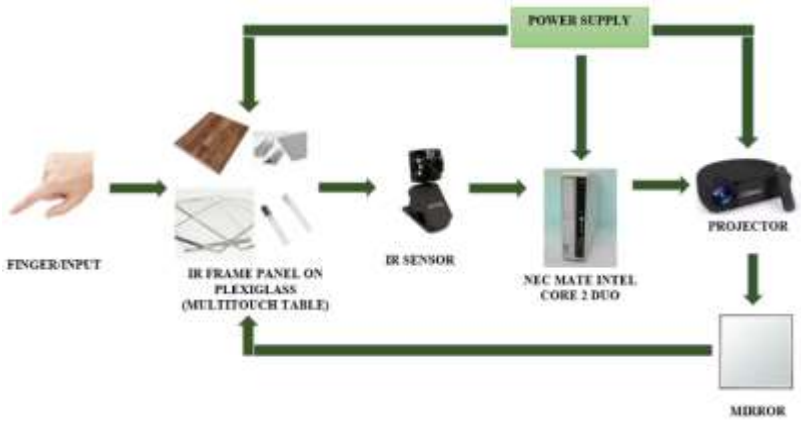

Figure 3. Pictorial Diagram.

The diagram above shows process of the study represented by the raw materials. The input is from the movement of the finger as it touches the surface. This surface is made up of the acrylic glass in which an IR frame is suspended around it. Depending upon the changes on the illumination, the IR sensor would feed signal towards the CPU. The processed data is then reflected back towards the multitouch table by the use of light reflection through the mirror.

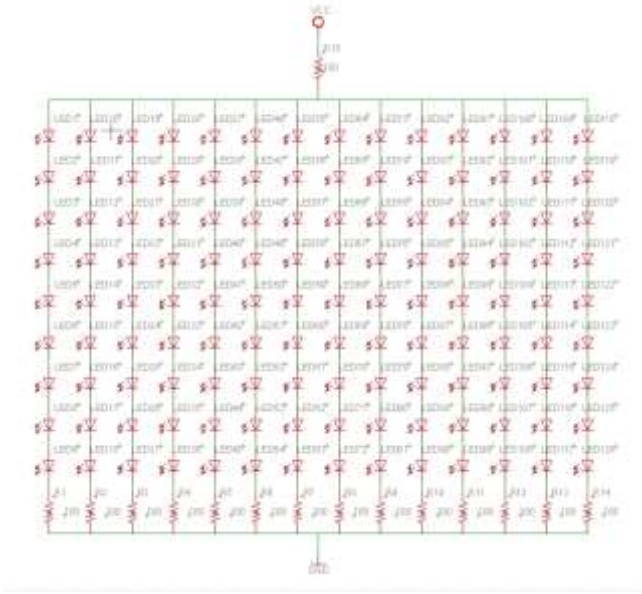

Figure 5. LED Matrix for the LED Frame.

The figure above shows the schematic diagram for the LED frame. In every nine (9) LEDs connected in series, a 100-ohm resistor is connected. This is made in order to protect the LED from destruction. Each group of nine (9) LEDs is linked to another batch in parallel. There are fourteen (14) groups of LEDs connected in parallel in a single supply of 18.5 V. In this, there is a total of one hundred and twenty-six (126) LEDs. Same connection is made as seen from above.

Figure 6. Illustration of the Personal Computer Connection.

The diagram above illustrates the connection between the external components and the processor. The personal computer is connected to the power supply. The projector is linked to the personal computer through the VGA port. On the other hand, the IR sensor would be associated to the personal computer through the USB port. In here, all other peripherals is linked to the CPU by the use of the available ports and terminals of the personal computer.

Table 1. Dimensions of the Table Parameters

	Length	Width	Height	Thickness
Table	78 cm	76 cm	125.5 cm	N/A
Acrylic Glass	68 cm	40 cm	N/A	0.6 cm

The table above contains the dimensions of important parameters in developing the system. These are mainly the wooden frame of the table and the acrylic plexiglass used.

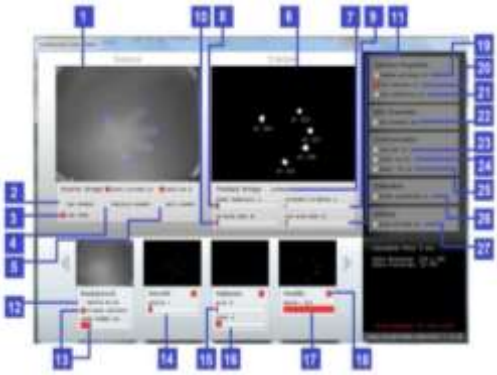

Figure 7. Community Core Vision.

Community Core Vision (CCV) is an open-source computer vision application developed for multitouch tables. It uses openFrameworks for the creative framework and OpenGL for interpretation of the Graphical User Interface (GUI). In addition, OpenCV is used for the vision part. The application is specifically intended for multitouch tables. Other uses are for tracking objects. It takes a video input stream and outputs tracing data and events. It can interface on various web cameras and video devices as well connect to various TUIO/OSC/XML enabled applications. This also supports many lighting techniques such as FTIR, DI, DSI and LLP with expansion planned for some other future vision applications.

Figure 8. Flowchart.

The process starts with the blob formation through the FTIR principle. Then, the IR sensor would detect these IR light from the table surface. These blob position has corresponding functions within the microprocessor and therefore processed and calibrated by the use of CCV and TUIO. Processing of data in the CPU hence follows. The output is simultaneously displayed on the acrylic glass wherein the interaction occurs. This is through the use of the VGA projector which is connected to the processor.

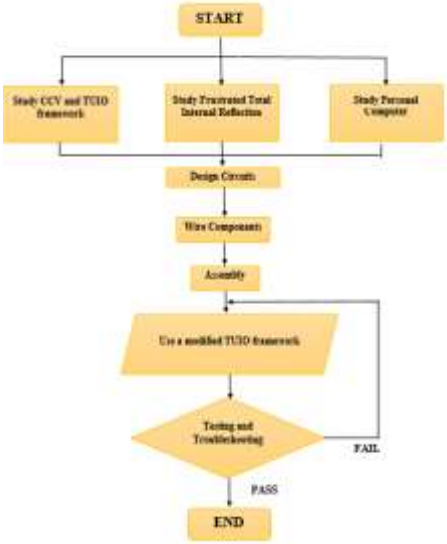

Figure 9. Research Flow Process.

The figure above discusses the procedure on developing the system. The researchers start with studying the technology used for enabling the touch screen mechanism on large surfaces. This is composed of the FTIR and the TUIO framework which would lead into defining the hardware needed for this study. Simultaneously, the Intel Core 2 Duo is also considered for the compatibility of the Operating System of the microprocessor and the programs and algorithm that are necessary. Upon gathering the information, the researchers are able to design corresponding circuits and determining the essential components. After wiring and assembling, they are now subjected for creating various programs for different applications inclusive with the study's scope and limitations. Consequently, testing and troubleshooting of the design would be processed. If it failed the qualifications, recreating of codes and further modifications would be done. In the event that it passed, the system and procedure is completed.

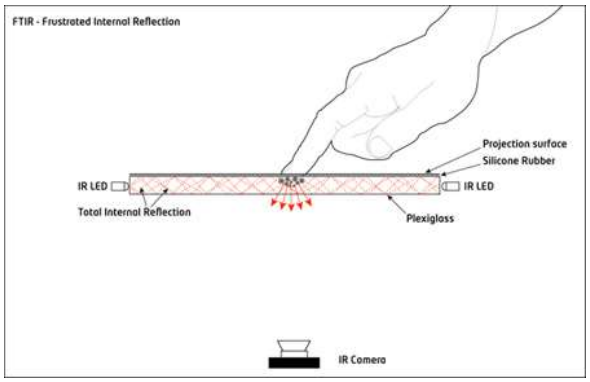

Figure 10. Frustrated Total Internal Reflection.

Frustrated Total Internal Reflection (FTIR) is a form of procedure applied for optical technology. More particularly, it is used for implementation of multitouch surfaces. Total internal reflection is a condition existing when light enters one material coming from another material with a higher refractive index when angle of incidence is greater than a specific angle. No refraction occurs in the material so light beam is entirely reflected. The inside of the acrylic is flooded with infrared light by trapping the light rays within the acrylic. The light rays are said to be frustrated when the user makes a contact with the surface of the acrylic since they can pass now through the contact material, usually the user's skin, and the reflection is no longer total at the point where the contact point is made. This will become clearly visible to the camera below. The tracking of blob by the camera is directly dependent on the fps speed of the camera. The diffuser is essential for evenly distributing the light especially from a rear projected image. A silicone layer is often used as the diffuser or a compliant surface on top of the acrylic to make the dragging smoother and increase the touch sensitivity making it little responsive to little or no pressure.

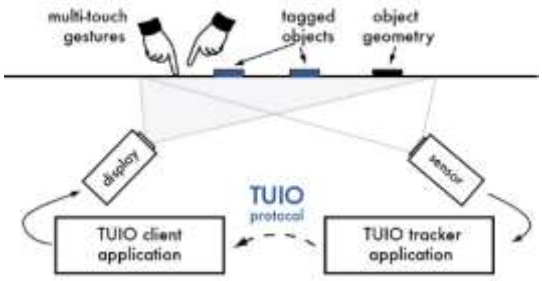

Figure 11. TUIO Framework.

The algorithm used in this study for the touch screen sensitivity is based on the TUIO protocol. TUIO protocol allows the transfer of a nonconcrete description of interactive surfaces, including touch and tangible object states. This then encodes control data from a tracker application and sends it to any client application that is capable of decoding the protocol.

4. EXPERIMENTS AND ANALYSIS OF RESULTS

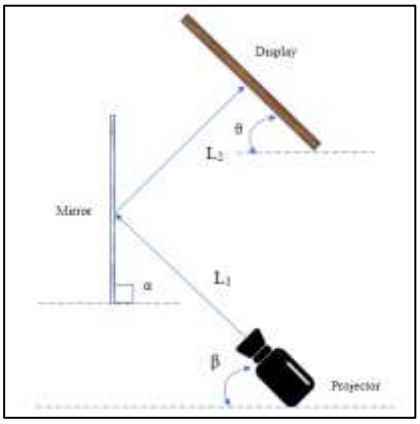

Figure 12. Diagram of the table parameters.

Figure 14 shows the diagram of the table parameters. Theta (θ) represents the angle of the display screen. Alpha (α) is the angle of the mirror and Beta (β) is the inclination of the projector all with respect to the horizontal.

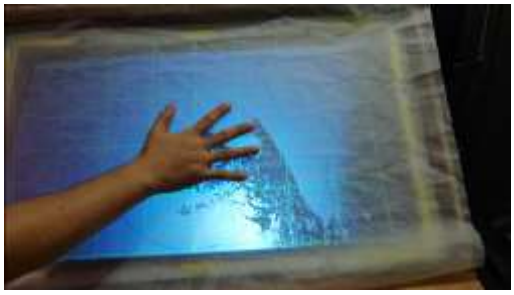

Figure 13. reacTIVision on Raspberry Pi 3.

In order to achieve the maximum output performance of the Raspberry Pi 3, it had to be updated and upgraded to the latest version. Cmake and compiler were installed in order to make use of the libraries needed for the reacTIVision to run on Linux OS. SDL2 was essential for the development of the libraries to provide a hardware abstraction layer. SDL2 was also compiled and rebuilt for its installation. This was done through the corresponding codes. Cmake was edited and configured to match Raspberry Pi's ARM Setup. There were certain libraries that were not available on the internet so alternatives were used. reacTIVision was installed on the Raspberry Pi 3. Upon using the software, the performance of the system was significantly slow. The frame rate of rendering the image is 1 fps. It has a six (6) second-delay before it processes the action.

Figure 14. CCV on NEC Intel Core 2 Duo with 1024x768 resolution without compliant surface.

The setup did not include a compliant surface. A wide-angle lens was also used in order for the camera to cover the whole screen display. CCV calibration was performed accordingly. By the use of Touch Injector, the system then responds to surface touches.

Figure 15. CCV on NEC Intel Core 2 Duo with 1024x768 resolution with a compliant surface.

This setup is similar to Figure 16 except that this one includes a compliant surface. The system found it hard to recognize a blob. Since the camera was using wide-angle lens and also has a low resolution, it mixed up the signal ad the noises present on the surface. Minimum blobs were detected.

Figure 16. CCV on Intel i3 with 800x600 resolution without compliant surface.

The USB camera used in this study has 320x240 resolution. Because of this, it is able to detect only a part of the projection display. The resolution of the display was then reduced in order to correlate the two. This setup also does not include a compliant surface.

Figure 17. CCV on Intel i3 with 800x600 resolution with compliant surface.

A compliant surface was put on the acrylic glass. The performance of the system was desirable in terms that it could respond to the touches better than the

other configurations. The blobs were also illuminated bright enough for the system to recognize it.

Figure 18. The Prototype.

5. CONCLUSION

Upon the development of this project study, there were numerous considerations that had to be taken into account. Raspberry Pi 3 Model B is a Reduced Instruction Set Computer (RISC) machine. In this study, Community Core Vision (CCV) as the tracker application, runs on a 32-bit OS but is not designed for an ARM processor. This is the reason why it could not be installed on the Raspberry Pi 3 Model B. In addition, this microprocessor has 1 Gb of RAM and runs with 1.2 GHz. The requirement for CCV to run smoothly is at least 2-4 Gb of RAM with 2.5 Ghz. Therefore, as compared with the reacTIVision which performed poorly on the Raspberry Pi 3, CCV also has a tendency to render images slowly as it has more features and GUI than the other tracker application. SD cards also play an important role in establishing a system. It must then be assured that the used card must be in good condition.

With regards of the LED frame construction, IR LEDs must be properly aligned to the edges of a clear acrylic glass. In order to consume most of the light for the TIR, they must be trapped and reflected towards the glass as well as to avoid escaped light on top or under the acrylic surface. Diffuser sheet was meant to serve not only as a projection material but also to increase the system sensitivity with regards of blob detection. However, the materials used for the common diffuser were vellum paper and xylol which were very rare materials in the Philippines. As an alternative, the researchers rather used drafting paper and thinner mixed with the silicon. The result was different from what was expected. The drafting paper crumpled too fast and the thinner affected the diffuser as a whole. In order to improvise further, the use of lamination film was tested. As compared with the drafting paper, it is clearer which effects into more light passing through it. Nevertheless, the performance was quite better than with the drafting paper because it was not subjected into any crumpling. When it comes into the projector, this study supported the possibility of using long throw projector for multitouch table.

The calibration of the blobs detected using CCV was inaccurate for the reason of mismatched resolution of the display and the USB camera. In order to perform the camera interleaving feature of the CCV, it also has to be considered

that the resolutions are the same. The use of a wide-angle lens for the camera helped in covering a wider view of the display. However, the output is as well as affected because of the curved circumference of the camera's view. There were four final configurations used in order to compare the results and performance of the system. The first one is by the use of the Intel Core2Duo. Since this processor does not contain an Intel Graphics Card, the resolution adjustments are limited. This led into the use of a wide-angle lens on the camera. In comparison of the results between one with a compliant surface and another without the diffuser sheet, the latter setup was better. It was able to at least give off a fair amount of blob detection. The other configuration did not draw a desirable output. The reason for this is that the small resolution of the camera could not handle a high-resolution display as what was used in this study. It mixed up the noise with the input signal that was why it wasn't able to determine which was the information. The second configuration was through the use of an Intel i3 processor. Through this, the display resolution was reduced into the closest resolution with the camera available. Upon calibration, the output given off by the setup with and without diffuser sheet was similar. However, the one with the use of a compliant surface performs faster than the other configurations and also possessed a more accurate output. Hence comparing all those four, Intel i3 with reduced display resolution and a compliant surface was the most accurate configuration. In conclusion, along with the other hardware and software considerations, the matching of the camera and display resolutions play a vital role in achieving accurate system response for developing a multitouch table.

6. RECOMMENDATION

In order to further improve and expand this study, there are a lot of future actions which could have advance the performance of the system. For the regulation of the LED frame illumination, the use of a potentiometer must be considered in order to variate the result easier. The placement of the IR from the display could also be farther in order to observe more of the light behavior. For complying with the larger screen display, high-resolution cameras should be tested. Different material should be developed as for the projection sheet in order to avoid frequent crumpling and sticking to the surface. The accuracy and sensitivity of the system shall be subjected for testing using different test methods for the aim of improving the product as well. The use of an external audio speaker shall be helpful for the improved functionality of the system. The expansion of the product application is subjected for development.

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FUZZY LOGIC CONTROLLER IMPLEMENTATION TO AN ARDUINO-BASED SOLAR-POWERED AQUAPONICS SYSTEM PROTOTYPE

FAVIS JOSEPH C. BALINADO

Lyceum of the Philippines-Laguna
Makiling, Calamba, Laguna, Philippines
favisjoseph0620@yahoo.com
Mapua Institute of Technology
Intramuros, Manila, Philippines

Abstract

A fuzzy-logic control based controller is implemented to a solar-powered aquaponics system prototype using Arduino microcontroller. The system automates the process of maintaining the levels of the temperature, pH and level of the water in two basins where fish and plants are grown. Fuzzy-logic membership functions are designed to produce fast reaction time for the control.

