Experimental Study of Renewable Energy for Solar Parking in Universiti Teknologi PETRONAS (UTP)

by

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16813

Dissertation submitted in partial fulfilment of

the requirements for the

Degree of Engineering (Hons)

(Mechanical)

MAY 2015

Universiti Teknologi PETRONAS,

Bandar Seri Iskandar,

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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

____

(Ir. Dr. SUHAIMI BIN HASSAN)

UNIVERSITITEKNOLOGI PETRONAS

TRONOH, PERAK

May 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that original work is my own except as specify in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(CHE WAN JUWAIRIAH BINTI CHE WAN ZAIKI)

ABSTRACT

This project is conducted to get the best angle for optimum power generation based on the temperature distribution and the power output. The experimental work is carried out at Universiti Teknologi PETRONAS (UTP). Throughout the project, the solar photovoltaic experiment is conducted to collect the data of the project such as temperature of the air and irradiation that pass through on the photovoltaic plate. The power output and temperature on photovoltaic panel (PV) is considered in order to find the optimum power generation. The graph is plotted. The GAMBIT software is used to design and mesh the geometry. For the simulation, the radiation heat model have been modeled with radiation restricted within the annular region using Discrete Ordinates model. Besides, the solar fluxes and temperature have been modeled using the Solar Load Model. The comprehensive analysis is performed using ANSYS Fluent 15.0.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia's industrialization policy among other things has resulted high energy demand as increase 7% in 2010 and is expected will increase by 4.7% per annum by the year 2030. The electricity is still generated by using fossil fuels such as coal, oil and gas. As a result, it will give a big impact to the environment as the fossil fuel is one of the energy that contributes the pollution including carbon dioxide (CO_2) emissions and global warming (Saboori et al., 2014). Solar energy is considered one of an alternative source of renewable energy where the radiant from the sun is utilized to convert the energy into electricity. The energy can be manipulated into another type of energy by using the photovoltaic and concentrating solar thermal devices (Latiff, 2009). There are abundant of technologies that are used nowadays to harness the energy from the sun as solar thermal energy as the sun can radiate more energy in one second (Islam et al., 2010).

According to Cardas Research & Consulting Sdn Bhd,it has stated that Malaysia is a suitable location to develop solar technologies as it has a constant sunshine of up to eight hours with an average radiation of 4500 kWh/m^2. Thus, it can create an ideal environment due to renewable energy does not emit any greenhouse gases and it is very clean. Table 1.1 is showed the total world's primary energy consumption in 2009.

Table 1. 1: Total World's Primary Energy Consumption in 2009 (EIA, 2010)

Type of Energy	Fuel/Process	Percentage (%)
Non-Renewable Energy	Petroleum Oil	37
	Natural Gas	24
	Coal	23
	Nuclear Power	8.0
Renewable Energy	Biomass Material	4.3
	Geothermal and Hydropower	3.1
	Solar and Wind	0.6

1.2 Problem Statement

Tronoh area in Perak, has higher availability of solar energy. Therefore, the installation of PV is very suitable as the PV needed the sunlight to generate power output. However, the performance of solar is slightly reduced because of the tilt angle of the PV panel. Therefore, the investigation in terms of experimental study is required to understand and to determine the optimum angle of the fixed PV should be installed in order to get the maximum power output.

1.3 Objectives

The main objective(s) of this study are:

1. To study the alternative renewable energy from solar.
2. To study the optimum angle of solar photovoltaic based on experiment and simulation.
3. To investigate the power generation from solar panel system at different tilt angle

1.4 Scopes of Study

The scope of study involved the solar energy, solar radiation and working principle of PV system which will be used to carry out the experimental work. Besides, the FLUENT is used to complete the simulation. The project is planned to be done in form of simulation of the PV panel at different tilt of angle. In addition, the project also involved the tilt angle of PV panel based on the power output and temperature distribution on the PV panel surface. The project will be carried out in UTP.

The expected progress and timeline are deliberated in the subsequent chapters as demonstrate in the Gantt chart and project key milestone respectively.

CHAPTER 2

LITERATURE REVIEW

2.1 Renewable and Non-Renewable Energy

The industrialization policy in Malaysia has resulted high in term of energy demand for renewable and non-renewable energy (Saboori et al., 2014). Renewable energy can be defined as sources of energy that does not run out with use over time due to the energy can be found in abundance around us. Renewable also can be defined as "energy obtained from the continuous or repetitive currents of energy recurring in the natural environment" and "energy flows which are replenished at the same rate as they are used" (Baharin, 2007). The renewable energy is sustainable because can be found everywhere across the world in contrast to non-renewable and essentially clean and environmentally friendly (Latif, 2009). According to Mekhilef (2010) he concluded the renewable energy resources such as solar, biomass, hydro and wind power energy are friendly energy sources to the environmental.

Fossil fuels are example of the non-renewable energy, the main current sources of energy that are not sustainable which have negative impact on the environment by releasing CO_2 gas and caused a global warming (Saboori et al., 2014). In addition, Latif (2009) stated that the even though new reserves might be found in the future, the non-renewable energy still remain limited as the rate of energy demand increasing over the year. The examples of conventional energy that contribute to environmental damage and atmospheric cleanness issues are oil, natural gas, and coal.

2.2 Overview of Solar Energy

Tropical weather in Malaysia is suitable for the renewable energy development such as solar energy. It was reported that an average of sunshine is 8-12 hours per day and may be reached about 5.5 kilowatt hours per meter square (kWh/m^2) of the solar radiation (Saboori, 2014). Ahmed and Sulaiman (2003) defined the solar radiation is part of the energy spectrum of electromagnetic radiation emitted by the sun.

Solar energy is radiant energy that is produced by the giant ball which is sun and every day the sun radiates, or sends out an enormous amount of energy in every one second (Islam., 2010). According to Latif (2009), solar energy are clean, no pollution and environmental friendly. The solar energy are sustainable and plentiful as it can be found everywhere across the world in contrast to fossil fuels and minerals. Saboori et al. (2014), supported this statement by mentioning the solar energy is clean energy and can reduce the high emission from the conventional energy sources. They also mentioned solar source is limitless potential and free of cost.

In addition, solar energy is used for electricity power generation (Ahmed & Sulaiman, 2003). There are three types of solar energy usage, namely solar thermal energy, solar ponds and ocean thermal energy conversion. The first is solar thermal energy, the simplest and economical ways of utilization for hot water pool and space heating applications. For the solar ponds, the working principle is based on the capture of solar radiation in three different layers of salt concentration solution. The bottom water layer is a concentrated (saturated) salt solution, the middle layer is a salt concentration gradient with decreasing the salt concentration from the bottom water and the top layer is fresh water. The other type of solar energy usage is ocean thermal energy conversion, used the second law of thermodynamics that have efficiency 11% at a temperature $30^{o}C$. The efficiency shows the low conversion of heat to electricity. Therefore, it will become a disadvantage to the ocean thermal energy (Islam et al., 2010).

2.3 Working Principle of PV System

There are four major types of PV cells namely, mono-crystalline (or single crystalline), poly-crystalline, amorphous and organic cells. Nano PV is also a newly introduced kind of solar cells. The mono-crystalline is formed by melting the high purity of silicon, then it will be sliced very thinly and will be processed into solar panel. The poly-crystalline is made up from pure metal silicon (Mondola, et al., 2011).

Sunlight is made up of the photons which is the small particles of energy. In addition, the PV cell, also called solar cell can produce a voltage difference when a source of light shines on it. When the solar cell gets connected to wires, the electrical current will flows through the wire, as a result work will be produced. (Akhmad, K., et al., 1994).

