DESIGN AND FABRICATION OF CONCENTRATED SOLAR THERMAL (CST) SYSTEM FOR SOLAR COOKER APPLICATION

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Report submitted in partial fulfilment of requirements for
the award of Diploma in Mechanical Engineering

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NOVEMBER 2010

SUPERVISOR DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

Signature :
Name of Supervisor :
Position :
Date :

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any diploma and is not concurrently submitted for award of other diploma.

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ACKNOWLEDGEMENT

Praise to God as I had completed my Final Year Project, design and fabrication of concentrated solar thermal system for solar cooker application. I'm very thankful and grateful to my supervisor, Mr. Amir Abdul Razak for the moral support and guidance in finishing this project. I appreciate his help since the first week of my project to the final week of my project.

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ABSTRACT

This report is about the design and fabrication of concentrated solar thermal system for solar cooker application. This project encourages the study of concentrated solar thermal system and also the solar cooker. Solar cooker is a device used for cooking application using the energy from the sun light. Concentrated solar thermal system help the solar cooker to gain a better heat concentration. Project is start with the study and research. From the information gathered from the literature study, four designs had been created. One of the designs is chosen using design screening process and modification is made. With the final design, fabrication is started. The process involves in fabrication are cutting, glass fibre works, arc welding and glass fibre's moulding process. When the product is finished, it is tested to determine the temperature obtained and to prove that the product is working and success. Any further problem and recommendation regarding the product is discussed on the last chapter.

ABSTRAK

Ini adalah laporan mengenai lakaran dan pembuatan sistem haba matahari tertumpu untuk kegunaan pemasak solar. Projek ini menggalakkan kajian terhadap sistem haba matahari tertumpu dan juga pemasak solar. Pemasak solar adalah alat yang digunakan untuk memasak menggunakan tenaga dari cahaya matahari. Sistem haba matahari tertumpu membantu pemasak solar utnuk mendapatkan penumpuan haba yang terbaik. Projek ini bermula dengan melakar pemasak solar. Berdasarkan maklumat yang diperolehi dari kajian sejarah, empat lakaran telah pun dibuat. Salah satu daripada lakaran-lakaran ini dipilih menggunakan proses penyaringan lakaran dan pengubahsuaian dibuat ke atas lakaran yang terpilih. Sesudah lakaran terakhir, pembuatan dimulakan. Proses yang terlibat dalam pembuatan adalah pemotongan, kerja-kerja serabut kaca, kimpalan arka dan proses pembuatan acuan untuk serabut kaca. Apabila produk sudah siap, ianya diuji untuk menentukan suhu yang diperoleh dan untuk membuktikan bahawa produk ini berfungsi dan berjaya. Sebarang permasalahan yang berkaitan dan cadangan mengenai product ini dibincangkan di bab terakhir.

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LIST OF SYMBOLS

mm	millimetre
ml	millilitre
°C	Degree Celsius
°F	Degree Fahrenheit

LIST OF ABBREVIATIONS

CAD	Computer Aided Drawing/Drafting
CST	Concentrated Solar Thermal
GTC	Gran Telescopio Canarias

CHAPTER 1

INTRODUCTION

1.1 PROJECT SYNOPSES

1.1.1 General Project Synopsis

This project is about the design and fabrication process of Concentrated Solar Thermal (CST) system for solar cooker application. This CST system is the medium to increase the sun light heat for cooking's energy source. The reason of choosing this project is because the support of the green product is rising nowadays as the usage of other energy sources could cause a massive pollution. The product made will be used for the study of the solar cooker for future. That’s why the fabrication of the CST system for a solar cooker is suggested. When the fabrication is finished, the product is tested for the functionality and efficiency. The duration of this project is one semester and it’s only covers the design and fabrication process. Basically this product is a cooker that using heat energy from the sun light for a cooking purpose.

1.1.2 Specific Project Synopsis

A solar cooker is a device which uses sun light as its energy source. Because of they use no fuel and they cost nothing to run, humanitarian organizations are promoting their use worldwide to help slow deforestation and desertification; caused by using wood as fuel for cooking. However, the natural sun light source does not provide enough heat for a cooking purpose. Hence, solar collector system is introduced for the solar cooker application. Among of the group of solar collector, concentrated type of collector is the best (Ghosh, 2008). Concentrated Solar Thermal (CST) is one of the concentrated collectors. It is the system that concentrated the sun light into the focus of the system to get the higher intensity of light than that naturally available. It is either to use the concept of refraction of light or reflection of light. Those focus point will have high amount of heat than the natural sun light. And the heat source is used for cooking purpose. Perhaps, for general information, this solar cooker is not available on Malaysia market at the moment.

1.2 PROBLEM STATEMENT

Nowadays, green products or simply called eco-friendly products are rising up in the market stock. It is due to support of environment control program to reduce the global warming effect on earth. Solar cooker is one of the green products which are now getting itself famous on the market. Most of the recent design of the solar cooker is using concentrated solar thermal system to amplify the heat from the sun light. But the problem is the design of the concentrated solar thermal system doesn’t suits the solar cooker well in terms of the portability, ergonomics, cooking flexibility and concentration ratio. The concentrated solar thermal system also does not optimized well. To help in solving this problem, a better concentrated solar thermal must be invented.

1.3 PROJECT OBJECTIVES

1.3.1 General objective

The objective of this project is to train and expose the student on the process of design and fabricate a product. In addition student also able to apply their knowledge and skill they learnt before either during the class or outside the class. This project challenge the student to do research and solving any come out problem towards a successful project. This project trains the student to run a project with minimal supervision and test the student soft skills.

1.3.2 Specific Project Objective

One of the main project's aims is to design a Concentrated Solar Thermal system for solar cooker application using Computer-Aided-Drawing/Drafting (CAD) Software and the project also aims for the fabrication of the CST system based on design created earlier. This product should be able to heat ups s medium such as water and any material such as copper sheet metal to a certain degree of temperature to prove that this product can be used as (solar) cooker. Instead of design and fabrication of CST system, any related part and system such as cooker stand and grate is needed to be fabricated.

1.4 PROJECT SCOPES

To ensure to project is under control and stick with the title, the scopes of project is discussed. Every scopes of this project are the task of the student and it is under student responsibilities.

This project covers:-

- The design and fabrication of CST system in full scale.
- The design and fabrication of solar cooker stand cooking grate.
- The fabrication of mould for glass fibre process for parabolic dish fabrication and any related system.

1.5 PROJECT PLANNING

This project begins with the briefing of the title from the supervisor on the first meeting with supervisor. During the briefing, the main objective and the project scopes are prepared. On that meeting, supervisor prepares the schedule of the right time for the next meeting with him. The meeting with supervisor shall be arranged if help needed.

To manage the timeline of the project, a flowchart (refer to the sub-topic 3.2) and the Gantt chart (refer the appendix A) is prepared. The project is for one semester of study; about 14 weeks. Therefore the Gantt chart must cover the project in 14 weeks. Project proceeds with gathering the information regarding solar cooker and concentrated solar thermal system. The source and reference is mainly books and aided by internet. With those references, a research and literature review is conducted. This information helps mostly in design generation process. Those designs then undergo a selection system to find a better final design. This process is called design selection.

The criteria considered in the design selection are based on the problems during the problem statement. Each of design is referred to the datum in kind of improvement of the design than the datum product. The final design then presented to the supervisor to make sure the design fulfil the project requirements.

After that, the project proceeds with material selection, fabrication process selection and fabrication planning. Thus, fabrication process of product can be started as well. If modification needed, a new design must be created or the current final design is modified.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

CST is one of the examples of solar collectors. Its' come in various designs in the market. Therefore some review is done on CST system to find out any available products that use this concept and to study the CST itself. This kind of research is needed as it will help in making the better understanding on CST. It also encourages the creativity and idea for designing process. A research on how heat is generated from the sun light also is made. The research would cover the CST and its related information, the material used and the fabrication used. Another solar collector instead of CST is also discussed.

2.2 HISTORY OF SOLAR COOKER

Sun as the heat energy sources for food is known long time ago. It had been used for food drying and food heating. The example is drying any fruit by expose it directly to the sun light or by placing it on the hot rocks which is mostly available at desert. From this observation, this method (use of sun light for food) was the first method of cooking on earth (Halacy, 2002).

2.3 SOLAR COLLECTORS

Solar collector is a device use to collect heat from sun light. It collects heat by transforms solar radiant energy into heat (Beckman, 1996). The process will be explained on subtopic of solar radiation. There is various type of solar concentrator use on solar cooker such as flat bed collector, Fresnel collector, solar oven and many more. This type of collector had been categorized into concentrated, non-concentrated, evacuated and non-evacuated. The Figure 2.1 shows the tree diagram of the known solar collectors.

