UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION OF DIFFERENT TYPES OF REFLECTOR CONFIGURATIONS IN MAXIMIZING SOLAR PANEL EFFICIENCY

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

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DECLARATION

I hereby, declared this report entitled "Investigation of Different Types of Reflector Configurations in Maximizing Solar Panel Efficiency" is the results of my own research except as cited in references.

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APPROVAL

This report submitted to the Faculty of Electrical and Electronic Engineering Technology of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follows:

…………………………………………

(Zaihasraf Bin Zakaria)

ABSTRAK

Tenaga solar telah memacu dalam kemajuan tenaga dalam banyak negara berkembang dan berpotensi ke negara maju seperti Malaysia yang dijangkan akan diguna pakai untuk tenaga bersih. Projek bertujuan untuk menyiasat jenis pemantul dalam sistem tenaga solar, dengan kaedah penumpuan dan menggiatkan lebih banyak sinaran matahari memancar ke panel solar yang akan meningkatkan pengeluaran tenaga. Objektif adalah untuk merekabentuk dan membina model fotovoltaik (FV) dengan pelbagai jenis pemantul. Projek ini akan menggunakan fotovolta (FV) 5 Watt, 18 Voltan Polycrystalline dengan reka bentuk kerangka panel solar dalam perisian SolidWorks. Parameter dalam menghasilkan tiga konfigurasi pemantul; 'pemantul laluan V' pemantul, 'pemantul campuran kandungan parabola' (CPC) pemantul dan pemantul mendatar, dan juga dengan pelarasan sudut kecondongan panel solar $(0°, 10°, 20°, 30°, 40°)$ untuk mendapatkan pengeluaran tenaga yang maksimum. Hasilnya terdiri daripada parameter kecerahan dan parameter elektrik, dimana untuk mengenal pasti intensiti sinaran matahari melalui panel solar dengan konfigurasi pemantul yang berlainan. Kemudian, parameter elektrik untuk mengukur keluaran kecekapan setiap konfigurasi pemantul jenis yang berlainan. Dengan projek ini, adalah untuk mendapatkan pengetahuan mengenai system solar dalam solar panel, pemantul solar dan juga mengetahui kecekapan untuk setiap jenis pemantul.

ABSTRACT

Solar energy has been in the cutting edge of energy progress in numerous grow countries and potential energy to progressing countries like Malaysia that will anticipated to be the clean energy of tomorrow. This project means to demonstrate that actualizing unique kinds of reflectors in solar energy systems, by methods for concentrating and intensifying more sun ray onto a solar panel that will enhance energy production. The objective is to design and construct the photovoltaic (PV) model with different type of reflector configurations. This project will use PV panel of 5 Watt, 12 Volt Polycrystalline with design of framework of solar panel in Solidwork software. The parameter in gaining result with three type of reflector configuration; V-through, Compound Parabolic Concentrator (CPC) reflector and Horizontal reflector, and with adjustment of tilt angle ($0°, 10°, 20°, 30°, 40°$) to gaining maximum output. The result gaining consist of irradiance parameter and electrical parameter, which irradiance for identifying the intensity of sun beams through solar panel with different reflector configuration. Then, electrical parameter to measure the efficiency output of each different type reflector configuration. With this project, is to gaining knowledge about solar system in solar panel, solar reflector and mostly to know which the efficiency are between reflectors.

DEDICATION

To my beloved parents Mr. Sharulnahar Bin Jaafar and Mrs. Wan Faridah Binti Wan Salleh for their support and pray. A full appreciation to my supervisor Zaihasraf Bin Zakaria for advising and helping through this project.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.0 Project Background

Renewable energy has becoming an important source that applying energy that useful to optimize the application of domestic energy resources which will give economic beneficial to community. The global requesting for renewable energy process to the power grids point it the importance of economic and technological matters included with growing levels of flat-panel Photovoltaic (PV), Concentrated Solar Power (CSP), and Concentrated PV (CPV) piercing into the power grid.

The increment of solar energy in efficiency and its price levels have boost dramatically. Today the theoretical efficiency of a solar PV cell well known around the 25% to 30% mark and a practical efficiency about 17% mark. The progressing in efficiency production of solar energy system will make huge difference in the application of solar panels.

Commonly, households and business suitable for flat panel solar module, where it can produce electrical or mechanical energy from solar energy conversion. Actualizing a reflector system for these solar panel modules, a hypothesis that has been tried and built up that general yield and effectiveness can be improved. Sustainable power source frameworks particularly sun energy systems in the course of recent years has ended up one of the primary central focuses in growing new innovations were vitality can be created with effective outcomes. However with new advances comes the way that they won't be shabby to buy and run. The primary point of this paper is to perceive what methods for sunlight based fixation can deliver productive power for homes and different conditions. (Rizk and Nagrial, 2009)

1.1 Objectives

The objectives of this project are:

1. To investigate and compare the efficiency between types of reflector configurations also without reflector on solar panel.
2. To design and construct the photovoltaic (PV) model with different type of reflector configurations.
3. To collect and analyse data of the experiment in efficiencies of photovoltaic system.