Then, the photon is absorbed by and pass through the material of the photovoltaic panel. By the absorption of the photon through the material, the electron in the cell will be agitated and will produced the movement. Due to these movement, it will routed into a current. These electrons will be conducted by the wire to the batteries as batteries function to store the energy for later use. Thus, the electricity power can be generated by the movement of electrons along a path of photovoltaic (Jamaludin, 2008). Correspondingly, Ahmed and Sulaiman (2003) mentioned the solar energy is used for power generation purpose too.The conversion of the light to electricity by using some kind of material was discovered by French Scientist, Edmund Becquerel (Akhmad, et al., 1994).

There are several elements to be considered before installation the solar panel. According to Ahmed and Sulaiman (2003), the area of solar presence is affected the solar energy power. Hence, before install the solar panel, the sun information must be corrected, accurate and the amount of the energy received from the sun are necessary to be evaluated based on the area. On the other hand, the basic parameters of solar energy system are needed to be as accurate as possible to make sure the solar energy can generate the power as maximum as it can. The solar working principle is showed in Figure 2.1.

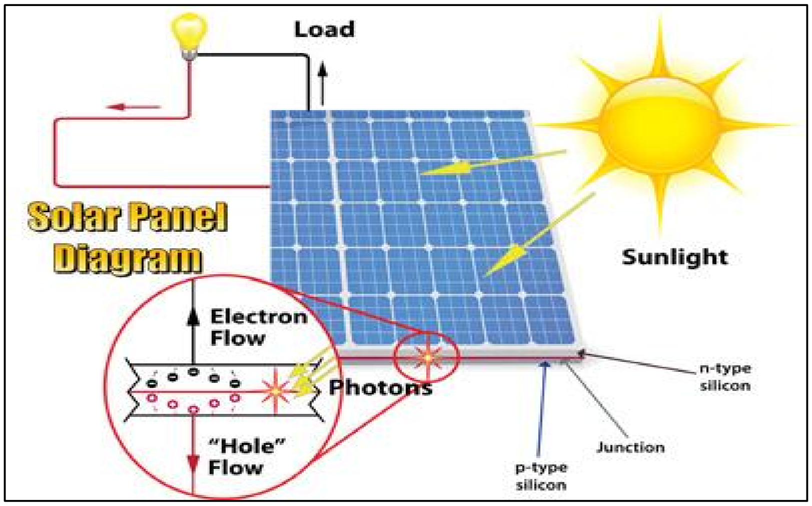


Figure 2. 1: Photovoltaic System

2.4 Solar Geometry

The solar geometry can establish the theoretical data of seasonal and hourly changing position of the sun (Surles, 2009). Writz et al. reported laboratory experiments on natural convection across a tilted rectangular enclosure where the uniform temperature difference is maintained between two opposite side walls. The showed that the maximum heat transfer occurs at a tilt angle between 50° and 60°. Based on the experiment, the optimum tilt angles of the solar panels may be determined when the tilted angle is varied from 0° to 90° as shown in Figure 2.2 (Bakirci, 2012).

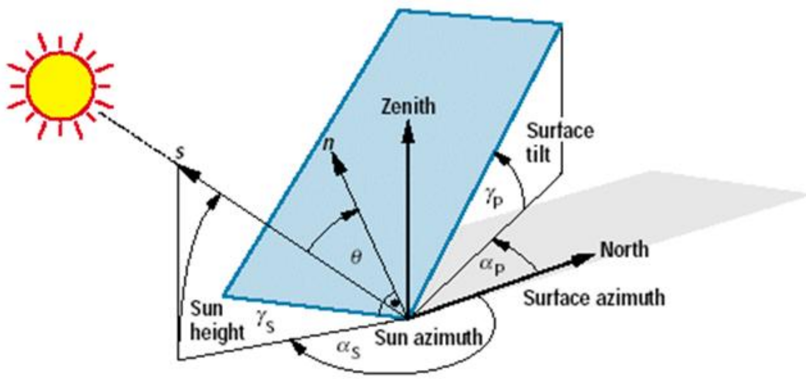


Figure 2. 2: Solar Angle

Below are the summary of the solar geometry angles (Surles, 2009):

A) Zenith Angle, θ_Z– Zenith Angle is the angle distance between the subsolar points and the current place latitude.

B) Elevation Angle, α_s – Angle between the lines that point to the sun and the horizontal plane. Sun angle is the complement of Zenith Angle (Sun Angle = 90° -Zenith Angle). Some other sources call this as beam angle, elevation angle and solar altitude angle.

C) Solar Azimuth Angle, γ_S – The angle between the line that point to the sun and the line that point to the south.

D) Surface Azimuth Angle, γ – The angle between the line that points straight out of the photovoltaic panel and south.

E) Declination Angle, δ – Declination Angle varies seasonally due to the tilt of the Earth on its axis of rotation and rotation of Earth around the sun. The range of the angle will change from 23.45° to 0° and then to -23.45°.

F) Angle of Incidence, θ – Angle between the line that point to the sun and the angle that point straight out of the solar photovoltaic panel.

2.5 Tilt Angle of PV Panel

A photovoltaic (PV) system should be installed to maximize the solar contribution to a particular load. Usually, a surface with tilt angle identical to the latitude of a location obtains maximum insolation. (Mondola, et al., 2011).The optimum tilt angle is thus site dependent and calculation of this angle requires solar radiation data for that particular site for the whole year. In general, during summer, the incident insolation is maximized for a surface with an inclination 10–151 less than the latitude and, during winter, 10–151 more than the latitude (Duffie, and Beckman, 1991).

In fact, for housing users who pay a constant utility rate, the greatest PV surface inclination and orientation directs to the maximum total annual PV generation (Mondola, et al., 2011).

Furthermore, Nakamura et al.,(2011) have reported that PV efficiency reduced by 1% for a horizontal surface than for a 301-tilted surface due to difference of solar incident angle, solar spectrum and dirt on the module surface for a location at latitude 34.451N and longitude 137.41.

In another research paper, an experimental study demonstrated that for a location with latitude 35.71N and longitude 51.41, the maximum PV energy was created by a surface with tilt angle of 29º (Soleimani, et al., 2001).The voltage at the maximum power point reduced to half when the azimuth angle was between 01 and 151 whereas, output power declined by 75% when PV array was oriented 901 east and west from due south (Akhmad, et al., 1994).

Shading drastically lessens the solar collector's efficiency "η" by reducing cell power "PMP", and varying the short circuit-current "ISC", the open circuit voltage "VOC", and the fill factor "FF" (Partain and Fraas, 2011). The shading on a collector may be cast by its neighbor and or by a fence, and is reliant on the spacing between collectors, and on collector height, row length, tilt angle and latitude location (Joe, 2005; Appelbaum and Bany, 1979).

In this scope, there are two important parameters for solar design projects are the altitude angle and azimuth angle (Guo et al., 2012). The azimuth angle is calculated in the horizontal plane between the due-south direction and the projection of the sun-earth line onto the horizontal plane. Azimuth angles have a sign convention, as do other solar angles. The altitude angle depends on three fundamental angles: the solar declination (δ), the latitude (ϕ), and the solar hour angle (ω) (Liu and Jordan, 1960).

Even more, there was an analytical equation to find the daily optimal tilt angle at any latitude has also been used (El-Kassaby and Hassab, 1994). As for example, the average optimal tilt angle on Cyprus (latitude φ = 35°N) equals 48° in the winter months (φ + 13°) and 14° (φ – 21°) in the summer months (Ibrahim, 1995). The optimal tilt was estimated for Brunei Darussalam on the basis of maximising the global solar irradiation reaching the collector surface for each month and year (Yakup and Malik, 2001).

The optimal tilt angle in Turkey varies from 13°–61° from summer to winter (Kacira et al., 2004), while the monthly optimized tilt in Ireland can vary from 10° to 70° (Mondol et al., 2007). The optimal tilt for the whole of Europe (PVGIS) shows that climate characteristics have a huge influence on the optimal tilt (Huld et al., 2008). In this input, therefore we particularly emphasize local weather and climatic conditions when computing the optimal orientation and tilt.

