OPTIMIZATION AND PERFORMANCE ANALYSIS OF A PORTABLE SOLAR COOKER SYSTEM

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OPTIMIZATION AND PERFORMANCE ANALYSIS OF A PORTABLE SOLAR COOKER SYSTEM

AMIRUL AZFAR BIN ELIAS

Thesis submitted in partial fulfillment of the requirements
for the awards of the degree of
Bachelor of Mechanical Engineering

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UNIVERSITI MALAYSIA PAHANG
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IN THE NAME OF ALLAH, THE MOST BENEFICENT, THE MOST MERCIFUL

A special dedication of This Grateful Feeling to my...

Beloved parents, for giving me full of moral support and financial support. It is very meaningful to me in order to finish up my degree's study. Not forget also to all my friends and last but not least to all my lovely lecturers and faculty's staffs.

Thanks for giving me Love, Support and Best Wishes

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ABSTRACT

In rural areas where supply of electricity and energy resource are very scarce, cooking will mostly being done using conventional way by burning woods, A passive solar cooker is one of the solution to overcome the environmental problem caused the conventional cooking method as well as providing the residents a free and convenient way to cook. Parabolic dish was fabricated using fibre glass and the system is designed considering the factor of portability and performance. Many type of material could be use as the reflector thus, need to investigate the better material to be use to get the high percentage of heat radiation. Besides, experiment had been run twice, without thermal energy storage and without thermal energy storage. Experiment has been run using 3 spotlight to consider having radiation of 880W/m². The testing and performance of the concentrated solar thermal cooker (CSTC) has been investigated by measuring a 1kg steel of bar temperature. CSTC without using thermal energy storage able to heat up the steel bar to 100°C within 1 hour compare to CSTC with using thermal energy storage able to heat up the steel bar to 65°C within 1 hour. Efficiency of the solar cooker without thermal energy storage ranging up to 12.12% and solar cooker with thermal energy storage is up to 8.92%.

ABSTRAK

Di kawasan luar bandar di mana bekalan elektrik dan sumber tenaga yang kurang, memasak kebanyakannya akan dilakukan menggunakan cara konvensional dengan membakar hutan, periuk memasak menggunakan tenaga solar adalah salah satu penyelesaian untuk mengatasi masalah alam sekitar dan ia merupakan kaedah memasak konvensional malah ia merupakan dari sumber yang percuma dan cara yang mudah untuk memasak. Piring parabola telah di hasilkan menggunakan kaca gentian dan sistem itu telah direka dengan menitik beratkan faktor kemudah alihan dan prestasi. Banyak jenis bahan boleh digunakan sebagai pemantul itu, maka perlu untuk memlilih bahan yang lebih baik akan gunakan untuk mendapatkan peratusan sinaran haba yang tinggi. Selain itu, eksperimen telah dijalankan sebanyak dua cara, yang pertama tanpa penyimpanan tenaga termal dan kedua tanpa penyimpanan tenaga termal. Eksperimen telah dikendalikan menggunakan 3 lampu ‘spotlight’ yang menghasilkan radiasi 880W/m² untuk eksperimen ini . Ujian dan prestasi periuk solar terma pekat (CSTC) telah disiasat dengan mengukur keluli 1kg suhu bar. CSTC tanpa menggunakan penyimpanan tenaga termal dapat memanaskan bar keluli kepada 100 ° C dalam masa 1 jam berbanding dengan CSTC dengan menggunakan penyimpanan tenaga termal dapat memanaskan keluli kepada 65 ° C dalam 1 jam. Prestasi periuk solar tanpa haba penyimpanan tenaga sehingga 12.12% dan periuk solar dengan penyimpanan tenaga termal sehingga kepada 8.92%.

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LIST OF SYMBOLS

F	Focal length
D	Depth of dish
R	Radius
M	Mass
kg	Kilogram
Cp	Specific heat
J	Joule
k	Kelvin
Θ	Temperature different
ŋ。	Coefficient
m	Meter
A	Collector aperture surface area
I	Instantaneous solar radiation energy
t	Time
T	Absolute temperature
mm	Millimeters
cm	Centimeters

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
CSTC	Concentrated Solar thermal Cooker
SC	Solar Collector
SPC	Solar Parabolic Cooker

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Solar cooking system represents the simplest application of solar thermal energy and has a great potential for reducing dependence on the conventional fuels in the domestic sector. The different types of solar cookers developed for cooking are a box type, a concentrator type and an indirect type.

Solar cooker system is a device that uses sun light as its energy resource. This is somehow as a renewable energy product because no fuel or electric needed. However, the natural sun light source does not provide enough heat for cooking purpose. So, solar collector system is introduced for this application. Among it, concentrated type are the best collector. It is the system that concentrated the sun light into the focus of the system to get the overall high intensity of light than that naturally available. It is either to use the concept of reflection of light. Those focus will have high amount of heat than natural sun light and it heat will be used for cooking purpose.

1.2 PROBLEM STATEMENT

1. Referring to previous project by Jolhi Ibrahim with the title of 'Design and Fabrication of Concentrated Solar Thermal (CST) System for Solar Cooker Application', the efficiency was 7.37%. A better material has to be selected as the reflector to increase the efficiency of system.

2. Redesign the grate part to be friendly use. According to the previous project by Jolhi Ibrahim with the title of 'Design and Fabrication of Concentrated Solar Thermal (CST) System for Solar Cooker Application', the grate will collide with the parabolic dish when user wants to adjust the parabolic dish to get the solar radiation towards its focus point.

1.3 PROJECT OBJECTIVES

1. Optimize the reflector to gain better solar radiation.
2. Redesign the holder of the grate by using SolidWorks software and ALGOR software to analyses it.

1.4 PROJECT SCOPES

To ensure this project progress is smoothly under control and stick with its title, scopes of project is discussed. Every scopes of the project are the task of the student and it is under responsibility of the student. The project covers:

1. Experimental works to collect data on the system sun radiation during experiment has to be taken into consideration
2. Determine performance characteristics of a solar cooker system from gathered data.
3. Review on methods of solar cooker system optimization (design/technology)
4. Propose a concept and design new solar cooker system. Fabrication of the product.

1.5 PROJECT PLANNING

This project begins with the briefing of the title from the supervisor on the first meeting. During the briefing, the main objective and the project scopes are prepared. Supervisor prepares the schedule of the right time for the next meeting. All the sudden meeting can be made if help needed by doing an appointment.

To manage the timeline of the project, a flowchart (refer to Figure 3.1) and the Gantt chart (refer to Appendices A and B) is prepared. This is a two semester of study project. Project proceed with gathering all the information regarding solar cooker system and concentrate to optimizing the reflector to gain better solar radiation. The source and reference is mainly from books, internet and also journals. With those references, research and literature reviews are conducted. This information helps mostly in redesign generation process. The previous project makes the student easy because student will just focus with the design.

The criteria for choosing the best material for reflector are based on the problems during the problem statement. Each of it will be finalized by experimenting it first. The final material then will be present to the supervisor to make sure it will fulfil the project requirements.

After the best reflector been decided, redesigning the holder will be start. It considers the student to use SolidWorks software to design it and ALGOR software to discover its deformation.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Solar cooker system has become popular around the world mainly at western countries because they heat and cook without consuming fuels which are not always readily available. It can reach higher temperatures than the surrounding atmosphere because solar cookers will concentrate a large amount of sun light reflecting directly to one point. This method (using sunlight to cook food) was the first method in the world for cooking (Halacy, 2002).

2.2 HISTORY OF SOLAR COOKER

Sun is well known as heat energy sources for food long time ago. It had been used for cooking, drying and heating foods and water. For example, drying any fruit by expose it directly to the sun light or by placing it on the hot rocks which is mostly been use at desert. In Asia countries, drying fishes also can be seen. From this observation, this method (use of sun light for food) was the first method of cooking on earth (Halacy, 2002).

2.3 SUNLIGHT REFLECTION

Parabolic system that been used for this solar cooker type will reflect sunlight to one focus point. Before how solar cookers concentrate light is discussed, the law of reflection must be first being understood.

Parabolic shape could reflect light onto a single focus point but it is only useful when light has an incoming angle of 90°. The reflected rays completely miss the focal point at any other incoming angle. Because solar cookers are concentrating light to a surface (grate area), rather than a single focus point, the solar can still function well at angles slightly less than 90°. For curved surfaces, the normal is perpendicular to the tangent at the incidence point shown on Figure 2.1.

