IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 7, July 2021

DOI: 10.17148/IARJSET.2021.8780

Fabrication and Analysis of Parabolic Concentrated Solar Water Heater with Solar Tracking System

Gaurav Pandey[1], Amit Kumar Singh[2], Shivanshu Kumar[3], Er.Vivek Agnihotri[4], Er.Mayank Kumar[5]

Mechanical Engineering Department, Shri Ramswaroop Memorial College of Engineering and Management, Lucknow, Uttar Pradesh, India[1,2,3]

Faculty member in mechanical department at SRMCEM, Lucknow Uttar Pradesh, India[4,5]

Abstract: The purpose of this project is to fabricates and conduct experimental or analysis work on parabolic concentrated solar water heater with solar tracking system that can heat the water from nearly any sources, a system that is relatively cheap, portable, and depends only on renewable solar energy. The motivation for this project is there are many applications of solar thermal energy in different temperature range such as high temperature ranges (above 448K) medium temperature ranges (373K to 448K) and low temperature ranges (below 273K) and one more motivation is their application in agricultural and industrial process heat. Our project goal is to promotes the more and more use of renewable energy resources and to fabrication and analysis or experimental work on parabolic concentrated solar water heater with solar tracking system (manual tracking). Another objective of the project is to understand various components, various relation and equation related to making of solar parabolic collector, and also various relations related to tracking system such as plot sun path diagram, understand solar radiation geometry and also understand the estimation of average solar radiation and analysis of parabolic concentrating collectors. To interpret the results from tabulated values taken from observation. The project entitled Fabrication and analysis of parabolic concentrated solar water heater with solar tracking system consisting the two main works which are as follows: -1 - Fabrication works 2 - Analysis or experimental data calculation works. Fabrications works contains the different fabricated works such as making of parabolic shaped rib skeletons which provide supports to the reflecting surface (such as steel reflecting sheet and chromium reflecting sheets), making of parabolic trough collector, receiver tubes fitting, and making of balances system to provide balances to the system. The analysis or experiment work is conducted with water as a working fluid and reading taken for different flow rates and reflecting surfaces. The calculated values will be tabulated, graphs will be plot and hence efficiency and their performances will be determined for the experimental setups.

Keywords: Parabolic concentrating collector, sun path diagram, solar geometry, Manual tracking system, Parabolic rib skeletons.

INTRODUCTION

Concentrating or Focussing collector is a device to collects solar energy with high intensity of solar radiation on the energy absorbing surfaces. Such collectors generally use optical system in the form of reflectors or refractors. A focusing collector is a special form of flat plate collector modified by introducing a reflecting (or refracting) surface (concentrators) between solar radiations and the absorber. These types of collectors can have radiation increases from low values of 1.5 to 2 to high values of the order of 10,000. In these collectors' radiation failing on a relatively large area is focused on to a receiver (or absorber) of considerably smaller area. As a results of the energy concentration, fluids can be heated to temperatures 500^{o}C or more. An importance difference between collectors of the non-focusing and focusing types in that the latter concentrate only direct radiation coming from a specific direction, since diffuse radiation arrives from all directions, only a very small proportion is the from the direction for which focusing occurs. The optical system directs the solar radiation on to an absorber of smaller area which is usually surrounded by a transparent cover because of the optical system, certain losses (in addition to those which occur while the radiation is transmitted through the cover) are introduced. These include reflection and absorption.

IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

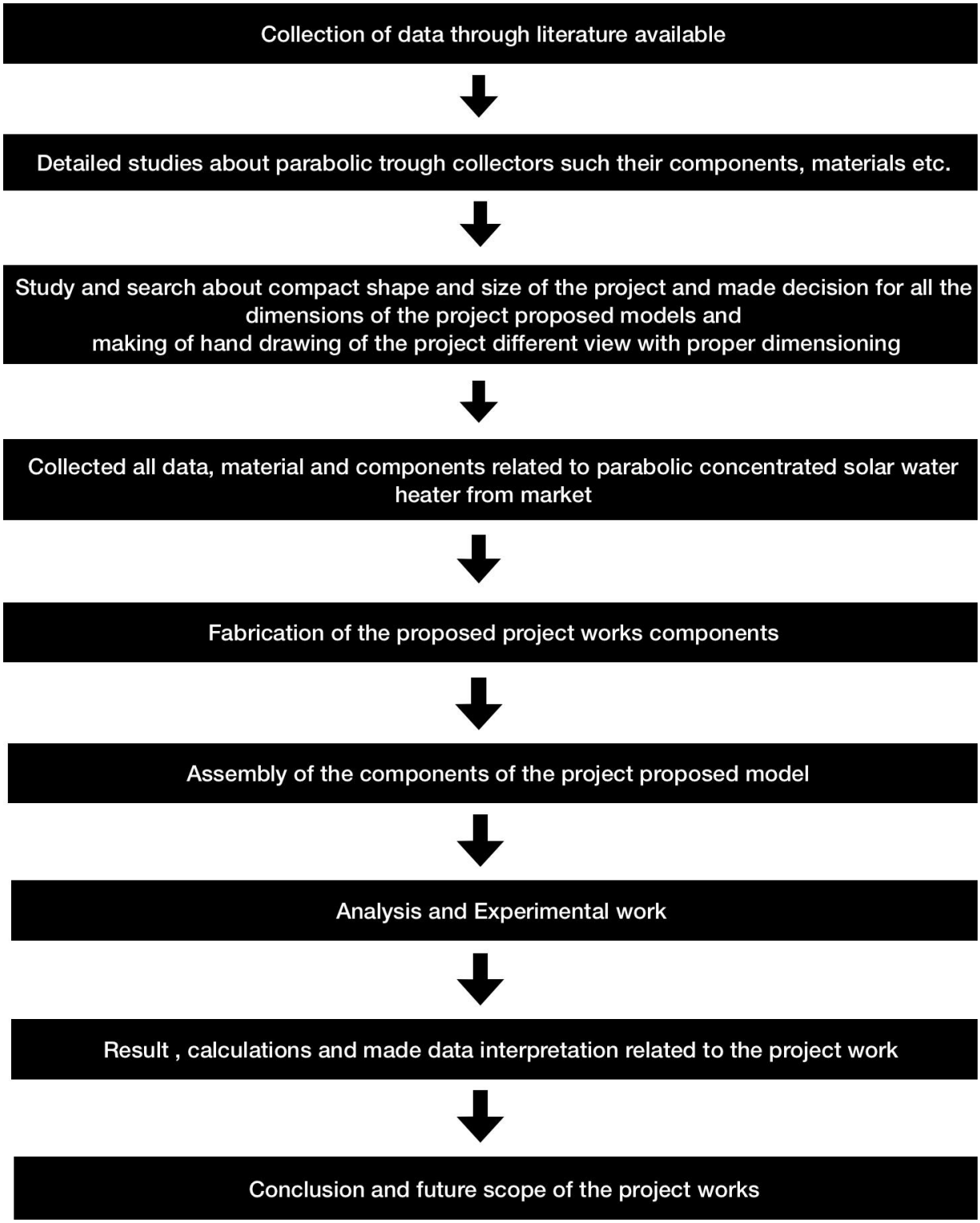
International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 7, July 2021

DOI: 10.17148/IARJSET.2021.8780

METHODOLOGY

Steps involved in Methodology of the proposed project works can be explained through given flow charts:



IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 7, July 2021

DOI: 10.17148/IARJSET.2021.8780

III FABRICATIONS WORKS

Fabrication of parabolic trough concentrated solar water heater is an important part of the project making in which we fabricate the different parts or components of the proposed projects works which are as:

1. Fabrication of parabolic trough collector.
2. Fabrication of the balance system to provides the support to whole structure or frame of the projects model.
3. Fabrication of receiver tube.
4. Arrangement for water inlet and water outlet valve with the receiver.
5. Fabrication of rib skeleton which support the parabolic trough.
6. Fabrication of manual tracking system
7. Fabrication of elevated and horizontal frame structure for the PTC

- **Two methods are used in Drawing of parabolic shape:**

Method 1: - simple drawing methods:

Create a Parabola from Lines and a Right-Angle

Step 1: - Draw a right angle and mark two lines of equal length at equal intervals. It should look like you are making a coordinate plane to graph an equation.