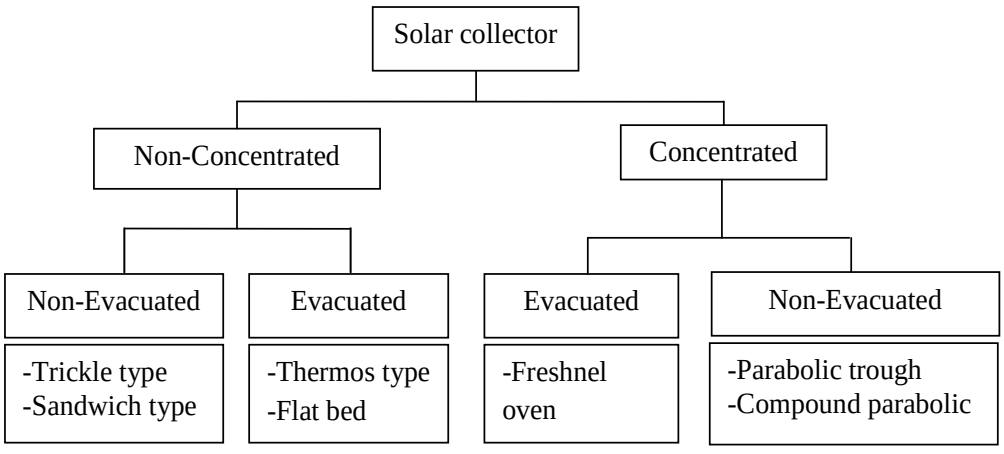


Figure 2.1: Classification of solar collector

Every category of collectors has their own advantages and disadvantages. Non-concentrated type of collector is good for low heat requirement but long heat supply requirement. This type of collectors is easy to use as it requires no adjusting of the elevation toward the position of the sun. Flat bed or flat plate collector is categorized as non-concentrated collectors. Flat plate collectors are the main stay of domestic solar water heating (Beckman, 1996). The purpose of the system using this type of collector is commonly for food drying, low-heating process and water purification or pasteurization in conventional way.

2.4 CONCENTRATED SOLAR THERMAL SYSTEM

CST system is implemented after the ideas of heat ups things using sun light with aid of other device were started. There are many type of CST design available on the market such as parabolic trough and Fresnel oven. The concept of concentration is divided into two classes; refraction and reflection. The application of concentrating the light had been used widely such as the spectacles, magnifier and microscope.

Under the refraction concept, the simple example of the CST is the magnifier where had been used to ignite fire using dry dead leafs and the sun light as the energy source. It is either to focus the sun light into a single focal point or into a single focal line. Actually there are two groups of refraction collector, single surface lens and equivalent lens as shown in Figure 2.2. Fresnel lens always good for compact application but single surface lens is the good one (Sen, 2008). Fresnel is compact however the light concentration by this type of lens is not very optimized as single surface lens.

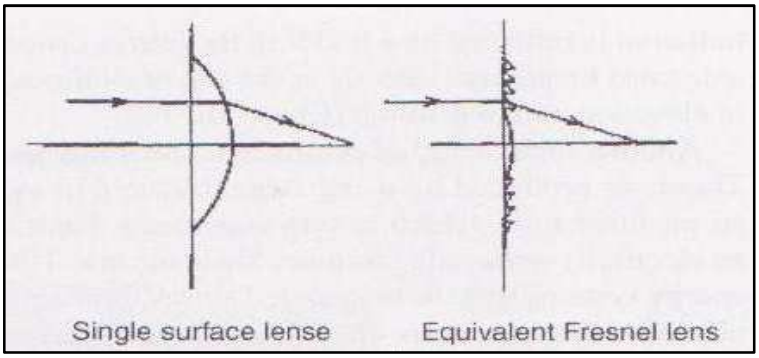


Figure 2.2: Method of refraction

Source: Ghosh, 2008

However, the fabrication process of the refraction type of CST is too costly. It is because this concept requires the quality control on the material and clearness of the refractors and also the index of light refraction. A maintenance cost and time consumption would be higher than the reflection concept. When the lens had been defect, it would need to be remade again. Furthermore the refactory process for the defect product is also required the high cost (Baker, 2004).

Reflection method is used to replace the refraction type of CST when cost saving and large scale device is needed. The biggest telescope in the world, Gran Telescopio Canarias (GTC) located at Canary Island used the reflection concept which is consisting of segmented mirror (Duffie, 2006). It is because this method much easier to maintain as the surface of reflection can be polished and serviced every time. Any minor defect can be repaired directly and refactory is less needed.

Just like the refraction, there are two types of reflection concept are used. It is concave mirror and equivalent Fresnel mirror as shown on Figure 2.3. Fresnel mirror or can be called segmented mirrors always be use when limited space is concerned. Segmented mirrors are always the chosen one as it requires no curving surface therefore the usage of flat mirrors or reflectors are possible.

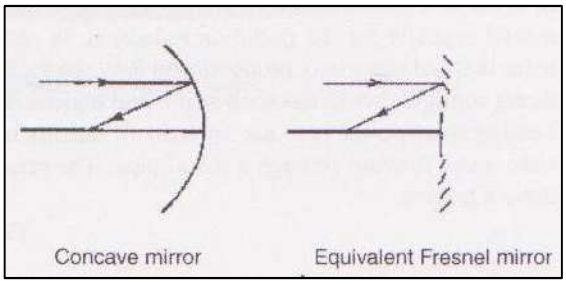


Figure 2.3: Method of reflection

Source: Ghosh, 2008

Concentration method is always produced a high temperature rising which is may exceeds the boiling point of water. Therefore it is always being used in solar electrical generators. However, this kind of method is always needs the collectors pointing to the sun to reach the optimum performance. But the concentrated method is still the best in making the high rise of temperature.

2.5 SOLAR RADIATION

Solar heat is gained from the solar radiant and sun light. It is happen when the material absorbs the radioactive wave that come together with the solar radiant. The reason of solar heat can be reflected is because it comes with sun light in form of short visible wave or be called solar radiant. The sun light come in the range of the long wave form (infrared) to the short wave form (ultraviolet) (Sherwin, 1996). Every surface could reflect the wave especially reflective surface (Sherwin, 1996). The more the material absorbs the solar radiant, the more the heat gained. That's why most blackened surface is the good heat absorber. But black surface also the good heat emitter (Sherwin, 1996). Because of that the temperature is rising and dropping fast. Actually heat come from the energy from the sun which is come together with photon. That's why to measure the intensity of sun light intensity of photon energy is measured and not the temperature.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Project is started with the designing process. These designs were created based on the project's and product's requirement. There are a few of design created without changing the original product's functionality. Material selection is being considered in the design process. The design is presented in three-dimensional drawing instead of sketching so it is easy to understand. Then the process continues to design screening and finalization. After the final design has been chosen, the project continues to the next phase which is the fabrication process.

3.2 PROJECT PROCESS

This project is started with the design process. The design process considers the findings during the literature review. From the information gathered, four various designs are prepared. After the design process, the project continues with the design screening. When a final design had been selected, the project proceeds with fabrication. There is a flow 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.