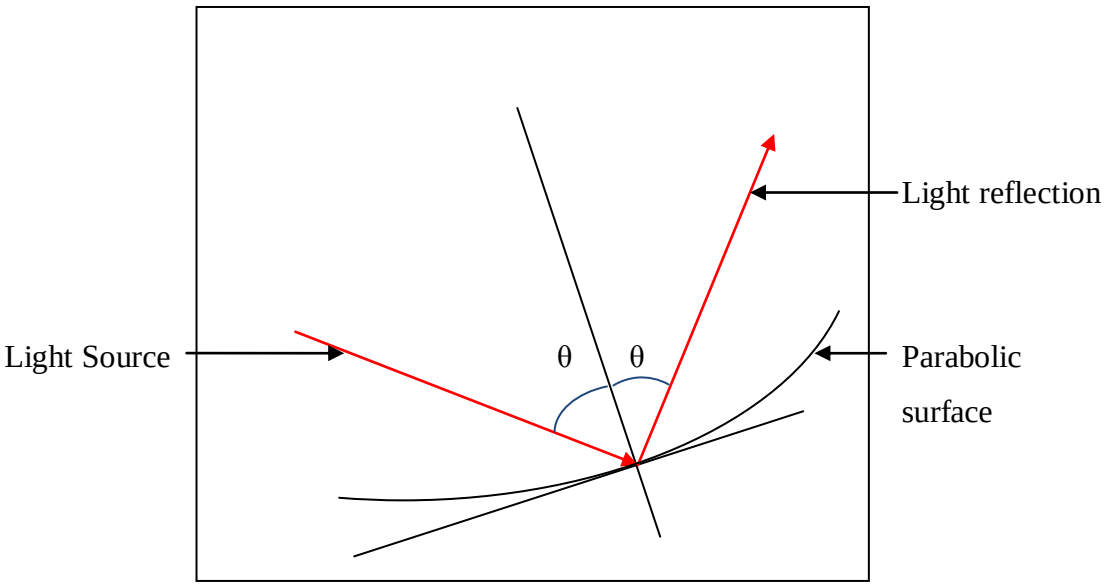


Figure 2.1: Single focus light reflection

The dimensions of a symmetrical paraboloidal dish are related by the equation

$$4FD=R^2 \quad (2.1)$$

Where **F** is the focal length, **D** is the depth of the dish (measured along the axis of symmetry from the vertex to the plane of the rim), and **R** is the radius of the rim. It can be referring to as shown on Figure 2.2.

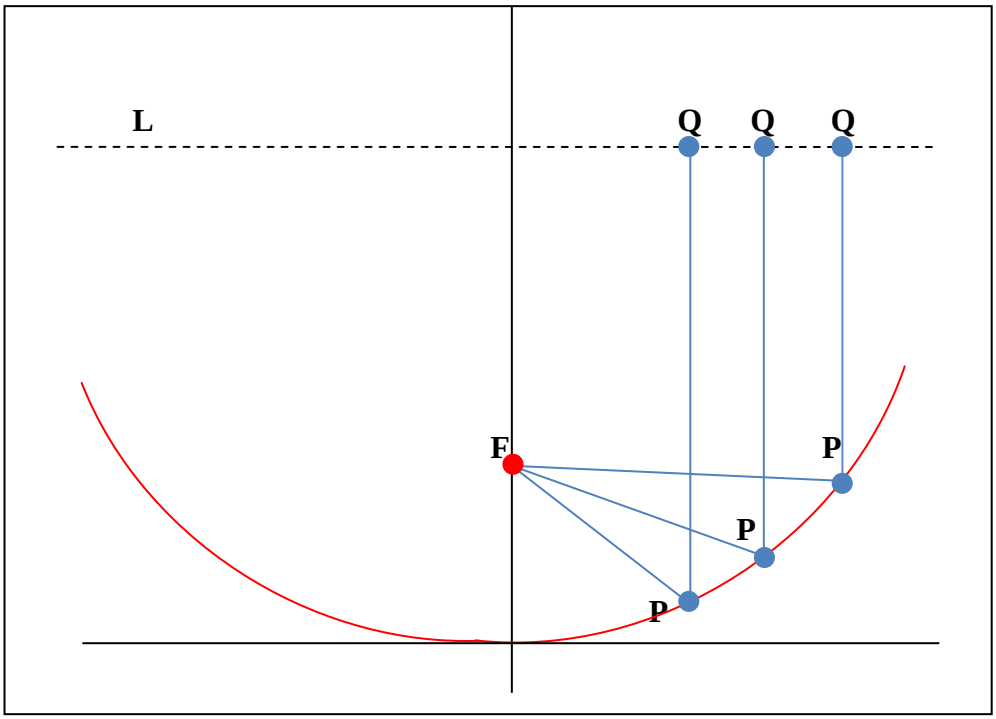


Figure 2.2: Sunlight reflect to the focus

Where **F** is the focus point, **P** is the reflection point on parabolic surface, **Q** is the heat source, **L** is the level height of the light.

The solar cooker is a storage-collector without any power transported out of the system. The energy balance in this system can be written as

$$m.Cp\frac{d\theta}{dt} = \{\eta o.I - U.\theta\}.A \quad (2.2)$$

Where **m** is the mass in the pot in kg, **Cp** is the specific heat capacity at constant pressure in **J/ (Kg.K)**, θ is the temperature difference between the pot content and the ambient in K, $n0$ is the optical efficiency, **I** is the global solar radiation in **W/m^2, U** is the thermal loss coefficient in **W/ (m^2.K),** and **A** is the collector aperture surface in **m^2.**

2.4 SOLAR COLLECTORS

Solar collector is a devise used to get heat from the sun light. It collects heat by transforms solar radiant energy into heat (Beckman, 1996). There is various type of solar collector for solar cooker but for this project, concentrate solar collector in the other words, parabolic reflector will be use. The known solar collectors were list as shown on Figure 2.3.

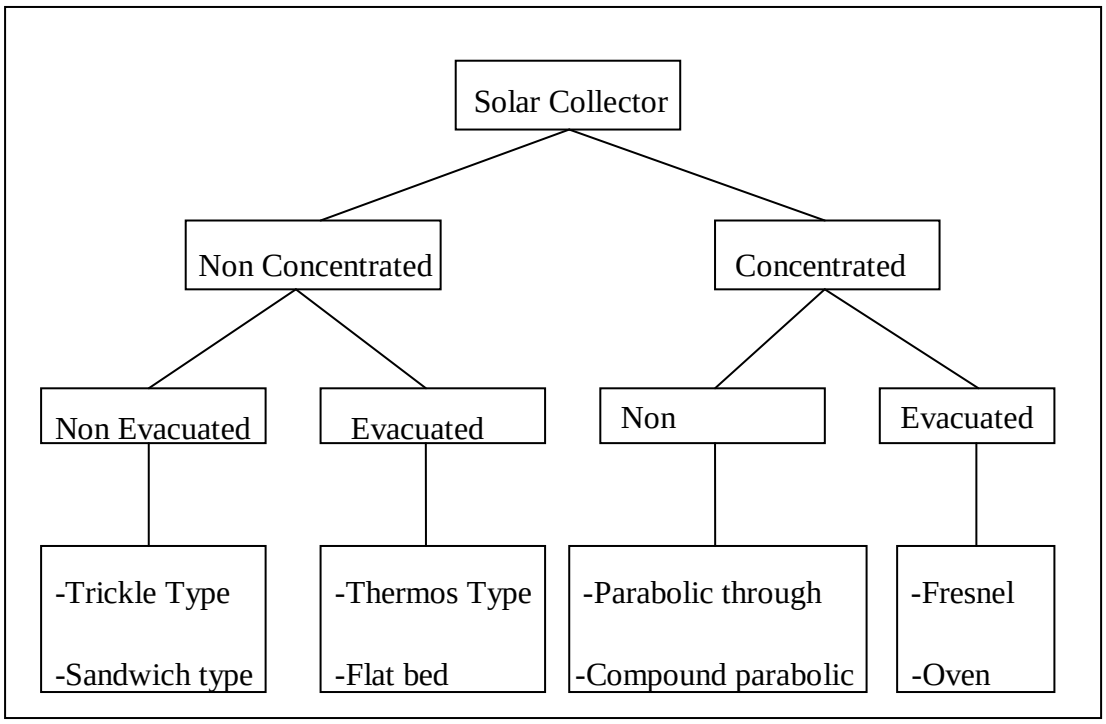


Figure 2.3: Classification of solar collector

Each category of collectors has their own advantages and disadvantages. Non-concentrated type is good for low heat requirement but long supply requirement. It is easy to use because requires no adjusting of the elevation to get solar light. Flat bed or flat plate collector are the main stay of domestic solar water heating (Beckman, 1996).

Advantages of concentrating cookers include high cooking temperatures, cooking any types of food and short heat up times. Disadvantages are their size, cost, the risk of fires and burns and the inconvenience to adjust the cooker as it requires frequent directional adjustment (Muthusivagami, 2010).

2.5 SOLAR RADIATION

Heat gain from solar radiant and sun light. It is happen when the material absorbs the radioactive wave that come together with the solar radiant. The sun light in the range of the long wave form (infrared) to the short wave form (ultraviolet) and every surface could reflect the wave (Sherwin, 1996). The more material absorbing solar radiant, the more heat will be gain. That's the reason most blackened surface is good heat absorber. But, black surface also good in emitting heat (Sherwin, 1996) because of that, temperature is rising and dropping fast. Actually heat come from the energy from the sun which is come together with photon. Thus, the sun light intensity of photon energy is measured and not the temperature.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Project is started with the selecting material. These material were chooses among the best of reflector material that have been made before this in Europe. The design of grate will be presented in three-dimensional drawing instead of sketching so it is easy to understand. Then the process will continue to design screening and finalization.

3.2 PROJECT PROCESS

This project is started with choosing material. The material will be considered toward referring literature reviews about the solar radiation. From the information gathered, two type of material; Chrome spray and aluminium foil were choose to be use through an experiments. When a final material has been chosen, the project will continue doing on its real reflector. Optimization of grate process will be continuing after the optimization of reflector donned.

There is a flow chart diagram represent the whole project process. The flow diagram is shown on Figure 3.1. This kind of chart helps in the process flow and makes the procedures become well-organize and structured well.