Keywords: Aquaponics, hydroponics, aquaculture, arduino, fuzzy logic, pH

1. Introduction

Aquaponics is a combination of aquaculture & hydroponics. This means that fish and plants are grown in an integrated system, creating a symbiotic relationship between the two. An Aquaponic system uses the water from the fish tank to circulate through a grow bed where the plants are grown. The effluent is treated by nitrogenfixing bacteria (nitrification) transforming ammonia via nitrites into nitrates, which are utilized by the plants as nutrients. The water is then re-circulated back to the aquaculture system [1]. The plants use these nutrients as their main nutrient supply. The fish also benefit from this process, as the water is filtered by the plants, giving the fish clean water to live in. This integrated system of Aquaponics has benefits not achievable when Aquaculture and Hydroponics are done separately [2]. Aquaculture has the problem of build-up of wastes in the water, requiring filtering systems to clean the water as well as periodic releasing of waste water into the environment. Hydroponics uses chemical nutrients that eventually build up in the water and create toxic water. This water can no longer be used in the irrigation of the plants and is disposed of into the environment. Aquaponics takes both of these problems and turns them into solutions, as the waste in the water is used to feed the plants, therefore not requiring any chemical nutrients to be added to the system, and can have no pollution of the environment by either fish wastes or chemical pollutants [3].

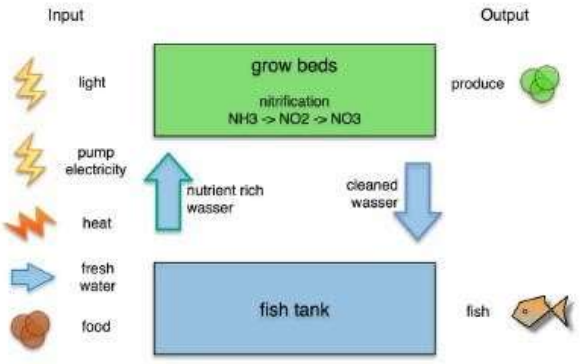

Figure 1 Aquaponics system [1]

Figure 1 shows the aquaponic system components. The system needs electricity for lighting and pumps as well as heat for the fish tanks and plants. In addition, fishes need to be fed and fresh water is needed to make up for evaporation. The outputs are fish and produce [4].

2. Methodology

A. Process

Fig. 2 shows the methodology used for this study that includes the design, implementation both in software and hardware, implementation, data gathering, interpretation of results and conclusion.

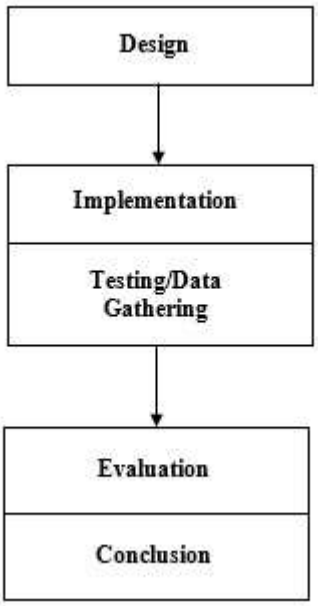

Figure 2 Methodology

CONCEPTUAL FRAMEWORK

The conceptual framework of the system is shown in Fig. 3.

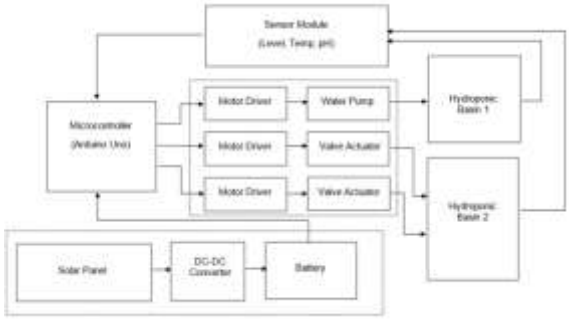

Figure 3 Conceptual Framework

The system is mainly composed of two basins; the upper, and the lower basin. The upper basin serves as the hydroponic area where plants are nourished and cultivated. The lower basin serves as the aquaculture area where fishes are grown.

The initial set-up includes filling-up the basins with fresh water. The components needed for each basin is discussed in the hardware implementation. After the plants and the fishes are being deployed in the

basins, monitoring of water level, pH and temperature is automatically done by the system.
The data gathered is fed to the microcontroller that activates the actuators. Actuators include the water pump, valve control and base fluid dispenser.
The nutrient-rich water in the lower basin is continuously pumped to the upper basin. Water level sensors in the upper basin are activated once the water reaches specific levels. Once the highest water level is reached, the water pump stops. The microcontroller will now start the timer with the set interval. Simultaneously, the pH level of water in the lower basin is monitored. When the water reaches above the pH setting, the microcontroller activates the motor that dispenses basic compound to lower the pH level until it reaches the requirement. The system maintains the pH level through this continued pH level control process. The temperature is also maintained through bypassing the time interval and forcing the water pump and valve. Thus, there is a continuous cycle of water that cools it.
After the time interval that enables the plants to filter the nutrients and nitrogen from the water, the microcontroller activates the valve to drain the upper basin. The clean water then goes down to the fishes.
The cycle is repeated until the fish and plants are ready for harvest. The water in the system can be totally replaced by draining it through the manual valves installed in both basins.

IMPLEMENTATION

A. Organic Elements

1.) Plant

Almost any variety of plant can be cultivated in the aquaponics system based on studies. The pandan plant is used in this set-up to be tested. Coconut husks are used to cover the roots of the plants and make them stay in their positions. The husks have water-absorption capabilities to provide the plants the moisture needed during the process.

2.) Fish

Tilapia was chosen to be the fish for testing since it is locally available and known to be one of the major fish variety in the market supply.

B. Hardware

The hardware mainly includes Arduino Uno microcontroller, motor drivers, motors/actuators, water level/pH/temperature sensors. Solar panel is used to charge the battery that supplies power to the system. The voltage from the solar panel is regulated by the charge controller/DC-DC converter.

Fig. 4 shows the relay circuit that will be used to drive the water pump through the microcontroller pin outs.

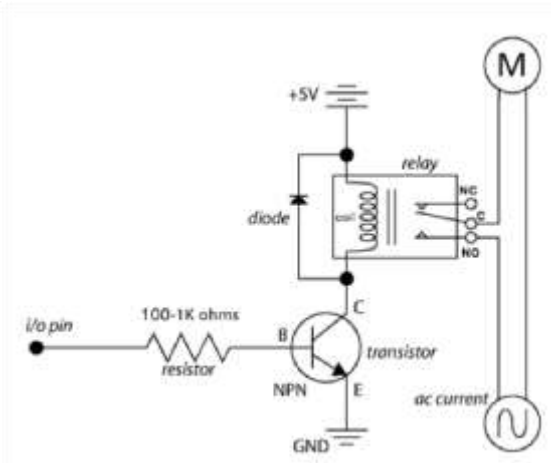

Figure 4 Relay Circuit

Figure 5 Fluid valve set-up

Fig. 5 shows the set-up for fluid-valve. This is primarily composed of a servo motor, water valve and rubber tubing. The arduino is programmed to drive the servo motor that turns its shaft to close or open the valve where the water from the upper basin flows through towards the lower basin.

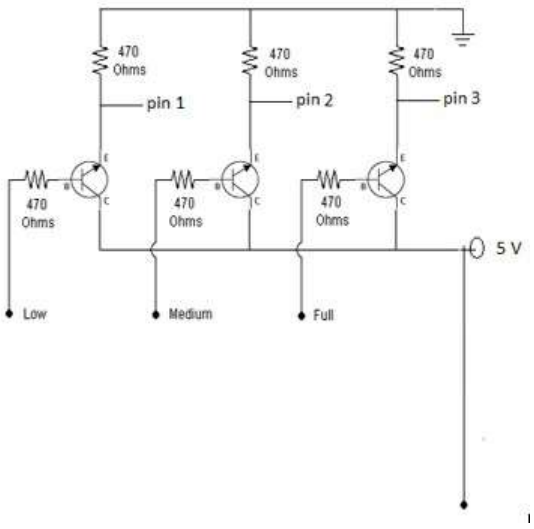

Figure 6 Water-level indicator schematic

Fig. 6 shows the schematic diagram of the water-level indicator. The three npn transistors are switched on when the water reaches their respective input terminals that correspond to the water levels (i.e. low, medium and full). Once activated, the circuit gives 5 volt output from each output terminal for the arduino.

Figure 7 Basin 1

Fig. 7 shows the Basin 1 with the waterlevel indicator and water-shower system. Water is pumped from the larger basin (i.e. Basin 2) to irrigate the plants in the Basin 1. The water-level detector continuously monitors the level of the water.
The signal is sent down to the microcontroller set-up. The solar panel set-up is also seen in this figure. Basin 1 set-up also includes the pH sensor that monitors the level of pH of the water.

Figure 8 Basin 2

Basin 2 set-up is shown is Fig. 8. The water-pump, aerator and temperature sensor are installed here. Water shower tube provides the corrected water from the Basin 1. pH correction is done before water is given back to the Basin 2 for the fish.

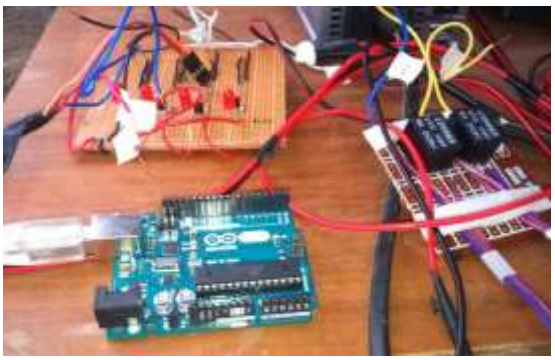

Figure 9 Microcontroller set-up

The control panel is composed of the microcontroller set-up, relay circuit, water level indicator system, solar-panel set-up, dc-dc converter and the battery. Fig. 9 shows the set-up of the controller used.

C. Software

Fuzzy-logic algorithm is used in the control of temperature, pH and water level. This algorithm is implemented in Arduino Uno microcontroller [5].

1) Pseudo-Code

Start

2) Fuzzy Logic

The input parameters are temperature level, water level and pH level. The membership functions for the inpunts are lowpH, normalpH, highpH, lowwater, normalwater, highwater, lowtemp, normaltemp and Check for the pH, water level, temperature

If the pH is lower than 7, add basic compound until pH = 7

If water level = high, Timer starts pinch

valve = on

Else pinch valve = off

Motor pump = on

If water temperature > set point, motor pump on pinch

valve = on

---

hightemp.

The output parameters consist of the time duration to open the valve for each corrective action set-ups (i.e. pH, water level and temperature). Membership functions for the outputs are lowdispense, mediumdispense and highdispense. Sample membership functions for the input and output are shown in Fig. 10 and 11 respectively.

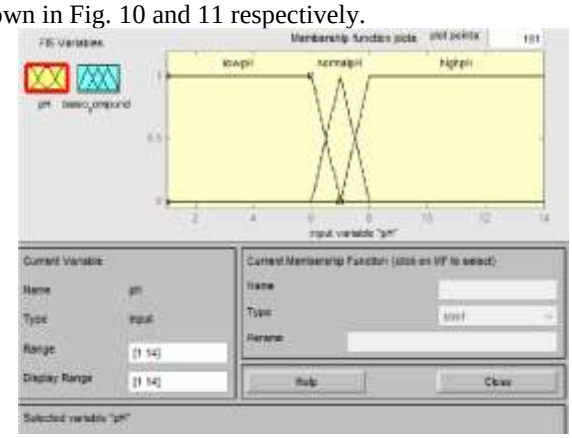

Figure 10 Input membership functions

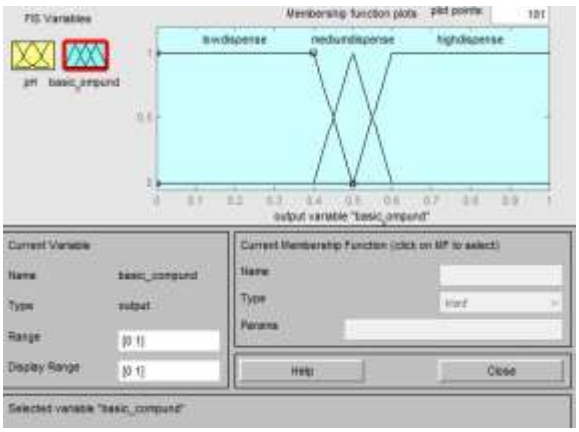

Figure 12 Output surface plot

Figure 11 Output membership functions

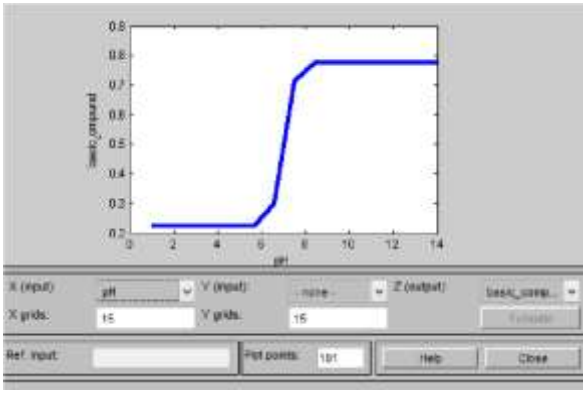

Figure 12 Output surface Plot

The surface plot of the input-output relationship is shown in Fig. 12. It is noticed that when the input levels are low, the output levels are also low and then vice versa.

3. Results and Discussion

The system prototype is tested with the fish and the plants for 1 hour. The sensors are activated and the control mechanisms are enabled. The temperature of the water is maintained at 28ºC. The pH of the water is maintained at 7 and the water level of the system is constantly changing based on the flushing requirement.
The battery is observed to be charging through the solar-panel set-up. The microcontroller that houses the intelligence of the system is working well with the sensors and the relays. Fig 13 shows the actual system prototype under test

Figure 13 Actual system prototype

4, Conclusion

Fuzzy logic algorithm is successfully implemented and tested with the developed aquaponics system prototype. The controller smoothly automates the process of maintaining the required temperature, pH and water levels of the water in the basins. Fast response time can be observed in the system because of the ruggedness of the Arduino microcontroller and the simplicity of the FLC codes.

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AERIAL HUMAN DETECTION USING IMAGE PROCESSING FOR SEARCH AND RESCUE OPERATIONS

GERVIN JOHN T. ARGENTE, IAN CARLO M. GANDOL, MICK REIY R. MEERA, *EVELYN L. DE CASTRO

College of Engineering, Lyceum of the Philippines University,
LIMA Campus, Cuta, Batangas City, Philippines
*Corresponding Author: eldecastro@lpubatangas.edu.ph

Abstract

The "Aerial Human Detection Using Image Processing For Search and Rescue Operations" aims to serve as additional tool that aids groups or search and rescue teams and can be included in their operational toolkit. The search and rescue groups will be able to assess the situation of the area and minimize consumption of time in gathering of information. Individuals who are in distress after an earthquake or typhoon that are in need to be rescued may expect fast response coming from the rescuers. The developers used an UAV to provide aerial assessment of a specific area or place. The UAV acts as the carrier of the Internet Protocol camera which is responsible for capturing of images and transmits the image through the network and the main server laptop which will process the given image and perform image processing applying You-Only-Look-Once (YOLO) algorithm to detect and count the number of detected humans.

Keywords: UAV, Image processing, Aerial human detection, You-Only-Look-Once (YOLO)

1. Introduction

Human detection also called as human sensing is the act of sensing or detecting human presence in a specific area or space, the common application of this is in search and rescue operations, monitoring and for customer analytics where counting of people is required. There are various ways to do a human detection, a lot of sensors are available in the market and are capable of such detection and there are software built to perform different type of detection. A lot of people often mistaken detection and recognition; [1] a detection is simply detecting a particular object while a recognition is the process of identifying the given object.

Unmanned Aerial Vehicle technology is the latest and growing technology that is applicable and being redesigned for various applications. A Unmanned Aerial Vehicle, also known as a drone refers to an unpiloted aircraft. Conceptually a UAV is a flying robot they can be remotely controlled or fly autonomously depend on the software-control plans in their embedded system. For the past years, [2] UAVs were most often used by the military like for practicing anti-aircraft target and controversially used as a weapon. UAVs are now widely used and applied to different applications (e.g., search and rescue

operation, photography, videography, monitoring, disaster management, agricultural and even in delivering products or services) based on the UAVs potential; businesses are head over heels in utilizing the capacity and capability of these machines to their extents.

In this study the developers applied the technology of image processing for human detection as part of their intention which is to build a tool necessary and applicable in some ways such as minimizing the time for detecting and determining the number of people to be rescued in a specific area or place for the search and rescue operations. Proper assessment of the situation is the key role in every operation. The success of a search and rescue operation also varies from a good and reliable information, good strategy and also efficient use of resources. This information is not that easy to obtain especially when there are infrastructures that have become a hindrance to a search and rescue operation [5]. Manual or general assessment of the situation by using people is hard especially when everything that surrounds a person is debris that increases the risk of situational assessment. A more reason for the developers to apply UAV technology for gathering data.