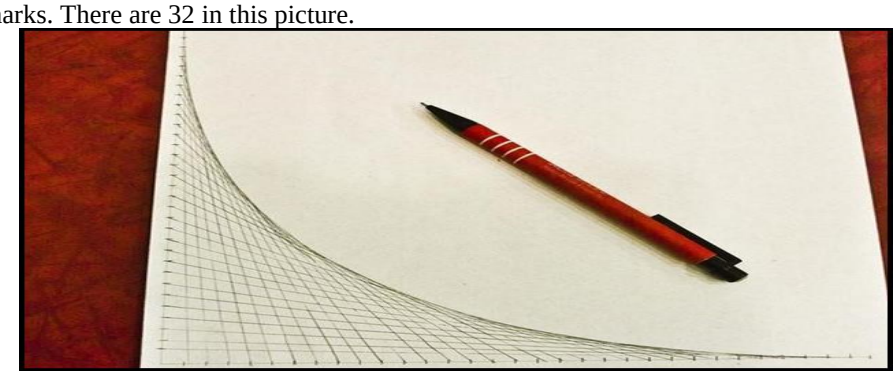
Step 2: - Draw a line from the farthest mark from the right angle on one line, to the closest mark to the right angle on the other line.

Step 3: - Now connect the 2nd farthest mark to the 2nd closest mark.

Step 4: - Continue connecting lines between the points as you step down one line and step up the other.

Step 5: - Here we have rotated the image 45 degrees so the parabola is oriented in the conventional way.

Step 6: - The curve was pretty smooth looking with eight marks on each line, but can be made smoother by adding more marks. There are 32 in this picture.



Methods 2: - analytical methods: -

Equation : - Parabolice Shape. $y = x^2/4f$

$y = x^2 \div (4 \times 320)$

$y = 0.0007813x^2$

Putting the different value of x in above equation we will get a parabola

The value of x, taken from Fabricated experiment:

x	**$.0007813x^2$**
-600	281.268
-550	236.34325
-500	195.325
-450	158.21325
-400	125.008
-350	95.70925

IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

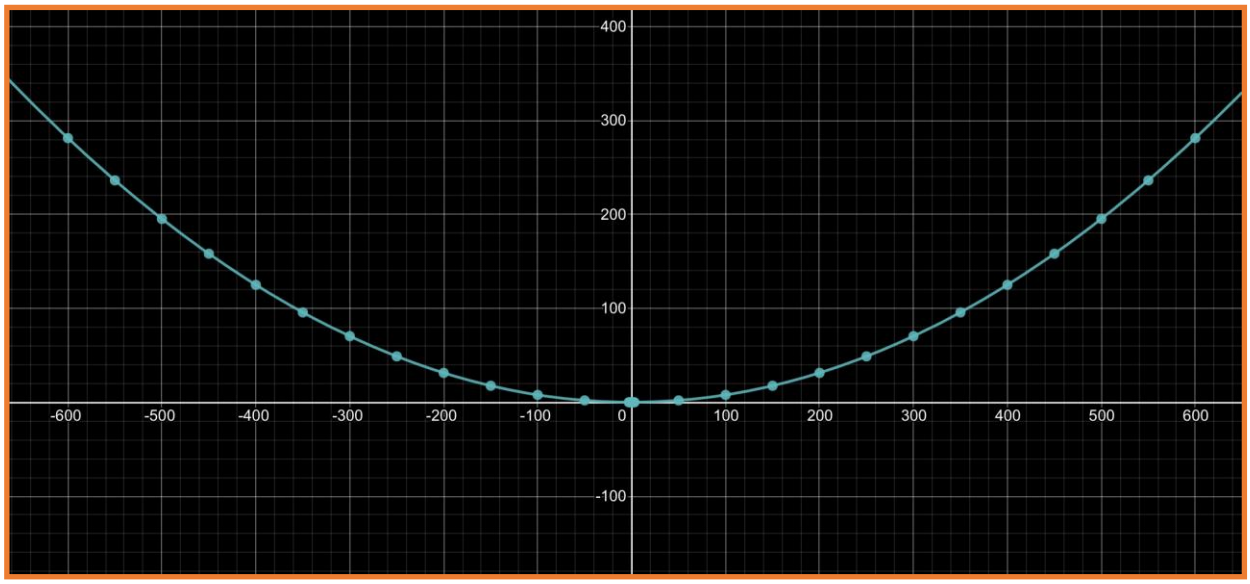
Vol. 8, Issue 7, July 2021

DOI: 10.17148/IARJSET.2021.8780

-300	70.317
-250	48.83125
-200	31.252
-150	17.57925
-100	7.813
-3	0.0070317
-2	0.0031252
-1	0.0007813
0	0
1	1
2	0.0031252
3	0.0070317
50	1.95325
100	7.813
150	17.57925
200	31.252
250	48.83125

With reference of above value, draw the graph:

Graphical curve of parabola



IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 7, July 2021

DOI: 10.17148/IARJSET.2021.8780

Fabrication works and assembly works: -

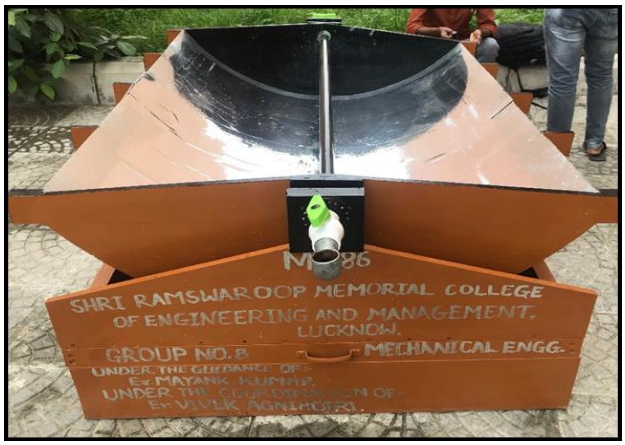


Fig.. Tracking mechanism for frame fitted with nut and bolts

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue x, Month 2021

DOI: 10.17148/IARJSET.2021.8

Graph-Plotted:

The various parameters like heat absorbed by collector, heat absorbed by concentrator, heat gained by water, thermal efficiency for both the absorbers are calculated for the different setups.

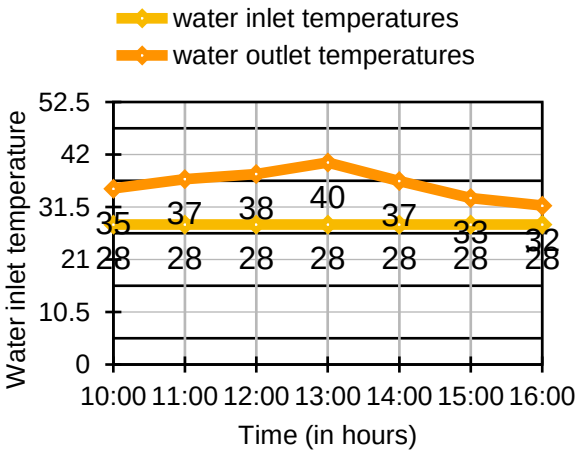
The following graphs will be plotted:

1. Time v/s Intensity
2. Time v/s Efficiency
3. Absorber plate efficiency v/s Time

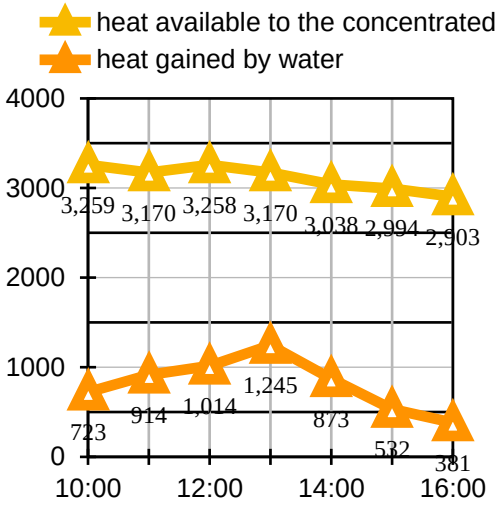
Day 1 dated on 3 July 2021

Observation Table 1

Time	Flow rates (kg/hr)	Solar intensity	Water inlet temperature (degree Celsius)	Water outlet temperaturee (Degree Celsius)	Absorber/ receiver plate temperaturee	Collector plate Temperaturere (degree Celsius)	Heat available to the concentrateor (kJ/hr)	Heat gained by water kJ/ hr	Efficiency (%)
10:00	24kg/hr	3242.77	28	35.2	56.6	70	3258.5112	722.6496	22.17%
11:00	24kg/hr	3252.43	28	37.1	57.4	74	3170.4594	913.3488	28.80%
12:00	24kg/hr	3342.25	28	38.1	60.3	76.2	3258.0156	1013.7168	31.11%
13:00	24kg/hr	3252.43	28	40.4	65.8	78.5	3170.4594	1244.5632	39.25%
14:00	24kg/hr	3116.91	28	36.7	61.2	77	3038.3548	873.2016	29.73%
15:00	24kg/hr	3071.74	28	33.3	58.3	73.6	2994.3233	531.9504	17.76%
16:00	24kg/hr	2978.08	28	31.8	55	69.6	2903.0238	381.3984	13.13%



Graph 7.1 plotted between water inlet temperature and water outlet temperature vs Time



Graph 7.2 heat available to the concentrator and heat gained by water vs time

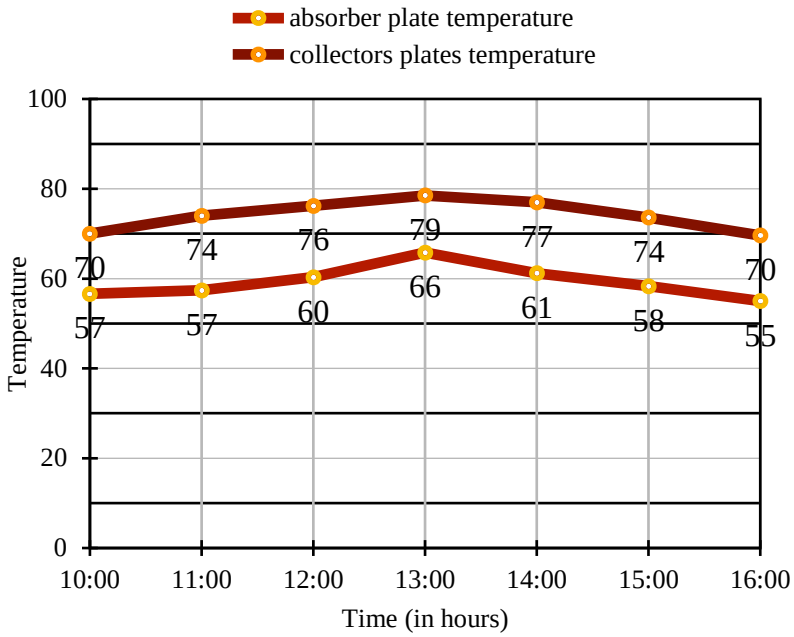
IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue x, Month 2021

DOI: 10.17148/IARJSET.2021.8



Graph 7.3 . Plotted between absorber plate temperature and collector plate temperature vs Time

Observation Table 2

Time	Flow rates (kg/hr)	Solar intensity (kW/hr-m^2)	Water inlet temperature (degree Celsius)	Water outlet temperature (Degree Celsius)	Absorber/ receiver plate temperature	Collector plate Temperature (degree Celsius)	Heat available to the concentrator (kJ/hr)	Heat gained by water kJ/hr	Efficiency (%)
10:00	21	3297.60	32	45	55	64	3214.49	1141.686	35.51%
11:00	21	3342.77	32	46	56	67	3161.04	1229.508	38.89%
12:00	21	3433.12	33	48.7	59	68.8	3346.59	1378.8054	41.20%
13:00	21	3297.6	35	51.2	60	70	3214.49	1422.7164	44.25%
14:00	21	3207.25	32	45.8	57	66	3126.41	1211.9436	38.76%
15:00	21	3116.9	31	42.1	53	63	3038.34	974.8242	32.55%
16:00	21	3071.74	30	40	51	62	2994.32	878.22	29.32%