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 Project Work

In order to assist execution of the project, the experimental and simulation activities need to be done to arrive at more complete understanding and background of the project. The following project work is proposed as shown in Figure 3.1.

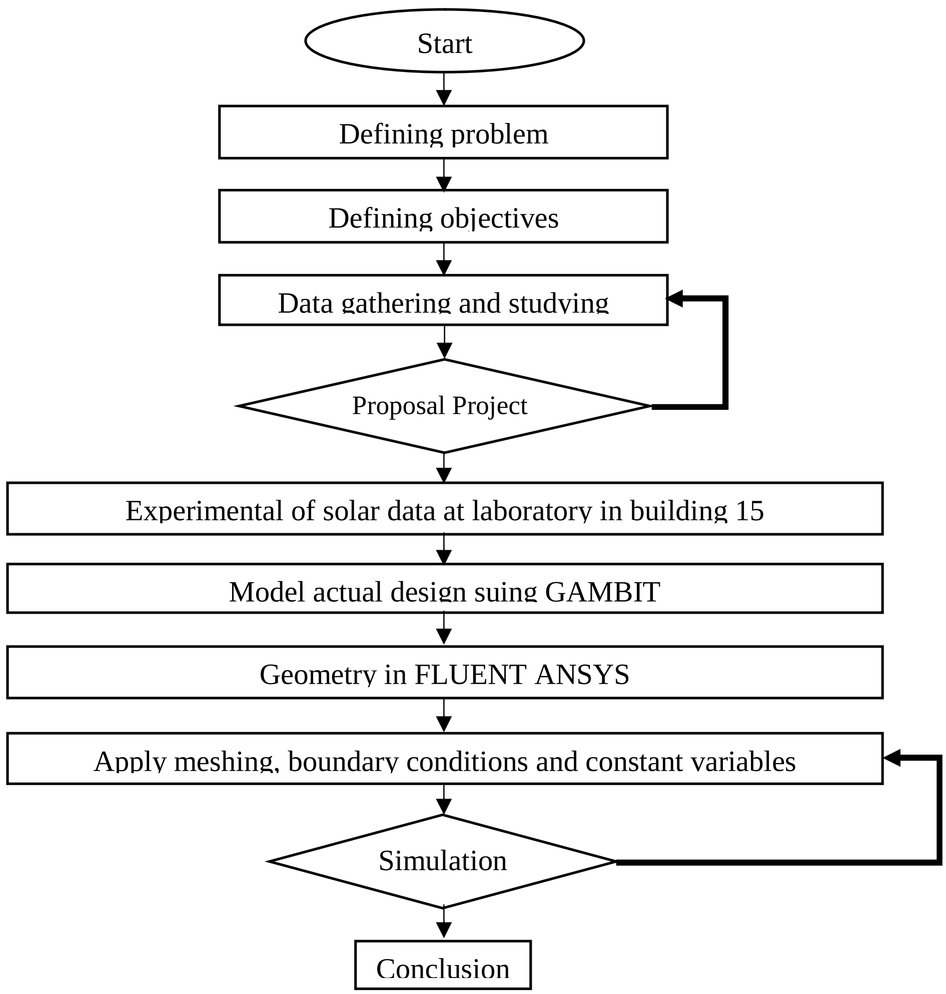


Figure 3. 1: The project work

3.2 Gantt-Chart

The Gantt-chart for Final Year Project I and II are attached in Table 3.1 and 3.2

3.2.1 Final Year Project 1

Table 3. 1: Gantt-Chart for FYP 1

Activity	Jan		Feb				March					April		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Introduction														
Solar Photovoltaic system														
Research/Literature Review														
Finding Research Papers														
Understanding the working principle of PV system														
Literature Review														
Experimental Work														
The optimum angle of PV panel														
Conceptual Design														
Using CATIA v5 to design the actual PV system in laboratory														
Report Submission														
Proposal Drafting						●								
Extended Report						●								
Proposal Defense at Building 18														
Project Work Continues														
Interim Draft Report													●	
Interim Report														●

Table 3. 2: Gantt-Chart for FYP 1

Activity	May			June				July				August			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ANSYS Workbench															
Study Software Simulation	■	■	■	■	■	■									
Model the actual PV System					■	■	■	■	■	■	■	■			
Run the simulation for 0°, 30°, and 60°					■	■	■	■	■	■	■	■			
Run the experiment															
Other Parameter that affected the performance of PV system											■	■			
Report Submission															
Submission of Progress Report							●								
Pre-SEDEX										●					
Draft Final Report											●				
Dissertation (Soft bound)												●			
Technical Paper												●			
Viva Presentation													●		
Project Dissertation (Hard Bound)															●

Legend

■	Process
●	Key Milestone

3.3 Experimental Set-up and procedure

The experiment was conducted using PV polycrystalline solar panel with specification as shown in Table 3.3. The panel is illustrated as Figure 3.2. The purpose of experiment is s to find the optimum tilt angle of PV by analyze the optimum power output.

Table 3. 3: Specification of PV Panel

Type	**Polycrystalline**
Dimensions (mm)	778 x 659 x 35
Short Circuit Current (lsc)	4.05 A
Max Power Output (W)	66

Figure 3. 2: PV panel

3.3.1 Instrumentation

The instrumentations were used to measure the parameters that involved in the project. Below are the list of the instrumentations:

A) Photo-radiometer is used to measure the irradiation absorb from PV panel as in Figure 3.3 with specification in Table 3.4.

Table 3. 4 : Specification of Photo-Radiometer

Dimension (mm)	140 x 88 x 38
Weight	160g
Material	ABS
Measuring range of	1.0 mW/m² - 2000W/m²

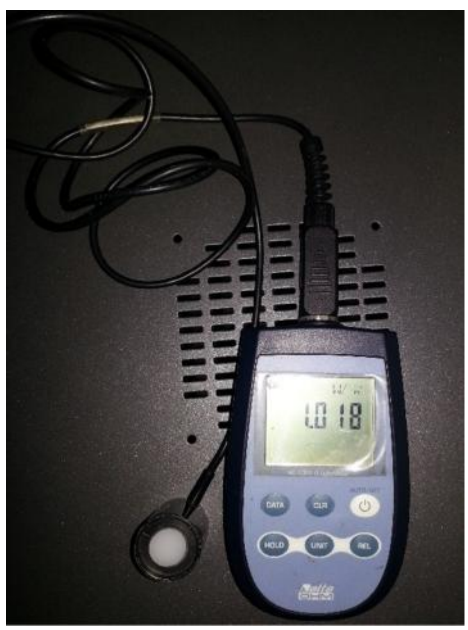


Figure 3. 3: The Photo-Radiometer

B) MY64 Digital Multimeter is used to measure the current and voltage of PV panel during the experiment. The specification of multimeter is attached as in Tabble 3.5.

Table 3. 5: Specification of multimeter

Max.LCD display	1999
Range selection	Manual
DC voltage	200m/2/20/200V ±0.5%,1000V ±0.8%
AC voltage	2/20/200V ±0.8%, 700V ±1.2%
DC current	2m/20mA ±0.8%,200mA ±1.5%,10A ±2.0%
AC current	2m/20mA ±1.0%,200mA ±1.8%,10A ±3.0%
Resistance	200/2k/20k/200k/2MΩ ±0.8%,20MΩ
Capacity	2n/20n/200n/2µ/20µF ±4.0%
Frequency	20kHz ±1.5%
Temperature	-20°C ÷ 1000°C
Accuracy	0.5%
Bandwidth	40 ÷ 400 Hz
Diode test	0.8A / 3V
Auto power off	yes
Battery indicator	yes
Impedance	10 MΩ
Power	9V 6F22 battery

C) Anemometer is used to measure the velocity and temperature of the ambient on the surface of the PV panel during the experiment as in Figure 3.4.

