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Performance and Evaluation of Parabolic Solar Concentrator by Using Different Types of Material with or without Insulation

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***Abstract:** The utilization of solar energy has garnered substantial attention as a sustainable solution to address the world's increasing energy demand. Parabolic solar concentrators, known for their ability to focus sunlight onto a single point, play a crucial role in enhancing solar energy collection efficiency. This study investigates the performance of parabolic solar concentrators, specifically focusing on the impact of utilizing different types of materials and the incorporation of insulation.*

Through comprehensive experimentation and analysis, this research assesses the efficiency of parabolic solar concentrators constructed from various materials, ranging from traditional metals to novel reflective coatings. Furthermore, the study evaluates the influence of incorporating insulation around the concentrator structure to mitigate heat losses, thus enhancing overall energy capture. The findings of this research contribute to a deeper understanding of the interplay between material selection, insulation integration, and solar energy concentration efficiency. This knowledge holds paramount importance in designing and optimizing solar concentrator systems for diverse applications, such as electricity generation and thermal heating. Ultimately, the outcomes of this study facilitate informed decision-making in selecting the most suitable materials and strategies for enhancing the performance of parabolic solar concentrators in harnessing renewable solar energy.

***Keywords:** Solar concentration systems, concentrating collector, Performance optimization, Thermal efficiency, Energy generation, Solar technologies.*

I. INTRODUCTION

The sun radiates an immense amount of energy, which serves as the primary source of energy on Earth. Other forms of energy, such as wind energy and fossil fuels, are ultimately derived from solar energy. Solar power, also known as renewable energy, involves harnessing radiant heat and light from the sun and converting it into electrical power or heat sources. This conversion is achieved through crystalline or amorphous silicon photovoltaic panels, with crystalline silicon panels being more popular due to their higher output per square inch.

A. The Sun's Energy

The sun, at the center of the solar system, emits electromagnetic radiation at a constant rate of 3.83×1026 W, releasing energy equivalent to that coming from a furnace at a temperature of about 6000 K. Although the sun's energy could theoretically meet the world's current energy demand if harvested from just 10 hectares of its surface, practical limitations prevent this from being feasible. Several factors contribute to this limitation: the displacement of the earth from the sun, the earth's rotation, and the effects of the earth's atmosphere, which can reduce solar radiation reaching the earth's surface on cloudy days.

Solar radiation processes classified as follows.

1) *Helio Thermal:* This is the system solar energy in which the incident radiation on any surface is absorbed and turned into heat energy such as PDC, PTC
2) *Helio Chemical:* In which radiation between 0.3 and 1.0μ m can cause chemical reactions, sustain growth of plants and animals and through Photosynthesis converts exhaled carbon dioxide to breakable oxygen.
3) *Helio Electrical:* Solar radiation processes are classified as heliothermal, heliochemical, and helioelectrical. Heliothermal systems absorb incident radiation on a surface and convert it into heat energy, while heliochemical processes involve radiation between 0.3 and 1.0 µm causing chemical reactions and sustaining growth in plants and animals. Helioelectrical processes convert part of the radiation between 0.33 and 1.2 µm directly into electricity using photovoltaic cells.

The incoming solar radiation suffers depletion in the following ways:

- Absorption by the ozone in the upper atmosphere.
- Scattering by dry air.
- Absorption, scattering and diffuse reflection by suspended solid particles.
- Absorption and scattering by thin cloud layers.
- Absorption and scattering by water vapor.

B. *Concentrated Solar Power System*

Solar radiation can be converted into various forms of energy, including electricity, through photovoltaic cells, or it can be collected and used for heating purposes in a solar collector system. Concentrated solar power (CSP) plants produce electric power by converting solar energy into high-temperature heat using mirror configurations. The collected heat is then used to operate a conventional power cycle, such as a steam turbine or a stirling engine.

Solar heat collected during the day can also be stored in steam, liquid or solid media like molten salts, phase-changing salt mixtures. The surfaces of the collectors are low emission and high absorption of energy. Solar energy conversion is classified as shown in Figure 1.2.

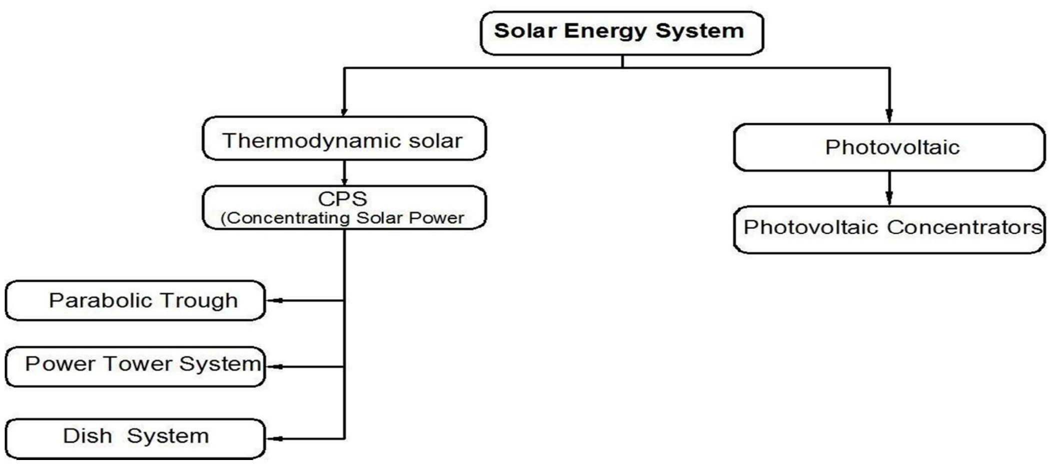


Figure 1 Classification of solar energy systems

Sun energy radiated as follows

- 7% ultraviolet light
- 47% visible light
- 46% infrared light
- This infrared sun light is converted into PV solar power
- The sun radiate approximately 1.4 kW/m2
- Solar cell efficiency approximately 10% to 15%

The experimental setup was built and installed at the solar energy lab of SRCEM College in Morena. Figure 2 depicts the developed solar concentrator without insulation. The parabolic reflector's major (a) and minor (b) axes are each 55 $ 53 inches long.The parabolic surface is covered with a 9mm thick aluminum sheet to maximize light reflection. The different temperatures are degreed using five thermocouples. During experiments, the solar concentrator is oriented east-west. From 11 am until 3 pm, the experiment was conducted using a solar concentrator.

Table 1: Description of Instruments used

Instrument	Purpose	Range
Thermocouple	Used to measure temperature at specific point	-20-120°C
Solarimeter	Used to measure solar radiation	0-1999 w/m2
Measuring Tape	Used to measure dimension of concentrator	6-40 inch

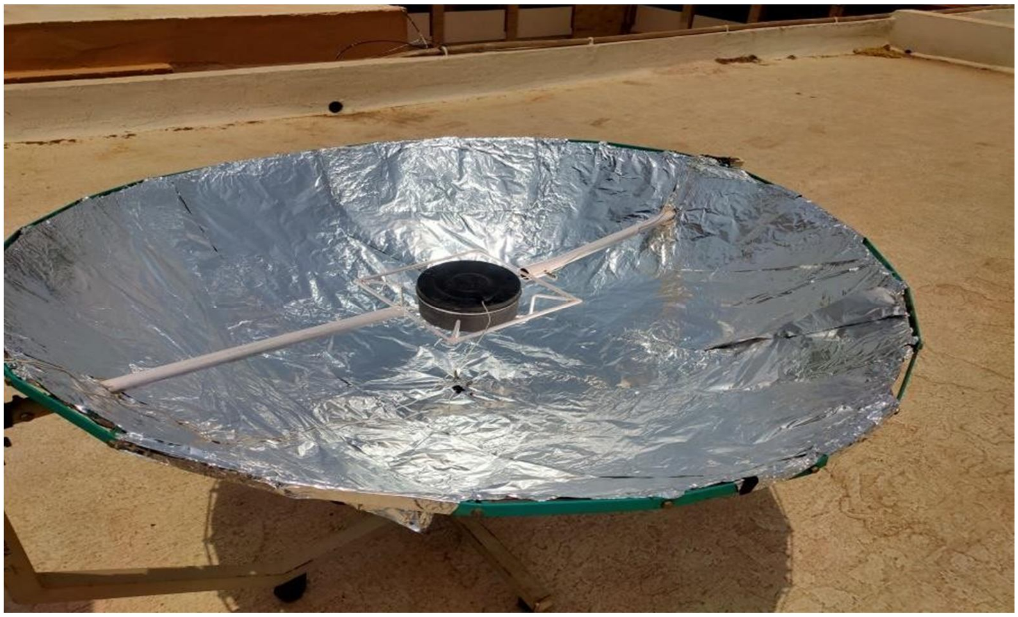


Fig.2. Experimental setup

Fig. 3. Rice cooking in the solar concentrator

Fig. 4. Rice cooked in solar concentrator

Heat input by solar radiation can be calculated from the Eq. (1)

$$\mathbf{Q_{input} = A\left[\sum_{i=1}^{5} I_i\right] \times \Delta t} \qquad \textbf{(1)}$$

Value of **A** and I can be calculated from Eq. (2) and from Table 4

Area of solar concentrator can be calculated using the relation,

$$\mathbf{(A) = \pi \times a \times b} \qquad \textbf{(2)}$$

Where values of **a** and **b** are **55** and **53** inches respectively

Heat utilization by water can calculated from the Eq. (3)

$$\mathbf{(Q) = \sum mC_{water} \times \Delta Ti} \qquad \textbf{(3)}$$

Where values of **m** and **C**water are **0.4kg** and **4.186 J/Kcal**

Efficiency of the solar concentrator can be computed from the Eq. (4)

$$\textbf{Overall efficiency} = [Q_{utilization} \div Q_{input}] \times 100 \quad (4)$$

The purpose of this study is to examine and evaluate how solar concentrators work in various environments. We will specifically look at how insulation and the selection of coating materials, including aluminum and silver, affect the concentrator's general efficiency. The study's findings will offer important information on the viability of making such improvements to increase solar concentrator efficiency.

C. Using Aluminium Foil Without Insulation

The readings of various temperatures that are taken while conducting tests at intervals of 30 minutes are listed in Table 2. The first reading was conducted at 11:00 AM, and the last reading was conducted at 3 PM. The study of heat transmission will benefit from the wide range of temperature values that exist. The highest temperatures that were obtained were 42.4, 82.5, 62.2, and 83.5 degrees Celsius for the ambient temperature (Ta), the pot's outlet temperature (To), the disk's outer surface (Tdiskouter), and the pot's core (Tcenter).

Table 2 : Temperature Aluminium Foil Without insulation

Time	Ti(°C)	To(°C)	Ta(°C)	Tdiskouter(°C)	Tcenter(°C)
11:00	49	70.4	36.6	47.8	60.4
11:30	78.4	71	37.4	43.5	61.2
12:00	83.5	82.5	38.2	42.2	83.5
12:30	65.2	50.1	39	51.4	70.8
13:00	62.1	54.6	40.2	62.2	52.7
13:30	54.1	42.7	41.1	55.1	50.3
14:00	46.4	41.1	41.2	41.4	45.3
14:30	42.7	40.4	42.4	39.4	44.2
15:00	40.4	39.2	38.1	36.7	34

The specifics of all the parameters, including the heat input to the water, the heat input to the water, the heat losses, and the efficiency in % at every hour of time interval, are listed in Table 3. The following parameter's fluctuation over time is also shown in this table. The highest possible values for heat intake, output, heat losses, and efficiency are 22172.89 kJ, 75.85 kJ, 22097.08 kJ, and 0.3418%, respectively.

