3.2 SOLAR COOKER PROJECT

3.2.1 Introduction

During the training period, I was assigned to design an efficient solar cooker. A Model which had been made with a cardboard box was given as shown in Figure 3.1. The experiments that had previously been done using this cardboard model had given 60°C as the maximum temperature. It had not been enough to boil the egg as it was just the temperature that the outer white was watery and fluid, and the white connected to the yolk was just starting to set and starting to turn opaque white with a warm runny egg yolk.

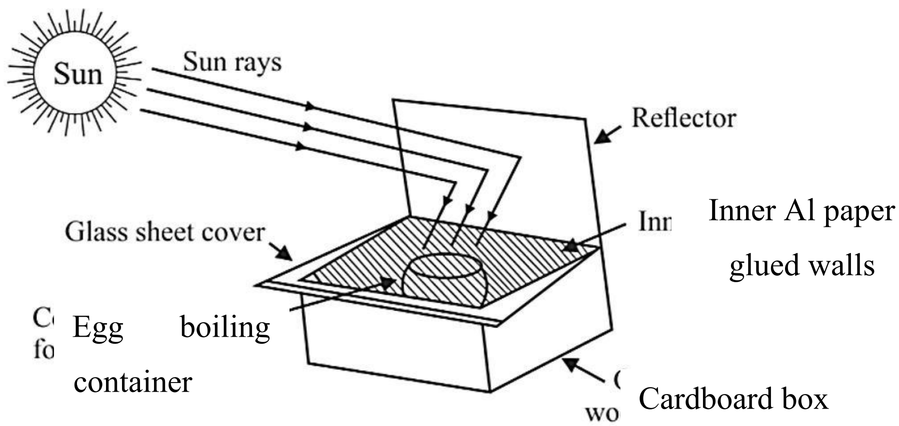

Figure 3.1 Cardboard Model Sketch

3.2.2 Problem Statement

The problem was to design a prototype solar cooker to increase the inside temperature of the cooker up to egg boiling temperature (80-88 degrees Celsius) by pressurizing the inner air, minimizing the errors that occurred in the existing model which is shown in Figure 3.2.

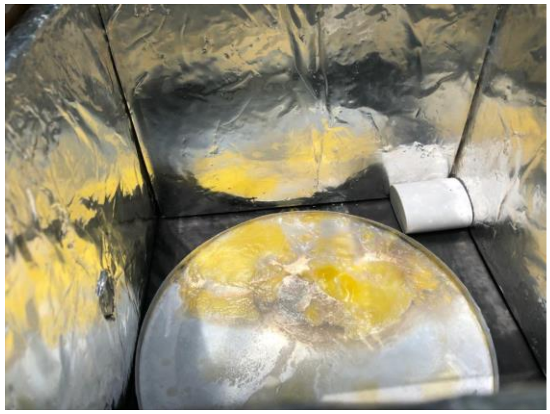

Figure 3.2:Inner view of existing solar cooker model

3.2.3 Research Methodology

First of all, research was done to gather information related to solar cookers. The information was gathered under the categories below.

- Research into the latest developments in solar cookers and how they are being used.
- Analysis of the current design of the prototype solar cooker and how it can be improved.
- Study of materials that can be used to improve the design of the prototype solar cooker.
- Research into the best methods to increase the inside temperature of the cooker up to egg boiling temperature.

Solar cookers have been developed in many ways all over the world and some examples are given in Figure 3.3. However, they have been developed considering increasing the quantity of heat that enters into the cooker. But our target was to increase the temperature inside the cooker by pressurizing the air (PV=ZnRT)

