DESIGN AND CONSTRUCTION OF A BOX TYPE SOLAR COOKER

A report submitted to the Department of Mechanical, Sonargaon University of Bangladesh in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Mechanical Engineering.

Submitted by

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ABSTRACT

Now a day non-renewable energy available less percentage, that's why we have to use renewable energy i.e., solar energy, wind energy etc. Nothing is cheaper than free of cost. But solar energy is available in abundant amount in nature at free of cost. So, that we can use solar energy as option for non-renewable energy source. The cooking is the most important energy consuming operation at home, most of the country used firewood as a fuel and LPG and other energy sources are also using as fuel, but they are in less percentage compare to firewood. In urban region of our country of firewood is less than as compared to rural area. Hence to replace traditional cooking method by solar energy can be considered. Solar cooker is one of the best appliances to utilize solar energy for cooking. Solar cooking is a form of outdoor cooking and is often used in situation where minimum fuel consumption is important or the danger of accidental fire is high and the health and environmental consequences of alternative are severe. This review paper will provide a better understanding about solar cooker.

ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of **Khandoker Mohammad Faisal Karim**, Assistant course coordinator, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

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DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate

We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Energy is an ability to do work. According to law of conservation of energy is a property of object which can be transferred to other object or converted into different forms but can't be created or destroyed. There mainly two types of energy i.e., renewable and non-renewable energy. Renewable energy sources are solar energy, wind energy etc. and nonrenewable energy sources are petroleum oil, wood, coal etc.

In non-renewable energy sources have limitation on its use. Wood is primary energy source which was used all world. Since it has observed it is the simplest way to obtain the energy. Due to use of wood as substance for energy production. The problem like deforestation and pollution occurs. Mostly 50% total primary energy consumption is used. According to Indian government survey, over 77% of rural households in the country were estimated to depend on fire wood and chip for cooking. Over 7% uses dung cake and only 9% used LPG. In urban region LPG was primary energy sources mostly used near about 62% .

It is necessary to produce energy which will fulfill our needs in future. Among this solar energy is the best option for production of clean energy which is free of cost available in nature. Earth receives near about 3.84 million EJ of solar energy per year. Solar energy has wide range of application like thermal application ie. for cooking, solar heater, solar dryer and also we can use solar energy for produce electricity. But our intention to study about solar cooking because of in India sun is available nearly 8 to 11 hours/day though all year. So that solar energy should be alternative energy source for cooking. Solar energy is simple, safe and convenient without consuming fuel and polluting the environment. Solar cookers can also be use for boiling of drinking water, milk and provide access to safe hot water.

1.2 Background

Solar cooker is a device that cooks food using only sun energy in the form of solar radiation. The solar cooking saves a significant number of conventional fuels. The solar cooking is the simplest, safest, clean, environment friendly, and most convenient way to cook food without consuming fuels or heating up the kitchen. A major concern of today is the rapidly depleting natural resources. So, it is the urgent need of time to reduce the dependency on non-renewable sources, judiciously using the remaining sources and at the same time switching to new and better alternatives and renewable source of energy. [1,2] In most parts of India, solar energy is available almost throughout the year and can be used as alternate input to meet out energy needs. Solar energy is the cheapest, inexhaustible and can be used for various domestic and agricultural requirements including cooking, drying, dehydration, heating, cooling and solar power generation [3]. Solar cookers have a long history dating back almost 18th century when Nicholas-de-Saussure built first ever Solar Box Cooker.

1.3 Motivation

The method of cooking in sunlight has been around for a long time. Many people have made their project in many ways. In this, everyone got different output. Although it is very difficult to cook using solar energy, the cost of making this system is much less. Many systems in the market have many advantages and limitations. We are also trying to make a box type solar cooker by overcoming all these limitations. Which, of course, made the video an overnight sensation. We are trying to make ET for cooking using solar energy at low cost and have been inspired to make it.

1.4 Objectives:

The objectives of this project are:

- To study about **Design And Construction Of A Box Type Solar Cooker.**
- To design and construct of a Solar Cooker Model.
- To implement cooking system using Solar Power.
- To test the performance of the Solar Cooker Model.

1.5 Structure of the Project

This project book consists of six chapters. The first chapter contains the statement of the introduction, our background study for the project, objectives of the study in the project and the project organization. Chapter two contains literature review, details discussion about home automation system. Chapter four deals with the design of this project, block diagram and circuit diagram, working principle. Chapter three describes the background and real project, details of component and instrument details of the whole project. The chapter five, we discuss about result and discussion and shows the complete prototype of the project that we have built. In the final and chapter six we discuss about future scope and conclusion of our project.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In this section topics related to Heat Collector Solar Cooker System are included. These provide a sampling of problems appropriate for application of solar cooker box type system. The references are summarized below.