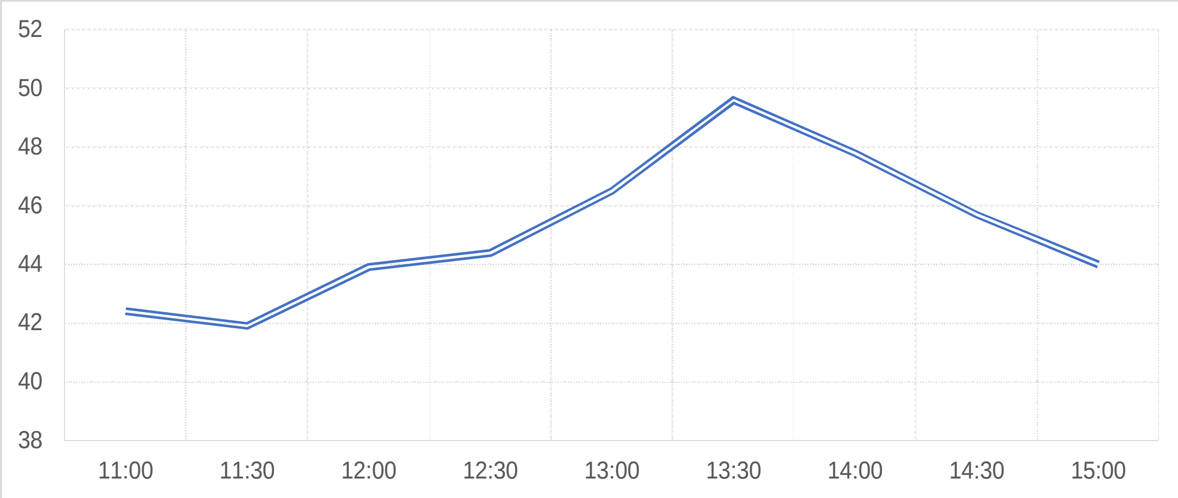
Table 3: Parameters calculated for Aluminium Foil Without insulation

Time(Hrs.)	Qinput(KJ)	Qoutput(KJ)	Qloss(KJ)	η (%)
11:00	19876.95	20.76	19856.19	0.104
12:00	22172.89	75.85	22097.08	0.3418
13:00	20365.90	36.66	20329.23	0.1800
14:00	17942.40	8.706	17933.69	0.0485
15:00	13626.87	3.85	13625.02	0.0280

Information on the depth of solar radiation at various times is provided in Table 4. It includes the reading at hourly intervals. The chart shows that the intensity ranges from 844 to 1043 w/m2.

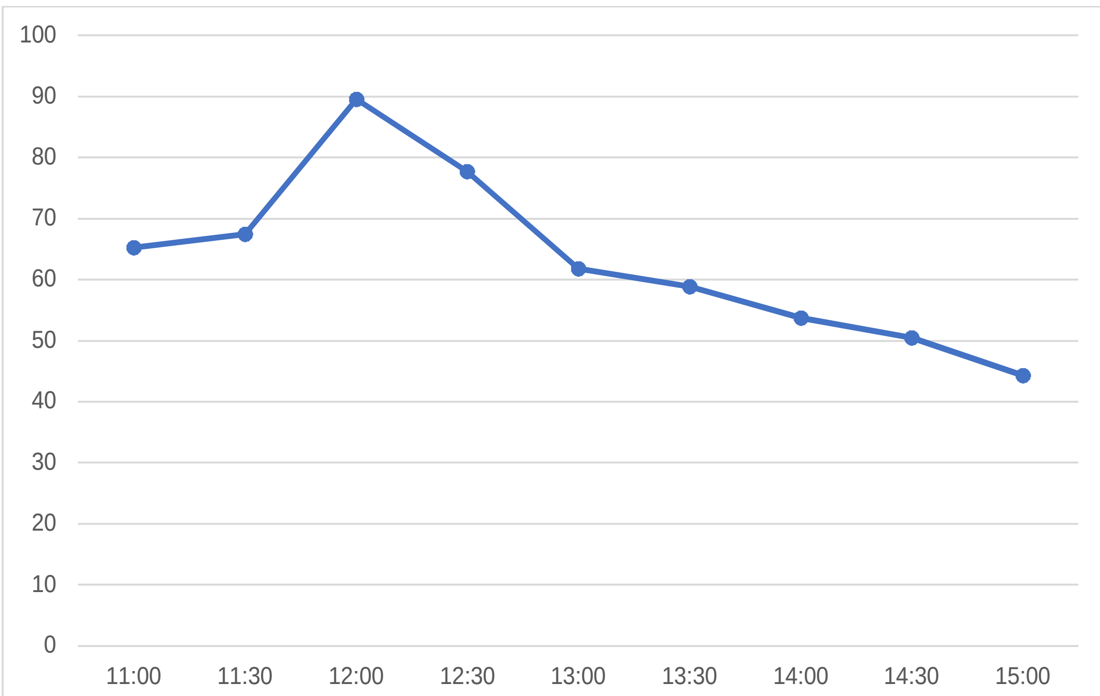
Table 4: Solar Radiation Aluminium Foil Without insulation

Time(hrs)	Solar Radiation(W/m2)
11:00	935
12:00	1043
13:00	958
14:00	844
15:00	641



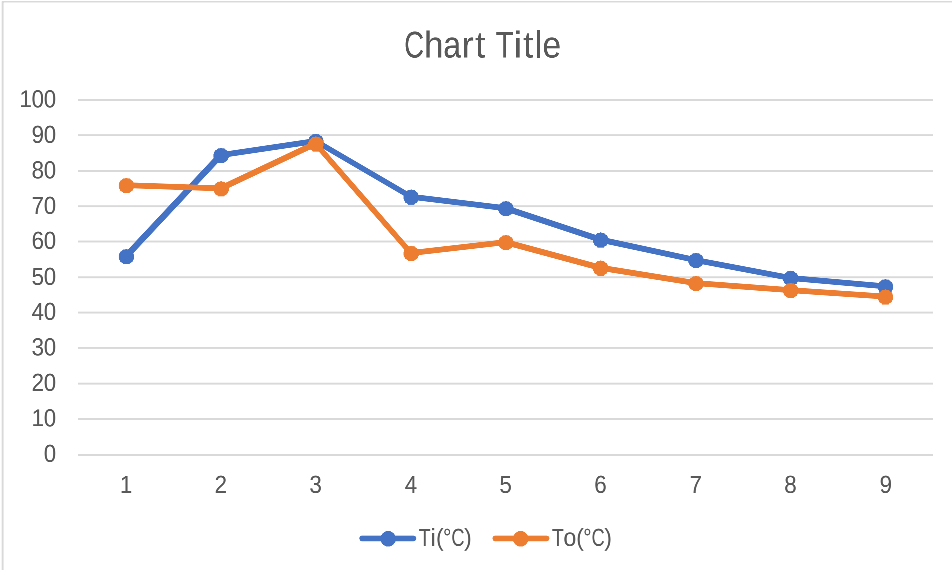
Graph.1 Graph showing ambient temperature variation with time

The amount of heat that water uses is directly correlated with the ambient temperature. As the ambient temperature rises, more heat is used by the water in a given amount of time because the ambient temperature and the inner temperature of the water are different. The characteristic curve presented in the graph makes it simple to notice how the ambient temperature changes over time.



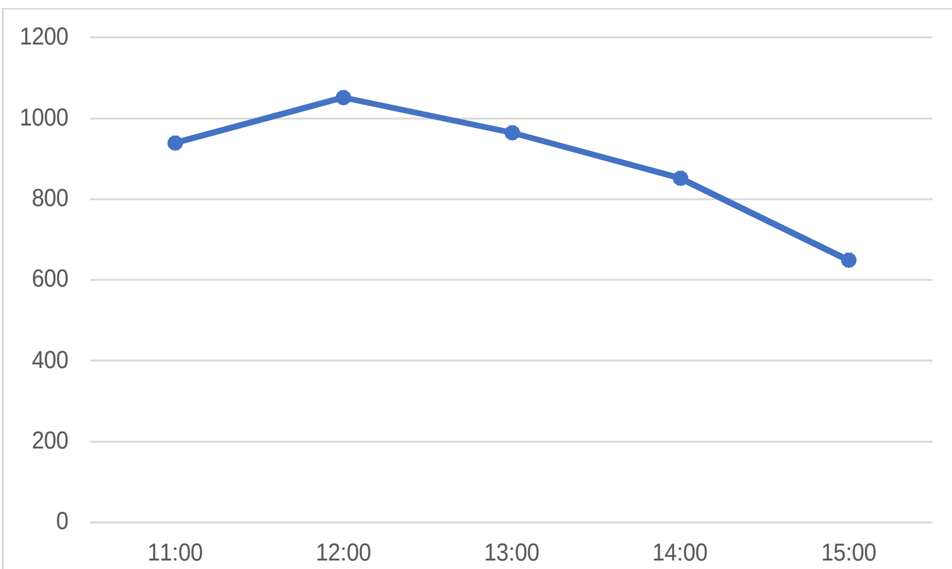
Graph 2. Graph showing variation center temperature

The parabola as it ages The dish outer is more open to the atmosphere than the center of the parabola, so the center temperature (Tc) is always higher than the dish outer temperature (To). This is because convection heat transfer is less efficient at the center than it is at the dish outer temperature. Convection heat transmission is dependent on the medium result, the temperature in the middle of the dish is higher than it is on the outside. From graph 2, it is clear that the center temperature is obtained at a maximum of 83.5°C and the lowest temperature is 38°C.



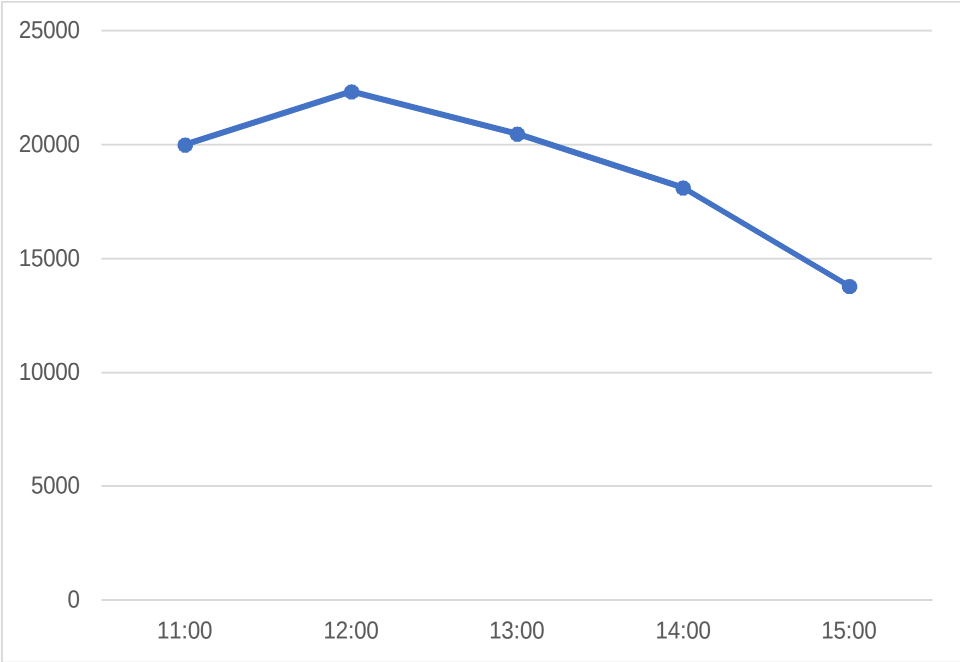
Graph 3. Graph showing inlet and outlet temperature of cooking pot

When there is no electricity, the water is drawn from a water cooler, so the inlet temperature of the water is lower than the outlet temperature of the dish. However, because the dish's outlet is directly exposed to the atmosphere and is situated at the parabola's center, where maximum heat is generated, the inlet temperature of the water rises more over time than the outlet temperature does. However, because the environment is open to the atmosphere and air acts as a medium for heat transmission through convection in this situation, convection losses account for the majority of heat loss. Because of this, the graph shows that the entrance temperature at the dish is rising more quickly than the output temperature at every time. Maximum temperature at the intake is 83.5°C, and the dish's opening is 83.5°C. Minimum temperature at the inlet is 42.7°C, and maximum temperature at the exit is 38°C. These facts are easily shown by graph 3.



