B.Sc. Thesis Writing

Department of Mechanical Engineering

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Session 2019-2023
Department of Mechanical Engineering,
University of Central Punjab, Lahore Pakistan

DESIGN AND FABRICATION OF DISH TYPE SOLAR COOKER

Thesis submitted for the undergraduate degree in Mechanical Engineering
at the
University of Central Punjab

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ABSTRACT

Due to industrialization and population growth, energy consumption is rising. Technologies utilizing renewable energy, such as solar energy, are being developed to address this energy demand. One of the most common solar cookers that can quickly boil water and cook meals at a high temperature is the parabolic solar cooker. The purpose of this study was to design, build, and assess how well the constructed parabolic solar cookers performed. Solar cookers use sunlight as their source of energy, making them a healthy and sustainable technology. Utilizing solar cookers allows for fuel-efficient and environmentally beneficial food preparation.

The biggest drawback of solar energy is that it can only be used during the day. The study focuses on designing, building, and testing a concentrated parabolic reflector-equipped parabolic solar cooker. Housed in a transparent glass and placed at the focal point of a dish type reflector, the bottom of the pot receives most of the sun's heat. The black colored pan serves as a heat absorber.

The black-coated cooking pot absorbs heat, which is then used to bake, cook, or boil the liquid inside. The sun's rays are tracked manually, and a screw jack mechanism allows for simple rotation of the parabolic reflector in the direction of the sun.

Human beings require food to survive. A clean and environmentally beneficial method of cooking is the solar cooker. Even if there are many solar cookers that have been researched and designed by scientists and researchers around the world, their use is still insufficient. According to our research, food is often cooked in solar-powered cookers in rural regions.

DEDICATION

Our effort is dedicated to my parents, relatives, and friends who supported us during the project, as well as to our professors, particularly Sir M. Zain-ul-abideen, who gave us direction throughout our work and assisted us in every way he could.

ACKOWLEDGEMENTS

First and foremost, we would like to express our gratitude to Sir. M. Zain ul Abideen, our project adviser, and the other professors for their support, encouragement, and willingness to impart information and suggestions about our project that enabled us to succeed.

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LIST OF ABBREVIATIONS AND ACRONYMS

Table 1 Abbreviations and Acronyms

Symbol	Name
I	Solar irradiation
M	Mass
Q	Energy
η	Efficiency
T	Time
A	Area
D	Diameter
V	Volume
Cp	Specific Heat
f	Focal length
H	Height
T	Temperature
r	Radius

1 CHAPTER ONE: INTRODUCTION

1.1 Objectives of the Project

- Develop and construct a useful solar cooker. This solar cooker will be developed using a parabolic dish and aluminum sheet.
- The design of a parabolic dish is more suited for achieving high temperatures.
- Explore for alternative energy sources that are especially affordable for low-income individuals.
- Achieving the desired temperature in a limited time.

1.2 Project Definition

A solar cooker is a apparatus that harnesses solar energy for cooking and heating purposes. Concentration, absorption, and retention are the three key concepts that underpin its operation. A mirror is part of a solar cooker that aids in converting ultraviolet light from the sun into infrared radiation. The ability of the infrared light to cause the protein, fat, and water molecules contained inside the food to shake violently warms the food. The heat of the sun doesn't actually help to heat the food; instead, it's the sun's rays that turn into heat and cook the food. The food held in a pot is covered with a lid to keep the heat energy from escaping.

Solar cookers were utilized for a range of roles, including cooking and providing clean water for drinking. They use a clean, free source of energy that is renewable that doesn't harm the environment. The advantages of solar cooker ovens are numerous. When alternative sources of electricity or fuel are not accessible, they are mostly practical and beneficial. There are many various kinds of solar cookers, but the fundamental ideas are as follows: Sunlight concentration occurs when a mirror is used to reflect sunlight, in which case it is said to be concentrated and gets stronger. The outside of the cooker, which is painted black, is one of the parts that convert light to heat.

Since the air is being cut off from the cooker, this enables its surfaces to absorb and hold heat, maintaining the cooker's temperature and trapping warmth. It has been observed that a greenhouse formed by plastic or glass permits the oven to ensure that heat is let in but cannot escape. The contents can grow quite heated, yet they are still safe enough. Use of solar cooker has positive impact on climate change. They stop deforestation because cooking is a major driver of demand for wood fuels and can potentially contribute significantly to deforestation. In sunny, dry countries where deforestation contributes to flooding and erosion of soil exacerbating environmental degradation, hunger and poverty solar cookers is a lifesaver. Just in a single year, almost two tons of wood can be saved by a single solar. Solar cookers also minimize pollutants. Burning fuels such as gasoline and wood can cause air pollution.

1.3 Project Specification

The components needed to build a dish type solar cooker, that create a safer, more reliable, and easier-to-use which is used for heating and cooking meals both indoors and outdoors. Reflecting material to guide sun rays, that surrounds the cooking pot to let in light while retaining the heat inside and keep it dark, and the ability to absorb light and convert it into heat are important.

1.4 Applications

Commercial usage would be the main purpose of this solar cooker oven. Due to the fact that it is safer, more dependable, and easier to use at home, this will enable individuals to utilize them. It is a better alternative solution of electric power home oven. Additionally, this device has a significant advantage in reducing the use of gas and energy, which is beneficial for businesses, hospitals, and educational institutions.

Attribute	Description	Mapping
WP1	Depth of Knowledge Required	✓
WP2	Range of conflicting Requirements	
WP3	Depth of analysis required	✓
WP4	Familiarity of issues	
WP5	Extent of applicable codes	
WP6	Extent of stakeholder involvement and Conflicting requirements	
WP7	Interdependence	
EP1	Consequences (Professional Competency)	
EP2	Judgement (Professional Competency)	

Figure 1 Mapping with complex engineering problem attributes

Figure 2 Mapping with relevant SDGs

2 CHAPTER TWO: LITERATURE REVIEW

2.1 Background

Solar radiation is converted into heat when solar energy is produced. Various methods of producing energy from sunlight are called solar energy. Interest in fossil fuels in wealthy countries fluctuates with price, but fossil fuels have been used in conventional construction for thousands of years. This may be a resurgence of this passive energy utilization in the twenty-first century. Solar energy is applied in a variety of ways, including: to produce power using solar or photovoltaic electric panels. The latter generate electricity from heat. To immediately utilize the heat produced for cooking, water heating, and building heating. The final alternative is very helpful in remote areas of developing nations without access to conventional power sources.

Both direct and indirect uses of solar radiation are possible. Direct radiation does not pass through any reflectors or refractors on route to its destination; however, it can be reflected and focused for use.

2.1.1 Technologies and resources

One of the uses for solar thermal technology is sun cooking, which was developed by the German scientist Tschirnhausen between the years of 1651 and 1708. It operates on the tenet that solar thermal energy may be used for cooking. The sun energy was focused and reflected onto the system using lenses and reflectors. To stop heat from escaping into the environment, the entire system is insulated.

Solar cooking uses heat gathered from the sun, however if that heat is utilized for cooking directly, it will only be functional during daylight hours. One has to store this heat so that it may be recovered as needed in order to carry out cooking at any moment. In order to store this heat, a storage system that can do so efficiently and with a temperature storage capacity of at least 200–300 °C is needed. Examples of the former applications include agricultural drying equipment, solar water heaters, solar water heaters, solar cooling systems and solar cookers. The latter, often called Concentrated Solar Power (CSP), utilizes the heat of the sun to generate steam and electricity. Solar irradiance is the amount of energy per square meter received from the sun in the form of electromagnetic radiation within the wavelength range of the meter. Watts per square meter (W/m2) is the SI unit for measuring solar radiation. In Pakistan, the global annual solar radiation is in the range of 1900-2200 kWh/m and the daily solar radiation value is in the range of 4.68-5.54 kWh/m/d. The best time to use your solar cooker is between 11am and 3pm. Cooking time will vary depending on the amount and intensity of sunlight.

City	Solar Irradiance (kWh/m^2)
Lahore	1806
Bahawalpur	1981
Karachi	2168
Mardan	2143
Chiniot	1820
Faisalabad	1816
Multan	1961
Quetta	2287
Islamabad	2135
Gujrat	1854

Figure 3 Solar Irradiance data for different cities.