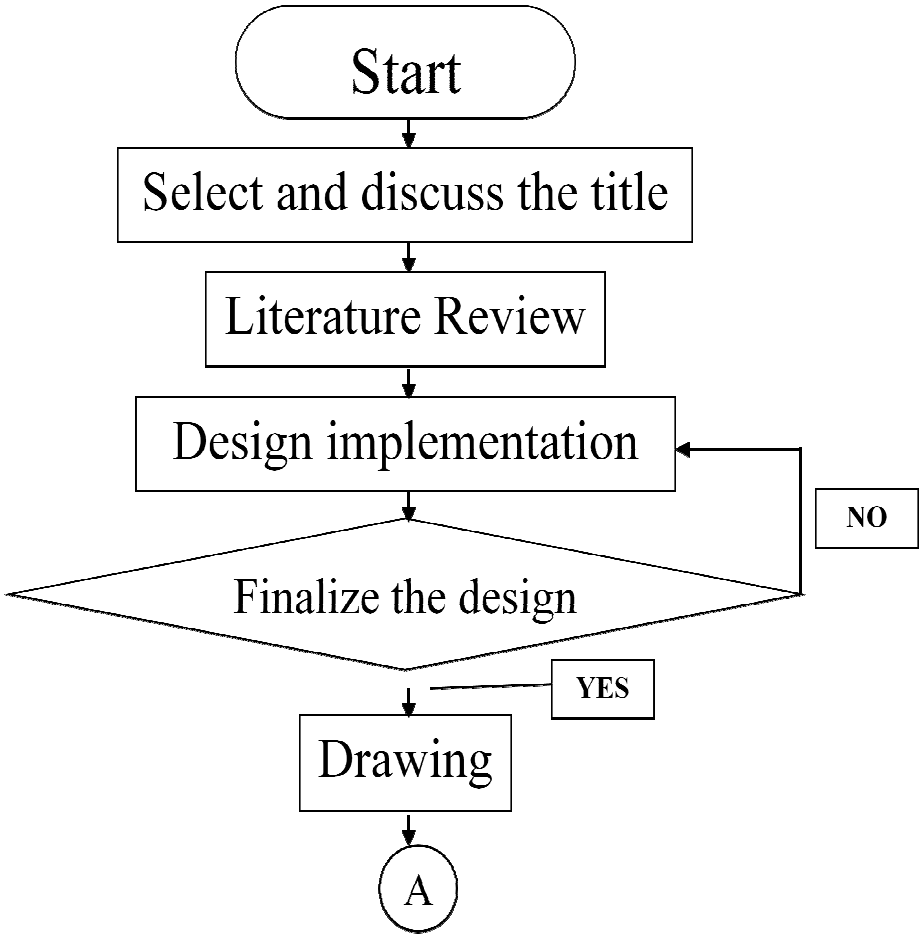


Figure 3.1: Project flow diagram

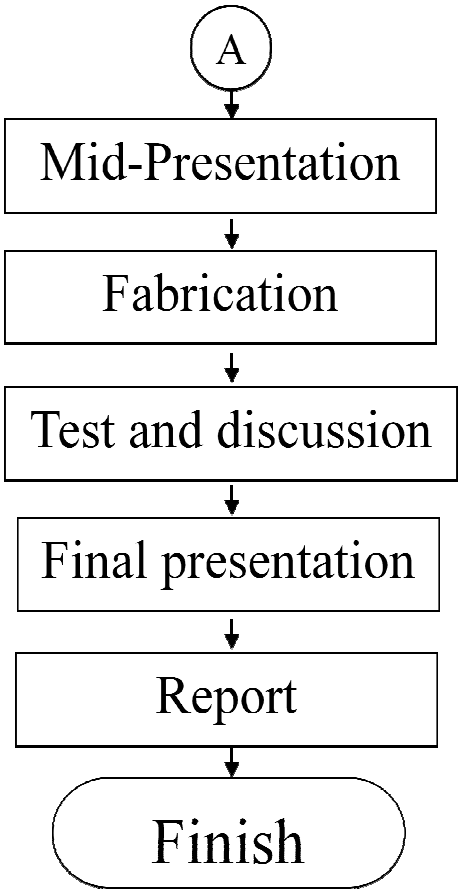


Figure 3.1: Continue

3.3 DESIGN SELECTION

There are four design created. Each of the design considers its own look, stability, portability and material. This design will be presented to the supervisor to ensure the design is still cover the project's title. Each of design is explained briefly in terms of functionality and material. In case of the design does not suit the project title well, modification or new design is need to be created. All of four designs will use parabolic shape of reflector. This reflector also is called as parabolic dish. The reason of using only one type of reflector because to make small differences of each design but could varies in kind of material used and the fabrication process.

3.3.1 Design A

The three-dimensional drawing for first design, Design A is shown on Figure 3.2. Each of the main parts is labelled but not the small system.

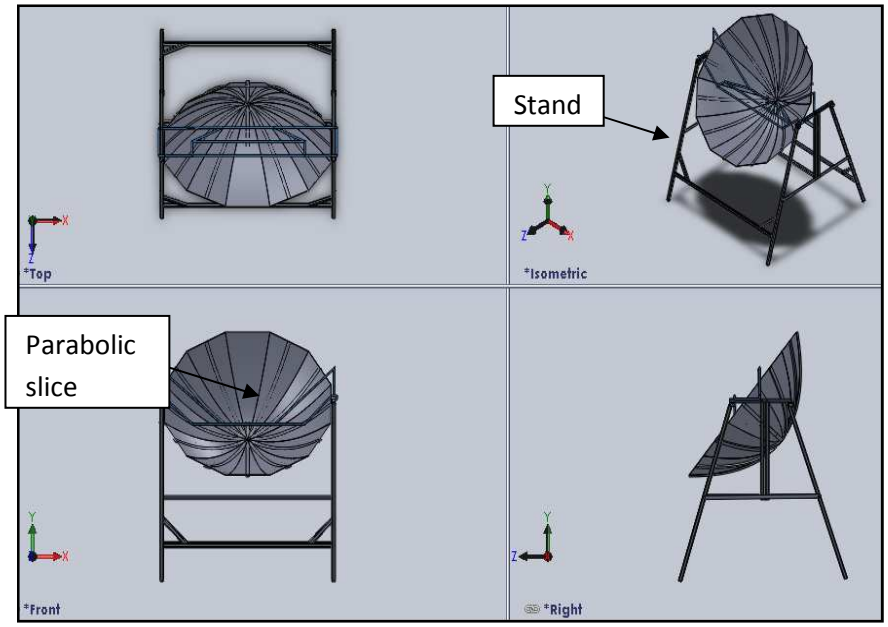


Figure 3.2: 3D view of Design A

Design A consist of two parts, Part A is the parabolic slice and Part B is the stand. Part A is made of aluminium sheet as the reflector and aluminium plate as the aluminium sheet support. The support is bent into a parabolic shape. Part B is made of mild steel and welded together. Every movable and not fixed joint is joined by bolts and nuts. The parabolic slice is adjustable in term of the inclination since it requires tracking of the sun light. This design is made off as foldable to make it easy to store which required just a small space when not in use. Figure 3.3 shows the condition when this design is folded. Whet it is in folded condition, the cooking grate can be inverted upside down. However this design has no tires attached on it.

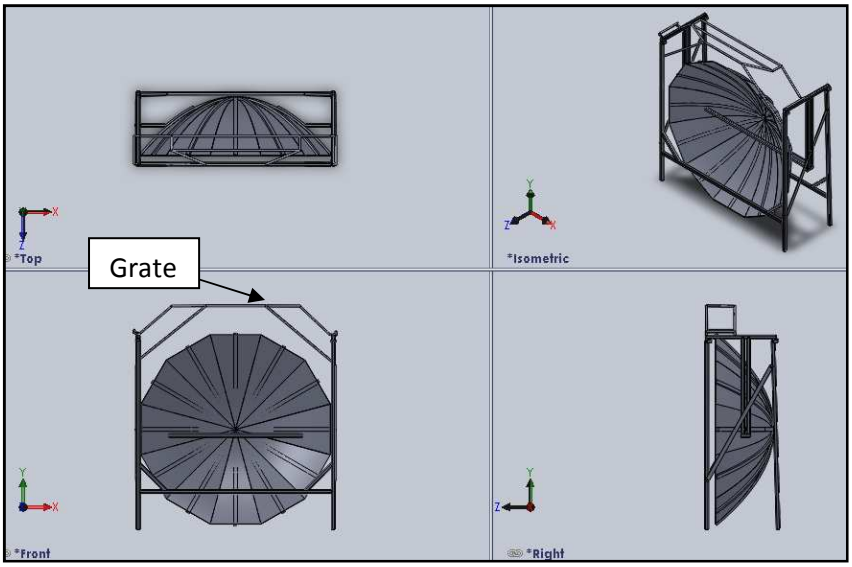


Figure 3.3: Design A in folded condition

3.3.2 Design B

This design is very different with the Design A and not a modification of Design A. The three dimensional drawing is shown on Figure 3.4.