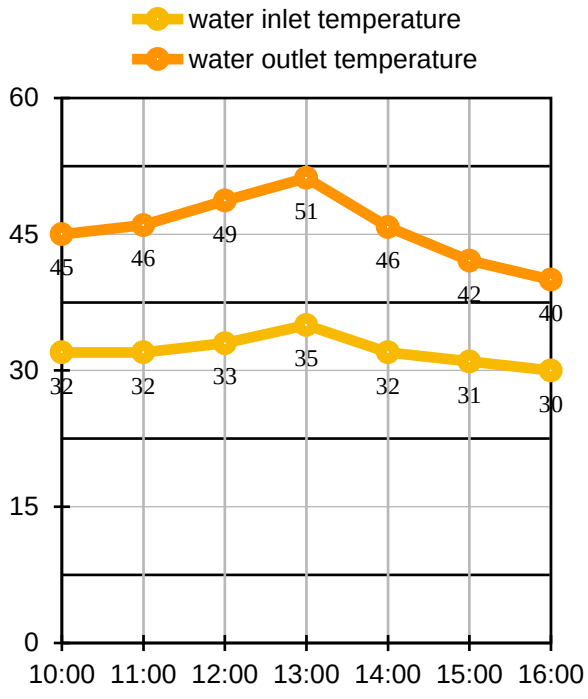
IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

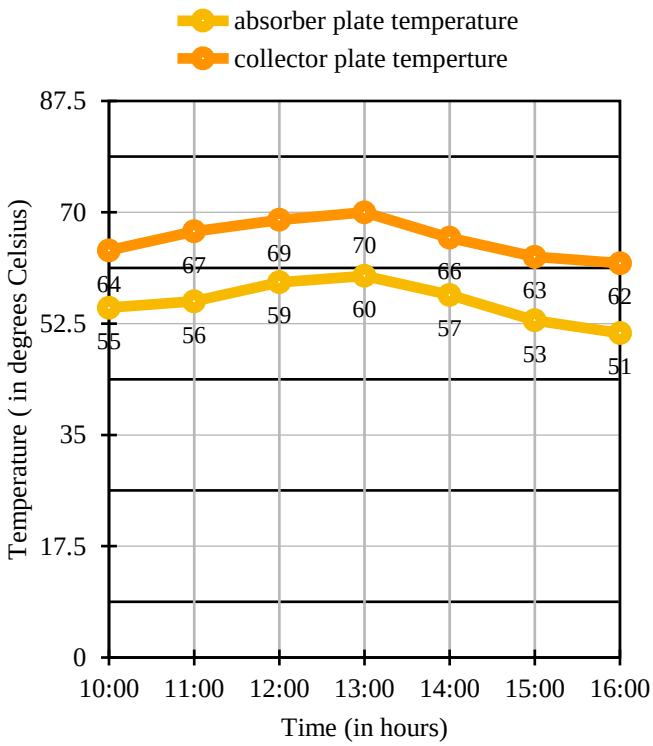
International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue x, Month 2021