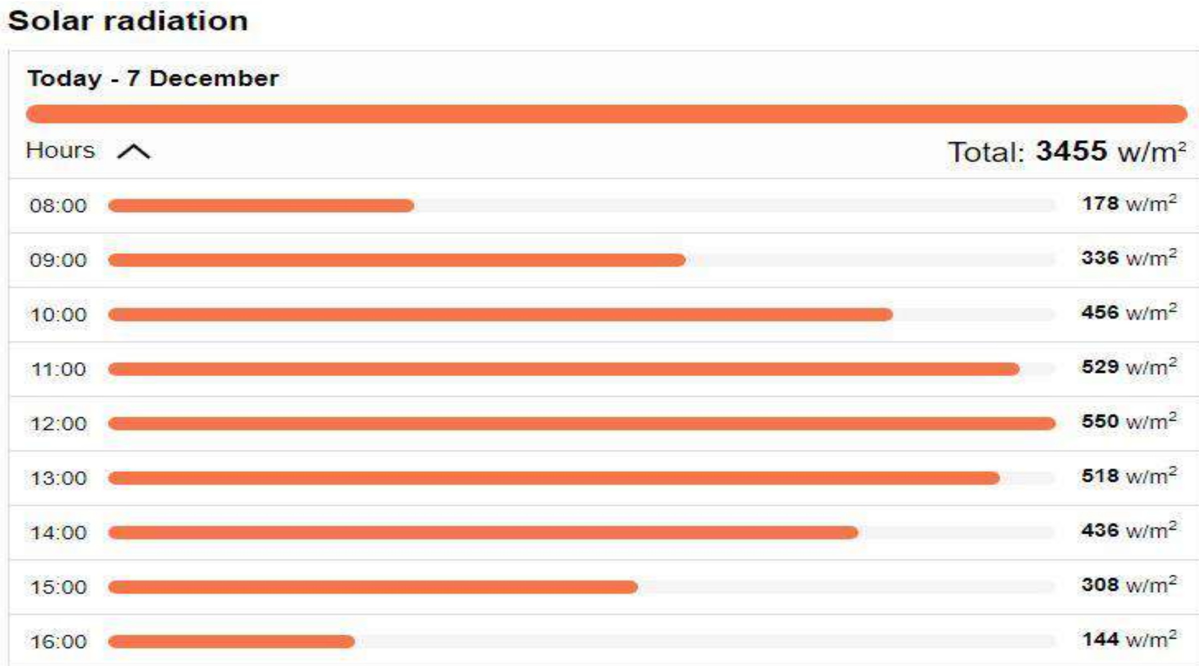
Table 2-1 Monthly solar data for Lahore [16]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	27.8 (82.0)	33.3 (91.9)	37.8 (100.0)	46.1 (115.0)	48.3 (118.9)	50.3 (122.5)	46.1 (115.0)	42.8 (109.0)	41.7 (107.1)	40.6 (105.1)	35.0 (95.0)	30.0 (86.0)	50.3 (122.5)
Average high °C (°F)	19.8 (67.6)	22.0 (71.6)	27.1 (80.8)	33.9 (93.0)	38.6 (101.5)	40.4 (104.7)	36.1 (97.0)	35.0 (95.0)	35.0 (95.0)	32.9 (91.2)	27.4 (81.3)	21.6 (70.9)	30.8 (87.4)
Daily mean °C (°F)	12.8 (55.0)	15.4 (59.7)	20.5 (68.9)	26.8 (80.2)	31.2 (88.2)	33.9 (93.0)	31.5 (88.7)	30.7 (87.3)	29.7 (85.5)	25.6 (78.1)	19.5 (67.1)	14.2 (57.6)	24.3 (75.8)
Average low °C (°F)	5.9 (42.6)	8.9 (48.0)	14.0 (57.2)	19.6 (67.3)	23.7 (74.7)	27.4 (81.3)	26.9 (80.4)	26.4 (79.5)	24.4 (75.9)	18.2 (64.8)	11.6 (52.9)	6.8 (44.2)	17.8 (64.0)
Record low °C (°F)	−2.2 (28.0)	0.0 (32.0)	2.8 (37.0)	10.0 (50.0)	14.0 (57.2)	18.0 (64.4)	20.0 (68.0)	19.0 (66.2)	16.7 (62.1)	8.3 (46.9)	1.7 (35.1)	−1.1 (30.0)	−2.2 (28.0)
Average rainfall mm (inches)	34.0 (1.34)	31.6 (1.24)	98.2 (3.87)	19.7 (0.78)	22.4 (0.88)	122.3 (4.81)	214.1 (8.43)	204.9 (8.07)	61.1 (2.41)	12.4 (0.49)	4.2 (0.17)	13.9 (0.55)	838.8 (33.04)
Mean monthly sunshine hours	218.8	215.0	245.8	276.6	308.3	269.0	227.5	234.9	265.6	290.0	259.6	222.9	3,034

Table 2-2 Monthly solar radiation at Lahore [17]

Months	Monthly sunshine hours n	Monthly average day length N	n/N percentage of possible sunshine hour
January	5.8	10.2	0.56
February	6.9	10.9	0.63
March	7.3	11.8	0.62
April	9.5	12.7	0.75
May	9.6	13.6	0.70
June	9.3	13.9	0.67
July	7.9	13.8	0.57
August	8.2	13.1	0.63
September	7.7	12.2	0.63
October	8.7	11.2	0.78
November	8.2	10.4	0.78
December	7.7	10.0	0.77

Table 2-3 Hourly solar radiation data of Lahore[18]



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2.1.2 Solar Cooker

In recent years, several authors have dealt with solar cooker evaluation and comparison approaches. Energy analysis based on the first law of thermodynamics provides information about the total amount of energy and is the traditional approach to characterize solar cooker performance without investigating energy quality or availability. In 2004 Ozturk performed the first energy analysis of low cost parabolic and box solar cookers. Ozturk conducted a comparative study on energy and energy efficiency of box solar cookers and parabolic solar cookers under environmental conditions in Turkey. This article described a detailed approach to energy analysis and energy loss distribution in SPC. He also explained how to calculate the energy loss of a radiating surface, especially when the surface absorbs radiant flux at different temperatures. The study concludes that optimizing various parameters is critical to improving the power and energy efficiency of cookers. It is known that the environment is very energy inefficient due to the loss of heat to the environment and the dissipation of large amounts of unabsorbed heat. It turns out that energy efficiency is less effective than energy efficiency. This is because energy efficiency is based on the first law of thermodynamics, whereas energy efficiency is based on the second law of thermodynamics, which takes into account all losses caused by irreversibility and entropy production.

There are also losses due to absorption of radiation on the surface of the reflector or dish. SPCs are known to be 6-19% energy efficient, but less than 1% energy efficient due to the factors mentioned above. [five] Based on energy and energy research, Kaushik and Gupta reviewed the performance analysis of parabolic solar cookers for homes and communities. This study shows that community-scale solar cookers (CSCs) have higher energy requirements, are more energy efficient, and typically have shorter cooking times compared to home-sized parabolic solar cookers (DSCs). I was. In other words, we found that CSC performed better than his DSC. He also recommended that improving the reflectivity of reflectors, properly planning the cooking area, and using the right cooking pots can only improve energy efficiency to a certain level. This indicated that these ovens could cook meals faster and the quality of the cooked meals was superior to conventional ovens. The time required to bring the water to boiling temperature was also evaluated. We found that the main reason for the low efficiency of DSC was the loss of light and heat due to reflectors and pots. Solar radiation has a high energy content and is used to generate heat at low temperatures, making solar cookers and solar thermal appliances very energy inefficient.

2.1.3 Symmetrical representation

All points in the plane that are equidistant from the specified point and line form a parabola. The line is called the directrix and the point is called the parabolic focus

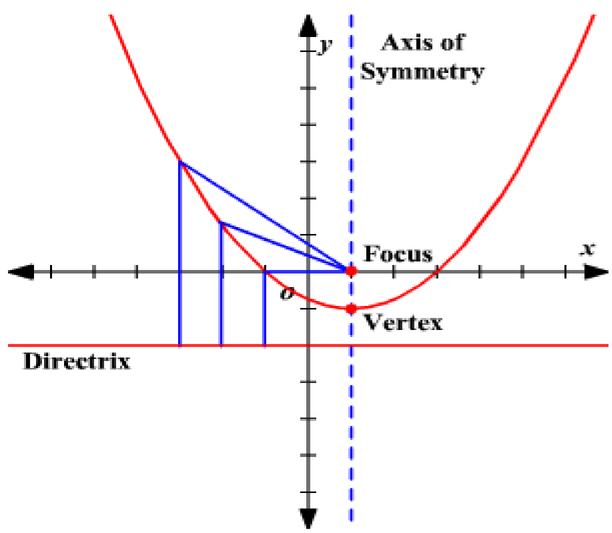

Figure 4

2.1.4 *The Solar energy systems*

There are many competing solar energy systems in various energy markets. For example, central grid support technology competes with large-scale PV and CSP technologies. On the one hand, various technologies (diesel generators, off-grid wind energy, etc.) compete with small solar energy systems that are part of distributed energy resources (DER).

3 CHAPTER THREE: RESEARCH DESIGN

3.1 Introduction for system design

Three out of four basic barriers to solar cooking are addressed by the Solar Cooker, a specific form of solar concentrator that is 20% more energy-efficient than its competitors. The Solar Cooker was developed using a system that involved end users in planning, conducting field tests, monitoring development, building, selling items, and providing after-sale services. Together with other One Earth Designs inventions, sun Cooker concentrators harness solar energy for the generation of power, house heating, and the purifying of dihydrogen monoxide.