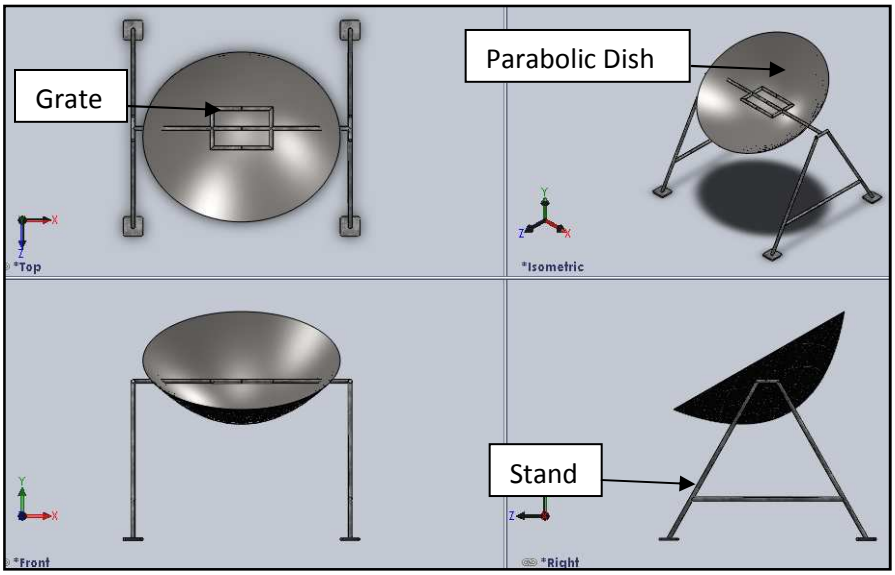


Figure 3.4: 3D view of Design B

Design B does not foldable. It is very simple. There are four plates placed on the design base to support the design when it is used on soft land. However it could take more space when it is stored rather than Design A. The cooking grate is fixed and not detachable like Design A. This design does not have tires attached on. That's mean this design is hard to move.

3.3.3 Design C

For the Design C, it is most likely the Design B. There are few differences between both designs. The material for the stand of Design B is galvanized iron pipe while Design C used hollow square mild steel. Design C have tire added on the bottom side or base of the stand. Actually the parabolic slice for both design use thermoplastic and coated with chrome finishing. Figure 3.5 show the three dimensional drawing of Design C. The grate is fixed and not detachable as Design B. The good of this grate is it become tougher than the grate of Design A. The grate for this design is wider than the grate of Design B.

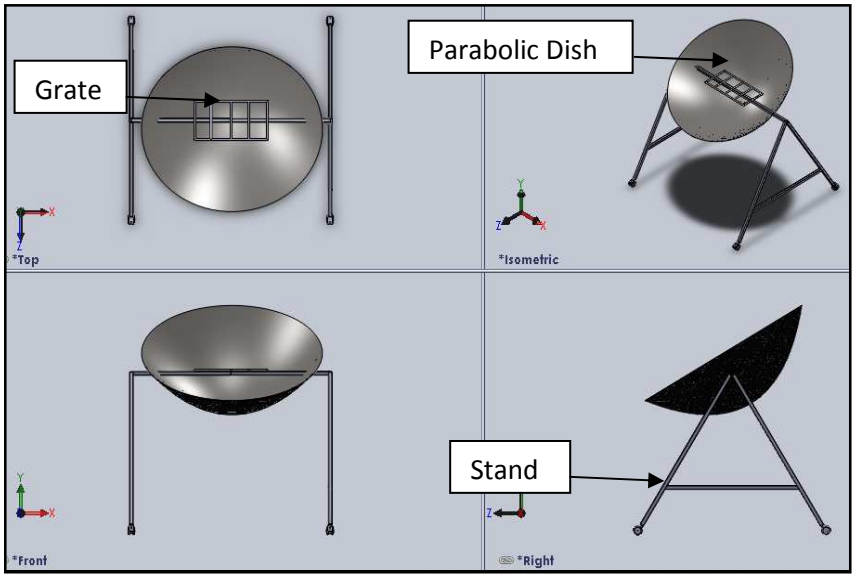


Figure 3.5: Design C

3.3.4 Design D

Design D's look is almost the same as the Design A. The three dimensional drawing of this design is shown on Figure 3.6. Most of different on this design than the Design A is lies on the stand.

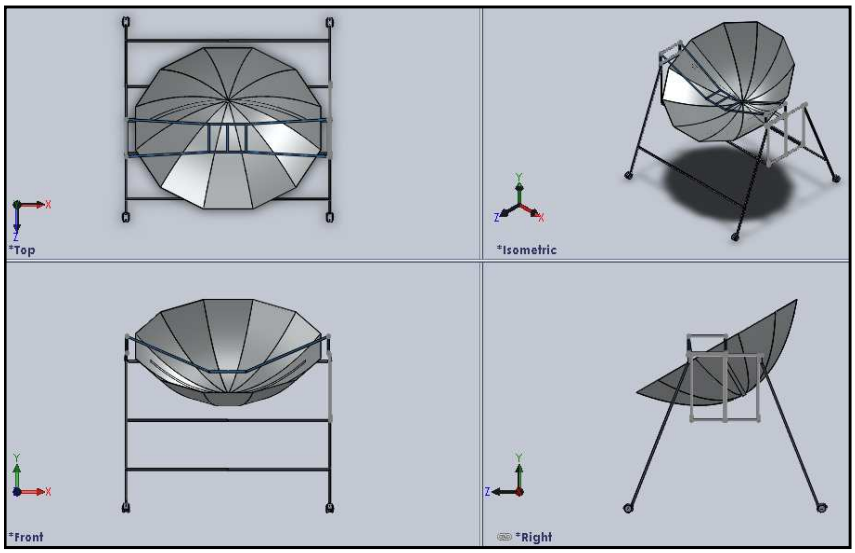


Figure 3.6: Design D

The drawing of Design D in folded mode is shown on Figure 3.7. Design D is foldable make it easy to store and use only small space. There are tires added so the design is easy to move. The parabolic slice were made of stainless steel sheet, welded together and have a chrome finish coated inside the parabolic dish. The chrome coating is used to reflect sun light. The stand is made of hollow square mild steel and welded on every joint.

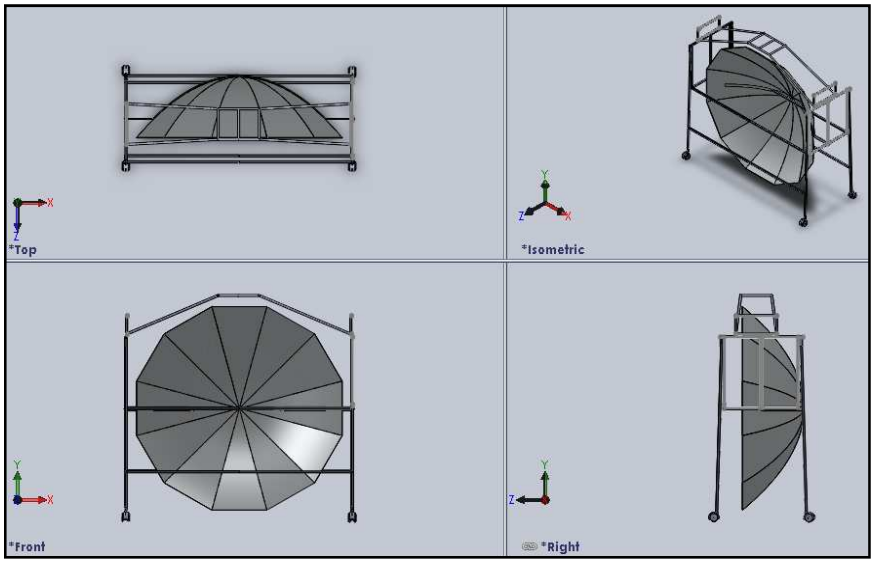


Figure 3.7: Design D when it is folded

3.3.5 Design Finalization

Among of the four designs, one design will be selected as final design through the design selection. The method used in this design selection is concept screening with one datum product. The datum product is selected from the current product. It is used to measure the best or the worse of the implemented design. The datum is shown on Figure 3.8. During the concept screening, improvement of the design will get the positive mark labelled with positive (+) sign while if the datum product has the better characteristic than the design, negative mark will be given labelled with negative (-) sign. For the same characteristic which is mean no change is made, the design will get zero mark labelled with zero (0). Table 3.1 show the concept screening Table.

Figure 3.8: Datum product

Source: William, 2008

Table 3.1: Concept screening

Criteria	Datum	Design A	Design B	Design C	Design D
Portability	0	-	0	+	+
Ergonomic	0	+	+	-	+
Concentration Ratio	0	0	+	+	0
Cooking flexibility	0	+	0	0	+
Space saving	0	+	0	0	+
Number of '+'	0	3	2	2	4
Number of '0'	5	1	3	2	1
Number of '-'	0	1	0	1	0
Net Score	0	2	2	1	4

Based on the Table 3.1, Design D has the highest net score. Therefore Design D is selected as the final design. But, Design D is not perfect enough because of its concentration ratio is lower than Design B and Design C. So some modification is made on the Design D. The parabolic dish is changed from using the stainless steel sheet to thermoplastic. The new design of Design D is shown on Figure 3.9.