Circuit	Custom one-chip of microprocessor LSI circuit.	
Display	LCD size : 58 mm x 34 mm.	
Measurement Unit	*Air velocity:* m/S (meters per second), Km/h (kilometers per hour), Ft/min (feet per minute), Knots (nautical miles per hour), Mile/h (miles per hour)	
	Air flow: CMM (m^3/min., cube meter per min.), CFM (m^3/min., cube feet per min.)	
	Air temperature: ℃, ℉	
	Type K/ Type J thermometer. ℃, ℉	
Sampling Time of Data Logger	Manual	Push the data logger button once will save data one time. *@Set the sampling time to 0 second*
	Auto	2 sec to 8 hour 59 min. 59 sec.
Sensor Structure	*Air velocity & Air flow :* Conventional twisted van arm and low friction ball bearing design, vane use metal material.	
	Air temperature : Thermistor.	
	Type K/ Type J thermometer. Thermocouple	
Temperature Compensation	Automatic temp. compensation for the Type K/J thermometer.	
Data Hold	Freeze the display reading.	
Memory Recall	Maximum & Minimum value.	

Figure 3. 4: Anemometer with the specification

3.3.2 Setting Up Experiment

The various angles is set up during the experiment as stated in Table **3.1** below. The angle is measure up by using protector as Figure **3.5** below.The experimental work is carried out nearest to building 15 in UTP. The data needed which the temperature and velocity on the PV panel, the irradiation absorb by PV panel and the voltage and current output are measured by using anemometer, photo-radiometer and multimeter respectively. The experiment was started from 10:00am to 3:00pm.

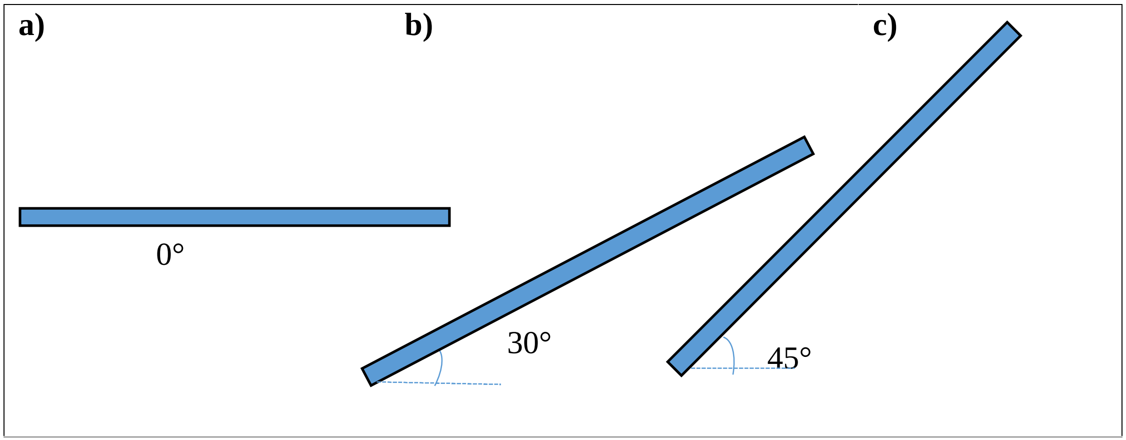


Figure 3. 5: a) At 0°, b) At 30°, c) At 45°

Table 3. 6: The setting angle during the experiment

No.	Angle, θ (°)
1	0
2	30
3	45

3.3.3 Temperature Data Collection

Anemometer as Figure 3.6 below is used to measure the temperature of air on the surface of solar photovoltaic by using different angle. The reading is taken three times at the same angle with five same point on photovoltaic to ensure the accuracy of the temperature by using the average of the reading.

Figure 3. 6: The anemometer can be measured temperature and velocity of air on solar photovoltaic surface.

3.4 Simulation

3.4.1 Gambit

The PV panel is designed based on the actual size by using the Gambit software. In the Gambit, the geometry can be meshed as attached in the figure above. After the mesh process in Gambit, the design is exported to ANSYS Workbench as Figure 3.7.

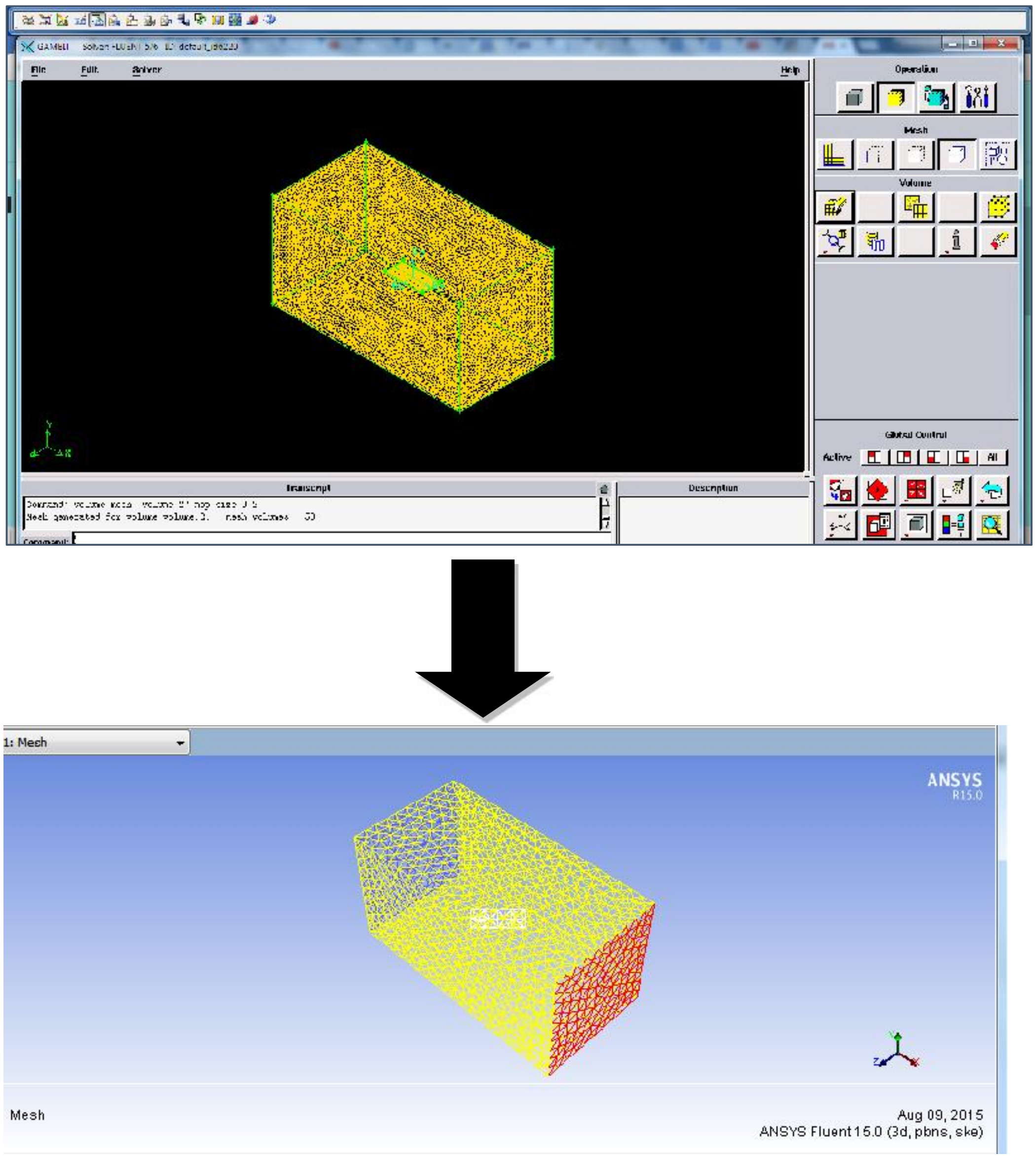


Figure 3. 7: The geometry of the mode

3.4.2 ANSYS 15 Workbench

A) Geometric Modelling and Meshing

The geometry consists of one plate (PV panel) in the fluid region. Table 3.7 describes the geometrical parameters of the plate.