2.2 Literature Review

Solar cookers are simple, cheap, and trouble-free with good efficiency. Solar cookers were used as early as 1776 by De Saussure, who used a hot box-type oven. There are several ways by which the performance of the box type solar cooker can be increased. Solar cooker based on parabolic dish collector with phase change thermal storage unit was investigated. In this experimental setup, solar cooker with phase change thermal storage unit was kept on absorber plate of parabolic dish collector. During day time, acetanilide (phase change material) stores solar heat and during evening, solar cooker is kept in the insulator box. Then, the phase change material delivers heat to the food.[1]

In a study an ordinary solar cooker was compared with the solar cooker painted black and solar cooker with outer surface painted black along with glazing, the temperatures obtained for each type is 119oC, 175.4oC, and 186.3oC, respectively[2].Experimental testing and performance of improved solar cooker was carried out, in which it was observed that solar ovens are more efficient than solar cookers, but on the contrary solar ovens are more expensive and bulkier along with requirement of more tracking time. Hence simple box cookers with some modifications can overcome its demerits. It was observed that when the horizontal surface of absorption was tilted for better (33% more) solar radiation acceptance. Here two adjustable mirror boosters were used for improvement in solar radiation absorption.

This resulted improvement in overall solar efficiency i.e 24.6% which is thus comparable with the solar oven. But it affected the cost of this improved solar cooker by

a minute amount of 10%. [3] Advancement in the solar cooker helps overcome flaws in it, especially in the box type solar cookers, in the 1980's scientists mainly focused on the maximum optimization of the geometry of the solar cookers in order to simplify the geometry, and thus to reduce the overall cost. It was mentioned that with use of single adjustable booster mirror to solar box, notable amount of energy received for various angles of incidences increased significantly; moreover with increase in the latitude position, energy absorbed increases. Phase changing materials storage unit is helpful for cooking in the evening. Transparent Insulation materials trap the heat in the solar box and since they are transparent, there is no barrier for solar radiation to pass by [4].

Solar parabolic cooker are alternative to box cookers, with better performance, the favorable conditions of cooking are from 1:30pm to 3:30 pm IST. Test procedures for heating and cooling were used. They were conducted to evaluate characteristic performance parameters of the parabolic solar cooker. The only problem is that the parabola requires a lot of space, and the construction is quite difficult, resulting in increment in the cost [5]. Various researches are being conducted on different solar cooking systems which can cook food for a family of about 4 to 5 members. A model developed was found to provide this need. An interesting point was put forward where the solar energy was used in the kitchen. The LPG (liquified petroleum gas) was supplemented by the solar thermal energy source. Here the solar energy is used for heating water, then the heated water is passed through an heat exchanger, where it is used to cook the food, the major problem encountered was the temperature to which the water gets heated is low, hence efforts are being made to increase the absorption capacity.[6]

CHAPTER 3
METHODOLOGY AND IMPLEMENTATION

3.1 Introduction

In this chapter we describe history of solar cooker, about its operation, working procedure and its applications. In this chapter we gave some idea of solar box type cooker.

3.2 History

This solar cooker system is so effective and safe process. It is mainly used in factory and industrial area. After it used, we reduce the manpower and time. That's way we get good efficiency. This machine is very easy to use and it works very effectively. A relevant picture is added below –

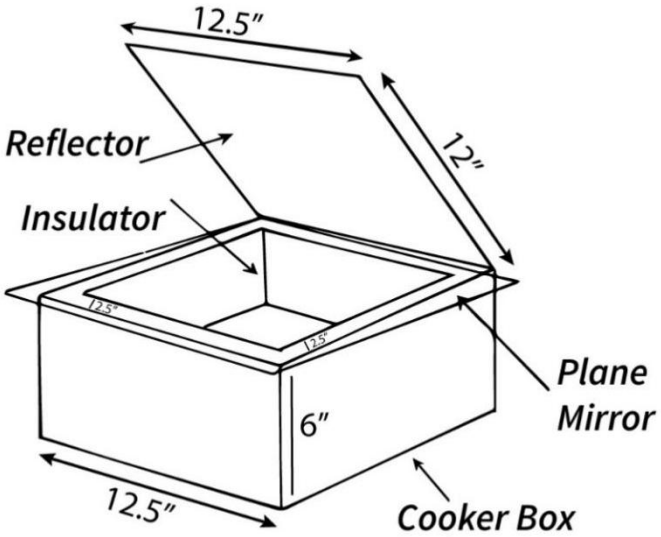

Figure 3.1: Solar Cooker System [13]

3.3 Solar Cooker

Cooking with solar energy is not new or novel idea. According to the Halacy and Halacy (1992) the first scientist who was done experiment with solar cooking was a German

physicist named Tschirnhausen (1651-1708). He used a large lens to focus the sun's rays an boiled water in a clay pot. That experiment was published in 1767 by Swiss scientist.