2. Materials and Methods

This part presents the developers methods or techniques and procedures for data gathering, data analysis and statistical treatment that were employed by the developers in interpreting and analyzing the results.

2.2. Design Process

Fig 1. Embedded System Design Process

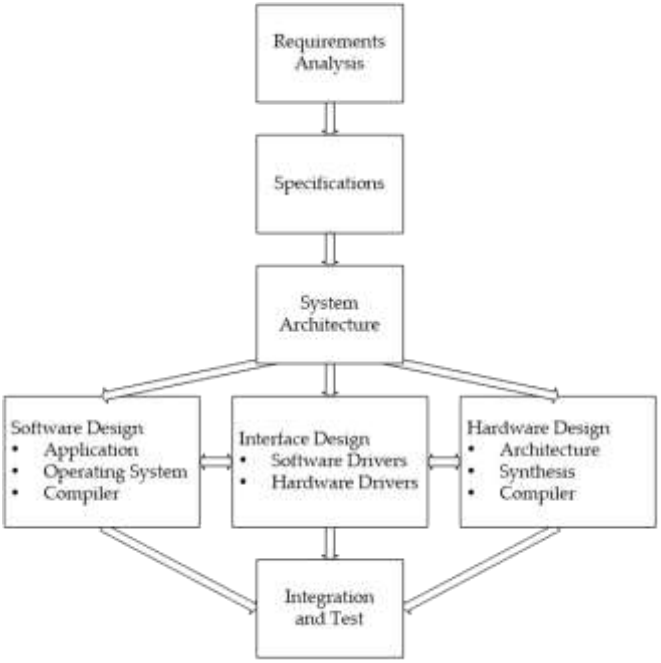


Figure 1 shows the process of the embedded system design. It presents the sequential procedure to be the basis in developing the designed project.

The first step involved, Requiring Analysis which is used by engineers in determining the user expectations and conditions for the development of the design. Features must be relevant to the requirements of the problem.

Specifications are measurable criteria that the product should be designed based on the satisfaction of the user.

System Architecture is the conceptual model that defines each design structure. It displays representation of each system or design that is organized that supports the reasoning of the system.

Integration and Test involved complete testing of the overall system and the subsystem or components.

2.3. Requirement Analysis

The developers considered different techniques and procedures to meet the requirements of the project. The developers conducted several brainstorming and research on the best and possible software and hardware components that will be used in the project. Through the help of studies published online, journals, articles, online forums and books it is much easier in determining the required components. The result, developers produced a visual representation of their project schedule present in the Appendix C.

The developers also considered different engineering constraints such as economic, environment, social, political, ethical, health and safety, manufacturability and sustainability. Through the help of these constraints the developers were able to build the device and identify which constraints were applicable to the device.

The developers performed different techniques and strategies to enhance and developed the system such as:

1. The developers have researched and read articles and related literatures of the design project and identify the possible use of the project and help them construct the project prototype.
2. The developers took some time studying how to implement the required system / software and understand its functionalities.
3. The developers perform some experiments to determine the best approach to their project.
4. Finally, the developers assure that each and every material are working properly and are functioning correctly based on the expected results.

2.4. Engineering Requirements

Through researched and the process of developing the device the developers were able to determine some realistic engineering constraints that are applicable to the design project.

- Ethical.

The device is built to help search and rescue operations that humanity will benefit. The developers followed the standard procedures in developing the design project. The design documented and presented the rules and regulation in flying the device and even considered the constraints such as height, distance and location.

- Sustainability.

The developers used materials that are available in the market. If there is a problem concerning one of the components of the device, it could easily be replaced resulting to ease of maintenance and prolong life.

- Health and Safety.

The device is equipped with recommended materials that passed different tests and do not have any toxic element that is harmful. It is also equipped with a voltage meter alarm that helps the user to monitor the battery charge to avoid possible collision.

- Marketing Requirement.

Table 1 presents the requirement specification for the project that has the ability to detect human presence in an image and display the number of detected human and also allow other devices to access the camera.

2.5. Hardware Design

The project is aimed to use the UAV technology as a device for data gathering of the situation on the affected area. It is equipped with IP camera for capturing of images and performing image processing technology to minimize the time of detecting and identifying the number of people to be rescued and be able to support in the search and rescue operations. The design of the device support the rescuers to identify number of survivors in an area. The project also provide the aerial footage on different devices such as smartphones, laptops and desktops that are connecting to the same network.

2.5.1. Morphological Chart

A morphological chart is a diagrammatic technique to catalog and help evaluate combinations of alternative system elements and also a chart that briefly shows the possible embodiments for each functional subsystem in the product system.

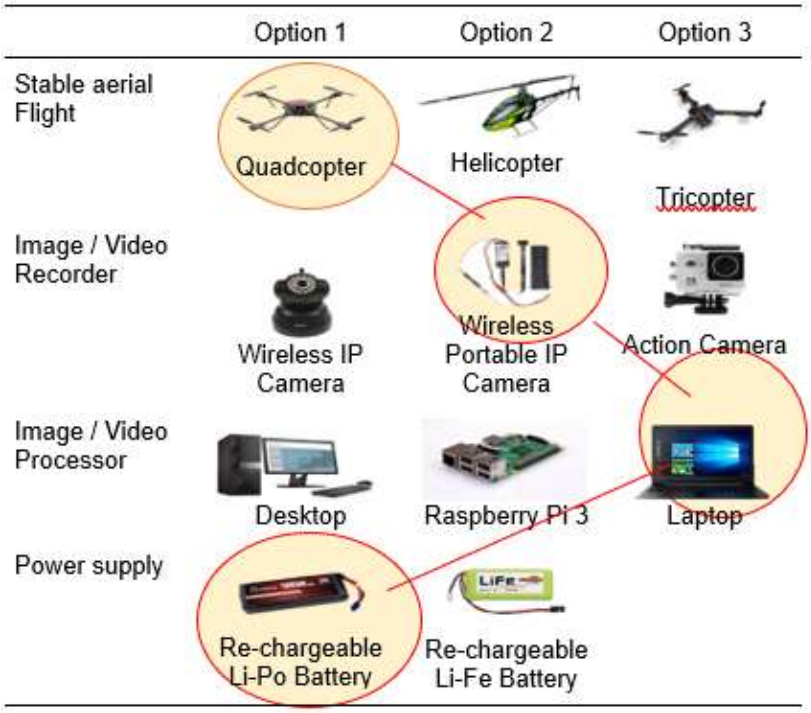


Table 1. Morphological Chart

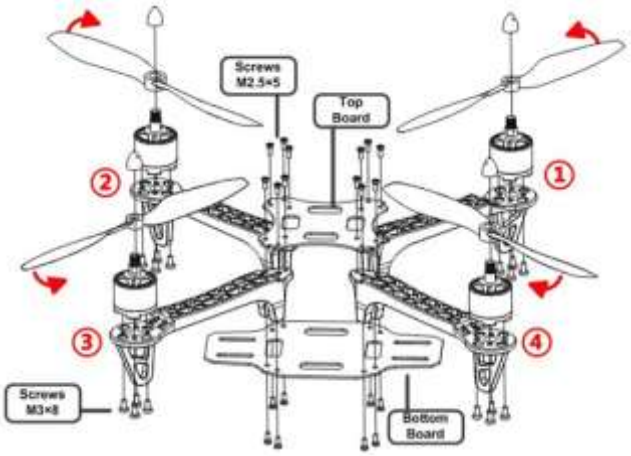
Table 1 shows the morphological chart. It is based from the function analysis and hardware requirements. Morphological chart displays different possible mechanisms or components to be used in the given function. On the left side part of the table presents the functions coordinated with the different chosen components on the right side. The developers made some research to determine which of the components presented in the morphological chart will best fit the design project.

First the developers arrived with the idea of using the quadcopter type UAV to be the device that will carry the camera. The reason for choosing the quadcopter is that according to researches conducted by the developers, among the three, the quadcopter is the most stable type of UAV when it comes to flying and also for newbies in flying a UAV, quadcopter also has more chance of crash recovery than the other two and quadcopter has more thrust and power since it has four (4) propellers and is much heavier making them able to resist wind.

The developers used the wireless portable IP camera because among the three it has less weight and has a rechargeable battery.

In choosing the type of computer to be used, the developers considered two factors such as, which device will provide better processing and which device is the most portable. The developers chose the laptop considering the two factors.

Lastly the developers used Li-Po battery between the Li-Fe battery because it



is lighter than the Li-Fe battery and LI-Po batteries are the most common battery of a quadcopter and best fitted for the chosen frame by the developers.

Fig 2. UAV Design Sketch

In figure 2, it shows the design sketch of the UAV. It presents the quadcopter chassis with its brushless motors and propellers. Propellers 1 and 3 are counter-clockwise propellers while the propellers 2 and 4 rotates clockwise. The designed project will be based on this sketch.

3. Results and Discussion

The results and discussion presents the findings and outcomes of the designed project.

3.1. Hardware Development

3.1.1. Component Diagram

This part shows and presents the wiring diagram of the main components of the Quadcopter.

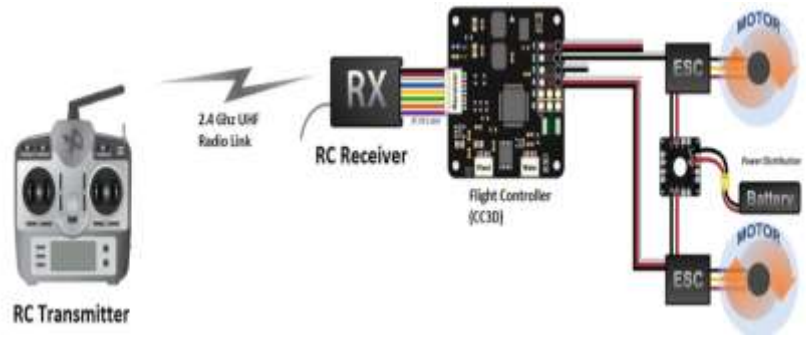


Fig 3. Component Diagram of the Quadcopter

In figure 3, it shows the wiring connections of the component of the Quadcopter. The RC receiver receives a signal from the RC transmitter via the 2.4GHz Radio link, then the RC receiver sends this data to the Flight controller that interprets the signal received which now controls the ESCs, then these ESCs power the motors.

3.1.2. Operational Design

The finished project is composed of four (4) components naming the UAV, Router, Computer (Laptop/Desktop) and the RC Controller including the pilot. See Appendix A for the Data and results.

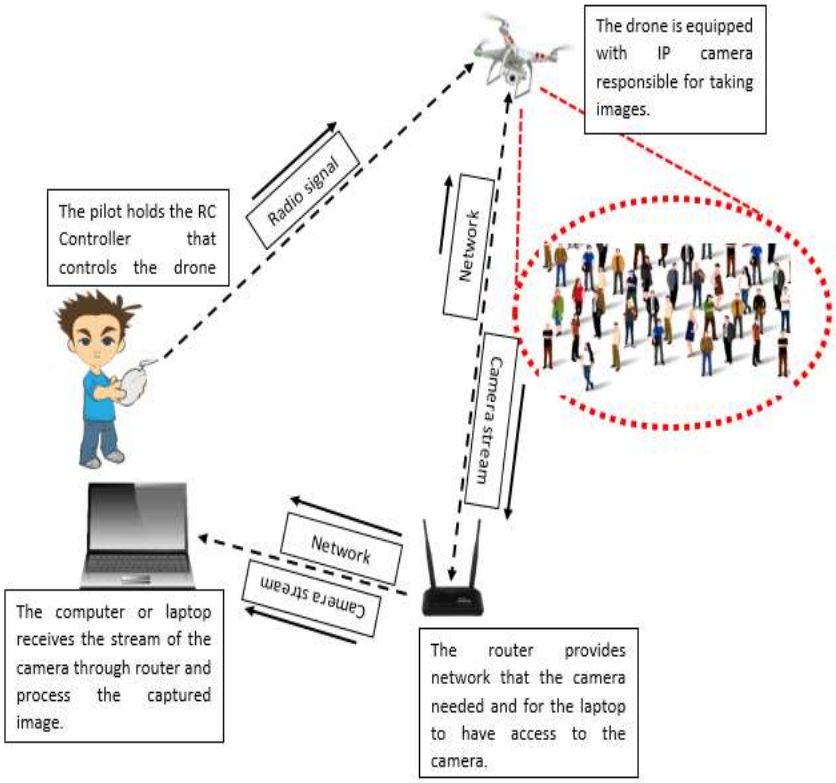


Fig 4. Operational Design of the project

Presented in Figure 4 is the operational design of the project. The router provides wireless local area network where the computer (desktop / laptop) is connected and also, where the IP camera is connected. The pilot holds and uses a RC controller to maneuver or fly the UAV. The laptop then receives the data feed coming from the IP camera through the network and processes the image for detection and displays the result.

3.1.3 Actual Project/Prototype

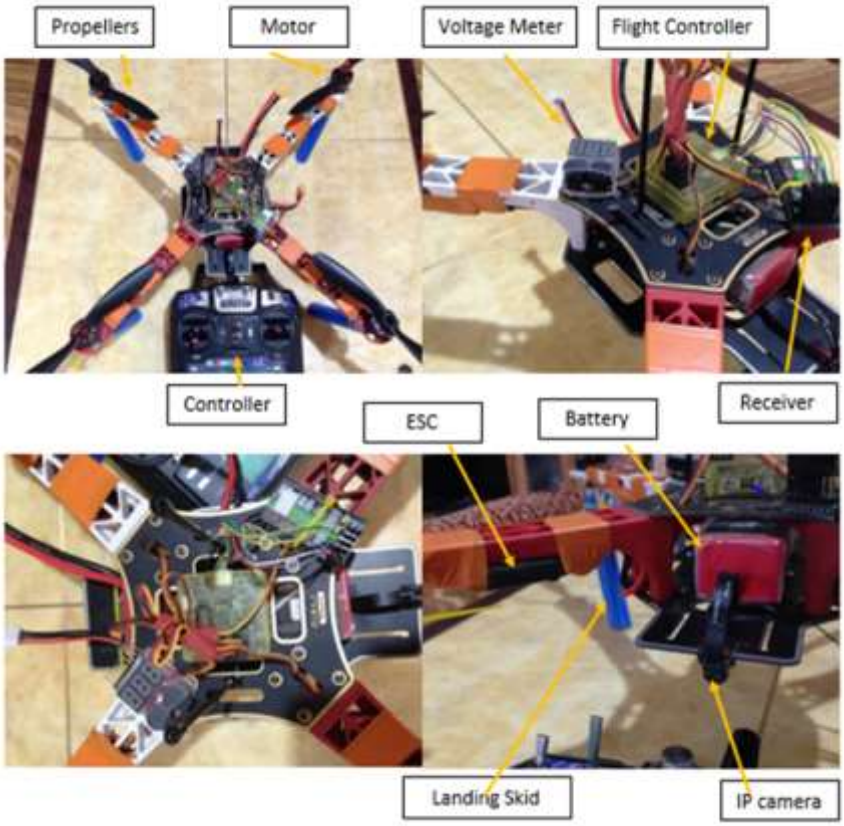


Fig. 5. Actual Prototype

Figure 5 presents the actual prototype and each component is labelled accordingly. Each propeller is attached to its corresponding motor. The ESCs are place underneath the frame to avoid possibility of contact with propeller. The voltage meter, flight controller and receiver are placed on top of the frame so that it is easy to reconfigure the drone if problem occurs. To balance the weight distribution, the battery is place undeath in the middle of the frame. For better view of the field and for better images the camera is placed in the front of the drone that is inclined 45 degrees facing downward.

4. Conclusions

The design project aimed to develop an Aerial Human Detection using Image Processing for Search and Rescue Operations. It was designed to gather data for the search and rescue organization or group analysis. After documenting and building the prototype of the system the developers conclude the following:

- The developers were able to learn the current and manual procedure of search and rescue groups before performing search and rescue operation.

- Aerial Human Detection using Image Processing for Search and Rescue Operations will help the search and rescue organization or group to gather data to use for analysis.
- The developers conducted research, data gathering, testing and evaluation to identify the hardware and software requirement of the system. From this, the developers determined that YOLO algorithm is the best and suited image processing algorithm and hardware components need to meet these requirements.
- The developers were able to determine appropriate hardware for the design project like the used of the IP camera for its ability to capture and broadcast its camera feed and the used of router to provide local area network necessary for data transmission.
- The developers are able to design the Aerial Human Detection using Image Processing for Search and Rescue Operations to detect humans in an image captured by the IP camera which is attached to the UAV or drone.
- Aerial Human Detection using Image Processing for Search and Rescue Operations functioned well such that it meets the functionality desired after different testing and evaluation.
- Through several tests and experiments, the developers were able to determine some limitations of the designed project. The device will provide better results if the drone is as high as 25 ft and the maximum distance that the device can broadcast its feed is at 120 meters away from the network source and 25 ft above the ground.