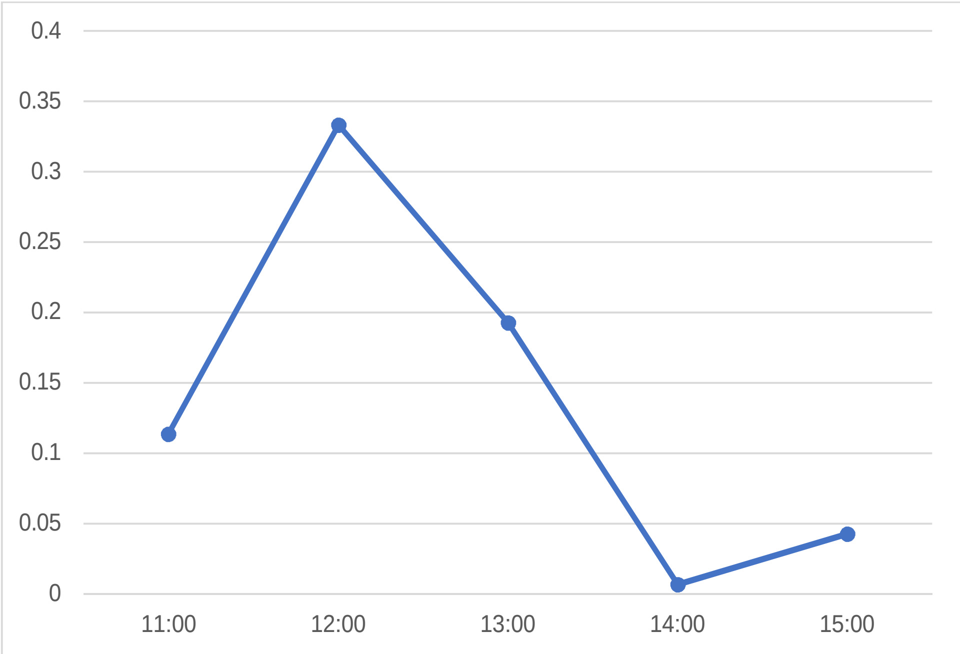
Graph 4. Graph showing variation of heat utilized by water with time

Heat used is the amount of heat that water uses per hour. The amount of heat used first rises, but as time goes on, the amount of heat used each hour falls, peaking around 3 o'clock. Heat utilization is directly influenced by the temperature differential since the governing equation for heat utilization is (Qutilized=mCwaterT) in this equation. The temperature difference increases at first and reaches its peak at noon. Thereafter, the temperature difference continues to decline, which causes the heat that the water absorbs to decline. These variations are all clearly seen in graph 4.



Graph.5 Graph showing variation of input heat with time

According to the formula for heat input (Qinput=IAt), solar irradiation and heat input are directly related to one another. Here, A, the area of the parabola, is a constant while t, the time, and A, the area are both constant, whereas due to changing solar irradiation, (I), is every instant at 12pm it is highest and it is lowest at 3pm. The graph 5 shows that the highest heat input is 22172.89 kJ and the minimum heat input is 13626.87 kJ.



Graph.6. Graph showing variation of efficiency with timeEfficiency

As the proportion of usable heat to total heat input. The ratio first increases and reaches its highest at 1 pm. Thereafter, efficiency continues to decline as the amount of heat used decreases after 1 pm and reaches its minimum at 3 pm. This fluctuation is clearly shown by the distinctive curve in graph 6.

D. Using Aluminium Foil With insulation

The readings of various temperatures that are taken while conducting tests at intervals of 30 minutes are shown in Table 4.The first reading was conducted at 11:00 AM, and the last reading was conducted at 3 PM. The study of heat transmission will benefit from the wide range of temperature values that exist. The highest temperatures that were obtained were 45.2, 84.7°C, 67.3°C, and 86.6°C for the ambient temperature (Ta), the pot's outlet temperature (To), the disk's outer surface (Tdiskouter), and the pot's core (Tcenter).

Table 5: Temperature Aluminium Foil With insulation

Time	Ti(°C)	To(°C)	Ta(°C)	Tdiskouter(°C)	Tcenter(°C)
11:00	51.1	72.8	39.3	49.9	63.3
11:30	80.1	73	39.5	44.6	61.4
12:00	86.3	84.7	40.3	45.5	86.6
12:30	69.5	53.3	41.1	21.1	72.7
13:00	65.1	57.7	43.2	67.3	58.8
13:30	57.0	46.5	45.2	58.5	54.4
14:00	49.2	45.1	43.1	42.6	49.6
14:30	46.6	43.4	41.7	40.7	48.3
15:00	44.3	41.3	41.2	39.6	40.1

The specifics of all the parameters, including the heat input to the water, heat output, heat losses, and efficiency in % for each hour of the time interval, are listed in Table 5. The following parameter's fluctuation over time is also shown in this table. Maximum heat intake, output, heat losses, and efficiency are, in order, 22215.43 kJ, 77.02 kJ, 22138.40 kJ, and 0.3466%.

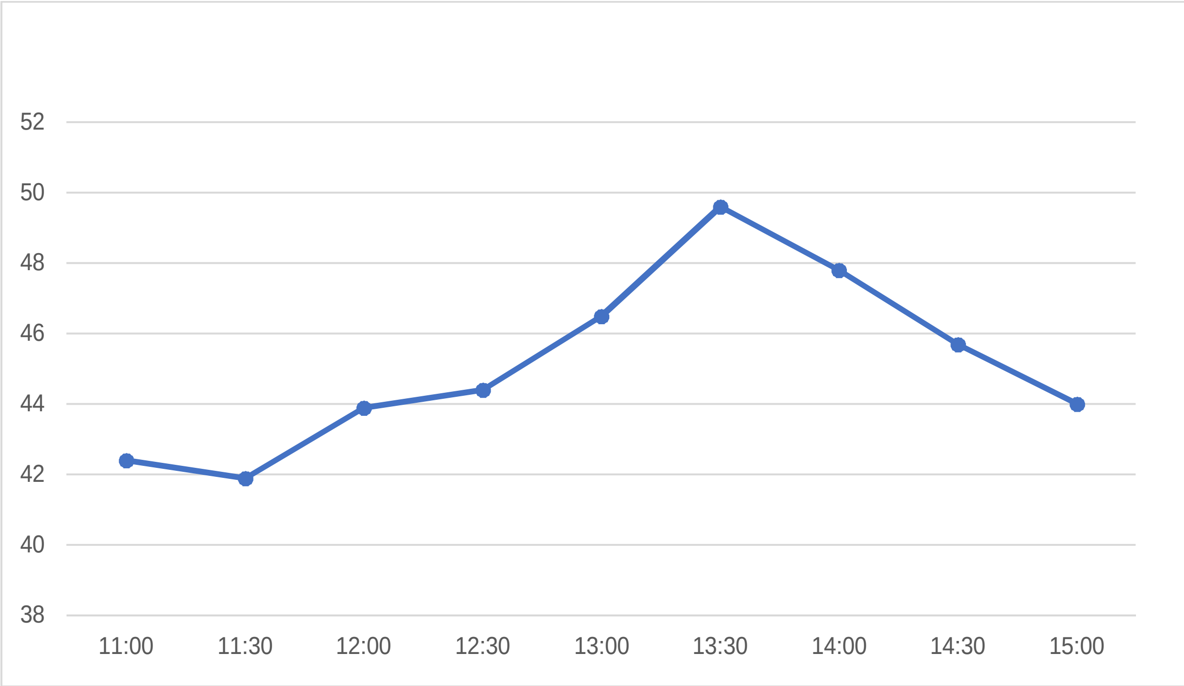
Table 6: Parameters calculated Aluminium Foil With insulation

Time(Hrs.)	Qinput(KJ)	Qoutput(KJ)	Qloss(KJ)	η (%)
11:00	19898.21	19.75	19878.46	0.0992
12:00	22215.43	77.02	22138.40	0.3466
13:00	20387.15	36.66	20350.49	0.1798
14:00	18006.17	10.21	17995.96	0.056
15:00	13711.94	5.190	13706.75	0.0402

Information on the depth of solar radiation at various times is provided in Table 7.It includes the reading at hourly intervals. The chart shows that the intensity ranges from 645 to 1045 w/m2.

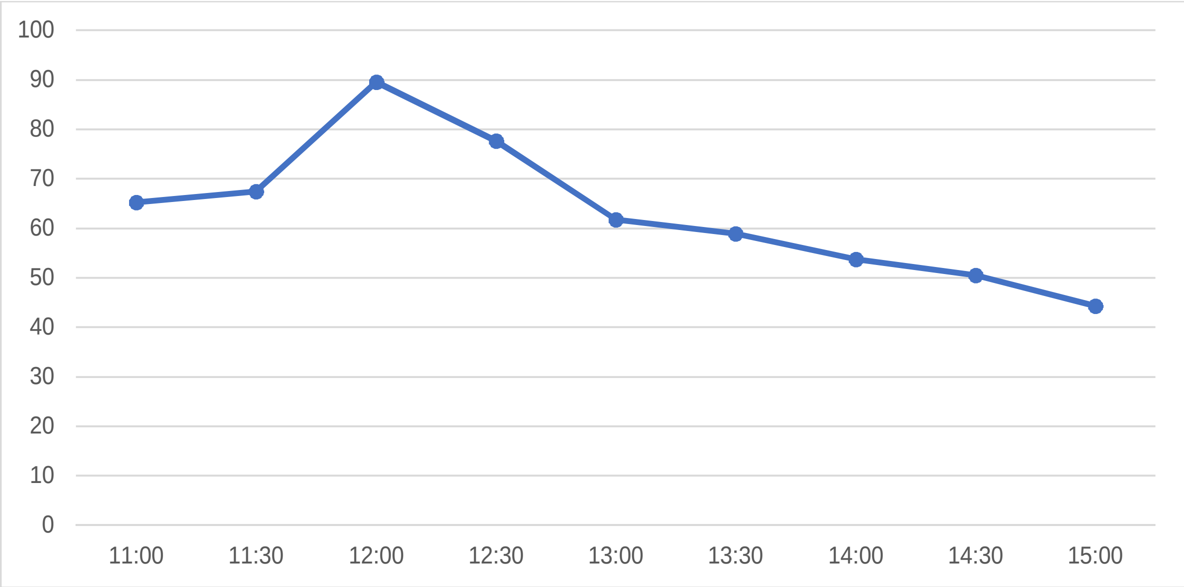
Table 7: Solar Radiation Aluminium Foil With insulation

Time(hrs)	Solar Radiation(W/m2)
11:00	936
12:00	1045
13:00	959
14:00	847
15:00	645



