UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN, OPTIMIZATION AND DEVELOPMENT OF PHYLLOTAXIS PATTERN SOLAR PANEL

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

Dr. Abdul Munir Hidayat Syah Lubis

(Project Supervisor)

ABSTRAK

Tenaga solar adalah sejenis tenaga yang mengandungi ciri-ciri tenaga hijau dan tenaga yang boleh diperbaharui kerana ia tidak mengeluarkan pelepasan yang membahayakan dan cahaya matahari adalah tanpa had. Panel solar yang menggunakan corak phyllotaxis telah diperkenalkan demi menyelesaikan masalah keberatan, ruang dan mudah alih. Panel solar bercorak phyllotaxis adalah panel solar yang boleh membuka sebagai sekuntum bunga bermekar. Projek ini dijalankan demi mereka panel solar bercorak phyllotaxis, membuat panel solar bercorak phyllotaxis dan mengoptimumkan keluaran panel solar. Konsep reka adalah dipilih melalui konsep pemarkahan. Bahagian yang diperbuat dengan menggunakan proses prototaip pantas adalah perumahan moto stepper, bar bercorak sarang lebah, bar penyambung dan bilah. Moto stepper telah digunakan untuk mengawal pembukaan bilah manakala mekanisme ereksi telah dikawal oleh penggerak linear. Merujuk kepada keputusan analisa, tekanan Von Mises bar bercorak sarang lebah dan bar penghubung adalah lebih rendah daripada kekuatan tegangan Nylon 66 yang bernilai 63.6 MPA. Panel solar mempunyai maksimum keluaran voltan sebanyak 5.5V dan arus elektrik sebanyak 90mA. Demi mengoptimumkan hasil keluaran voltan solar panel untuk mengecaskan 12V bateri, sel solar telah disusun secara selari kepada 4 baris yang mengandungi 4 sel solar yang disambung secara siri. Kesimpulannya, objektif-objektif telah dicapai dengan mereka panel solar bercorak phyllotaxis, membuat panel solar bercorak phyllotaxis dan mengoptimumkan keluaran panel solar.

ABSTRACT

Solar energy is an energy that comprises both characteristics of green energy and renewable energy as it does not give out harmful emission and the sunlight from the Sun is limitless, abundant and infinite. The solar panel with phyllotaxis pattern is introduced in order to solve the portable, weight and space issues. A phyllotaxis pattern solar panel is a solar panel that can be opened in the form of blooming flower. This project was carried out in order to design phyllotaxis solar panel, fabricate the prototype of phyllotaxis solar panel and optimize the output of phyllotaxis pattern of solar panel. A final concept of phyllotaxis solar panel was chosen by using concept scoring method. The parts of the phyllotaxis pattern solar pattern which were produced by using rapid prototyping process with Nylon PA66 were stepper motor housing, honeycomb stand bar, link bar, blades and base. A stepper motor was used in opening and closing the solar panels while the erection mechanism was controlled by a linear actuator. According to the analysis result, the Von Mises stress of the honeycomb pattern stand bar and link bar were less than tensile strength of assigned material Nylon 66 which is 63.6MPa hence the design and material of the critical parts are passed for further fabrication process. The voltage output of 2 series connected solar cells doubles the voltage output of a single solar cell. The result collected for parallel connected solar cells is close to the statement that the current is the same for every component connected in series. A single solar cell has a maximum output voltage of 5.5V and maximum current of 90mA while a pair of series connected solar cell has maximum voltage output of 11V and maximum current of 40mA. In order to optimize the output voltage output of solar panel to charge a 12V battery, the solar cells are arranged in parallel into 4 rows with each row consist of 4 solar cells. In conclusion, the objectives of the project were achieved by designing, fabricating and optimizing a phyllotaxis pattern solar panel.

DEDICATION

To my beloved parents

Ong Sing Teck
Choong Yoke Thai

Thank you for all supports, sacrifices, patient and willing to spend your time for me.