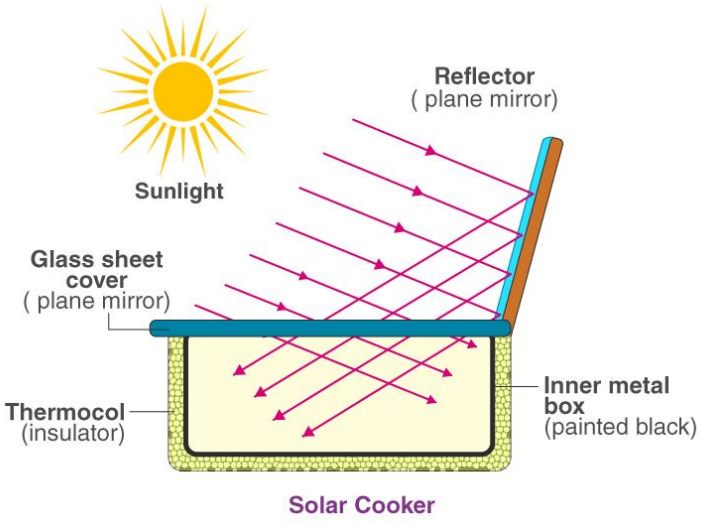

Figure 3.2: Solar Cooker Mechanism [14]

3.4 Principle

A mirrored surface having high reflectivity is used to concentrate light coming from sun on a small cooking area, but it is depending on geometry of cooking surface. Solar cookers are typically designed to achieve temperature 650 to 4000 on a sunny day. Solar cookers concentrate sunlight on cooking pan. Interaction between receiver material and sunlight converts sunlight into heat energy. Pots and pan used for cooking must be in black color only. It is most important to insulate the cooker simply by using glass lid on pot. It minimizes convection loss of heat energy in the solar cooker.

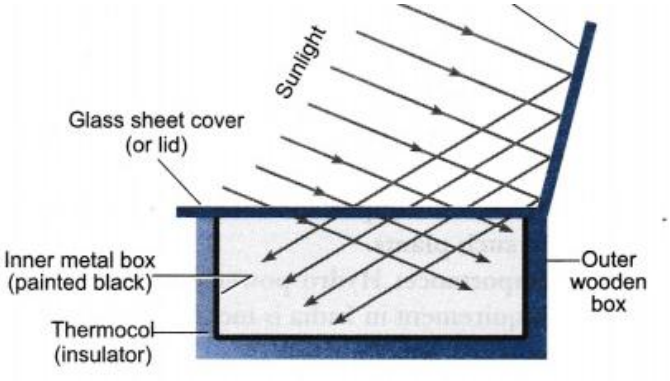

Figure 3.3: Solar Cooker Principle [15]

3.5 Operation

Different solar cooker has different working principle but most of them have same basic principle. Food cooks faster when it is in smaller pieces. Usually, small pieces of food placed in solar cooker. potatoes are normally cut into in small piece and cook. They should not whole. For simple cooking like melting butter, it is not necessary. If we have to cook different foods, then put them in different containers. After that container is placed inside the solar cooker. Food that cooks quickly that should place latter. Rice for lunch might be started early in the morning. Depending on size and capacity of solar cooker, quantity of cooked food, family can use one or more cooker. Solar cooker turned towards the sun and left until and unless food is cooked. Food in a solar oven is generally not stirred. Solar oven may be checked every one and two hrs., to turn the oven towards the sun. Make ensure about shadow of nearly building or tree. Cooking being used, quantity of food, air temperature, wind and latitude also effect on performance. By using small solar panel cooker it might be possible to cook rice for four people in four hrs. melting butter in 15 minutes.