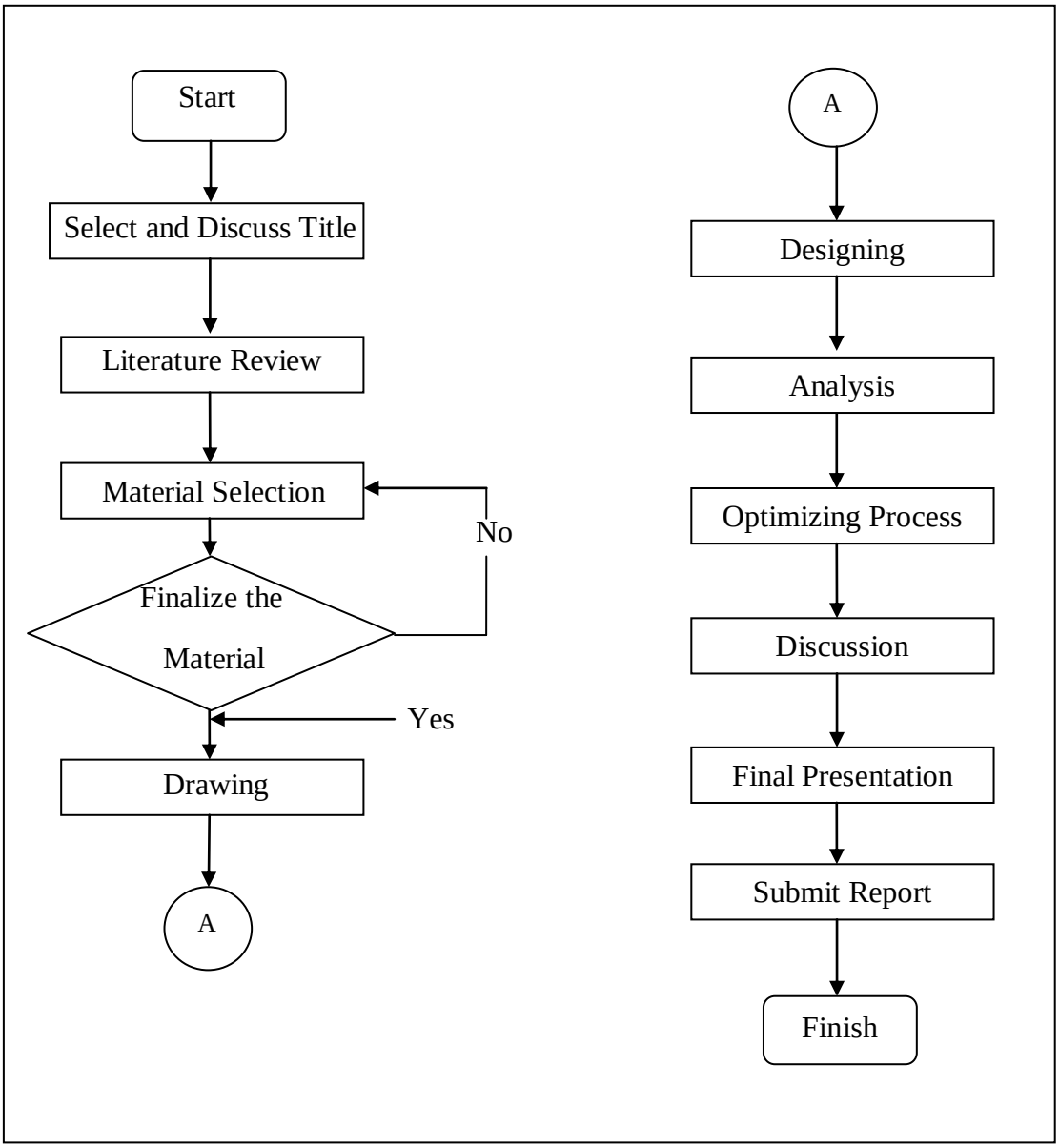


Figure 3.1: Process Flow

3.3 MATERIAL SELECTION

3.3.1 Reflector

For this project, objective is to optimizing previous project. So, two type of material for reflector been selected. It is aluminium foil and chrome spray. Both materials have been test by applying to two pans for having the parabolic shape.

Referring to Figure 3.2, aluminium foil is the best reflector because of high percentage of solar radiation can be achieved. Comparison has been made using study lamp to compare its reflection and the best reflector is aluminium foil but because of several problem, chrome spray been chosen.

Figure 3.2: Aluminium foil reflector

Due to difficult to place it onto the parabolic dish, we use chrome spray as the alternative reflector material. It is much easier than placing aluminium foil as the reflector. Besides, it does reflect almost same with the aluminium foil material. It also cheaper than aluminium foils. Figure 3.3 shown chrome spray reflector.

Figure 3.3: Chrome spray reflector

3.3.2 Sketch Selection for Grate

Previous grate can hold up to 10kg of weight and for current project. Optimization for that part will be done by increase the holder diameter and to build a pan that can be put river stone to install heat so that it can have constant temperature even if at one time there is cloud covering the sun light.

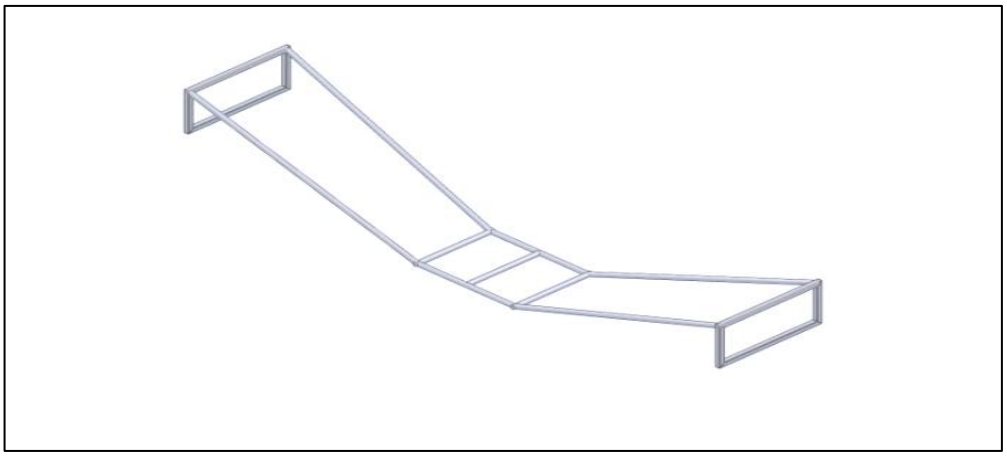


Figure 3.4: Previous grate

So by referring to journal and reference books, the grate holder will be optimizing by increase the holder diameter. It will make sure will make it have high percentage in holding more weight. Next is the designing process of the pan design that will be put river stone. River stone is among the best thermal energy storage to store heat so that it can have constant temperature even if at one time there is cloud covering the sun light (Ayu, 1998).

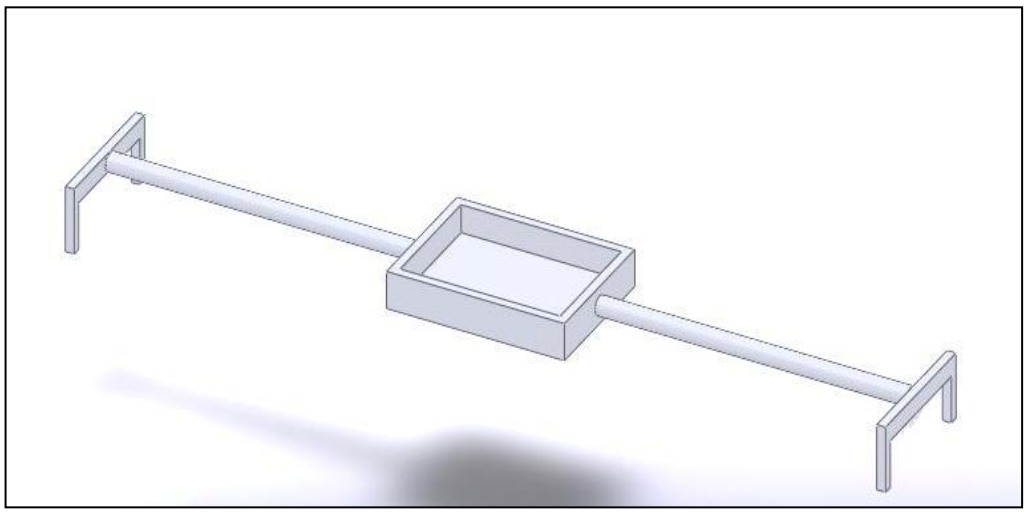


Figure 3.5: Planning of grate to be

Analysis has been done to determine whether it can hold more weight. Analysis has been done using ALGOR software to check it can hold weight up to 20kg or not. Analysis has been done with applying stress with load of 10kg and 20kg.