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Appendix A

Experiments

A.1. Experiment for checking the stability of flight through propeller

Introduction

With regards to the design project, the developers performed flight stability test based on the size of propeller to be used. The torque and thrust generated by the propeller will let that drone fly, placement of the right size propeller results in stable and easy to maneuver drone. This process is needed for the developers to see whether the given size of propeller is enough to have a stable flight control.

Objectives

1. To determine the ease of maneuverability using 10 inches and 8 inches propeller in flying the drone.
2. To determine which of the given propeller produced stable flight condition

Materials

- Drone
- 10 inches propellers
- 8 inches propellers
- RC Transmitter

Procedures

1. Place the 10 inches propeller to its designated motors.
2. Lock each propeller to their respective motors.
3. Connect the battery to the supply board of drone positive (+) to positive (+) and negative (-) to negative (-).
4. Wait before the confirmation beeps stop.
5. Connect your RC transmitter to the receiver attached to the drone.
6. Once connected try to fly the drone and observe the behavior from throttle to flight.
7. Repeat the same step using the 8 inches propeller.

Data and Results

Propeller Size	Trial No.	Propeller Attachment	Condition Status	Maneuverability
10 in.	1	Attach the 10 inches propeller to its designated motor	Goes left or right and flips	Hard
	2		Goes left or right and flips	Hard
	3		Flips	Hard
8 in.	1	Attach the 8 inches propeller to its designated motor	Straightly goes up	Easy
	2		Fly with minimal movement	Easy
	3		Straightly goes up	Easy

Conclusion

With the result of the experiment performed, the developers decided to use the 8 inches size propeller for the drone because using 10 inches propeller is hard to maneuver, the amount of torque and thrust it generates overpowers the whole frame and results to unstable take off, while an 8 inches propeller generates enough torque and thrust that results to more stable take off and an easy to maneuver flight.

The table above also shows which propeller outputs a more stable flight. By the series of trial flying the drone with a 10 inches propeller, the take-off and flight status results in going left or right that most of the time flips which is dangerous or unsafe while in the other hand flying a drone with an 8 inches propeller results in better take off and minimal movement in the air. Therefore, the developers conclude that between the two propellers, using 8 inches is more desirable and will better give a more stable flight and ease of maneuver.

A.2. Experiment on the Accuracy of Detection

Introduction

The developers experimented the accuracy of the image processing system of the design project. It is important to consider the quality and clarity of the image in performing data collection through image processing. The result of the process depends on the quality and clarity of the image being process. This experiment is important to the developers to identify how accurate the system is.

Objectives

1. To examine the accuracy of the design project.
2. To determine some factors that affect the accuracy of the design project.
3. To determine the ideal altitude for better accuracy of detection.

Materials

- Drone
- IP camera

- Laptop
- Router
- RC Transmitter

Instructions

1. Check whether all propellers are locked to their respective motors.
2. Connect the battery to the supply board of drone positive (+) to positive (+) and negative (-) to negative (-).
3. Pair your RC controller to the receiver attached to the UAV
4. Fly your drone
5. Click capture image in the widget present in the laptop.
6. Now click evaluate image and wait for the result.
7. Press Refresh to see how many persons are detected, compare it with manual counting and determine the accuracy.
8. Repeat all steps.

Data and Results

Number of people	Altitude (ft)	Test No.	Objects Position	Number of detected	Accuracy	Average Accuracy
5	25	1	Distant to each other	5	100%	86.67%
		2	Two are close to each other	5	100%	
		3	Four are close to each other	3	60%	
5	50	1	Distant to each other	5	100%	73.33%
		2	Two are close to each other	4	80%	
		3	Four are close to each other	2	40%	
5	100	1	Distant to each other	0	0%	0 %
		2	Two are close to each other	0	0%	
		3	Four are close to each other	0	0%	

Conclusion

The table above showed the results of each trial in the experiment. The developers are able to examine the accuracy of the design project based on the given data and conditions. The developers achieved the first objective which is to examine the accuracy of the design project.

Based on the results of the experiment and observation of the developers while performing the experiment, the developers arrived with the conclusion

which is that the altitude of the UAV affects greatly in having an accurate detection and also the position of the objects is greatly noticed when the objects are closed to each other like for example when four (4) person is closed to each other the system is unable to accurately detect each person but the accuracy of detection increases when the altitude is closer to the object. Therefore, in this experiment, the developers concluded that to have better accuracy flying the drone with altitude less than or close to 25 ft will give a better result.

A.3. Experiment on the wireless network range based on the altitude and distance of UAV

Introduction

The developers experimented the range of the wireless network of the design project. It is important to determine how far can the design project transmit data through network connection, the result of the experiment depends on the altitude and distance of the drone from the router or network provider. This experiment is important to the developers to identify the limit of network connection.

Objectives

1. 1.To examine the range of wireless network of the design project.
2. 2.To determine the role of altitude in the design project

Materials

- Drone
- IP camera
- Laptop
- Router
- RC Transmitter

Instructions

1. Check whether all propellers are locked to their respective motors.
2. Connect the battery to the supply board of drone positive (+) to positive (+) and negative (-) to negative (-).
3. Pair your RC controller to the receiver attached to the UAV
4. Pair or connect your IP camera to the network.
5. Fly your UAV with distance and altitude depending on the table.
6. Check the camera feed.
7. Repeat all steps.

Data and Results

Distance (meters)	Trial No.	Altitude (ft) (approximate)	Remarks	Network Connection
30	1	25	Slight delay in feed, objects are still recognizable.	Connected
	2	50	Slight delay in feed, objects are still recognizable.	Connected
	3	100	Slight delay in feed, small objects are hard to recognize	connected

Data and Results

Distance (meters)	Trial No.	Altitude (ft) (approximate)	Remarks	Network Connection
60	1	25	Slight delay in feed, objects are still recognizable.	Connected
	2	50	Slight delay in feed, objects are still recognizable.	Connected
	3	100	Camera feed begins to have unstable connection. Small objects are hard to recognize	Unstable connection

Data and Results

Distance (meters)	Trial No.	Altitude (ft) (approximate)	Remarks	Network Connection
90	1	25	Slight delay in feed, objects are still recognizable.	Connected
	2	50	Camera feed lost. Small objects are still recognizable	Lost-connection
	3	100	Camera feed lost. Small objects are hard to recognize.	Lost-connection

Data and Results

Distance (meters)	Trial No.	Altitude (ft) (approximate)	Remarks	Network Connection
120	1	25	Slight delay in feed, objects are still recognizable.	Connected
	2	50	Camera feed lost. Small objects are still recognizable	Lost-connection
	3	100	Camera feed lost. Small objects are hard to recognize.	Lost-connection

Conclusion

The tables above displayed the result of experimenting the range of the wireless network. Based on the results of each trial the developers succeeded in examining the range capacity of the wireless network that will be used in the design project. The developers achieved the first objective of the experiment which is to examine the range of the wireless network of the design project.

To determine the factors that affect the signal strength or network connection the developers used the data of each table above and arrived with a conclusion. The data presented that the wireless connection is still in range even in 120 meters but when the altitude is combined lost connection occurs. The data also say that the design project can stay connected even with 120 meters distance and with a 25 ft altitude but when the altitude gets higher loss of the camera feed or the network connection occurs. Therefore, the developers concluded that the altitude plays an important role in the design project because it affects the network connection which is very important in the design project.

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MECHANICAL PERFORMANCE AND BIODEGRADABILITY OF POLYVINYL ALCOHOL NANOCOMPOSITE FILMS

THAI KIAT ONG[1*], SHEI LI CHUNG[1], KIM YEOW TSHAI[2], POI SIM, KHIEW[2], HUI LENG CHOO[3]

[1]Faculty of Engineering and Technology, Tunku Abdul Rahman University College, 53100, Kuala Lumpur, Malaysia.
[2]Faculty of Engineering, University of Nottingham Malaysia Campus, Jalan Broga, 43500 Semenyih, Selangor, Malaysia
[3]School of Engineering, Taylor's University, No. 1 Jalan Taylor's, 47500, Subang Jaya, Selangor DE, Malaysia
*Corresponding Author: ongtk@tarc.edu.my

Abstract

This study aimed to investigate the mechanical properties and biodegradability of polyvinlyl alcohol (PVA) composite films. 3 wt % and 5 wt % of microcrystalline cellulose (MCC), commercial grade cellulose nanocrystals (NCC_A) and nanocellulose (NCC_B) extracted from oil palm fibre (OPF) was incorporated into PVA matrix by solvent casting. The morphological properties of fillers were studied with aid of Field Emission scanning electron microscope (FESEM). The FESEM images indicated average particle size of MCC is 12.07 µm. NCC_A and NCC_B having average particle size of 500 nm and 80.65 nm respectively.

The mechanical performance of PVA composite films were studied by tensile test. The results showed that addition of reinforcing fillers could improve the tensile properties of the composites. Microcrystalline cellulose was able to improve the ultimate tensile strength (UTS) and the yield strength of PVA films but sacrifice the maximum elongation. Nanocellulose could improve UTS and yield strength while maintain the maximum elongation. The optimum filler loading level is 5 wt% of nanocellulose.

Soil burial test was conducted to examine the weight loss rate of PVA composite film. It was found that presence of moisture will accelerate the degradation rate of PVA composites film dramatically. The PVA test specimens were fully dissolved in the soil. In spite of that, the weight of PVA composites do not have significant reduction after 14 days in controlled condition. It indicated that Soil moisture is important catalyst in biodegradation activity of PVA composite films.

Keywords: nanocellulose, polymer nanocomposites, solvent casting,

1. Introduction

Cellulose is found naturally as the main constituent in the cell wall of trees and plants, one of the most abundant and renewable biopolymers. Cellulose fibrils are structural entities formed through cellular manufacturing process, cellulose biogenesis, stabilized by hydrogen bonds and van der Waals forces. The fibrils contain crystalline and amorphous regions that can be generally separated from cellulose source. According to research, oil palm fibres (OPF) should contain 41 - 65% of cellulose, 17.1 % of hemicellulose and 13.2 – 25.31% of lignin

theoretically [1]. Natural fibres present as one of the outstanding materials for different applications including bio-based polymer and polymer composites.

Plastics are typically organic polymers that are derived from petrochemicals, which are produced and used worldwide. Human society has benefited tremendously from the use of plastics due to their extraordinary versatility. Plastics have become the major materials substituting the traditional paper, glass, steel and aluminium. They have been thriving with other materials in many applications regarding to their low cost, especially in processing as well as due to their outstanding performance. Plastics are inherently inert to microorganisms or the chemicals in an environment. Thus, the disposal of immense amount of plastics, which takes a long time to decompose, possesses huge environmental problem. Along with the depletion of petroleum resources and increasing environmental awareness have prompt a growing urgency for the development of new materials that are environmental friendly and available resourcefully to fulfil rising demands for plastics. The potential of biodegradable polymers, particular those polymers generated from renewable natural resources have long been recognized. In this direction the use of natural fibres can be an interesting path in order to improve the overall mechanical properties and to impart degradability of polymer composite materials [2].

In recent decades, natural fibres as an alternative reinforcement in polymer composites have attracted attention from many researchers and scientists attributable to their advantages including abundant availability, low cost, low density, comparable specific tensile properties, non-abrasive to equipment, non-irritable to skin, reduced energy consumption, less health risk, renewability, high durability and biodegradability [2]. The emerging nanotechnology has triggered the researchers and scientists to develop the nanometre-sized natural fibres as reinforcing agents in polymer composites. This has eventually contributed to the development in different types of nanocelluloses, for instance, cellulose nanocrystals (CNCs), cellulose nanofibrils (CNFs) and bacteria nanocellulose (BNCs). Nanocellulose as promising renewable green material can be used as reinforcing agent in high performance polymer nanocomposites. Many new nanocomposite materials with attractive properties were obtained by physical incorporation of nanocellulose into either natural or synthetic polymer matrix [3]. The mechanisms and aspects of properties enhancement in polymer composites by introducing nanocellulose as reinforcement materials embraces aspect ratio, homogeneous dispersion of reinforcements, formation of entanglement, better bonding and minimization of surface defects.

The geometrical aspect ratio, defined as the length-to-diameter (L/d), is a major factor that controls the mechanical properties of nanocomposites and determines the percolation threshold value. In other words, fillers with a high aspect ratio give the best reinforcing effect [3]. This phenomenon as aforementioned can be exemplified with the case of CNFs, in which their lengths are in micrometre and widths in nanometre scales. When the diameter of the cellulose reduces to nanometre, aspect ratio increases as aspect ratio is inversely proportional to the diameter of the materials [4]. Homogeneous dispersion of nanocellulose in polymer matrix becomes critical factor when incorporation of nanocellulose as reinforcing agents in polymer composites. It is suggested that simple chemical modification on nanocellulose surface holds the potential to improve its dispersibility in different solvents and expand its utilization in nano-related

applications, namely drug delivery, protein mobilization, inorganic reaction templates and etc [3]. CNFs are also addressed to generate tangling effect among themselves and also with the polymer matrix due to their length. In the event that the length of CNF is in micrometre while diameter reduced to nanometre, a flexible and hirsute CNF is observed [5]. Meanwhile, some of the researchers claimed that the reinforcing effect of nanocellulose fillers occurs most probably from the cellulose hydrogen bonding network within the polymer matrix. CNF reinforced polymer composite showed the greatest improvements in mechanical and thermal behaviour between two of these reinforcement material due to its morphology [5]. In fact, fillers often fracture because of surface imperfections, inclusions and defects. By making the diameter of the fillers to as small as possible provides the filler less surface area and, consequently, fewer flaws that might propagate during processing or under a loading condition.

Referring Table 1, Jonoobi et al added nanocellulose fibrils into polylactic acid (PLA) by using solvent casting followed by twin-screw extruder method, the results showed that the UTS of PLA-CNF5 (5 wt% of nanofibers) increased by 21 % while elastic modulus increased by 24% due to the presence of interaction between PLA and the CNFs [6]. Sami Boufi et al found that adding 5 wt% of CNC and CNF in latex could generate a 190 to 450-fold enhancement in elastic modulus [7]. In addition, Montero et al reported that the stiffness of composites was increased by adding CNC into thermoplastic starch [8]. Rosilo et al reported that the tensile strength was increased by approximately 128% by incorporating CNC derived from ground Whatman 541 ashless filter paper into Poly(Butadiene) rubber (PBD) due to space filling of the intercalated mCNC/PBD domains [9]. Researchers, Shiv Shankar and Jong-Whan Rhim claimed an increase of 13% in UTS when 3wt% of CNC was added to agar due to nano size of CNC with high surface area, which induced a strong interfacial interaction through hydrogen or ionic bonds between the CNC and the polymer matrix [10]. Hence, it is envisaged that incorporating nanocellulose into polymer matrix will produce better performance polymer nanocomposites.

Table 1: Different Nanocellulose Reinforced Polymer Nanocomposites

Type of Fillers	Polymer Matrix	Mixing Process	References
CNF	Polylactic acid	Solvent casting and follow by melt blending	[6]
CNC and CNF	Latex	Solution casting	[7]
CNC	Thermoplastic Starch	Solution casting	[8]
CNC	Poly(Butadiene) rubber	Solvent casting	[9]
CNC	Agar	Solution casting	[10]

The increasing trend on green materials eventually leads to an arousing topic for environmental friendly polymer composites. This phenomenon is exemplified by the increasing government initiatives to support green

packaging and this has driven the global market demand for water soluble or biodegradable films, such as Polyvinyl Alcohol (PVA) films. PVA is a synthetic polymer which has good chemical and oil resistant, excellent film-forming property, and also a potential candidate for oxygen and aroma barrier applications. PVA film is primarily found in the manufacturing of liquid crystal display (LCD) panels. It is reported to have a huge potential in water-soluble and biodegradable packaging application in various industries, ranging from household packaging for hazardous chemicals to agrochemical and polarizer applications [11]. The objectives of the study was to fabricate nanocellulose reinforced PVA composite films and study their mechanical performance and biodegradability.

2. Experimental Methodology

2.6. Materials

Microcrystalline cellulose (MCC) was supplied by Sigma-Aldrich. Its particle size is approximately 18-22 um and a bulk density of 0.5 g/mL. The empty fruit bunch (EFB) fibre was supplied by Kah Hwa Industries Sdn. Bhd. Acetic acid, 99.8% and sodium hydroxide (NaOH), 98% were supplied by Wataka Trading. Sodium hypochlorite (industrial grade) was supplied by Staren Watech (M) Sdn. Bhd. Cellulose Nano crystals (NCCA) with a bulk density of 0.7 g/cc was purchased from CelluForce, Inc. Polyvinyl alcohol (PVA 1799) with a viscosity of 22-28.9 cps was supplied by Multi Filter Sdn Bhd.

2.7. Extraction of nanocellulose from Oil Palm Fibre (OPF)

Figure 1: Extraction of Nanocellulose from Oil Palm Fibre

With reference to Figure 1, 5 g of 3 – 5 mm OPF first undergone delignification process. The delignification process was carried out by adding 5 g of OPF, 8 ml of acetic acid, and 16 ml of sodium hypochlorite (NaClO) into 80 ml of deionized water. The mixture was heated in a water bath at a temperature of 70 °C for 60 minutes. Another 8 ml acetic acid and 16 ml of NaClO were added into the solution every hour until the solution contained 40 ml of acetic acid and 96 ml of NaClO. The sample was left in the water bath overnight. After 24 hours of reaction, the samples were cooled and the holocelluloses were filtered out. Drying of holocelluloses took place at 80 °C for 5 hours in an aging oven.