To my honoured supervisor and co supervisor,

Dr. Abdul Munir Hidayat Syah Lubis, Encik Mohd Idain Fahmy bin Rosley and all UTeM lecturers

Thank you for always show me the guidance and persistence in helping to complete this project thesis.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Ag	-	Silver
Au	-	Gold
CdTe	-	Cadmium Telluride
CIGS	-	Copper Indium Gallium Selenide
CH_4	-	Methane
CO_2	-	Carbon Dioxide
DC	-	Direct Current
DSSC	-	Dye-Sensitised Solar Cell
eV	-	Electron volt
FF	-	Fill Factor
HF	-	Hydrofluoric Acid
HCL	-	Hydrochloric Acid
H_2O_2	-	Hydrogen Peroxide
HF-HCL- H_2O_2	-	Hydrofluoric Acid, Hydrochloric Acid and Hydrogen Peroxide
I	-	Current
Isc	-	Short Circuit Current
ITO/FTO	-	Indium/Fluorine Tin Oxide Glass
$J_{L,M}$	-	Current at Maximum Power Condition
J_o	-	Dark Current
J_s	-	Short Circuit Current
$J_{L,M}$	-	Current At Maximum Power Condition
K	-	Boltzmann Constant
NRAs	-	Zno Nanorod Arrays
N_2O	-	Nitrous Oxide
NO_x	-	Nitrogen Oxides
PI	-	Polyimide
Pt	-	Platinum
Pmax	-	Maximum Power Deliver to Load

SLG	-	Soda Lime Glass
SO_2	-	Sulphur Dioxide
T	-	Temperature at Kelvin
TCOs	-	Transparent Conductive Oxides
TiO	-	Titanium Dioxide
USB	-	Universal Serial Bus
Voc	-	Voltage Open Circuit
V_m	-	Voltage at Maximum Power
ZnO	-	Zinc Oxide
Ƞ	-	Efficiency
e_o	-	Charge of an Electron

CHAPTER 1

INTRODUCTION

1.1 Project Background

There are uncountable cases of pollution happened in past 10 years. Pollution are categorised into different types for example sound pollution, air pollution, water pollution and etc. but all of them are threats to the Earth. If the issues are not taken care carefully, habitats of human, flora and fauna will be damaged and the future generation might going to live in a poor environment.

Electricity is first discovered by Benjamin Franklin. Electricity can be generated using different types of energy and these energy are also categorised into non-renewable energy and renewable energy. During the old times, electricity were generated mostly using non-renewable energy and it is still using now. The production of non-renewable energy uses the sources or materials that will be finished after use for example natural gas, coal, petroleum and diesel. Hence, the production of non-renewable energy requires tons of raw material which majority of the materials are obtained underneath the Earth surface.

In order to reduce and minimise the pollution, renewable and green energy are the preferable energy used to generating electricity. Renewable energy is different from green energy; renewable energy is a type of energy that can be produced continuously using an infinite resource while the green energy is an energy produced that does not give out any emission that harms the environment. Solar energy is an energy that comprises both characteristics of green energy and renewable energy as it

does not give out harmful emission and the sunlight from the Sun is limitless, abundant and infinite.

Solar panel with phyllotaxis pattern is designed and fabricated to achieve the objective of this project. The main reason of applying phyllotaxis pattern concept into the design is to enable the solar panel to be opened and closed in the form of bloom flower so that the user can carry it along easily. The solar panel can be folded up and kept in a storage space to ease in transportation. The solar panel also designed to come with a USB port so that the user can connect the solar panel to other device easily.

1.2 Problem Statement

The common method used to generate electricity is by using fossil fuel either petroleum or diesel. Both types of fuel gives harmful emission to the environment. The generation of electricity that uses fossil fuel gives out greenhouse gases such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) other than air pollutants such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x).

Besides, Mitsos said that concentrated thermal solar energy requires tremendous spaces (Chu, 2012), so a lot of rooms are going to be taken up to generate corresponding electricity. Another issue faced by solar panel is the weight of the solar panel, heavy solar panel will be difficult to be carried along. In addition, mobility is also an issue facing by the solar panel product available in the market. Users cannot bring along the solar panel when they are travelling away from their home. It is hard to search for the plug or power supply in outdoors.

1.3 Objectives

The objectives of this project are as follows:

i. To design phyllotaxis pattern solar panel.
ii. To fabricate prototype of phyllotaxis pattern solar panel.
iii. To optimize the output of phyllotaxis pattern solar panel.