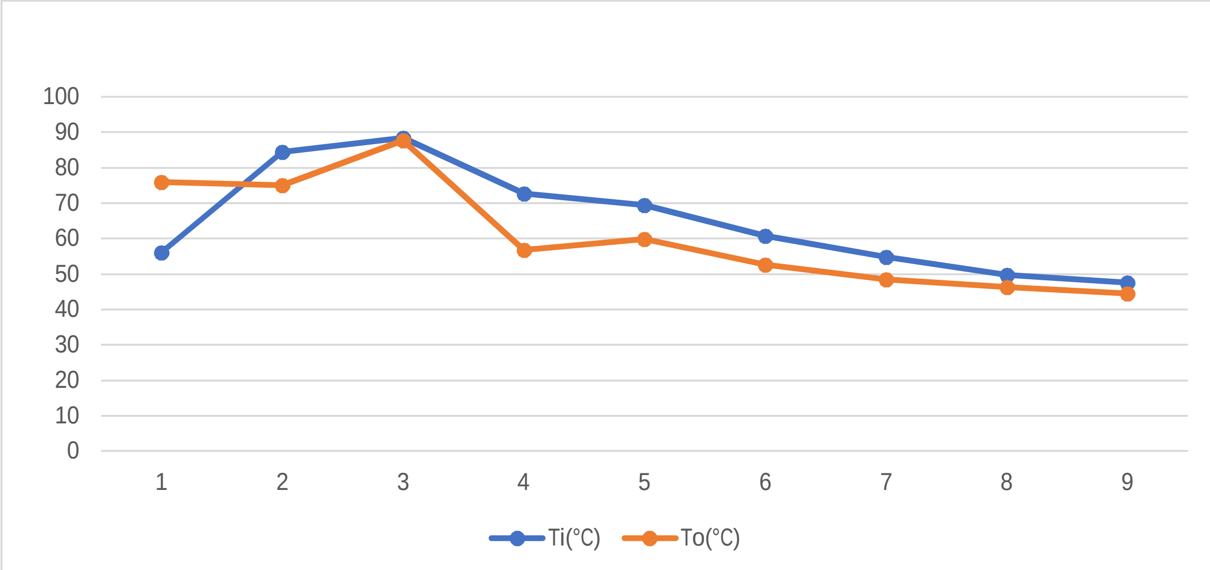
Graph 7 Showing ambient temperature variation with time

The amount of heat that water uses is directly correlated with the ambient temperature. As the ambient temperature rises, more heat is used by the water in a given amount of time because the ambient temperature and the inner temperature of the water are different. The characteristic curve shown in graph 7 makes it simple to understand how the ambient temperature changes over time.



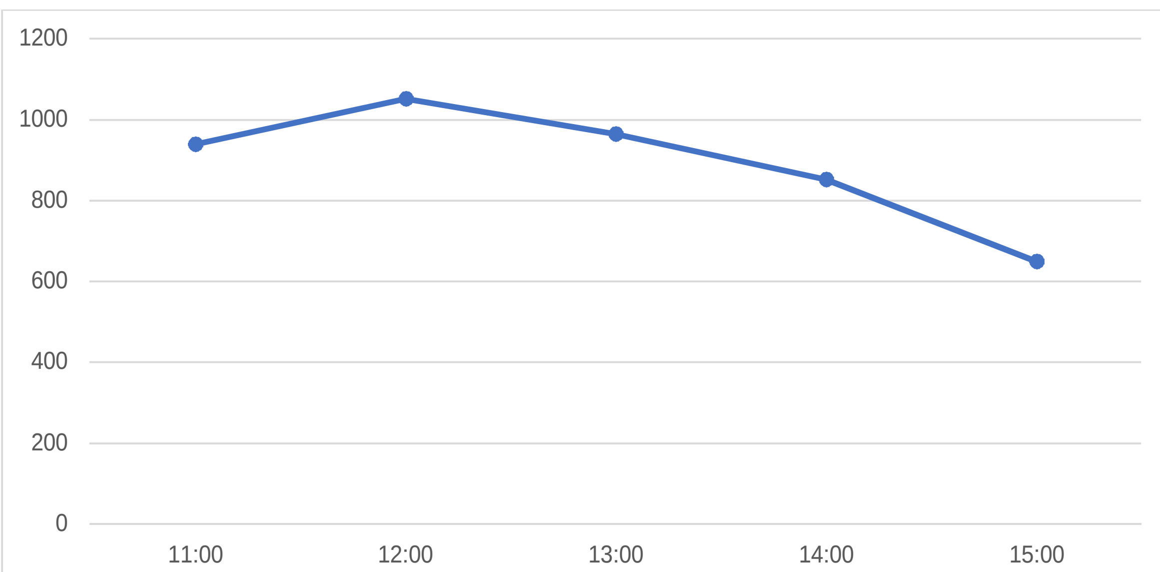
Graph 8 showing variation center temperature of the parabola with time Center temperature (Tc)

The dish outer is more open to the atmosphere than the center of the parabola, therefore the dish outer temperature is always higher than the dish outer temperature (To). This is because convective heat transfer is less efficient at the center than it is at the dish outer temperature. Convection heat transmission depends on the medium; in this case, air serves as the medium. As a result, the temperature in the middle of the dish is higher than it is on the dish's exterior. Graph 8 clearly illustrates this data, showing that the center's greatest temperature is 86.6°C and its lowest temperature is 40°C.



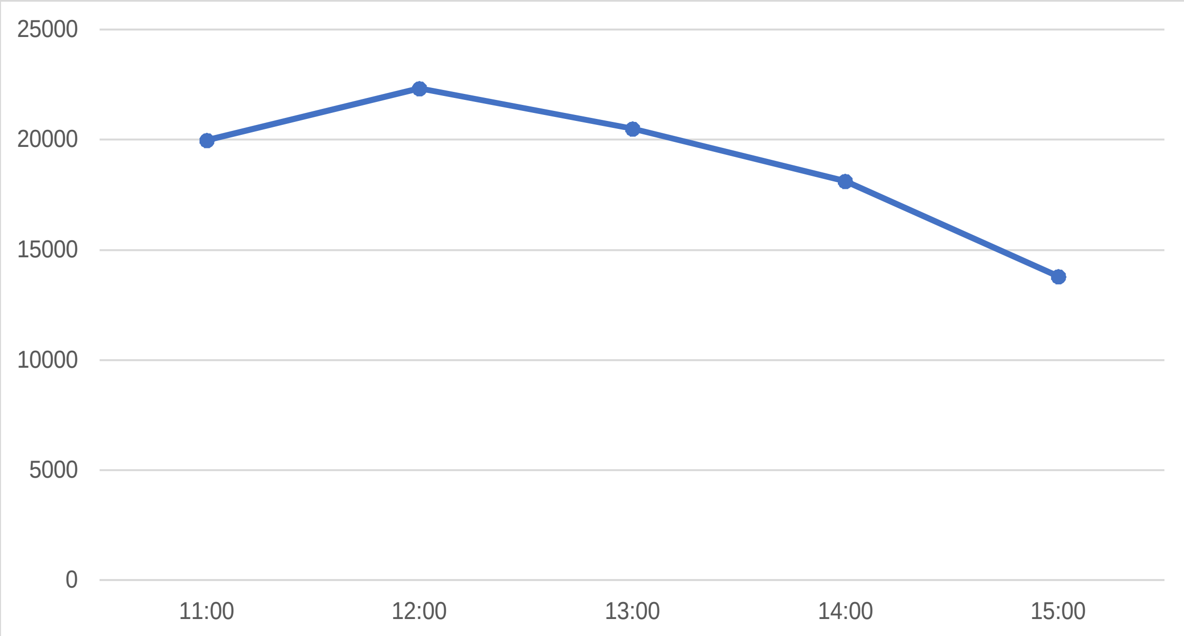
Graph 9 showing inlet and outlet temperature of cooking pot

When there is no electricity, the water is drawn from a water cooler, so the inlet temperature of the water is lower than the outlet temperature of the dish. However, because the dish's outlet is directly exposed to the atmosphere and is situated at the parabola's center, where maximum heat is generated, the inlet temperature of the water rises more over time than the outlet temperature does. When there is no electricity, the water is drawn from a water cooler, so the inlet temperature of the water is lower than the outlet temperature of the dish. However, because the dish's outlet is directly exposed to the atmosphere and is situated at the parabola's center, where maximum heat is generated, the inlet temperature of the water rises more over time than the outlet temperature does.



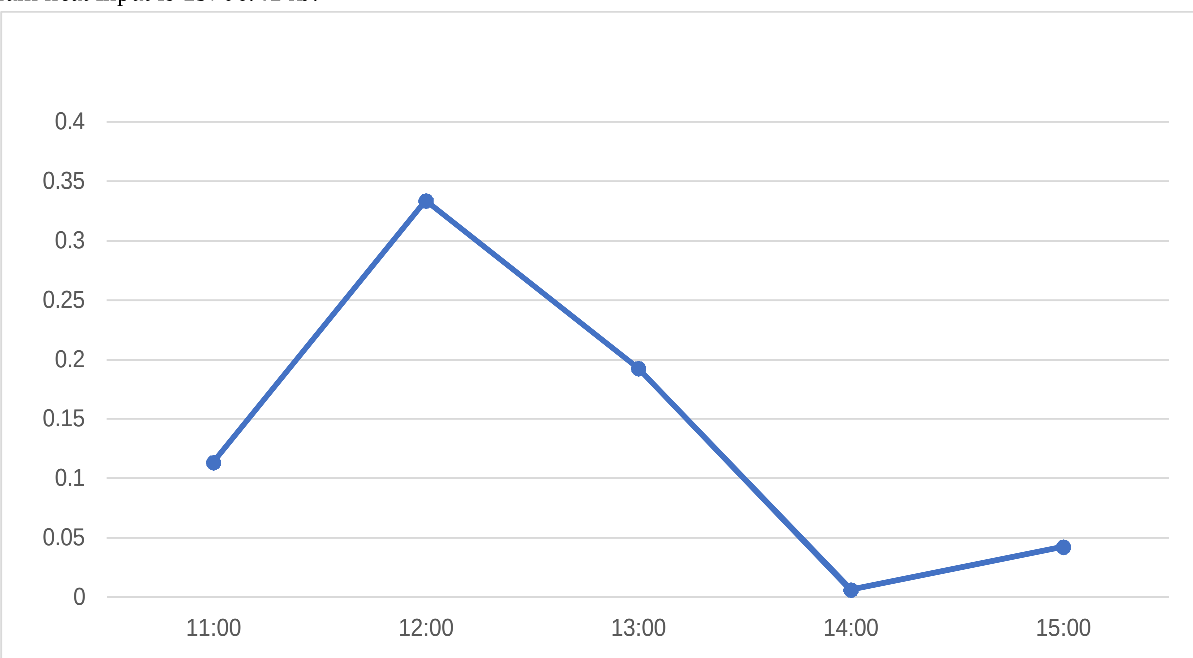
Graph 10 showing variation of heat utilized by water with time

Transmission because the outside is exposed to the environment, which acts as a medium for heat losses by convection. Because of this, the graph shows that the entrance temperature at the dish is rising more quickly than the output temperature at every time. The highest temperature at the inlet is 86.3°C, the dish's opening is 84.7°C, and the minimum temperatures at the inlet and outlet are 44.5°C and 41.3°C, respectively. These truths are easily shown by Graph 10.



Graph 11 showing variation of input heat with time

According to the formula for heat input (Qinput=IAt), solar irradiation and heat input are directly related to one another. Here, A, the area of the parabola, is a constant while t, the time, and A, the area are both constant, whereas due to changing solar irradiation, (I), is every instant at 12pm it is highest and it is lowest at 3pm. Graph 11 clearly shows that the highest heat input is 22215.43 kJ and the minimum heat input is 13706.41 kJ.