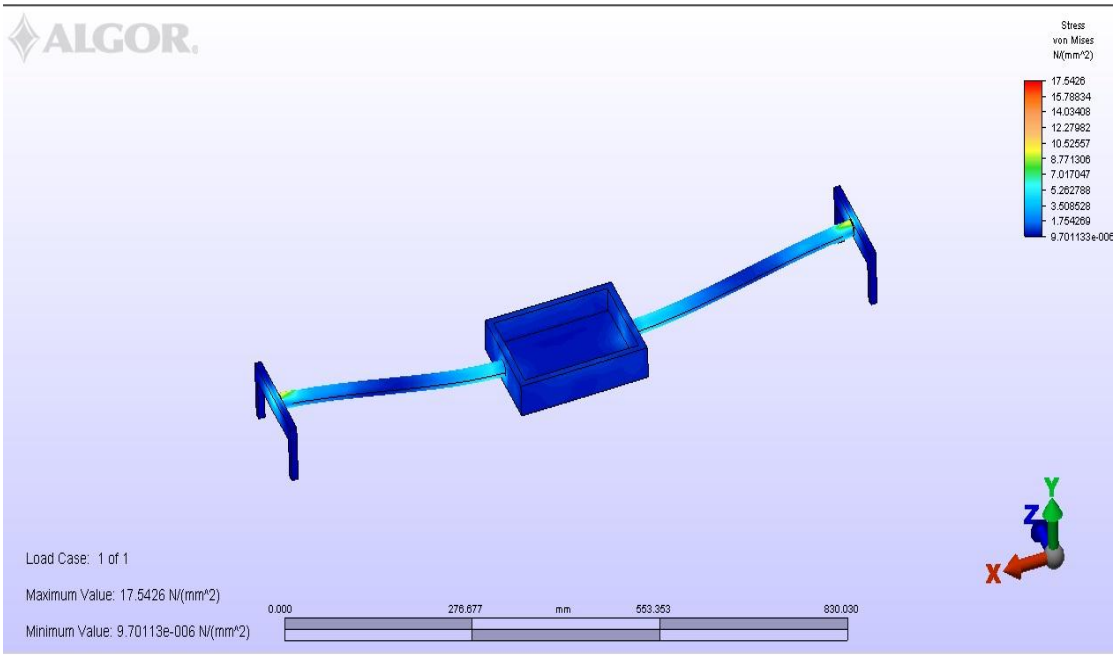


Figure 3.6: Analysis with weight of 10kg

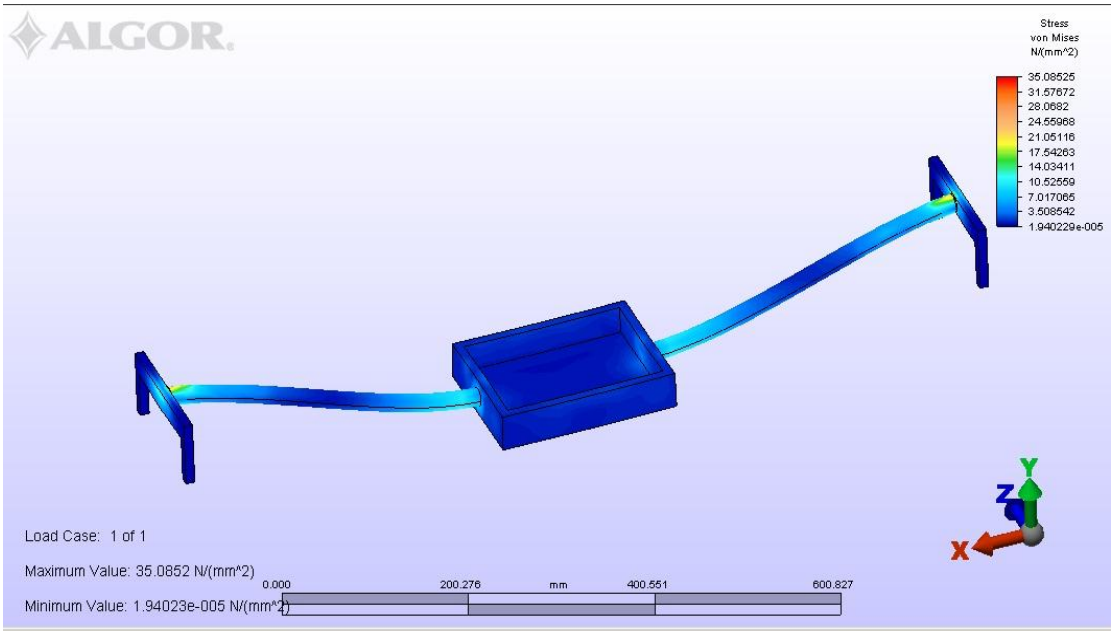


Figure 3.7: Analysis with weight of 20kg

3.4 FABRICATION PROCESS

A plan is prepared for fabrication process for a manageable work. This plan covers the rime consumed, fabrication grate and the task covered. The fabrication process covers the product grill, parabolic dish reflector and any related system. While the tires, bolts and nut are using the past project with renew that been buy from hardware store. The first thing is the optimizing the reflector of the parabolic dish and followed by the grill and lastly the small mechanism to complete the system. The process starts with the parabolic dish because it is the main and the most important part in this project and it is the concentrated solar thermal cooker (CSTC) system.

3.4.1 Fabrication of parabolic dish reflector

First thing first, previous reflector needed to be peeling off as shown on Figure 3.8. This is important to make sure the dish is smooth to continue to the second step. This process is easy to be done because it just peels by using hand and a knife to peel off the sticker.

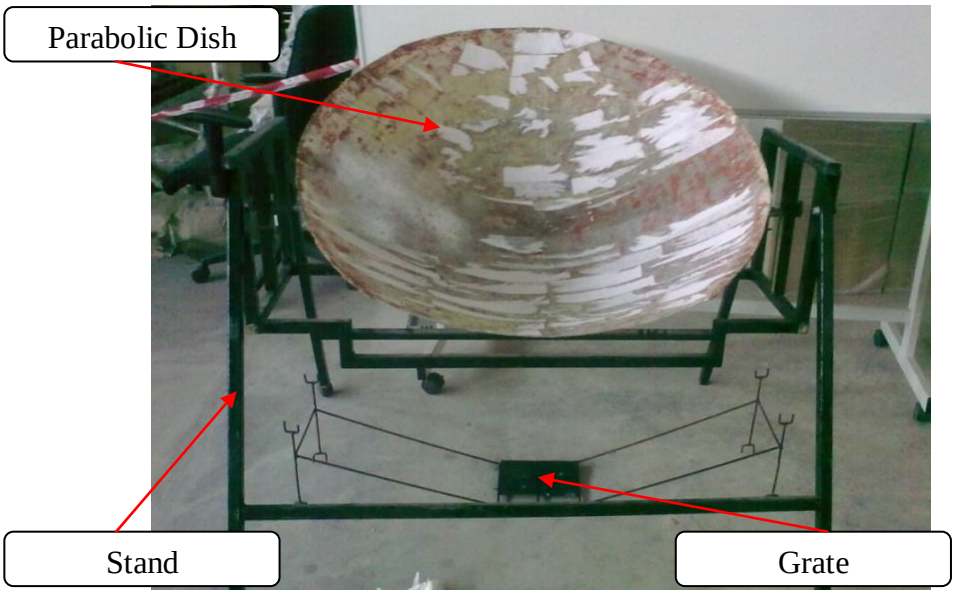


Figure 3.8: First step during upgrading the reflector

For the next step, chrome spray been spray as shown on Figure 3.9 to analysis either just using chrome spray is it enough to reflect the light. The result is fail because the parabolic is not smooth as a paper. It has lots of holes and it kind of absorbing heat more than reflect it.

Figure 3.9: Parabolic dish with chrome spray

Next analysis is by using aluminium foil as shown on Figure 3.10. It has been paste by using double sallotape. The result of it is it does not reflect very well as it is not smooth at all. It cause bigger focus point as its surface is not smooth.

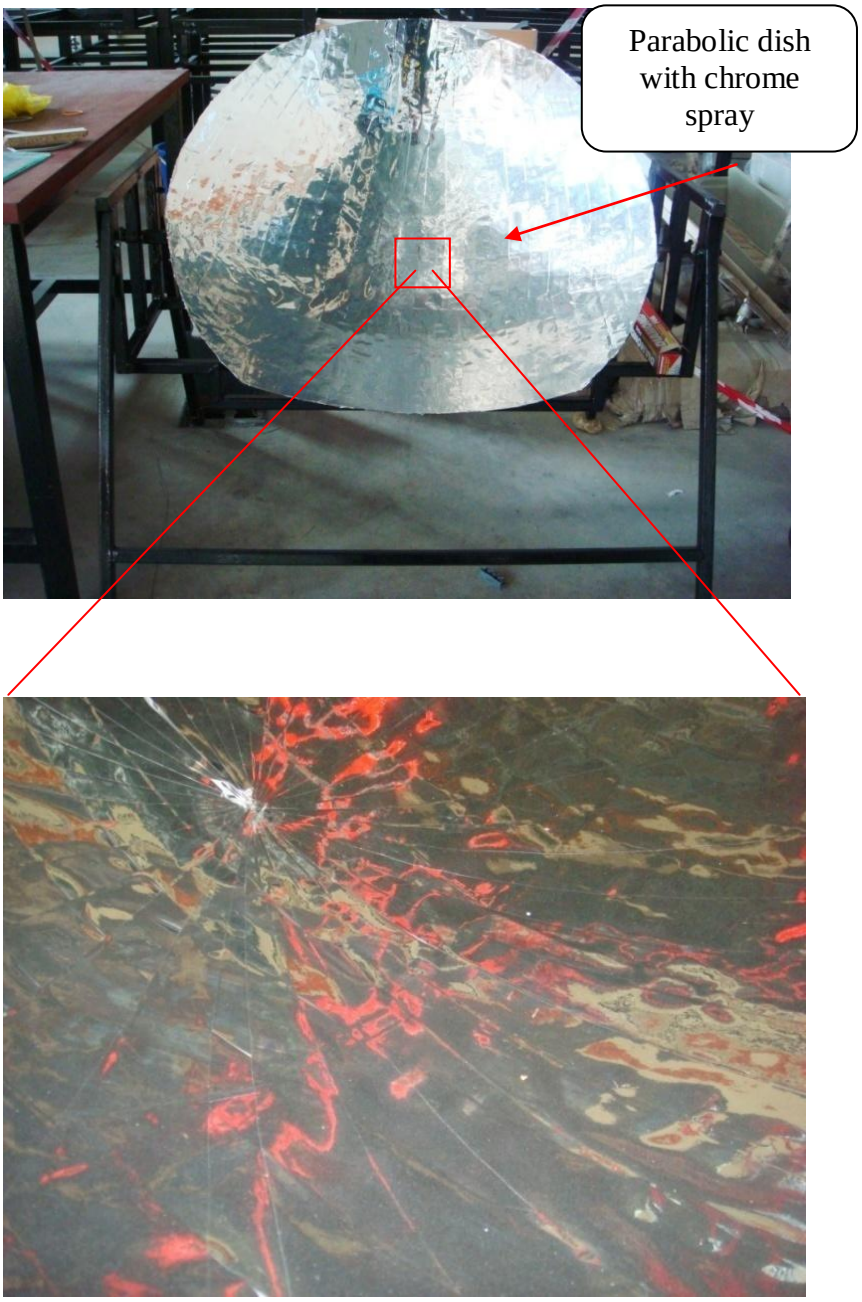
Figure 3.10: Parabolic dish with aluminium foil

The final analysis in fabrication parabolic reflector is by using chrome sticker as shown on Figure 3.11. It has been paste using double sallotape and the surface also smooth. It causes the focus point to be smaller and directly focus onto below of the grill.