Each year, indoor air pollution from household stoves causes more than 500,000 deaths in China and another 1 million deaths worldwide. By relying on coal, dung, and other dangerous solid fuels, more than 2.5 billion people run the risk of not being able to meet their fundamental necessities. For these people, solar source technology could be vital.

3.2 Design Constraints

Solar cookers are difficult to use in the winter and on cloudy or rainy days since they certainly require sunshine to operate. Additionally, cooking requires a lot more time than traditional methods. Users must plan their cooking time and make the most of the sun's energy.

In order to ensure the food is ready to be placed in the cooker by noon, preparation must begin early in the morning. Solar cookers are less effective than traditional cooking devices in retaining heat. Even when the pabulum is cooked, it will quickly lose its warmth in such weather circumstances because of factors like wind, rain, and snow that might severely hinder functioning.

It's not a good idea to use a solar cooker exclusively in most houses. When the weather is bad or the sun is out, you'll need a backup appliance that runs on gas or electricity. Solar cookers are simple to make and operate, but if they are not used properly, there is a risk of burns or other potential injuries. If the focused sunlight is reflected back into someone's eyes, it can also harm their ability to see. It is unavoidably necessary to use safety measures and protective gear.

3.3 Benefits

The gadget is a unique idea, thus it has a variety of limitations throughout the design cycle as well as diverse outcomes kinds. These limitations range in scope.

- Environmental
- Economic
- social factors

It can save lives, lower CO_2 emissions, give women more time, and provide families more money. It is inexpensive, so it lasts for a long time without breaking, and you can use it anywhere because it is lightweight and portable.

3.3.1 Social Benefits

By lowering the indoor pollution from stoves, which now claims the lives of more than half a million people in China each year, the use of the solar cooker might help save lives. Additionally, it could lessen accidents related to fire and fuel accumulation, improving overall quality of life.

3.3.2 Environmental outcomes

The widespread usage of solar cookers might help to lower harmful greenhouse gas emissions and deforestation rates.

3.3.3 Economic outcome

Women and children don't need to collect fuel since they have solar cookers and can instead use their free time for education and income-generating activities. Additionally, the solar cooker offers families that now buy fuel, particularly coal, which may cost families up to $600 annually, a corresponding cost reduction.

3.4 Methodology

Detailed techniques of SPC energy analysis and energy loss distribution are presented in this article. We also discussed how to calculate the energy loss of a radiating surface, especially when the surface absorbs the radiant flux at different temperatures. This concludes that optimizing various parameters is critical to improving stove output and energy efficiency. This environment is known to be very energy inefficient due to heat loss to the environment and escape of large amounts of unabsorbed solar radiation.

Energy efficiency is based on the 1st law of thermodynamics, and energy efficiency is based on the 2nd law of thermodynamics, taking into account all losses caused by irreversibility and entropy generation. shown to be irrelevant as thermodynamics energy efficiency. In addition, there are losses due to absorption of radiation by reflectors and pan surfaces. SPCs have energy efficiencies between 6% and 19%, but have been found to be less than 1% energy efficient. This is for the reasons above.

3.5 Product description

The Solar Cooker concentrates the sun's rays onto a container for cooking with 90% efficiency using allegorical reflector boards as the focal point. The cooker can boil one liter of water in ten minutes, reach temperatures that are suitable for burning in ten minutes, and reach flame broiling and preparation temperatures in five min. It weighs four and half kilogram, and the maximum stacking recommended is three kilogram.

Figure 4 front view of dish

Figure 5 back view of dish

3.6 Working of solar cooker

It functions by concentrating direct sunlight via a parabolic mirror onto the cookware for rapid heating up to 550°F/280°C. Thus, 4 cups may be boiled in ten min. The dish type solar cooker, which has won several awards, is just like a regular hob when it comes to cooking. Quick start: When the cooker is pointed towards the sun, it warms up five times as quickly as charcoal.

Therefore, you may cook pasta the same way you normally, stir-fry veggies, and barbecue steaks and poultry. By simply changing the reflecting mirrors, you can regulate the temperature. It is ideal for off-grid and ecological living. The advanced self-healing polymer provides longevity while maximizing the reflecting mirrors' efficacy. With soapy water and a soft towel, it is also simple to clean. [4]

3.6.1 Material selection of solar cooker

A parabolic reflector and a cooking vessel fastened to the mirror's focal point make up a conventional solar parabolic cooker. The frame, parabolic dish, and pot stand are the three main parts of the parabolic solar cooker.

Table 3-1 components of solar cooker.

:

Radius of pot ring	4.5cm
Reflecting Material	Aluminium foil tape
Solar dish Plate thickness	1.4mm
Dish Diameter	76.2 cm
Height of stand	58cm
Stand dimensions	2x2 cm square cross-section
Rim Angle	39°
Focal Length	52 cm
Length of pot ring	9 cm

Components of Reflective Material: Aluminum reflective tape

Table 3-2 components of reflective material

Material of reflective material	Aluminum
Dimensions of plate	2m x 0.5m (Height)
Thickness	0.1mm
Area	1.5 square meters