Graph 12 showing variation of efficiency with time

The ratio of the usable heat to the total heat input is known as efficiency. This fluctuation may be clearly represented from the typical curve provided in Graph 12, which shows that the ratio first increases and reaches its maximum at 1pm. Thereafter, efficiency continues to decline as the heat used decreases after 1pm and reaches its minimum at 3pm.

E. Using Silver Foil Without insulation

The readings of various temperatures that are taken while conducting tests at intervals of 30 minutes are shown in Table 8.The first reading was conducted at 11:00 AM, and the last reading was conducted at 3 PM. The study of heat transmission will benefit from the wide range of temperature values that exist. The highest temperatures that were obtained were 47.4, 85.6°C, 68.3°C, and 87.8°C for the ambient temperature (Ta), the pot's outlet temperature (To), the disk's outer surface (Tdiskouter), and the pot's core (Tcenter).

Table 8: Temperature reading Using Silver Foil Without insulation

Time	Ti(°C)	To(°C)	Ta(°C)	Tdiskouter(°C)	Tcenter(°C)
11:00	54.1	73.8	40.3	50.9	64.1
11:30	82.2	74	39.8	47.6	63.2
12:00	87.5	85.6	41.7	46.5	87.8
12:30	70.4	54.4	42.2	24.1	74.5
13:00	67.2	58.8	44.3	68.3	59.4
13:30	58.1	48.5	47.4	59.5	55.7
14:00	52.4	46.3	44.5	45.6	50.5
14:30	48.6	44.2	43.6	43.7	49.3
15:00	45.3	42.3	43.2	40.6	42.1

Details of all the parameters, including heat input to water, heat output from water, heat losses from water, and efficiency in % at each hourly time interval, are provided in Table 9. The following parameter's fluctuation over time is also shown in this table. Maximum values for heat intake, output, losses from heat, and efficiency are 22279.19 kJ, 76.68 kJ, 22202.51 kJ, and 0.3441%, respectively.

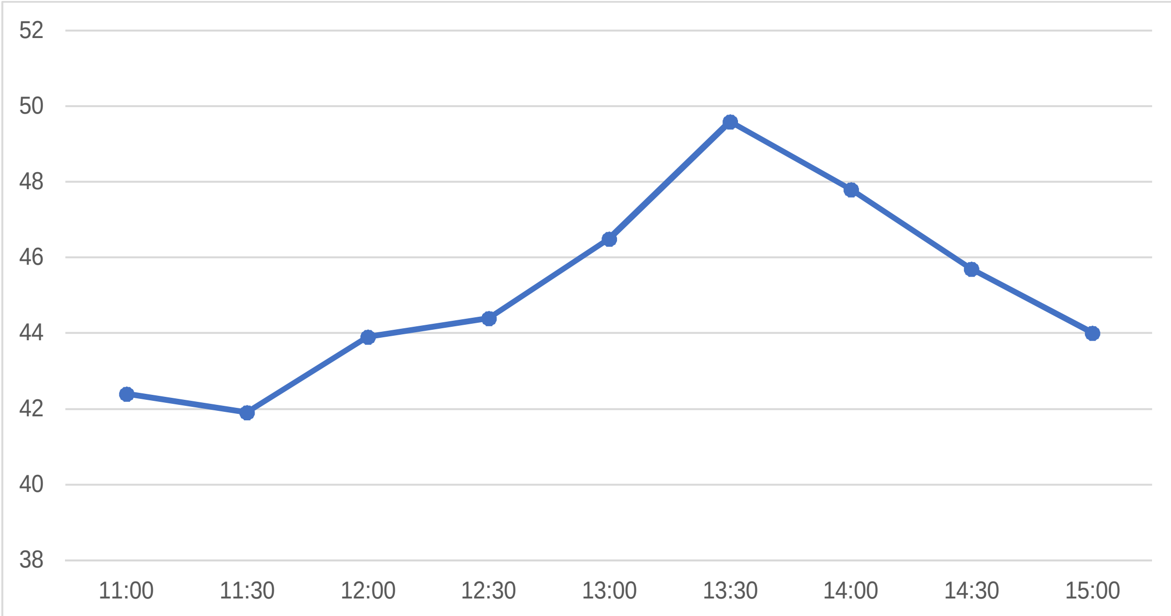
Table 9 : Parameters calculated Using Silver Foil Without insulation

Time(Hrs.)	Qinput(KJ)	Qoutput(KJ)	Qloss(KJ)	η (%)
11:00	19940.72	23.106	19917.61	0.1149
12:00	22279.19	76.68	22202.51	0.3441
13:00	20429.67	38.34	20391.33	0.1876
14:00	18048.69	13.22	18035.47	0.0732
15:00	13754.42	3.516	13750.90	0.0255

Details on the intensity of solar radiation at various time intervals are provided in Table 10. It includes the reading at hourly intervals. The chart shows that the intensity ranges from 647 to 1048 w/m2.

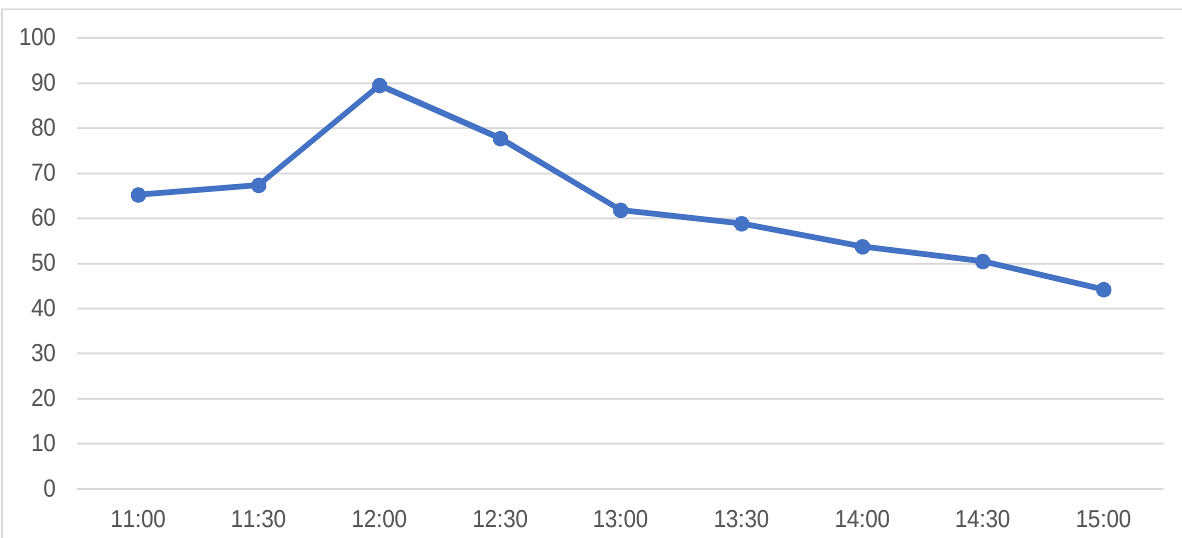
Table 10: Solar Radiation reading Using Silver Foil Without insulation

Time(hrs)	Solar Radiation(W/m2)
11:00	938
12:00	1048
13:00	961
14:00	849
15:00	647



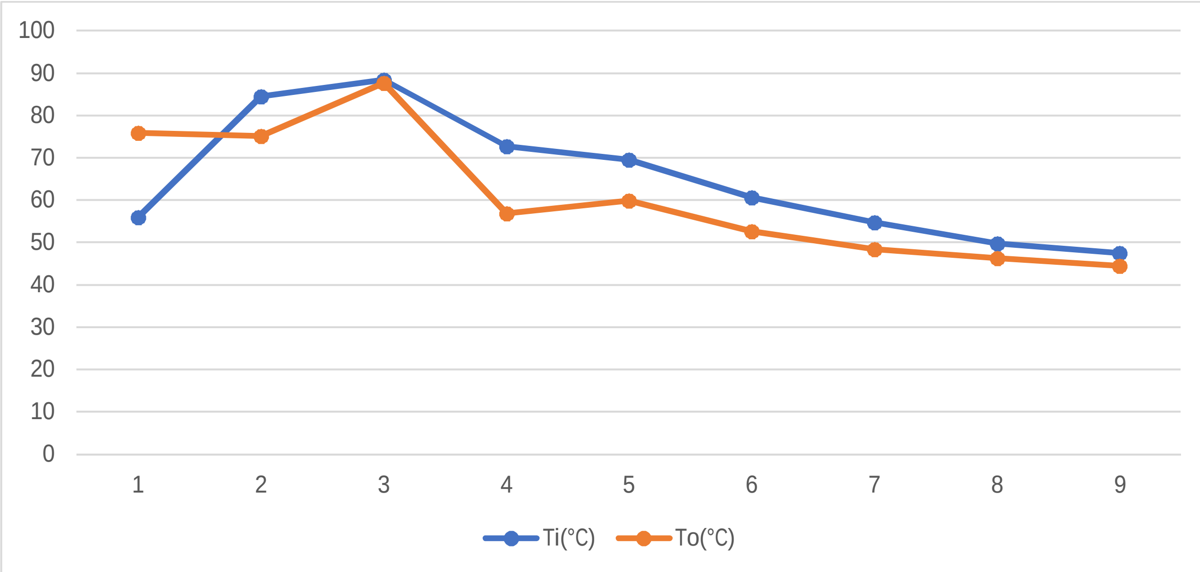
Graph 13 showing ambient temperature variation with time

The amount of heat that water uses is directly correlated with the ambient temperature. As the ambient temperature rises, more heat is used by the water in a given amount of time because the ambient temperature and the inner temperature of the water are different. The characteristic curve shown in Graph 13 makes it simple to understand how ambient temperature changes over time.



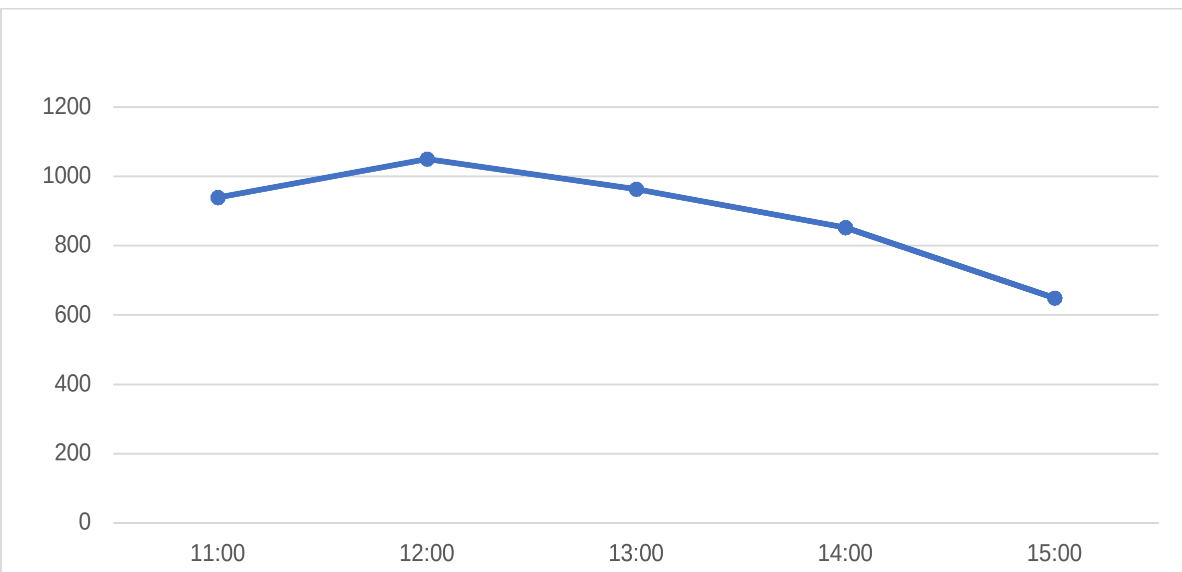
Graph 14. showing variation center temperature of the parabola with time Center temperature (Tc)is

The temperature at the parabola's center, which is always higher than the dish's outer temperature because the center's convective heat transfer is less efficient than that of the dish's outer temperature and the dish's outside surface is more exposed to the atmosphere. Convection heat transmission is dependent on the medium; in this case, air serves as the medium. As a result, the temperature in the middle of the dish is higher than it is on the outside. From Graph14, it is clear to see that the center's greatest temperature is 87.8°C and its lowest temperature is 42°C.