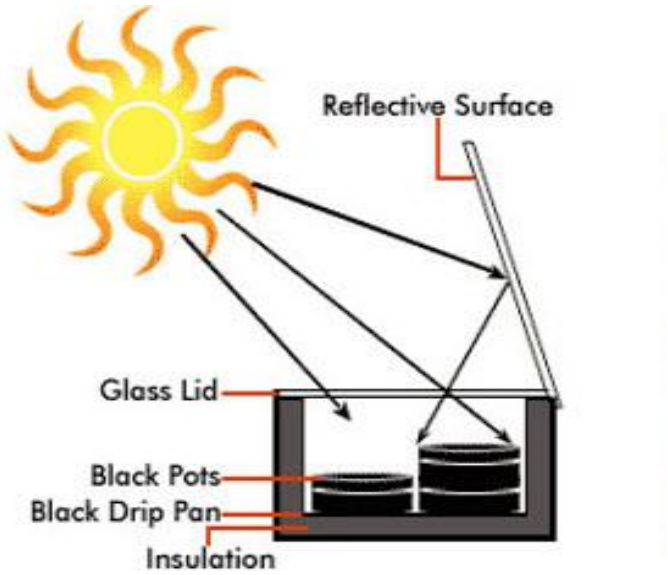

Figure 3.4: Solar Cooker Operation [16]

3.6 Applications of Solar Cooker

1. Fuel cost must be reducing.
2. Due use of non-renewable carbon % is
3. increasing, so that we are facing problems.
4. like global warming, increase in sea level.
5. It is free of cost energy.

CHAPTER 4
EXPERIMENTAL PROCEDURES

4.1 Introduction

In this chapter we describe our project methodology, working flow, working principle, final project view and brief description of our components. In this part we get a brief knowledge about our project structure.

4.2 Methodology

- Creating an idea for a **Design And Construction Of A Box Type Solar Cooker** And drawing and listed of components/materials to know which components/materials need to construct it.
- Collecting the all components/materials construct the system.
- Finally, we constructed this system & checked it finally that working very well.

4.3 Working Flow Chart

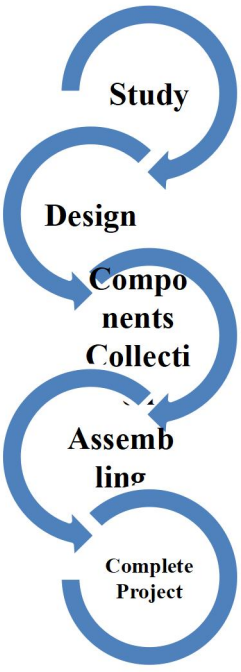

Figure 4.1: Working Flow Chart of Our Project. [17]

4.4 Block Diagram:

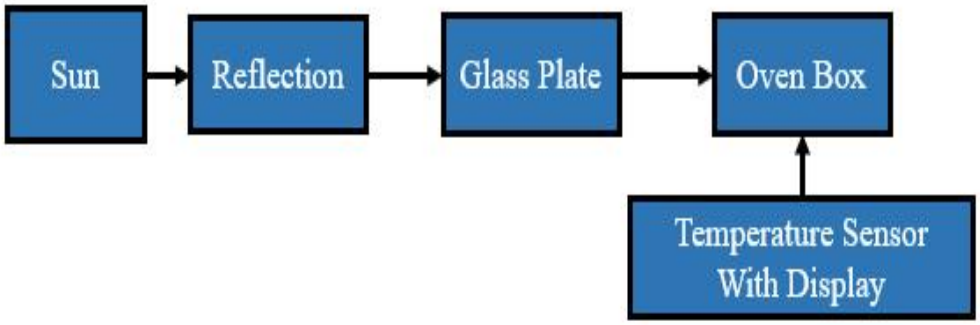

Figure 4.2: Block Diagram of Box Type Solar Cooker.

4.5 Working Principle

A mirror surface with high spectacular reflection is used to concentrate and channelize light from the sun into a small cooking space. The solar cooker placed in sunlight and a plane mirror reflector is adjusted in a way such that the strong beam of sunlight enters the box through the glass sheet. The blackened metal surfaces in the wooden box absorb infra-red radiations from the beam of sunlight and heat produced raises the temperature of a blackened metal surface to about 65°C. The food absorbs heat from the black surface and gets cooked. The thick glass sheet does not allow the heat to escape and thus, helps in raising the temperature in the box to a sufficiently high degree to cook the food.