Afterward, holocelluloses were subjected to alkali-treatment. 4 grams of holocellulose and 20 ml of 17.5wt % NaOH solution were mixed and soaked in ultrasonic bath at room temperature (27 – 33 °C). 10 ml of 17.5wt % NaOH solution was added after 5 minutes and this step was repeated 3 times. The mixture was then soaked in ultrasonic bath for another 30 minutes. Subsequently,

66 ml of deionized water was added into mixture. The mixture was stirred thoroughly with a glass rod and soaked in sonicated water bath at room temperature for 60 minutes. The cellulose was then filtered out to remove alkali solution and dried at a temperature of 80 °C

During acid hydrolysis, 20 ml of 64 wt % of sulphuric acid was used to treat 2 g of cellulose. The process was conducted on a hot plate stirrer at a temperature of 40°C and a fixed speed of 750 rpm. 200 ml of cold deionized water was added to the solution to stop the chemical reaction after 30 minutes. The solution was transferred into visking tubes for dialysis. Dialysis was done by changing 4L of deionized water daily for a period of 3 days until the pH value of deionized water became neutral. (NCC_B)

2.8. Preparation of PVA Nanocomposite Films

Solvent casting technique was used to produce nanocellulose reinforced PVA films. 20 g of mixture was prepared by adding 3 wt % and 5 wt % of MCC, NCCA and NCCB with 97 wt % and 95 wt % of PVA powder respectively. The mixtures were dissolved in 200 ml of deionized water with the aid of stirring. The mixtures were then transferred to ultrasonic bath for degassing. The solution was poured onto a non-stick plate and heated in oven at a temperature of 80 ˚C for 5 hours.

2.9. Characterization of Morphological Properties

FEI Quanta 400F Field Emission Scanning Electron Microscopy (FESEM) was used to observe the morphological properties of the test samples. The test samples were prepared by air-dried method and scanning transmission electron microscopy (STEM) method prior to observation at a low vacuum environment with an accelerating voltage of 5 – 10 kV.

2.10. Tensile Test

The tensile test specimens were cut into rectangular shape (20 mm wide x 150 mm long) and conditioning in accordance to ASTM D882 standard. The tensile test was conducted by using GT-TCS-2000 universal testing machine with aid of 100 kgf load cell. The crosshead speed was set at 50 mm/min.

2.11. Soil Burial test

Soil burial test was conducted to study the biodegradability properties of the test samples. The PVA composite films were cut into square shape (50 mm x 50 mm) and tested under two conditions. The first soil burial test was carried out in university compound. The test specimens were buried at a depth of 5 cm in the land beside Materials Engineering Laboratory. All weathering factors such as temperature, humidity and rainfall were left uncontrolled. The second burial test was conducted in a controlled condition. The environmental temperature was kept at approximately 25 ± 5 °C and the humidity at around 55 ± 5 %. The test specimens were buried at a depth of 5 cm in compost soil, which was purchased from nursery and stored in a tank as shown in Figure 2.

The weight of test specimens were measured after 7 days, 14 days and 30 days. The weight loss rate (%) was calculated by following formula:

$$Weight\ loss\ rate, W_{loss} = \frac{W_{Initial} - W_{Final}}{W_{Initial}}\ x\ 100\ \% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where $W_{Initial}$ is the dry weight of the test specimens before conducting soil burial test and W_{Final} is the dry weight of the specimens after soil burial test.

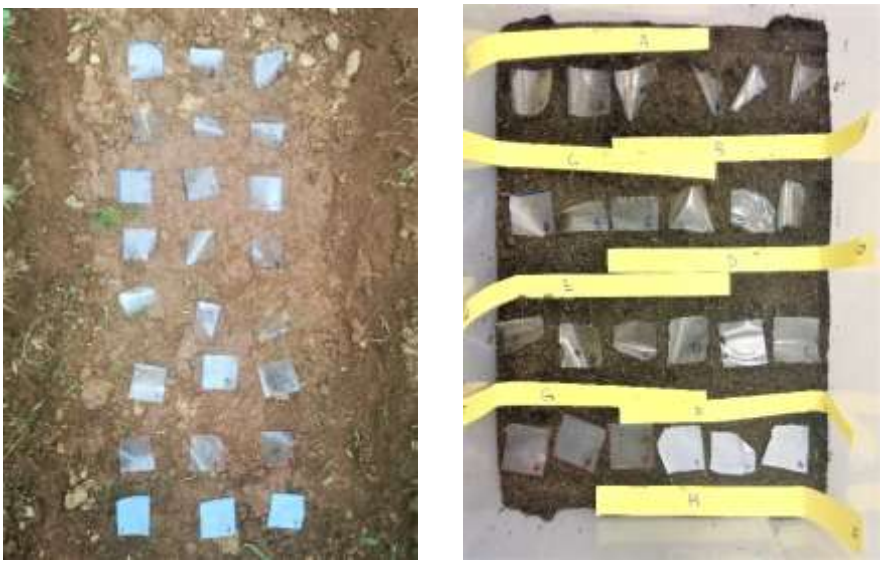
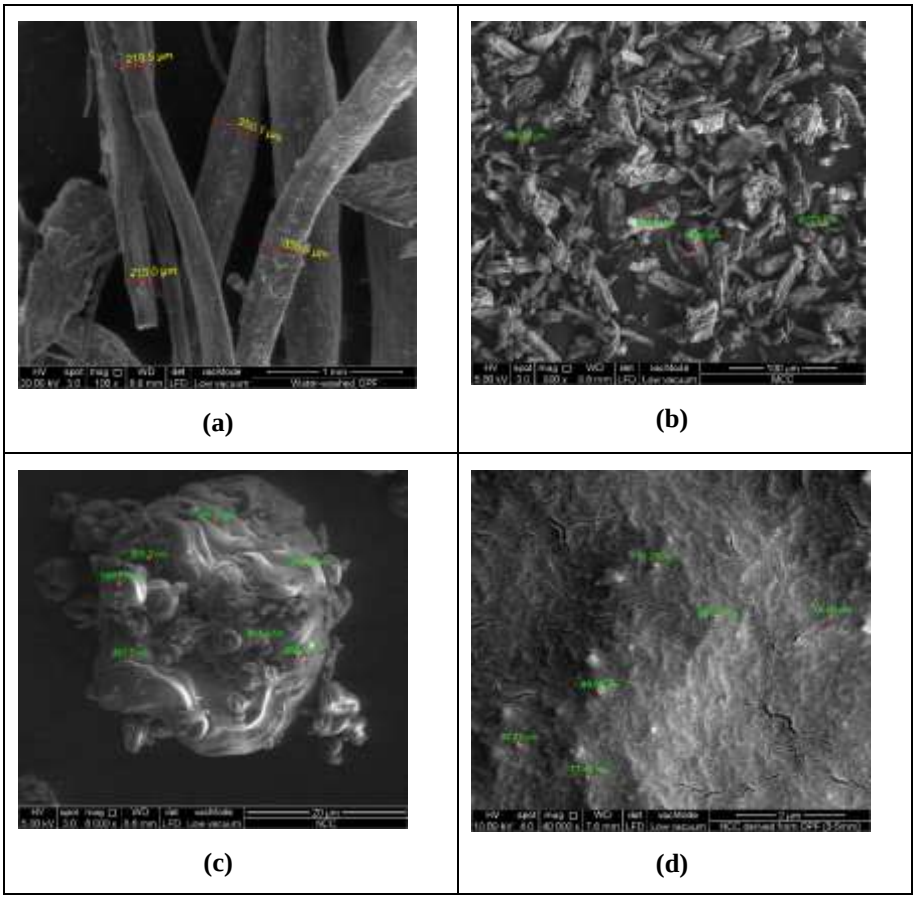


Figure 2: Set up of Soil Burial Test (a) In land beside Materials Engineering Laboratory (b) In controlled condition

3. Results and Discussion

3.1. Morphology of nanocellulose extracted from Oil palm fibre

FESEM observation was conducted on different types of fillers. As illustrated in Figure 3(a), raw OPFs have an average diameter of 204.8 µm. The diameter of raw natural fibre is inconsistent as compared to synthetic fibre. Thus, its reinforcing efficiency is lower than synthetic fibre. The average particle size of microcrystalline cellulose (MCC) as observed from Figure 3(b) is around 12.07 µm. Figure 3 (c) and 3 (d) indicated that cellulose nano crystals (NCC_A) and nanocellulose derived from OPF (NCC_B) have an average particle size of 500 nm and 80.65 nm respectively. Nanocelloluse tend to agglomerate into cluster in dry form.



(a) **(b)** **(c)** **(d)**

Figure 3: FESEM Image of (a) OPF, (b) MCC, (c) NCC_A and (d) NCC_B

3.2. Tensile Properties of PVA nanocomposite films

Tensile Properties of different PVA composite films were tabulated in Table 2. Figure 4 and 5 illustrate the trends of UTS and elastic modulus of different PVA composite films. The UTS and elastic modulus of neat PVA film is 39.2MPa and 905.68 MPa respectively. It was found that adding MCC, NCC_A and NCC_B into PVA matrix could increase UTS. The highest improvement was found in 5 wt % filler loading. Adding 5 wt % of these reinforcing fillers into PVA matrix could increase UTS of PVA films by 11.15 – 12.45 %. The reinforcement is attributed to well dispersion of fillers within PVA matrix. Forming of hydrogen bonds between fillers and PVA matrix facilitate the stress transfer from matrix to fillers. [12][13] In addition, MCC and NCC_B can greatly improve elastic modulus of PVA films. These samples showed increment in elastic modulus by 95.1 % - 162.8 %.

In spite of that, Figure 6 exhibited that the addition of MCC tend to make PVA composite films brittle while incorporating of NCC_A and NCC_B able to maintain maximum elongation of composites. Maximum elongation at break

was reduced by approximately 56 % after adding MCC into PVA composites. NCC_A is able to dramatically increase maximum elongation of PVA films. $03NCC_A97PVA$ and $05NCC_A95PVA$ recorded increment in maximum elongation by 26.78 % and 59.24 % respectively.

With reference to Figure 7, a correlation can be established between UTS and yield strength of PVA films. It was realised that incorporating reinforcing fillers such as MCC, NCC_A and NCC_B into PVA matrix generally increased both UTS and yield strength of PVA composite films. Compared with biodegradable plastic bag (Bio-PB) sample, PVA composites are able to achieve higher UTS, elastic modulus and yield strength. Adding nanocellulose as fillers could help to retain maximum elongation of PVA films. However, Bio-PB sample demonstrated higher elongation at yield as compared to PVA composite films. Figure 8 revealed that PVA composite films

Table 2: Tensile Properties of Different PVA Composite Films

Sample Name	Ultimate Tensile Strength (MPa)	Elastic Modulus (MPa)	Yield Strength (MPa)	Elongation at Break (%)	Elongation at Yield (%)
100PVA	39.36	905.68	16.8	102.67	2.4993
03MCC97PVA	40.48	1825.15	25.38	45.12	1.7651
05MCC95PVA	43.75	1767.04	32.49	44.8	2.2258
$03NCC_A97PVA$	42.42	902.63	18.1	130.17	2.7180
$05NCC_A95PVA$	44.26	907.9	17.59	163.5	2.7711
$03NCC_B97PVA$	44.9	1891.12	32.69	29.41	2.0026
$05NCC_B95PVA$	44.11	2380.05	28.41	111.87	2.0882
Bio-PB	20.81	173.79	7.83	150.57	3.7056

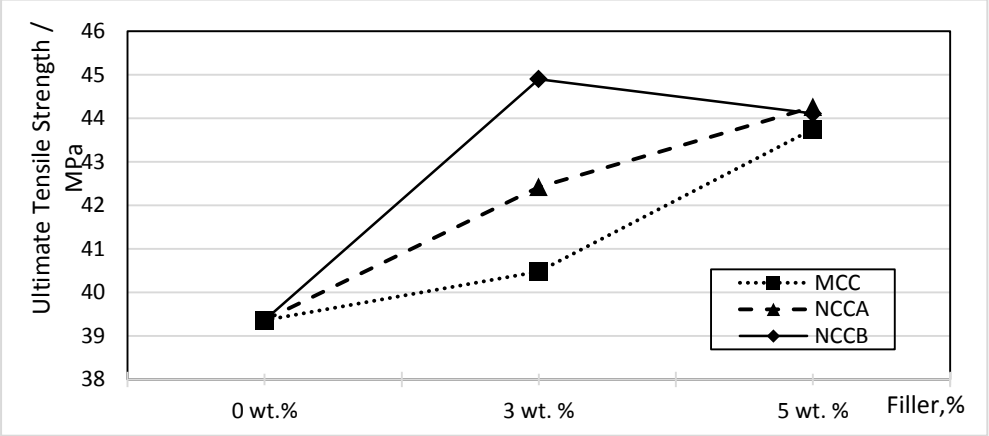


Figure 4: Ultimate Tensile Strength (UTS) of Different PVA Composite Films

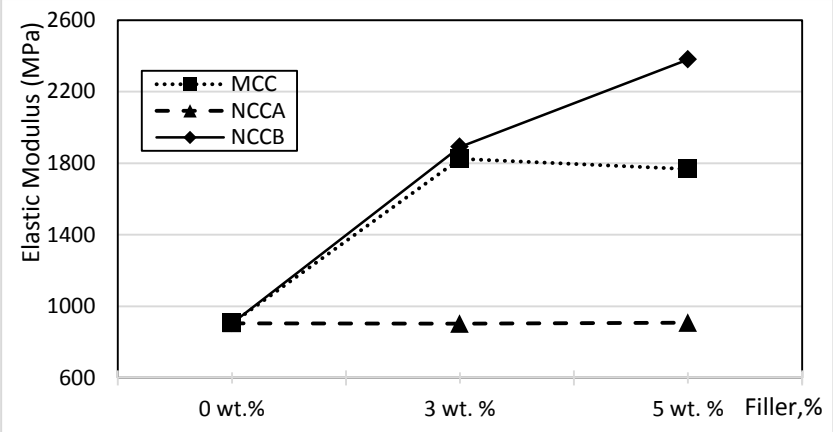


Figure 5: Elastic Modulus of Different PVA Composite Films

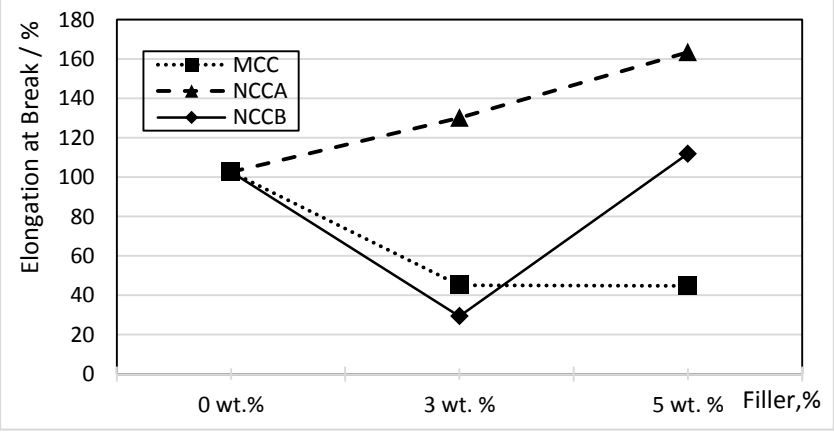


Figure 6: Maximum Elongation at Break of Different PVA Composite Films

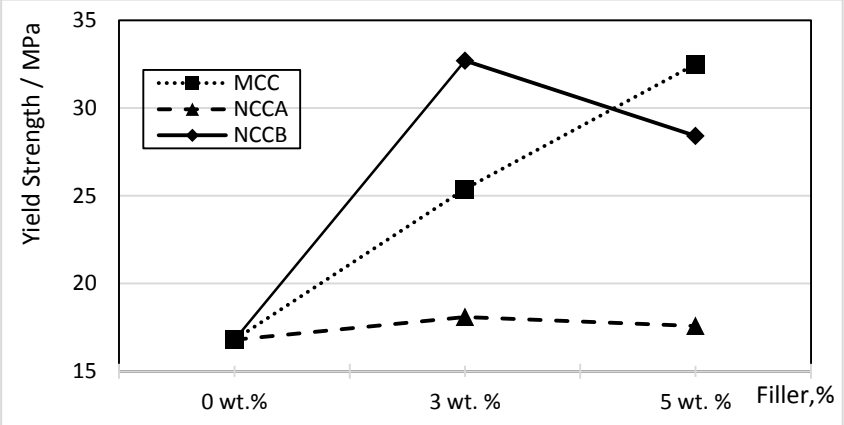


Figure 7: Yield Strength of Different PVA Composite Films

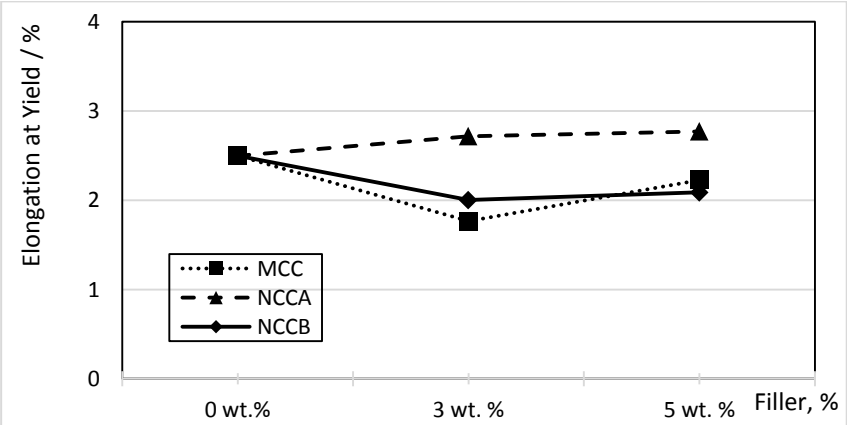


Figure 8: Elongation at Yield of Different PVA Composite Films

3.3 Biodegrability of PVA films

Table 3 summarised the weight loss rate of PVA composites in uncontrolled condition. Control samples are test specimens that stored in humidity cabinet at temperature of 23 ± 2 °C and humidity: 50 ± 5° %. The weight loss rate of all control samples are within 3 wt. %. The variation could be due to measurement and samples store condition.