Table 3. 7: Geometrical parameters of the PV panel

PV panel configuration	Parameter
Area (mm)	778 x 659
Thickness of the plate (mm)	35

The plate is modeled at different angle which is 0°, 30° and 45° with the same position. The time for each simulation is same, 9:00 am, 12:00 pm and 3:00 pm by using the solar calculator.

B) Setup

ANSYS Fluent provides a model that can be used to calculate the radiation effects form the ray of the sun that enter a computational domain. The date, time, longitudinal, latitude and timezone (+GMT) are needed in order to set input the solar calculator. Therefore, the ANSYS Fluent application can help in locating the exact position of the sun radiation.

The corresponding geometries at three different angle and at three different times are tabulated and demonstrated in the Table 3.8 and Figure 3.8 respectively.

Table 3. 8: Time of the simulation with the position of solar irradiation

Time of the day	Solar Irradiation (W/m^2)	Position of Solar Irradiation (x, y, z)
9:00 am	667.766	(0.803, 0.364, 0.421)
12:00 pm	863.742	(0.310, 0.328, 0.891)
3:00 pm	856.06	(-0.391, 0.331, 0.858)

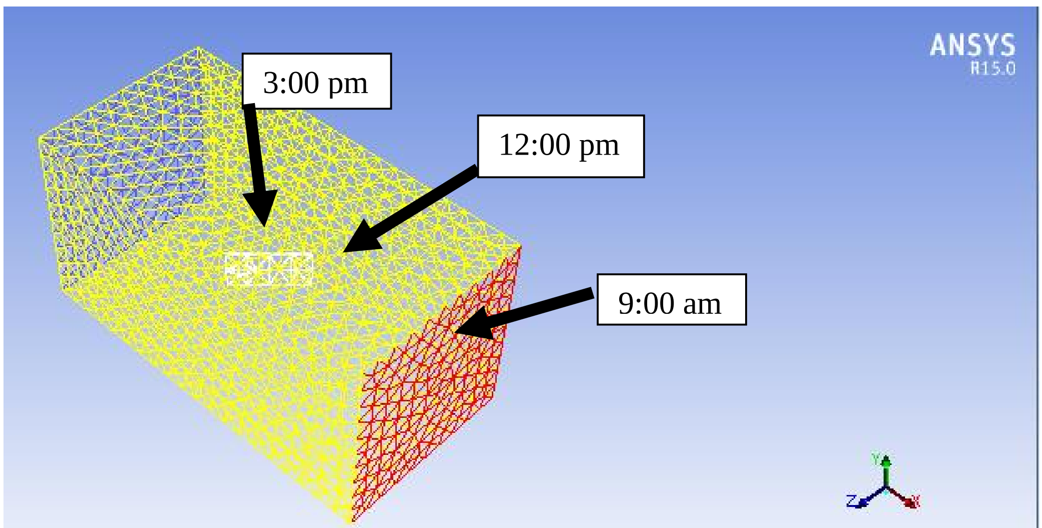


Figure 3. 8: The axis of the sun radiation based on time

C) Solution

The iteration used in the simulation is about 10000 in order to make sure the simulation is completely converge.

D) Result

Results are attached in the discussion in Chapter 4.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

There are two results in this project. The first result is from the experimental work and followed by the simulation result. The experimental and simulation result was recorded on 27th June 2015 at car parking building 15 and by using simulation correspondingly. The reading of temperature of air, irradiation, current and voltage are taken five times to get the accurate average of the data. For the simulation, the software used is ANSYS 15 to find the temperature distribution and heat fluxes on the panel.

4.1 Experimental result

4.1.1 Solar Insolation Data

The solar insolation data were taken from a research on development of optimum solar electricity generating system in UTP (Najib, 2013).Based on research paper, the data was recorded from 7 am to 7pm. Table 3.1 shows the data from 10:00 am to 3 pm due to the scope of this project only cover from 9:00 am to 3pm.

Table 4. 1: Hourly Solar Insolation Data

Time	Average W/m^2
9:00 – 10:00	221.8053
10:00 - 11:00	538.9889
11:00 – 12:00	667.0619
12:00 – 01:00	712.4719
01:00 – 02:00	517.8383
02:00 – 03:00	405.1090

4.2.2 The irradiation on PV panel at different inclination angle

The result shows the irradiation absorb by PV for at inclination of 0°, 30° and 45°. The data was recorded from 9:00 am to 3:00pm. Based on the project, the data was compared with simulation at 9:00 am, 12:00 pm and 3:00 pm only due to the position of sun was obviously changes in gap of three hour.

At 9:00 am the inclination of 45° has the highest irradiation which is 0.7176 W/m^2 while the 0° and 30° recorded 0.4572 W/m^2 and 0.5722W/m^2 individually. At 12:00 pm and 3:00 pm, angle 30° is the highest irradiation, 1.4142W/m^2 and 1.1068W/m^2 individually. The result shows that the irradiation of the sun strongly be affected by tilt angle of the PV panel. Although the angle of the sun changed at 3:00 pm, the panel for 30º recorded the highest data because the surface still can be exposed to the sun.

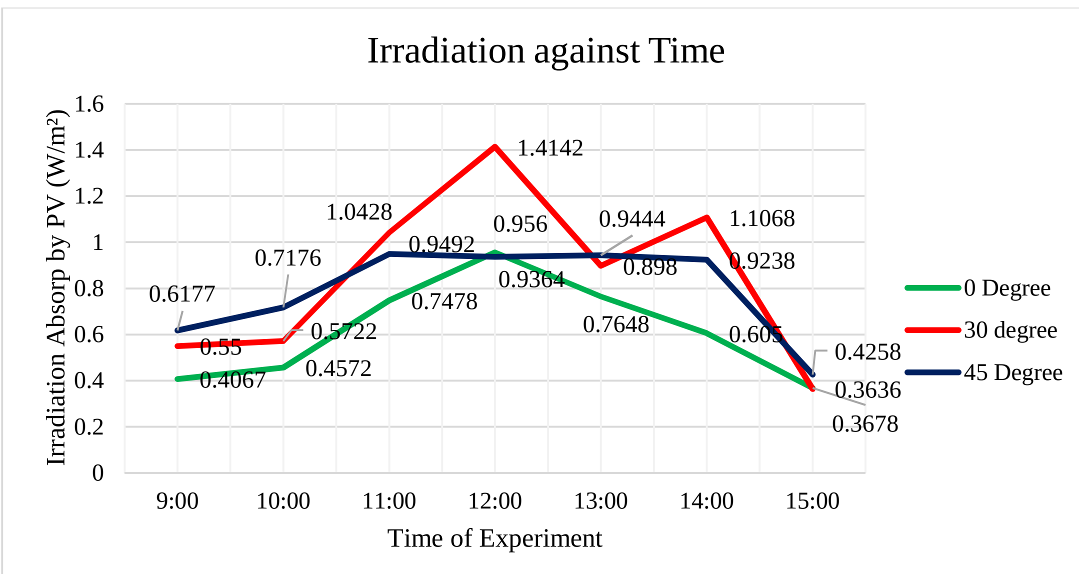


Figure 4. 1: The irradiation on PV surface

4.2.3 The power output at different inclination angle

The power also compared for 9:00am, 12:00pm and 3:00pm. Based on the Figure 4.2, the power is slightly increased as the increasing of the irradiation. The power is calculated as below:

$$P = IV$$

Where,

P is power (Watt)

I is current (Ampere)

V is voltage (Volt)

Based on the results, the current and voltage are increase as the solar irradiation increase and vice versa. Based on the observation, at 9:00 am, the 45° angle is highest power output while at 12:00 pm and 3:00 pm, 30° angle recorded the highest power output. This is because the explosion of the panel to the sun.