4.6 Complete Project Prototype Image :

Figure 4.3: Project Inner View of Design and construction of a box type solar cooker

This is our final project prototype picture[4.3]. In our system we are now fully prepared to measure the temperature

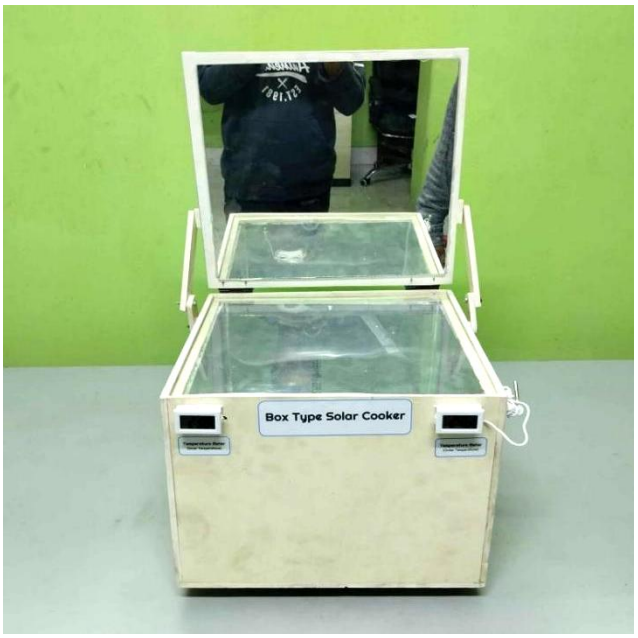

Figure 4.4: Final Project Prototype Image of Design and construction of a box type solar cooker

This is a fragmentary image [4.4]of our final project prototype examining the temperature in Crete. We kept this setup on our roof for a long time. And the amount of heat that is generated here can be seen in a temperature sensor

4.7 Components List:

1. Reflector (Aluminum Sheet)
2. Glass Sheet Cover (Plane Mirror)
3. Inner Metal Box
4. Temperature Sensor with Display

4.8 Plane Mirror

A plane mirror is a mirror with a flat (planar) reflective surface. For light rays striking a plane mirror, the angle of reflection equals the angle of incidence. The angle of the incidence is the angle between the incident ray and the surface normal (an imaginary line perpendicular to the surface). Therefore, the angle of reflection is the angle between the reflected ray and the normal and a collimated beam of light does not spread out after reflection from a plane mirror, except for diffraction effects.

A plane mirror makes an image of objects in front of the mirror; these images appear to be behind the plane in which than mirror lies. A straight line drawn from part of an object to the corresponding part of its image makes a right angle with, and is bisected by, the surface of the plane mirror. The image formed by a plane mirror can either be virtual (meaning that the light rays do not actually come from the image) or real (meaning that the light rays do actually come from the image). But it is always upright, and of the same shape and size as the object it is reflecting.

A virtual image is a copy of an object formed at the location from which the light rays appear to come. Actually, the image formed in the mirror is a perverted image (Perversion), there is a misconception among people about having confused with perverted and laterally-inverted image. If a person is reflected in a plane mirror, the image of his right hand appears to be the left hand of the image. Plane mirrors are the only type of mirror for which a object always produces an image that is virtual, erect and

of the same size as the object. however. The focal length of a plane mirror is infinity; its optical power is zero.

Using the mirror formula:

$1/u + 1/v = 1/f$

$1/u = -1/v$ since $[1/f = 0]$

$\Rightarrow u = -v$

Concave and Convex mirrors (spherical mirrors) are also able to produce virtual images similar to a plane mirror. However, the images formed by them are not of the same size as the object like they are in a plane mirror. In a convex mirror, the virtual image formed is always diminished, whereas in a concave mirror when the object is placed between the focus and the pole, an enlarged virtual image is formed. Therefore, in applications where a virtual image of the same size is required, a plane mirror is preferred over spherical mirrors.

Preparation

plane mirror is made using some highly reflecting and polished surface such as a silver or aluminum surface in a process called silvering. After silvering, a thin layer of red lead oxide is applied at the back of the mirror. The reflecting surface reflects most of the light striking it as long as the surface remains uncontaminated by tarnishing or oxidation.

Figure 4.5: Plain Mirror [18]

Most modern plane mirrors are designed with a thin piece of plate glass that protects and strengthens the mirror surface and helps prevent tarnishing. Historically, mirrors were simply flat pieces of polished copper, obsidian, brass, or a precious metal. Mirrors made from liquid also exist, as the elements gallium and mercury are both highly reflective in their liquid state.

4.9 Thermocol Aluminium Sheet

Polystyrene is used to make disposal plastic such as thermocol. Thermocol, alternatively known as **Styrofoam**, is one of the widely used products at present today. Thermocol are also used to make loose packaging products known as packing peanuts and insulation boards for floors, walls, and roofs in buildings.

As a thermoplastic polymer, polystyrene is in a solid (glassy) state at room temperature but flows if heated above about 100 °C, its glass transition temperature. It becomes rigid again when cooled. This temperature behavior is exploited for extrusion (as in Styrofoam) and also for molding and vacuum forming, since it can be cast into molds with fine detail.