1.4 Scopes

i. Design phyllotaxis pattern solar panel using CATIA design software.
ii. Develop the electrical circuit as output of solar panel by modifying the circuit.
iii. Fabricate the prototype and analyse electrical output of the prototype.
iv. Optimize the output of phyllotaxis pattern solar panel by rearranging the electrical circuit.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Phyllotaxis is the form that plant's organs such as petal and leaf are arranged around the stem. Phyllotaxis form is not necessary to be the floret and leaf arrangement but it also can be the arrangement of fruitlets on pineapple, sunflower seeds on sunflower and the scales on pine cones (Korn, 2008). This kind of form has attracted numbers of botanist, biologist and mathematician to carry out studies towards it. Even Charles Darwin was frustrated to solve the mystery of the phyllotaxis arrangement in terms of the divergence angle of the plant's organ with respect to its neighbour ones (Darwin, 1861).

Phyllotaxis arrangement can be characterised geometrically into centric view and cylindrical view in which that centric view is the top view while cylindrical view represents side view (Korn, 2008). Phyllotaxis pattern can be observed in sunflower seed arrangement under centric view; fruitlet arrangement on pineapple shows phyllotaxis pattern when it is observed under cylindrical view as shown in Figure 2.1 and Figure 2.2. The arrangement might be winded in anticlockwise or clockwise direction.

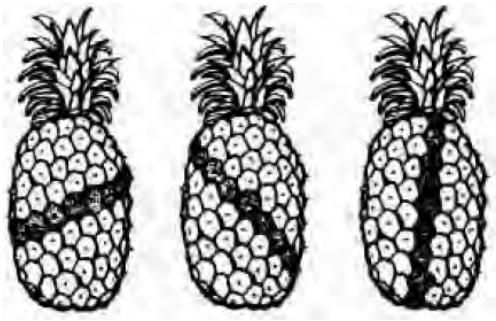

Figure 2.1: Phyllotaxis pattern under cylindrical view (Seewald, 2017)

Figure 2.2: Phyllotaxis pattern under centric view (Retrieved from http://produto.mercadolivre.stfi.re/MLB-695832344-20-sementes-suculenta-agave-mix-cactos-flor-p-mudas-planta-_JM?sf=ngwjzbe#aa)

Leaf arrangement obeys the Fibonacci sequence during the growth of the plant however surprisingly (Okabe, 2015) discovered that the divergence angle remains the same in 137.5° which is called as the golden angle. Golden angle enables leaf or flower to be arranged effectively along the spiral (Seewald, 2017). Another interesting fact of golden angle is that the arrangement of leaf or petal around the stem will not overlap completely (Valladares & Brites, 2004) thereby optimizes the sunlight absorption and enhances photosynthesis process to obtain sufficient carbon (King et al., 2004). A minor change in divergence angle in leaf arrangement results in diverse arrangement pattern; for example with the difference of 2.5° divergence angle (from 135° to 137.5°), the first divergence angle of 135° had 8 leaves shoot by light while divergence angle of 137.5° had more leaves (85) shoot by light (Valladares & Brites, 2004).

Phyllotaxis arrangement is an amazing creation from God as it maximises sunlight absorption with no overlapping of leaves with each other and hence enhances the photosynthesis process. These unique characteristics can be substituted into a solar panel arrangement design and helps in optimizes sunlight absorption and hence increases the energy conversion efficiency.

2.2 History of Solar Cell

Solar energy, the energy in the form of radiation from the Sun, is the most abundant, limitless and infinite energy. Solar energy as the precious gift from the Sun is used since ages to convert solar energy into various form of energy such as heat energy and recently, electricity (Silvi, 2008). Solar energy is said to be one of the favourable renewable energy in the world due to its emission-free characteristic, long lifetime of 20 to 30 years with low operation cost and little maintenance (Bagher, 2015). It is completely environmentally friendly form of energy hence a lot of studies and researches were carried out to maximize solar energy harvesting as the alternative solution to electricity generation using fossil fuel that produces waste products and lead to environmental pollution.

In 1839, photovoltaic effect was observed by Alexandro Edmond Becquerel that claimed electricity can be generated by solar energy. Later in early 1880s, Charles Fritts invented the first ever solar cell by using selenium as the top layer on metal plate coated with gold leaf. The solar cell showed the possibility of generating more electricity when it is placed under sunlight. Although this invention had only about 1% efficiency, it is the most important milestone in solar cell technology and it opened the journey for the scientists to discover materials or method in producing higher efficiency photovoltaic cell.