All PVA composite specimens were found dissolved in soil after 7 days of buried times. It implied that adding MCC, NCC_A and NCC_B do not affect weight loss rate of PVA composites film. The high weight loss rate could be attributed to high soil moisture content. Humid and rainy weather in Malaysia caused the land consists of high soil moisture and hence it leads to fast degradation rate of PVA specimen. [14] As compared to Bio-PB, 7 days buried time is insufficient to start biodegradation.

Table 3: Weight Loss Rate of PVA Composite Films in Uncontrolled Condition

Sample Name	Weight loss rate (%)	
	Control Sample	7 Days Buried time
100PVA	2.19	100.00
03MCC97PVA	0.08	100.00
05MCC95PVA	1.60	100.00
03NCCA97PVA	2.51	100.00
05NCCA95PVA	2.00	100.00
03NCCB97PVA	1.81	100.00
05NCCB95PVA	0.96	100.00
Bio-PB	1.95	0.71

Figure 9 revealed the weight loss rate of PVA composites films in control condition. The result indicated the weight changes of PVA composites are not noticeable after 14 days of buried time. Most samples recorded weight change of ± 5 wt. % except 03MCC97PVA and 03NCC$_A$97PVA. The highest weight loss is 9.75 wt. % and 7.8 wt. % respectively. It indicated that Soil moisture is important catalyst in biodegradation activity of PVA composite films

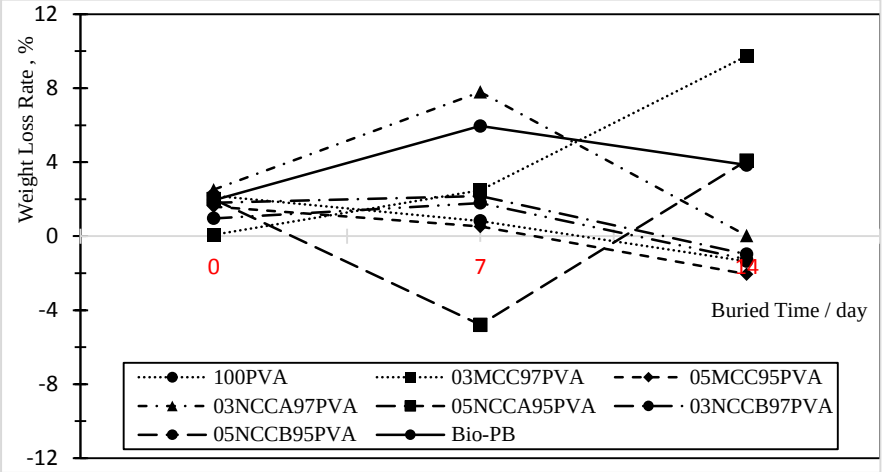


Figure 9: Weight Loss Rate of PVA Composite Films in controlled condition

4. Conclusions

The following concluding remarks can be drawn from the observations attained through various analyses conducted in this work:

- FESEM images clearly exhibited the morphological properties of PVA composite films.
- The optimum filler loading is 5 wt %. Adding 5 wt % of nanocellulose derived from OPF into PVA is able to increase UTS, yield strength, elastic modulus and maximum elongation of PVA films.
- Good dispersion of fillers within PVA matrix resulted in tensile properties enhancement.
- High soil moisture content accelerate biodegradation rate of PVA composites.

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A HYBRID T-TYPE MULTILEVEL INVERTER WITH A NOVEL MODULATION STRATEGY FOR ISOLATED SUPPLY ELECTRIC SYSTEMS

JEBY THOMAS JACOB*, D. KIRUBAKARAN

Research Scholar, Sathyabama University,Chennai, India
HoD-EEE,St.Joseph's Institute of Technology,Chennai,India
*Corresponding Author: thomasjebyj@gmail.com

Abstract

Proliferation of multilevel inverters during the last decade focusses mainly on medium and high-power applications. The necessity for low power high efficiency multilevel inverters (MLI) were contented by T-Type topologies. This paper proposes a hybrid multilevel inverter topology suitable for isolated supply electric systems. The proposed system is a congregation of T-type and Active Neutral Point Clamped (ANPC) converter modules powered from isolated battery sources. The topology is designed to operate as a boost rectifier also for charging it's battery system. A multi input Fuzzy controller is employed to optimize the utilization of battery sources powering the system. A distinct Variable Frequency Overlapped Carrier (VFOC) level shifted modulation strategy based on sinusoidal pulse width modulation is developed for efficient switching. VFOC modulation technique aims at reduction in higher order harmonics and minimization of switching losses. Inherent voltage balancing between floating capacitor is another topological peculiarity of the proposed system. Analysis confirms phenomenal reduction in total harmonic distortion compared to its conventional counterparts. Performance and reliability of the proposed MLI is verified for different modulation indices and various kinds of loads. Reliability and effectiveness of the proposed system has been investigated with a simulation model and hardware prototype.

Keywords: Hybrid Multilevel Inverters, T-Type Inverters, ANPC converters, Carrier Based Modulation Technique, Total Harmonic Distortion.

1. Introduction

Multilevel inverters (MLI) are developed as a result of the fifty-year-old investigations led by researchers to realize a new category [1] of inverter topology with higher nominal power handling capability using existing limited power devices. MLI's present obvious advantage over two level conventional converters such as superior output wave shape quality, lower harmonic distortion and less power loss. Multilevel inverters are basically divided into three main categories viz., Neutral Point Clamped (NPC), Flying Capacitor (FC) and Cascaded H-Bridge (CHB).

Complexity of these conventional multilevel inverters increases with the number of levels due to its proportional increment in number of semiconductor devices and driver circuits. This increased number of discrete components affects the reliability of the system also. Each topology possesses its own particular advantages along with some drawbacks. Consequently, a new category [2] of multilevel inverters were introduced named as Hybrid Multilevel Inverter. Hybrid topologies are generally developed to satisfy specific applications by overcoming the shortcomings posed by conventional MLI's. Hybrid topologies are also listed under symmetric and asymmetric structures. Symmetric topologies are based on similar dc voltage sources and have the advantage of modularity [3]. In contrary asymmetric topologies has a more complex design with dissimilar dc sources. But a smaller number of switching devices can be counted as an advantage. Major types of hybrid topologies introduced in the industry are H-bridge Neutral Point Clamped, Active Neutral Point Clamped (ANPC), Nested Neutral Point Clamped, T- Type Nested Neutral Point Clamped converters. Among the above, the most popular active neutral point converters are developed to generate higher number of voltage levels overcoming unbalanced thermal stresses of power semiconductor devices [4,5]. ANPC's combine the flexibility of a FC and an NPC. They are also employed in application where minimum THD level are to be maintained. In order to achieve higher voltage levels in ANPC's the number of flying capacitors also has to be increased. The voltage imbalance between dc-link capacitors are the major challenge confronted in any ANPC topology. Higher switching frequency operation of the converter is a mandatory requirement to control the capacitor voltage imbalance [6]. Popular ANPC's design used in the commercial sector are the 3-level and 5-level topology [7,8,9,10] as shown in Fig 1. In this the clamping switches are replaced with clamping diodes to balance the loss distribution between the switches by creating a path for the neutral current.

Nomenclatures

V_{dc}	DC voltage
V_{ph}	Phase voltage
m_a	Modulation index
m_f	Modulation frequency
A_c	Amplitude of carrier wave
A_{ref}	Amplitude of reference wave
L	Inductance
C	Capacitance
THD	Total Harmonic Distortion

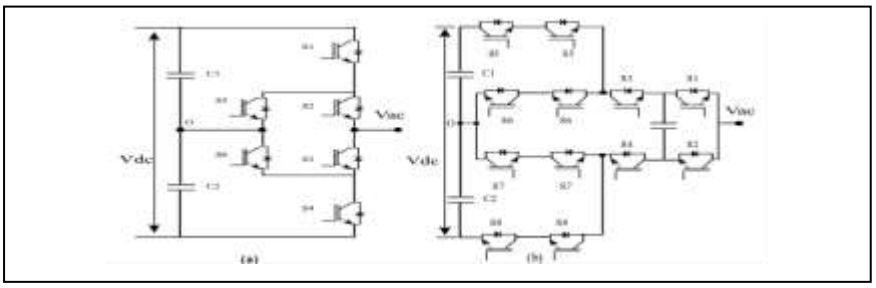


Fig.1 (a)Three Level-ANPC (b) Five Level- ANPC

This arrangement in other way aids for the inherent capacitor voltage balancing also. All the above discussed topologies of multilevel inverters are employed in medium or high-power applications. The need for a low power high efficiency multilevel topology was answered by the T- type inverters [11] shown in Fig 2
T type inverters are another class of MLI's discussed in the literature [11], this topology of multilevel inverters own the advantages of low conduction losses and high efficiency

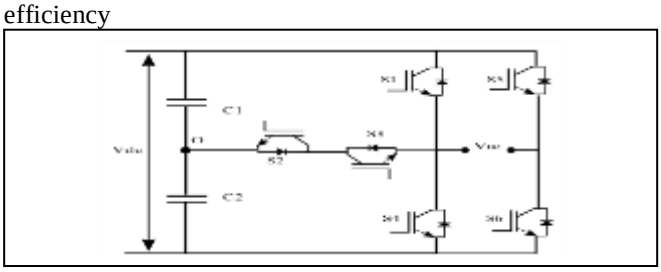


Fig 2.T-Type Three-Level MLI

They are a simple reduced switch topology structure derived from NPC. A T-bridge is basically formed by two conventional and one bidirectional device per phase. The authors claim to have achieved a switch count reduction up to 37.5% compared to conventional topologies with number of voltage levels [11]. A five level T- type multilevel structure with a new PWM method to balance the power losses in power switches is discussed in [12]. A better lifetime expectancy for power switches are claimed through redundant switching operation of the circuit.
In [13] a reduced switch count seven level T- type MLI is reported with multicarrier modulation technique, but the scheme poses serious drawback with high THD in line voltages. Another T- type five level asymmetrical converter is reported in [14,15,16]. The topology is built on an H-bridge configuration, where the bidirectional switches are connected to the central point of the DC-link as shown in Fig.3.

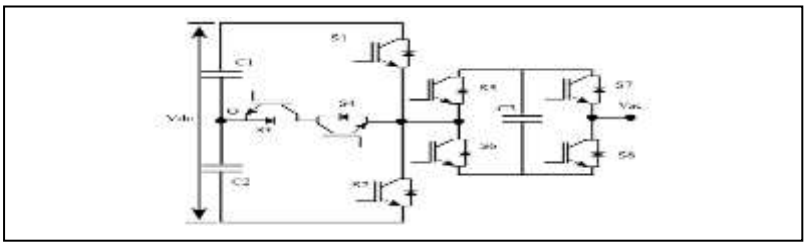


Fig 3. Seven Level- T-Type MLI

The work emphasizes on the reduction of leakage current present in the system according the European standards Analysis of the system shows that Linear modulation index is achieved only up to 0.48. Also, the investigation lacks discussions pertaining to, THD variation with respect to modulation index. A T-type five level MLI with level shifted opposite phase disposed carrier modulation technique is discussed in [17,18]. The modulation technique utilizes single frequency equal width carriers to generate the switching signals. Major drawback of this topology is the presence of 37% THD in the unfiltered output phase voltage. A square T- type module for asymmetric MLI's is discussed in [19] as shown in Fig.4, where ST- type modules with four DC sources are used to achieve the claimed 17 level output voltages at $V_{AB.}$

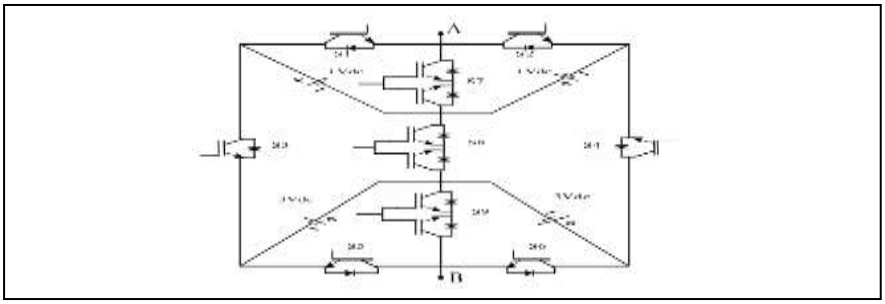


Fig.4. ST-type module MLI

In [20] a T2C converter is proposed for a low switching frequency MLI. The authors claimed to combine the merit of low conduction loss in two level converter and superior quality output of the three level converters. The system utilizes a bidirectional switch connection between the dc link midpoint voltage and the output. The conduction losses in the converter topology are minimized with this interconnection. Even though THD levels are within the limits, the number of switching devices and the practical application of this topology is a major concern. A multi input switched capacitor MLI(SCMLI) is proposed in [21] for high frequency application where the availability of asymmetric dc sources are present. Inherent capacitor voltage balancing is claimed to be the vital specialty of this converter topology. The proposed systems lack detailed investigation on harmonic performance under varying load conditions. The major challenge pertaining to battery powered multilevel inverter systems is the effective utilization of battery sources. The reliability of battery powered systems are always questioned in terms of its capability to operate long duration with minimum degradation of performance parameters. Since the controlling of battery sources is a multivariable problem, Fuzzy logic controllers will be better suited for achieving the solution as discussed in several research articles [22,23,24].

From the aforementioned literature review about T-type topologies and its modulation techniques it can be observed that, most of systems presented either fall short in its line THD performance or in its capability to operate efficiently from an isolated power supply source. Thus, the need to devise a novel topology of T-type multilevel inverter to cater the segment of isolated powered systems

like industrial cranes, fork lifts, electric vehicles etc., are very high. A novel design of circuit topology will be acceptable to the industry only if it possesses the capability to carry out multiple operations like charging the battery source along with optimized utilization of battery source. A novel topology also demands for a new modulation strategy since the conventional PWM techniques are prone to poor line THD.

This paper proposes a hybrid T-Type multilevel inverter topology with inherent charging capability. A novel VFOC modulation technique is also introduced for minimizing the line THD harmonics of the system. A two-input fuzzy logic controller is devised for the optimized utilization of isolated power supply sources. The structure of this paper is as follows: In section 2, proposed topology is explained in detail, section 3 details the VFOC modulation technique employed in the proposed system. Section 4 explains about the inherent battery charger in the proposed system and section 5 details about the design of a fuzzy logic controller. Section 6 discusses about simulation and hardware results.

2. Proposed System

In view of the stated literature, this paper aims to introduce a battery powered Modified T-Type ANPC topology with a hybrid modulation strategy suitable for low power critical circuits. Battery powered or independent DC sources are related to the category of Isolated power supply systems. The proposed topology is a congregation of an ANPC and T type MLI structure as shown in Fig.5. To obtain five levels in phase voltage, nine power semiconductor switches S1-S9 are used. The topology is designed to work as a boost rectifier also for charging operation of battery source. This peculiarity makes the topology multifunctional in operation.