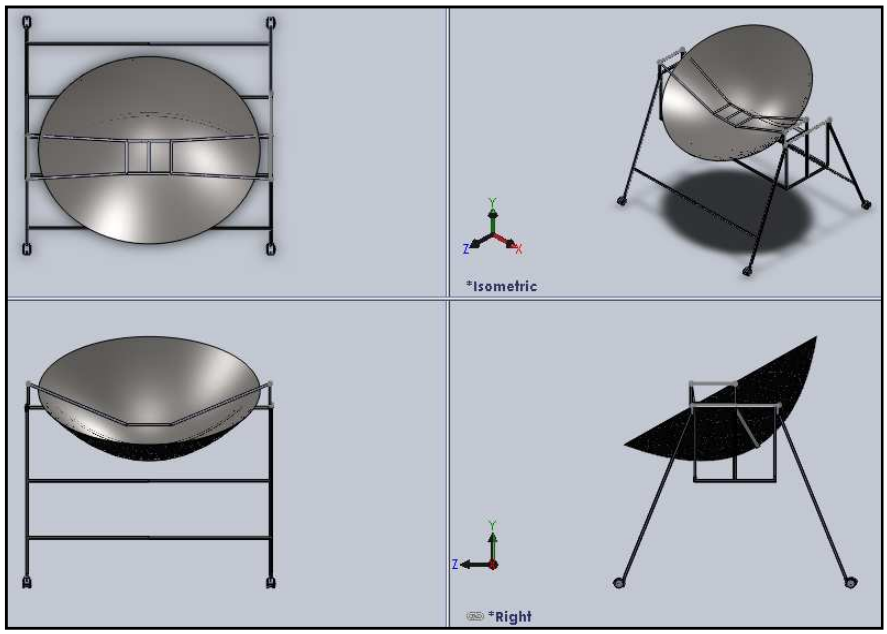


Figure 3.9: Final Design

The final design is a bit small than the datum. This factor could help the product to achieve the portability with addition of tires. The small size supports the ergonomics factor which is sufficient with Malaysian. The brief dimension of the final product is presented in Figure 3.10.

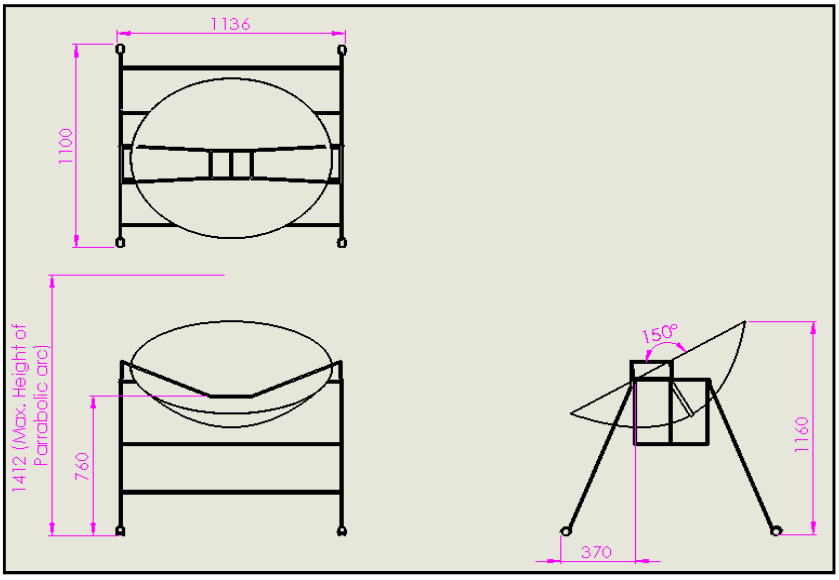


Figure 3.10: Dimension overview of final design

3.4 MATERIAL SELECTION

Aluminium is the first famous material used in making the reflector. It is either use the aluminium foil or aluminium sheet (Baker, 2004). Aluminium is good because it is recyclable. But aluminium is not always the right choice. Aluminium is a bit heavy than the new alternative material which is thermoplastic. Thermoplastic suits well especially for the mass production. To make the thermoplastic able to reflect the sun light, the inner surface is coated with chrome finishing.

During the design selection, thermoplastic is chosen material for the parabolic dish with chrome coated on the inner surface. However to fabricate the parabolic dish, especially the chrome coated surface, a professional assistant is required and need to be fabricate at plating industry. Furthermore the fabrication of thermoplastic required mould for thermoplastic which could be involved in injection moulding and this kind of process is very useful for massive production. But this process is very costly and not sufficient for this project because there is only one product need to be fabricated. Alternative material is required to substitute the thermoplastic. The

material is shall be a poor heat conductor and sufficient for complex geometrical shape's fabrication.

Glass fibres seem suitable to replace the thermoplastic. It is good for making a product with complex geometrical shape (Baker, 2004). Therefore it is very suitable to complex geometrical shape like a parabolic dish. Glass fibre also requires mould but the mould is not complicated as the mould use in making thermoplastic products. This material is lightweight material compare to aluminium (Baker, 2004). Glass fibres are also widely used in boat fabrication industry and also automobile's custom body fabrication. This material also can be made as 'Do-It-Yourself' project which is meant that the fabrication process is easy and achievable by an amateur or student especially.

3.5 FABRICATION PROCESS

A plan is prepared for the fabrication process for a manageable work. This plan covers the time consumed, fabrication stages and the task covered. The fabrication process covers the product stand, grill, parabolic dish and any related system. While the tires, bolt and nut are bought at any hardware store. The first thing to fabricate is the mould for the parabolic dish. Next is the stand and followed by the grill and lastly the small mechanism to complete the system. The process start with the parabolic dish is because it is the most important part in this project and it is the CST system.

3.5.1 Fabrication of mould

First to know is how to make the mould and what to be used? The idea is to make a parabolic shape template and revolve it on a circle on a flat base. The mould would need a base with a center pole. The base will be made of wood and the center

pole is made of hollow square mild steel. Figure 3.11 shows the mould base while Figure 3.12 shows the parabolic template.

Figure 3.11: Mould base

Figure 3.12: Parabolic template

Then, polystyrene is used to fill up the cavity under the parabolic shape of the mould. When all cavity side is covered, the remaining space between the polystyrene and the parabolic template is filled up with plaster. Poly putty is used to cover the uneven surface and to help in giving the smooth finishing on the mould surface.

Figure 3.13 shows the mould after polystyrene is added. Figure 3.14 shows the mould when plaster is added and show the mould while adding the poly putty.

Figure 3.13: Mould after adding the polystyrene

Figure 3.14: Mould with plaster

3.5.2 Fabrication of parabolic dish

The mould is now ready as shown on Figure 3.15. To proceed with the glass fibre process, the mould surface is needed to be smooth. The mould surface is sanded and sprayed with the mould releaser agent. This is to make sure the glass fibre is not sticking to the mould when the process is done. This process is using 3 litres of resin, 2 percents of additive and a kilogram of fibreglass mat. The fibreglass mat used is the woven type. Mask is used during this process because it is very dangerous as the person could be exposed to the small glass's fibres and also the odours of the resins and additives.

Figure 3.15: Mould ready for glass fibre process

Resin and additive is mixed up together until its mixed well. The first layer is started with pour the resin solution onto the whole mould surface evenly. Then apply the fibreglass mat to the mould until it covers whole area. Then apply the resin solution until the fibreglass mat look clear and no more white as shown o Figure 3.16. When finish let the first layer dried up under the room temperature. After a day and the first layer already dried, sand the surface and continue with second layer and further. For the second and further layer, no need to wait the layer to dried up (Baker, 2004). More and more layer can be added without a need of waiting for the previous

layer to dry up. And for this project, it use only two layers but it is advisable to make more than two layers for a tougher glass fibre. After the glass fibre dried up, the parabolic side is marked and cut by saw to remove the uneven side. The parabolic dish then is sanded and attached to the ring and the chrome sticker is pasted on the surface inside the parabolic dish.

Figure 3.16: Fibreglass process completed

3.5.3 Fabrication of stand and grate

The stand of this project is made of hollow square mild steel. Each of the hollow square mild steel is six metres long. This project use two of it and its' were cut into specific dimension as designated. Then groove is made on every ends of the hollow square mild steel as it is preparation for welding process. Arc welding process is selected for the joining the part because this process is cheap and widely available. The stand is then sanded as a preparation for finishing. For finishing the stand is painted with black colour using protective paint. Figure 3.17 show the cutting process using disc cutter and Figure 3.18show the groove on each end to be welded.