Under ASTM standards, polystyrene is regarded as not biodegradable. It is accumulating as a form of litter in the outside environment, particularly along shores and waterways, especially in its foam form, and in the Pacific Ocean.

Figure 4.6: Thermocol Aluminium Sheet

4.10 Digital Thermometer

A thermometer is a device that measures temperature or a temperature gradient (the degree of hotness or coldness of an object). A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the pyrometric sensor in an infrared thermometer) in which some change occurs with a change in temperature; and (2) some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model). Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research.

Some of the principles of the thermometer were known to Greek philosophers of two thousand years ago. As Henry Carrington Bolton (1900) noted, the thermometer's "development from a crude toy to an instrument of precision occupied more than a century, and its early history is encumbered with erroneous statements that have been reiterated with such dogmatism that they have received the false stamp of authority."

The Italian physician Santorio Santorio (Sanctorius, 1561-1636) is commonly credited with the invention of the first thermometer, but its standardization was completed through the 17th and 18th centuries. In the first decades of the 18th century in the Dutch Republic, Daniel Gabriel Fahrenheit made two revolutionary breakthroughs in the history of thermometry. He invented the mercury-in-glass thermometer (first widely used, accurate, practical thermometer) and Fahrenheit scale (first standardized temperature scale to be widely used).

Figure 4.7: Digital Temperature Sensor [19]

Specification

- Digital Display -50C to +110C.
- Modeling simple, elegant, LCD panels inline connections, moisture-resistant.
- Strong anti-interference, applies to refrigerated cabinets, display counters and other needs of temperature measurement and display of various equipment.
- Remote wired probe can read temperature up to 3 feet away.
- No need to wire to any permanent power source. Size:48 x 28 x 15 mm.

CHAPTER 5
EXPERIMENTAL RESULTS AND OBSERVATIONS

5.1 Introduction

In this chapter all about our project experimental data collection, temperature difference graph, project output temperature details and limitations of our project. In this chapter is the most important part because of the data collection and graph making was so tough for us. After solving all obstacle, we did our work successfully.

5.2 Result

Table 01: Temperature Data Collection Reading

S/N	Time	Atmospheric Temperature(C)	Solar box Temperature(C)
01	11am-11.10am	31.8	38.4
02	11.10am-11.20am	32.4	40
03	11.20am-11.30am	32.7	43.3
04	11.30am-11.40am	33.6	44.5
05	11.40am-11.50am	34.2	46.3
06	11.50am-12am	34	48.2
07	12am-12.10pm	34.2	49.1
08	12.10pm-12.20pm	34.6	50.2
09	12.20pm-12.30pm	34.7	51.4
10	12.30pm-12.40pm	35.3	53
11	12.40pm-12.50pm	35.5	55.5
12	12.50pm-1.00pm	35.9	59.2

13	1.00pm-1.10pm	36.5	65.5
14	1.10pm-1.20pm	36.9	70
15	1.20pm-1.30pm	37.3	78
16	1.30pm-1.40pm	37.8	84.8
17	1.40pm-1.50pm	38	86