In general, to achieve ‘n’ levels in phase voltage and 2n-1 levels in line voltages (for three phase topology), 5+(n-1) switches are required per phase, where four switches are for the H bridge and five switches are for the ANPC -T type inter connection. The proposed system uses three DC sources and two floating capacitors. The floating capacitors are C1 and C2 are dedicated for the T-bridge

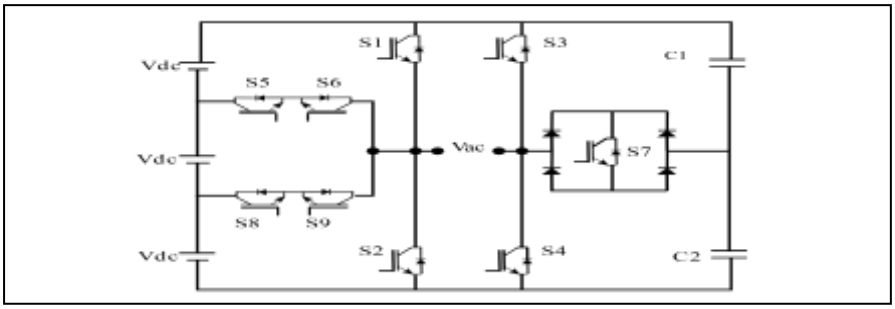


Fig.5.Proposed Hybrid T-Type Five level MLI

Voltage level obtained are V/6, V/3, V/2, 2V/3, and V, where V is the input dc voltage. The switching states are shown in Table I.

TABLE I
Voltage levels/Switching states of the proposed converter

Voltage Levels	Switching States								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
V	1			1					
2V/3				1		1			
V/2	1						1		
V/3				1					1
V/6						1	1		
0V		1		1					
(-) V/6							1	1	
(-) V/3			1		1				
(-) V/2		1					1		
(-)2V/3			1					1	
(-)V		1	1						

(S1,S2),(S3,S4),(S5,S6) and (S8,S9) are the four pairs of complementary switching states involved in the generation of output voltage levels. Consider S*f*1, S*f*2, S*f*3, S*f*4, S*f*5, S*f*6, S*f*7 S*f*8, S*f*9 as the switching function for switches S1-S9. The switching function takes either logic 0 for OFF condition or logic 1 for ON condition. The output phase voltage V_{ph} can be determined from the mathematical equations (1) and (2)

$$\overline{Sf2}\left[\frac{Vdc.Sf1}{4}+\frac{3Vdc.Sf4}{4}-\frac{Vdc.Sf6}{12}+\frac{Vdc.Sf7}{4}-\frac{5Vdc.Sf9}{12}\right]=V_{ph(+)} \quad (1)$$

$$\overline{Sf4}\left[\frac{-Vdc.Sf2}{4}-\frac{3Vdc.Sf3}{4}+\frac{Vdc.Sf8}{12}-\frac{Vdc.Sf7}{4}+\frac{5Vdc.Sf5}{12}\right]=V_{ph(-)} \quad (2)$$

Equation (1) and (2) depicts the generation of positive and negative phase voltages. i.e, for generating a phase voltage of V/2, switches S1 and S7 will be ON which make the switching function S*f*1 and S*f*7 to be 1 and rest switching states 0. Substituting the switching state in (1) gives:

$$1\left[\frac{Vdc.1}{4}+\frac{Vdc.1}{4}\right]=\frac{Vdc}{2}= \quad V_{ph(+)}$$

Some of the obvious advantages of the proposed topology are (1) ease of extension to generate higher number of voltage levels due to its modularity (2) inherent capacitor voltage balancing due to the bifurcation in floating capacitors (3)lower number of circuit components and reduced switching losses. Discussions pertaining to higher voltage levels are withheld in this paper to avoid complexity due to higher number of switching states.

3. Hybrid Modulation Technique

The novel hybrid modulation technique with VFOC triangular carriers are

compared with a reference sine wave to generate the switching signals. This hybrid modulation technique is a modification of the phase disposed sine pulse width modulation (PD-SPWM) scheme discussed in [13].
PD-SPWM is widely accepted as a modulating technique for MLI's due to its simplicity and inherent capacitor voltage balancing.

The modulation amplitude m_a (modulation index) is given by:

$$m_a = \frac{Amplitude\ of\ the\ Reference\ Signal(Sine\ Wave)}{(n-1).Amplitude\ of\ the\ Carrier} \quad (3)$$

Where 'n' is the number of phase voltage levels. Modulation frequency can be expressed as

$$m_f = \frac{frequency\ of\ the\ Carrier}{frequency\ of\ the\ modulating\ wave} \quad (4)$$

The value of m_f is 40 in this proposed method. Arrangement of triangular carriers and sinusoidal reference signal in the proposed hybrid modulation scheme for the Five level T-type hybrid MLI is shown in Fig.6.

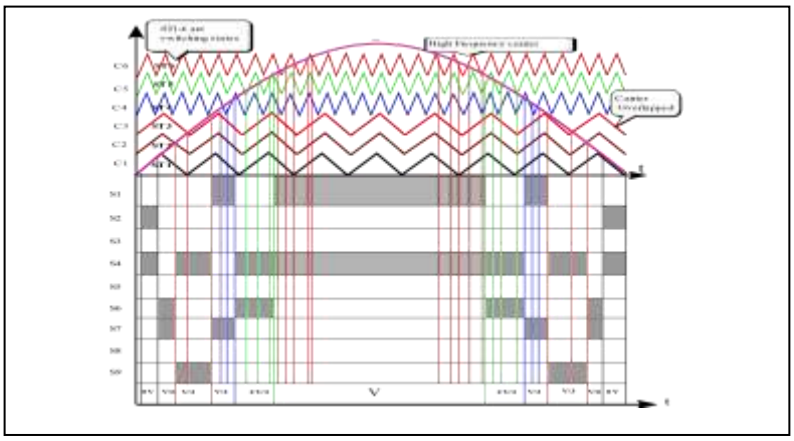


Fig.6.Variable frequency overlapped carrier level shifted modulation strategy

Amplitude of the carrier signals can be calculated as:

$$A_c = \frac{\text{Aref}}{n-1} \quad (5)$$

Where A_{ref} is the amplitude of reference sine wave and A_c is the amplitude of carrier. The carrier signals are overlapped by a factor corresponding to the modulation index as per the control strategy shown in Fig 7.

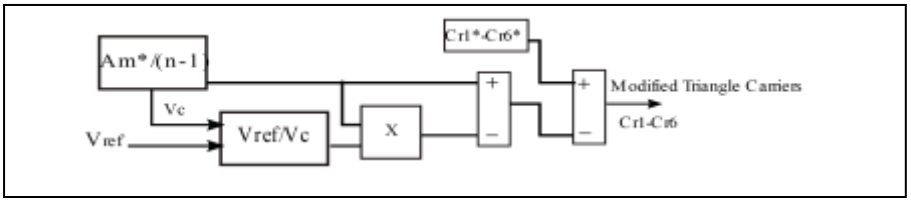


Fig.7.Block diagram showing the control strategy for carrier overlapping

Since the number phase voltage levels are restricted to five, there are six switching states ST1- ST6 and six carriers Cr1- Cr6. The frequency "f" of carriers corresponding to the states ST1-ST3 are switching at a frequency of "f/2" with respect to the frequency of carriers switching from ST4- ST6.
This particular strategy in carrier modulation is adopted to minimize the harmonic content in the output waveform. From the observed harmonic spectra shown in Section VI two observations can be made:
1)Even order harmonic content is zero and the 3rd, 5th ,7^{th}, 9th and 11th order harmonics are mitigated from the output waveforms.
2)Linear variation of the output voltage is obtained even at low modulation index,m_a=0.1. The voltage levels are maintained upto a modulation index of 0.4.

4.Integrated Battery Charger

The H- Bridge in the proposed topology comprising of switches S1,S2,S3 and S4 are intended to perform the operation of a PWM rectifier also as shown in Fig.8. This mode of operation can charge the inverters battery source through a controlled boost rectification. Single phase PWM rectifiers are mainly used for rectification purpose in order to preserve the quality of input sinusoidal waveform and maintain unity power factor [25]. An ac side inductor (Ls) shall be added with the bridge topology to achieve the boost rectification.

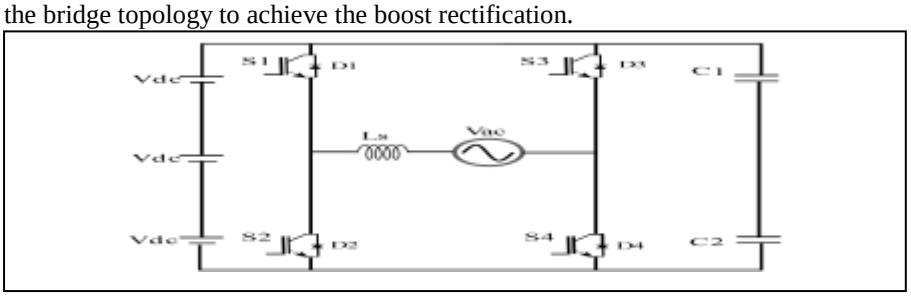


Fig.8 Integrated boost rectifier circuit

The operation is divided into four modes over positive and negative half cycles of input ac voltage: Mode I and II will be operating only during the positive phase of the supply voltage. The boost inductor Ls stores energy during mode I when the switch S2 is ON through Vs-Ls-S2-D4. In mode 2 when S2 is off the inductor will discharge through Vs-Ls-D1 and to the battery bank and D4. Mode III and IV will be operating during the negative phase of the supply voltage. During mode III, S1 will be on charging the inductor with current path Vs-D3-S1-L. Discharging of inductor takes place during mode IV when switch S1 is OFF through Vs-D3-Battery bank – D2 and L.

Inductive element is used for the boost operation and bidirectional power flow whereas the capacitor is included in the circuit to maintain the constant DC output to the load. The output voltage obtained from the boost rectifier is given by

$$\frac{V_S M}{1-d} \quad (6)$$

$V_s - Supply\ voltage$,M-Modulation Index, D=switching period
Inductance Value is calculated by

$$L = \sqrt{(V_r^2 - V_s^2) + (\omega^2 I_s^2)} \quad (7)$$

Where Vr is the voltage at the converter terminals, Vs is the source voltage. Is is the source current.

Capacitance is calculated by $C \geq \frac{(M.I_S)}{4\omega\Delta V}$ (8)

M is the modulation index and ΔV is the ripple voltage

The capacitance value is adjusted to match the circuit floating capacitor and the inductance value is calculated to be 7.5 mH for a rectified DC voltage of 300V. The boost rectified DC voltage obtained through the charging operation is shown in Fig.9

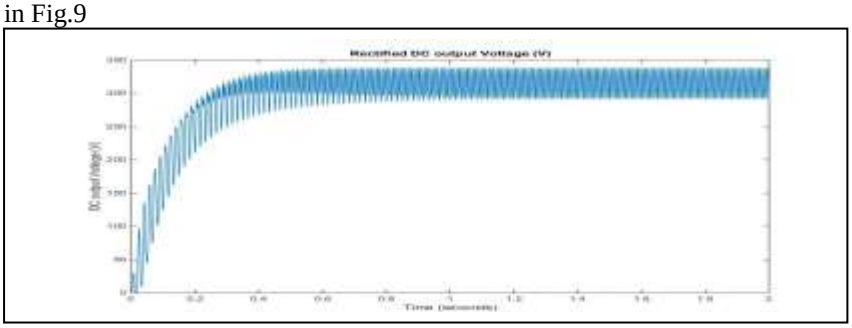


Fig.9. Boost rectified DC output voltage from integrated charger

4. Design of Fuzzy Logic Controller for Battery Management

A fuzzy system is designed to control the SoC (state of charge of the battery) for the optimised utilisation of isolated power supply source. As the state of charge of battery deteriorates during usage, the modulation index as well as the overlap factor of the triangle carriers are adjusted to sustain the operation of the inverter. Monitoring the SoC can avoid fast battery charge dissipation. Battery SoC and rate of change of SoC are taken as the input variables, modulation index and carrier overlap factor are the output variable. Fuzzy system is divided to three process as shown in Fig.10 i.e., fuzzification, inferencing and defuzzification

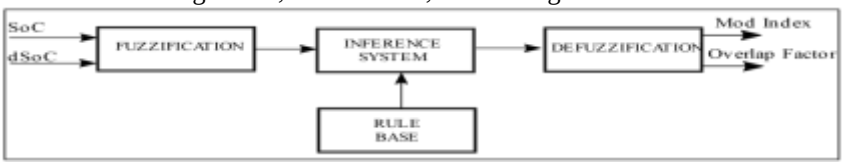


Fig 10. Block diagram of the fuzzy control system

The input variable are converted to linguistic range. Universe of discourse of input variables battery state of charge (SoC) and change of SoC(dSoC) has three and five subsets respectively. Universe of discourse of the output variables, modulation index and overlap factor has three subsets each. The inferencing mechanism uses IF THEN rule base as shown in Tables II and III. to define a fuzzy relationship between the input and output variables.

Table II. Rule Table for Mod. Index

MoD. Index		Change in SoC(dSoC)				
		VL	L	Med	High	Very High
SoC	L	L	L	L	L	L
	M	M	M	M	L	L

	N	H	H	H	M	M

Table III. Rule Table for Overlap Factor

Overlap Factor		Change in SoC(dSoC)				
		VL	L	M	H	VH
SoC	L	H	H	H	H	H
	M	M	M	M	H	H
	N	L	L	L	M	M

Fuzzy set for the input variable SoC is {L, M, N} and the range of SoC is selected from 0.5 to 1. Rate of change of SoC is defined by fuzzy set { VL, L, M , H,VH} the basic domain is [0 1] Fig.11 shows the membership functions for the input and output variables.

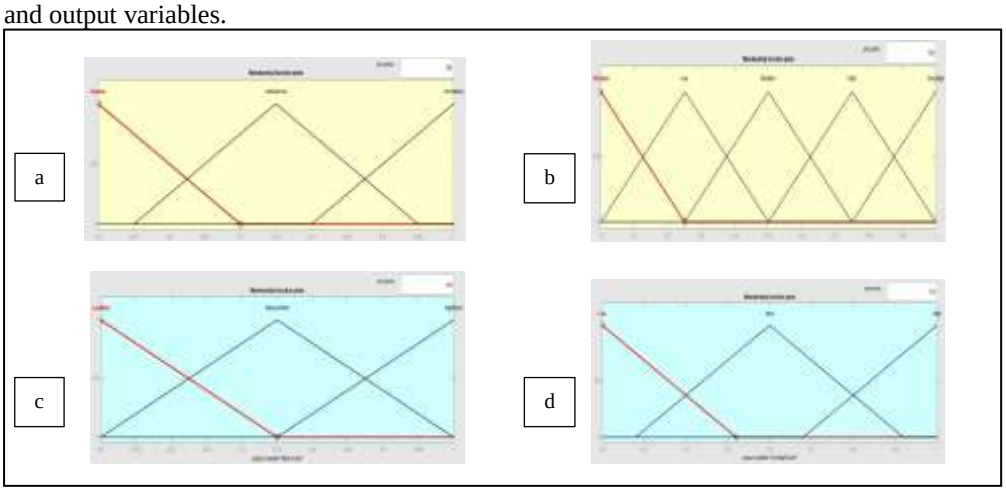


Fig.11. Membership function of input variable (a) SoC(b) dSOC and output variable (c)Mod.Index (d)Overlap factor

Surface view output of the controller is shown in Fig.12

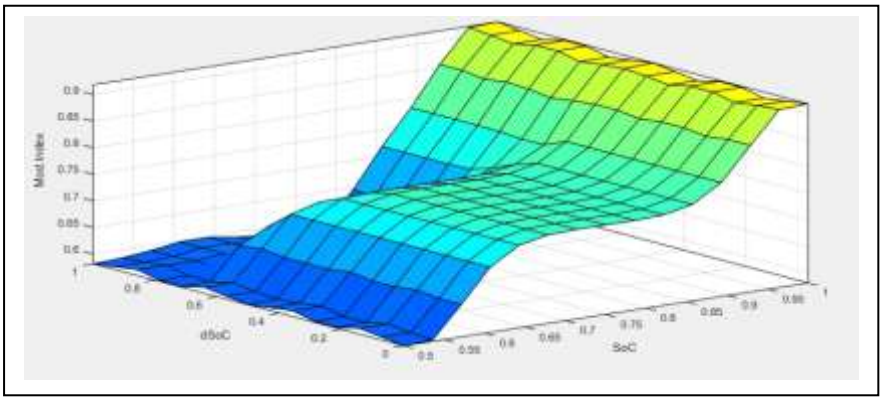


Fig.12. Surface view output of the fuzzy controller.

A Mamdani fuzzy inference system is used with triangular membership function to achieve high sensitive response. Centroid method is applied for the process of defuzzification.

6.Results and Discussion

6.1 Simulation Results

The single-phase five-level hybrid T-type MLI is simulated in MATLAB Simulink environment with VFOC based PWM method. Simulation parameters are shown in Table IV.

Table IV
Simulation parameter of the proposed system

Particulars	Specification
Input DC Voltage (Vdc)	300V
Switching Frequency	2000Hz
Output frequency	50Hz
Floating Capacitor(C1-C2)	4700μF
RL,Load	12 Ω, 5mH

Analysis has been done in the proposed Hybrid MLI for various modulation indices and loads. The harmonic spectra of the output waveforms prove the effectiveness of the modulation technique in reducing the higher order harmonics. Fig13 and Fig 14 shows the output phase voltage and harmonic spectrum of the proposed MLI for different modulation indices.
The simulation results of the proposed system have been compared with the results presented in [16] where a five level T-type multilevel inverter is presented with a dual reference modulation strategy.