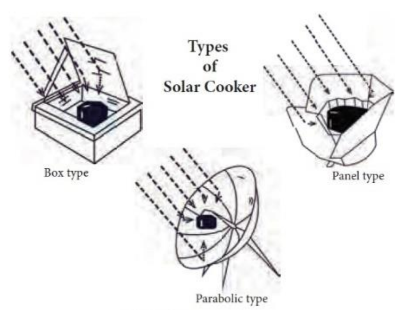

Figure 3.3:Types of solar cookers

While experimenting with the cardboard model, some considerable problematic situations occurred. The inner pressurized air leaked as the box couldn't be fully sealed. The sun's heat couldn’t get to a constant higher level due to the clouds and rain. Therefore IR machine was used to supply light and heat when natural light was lower but the glass of the model crashed due to the pointed, high-heated rays of the IR machine because of the quick expansion of the glass molecules. Apart from that, when the egg boiling started the inner humidity increased. Therefore, the light that entered the box was disturbed due to the sudden occurred low transparency. Figure 3.5 depicts how the humidity increased while the temperature was increasing during the experiment. The app used was OREL Home which had been created specifically by the Orel engineers. Therefore, the water vapor had to be removed manually by a tissue. The Al papers glued on the inner walls of the box were rough. Therefore the sunlight didn’t reflect 100% by the walls inside the box.

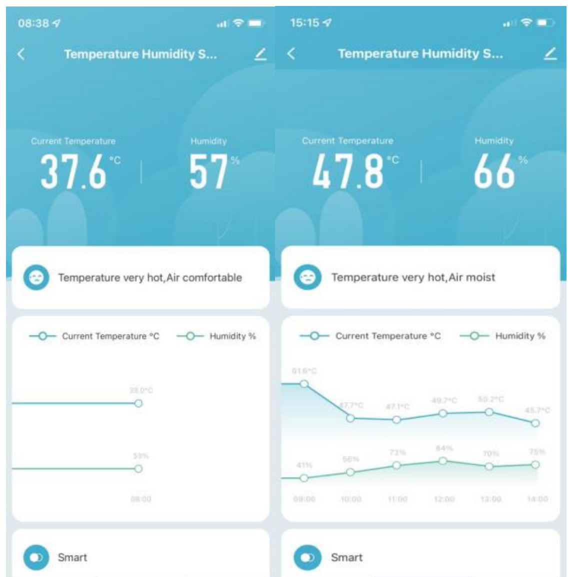

Figure 3.4 Variation of temperature and humidity from start to end of the day

After analyzing the existing cardboard model, some improvements were suggested to overcome those problems.

- Using a black matte pot to increase heat absorption instead of the aluminum pot.
- Implement methods to seal the cooker (use rubber grips to openings) and a specific locking system to the box.
- The area of the reflecting panel is increased using folding methods(mathematical models to perform origami) and the panel is made as its angle can be adjusted.
- Changing the design of casing the upper glass sheet cover

- Changing the material of the box from cardboard to metal sheet/wood to reduce the heat loss
- To reduce the radiation, mirrors for the walls, ceramic boards /alloy sheet/flex foam can be used
- To reduce convection, double-wall glassed walls can be implemented(vacuum tube technologies) or can use isolating air (greenhouse effect to heat retention)
- Silica jelly, Cotton, and Sodium have been suggested to reduce water vapor. However, Silicon jelly was rejected because it is poisonous to the human body. Cotton was better as it absorbed water 25 times of its weight.

Then, a solar cooker made of sheet metal was designed and implemented considering the limitations of the industry as well as the best method.

3.2.4 Design and Implementation

First, a similar model was designed using SolidWorks software. Then, it was modified, including the suggested improvements. The solid works model was then handed over to the sheet metal cutting unit. Subsequently, the drawbacks of the model that occurred when implementing the real prototype were identified, as shown in Figure 3.5. The bending machine couldn't do more than two bending in the same sheet and it couldn't bend a sheet into two same-size pairs at once. To overcome these drawbacks, the model was modified as shown in Figure 3.6 and Figure 3.7.