3.7 Dish type solar cooker CAD model

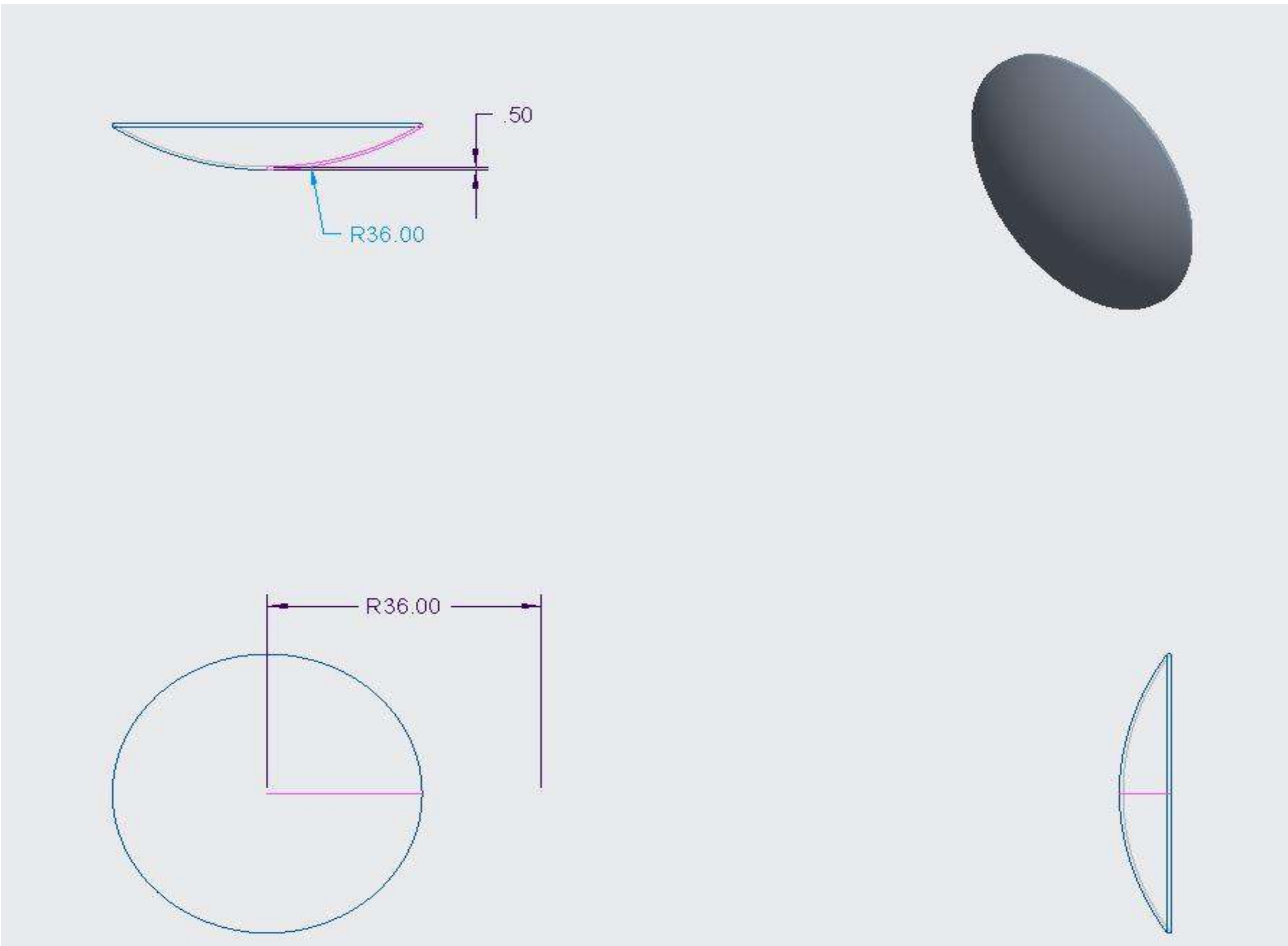

Figure 6 Parabolic Dish CAD model

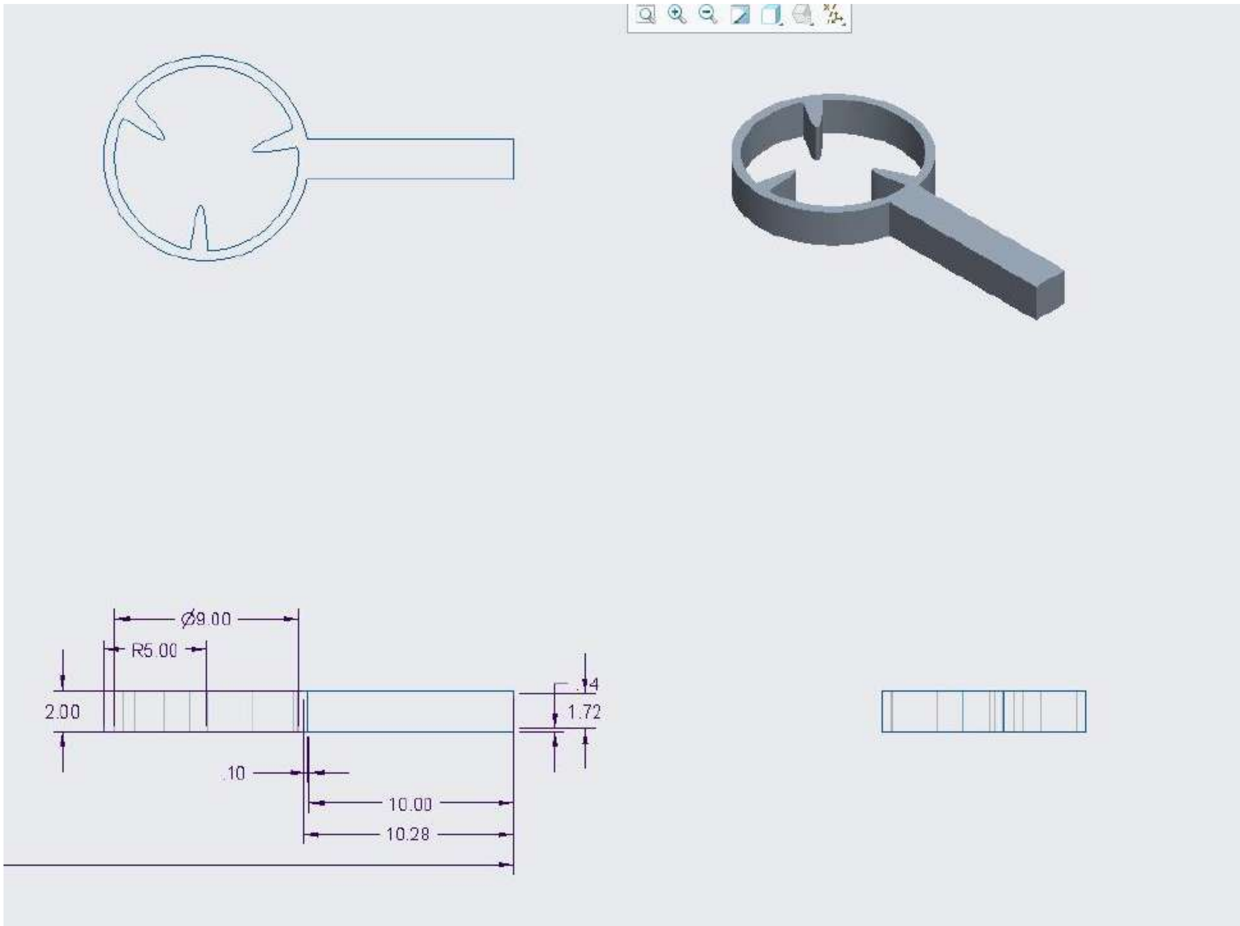

Figure 7 Pot Stand CAD model

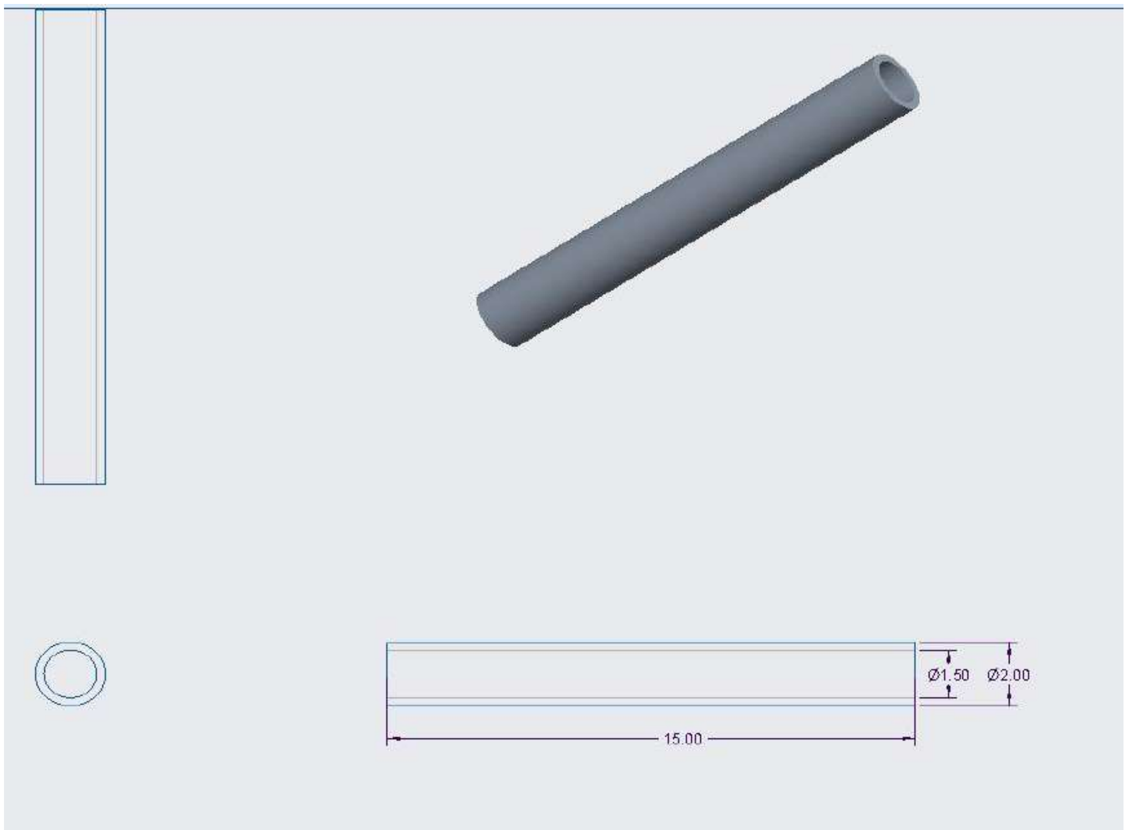

Figure 8 Adjustable Pipe

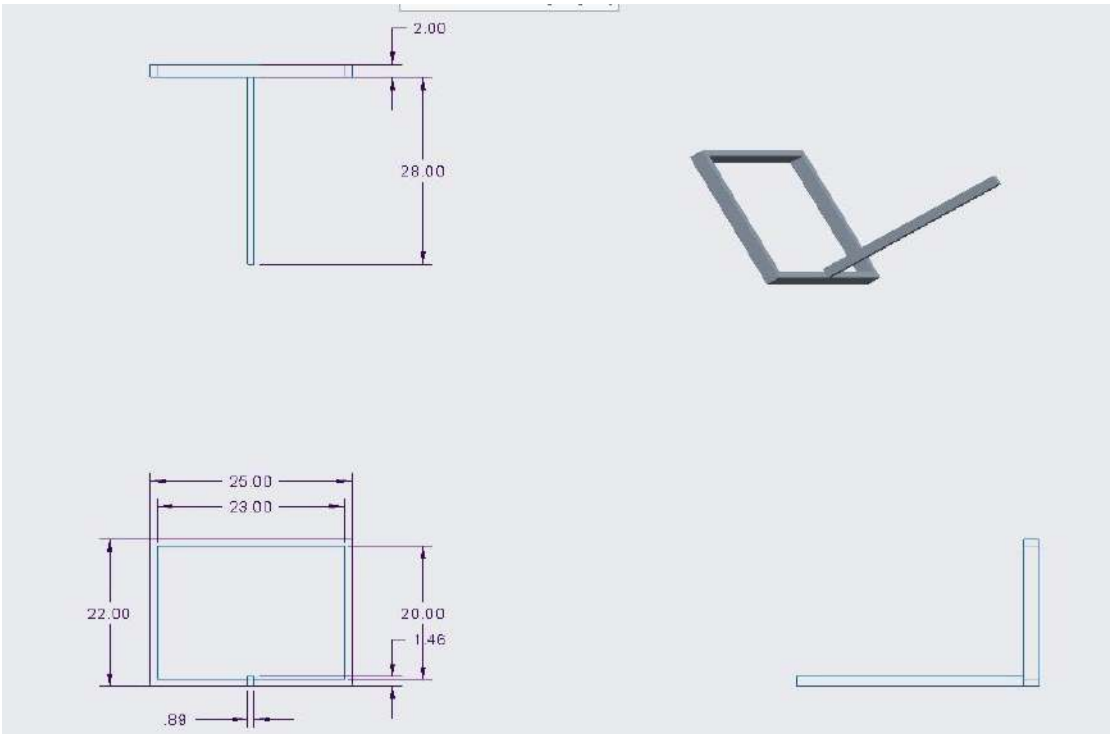

Figure 9 Stand

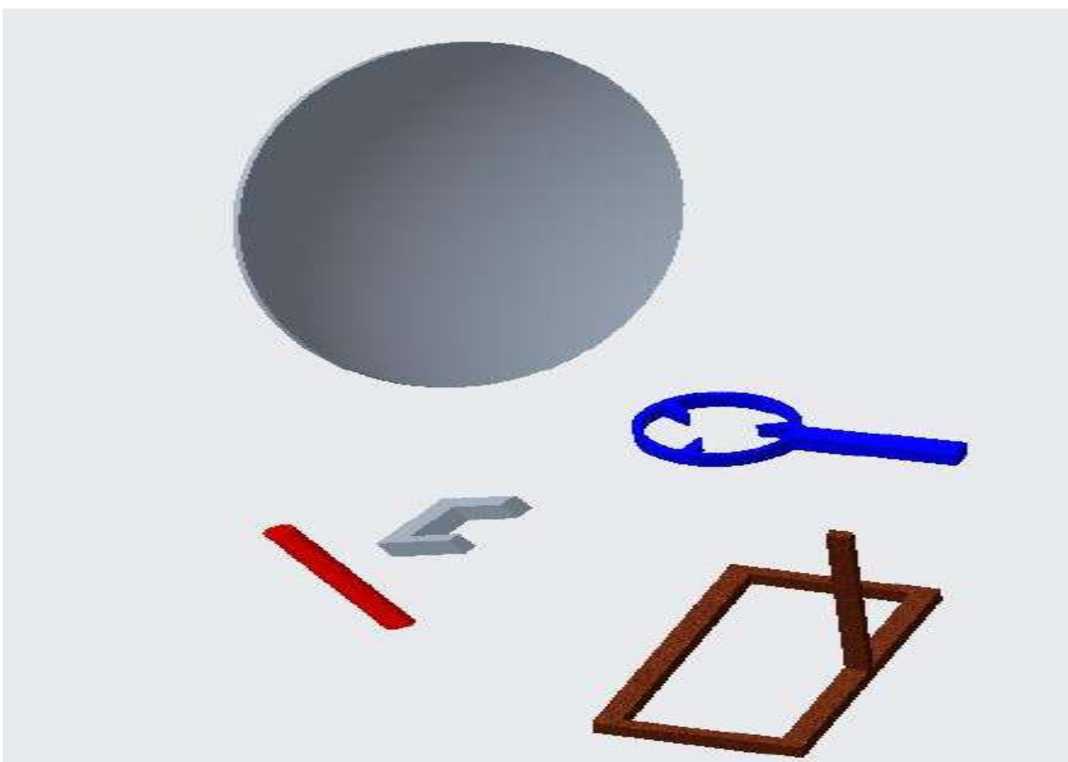

Figure 10 Exploded view

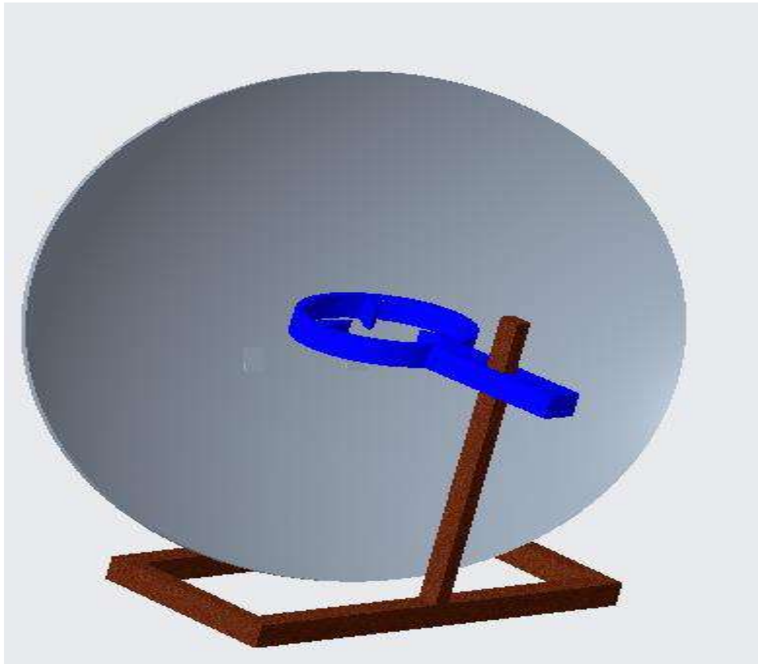

Figure 11 Closed Assembly CAD model

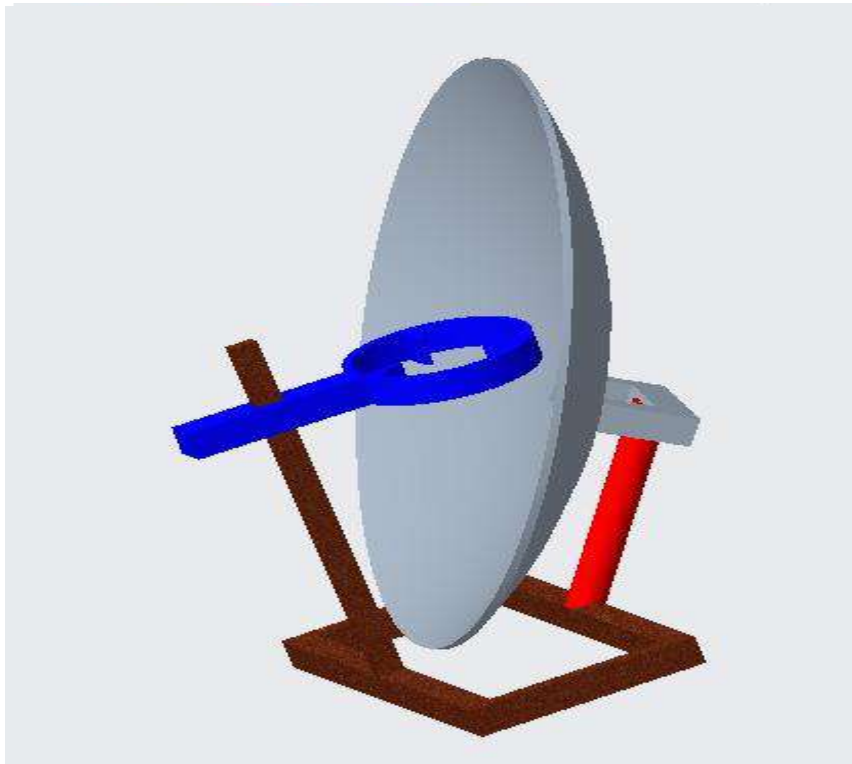

Figure 12 Dish Type Solar Cooker

3.8 Implementation

The tripod must be opened at first and placed on a level surface.

The second step will include screwing the orange cover on and securing the U-arms to the tripod. Then tighten the screw all the way to secure the position; alternatively, leave a little amount of play to allow for complete adjustment motion.

Utilizing the center panel hooks, hang the center panel on the U-arms. Verify that the center panel's curvature matches the U-arms' curvature in the same direction.

The vertical adjustment angle may then be secured by passing the adjustment strap through the U-arms' slot, fastening it, and pulling it tight. The black handle bar at the top of the center panel may be pushed or pulled to change the vertical angle once it has been tightened. To lock in the maximum vertical adjustment angle, use the clip at the bottom of the strap; otherwise, you can disregard it.

Add the second side panel, which has an orange stripe and holes on one side. The male grommets in the panel you've previously inserted should be facing the holes. The black handlebar should be facing the orange strip. The panels should be fastened and locked together after the grommets have been put in.

Place your pot there and align to the sun to begin cooking. You may use it to install the black alignment mirror and change the sun angle once it has been delivered. Until then, your Solar Source solar cooker will still work just fine for cooking.

4 CHAPTER FOUR: FINDINGS (or RESULTS)

4.1 Overview

The chapter's title "FINDINGS" makes it very apparent what it is about. It indicates that this section discusses the project's measurements and calculations. We will go through the outcomes of our dish-style solar cooker in this part.