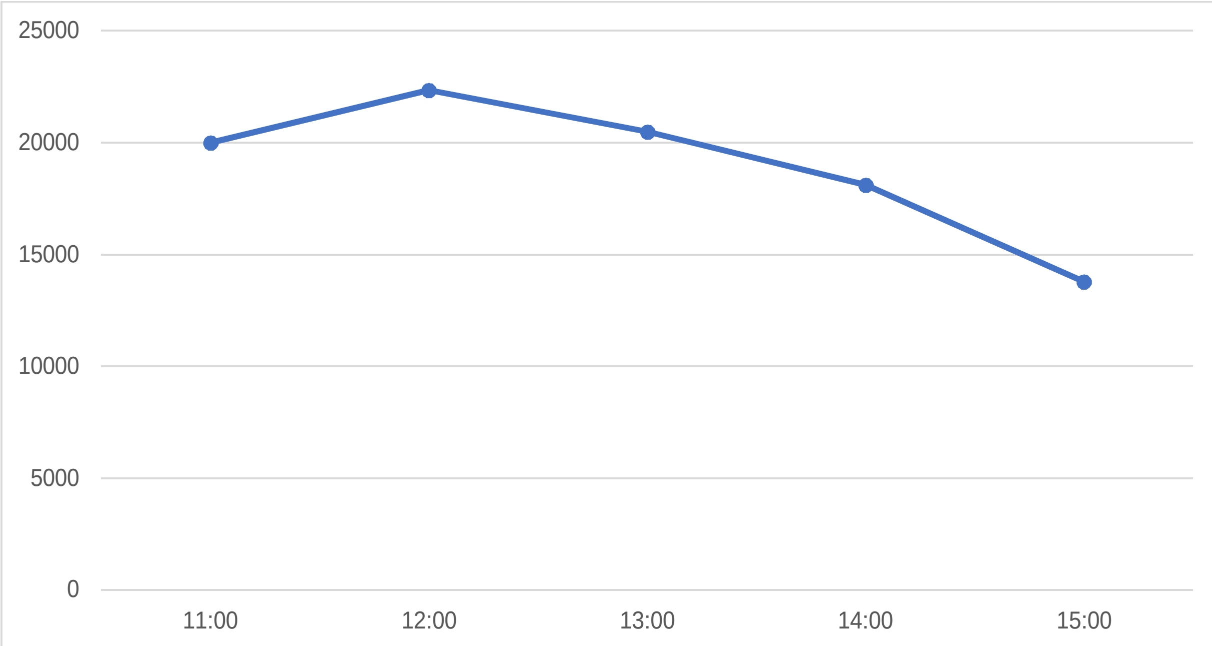
Graph 15 showing inlet and outlet temperature of cooking pot

When there is no electricity, the water is drawn from a water cooler, so the inlet temperature of the water is lower than the outlet temperature of the dish. However, because the dish's outlet is directly exposed to the atmosphere and is situated at the parabola's center, where maximum heat is generated, the inlet temperature of the water rises more over time than the outlet temperature does. transmission because the outside is exposed to the environment, which acts as a medium for heat losses by convection. Because of this, the graph shows that the entrance temperature at the dish is rising more quickly than the output temperature at every time. The highest temperature at the inlet is 87.5°C, the dish's opening is 85.6°C, and the minimum temperatures at the inlet and outflow are 45.3°C and 42.3°C, respectively. These facts are easily represented by Graph15



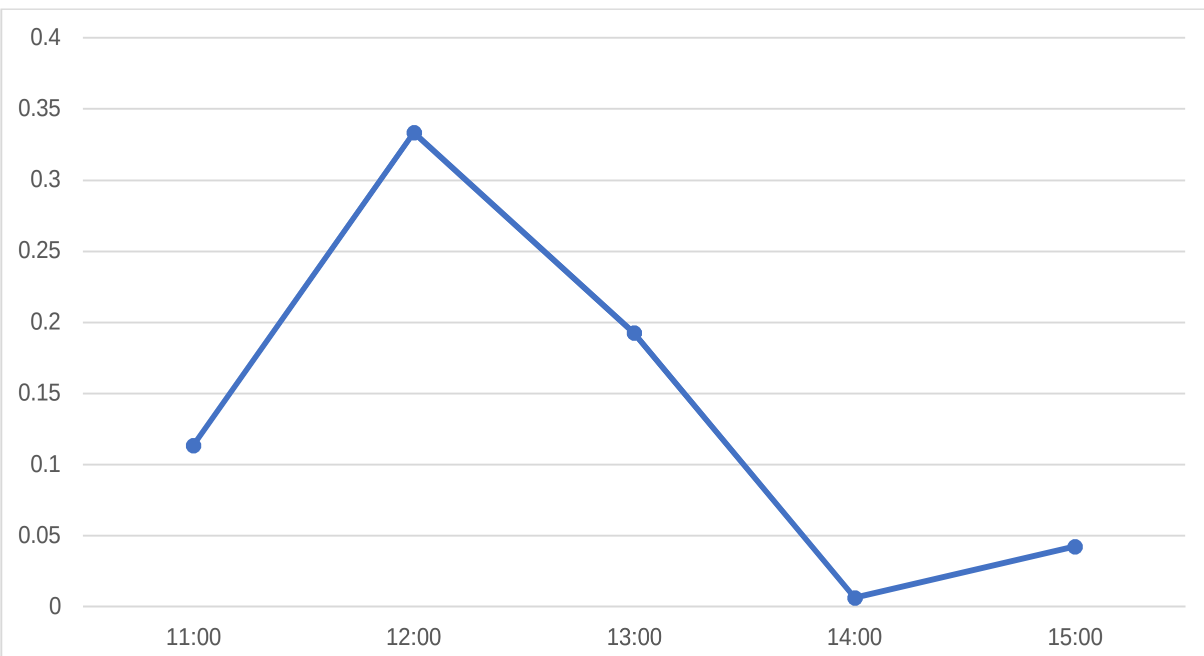
Graph 16 showing variation of heat utilized by water with time

Heat used is the amount of heat that water uses per hour. The amount of heat used first rises, but as time goes on, the amount of heat used each hour falls, peaking around 3 o'clock. Heat utilization is directly influenced by the temperature differential since the governing equation for heat utilization is (Qutilized=mCwaterT) in this equation. Initially, the temperature difference is growing and reaches its maximum at 12 o'clock. Thereafter, the temperature difference continues to decline, which causes the water to use less heat. These variations are all simply represented in Graph 16.



Graph 17 showing variation of input heat with time

According to the formula for heat input (Qinput=IAt), solar irradiation and heat input are directly related to one another. Here, A, the area of the parabola, is a constant while t, the time, and A, the area are both constant, whereas due to changing solar irradiation, (I), is every instant at 12pm it is highest and it is lowest at 3pm. The graph 17 shows that the highest heat input is 22279.19 kJ and the minimum heat input is 13754.42 kJ.



Graph4.18 showing variation of efficiency with time

As the proportion of usable heat to total heat input. The ratio first increases and reaches its highest at 1 pm. Thereafter, efficiency continues to decline as the amount of heat used decreases after 1 pm and reaches its minimum at 3 pm. This fluctuation is clearly shown by the distinctive curve in graph 18.

F. Using Silver Foil With insulation

The readings of various temperatures that are taken while conducting tests at intervals of 30 minutes are shown in Table 11. The first reading was conducted at 11:00 AM, and the last reading was conducted at 3 PM. The study of heat transmission will benefit from the wide range of temperature values that exist. The highest temperatures that were obtained were 49.6, 87.7°C, 69.3°C, and 89.6°C for the ambient temperature (Ta), the pot's outlet temperature (To), the disk's outer surface (Tdiskouter), and the pot's core (Tcenter).

Table 11: Temperature reading Using Silver Foil With insulation

Time	Ti(°C)	To(°C)	Ta(°C)	Tdiskouter(°C)	Tcenter(°C)
11:00	56.3	75.9	42.4	52.8	65.2
11:30	84.5	75.1	41.9	49.7	67.4
12:00	88.4	87.7	43.9	48.6	89.6
12:30	72.7	56.8	44.4	26.4	77.7
13:00	69.5	59.9	46.5	69.7	61.8
13:30	60.7	52.7	49.6	61.3	58.9
14:00	54.8	48.4	47.8	47.7	53.7
14:30	49.7	46.3	45.7	45.5	50.5
15:00	47.5	44.5	44	43.7	44.3

The specifics of all the parameters, including the heat input to the water, heat output, heat losses, and efficiency in % for each hour of the time interval, are listed in Table 12. The following parameter's fluctuation over time is also shown in this table. Maximum heat intake, output, heat losses, and efficiency are, in order, 22342.97 kJ, 74.511 kJ, 22268.45 kJ, and 0.3334%.

Table 12: Parameters calculated Using Silver Foil With insulation

Time(Hrs.)	Qinput(KJ)	Qoutput(KJ)	Qloss(KJ)	η (%)
11:00	19961.19	23.27	19937.92	0.1165
12:00	22342.97	74.511	22268.45	0.3334
13:00	20493.42	38.511	20454.90	0.1879
14:00	18112.41	11.720	18100.69	0.0647
15:00	13796.94	5.8604	13791.07	0.0424

Information on the depth of solar radiation at various times is provided in Table 13. It includes the reading at hourly intervals. The chart shows that the intensity ranges from 640 to 1042 w/m2.