Grate is part to place the cooking pot. It is made of a solid mild steel rod with a diameter of 8 millimetres. This part is simple and easy to make. The rod is cut into specific dimension using disc cutter and welded using arc welding process.

Figure 3.17: Cutting using Disk Cutter

Figure 3.18: Making the groove

3.5.4 Fabrication of locking system

The locking system is a system used to lock the parabolic dish to make it fixed on one inclination. The lock system is additional system to make the solar cooker working fine and functioning well. Figure 3.19 show how this locking system's look.

Figure 3.19: Locking system

This locking system can be pulled in toward the parabolic reflector during the positioning of solar cooker from its folded condition either to risen the parabolic dish or lowered the parabolic dish. To lock the inclination of the parabolic dish, twist the ring nut till it tightened.

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 inside 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 glass fibre instead of with thermoplastic.

4.2 TESTING THE PRODUCT

An experiment is conducted to determine either the product functioning well or not. The experiment is conducted by heating a can of water which is containing 350 ml of water. The water used is the tap water and filled in the common aluminium can which is not painted to black. The recorded data of experiment is the temperature of water. There are two can of aluminium experimented. One of it is used for test the CST and another one is used for controlled variable. The controlled variable experiment measure the water when exposed to sun light without any addition device or heater. Figure 4.1 show how the experiment is set up. The experiment is set at Foundry Lab, Faculty of Mechanical Engineering, Universiti Malaysia Pahang. It is started on 9.00 o'clock in the morning. It is set on Wednesday, 3rd November 2010.

Figure 4.1: Experiment setting

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 4.2.

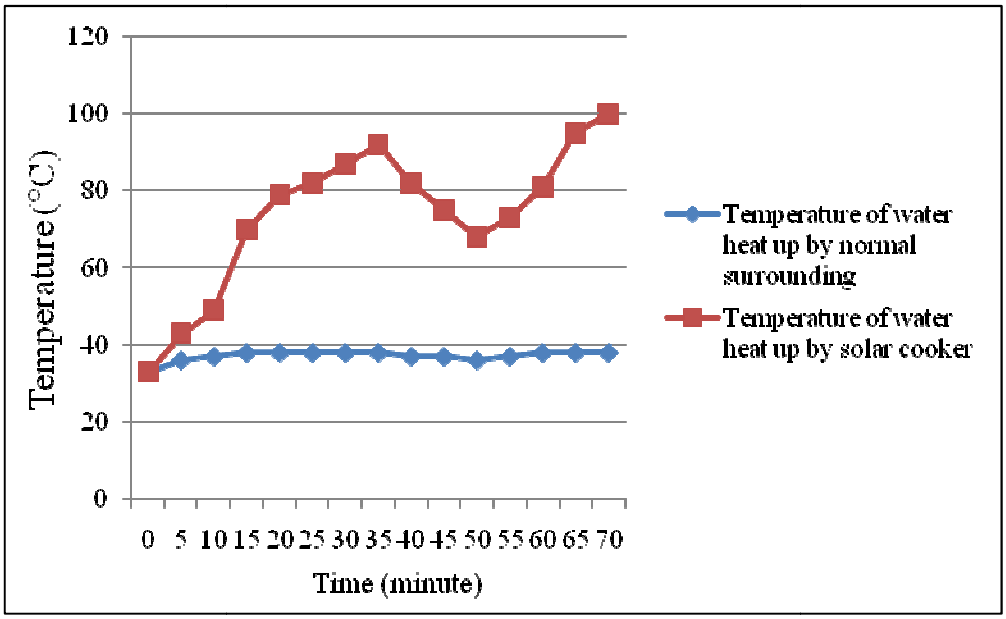


Figure 4.2: Result of experiment

To measure the maximum temperature that can be obtained from this product, an experiment of heating copper sheet metal is conducted. It is because the highest temperature of water is only on its boiling point, 100 °C (Beckman, 1996). Cooper is good heat conductor (Goswami, 2007). It can absorb heat and release heat in a short time. Therefore it is chosen for this kind of experiment. With these properties, an instantaneous temperature can be plotted. It is because the variations of the temperature toward weather need to be identified. The experiment is set up as shown on Figure 4.3. Infrared thermometer is used to measure the cooper temperature.

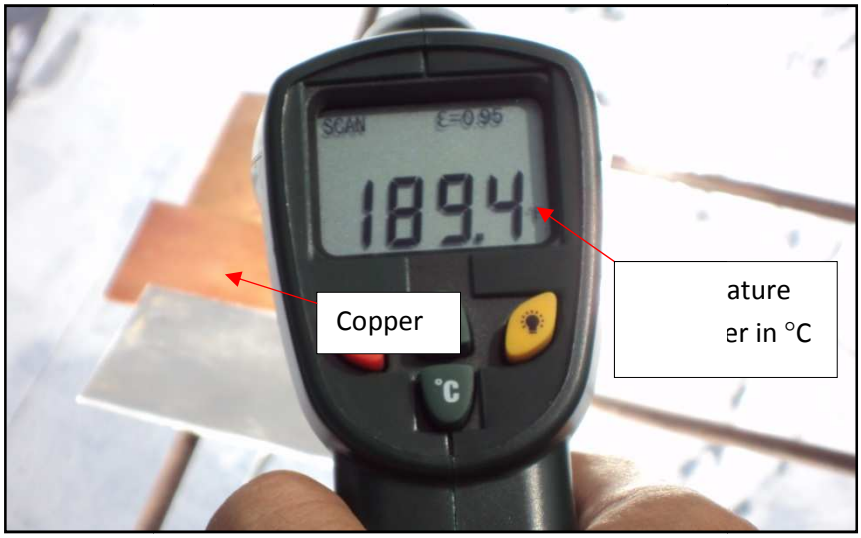


Figure 4.3: Copper experiment set

This experiment is set up on the same day on 11.00 o'clock in the morning. The temperature showed on the Figure the maximum temperature recorded during the experiment. The tabulation of the temperatures is presented in temperature versus time graph on Figure 4.4.

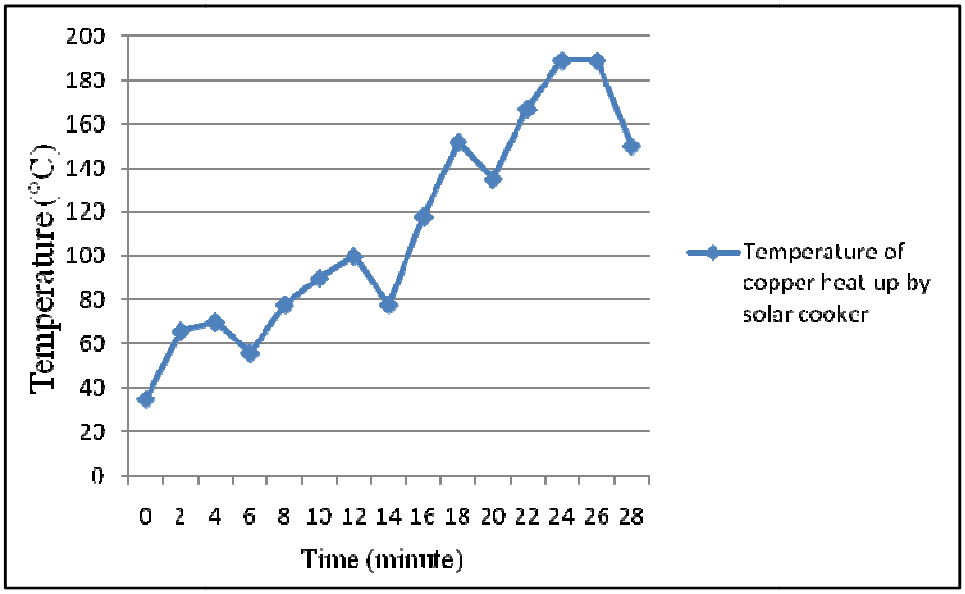


Figure 4.4: Result of copper experiment

To make the testing of the product more interesting, an experiment to ignite the common A4 size paper is conducted. The temperature level for igniting the A4 size paper is reviewed over the internet, paperwork and books. Ignition temperature is the temperature at which something catches fire and burns on its own. The ignition temperature of paper is 451 degrees Fahrenheit (°F), or 233 degrees Celsius (°C). This is the lowest result gathered on high school student using 80 grams A4 size paper. It is the same paper used on this experiment which is high quality of A4 size paper weighted 80 grams. The ignition time take 13 second to start. The burned paper is shown on Figure 4.5 by sequential images.