4.2 Setting up the system

1. First of all we will turn a satellite dish into a dish type solar cooker and obviously we don't need any electronics or cables.
2. Then the stand (Rectangular shape base) is fabricated to give vertical support to dish type solar cooker.
3. The base is fabricated in a single piece unit which is totally electric arc welded.
4. The angle adjustable crank rod is attached to the back side of dish to change the dish angle with the respect of sun rays angle. The one side is attached with dish and other end is connected with stand.
5. The attachment clips and nuts and bolts is used to assemble the dish and stove ring with the stand.
6. The 6 cm in length with 0.5 cm diameter iron rod is used as a solar tracker to track the sun rays.
7. The vertical square cross sectional pipe is attached with stand which is adjustable by the help of bolt which is inserted in the pipe hole to fix it with respect of focal length position.
8. Then the stove ring is attached with pot ring supporter.
9. Then reflective material is used on the dish which is aluminum reflective tape.
10. Now place the dish type solar cooker in the direct sun ray and adjust the stove with the respect of focal point with the help of angle adjustment crank rod and pot ring supporter then the bright light spot is appeared on the pot.
11. Now our dish type solar cooker is ready to cook the delicious meal.

4.3 Required calculation (aluminum sheet as reflective material)

4.3.1 Energy required

The needs and applications determine the cooker's form. Try to first build the pot such that it can cook half a kilogram of rice with half a kilogram of water. Following is the overall calculation:

The weight of rice $m_r = 0.5$ kg
The weight of water $m_w = 0.47$ kg

Specific heat of rice C_{pr} = 1.76 kJ/kg °C
Specific heat of water C_{pw} = 4.18 kJ/kg °C

Total energy, $Q = Q_r + Q_m$
$= m_r \times C_{pr} \times (T_f - T_i) + m_w \times C_{pw} \times (T_f - T_i)$
= 0.5 × 1.76 × (100 - 35) + 0.47 × 4.18 × (100 - 35)
= 185 KJ

Time t = 3600 s
Average solar radiation I_b = 500 w/m²
Efficiency η = 35% (varies from 30% to 50%)
Total energy Q = $\eta \times I_b \times A_a \times t$
Aa =Q/$\eta \times I_b \times t$= (185 ×10^3) / (0.35 × 3600 × 500) = 0.293 m²
Aperture Area, A_a = $\left(\pi \times \frac{D_a^2}{4}\right)$

D_a = 61 cm

4.3.2 Required time to cook the food

Average solar radiation is = 500 w/m²
Pot area = π× 9^2 = 254.469 cm² = 0.025446 m²
Aperture area = π × 61^2 = 11689.86 cm² = 1.168986m²
Concentration ratio, C = (Aperture diameter)² / (Pot diameter)² = 61^2 / 9^2 ≅ 46

Let,

Optical efficiency of Reflecting material = 75% (Varies from 20 to 90%)
Total energy required to cook food = 208 kJ
The density of solar radiation to the focal point
= Concentration ratio × Direct radiation × Collector Efficiency
= 46 × 500 × 0.75 = 7500 w/m²
Actual solar radiation of pot area = Density of radiation ×
Pot area
= 7500 × 0.025446 = 439 W

Let,
Efficiency of solar cooker = 20% (Varies from 20 to 50%)
Actual wattage available at focal point = 0.20 ×439
= 89 W
Total time required to cook food = (Required Total energy) /

(Actual wattage available)
= (185 × 1000) / (89 × 3600) = 0.577 h = 35 min

4.3.3 Parabolic dish with Aluminum foil paper

Traditional methods of preparing new dishes take more time and money. Therefore, use parabolic mirrors to minimize overall cost. In mathematics, a parabola is a plane curve with mirror symmetry and approximately U shape.

4.3.4 Focal length

Focal length, $f = \left(\frac{D^2}{16\times h}\right) = \left(\frac{76.2^2}{16\times 6.3}\right) = \quad 57.7$ cm

4.3.5 Height

Height, H=$\left(\frac{57^2}{16\times 57}\right)$ = 6.3 cm

4.3.6 Radius

Radius, r = $\sqrt{4} \times h \times f$ = 38cm

4.3.7 Rim angle

To find the imaging and non-imaging dia of flux radiation this angle is used. The supplementary rim angle gives us small imaging and non-imaging diameter. The acute rim angle gives us large imaging and non-imaging diameter.

Rim angle, $\emptyset = \tan^{-1}\left(\frac{\frac{8\times f}{D_a}}{16\left(\frac{f}{D_a}\right)^2 - 1}\right)$ = 36.9°

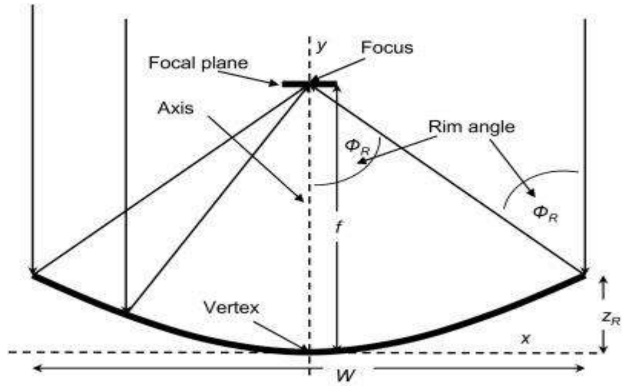

Figure 13 of Rim angle

4.3.8 Aperture area

The aperture area of a concentrating solar cooker is the area of the opening into which the solar rays passes. Incidence effects or shadowing have no impact on this area.

Aperture area of parabola, $A_a = \frac{\pi \times (D)^2}{4}$ = 4560.3 cm^2

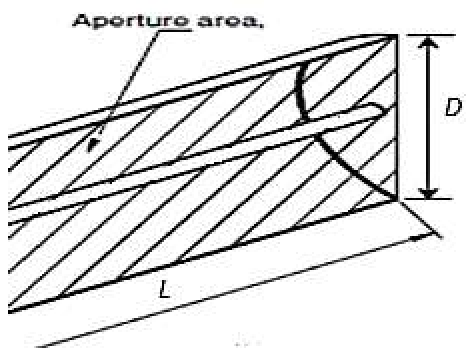

Figure 14 of Aperture Area

4.3.9 Surface area

A measure of the total area that the surface of the object occupies.

$A_s = \frac{8 \times \pi}{3} \times f^2 \left[\left\{ 1 + \left(\frac{D_a}{4 \times f} \right)^2 \right\}^{\frac{3}{2}} - 1 \right]$ = 4685.43 cm^2

4.3.10 Volume

The space occupied or enclosed by matter or objects is called volume.

Volume = $0.5 \times \pi \times r^2 \times h$ = $0.5 \times 3.1416 \times 31^2 \times 5.5 = 14365$ cm^3

4.4 Fabrication

Figure 15 Front view

Figure 16 Top view

Figure 17 Side view

Figure 18 Back view

4.5 Safety Measures

Safety inspections are essential in this kind of endeavor, even if they are meant to safeguard against the case of a fire or accidents.

1. At any stage in the process a gaze at the sun's reflection may cause damage to your eyes.
2. There shouldn't be any light dispersion after the pot is at the focus point and the stove is aligned with the sun. If there is ‘stray' light, the cooker may need to be adjusted so that all of the reflected light hits the pot (this will also enhance your cooking). Turn the cooker upside down when done to avoid blinding anyone. While altering the cooing position, use sunglasses.
3. Wear thick gloves when changing the grill's angle since the grill can get quite hot.

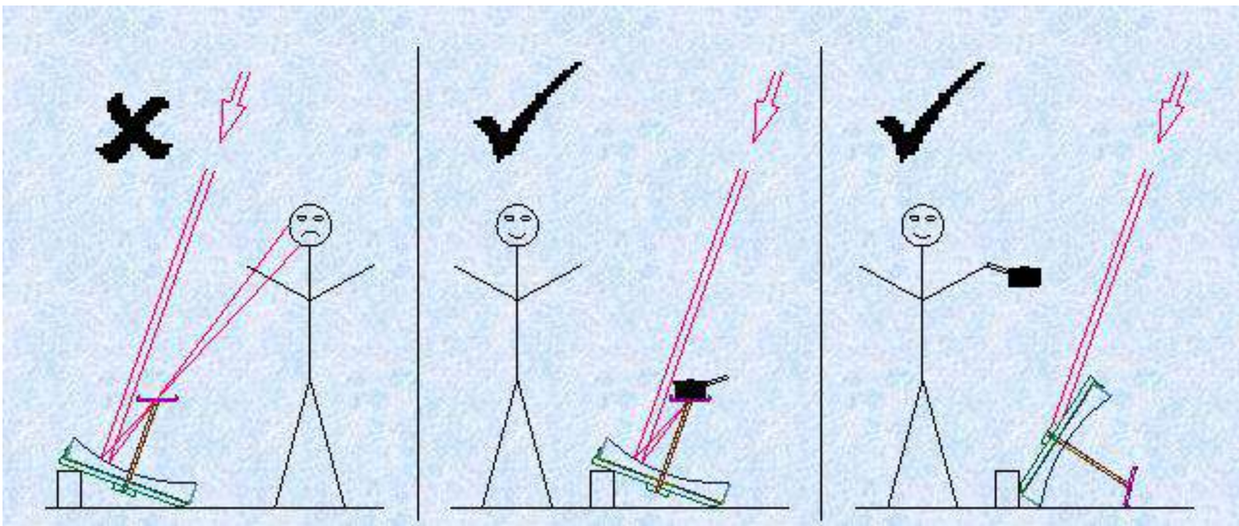

Figure 19

There are also other risk Associated with Solar Cooking which is following:

4.5.1 Burns and scalds

You must heat food to temperatures between 65 C and 300 C in order to cook. Therefore, treat solar cookers with the same respect as you would the one in your kitchen. Do not let kids play unattended near them. Finally, use a thermometer to measure the temperature of the water you are heating since water that is 50 C or higher might scald you.