Table 13: Solar Radiation reading Using Silver Foil With insulation

Time(hrs)	Solar Radiation(W/m2)
11:00	939
12:00	1051
13:00	964
14:00	852
15:00	649

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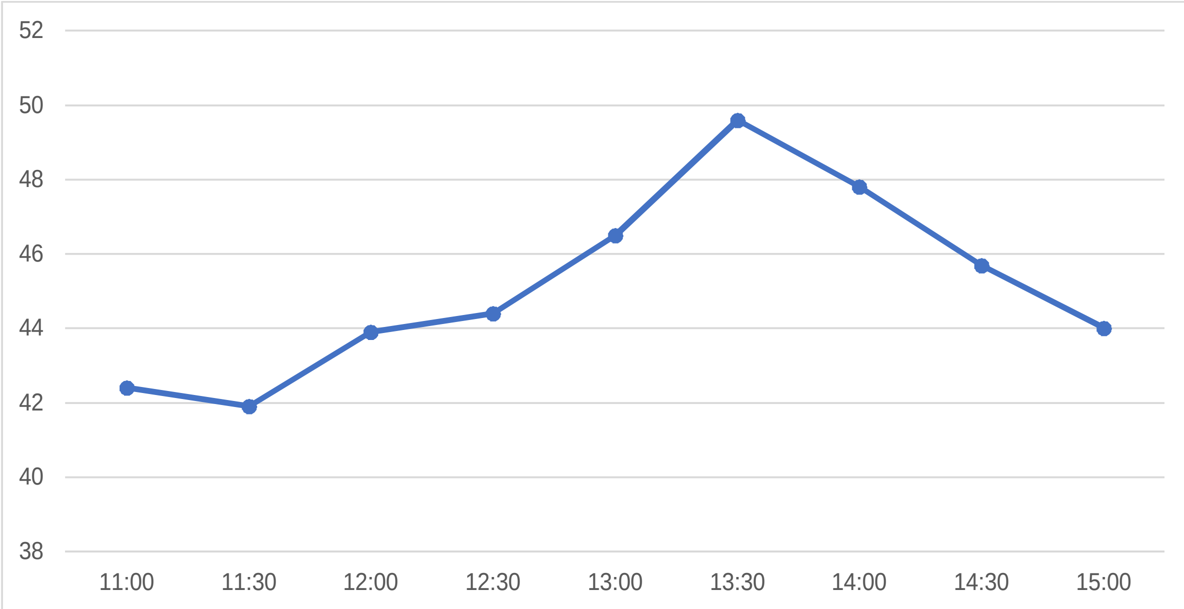
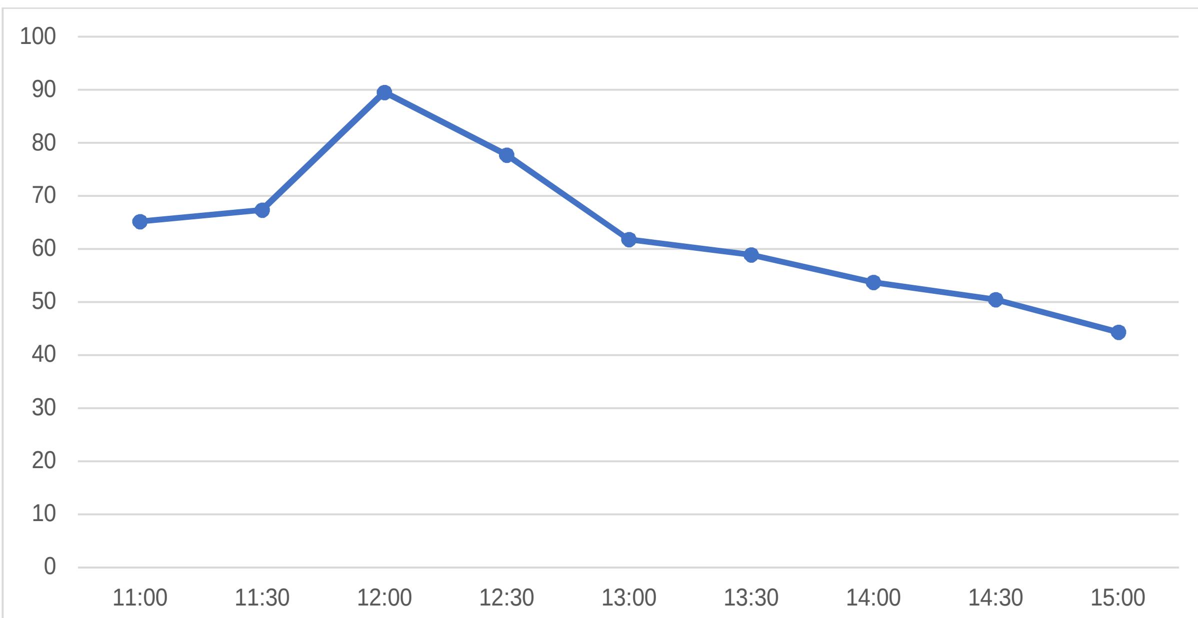


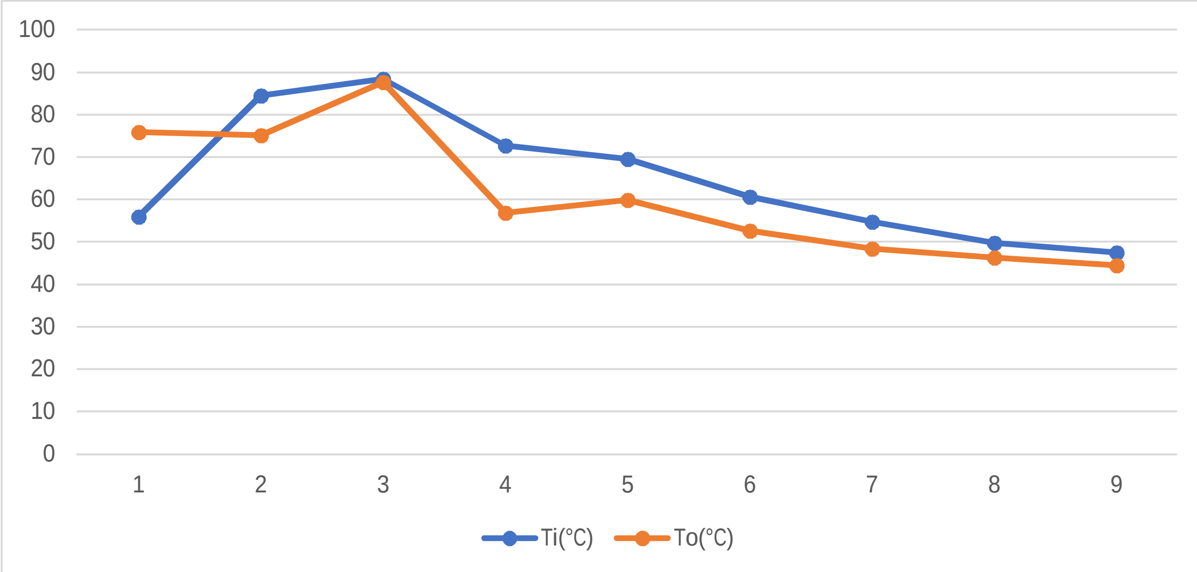
Graph 19 showing ambient temperature variation with time

The amount of heat that water uses is directly correlated with the ambient temperature. As the ambient temperature rises, more heat is used by the water in a given amount of time because the ambient temperature and the inner temperature of the water are different. The characteristic curve shown in graph 19 makes it simple to understand how the ambient temperature changes over time.



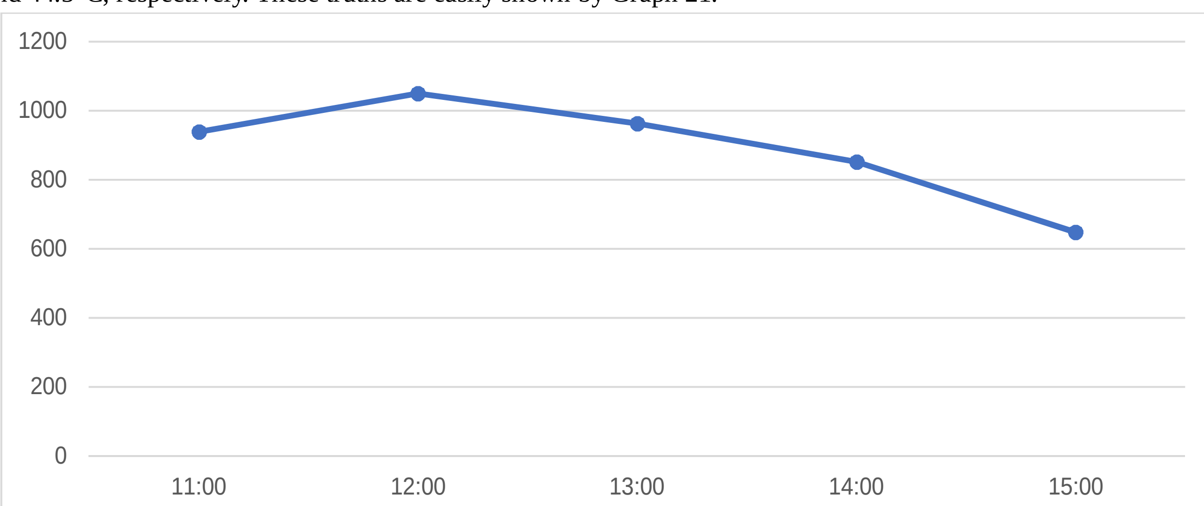
Graph 20 showing variation center temperature of the parabola with time Center temperature (Tc)is

The dish outer is more open to the atmosphere than the center of the parabola, therefore the dish outer temperature is always higher than the dish outer temperature (To). This is because convective heat transfer is less efficient at the center than it is at the dish outer temperature. Convection heat transmission depends on the medium; in this case, air serves as the medium. As a result, the temperature in the middle of the dish is higher than it is on the dish's exterior. Graph 20 clearly illustrates this data, showing that the center's greatest temperature is 89.6°C and its lowest temperature is 44.3°C.



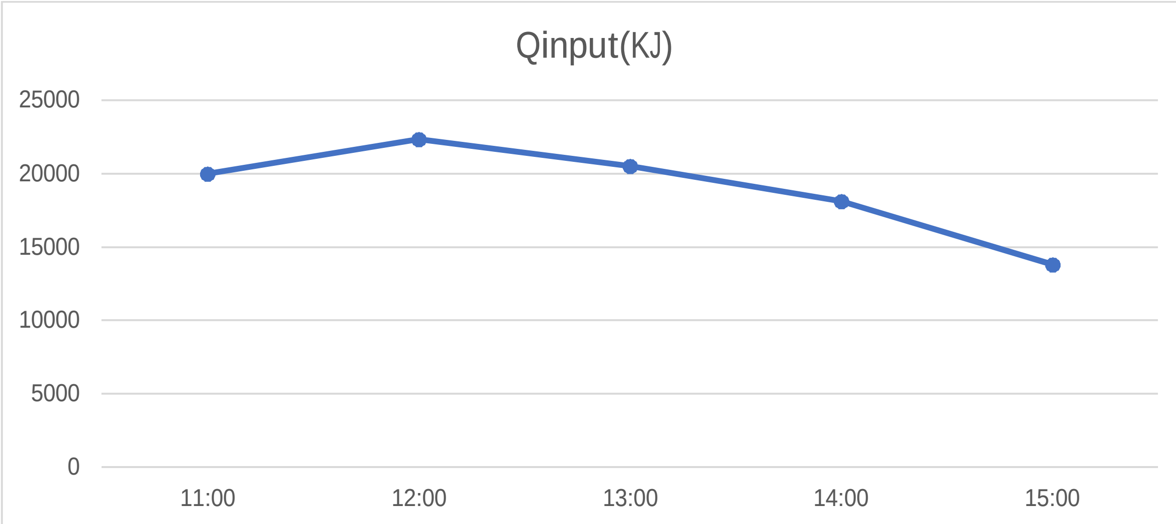
Graph 21 showing inlet and outlet temperature of cooking pot

When there is no electricity, the water is drawn from a water cooler, so the inlet temperature of the water is lower than the outlet temperature of the dish. However, because the dish's outlet is directly exposed to the atmosphere and is situated at the parabola's center, where maximum heat is generated, the inlet temperature of the water rises more over time than the outlet temperature does. When there is no electricity, the water is drawn from a water cooler, so the inlet temperature of the water is lower than the outlet temperature of the dish. However, because the dish's outlet is directly exposed to the atmosphere and is situated at the parabola's center, where maximum heat is generated, the inlet temperature of the water rises more over time than the outlet temperature does. . transmission because the outside is exposed to the environment, which acts as a medium for heat losses by convection. Because of this, the graph shows that the entrance temperature at the dish is rising more quickly than the output temperature at every time. The highest temperature at the inlet is 88.4°C, the dish's opening is 87.7°C, and the minimum temperatures at the inlet and outlet are 47.5°C and 44.5°C, respectively. These truths are easily shown by Graph 21.