Figure 3.11: Parabolic dish with Chrome sticker by vertical pasted

As shown on Figure 3.11, the chrome stickers were paste vertically and it affect the smooth of parabolic surface angle. As for that, the way of the sticker been paste were renew and pizza shape been choose to paste it onto the parabolic dish as shown on Figure 3.12. Figure 3.12 shown from the near angle ways that pizza shape looks like.

(a)



(b)

Figure 3.12: (a) Parabolic dish with chrome sticker with pizza shape pasted, (b) Pizza shape with zoom in

Figure 3.13 shows the different of temperature increment between selected materials. Experiment been donned from 10am to 11am on 19th Mac 2012 to 23rd Mac 2012 with the same radiation of 880W/m².

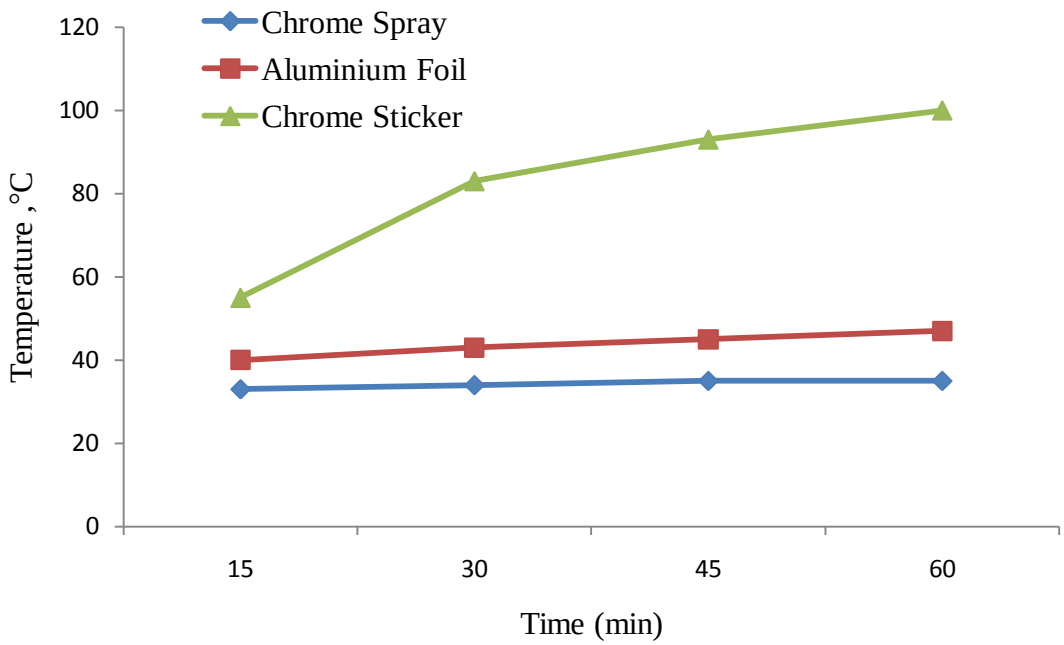


Figure 3.13: Comparison heat reflection at focus point using selected materials

In this experiment study, energy efficiency of a solar collector (SC) can be defined as the ration of energy output to the energy input (Ozturk,1998).Energy input is defined as instantaneous solar radiation energy reflected by the parabolic reflector of the dish to the container (Ozturk,1998). Thus the instantaneous energy efficiency of the solar parabolic collector (SPC) can be calculated as follows;

$$\eta = \left[mc\frac{Twf-Twi}{\Delta t}\right]/IA \qquad (3.1)$$

Where **A** is intercept area, **c** is specific heat of water, ***I*** is instantaneous solar radiation energy, **m** is mass of water, **t** is time and **T** is absolute temperature.

3.4.2 Fabrication of Grate

Grate is part the cooking pot. It is made of a solid cylinder steel rod as shown on Figure 3.14 with a diameter of 15mm. This part is simple and easy to make. The rod is cut into specific diameter similar to the previous grate using disc cutter and welded using arc welding process.

Figure 3.14: Steel rod

Grate parts been weld using arc welding machine as shown on Figure 3.15. It's been choose because the application by using it is excellent and quick welding together thin metal sheets and creates a secure fusion between welds. Moreover, this application also produces high productivity, high repeatability and quality results.

Figure 3.15: Arc welding machine

As shown on Figure 3.16, problem occur once it finish is when the grate did not fit to the stand and also the rod support are collide to the parabolic dish when it being set to the angle that perpendicular towards light.

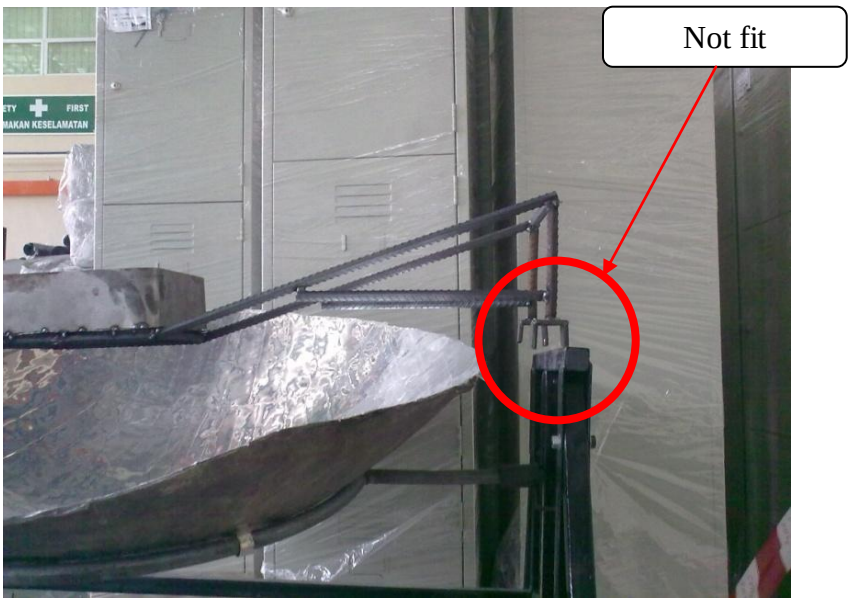


Figure 3.16: Problem occurred after welding grate

Repairing the grate is been done after noted that there were error. It occurs as the previous grate can be bent because there is no rod support unlike the new one.

As we noticed, the design are different compare to the design that been analysis by using ALGOR software. The design has been upgrade from 1 rod to 2 rod and it manages to hold more weight. Figure 3.17 below show the previous design of grate. It is 115cm long. Notice that the grate has no part to be put stones as thermal energy storage.

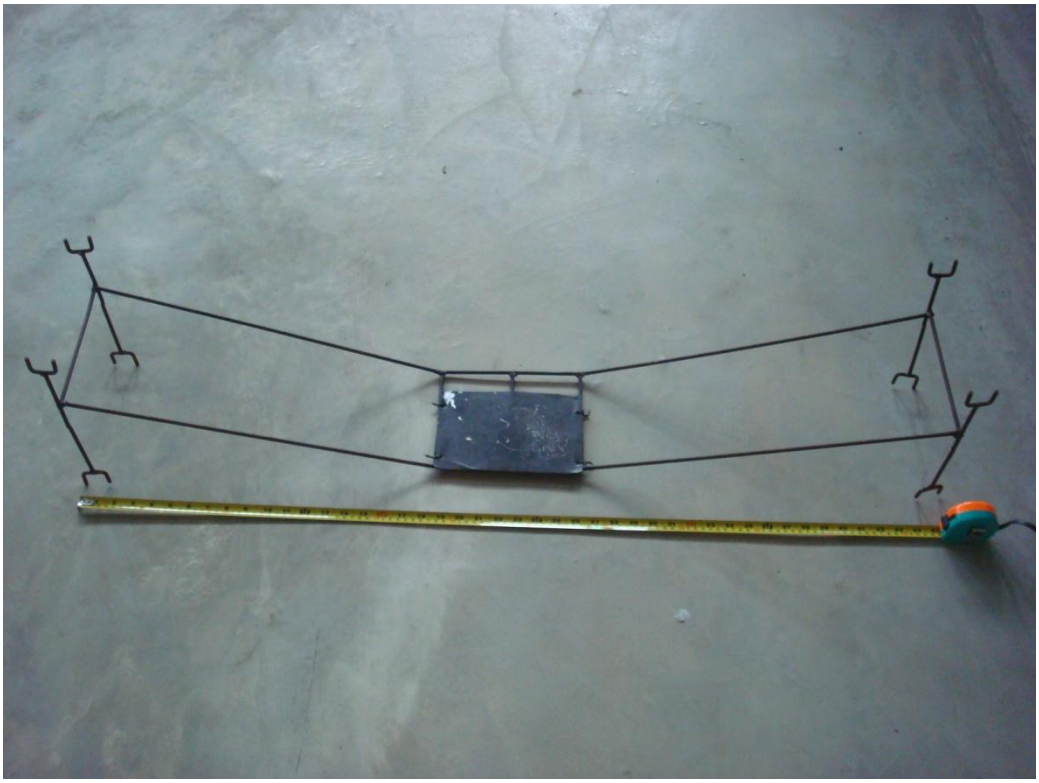


Figure 3.17: Previous grate

New grate has been design and been fabricate as shown on Figure 3.18. The different compare to the previous design is the rod is double diameter compare the previous grate, support rod has been add to hold more weight and there is a case as to put stones as the thermal energy storage. Besides, it also painted black in colour as black surface absorb more heat (Robert, 1994).