Figure3.5 Drawbacks of the initial design of the box

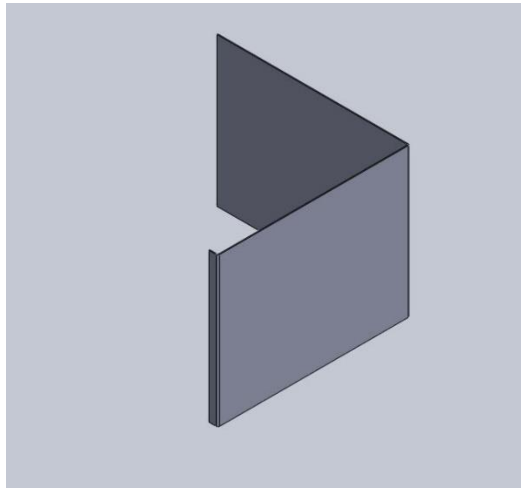

Figure 3.6 Isometric view of modified part of the Sheetmetal box(folded)

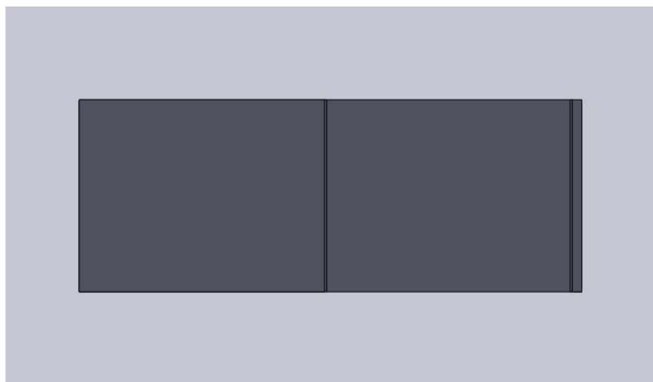

Figure 3.7:Unfolded pattern of the above part

In addition, the hinges used in the model were not available from OREL Corporation. Therefore, they must be changed according to the company's existing products (see Figure 3.8).

Figure 3.8 Already Existing Products in OREL(a hinge and a sheet metal box)

Considering all those factors, the box was modified as the finalized Solid works Model as shown in Figure 3.9

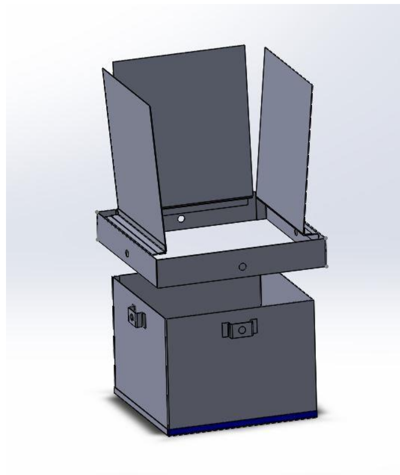

Figure3.9 Finalized Solid Works Model of the Solar Cooker

A prototype (see Figure 3.10) was then implemented. The box was powder-coated in black to absorb the heat from the outside. The rubber beading was mounted to seal the box with a piece of glass. A nut and bolt were used to fix the box to the upper panel part, as shown in Figure 3.11. The bolt was glued to the holes in the upper part to stop the movements of the upper panel. A reflective mirror material was used to line the inner walls of the cooker to ensure efficient reflection of sunlight. Additionally, a low-emissivity layer should be placed between the reflective material and the inner walls of the cooker to reduce the heat absorption of the inner walls.

Figure 3.10 Prototype of The Solar Cooker

Figure 3.11 Nut and bolt that was used to fix tightly the upper panel with box

3.2.4 Results and Discussion

The prototype solar cooker was able to reach the desired temperature of approximately 81 °C; however, some technical challenges hindered the process. First, the inner pressurized air leaked, which made it difficult to reach a constant higher level of sun heat. Second, the glass of the model crashed again because of the pointed and highly heated rays of the IR machine. Then, the IR machine was implemented as the rays did not point to a certain area of the glass. Then it didn't crash. Finally, the inner humidity increased when egg boiling started, affecting the transparency of the box.

To improve the design of the prototype solar cooker, it is important to identify and address the areas of improvement. To prevent the leakage of air, it would be necessary to design a better sealing mechanism but then we must consider the hardness of the wall material to prevent it from crashing due to high pressure. To prevent glass from crashing, it would be beneficial to use a more durable material. Finally, to reduce the inner humidity, it would be beneficial to use a better ventilation system. The cooker should also be equipped with a fan or blower to maintain the air pressure inside the cooker.