1.2 Problem Statement

The flat solar panel is efficiency in absorbing solar energy then convert to electricity. The flat solar panel absorbing the electricity power with specific output values, solar panel cannot collect maximum power. The maximum intensity of light must be concentrated on solar panel. Required more solar panel to gain more input from solar energy if the proper usage on solar panel limited. The solar panel can be varied usage in gaining maximum power, by adding reflector the light ray that didn't hit solar panel can be collect in collecting maximum power.

Users commonly use static solar panel without reflector, this concept system is impractical due to solar panel are not always directly 90° with the sun because the earth is continuously moving. This research is carry out to solve the ineffective usage of solar panel and bring awareness between users about the right usage on solar system. The functional solar panel without reflector are lesser because the solar panel are not fully absorbed. Hence, I will review the types of reflector configuration that produce maximum peak power with minimal cost. With this study, the solar consumers will understand and realize the best types of reflector configuration to use and know the advantages with reflector.

1.3 Scopes of the Project

The scopes involve in this project:

1. The implementation of circuit in collecting output power.
2. Choosing the suitable frame structure to hold the solar panel.
3. Choosing the best types of reflector configuration that collect light ray.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter discuss more on the identifying the justification of using reflector configuration system for PV panel to achieve its ideal efficiency, the acceptable design structure for the reflector. Furthermore, tilt angle of the PV panel and the reflector are to be pertinent in this experiment as the based method on the reflector configuration system, and the method require the layout on the based mainframe panel. This chapter also will discusses the theoretical related to the solar system and incident solar radiation that related in gaining more concentration on the reflector.

2.1 Laws of Reflector

2.1.1 Deviation of light by plane mirror

Assume a ray of light, AO, incident on a plane mirror XY (Fig. 2.1) at O, where OB is the reflection. The light ray of AO with plane mirror, XY, produced the angle AOX are known as the glancing angle(α). The glancing angle BOY formed from the reflected ray OB with the mirror is also same to α, since the angle of reflection is equal to the angle of incidence. The angle COY equal to the angle AOX, it follows that angle of deviation, d= 2α, so, generally the angle of deviation of a ray by a plane mirror or a plane surface are twice the glancing angle. (Krishnan and Sathiyasekar, 2015)

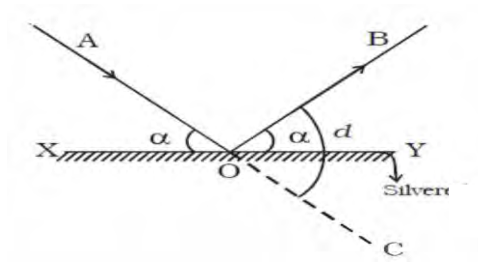

Figure 2.1 Deviation of light by a plane surface

2.1.2 Deviation of light due to rotation of a mirror

To be assume a ray of light AO incident on a plane surface XY at O and reflected to a direction OB. Let α be the glancing angle with XY (Fig. 2.2). We know that the angle of deviation $COB = 2\alpha$. **Angle of incidence**(θ), the angle between the beam radiations on a plane surface stated by (adhem101, 2015). Presume the plane surface is rotated through an angle θ to a position X'Y'.

The identical incident ray AO is now reflected along OP. The equation for glancing angle with X'Y' is$(\alpha + \theta)$. Thus, the new angle of deviation. $COP = 2(\alpha + \theta)$. An rotated of reflected ray through an angle BOP when the plane surface is rotated through an angle, θ.

$$\angle BOP = \angle COP - \angle COB$$

$$\angle BOP = 2(\alpha + \theta) - 2\alpha = 2\theta$$

When the plan surface is rotated through an angle with the same incident ray, the reflected ray are turn through double the angle. (Krishnan and Sathiyasekar, 2015)

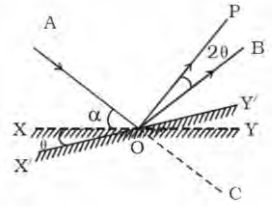

Figure 2.2 Deviation of light due to rotation of a plan surface

2.2 Tilt angle

For collecting the maximum solar radiance, adjust of tilt angle on the solar panels are one of the relevant parameters in solar energy system**.** The tilt angle are commonly area conditionally depend on track of sun in term of daily, monthly and yearly. Required of maximum energy performance in the system are the detail for ideal tilt angle of determination.