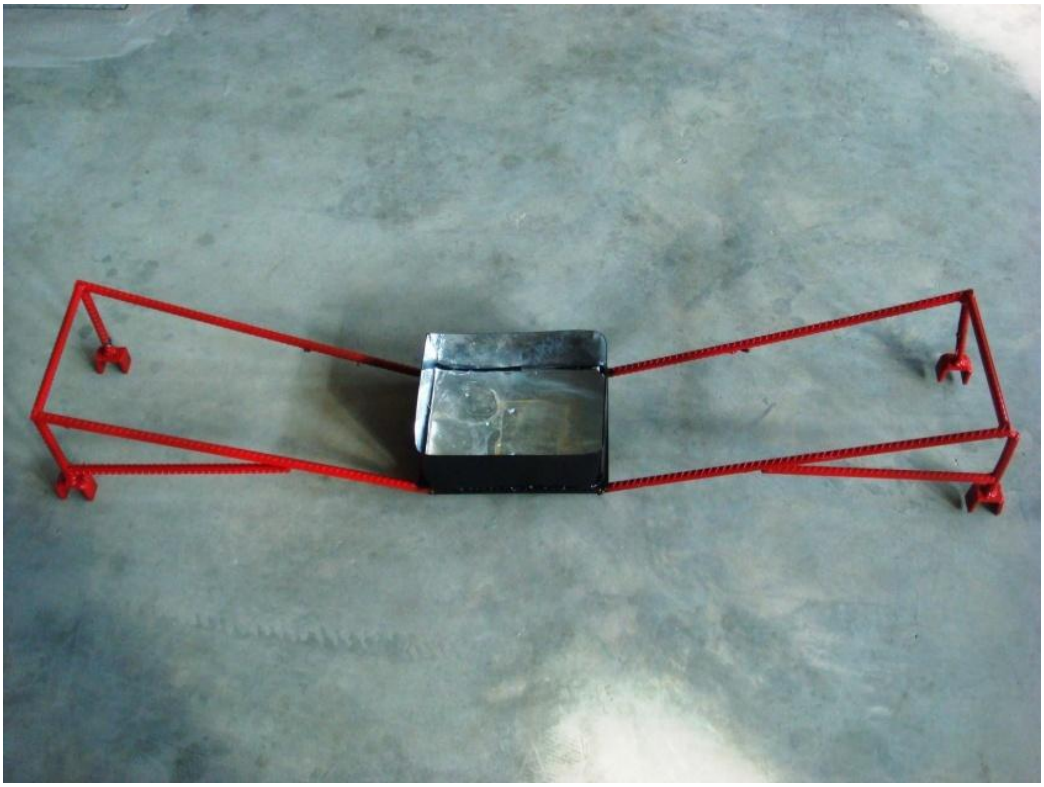


Figure 3.18: New grate

Aluminium strip is used to build the pot. It has been choose as aluminium is one of the materials that will not radically release heat (P.A Funk, 1997). Besides, it can hold high temperature as this experiment will manage to have high temperature according to the radiation delivered to the system.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

When the product fabrication is finished, the product is tested either it work and satisfy the target or not. The result of the experiment of the product will be discussed in this chapter. The experiment will be explained in this chapter including the problem that comes out while the product is tested. Any further discussion also will be discussed such as the reason of choosing uses of thermal storage (river stones).

4.2 EXPERIMENT

An experiment is conducted to determine either the product functioning well or not. The experiment is conducted by heating a 1kg steel bar. The reason choosing it compare using water is because to avoid final weight of water losses because it can be evaporate.

Figure 4.1 show how the experiment is set up. The experiment is set at HVAC lab, Faculty of Mechanical University Malaysia Pahang, Pekan. It has been test for about 3 hours heating and 1 hour cooling down (cut off heat supply).This experiment used 3 spotlights as to have similar radiation of the sun. It has been position perpendicular to the light/heat source (spotlight) to ensure maximum solar radiation incidence to the parabolic surface.

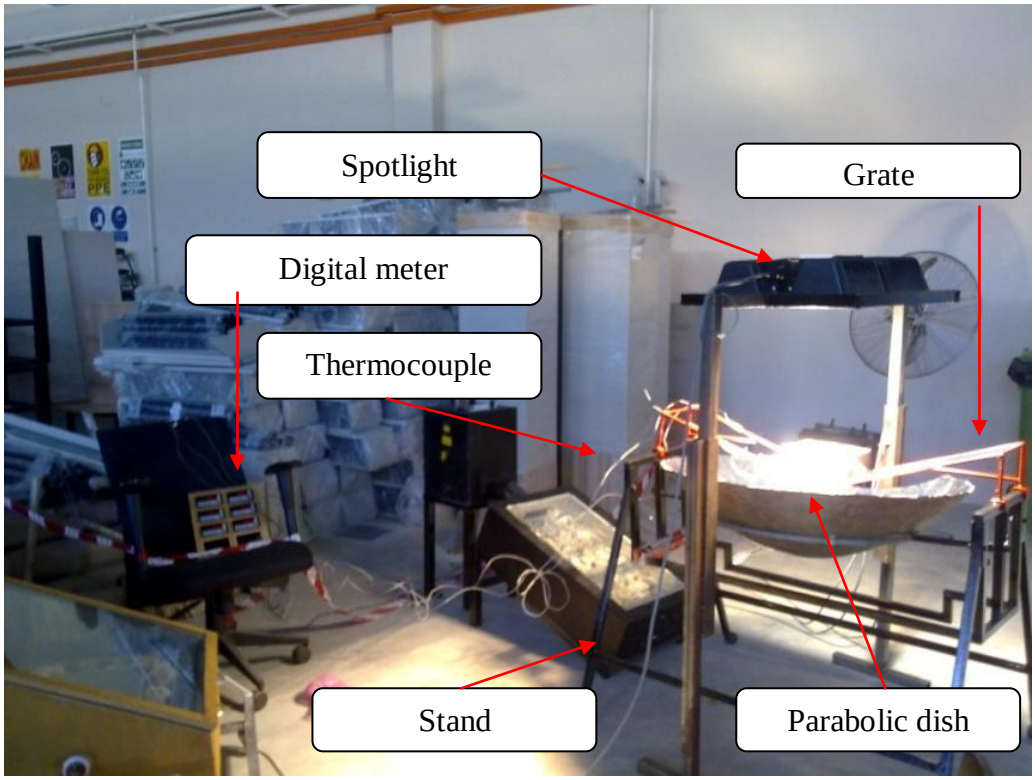


Figure 4.1: Experiment setting

The experiment is set up as shown on Figure 4.1. Digital meter and thermocouple is used to measure the steel temperature as shown on Figure 4.2.

Figure 4.2: Digital meter and Thermocouple

Before the experiment start, solar meter is used to measure the radiation from the spotlight using solar meter. The experiment has been run after the radiation is constant, 880W/m². This reading is similar with sun radiation at 10:30 am in the morning.

Figure 4.3 shown how the thermocouple sensor been place during measuring the temperature. It been placed before the experiment start and after setting the angle of the reflector perpendicular towards light.

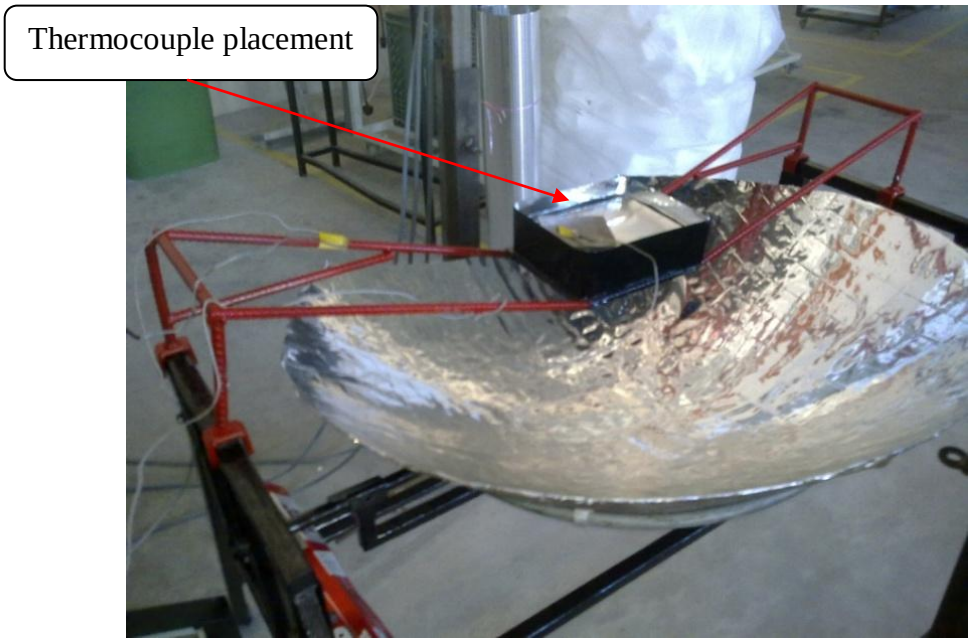


Figure 4.3: Thermocouple sensor setting

1st experiment as shown on Figure 4.4 is been sets to make a comparison without using thermal energy storage with using thermal energy storage. The comparison can be seen on Figure 4.7.