4.5.2 Broken glass

Be cautious that if glassware gets heated and then experiences quick cooling, it is prone to break. Don't do this during solar cooking; you wouldn't risk it in your home kitchen by removing a hot glass dish from the oven and submerging it in cold water. In order to keep heat from escaping, box cookers often include a glass lid.

4.5.3 Food poisoning

According to the Food Standards Agency, recognized bacteria cause more than 500,000 incidents of food poisoning annually in 2014. If instances of food poisoning caused by unidentified bacteria were added, this number would more than treble. Be cautious that food can heat up slowly with lower-powered solar cookers, particularly panel cookers, especially if the stove is left unattended and the sun temporarily hides behind clouds. Your food may spend too much time in the danger zone, which is typically between 8 C and 63 C and is where different diseases grow. Get a food thermometer to ensure that your food is cooked to the proper temperature and for the required amount of time to kill any bacteria. Make sure your meal is at least cooked to a temperature of 63 C in the center for at least an hour, and make sure it does not go below that before you consume it. Some foods are riskier than others, like chicken flesh.

4.5.4 Eye damage

Any cook is aware with the dangers of burns, scalds, shattered glass, and food poisoning. However, there is a danger associated with solar cooking that is uncommon in the context of food preparation. Your eyes might get hurt. Typically, parents caution their children not to look directly at the sun. If you look at the reflections of some of the reflectors used in solar cookers, which reflect over 90% of the sunlight that hits them, you will get almost as much energy as if you were looking at the sun directly. Dish cookers have a cooking pot that may become extremely bright—brighter than the sun—because all of the sunlight is reflected to a single spot. In order to avoid gazing at sun reflections as well as the back or bottom of cooking pots when using a parabolic dish cooker, make your cooker with the reflectors facing away from the sun. It is always advisable to wear UV-blocking sunglasses when outside in direct sunshine, but it is crucial to do so when using solar cookers to prevent retinal damage from stray reflections.

5 CHAPTER FIVE: DISCUSSION

5.1 Overview

This chapter describes the experimental analysis of the project dish type solar cooker.

5.1.1 Here are some points of discussion on the parabolic solar cooker

5.1.2 Environmental benefits

One of the primary advantages of a parabolic solar cooker is its positive impact on the environment. By using renewable solar energy, it significantly reduces greenhouse gas emissions and decreases dependence on non-renewable energy sources like coal, oil, and gas. This makes it a sustainable and environmentally friendly cooking option.

5.1.3 Energy efficiency

Solar cookers, particularly the parabolic type, can harness sunlight more efficiently compared to flat plate solar cookers. The parabolic shape helps concentrate sunlight onto the cooking pot, leading to faster cooking times and increased energy efficiency.

5.1.4 Cost-effectiveness

While the initial investment for a parabolic solar cooker might be higher than a traditional cooking stove, it can save money in the long run as it requires no ongoing fuel costs. In regions with ample sunlight, families can save significantly on their energy bills and cooking expenses.

5.1.5 Health benefits

Parabolic solar cookers do not produce smoke or harmful fumes, which are common in traditional cooking methods like using wood or charcoal stoves. As a result, indoor air pollution is reduced, leading to improved respiratory health and a safer cooking environment.

5.1.6 Versatility

Parabolic solar cookers can be used for various cooking methods, including boiling, frying, baking, and steaming. They are versatile enough to cook a wide range of dishes, making them suitable for different culinary traditions and preferences.

5.1.7 Limitations

While parabolic solar cookers are highly effective in sunny conditions, they may not be as efficient during cloudy days or in regions with limited sunlight. This limitation can be mitigated to some extent by using thermal storage materials to retain heat and prolong cooking times.

5.1.8 Adaptability in different regions

Parabolic solar cookers can be used in both rural and urban areas, providing a sustainable cooking option to communities that lack access to reliable electricity or clean cooking fuels.

5.1.9 Maintenance and durability

Proper maintenance is essential for the longevity of a parabolic solar cooker. Depending on the materials used, it may require periodic cleaning and adjustment to maintain optimal performance.

5.1.10 Promotion and awareness:

Encouraging the use of parabolic solar cookers requires raising awareness among communities about the benefits and proper usage of these devices. Governments, NGOs, and other organizations can play a significant role in promoting solar cooking as a viable alternative.

After considering the various aspects of a parabolic solar cooker, it can be concluded that this type of solar cooker offers several advantages and limitations. Here is a detailed conclusion on the parabolic solar cooker:

5.2 Limitations

5.2.1 Direct sunlight requirement

Parabolic solar cookers need direct sunlight to function efficiently. Cloudy or overcast weather can significantly reduce their performance, limiting their usability in certain regions or during certain times of the year.

5.2.2 Safety Concerns

The concentrated heat of a parabolic solar cooker can pose safety risks, especially if not handled properly. Users need to be cautious to avoid burns and other accidents while operating the cooker.

5.2.3 Complexity

Constructing a parabolic solar cooker can be more complicated than other types of solar cookers, and purchasing a pre-made one might be relatively expensive for some users.

5.2.4 Limited cooking window

Parabolic solar cookers are most effective during the peak hours of sunlight, typically from late morning to early afternoon. Outside of this window, their cooking efficiency decreases significantly.

5.2.5 Not suitable for large quantities

While parabolic solar cookers are efficient, their cooking area might be limited, making them less practical for preparing large quantities of food.
When a three-dimensional parabola is aligned towards the sun, all the incoming light on its mirrored surface converges at a specific point called the focus. By placing a black cooking pot at this focus, the pot can efficiently absorb the light's energy and become intensely hot. A parabolic shape, similar to a satellite dish, can be transformed into a solar cooker. Parabolic solar cookers heat up rapidly and function like standard stovetop ranges, allowing for frying foods, boiling water, and baking bread.

5.3 Focus point of parabolic & spherical curve

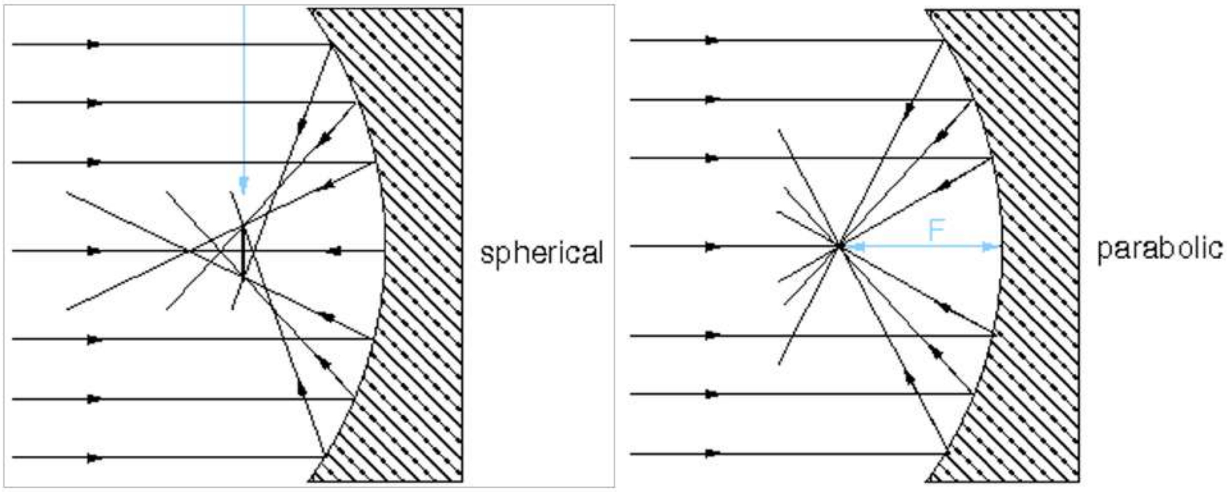

Figure 20

The focus point in both circular and parabolic curves refers to a specific point that plays a significant role in defining the shape and characteristics of the curve. However, the focus point is different for each type of curve:

5.3.1 Focus point in a circular curve:

In a circular curve, the focus point is the center of the circle from which the curve is derived. It is the point equidistant from all points on the curve. The curvature of a circular curve remains constant along its entire length because it is defined by the same radius of the circle throughout.