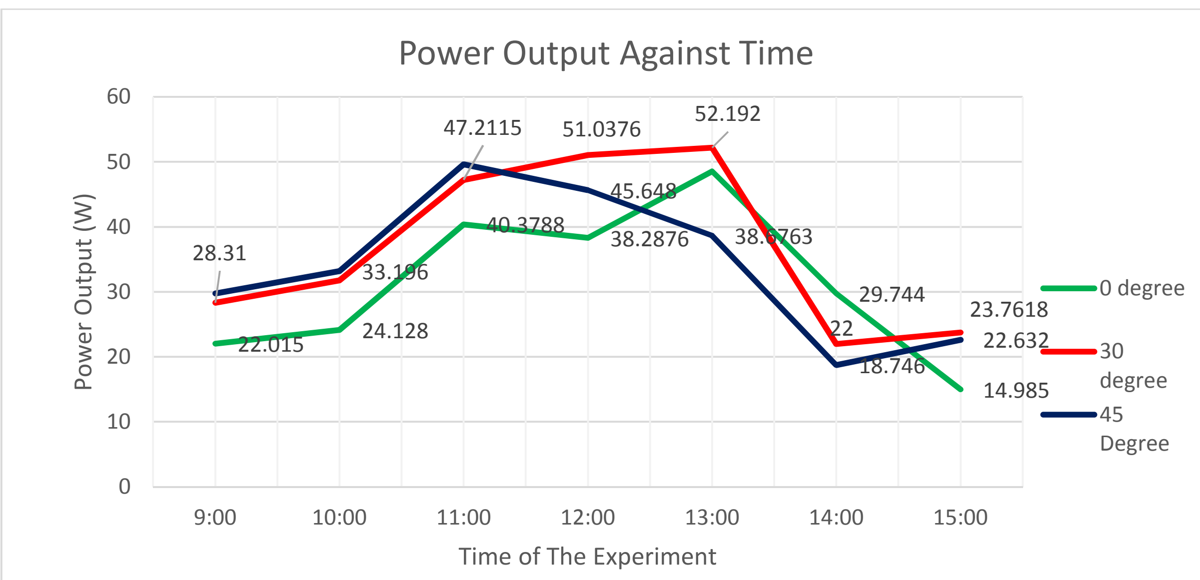


Figure 4. 2: Power output

4.2.4 The temperature distribution on the panel

The temperature on the PV panel is plotted as shown in Figure 4.3. The temperature is considered as the sun emitted electromagnetic light. More solar means more heat transfer will be occurred. Therefore, when there is a heat transfer, the temperature will be affected and will be increased. When the temperature was increased, means more light energy hit the panel. So, the power output will increase. Therefore, the more sunshine, the hotter the panel and the temperature will be increased. The 30° of angle plotted the highest temperature. It can be concluded that the angle of 30° is the maximum surface exposed to the sun radiation

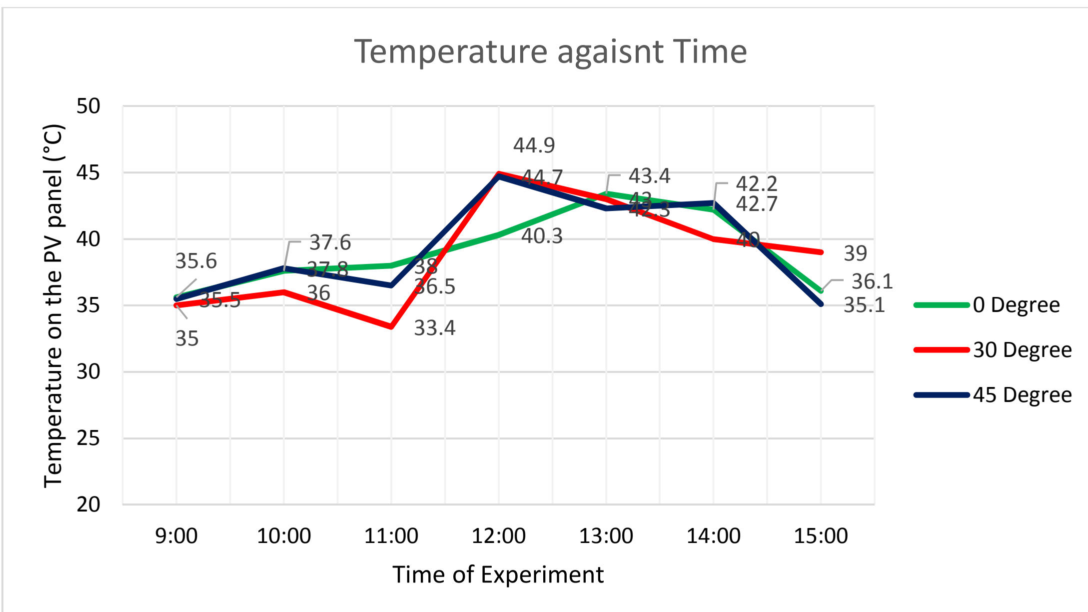


Figure 4. 3: Temperature distribution

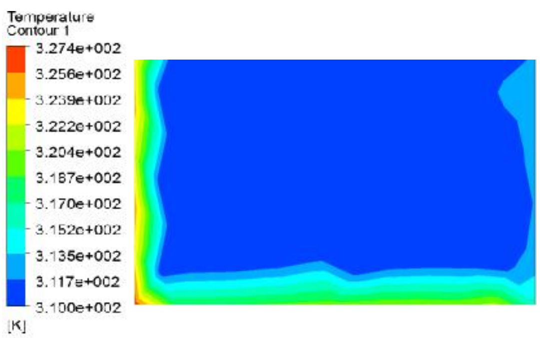
4.3 ANSYS Workbench Simulation

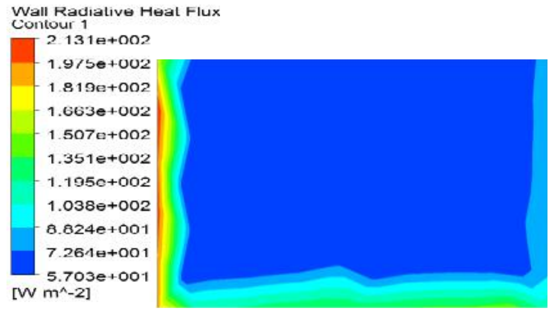
The Figure 4.4, 4.5and 4.6 attached in this chapter shows the result of the simulation based on the temperature and heat flux at upper surface the PV panel. The figure shows the solar intensity is transmitted via the upper surface. The temperature distribution is considered because the sun emitted electromagnetic light and will be released the heat on the Earth. Therefore, the more sunshine, the hotter the panel and the temperature will be increased.

The results variation due to the angle of the plate facing the light source is different. At 9:00 am, angle of 45° has a highest temperature distribution and heat flux. This is due to the plate facing directly to the light source. The contour shows the maximum temperature occur at the side of the sunset.

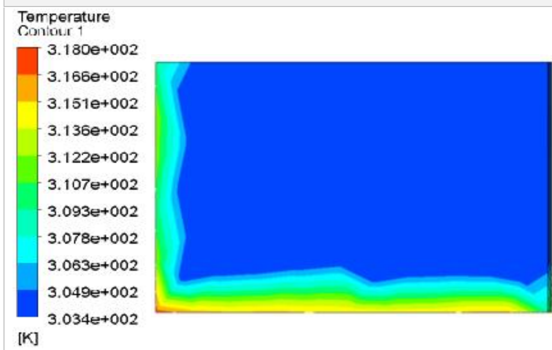
For 12:00 pm, the 30 degree shows the maximum contour for temperature and heat flux. At noon, the solar radiation is very large while 45 degree of angle shows the highest temperature and heat flux at 3:00 pm. Therefore, the suitable angle of PV panel that suitable for install is between 30-45 degree due to they can be exposed to sun high compare to 0 angle.