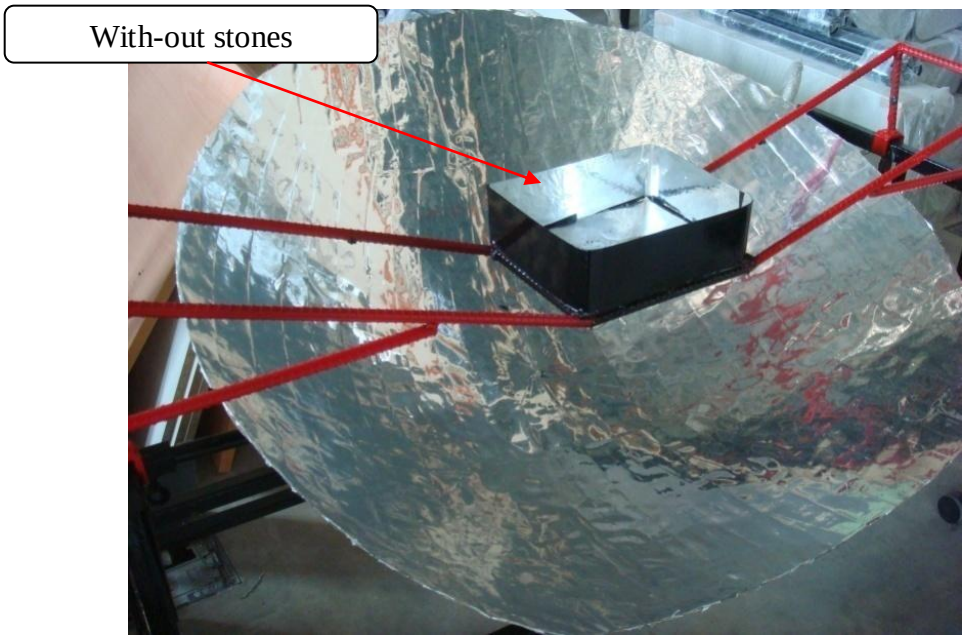


Figure 4.4: Experiment setting without thermal energy storage

1 kg of river stones is used as the thermal energy storage for 2nd experiment as shown on Figure 4.5. River stone are suitable to use as thermal energy storage (Hasan, 1998). Aluminium strip then be place onto the stones and food will be cook on the aluminium strip as shown on Figure 4.7.

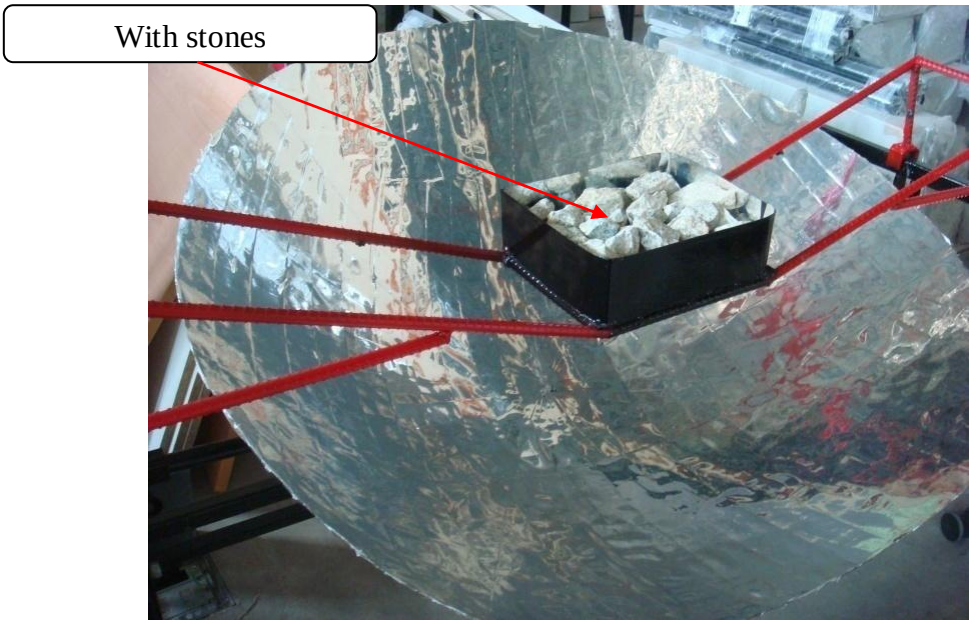


Figure 4.5: Experiment setting with thermal energy storage

The experiment set place as shown on Figure 4.6, spotlights is been place 1.5 metres from the ground. Height between grate to the spotlight is 0.66 metres.

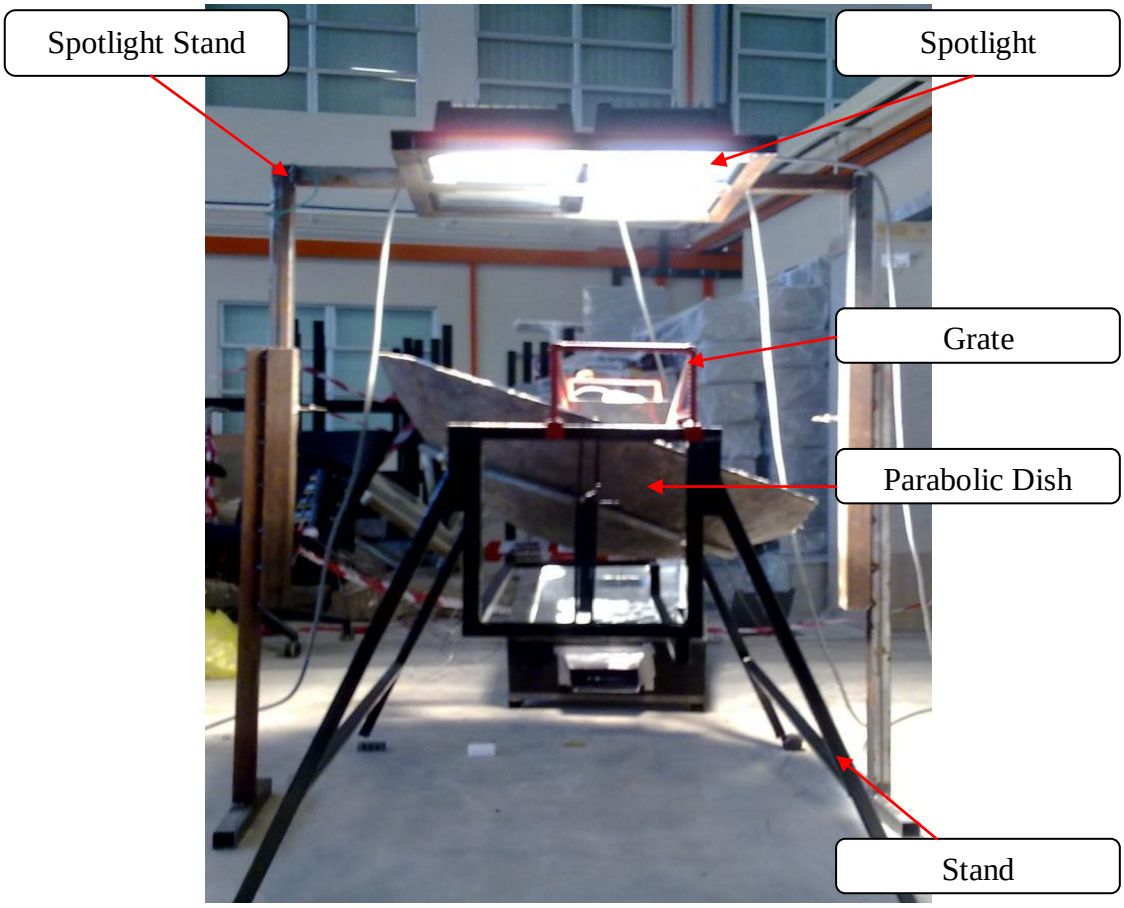


Figure 4.6: Experiment run

Spotlight that been use is a type of halogen lamp with specification of 1000W, 220V-240V, 50Hz. The temperature and time were recorded and presented in the form of line graph, temperature versus time graph. Result of the experiment in the form of graph is shown on Figure 4.7.

The height from the grate to the spotlight is set to be 66cm to get the radiation of 880W/m². Besides, during the experiment, the spotlight been placed exactly perpendicular towards grate.