5.3.2 Focus point in a parabolic curve:

In a parabolic curve, the focus point is a unique point on the curve called the "focus" or "focal point." A parabola is defined as the set of all points that are equidistant from the focus point and the directrix (a fixed line). The focus point is located on the axis of symmetry of the parabola, and the directrix is perpendicular to the axis at the vertex of the parabola.

The shape of the parabolic curve is determined by the relationship between the distance from any point on the curve to the focus and the distance from that point to the directrix. This property of parabolas is why they have varying curvature, with the curvature becoming more pronounced as the distance from the focus point increases.

In summary, while both circular and parabolic curves have focus points, the focus point in a circular curve is the center of the circle, while in a parabolic curve, it is a unique point on the axis of symmetry known as the "focus" point. Understanding these focus points is essential in analyzing and working with these curves in various applications such as engineering, architecture, and mathematics.

5.4 Sun angle at different time of the day Date: 02-06-2023

Table 3-3

Time	Azimuth angle	Elevation angle
10: 00	101.90°	61.63°
10: 15	105.10°	64.53°
10: 30	110.10°	68.19°
10:45	115.00°	70.94°
11: 00	121.22°	73.58°
12: 00	182.07°	80.60°
12: 15	198.50°	80.14°
12: 30	216.70°	78.54°
12: 45	228.48°	76.52°
13: 00	237.20°	74.14°
14: 00	258.34°	61.45°
14: 15	261.09°	58.51°
14: 30	263.54°	55.56°
14: 45	265.76°	52.59°
15: 00	268.36°	48.76°

5.5 Time & temperature graphical analysis of solar cooker

The data is collected on 2nd June, 2023 at university of central Punjab, Lahore

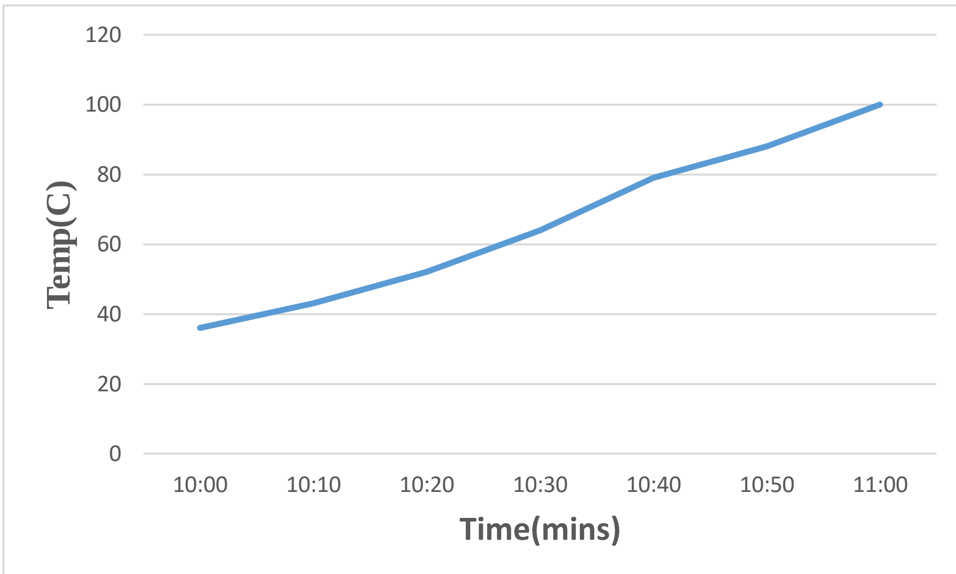

Figure 21

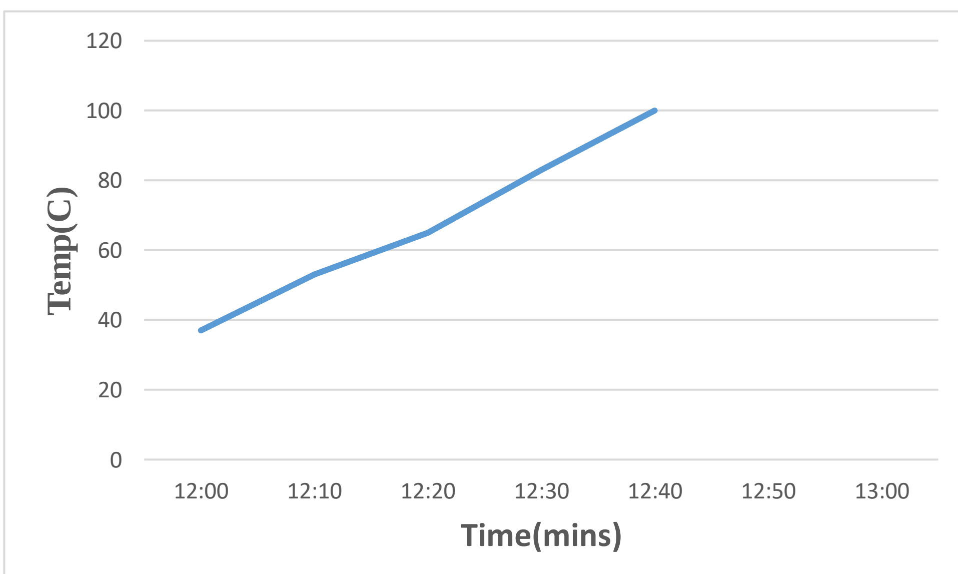

Figure 22

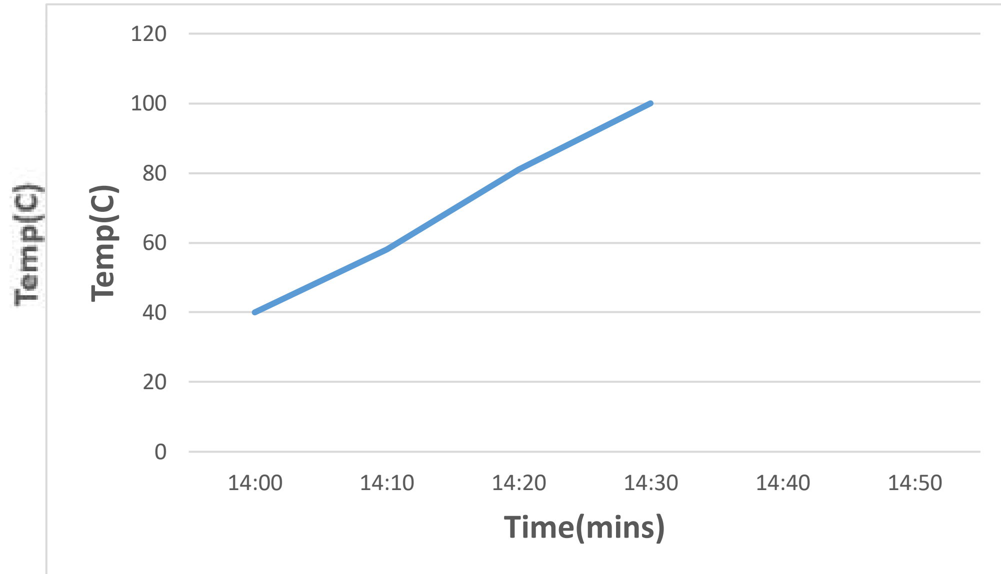

Figure 23 Black coated pot is used in 3rd observation

6 CHAPTER SIX: CONCLUSION

A parabolic solar cooker has been specifically designed for rural households, refugee camps, and disastrous situations. The cooker utilizes a black casted aluminum vessel, which is highly efficient in quickly absorbing heat, making it suitable for faster cooking. To ensure optimal performance and efficiency, a concentration ratio greater than 20 is recommended.

Through performance testing under various weather conditions, it has been established that the parabolic solar cooker utilizing aluminum foil as a reflective material. The aluminum foil enables rapid heat absorption, making it ideal for cooking various dishes. Additionally, this type of cooker can be manufactured at a relatively lower cost using locally available materials, and scaling up production for refugee camps can further reduce costs.

Based on its performance evaluation and efficiency, the parabolic dish solar cooker is suitable for use in tropical regions, disaster-affected areas, refugee camps, and rural households. Its adoption can contribute to green energy development and aid in reducing deforestation. For future improvements, considerations could be given to using high-quality reflecting materials or implementing a heat-insulated system to enhance its performance.

- During experimental testing, the most favorable cooking hours were observed to be between 13:30 and 14:30.
- Proper solar tracking was also found to significantly enhance the cooker's effectiveness.

In conclusion, the parabolic solar cooker is an ingenious solution to address the challenges of traditional cooking methods, such as environmental degradation and health hazards. While it has its limitations, its benefits in terms of sustainability, energy efficiency, and health make it a promising technology for a cleaner and healthier future.

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