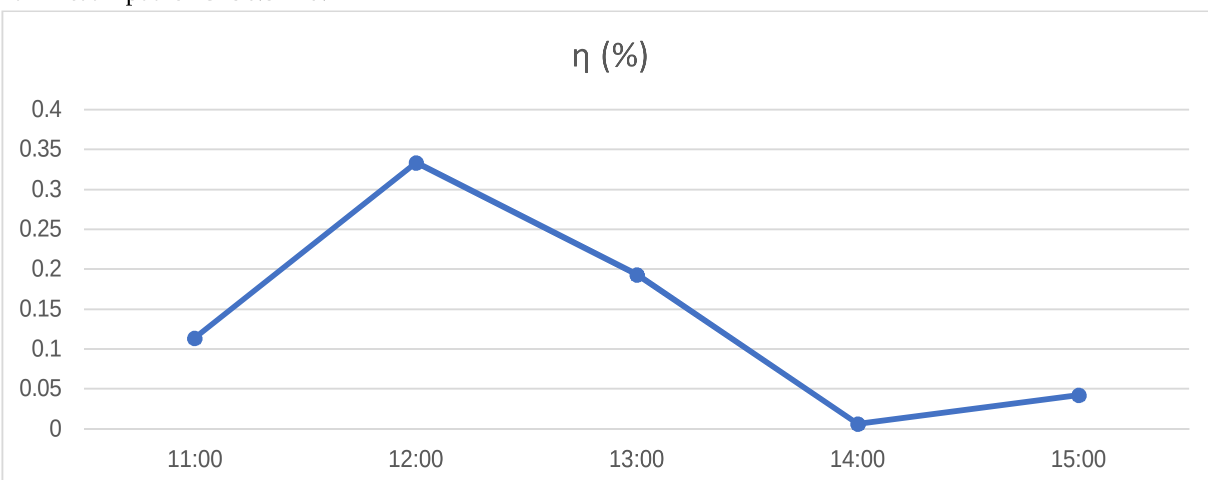
Graph 22 showing variation of heat utilized by water with time

Heat utilized means how much heat is utilized by water every hour initially the heat utilized is increasing but as the time spends the heat utilized per hour decreases and it is lowest at 3pm Because the governing equation for heat utilized is ($Q_{utilized}=mC_{water}\Delta T$) here in this equation Mass is constant, CWater is constant so heat utilized is directly dependent on the temperature difference. Initially the temperature difference is increasing and it is maximum at 12pm and after that the temperature difference is goes on decreasing so the heat utilized by water is decreases, these all variation can be easily depicted from Graph 22.



Graph 23 showing variation of input heat with time

According to the formula for heat input (Qinput=IAt), solar irradiation and heat input are directly related to one another. Here, A, the area of the parabola, is a constant while t, the time, and A, the area are both constant, whereas due to changing solar irradiation, (I), is every instant at 12pm it is highest and it is lowest at 3pm. Graph 23 clearly shows that the highest heat input is 22342.97 kJ and the minimum heat input is 13796.91 kJ.



Graph 24 showing variation of efficiency with time

Efficiency is defined as the ratio of the useful heat to the total heat input. Initially the ratio is increasing and it is maximum at 1pm after that efficiency goes on decreasing as the heat utilized is decreasing after 1pm and it is minimum at 3pm, this variation can be easily depicted from characteristic curve shown in graph 24

II. CONCLUSION

A. Using Aluminum Foil Without insulation and Using Aluminum Foil With insulation Time

The experiment involved comparing the use of aluminum foil with insulation, aluminum foil without insulation, and no aluminum foil to assess their impact on temperature variation and heat transfer. The conclusions derived from the provided data are as follows:

1) *Effect of Aluminum Foil with Insulation:* When using aluminum foil with insulation, the temperatures at the disk's outer surface (Tdiskouter) and center (Tcenter) were higher compared to the case without insulation. This indicates that the insulation, combined with aluminum foil, effectively trapped and distributed heat, resulting in higher temperatures within the disk.
2) *Temperature Attenuation:* Over time, the difference between the temperatures at the disk's outer surface and center decreased, indicating that the insulation and aluminum foil aided in distributing the heat more evenly across the disk.

3) *Heat Loss and Efficiency:* Despite the use of aluminum foil and insulation, there was still a significant amount of heat loss (Qloss) during the experiment. The efficiency (η) values obtained ranged from 0.0056% to 0.3466%, indicating that improvements are required to enhance the overall system's efficiency and reduce heat loss further.
4) *Comparison with Aluminum Foil without Insulation:* When comparing the results of using aluminum foil with and without insulation, it is evident that the presence of insulation improved the heat retention and distribution within the disk. The temperatures at both the outer surface and center of the disk were consistently higher when insulation was used.
5) *Effect of Solar Radiation:* The solar radiation data showed that the highest solar radiation intensity was observed around 12:00, correlating with the peak temperatures of the disk. This indicates that solar radiation had a significant influence on heating the disk and highlights its importance in the overall energy transfer process.
6) *Practical Considerations:* The use of aluminum foil with insulation, coupled with solar radiation, shows potential for harnessing and utilizing heat energy effectively. However, further improvements are necessary to optimize the system's efficiency, reduce heat loss, and enhance overall performance.

B. Using silver Foil Without insulation and Using silica Foil With insulation Time

The experiment compared the use of silver foil with and without insulation to assess their impact on temperature variation and heat transfer. The conclusions derived from the provided data are as follows:

1) *Effect of Silver Foil with Insulation:* The use of silica foil with insulation resulted in higher temperatures at both the outer surface (Tdiskouter) and center (Tcenter) of the disk compared to the case without insulation. This indicates that the insulation, in combination with silica foil, effectively trapped and distributed heat, leading to higher temperatures within the disk.
2) *Temperature Attenuation:* As the experiment progressed, the difference between the temperatures at the outer surface and centre of the disk decreased, suggesting that the insulation and silica foil aided in distributing heat more evenly across the disk.
3) *Heat Loss and Efficiency:* Despite the use of silica foil and insulation, there was still a significant amount of heat loss (Q loss) during the experiment. The efficiency (η) values ranged from 0.00647% to 0.3441%, indicating room for improvement to reduce heat loss and enhance the overall system's efficiency.
4) *Comparison with Silica Foil without Insulation:* When comparing the results of using silica foil with and without insulation, it is evident that the presence of insulation significantly improved heat retention and distribution within the disk. The temperatures at both the outer surface and center of the disk were consistently higher when insulation was used.
5) *Effect of Solar Radiation:* The solar radiation data showed that the highest solar radiation intensity occurred around 12:00, aligning with the peak temperatures of the disk. This indicates the crucial role of solar radiation in heating the disk and underscores the importance of harnessing solar energy for heat transfer.
6) *Practical Considerations:* The use of silica foil with insulation, in conjunction with solar radiation, demonstrates potential for effectively capturing and utilizing heat energy. However, further improvements are necessary to optimize the system's efficiency, reduce heat loss, and enhance its overall performance.

III. SCOPE FOR FUTURE WORK

A. Using Aluminum Foil Without insulation and Using Aluminum Foil With insulation Time

Future experiments could focus on refining the insulation and heat retention materials, as well as exploring alternative methods to improve heat transfer efficiency. Additionally, studying the impact of external factors like wind or ambient temperature could provide valuable insights into the system's performance under real-world conditions and aid in its practical applications.

B. Using Silver Foil Without Insulation and Using silver Foil With Insulation Time

Future experiments could focus on refining the insulation materials, exploring alternative methods to improve heat transfer efficiency, and investigating the impact of external factors such as wind or ambient temperature on the system's performance. Additionally, assessing the practical applications of the system in real-world conditions would provide valuable insights for potential advancements.

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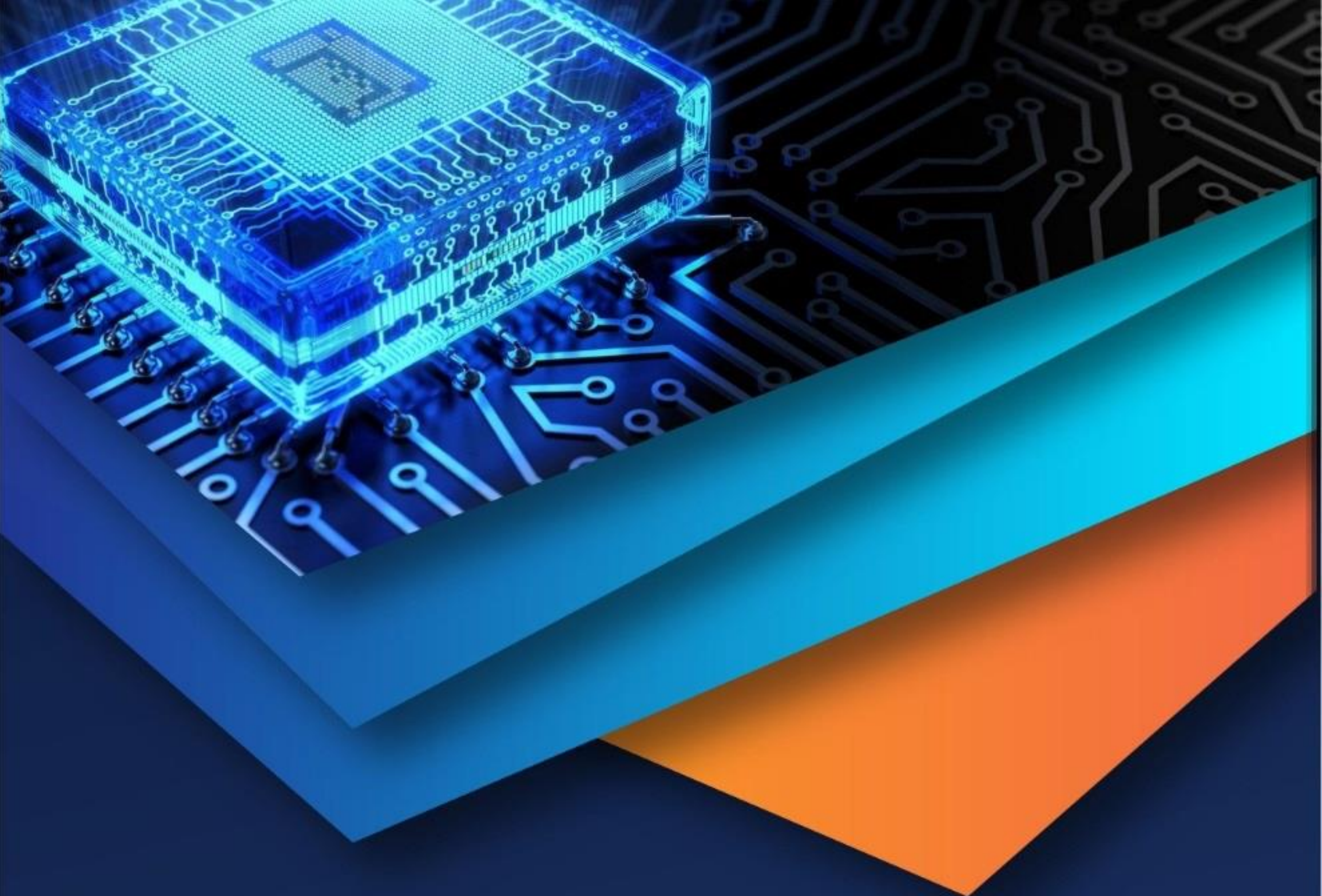

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