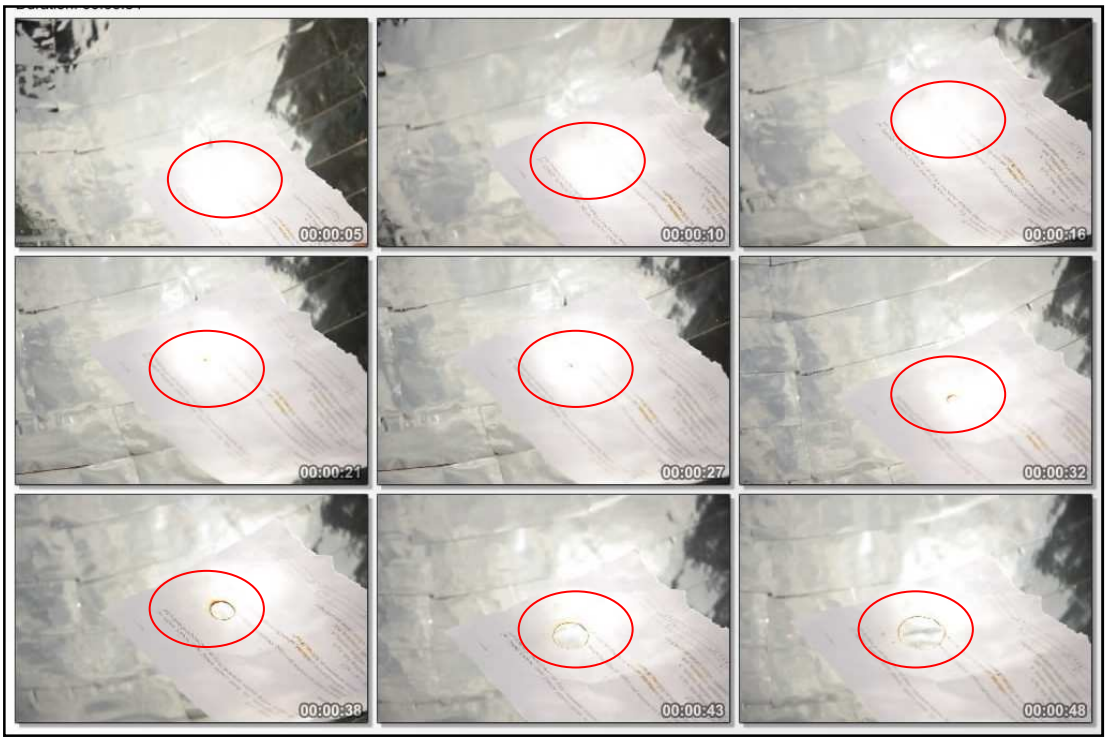


Figure 4.5: Ignition of paper

4.3 DISCUSSION

From the Figure 4.2 we can see that the temperature is not consistent and take more than an hour until it reaches the boiling point. It is because this product depends on the weather when the experiment is conducted. During the experiment, the weather is windy with sometime sunny and sometime cloudy. The fallen of the water temperature can be concluded as because of the cloudy weather. However as this experiment can boil the can of water, the aim of product is achieved. Therefore the project is success.

When the product is being experimented, the parabolic dish which the reflector of sun light have less temperature rising than the parabolic dish using the aluminium sheet. This is due to the characteristic of glass fibre as a composite material is poor in conducting heat. This factor helps this product in increasing the product efficiency. To be noted that the efficiency of CST cannot be measured on how much or high the temperature it produced. To measure the efficiency of the CST system, Pyranometer is used. This meter measures the amount of photon where photon is the energy carrier from the sunlight.

From the result of heating a cooper experiment, the peak of the temperature for the solar cooker during that day is 189.4 °C. But the highest temperature achievable by the solar cooker still do not confirm well. It is because the result lies on the weather when the solar cooker is used. That’s why the efficiency of solar cooker cannot simply be measured by the temperature it produced. But the temperature is the benchmark how high the heat temperature can be produce by the solar cooker. To be noted that Pyranometer measures the energy and not the temperature (Goswami, 2007). The temperature proves that this solar cooker can be used for cooking purpose. Next experiment is run by ignites the common office paper. When this solar cooker can ignite the paper, it shows that this solar cooker achieved the lowest autoignition temperature. The temperature for autoignition is as lower as 230 °C (Chung, 2003).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter conclude the whole project from the start to the end of project. This chapter shows on how the project conducted and each result. The whole project is simplified to one chapter. After finishing the project, there are some recommendations over this project for next and future references. Therefore this project can be improved for a better quality and result.

5.2 CONCLUSION

Design and fabrication of CST has hit the end. This project was successful and run very well from its beginning to the product testing. The product is functioning and achieved its aim. The highest temperature that had been achieved is 230 °C during the ignition of A4 paper experiment. The study of CST and the solar cooker is very helping during the design implementation. Among of the four designs proposed, Design D is selected and some modification is made on Design D to improve the design's functionality. Glass fibre is used instead of using thermoplastic for the parabolic dish for the sun light reflector. Beside of the process is easy to made, it also a low cost process and a cheap material. But glass fibre plus the chrome sticker for the reflector does not very sufficient for massive production. The stand and the other related system is fabricated well. The differences of this product with the datum product which had been discussed in design selection in Chapter 3 are this product is smaller than the datum products. The product size suits very well with Malaysian average size. During the product testing, some weaknesses are detected and need to be improved. It is discussed later on recommendation. The function of the product is maintained; for a cooking purposed. In addition, this product is portable and easy to store which requires less space than the datum product. Overall, the usage of sun light energy for the cooking purpose is possible and can be expanded for further research.

5.3 RECOMMENDATION

The problems of this project are in finding the true focal point and keeping the temperature consistent. There are some suggestions for these problems. First recommendation is 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 nearly like the Pyranometer is good idea. However this device could take some energy which causes the energy reduction for cooking process. Another suggestion, 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.

REFERENCES

Baker, A.A. 2004. *Composite Materials for Aircraft Structures.* Virginia:AIAA Education Series.

Beckman, W.A. 1996. Twentieth Annual Power Sources Conference. *An Experimental High Flux Solar Power System*, pp. 190.

Chung, L. 2003. Ignition Temperature of Paper. (online). http://hypertextbook.com/facts/2003/LewisChung.shtml(23 October 2010)

De Meo, E.A. 1990. *Advances in Solar and Wind Energy*. New York:American Solar Energy Society

Duffie, J.A. 2006. *Solar Engineering of Thermal Process*. New York:WILEY Pub.

Ghosh, G.K. 2008. *Solar Energy The Infinite Source*. New Delhi:ASHISH.

Goswami D.Y. 2007. *Advances in Solar Energy RnD Annual Review*. United Kingdom:Earthscan.

Halacy, B. 2002. *The Solar Cookery Book.* California:Peace P Inc.

Sen, Z. 2008. *Solar Energy Fundamentals and Modelling Techniques.* London:Springer Pub.

Sherwin, K. 1996. *Thermofluids.* London:Chapman& Hall.

William, D.D. 2008. Parabolic solar reflectors. (online). http://solarcooking.wikia.com/wiki/Parabolic_solar_reflectors (19 August 2010)

APPENDIX A

GANTT CHART

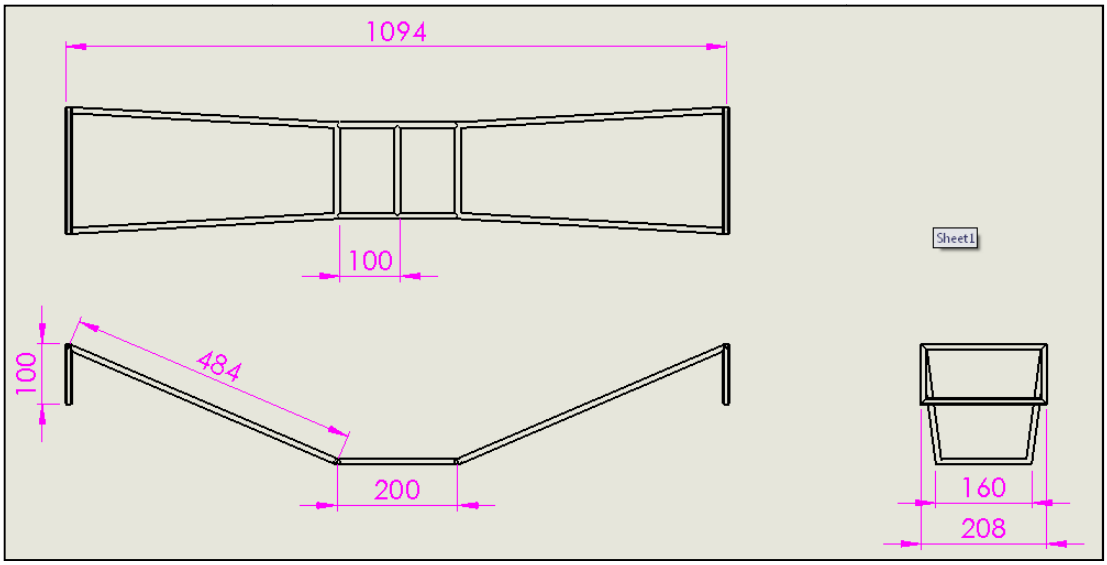
ACTIVITIES	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Title Selection, Scope, Objective	√													
	√	√												
Literature Review & Identify Problem	√	√												
		√	√											
Implement and Finalize the Design			√	√	√									
			√	√	√									
Mid-Presentation							√	√						
								√						
Fabrication / Testing / Evaluation (LAB)						√	√	√	√	√	√	√	√	
						√	√	√	√	√	√	√	√	
Final Report		√	√	√	√	√	√	√	√	√	√	√	√	
		√	√	√	√	√	√			√	√	√	√	
Final Presentation & Report Summation														√
														√