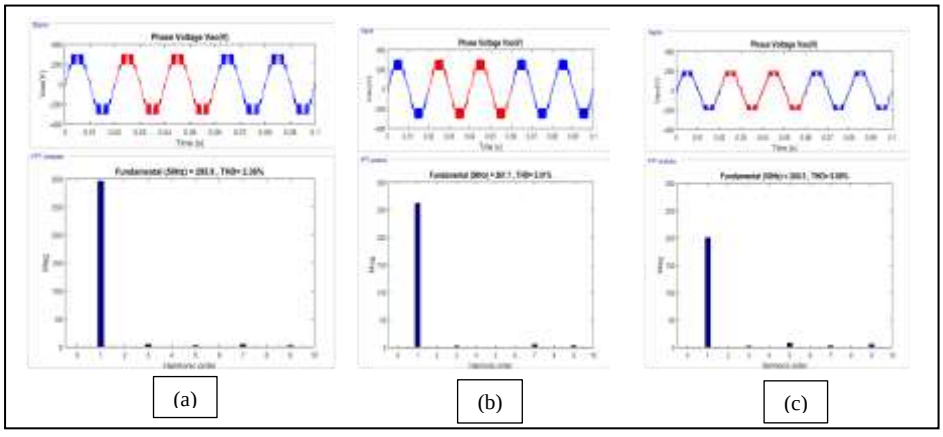


Fig.13. Output phase voltage and harmonic spectra for (a) $m_a = 1$ (b) $m_a = 0.8$ (c)0.6

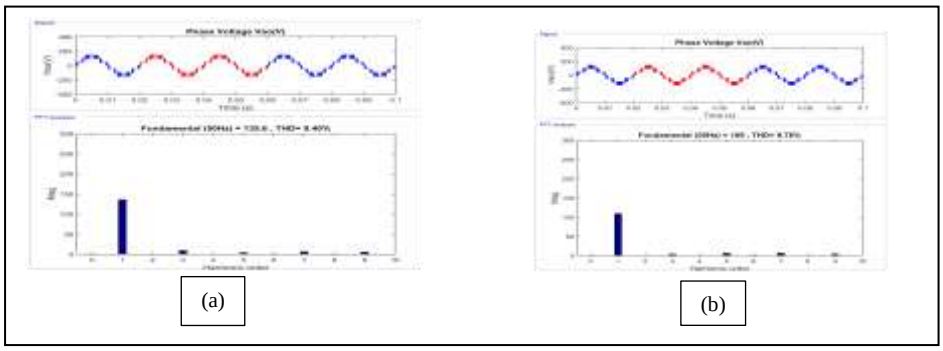


Fig.14. Output phase voltage and harmonic spectra for (a) $m_a = 0.4$ (b) $m_a = 0.3$

Variation of parameters in Fig.13-14 such as fundamental output voltage and THD with respect to the modulation index can be represented graphically as shown in Fig. 15.

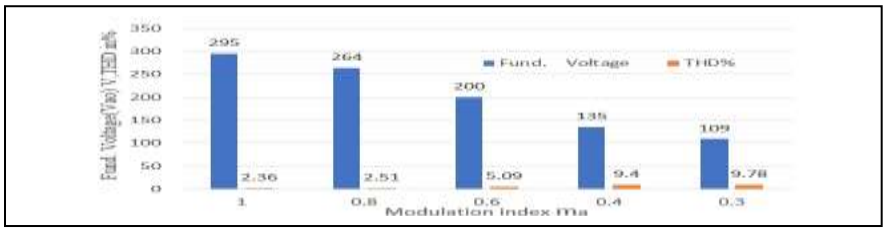


Fig.15 Variation of THD and fundamental output voltage with respect to modulation index m_a

Analysis of proposed system has been conducted on RL load (R=12Ω,L=3mH) from Fig 16 a linear variation in output current can be seen with minimal increment in THD.

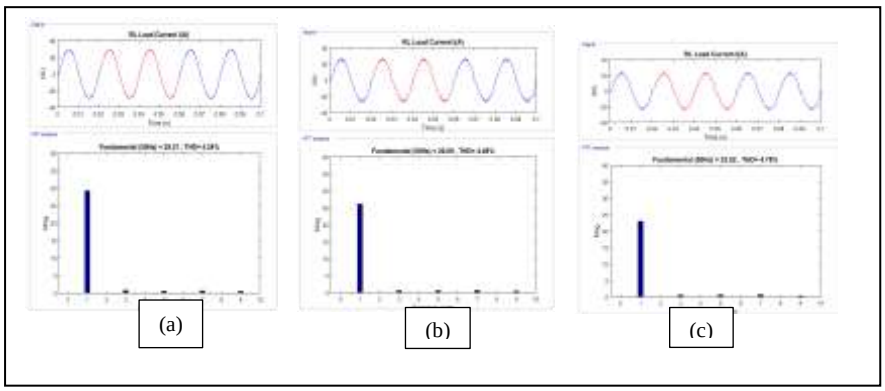


Fig 16. Load current I(A) with RL load for (a) m_a=1,(b) m_a=0.8 (c) m_a=0.6

Variation in output parameters such as load current and THD with respect to modulation index m_a is diagrammatically represented in Fig.17

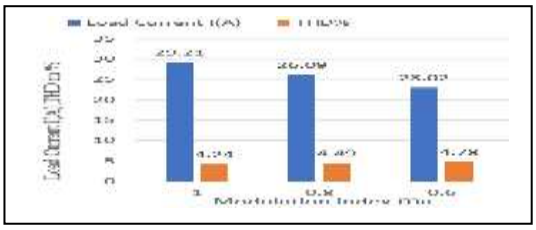


Fig.17 Variation of THD and load current with respect to modulation index m_a

The harmonic spectra of the current waveforms shown in Fig 16 and 17 sanction the proposed multilevel inverter for inductive loads such as low power motor drives, electric vehicles, portable cranes etc.,

The above analysis shows that the change in modulation index gives a linear variation of output voltage and current keeping THD to the limit.

This linear variation is output voltage is achieved through the control strategy discussed in Fig.7. The carrier control strategy also sustains the voltage levels even at low modulation index.

A graph plotting fundamental output voltage against modulation index in shown in Fig. 18. The graphs confirms linear relationship between output voltage and modulation index of the proposed system.

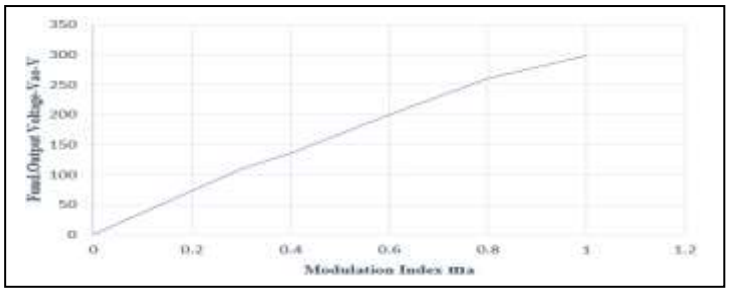


Fig.18. Fundamental Output voltage vs Modulation Index

Comparison of Harmonic spectrum pertaining five level T-type MLI and Cascaded H bridge MLI's discussed in [16] is shown in Fig 19.

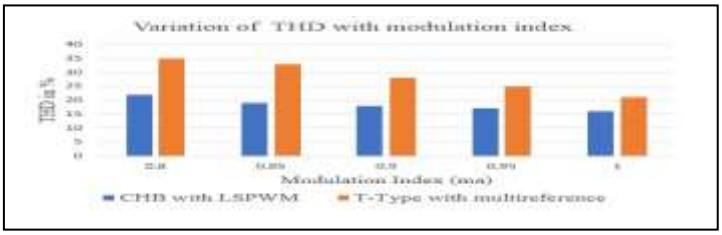


Fig.19. Comparative harmonic performance of T-type and CHB MLI presented in [16]

Variation of THD with different modulation indices shows that for the topology presented in [16], the THD levels are higher in the range of 17-25%. On comparison of Fig.15,17 and 19, it can be justified that the proposed Hybrid T-Type multilevel inverter with a VFOC modulation strategy can operate efficiently with a better harmonic spectrum and linear modulation index.
The proposed system can be allowed to generate output ac waveforms for higher frequency applications(>400Hz) also, since the duty ratio of switches other than the H bridge module are very low.
High frequency operation can improve the inherent capacitor balancing capability of the system. Fig.20 shows the FFT analysis of the proposed prototype modified for a 115Vac, 400Hz supply.

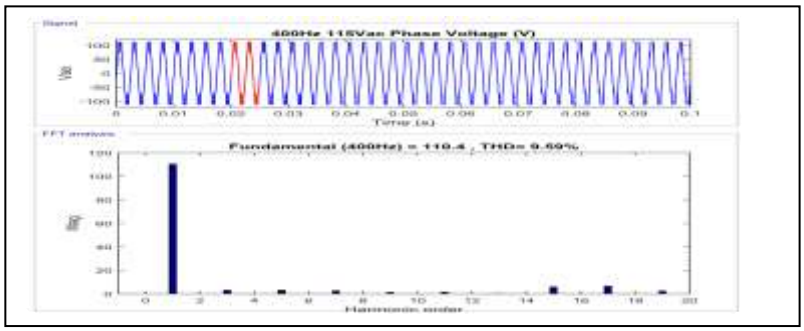


Fig.20. 400Hz,115Vac Output of MLI at m_a=1

Higher order harmonics 3rd,5th,7th are eliminated and a small magnitude of 9th order harmonics can be observed from the harmonic spectra of output phase voltage. From the FFT analysis we can see that even for a high frequency operation (Fundamental frequency=400Hz, Carrier Frequency=16000Hz) THD levels are maintained at acceptable levels for high frequency operation also.
This response of the proposed system makes it suitable for high frequency applications in field of aerospace and telecommunication. Table V compares with the conventional T- Type and ANPC multilevel inverters with the proposed system.

TABLE V
Comparison of the proposed system with its conventional counterparts

Type of MLI	No. of Switches	No. of Capacitors	No. of Dc Sources	THD (%)
5-Level ANPC	12	2	1	20
7 Level-T type MLI	8	3	1	15
7 Level-SCMLI	7	2	2	10
Proposed 11 level MLI (50Hz)	9	2	3	3
Proposed 11 level MLI(400Hz)	9	2	3	9.5

6.2 Capacitor Voltage Balancing

Capacitor voltages are balanced inherently with the VFOC modulation method as shown in Fig.21. The switching cycles are arranged in such a way that the duty cycle for a particular capacitor voltage falls within the duration of switching state. Hence the charging and discharging period of floating capacitors will not affect the output voltage of the system.

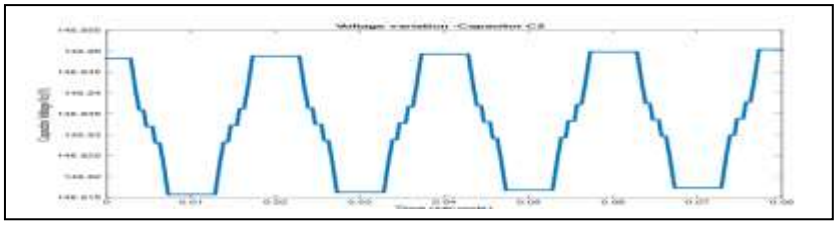


Fig 21. Charging and discharging cycles of capacitor C2

Fig.22 shows the hardware switching pulses generated through VFOC modulation technique, fed to switches S1-S9 at a frequency of 2kHz.

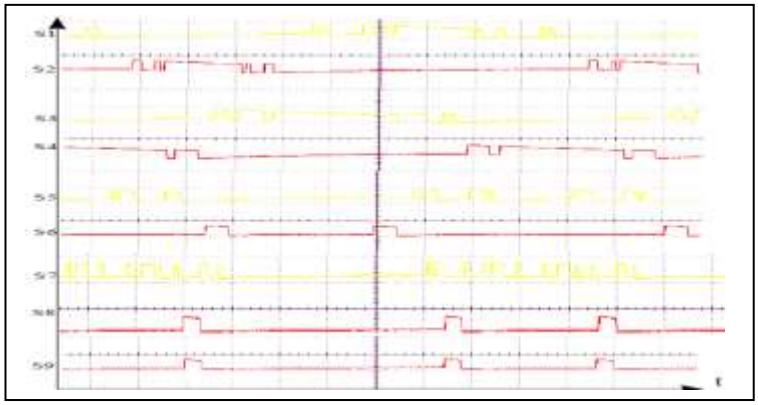


Fig.22. 2kHz hardware switching signals fed to switches S1-S9

6.3 Hardware Prototype

A low power experimental model of the proposed 11 level MLI is developed and tested for confirming the practicability of the proposed system. Specification of the components used in the hardware prototype is shown in Table VI.

TABLE VI

Specification and components list for the 11 level proposed MLI

Particulars	Specification
Semiconductor Switch, , IGBT	FGA25N120
Electrolytic Capacitor	4700µF
Diode	IN540
DC Source	36V
Microcontroller	Arduino Mega 2560

Fig. 23 shows the hardware set up of low power prototype developed.

A hardware prototype as shown is developed for an input DC voltage of 36 volts with three independent battery source of 12 volts. The hardware prototype is divided into three sections viz; Active neutral point clamped section, H Bridge section and Floating Capacitor section. Arduino Mega microcontroller is dedicated with the objective of switching signal generation along with parameter monitoring and control. The 36 volt prototype is also simulated in MATLAB Simulink to reaffirm the workability of the system with very low voltage systems.

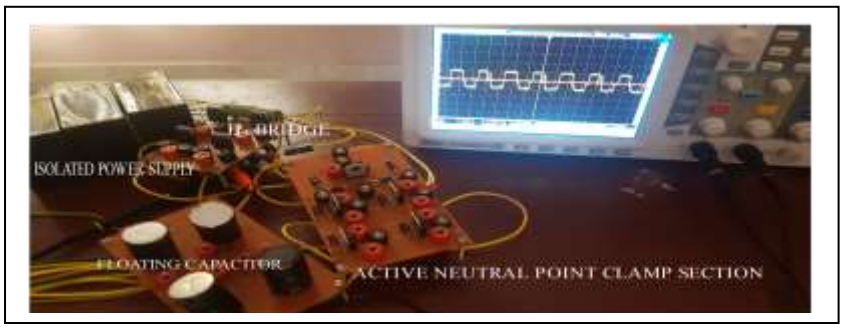


Fig 23. Annotated photograph of the hardware prototype

Fig. 24 shows the output phase voltage and harmonic spectra for a modulation index of 0.9

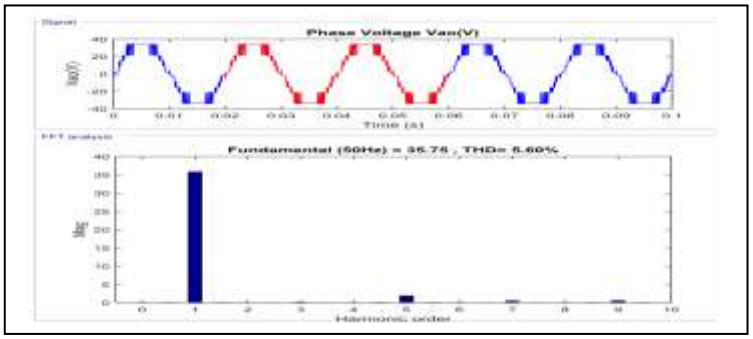
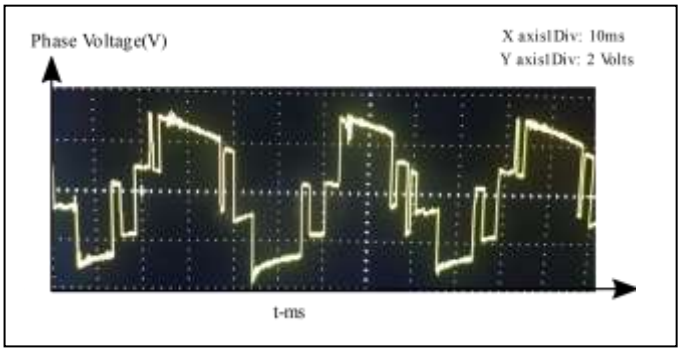


Fig.24.Output phase voltage and harmonic spectra for $m_a = 0.9$

The hardware prototype has been tested under varying load conditions and different modulation indices to confirm the adaptability of the system in rugged industrial conditions. Output phase voltage of the proposed system at a modulation index of 0.2 is shown in Fig.25. The output waveform confirms that, even at a low modulation index of 0.2 the voltage levels are maintained



without considerable degradation in the harmonic spectrum.

Fig.25. Output phase voltage of 36 V system with modulation index $m_a = 0.2$

7.Conclusion

A hybrid T-Type multilevel inverter is presented in this paper with a novel switching strategy. The proposed system caters toward applications under low power category with isolated power supply sources. The proposed topology operates in inversion and conversion mode. A fuzzy logic controller is employed for the optimised utilization of the battery sources in the system. Analysis of results confirm the inherent capacitor voltage balancing and harmonic mitigation with the VFOC modulation technique. The proposed system can also accommodate high frequency (400Hz ,115 Vac) operation without any change in the circuit topology. A laboratory prototype has been built and tested to verify the analysis.

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