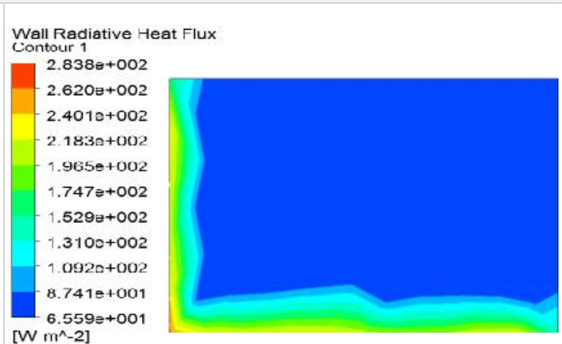
a) Simulation at 9:00 am.



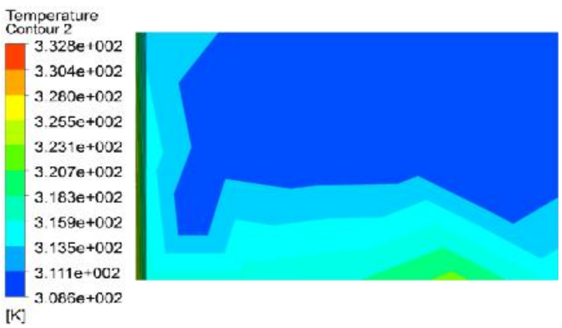


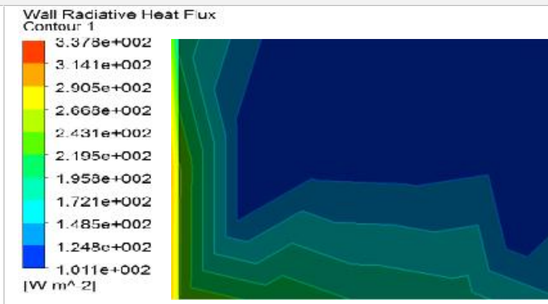
a) 0





b) 30



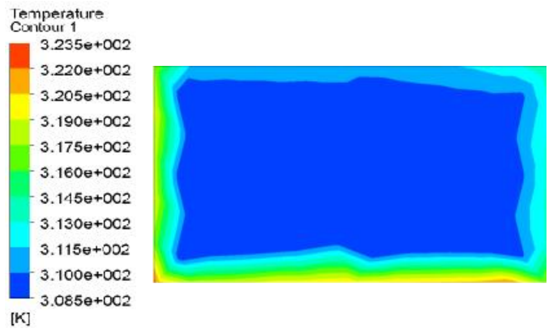


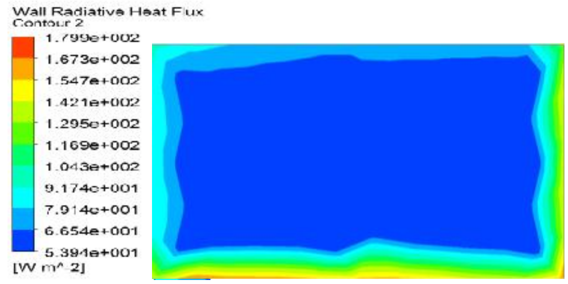
c)45

Wall Temperature Distribution (K)	**Solar Fluxes(W/m^2)**

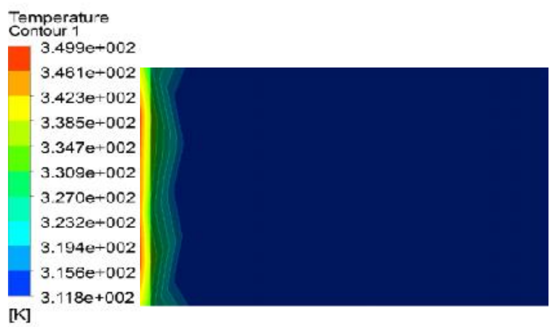
Figure 4. 4: Contour distribution at 9:00 am

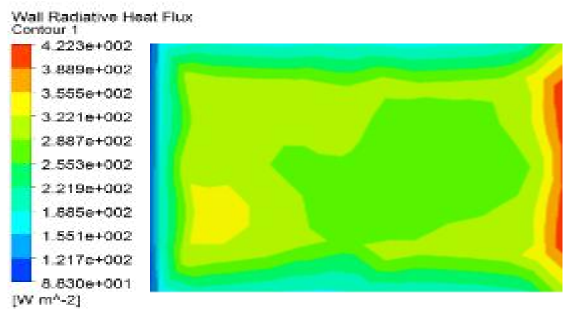
b) At 12:00 pm



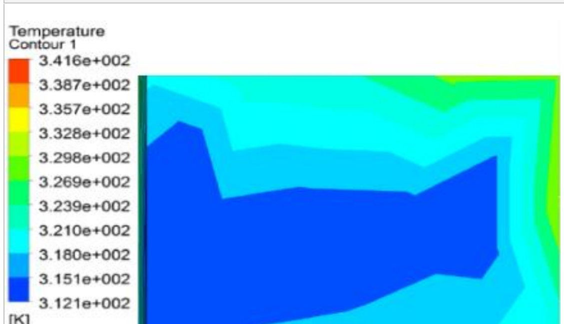


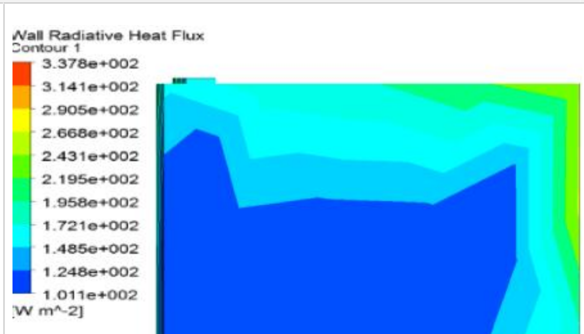
a) 0





b) 30



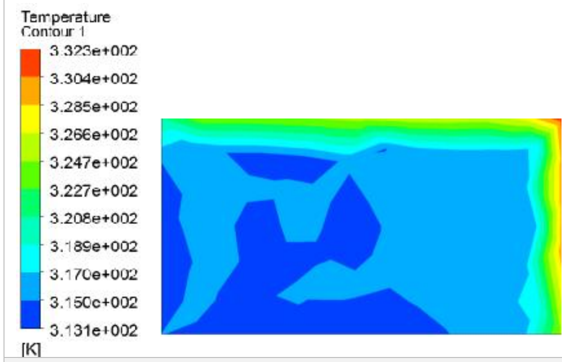


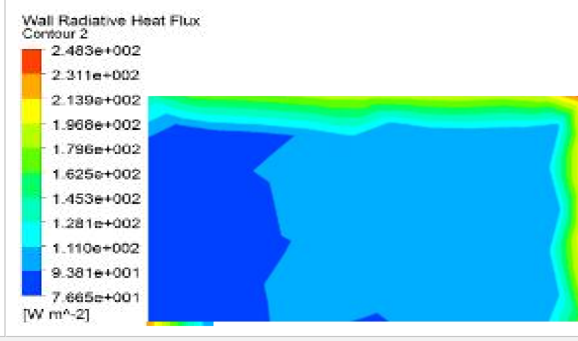
c)45

Wall Temperature Distribution (K)	**Solar Fluxes(W/m^2)**

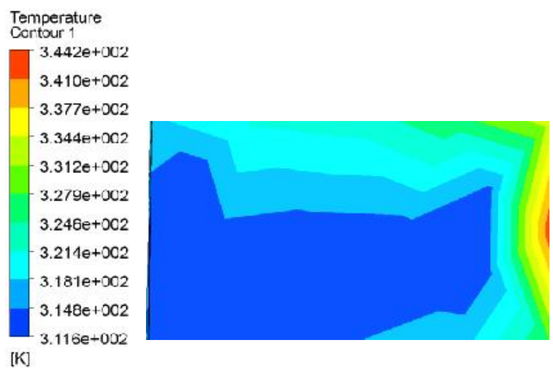
Figure 4. 5: Contour distribution at 12:00 pm