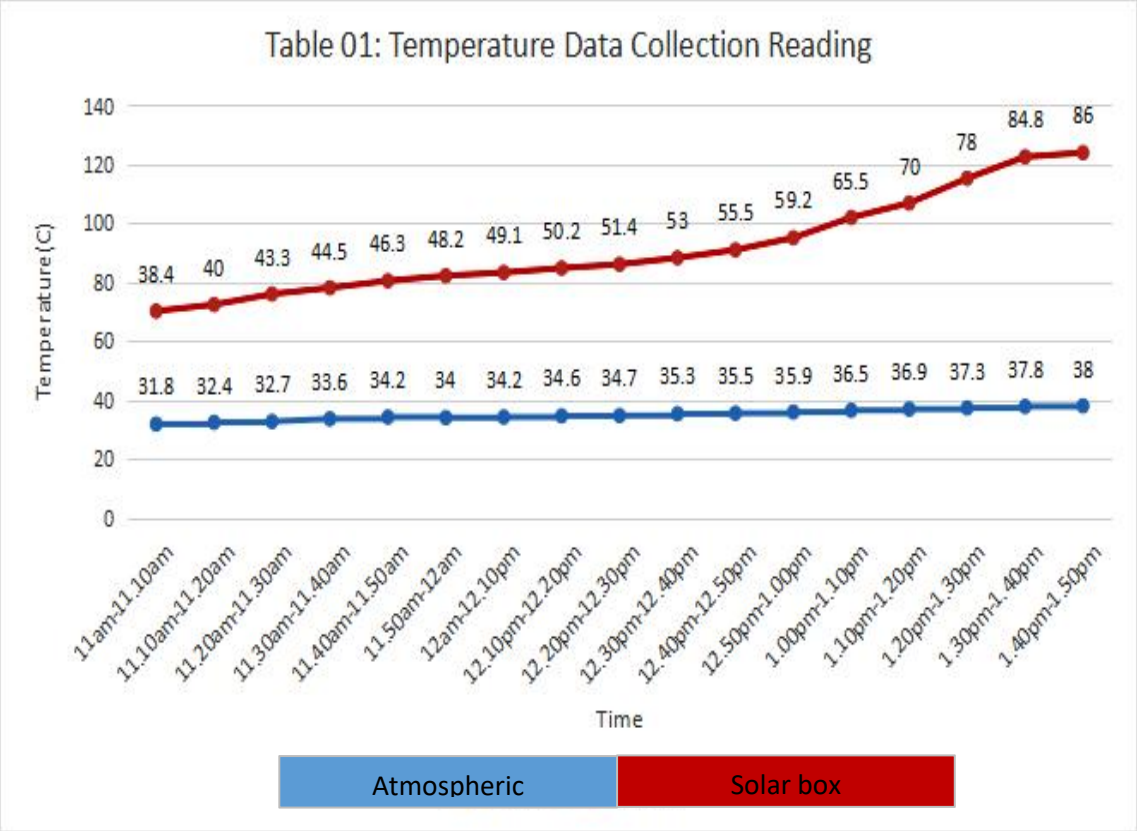

Figure 5.1: Temperature Curve for Experiment 01

This is the first experimental data reading [5.1] of atmospheric temperature and solar box temperature without reflector in our final project prototype. We collected this data in mid-November. The weather is not good at this time. However, we have tried to collect data every 10 minutes which is shown above in the form of data sheets and graphs.

Table 02: Temperature Data Collection Reading

S/N	Time	Atmospheric Temperature(C)	Solar box Temperature(C)
01	11am-11.10am	32.2	41.4
02	11.10am-11.20am	34.4	48.1
03	11.20am-11.30am	34.6	59.4
04	11.30am-11.40am	35.2	64.7
05	11.40am-11.50am	35.2	66.9
06	11.50am-12am	37.2	69.1
07	12am-12.10pm	37.2	79.1
08	12.10pm-12.20pm	36.5	83.7
09	12.20pm-12.30pm	37.5	85.3
10	12.30pm-12.40pm	37.9	86.3
11	12.40pm-12.50pm	37.6	87.3
12	12.50pm-1.00pm	38.1	90.5
13	1.00pm-1.10pm	38.5	97.3
14	1.10pm-1.20pm	39.2	100.1
15	1.20pm-1.30pm	39.9	107.7