Fundamental to be described, solar radiance on sloped surface can be known by solar radiance parameters and models. The outside the earth's atmosphere the solar radiance incident, called extra-terrestrial radiance for a day of the year, n are stated as

$$I_{ext} = \left\{ \begin{array}{c} I_{sc}\left[1.0 + 0.333\cos\left(\frac{360n}{365}\right)\right] \\ I_{sc}\,[1.000110 + 0.034211\cos\left((n-1)\left(\frac{360}{365}\right)\right) + 0.00128\sin\left((n-1)\left(\frac{360}{365}\right)\right) \\ +0.000719cos2\left((n-1)\left(\frac{360}{365}\right)\right) + 0.000077sin2((n-1)\left(\frac{360}{365}\right)) \end{array} \right\}$$

2.2.1 Solar Time

Given as follows the solar time:

Solar time = standard time + $4(L_{st} - L_{loc}) + E$

$$E = 229.2(0.000075 + 0.001868cosB - 0.032077sinB - 0.01461cos2B - 0.04089sin2B)$$

where $B = (n-1)\left(\frac{360}{365}\right)$, L_{st} is the standard meridian for the local time zone, L_{loc} is the longitude of the location. (Yadav and Chandel, 2013)

2.2.2 Solar Geometry

The zenith angle (θ_z) (Fig. 2.3) are given for the orientation of the sun in the sky. The **declination**$(\theta_z) - 23.45° \leq \delta \leq 23.45°$ of the sun at solar noon position. The **slope** (β); $0° \leq \beta \leq 180°$ $(\beta > 90°$ means that the surface has a downward-facing component) are the angle between the plane of surface and horizontal. The divergence of the projection on a horizontal plane of the normal to the local meridian surface, are called **surface azimuth angle** (γ); $-180° \leq \gamma \leq 180°$ with zero on south, east negative and west positive. The angular displacement of the sun east or west of the local meridian due to the orbital of the earth on it axis at 15° per hour with morning negative and afternoon positive are known as hour angle (w). (Yadav and Chandel, 2013)

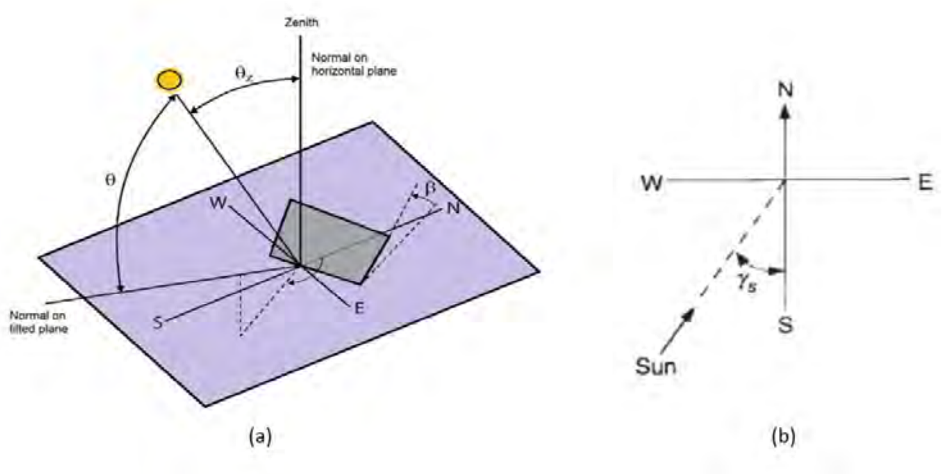

Figure 2.3 (a) Zenith angle, slope, surface azimuth angle and solar azimuth angle for a tilted surface. (b) Plan view showing solar azimuth angle

2.2.3 Global, beam, diffuse irradiance and the sky radiation distribution

The solar radiation for distribution over the atmosphere (Fig.2.4) contains of three components: isotropic dome, circumsolar and horizon brightening. The centre of the sun and skyline where the circumsolar and skyline brightening to be assumed concentrated. The cloudless skies of horizon brightening is the maximum at the skyline and its concentration decrease s apart from the horizon and for cloudy skies. Consist of disperse sky radiation in the circumsolar and horizontal brightening components of the solar radiation for anisotropic models. The intensity of disperse sky radiation to be assumed isotropic models are uniform over the sky dome. (Yadav and Chandel, 2013)