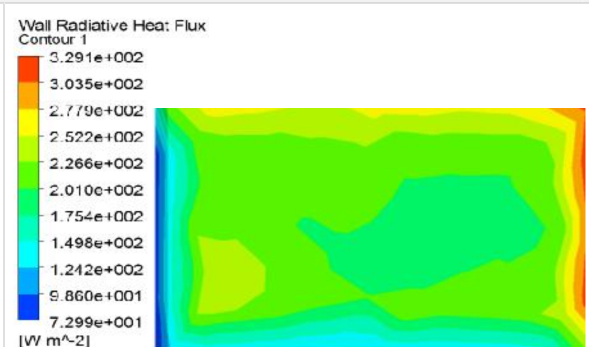
c) At 3:00pm



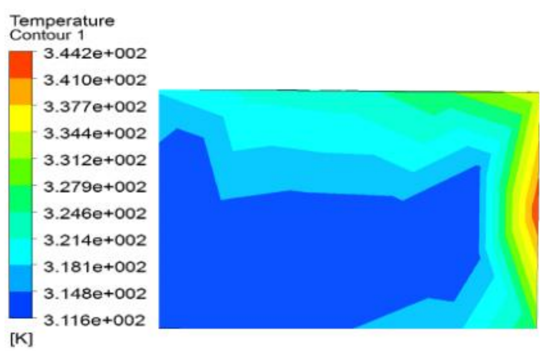


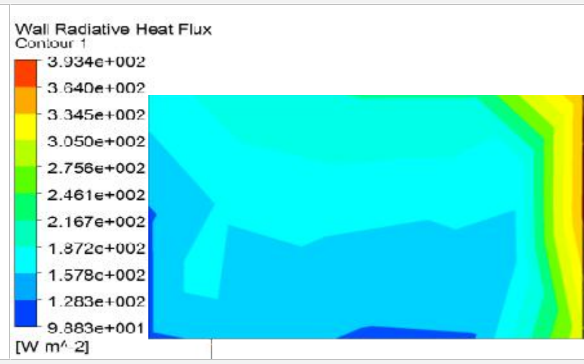
a) 0





b) 30





c)45

Wall Temperature Distribution (K)	**Solar Fluxes(W/m^2)**

Figure 4. 6: Contour distribution at 3:00 pm

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This study analyzed the angle of the panel should be installed to get the optimum power output in Tronoh, Perak. From the experiment results, the maximum power output at 9:00 am, 12:00 pm and 3:00 pm are 28.31Watt, 51.0376 Watt and 23.7618 Watt. This shows that the angle of 30 ° is most suitable angle to do an installation compared to other angles.

From the simulation shows that angle 30° to do an installation due to it can absorb more energy compared to others angle. The main objective are achieved.

For future research for this experiment, here are few recommendations:-

- For the experiment, the experiment need to be done on the sunny day and make sure the sun is not hidden by cloud. Besides, the factor can influence the PV system need to be studied to make sure the optimum power output can be generated.
- For more reliable result from ANSYS Simulation, increase the meshing nodes and elements to ensure more sensitive calculation process ran and simulated by ANSYS 15. Increase stability of result by try-and-error method while configuring the right setup for simulation. Note that, to ensure Fluent Simulation result is relatively near with experiment result, always take note on experimental field result.

CHAPTER 6

REFERENCES

Ahmed, M. M., & Sulaiman, M. (2003). Design and proper sizing of solar energy schemes for electricity production in Malaysia. National Power and Energy Conference (PECon) 2003 Proceeding Bangi, Malaysia.

Akhmad K, Belley F, Kitamura A, Yamamoto F, Akita S. Effect of installation conditions on the output characteristics of photovoltaic modules. In: IEEE photovoltaic specialists conference, Hawaii, 1994. p. 730–3.

American journal of applied science, 4(6), 386-389.Surles, A.W.W., Horanyi, E., Zarske, M.S., (2009, 14 June). Solar Angle and Tracking Systems.

Appelbaum J, Bany J (1979). Shadow effect of adjacent solar collectors in large scale systems. Solar Energy 23:497-507.

Baharin, K. A. B. (2007). Analysis of renewable energy potential in Malaysia. University of New South Wales, Australia.

Cardas Research & Consulting Sdn. Bhd. Overview of renewable energy in Malaysia 2010. (2010).

Duffie, J. A. and Beckman, W.A. Solar engineering of thermal processes, 2nd ed. Wiley; 1991.

EIA. (2010). International Energy outlook. Energy Information Administration, Department of Energy, U.S.A.

El-Kassaby, M. M. and Hassab, M.H. (1994). Investigation of a variable tilt angle Australian type solar collector. Renewable Energy, Vol. 4, No. 3, pp. 327-332, ISSN 0960-1481.

Guo M, Wang Z, Zhang J, Sun F, Zhang X (2012). Determination of the angular parameters in the general altitude” azimuth tracking angle formulas for a heliostat with a mirror-pivot offset based on experimental tracking data. Solar Energy 86:941-950.

Huld, T., Šúri, M. & Dunlop, E.D. (2008). Comparison of potential solar electricity output from fixed-inclined and two-axis tracking photovoltaic modules in Europe. Progress in Photovoltaics: Research and Applications, Vol. 16, No. 1, pp. 47-59, ISSN 1099-159X.

Ibrahim, D. (1995). Optimum tilt angle for solar collectors used in Cyprus. Renewable Energy, Vol. 6, No. 7, pp. 813-819, ISSN 0960-1481.

Islam, M. R., Saidur, R., Rahim, N. A., & Solangi, K. H. (2010). Usage of solar energy and its status in Malaysia. 5(1), 6-10.

Jamaludin, N. K. b. (2008). Solar Tackinng System. Universiti Malaysia Pahang.

Kacira, M., Simsek, M., Babur, Y. & Demirkol, S. (2004). Determining optimum tilt angles and orientations of photovoltaic panels in Sanliurfa, Turkey. Renewable Energy, Vol. 29, No. 8, pp. 1265-1275, ISSN 0960-1481.

Latiff, M. K. I. B. A. (2009). A study of using energy for stadium in Malaysia. (Degree of Engineering (Hons) (Mechanical)), Universiti Teknikal Malaysia, Melaka.

Liu BYH and Jordan RC (1960). The interrelationship and characteristic distribution of direct, diffuse and total solar radiation. Solar Energy 4:1-19.

Mekhilef, S. (2010). Renewable energy resources and technologies practice in Malaysia.

Mondola, J. D., Yigzaw, G. Yohanisa, Nortonb, B.) The impact of array inclination and orientation on the performance of a grid-connected photovoltaic system (Renewable Energy) 32 (2007) 118–140.

Nakamura, H., Yamada, T., Sugiura, T., Sakuta, K., Kurokawa, K. Data analysis on solar irradiance and performance characteristics of solar modules with a test facilityof various tilted angles and directions. Sol Energy Mater Sol Cells 2001;67:591–600.

Najib, N.S.M. (2013). Development of optimum solar electricity generating system.

Partain LD, Fraas LM (2011). 'Solar Cells and Their Applications.' (John Wiley & Sons).

Saboori, B., azman, A., & Sulaiman, J. (2014). Development of solar energy in Sabah Malaysia. 3(2), 90-95.

Soleimani, E., A, Farhangi, S., Zabihi, M. S. The effect of tilt angle, air pollution on performance of photovoltaic systems in Tehran. Renew Energy 2001;24:459–68.

Writz, R.A., Righi, J., & Zirill, F. Measurement of natural convection in cross tilted rectangular enclosure of ratio 0.1 ans 0.2.

Yakup, M.A. bin H.M. & Malik, A.Q. (2001). Optimum tilt angle and orientation for solar collector in Brunei Darussalam. Renewable Energy, Vol. 24, No. 2, pp. 223-234, ISSN0960-1481