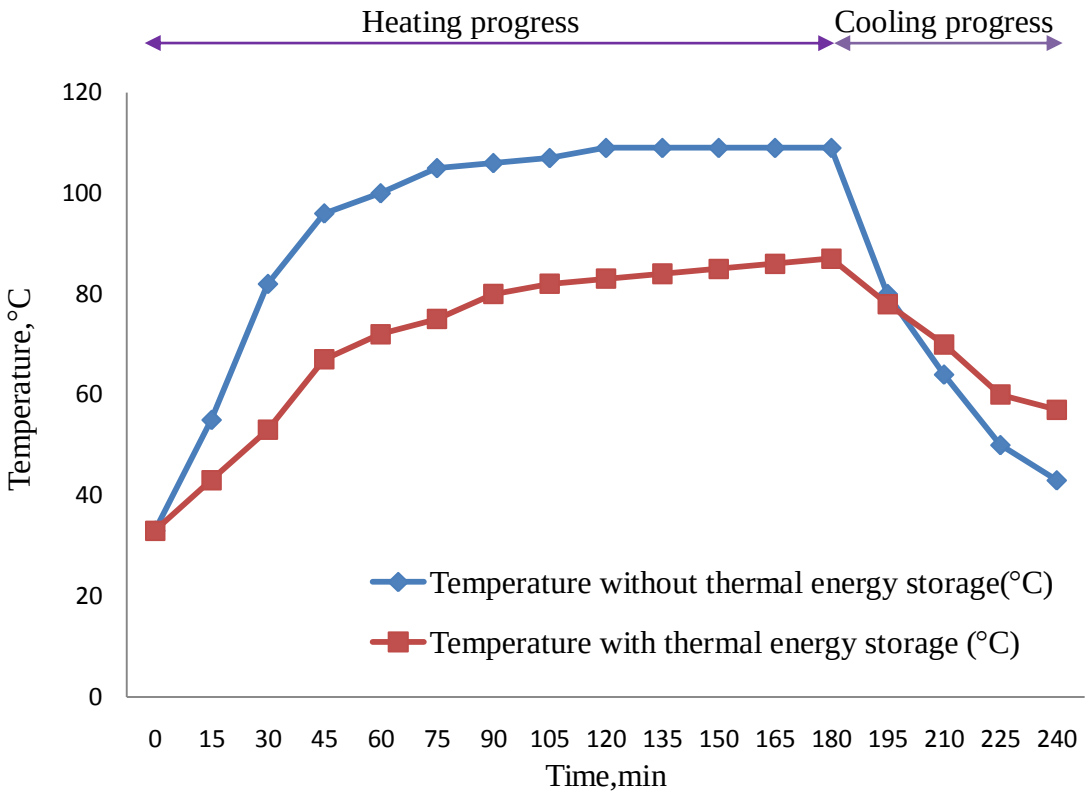


Figure 4.7: Result of experiment

According to graph in Figure 4.7, experiment been run for about 180 minutes heating and the last 60 minutes is the cooling down which mean cut off the light source. Experiment been run after the radiation is stable and in this experiment, 3 spotlight been used and the stable radiation are 880 W/m². Thermal storage that been used are river stones. The blue line is the temperature gradient without thermal energy storage and the red line is with thermal energy storage. Clearly we can see that with using thermal energy storage, the increasing of temperature are a bit slow and constantly at 120 minutes. Differently when without using thermal energy storage, the temperature was increasing radically. But, when we cut off the light source, without using thermal energy storage the temperature drop in 60 minutes is 63°C while when using thermal energy storage is only 35°C drops. It shows big different when we use thermal energy storage which mean, we will not to have worried if we use this cooker system outside when the sun is covered by the cloud and blocking the radiation to reach the reflector.

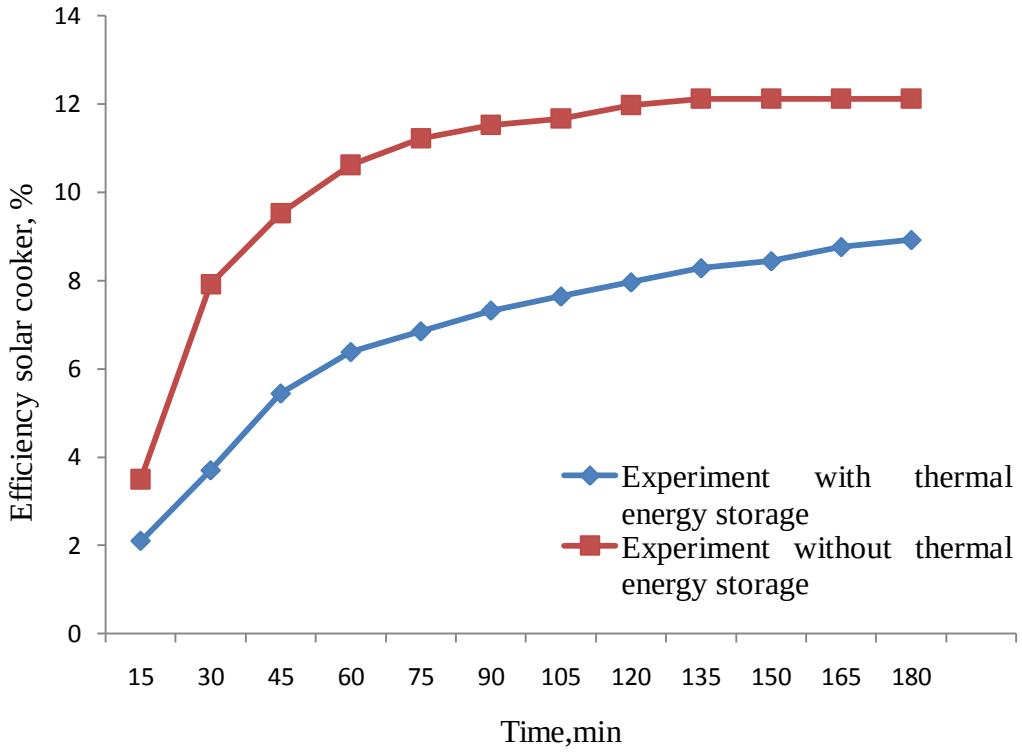


Figure 4.8: Variation of efficiency of solar cooker against time.

Using equation (3.1), the efficiency of concentrated solar thermal cooker (CSTC) has been calculated and plotted as shown on Figure 4.8. It can be summarize that the solar cooker was able to achieve of maximum 12.12% without using thermal energy storage. It is maximum efficiency of the CSTC is generally acceptable for a solar collector (SC) without thermal energy storage and insulation. The plot also show maximum of 8.92% with using thermal energy storage.

4.3 DISCUSSION

As can see from Figure 4.7,experiment have been run for 240 minutes heating and 60 minutes cooling down (cut off light source) without using thermal storage the temperature manage rise until 110°C. This is because we get 100% of heat radiation that been reflect by the parabolic dish. When using thermal storage, we just manage to get until 89° C. This is because, the heat that can be stored by river stone has a limits and that is around 80°C to 90°C. Besides, when using stone it is actually not received 100% of the heat that been reflected because it actually absorb heat from the river stone.

When the experiment is reach 180 minutes, the light source been cut off. It clearly shows that with using thermal energy storage, it could hold the temperature much better than without using thermal energy storage. Therefore the project is success.

Besides the good of thermal energy storage, the experiment success help by the reflector as it use chrome sticker that been paste with pizza shape. The way of the reflector pasted is also effect the performances of radiation reflect as it will make the surface smooth. During the experiment, the surface also has been clean first to remove dirt and dust on it so that no error will affect the result.

From the result of heating a steel experiment, the peak of the temperature for the solar cooker achieved is 110°C by without using thermal energy storage and 89°C by using thermal energy storage. But the highest temperature achievable by the solar cooker is greater than those temperatures. This is because; steel has its own specific heat capacity that is 420J/kg C. However, the temperature shown on Figure 4.7 is the benchmark how high the heat temperature can be produce by the solar cooker system.

CHAPTER 5

CONCLUSION AND RECOMENDATION

5.1 CONCLUSION

1. The temperature increase of system without thermal energy storage is better than system with thermal energy storage which in 1 hour, without using thermal energy storage, it increase up to 100℃ compare with using thermal energy storage it just 75℃.

2. The temperature drop is much better when using thermal energy storage compare with not using thermal energy storage with different of 28°C.

3. The efficiency of system without using thermal energy storage is up to 12.12% and with using thermal energy storage is up to 8.92%

5.2 RECOMMENDATIONS

To optimize the system to get better efficiency,

1. Find the true focal point and keeping the temperature more consistent. Invent an evacuated box specialize in placing the cooking pot and block incoming wind without blocking the sun light from entering the box. To find the focal point of the concentrated light, a device of light detector or device like the *Pyranometer* is good idea. However this device could take some energy which causes the energy reduction for cooking process.

2. For a massive production, thermoplastic is very sufficient material and the reflective surface is made of chrome plating process. This product a bit heavy because the material size used is oversize than the design. The design can be maintained by using a smaller material but the material size must not smaller than the material size in the design.

3. The reflector's surface must been upgrade to be smoother as so fabrication of new dish must be done. Besides, the reflector must use better material that similar to mirror.

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APPENDICES

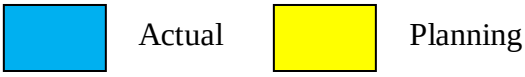
APPENDICE A

Final year project for 1st semester

Task	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15	W 16
Briefing on project overview																
Preparation for project flow																
Literature review progress																
Project equipment preparation																
Project material preparation																
Device testing and modification																
Preparation for FYP 1 report and presentation																
FYP 1 presentation																
Writing report submitting																

APPENDICE B

Final year project for 2nd semester



Task	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W14	W 15	W 16
Meeting with super visor																
Submit draft report of the project																
Design the experiment																
Run experiment																
Analysis and thesis writing																
Preparation for presentation FYP 2																
FYP 2 Presentation																
Submit the thesis																

APPENDICE C

Final Design for Grate