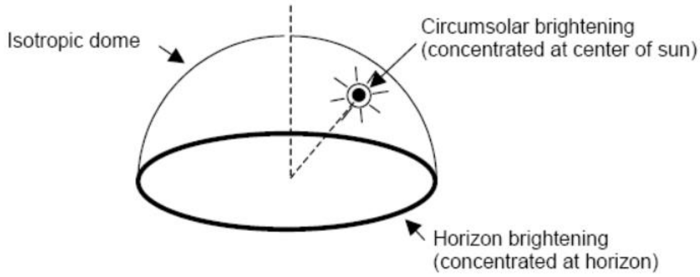

Figure 2.4 Schematic view of sky showing solar radiation distribution component

2.2.4 Solar radiance on sloped surfaces

The horizontal plane and the orientation for values of total solar radiance from which ray and diffuse radiance components get to the plane to determine of solar radiation on sloped surface. The varying of cloud and atmospheric clarity situations distribution of spread radiance influence the distribution of diffuse radiation over the sky dome. The spread solar radiation model contain of three components; receiving of solar radiation equality from the whole of sky dome stated of isotropic part; in circumsolar part, distribution happen because of the forward solar radiation are scattering; skyline brightening occur in sky without cloud and near the skyline. Hence the rakish dispersion of scattering radiance is an element of reflectance (albedo) of ground. Impression of sunlight based radiation back to the sky bringing about skyline lighting up are influenced by high albedo value. Therefore, tilted angle (I_T) of solar radiance incident is given by the relation:

$$I_T = I_{T,b} + I_{T,d,iso} + I_{T,d,cs} + I_{T,d,hz} + I_{T,ref1} \qquad (4)$$

Where $I_{T,b}$ the ray of radiation are, $I_{T,d,iso}$ is the isotropic component, $I_{T,d,cs}$ is the circumsolar component, $I_{T,d,hz}$ is the horizon brightening component of diffuse radiation and $I_{T,ref1}$ is reflected radiation. When radiation view factor is taken into consideration, (I_T) is as follows:

$$I_T = I_b R_b + I_{d,iso} F_{c-s} + I_{d,cs} R_b + I_{d,hz} F_{c-hz} + I_\rho F_{c-g} \qquad (5)$$

2.2.5 Optimum slope angle determination

The solar panel of ideal slope angle confirmation are basic to its well systematic operation because inaccurate positioning usher to potential solar power disappearance. Based on maximizing the solar radiation falling on a sloped surface according to the optimum slope angle calculations, differ types of optimization techniques are apply. (Yadav and Chandel, 2013)

2.2.6 Irradiance

Irradiance (w/m^2) are the rate at which radiant energy is incident on surface per unit area of surface.

2.3 I – V Characteristics of PV Systems

The output voltage of a cell or an array of cells falls as it is called upon to deliver more current with the graph in constant irradiance (Fig. 2.5). When maximum power deliver happens, the voltage has dropped to about 80% of open circuit voltage. The Fill Factor (FF) are know as the ratio between the power at the maximum power point and the product of the open circuit voltage and short circuit current. It is basically better than 75% for good quality solar cells. (Krishnan and Sathiyasekar, 2015)

- *Short – circuit current*(I_{SC}): I_{SC} is the current produced when the positive and negative terminals of the cell are short-circuited, and the voltage between the terminals is zero, which corresponds to zero load resistance. (Khaligh & Onar, 2010)
- *Open – circuit voltage*(V_{OC}): V_{OC} is the voltage across the positive and negative terminals under open-circuit conditions, when the current is zero, which corresponds to infinite load resistance. (Khaligh & Onar, 2010)

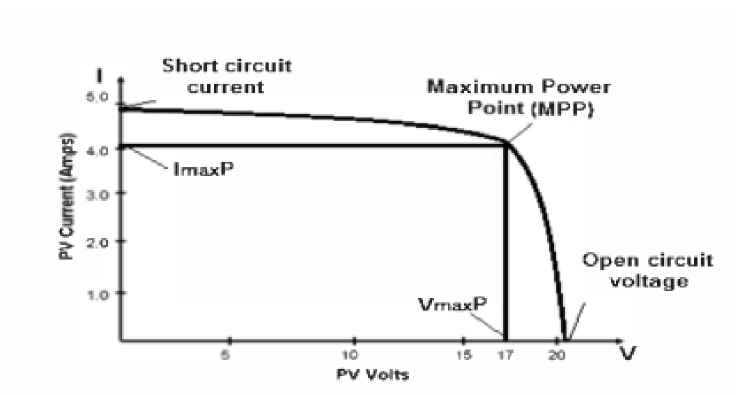

Figure 2.5 I – V characteristics of PV systems

2.4 CPC Solar Collectors

The concentration, C, and undertaking half-angle,θ, are related by $C = 1/\sin\theta$, the reflector is untruncated; the effect of truncated. The flat receiver arrangement has high optical transmission, τ, through the concentrator because its shape factor for straight radiation is larger. τ can be imprecise $\tau = \rho^{\langle n \rangle}$, respectively