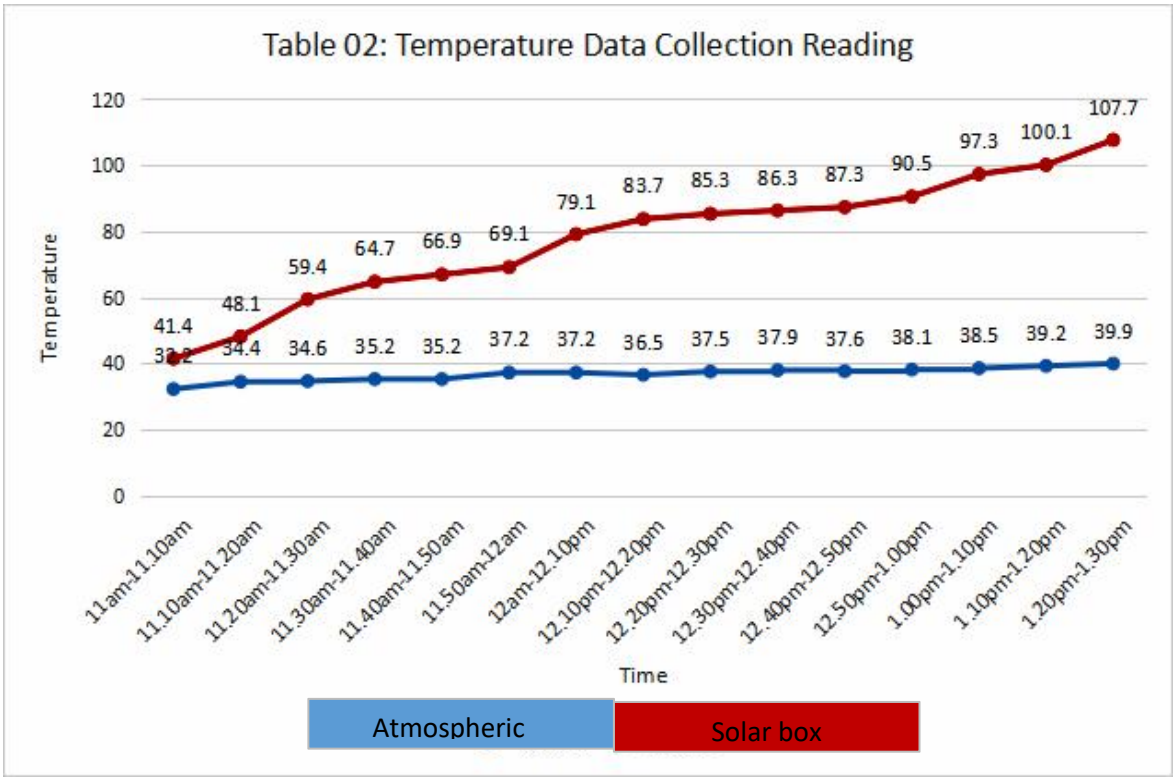

Figure 5.2: Temperature Curve for Experiment 02

This is the first experimental data reading [5.2] of atmospheric temperature and solar box temperature with reflector (Aluminum Foil Paper) in our final project prototype. We collected this data in 17-08-2023. The weather is not good at this time. However, we have tried to collect data every 10 minutes which is shown above in the form of data sheets and graphs.

5.3 Conclusion

In this chapter we take various temperature output of our project. Mainly we found various result form our project. We mainly take result in various condition. We take the data reading part in November months. In this month fall some temperature that's because we felt some problem to make some data. But we are able to finish our work successfully. All about our data in this chapter which is represent our project efficiency.

CHAPTER 6
DISCUSSION OF RESULT AND RELEVANCE

6.1 Introduction

In this chapter we describe our project advantages, disadvantage, applications and discussion about our result.

6.2 Discussion

Solar energy is free, environment friendly. Utilization of solar energy for various purposes is increasing day by day. Similarly, the use of solar cookers is not sufficient. Hence Advancement in solar cookers is required to improve the performance and reduce the cost, so that it will be easily available for people at low prices. Solar cookers can fully replace the firewood use in rural areas, and clean energy can be obtained. Statistics has shown that many people die only because of un-boiled food and inhaling dangerous gases produced due to burning of wood. This is definitely a serious issue. Vacuum tube solar cookers are very popular nowadays due to small size and portability. Solar cooking can be one of the best alternatives for cooking. This kind of project already many of student study before, but they use various critical way. But we make a simple construction for better output. When we made this project then we face some of problem. We did not run it smoothly. After hard work and team work, we did it.

6.3 Advantages

- Solar cooking is free.
- Food cooked with a solar cooker is healthy
- Solar cookers make no noise.
- Cooking with sunshine is kind to the environment
- Solar cooking ovens are portable.
- Power cuts is not an issue
- Cost-effectiveness
- Reduce energy waste.

- No Oil consumption.
- Installation is simplified very much.
- Simple construction
- Ease of operation.

6.4 Limitations

Although our project has many applications and advantages but there are some limitations of the project as well and the good thing is that these limitations are minor and doesn't affect the efficiency of the system. Limitations are given below:

- Solar energy is not accessible everywhere and at all time.
- On rainy days, some problems may occur which can hamper to create temperature.
- It cannot be used to cook everything.
- The system needs to be more efficient to produce more energy.

6.5 Applications

The project has a major application in the

- Domestic Cooking
- Community Kitchens.
- Outdoor Activities
- Educational Purposes

CHAPTER 7
CONCLUSION AND FUTURE WORK

7.1 Conclusion

In this paper, study of different solar cooker for domestic use has been done. Also, explanation has given about working and construction of different type of solar cooker and their advantages and disadvantages. There are many aspects about solar cooker require development and that should be subject for working in future. Cookers are not working at night but by using thermal storage will be possible in future.

7.2 Future Scopes

The model can be improved by making some changes in the program and components. Some suggestions are given below-

- **Portable and Compact Designs:** Future solar cookers may become more portable, lightweight, and compact, making them even more suitable for outdoor activities, camping, and emergency situations.

- **Smart and Integrated Systems:** Integration of smart technologies, such as sensors, IoT (Internet of Things), and automation, could lead to solar cookers that can optimize their performance based on weather conditions, adjust cooking temperatures automatically, and provide real-time data to users.

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