Actual

Planning

APPENDIX B1

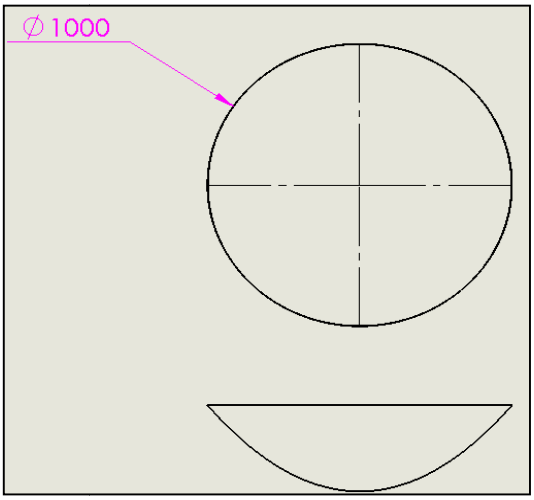
Final Design (Cooking Grill/Grate)



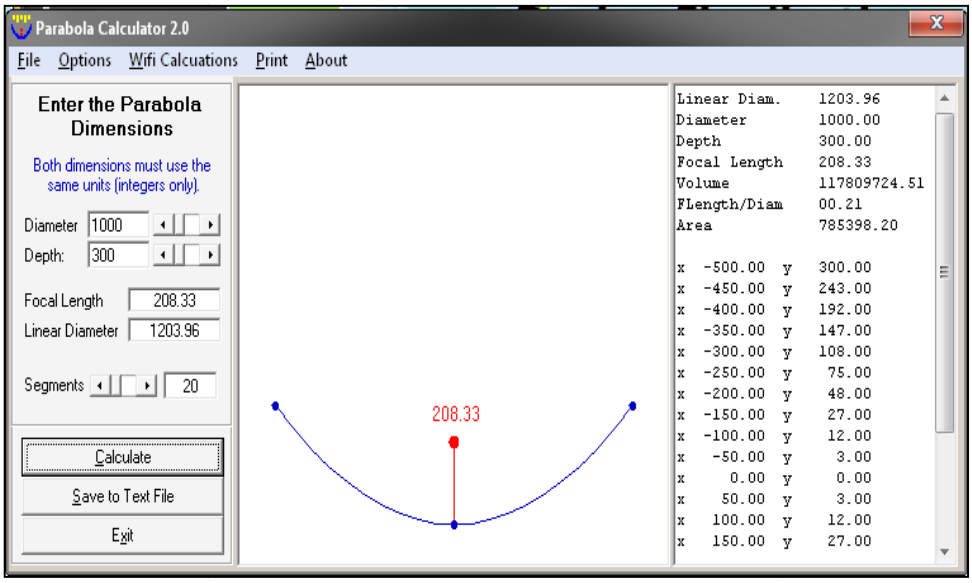
Cooking Grill/Grate drawing with dimension

APPENDIX B2

Final Design (Parabolic Dish/Reflector)



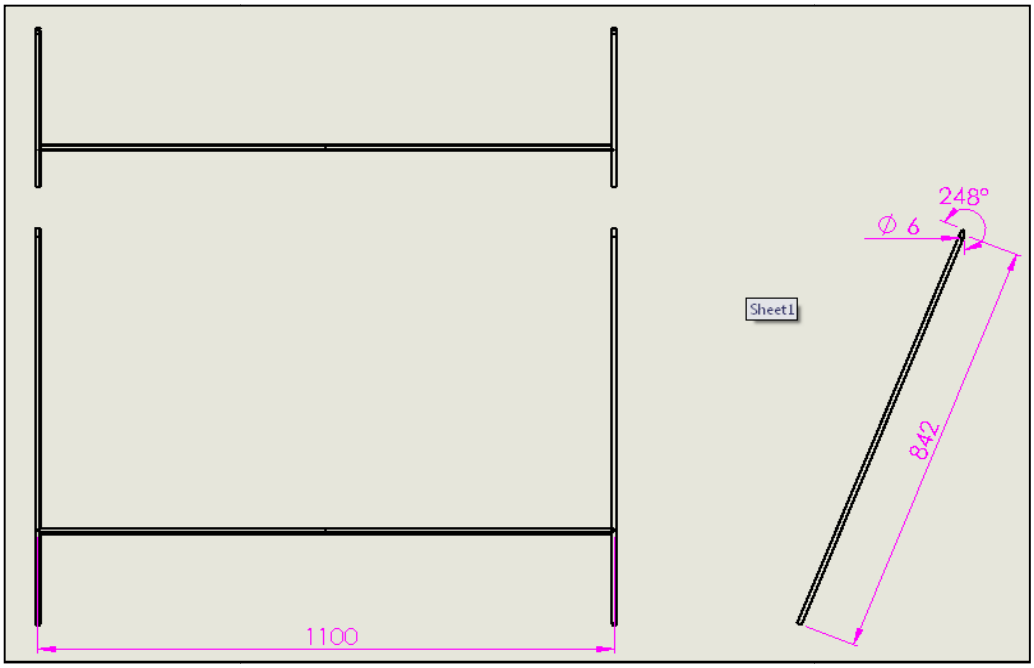
Parabolic Dish/Reflector drawing with dimension

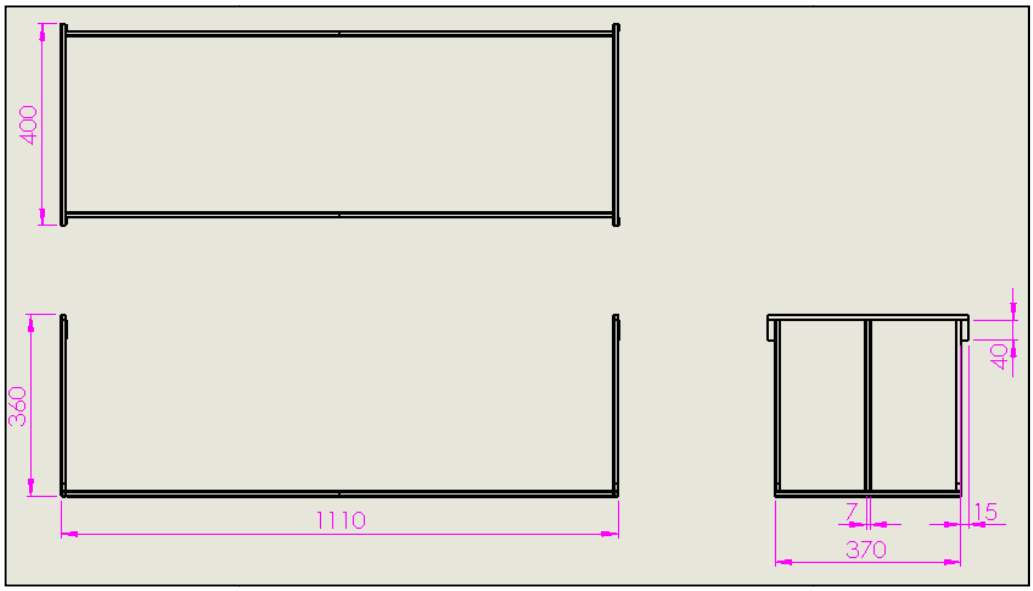


Software used to determine focal point and coordinate

APPENDIX B3

Final Design (Stand)





Unit : mm

Stand drawing with dimension