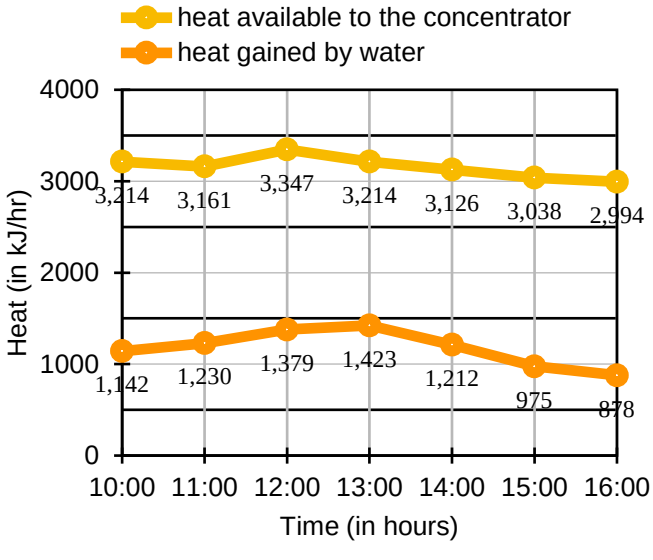
DOI: 10.17148/IARJSET.2021.8



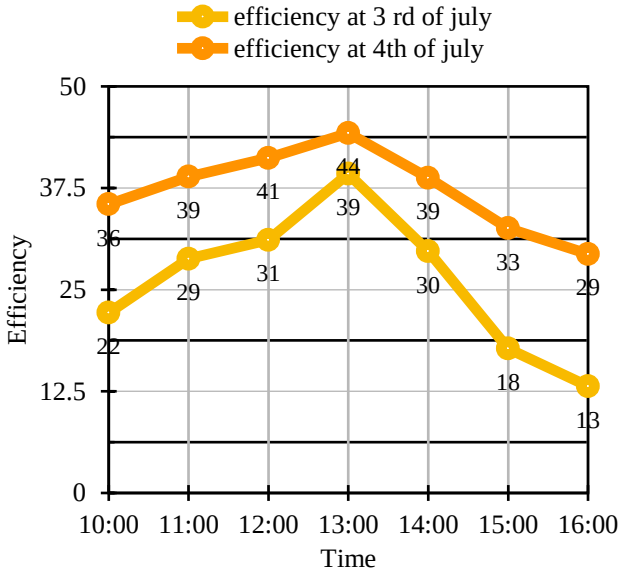
Graph plotted between water inlet temperature ,water outlet temperature vs Time



Graph different plates temperature vs Time



Graph heat vs time



Graph efficiency vs Time

IV. OBSERVATION

From the observation, we mainly conclude with the following results:

1. Heat available at the concentrator is greater than the heat gained by the water in both days of experiments works.
2. Keeping the water inlet temperature constant at day1 then we measure the water outlet temperature and on

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue x, Month 2021

DOI: 10.17148/IARJSET.2021.8

day 2 water inlet temperature may vary from 2 or 1 reading and then again measure water outlet temperature and we found that In day 1 there is less increase in temperature of water outlet temperature as compared to Day 2.

3. At comparing their efficiencies of both days, we conclude that the efficiency is much greater when water is heated at high temperature and we also conclude that at different flow the efficiency may increase or decrease.
4. At day 1 the flow rate of water is more we get less or low efficiencies.
5. At day 2 the flow rate of water is less we get high or more efficiencies.

V. CONCLUSION

We mainly conclude through the findings of our project how different flow rates play a major role in the working of a solar parabolic trough collector. As the efficiency shown by a parabolic trough collector is more than that of a flat plate collector, there is a scope for wider use as to increase the outcome of such. But there is a short disadvantage of parabolic trough collector as there needs to be a tracking device so as to check the functioning of the parabolic trough type collector. We further see that nature of reflecting surface also plays a major role in the output of the working of a solar collector.

In this project we developed a solar water heating system which gives efficiency which is greater than the system with natural circulation. It shows that time required for obtaining maximum temperature is less for forced circulation as compare to natural circulation solar water heating system. The need of compact sized solar water heating system is fulfilled by our system (Parabolic trough collector system). Our system costs less than conventional flat plate collector system available in market. In future if the system has to develop further, we can replace our steel surface of collector by glass surface to achieve temperature of 125° C and aluminium surface to achieve 103°C. By using flow control valves different flow rates can be achieved for getting better heating results.

From the observation, we mainly conclude with the following results:

Given the intensity be constant, the efficiency of a parabolic trough collector changes inversely with that of the flow rates. We see an increase of 50-70% in efficiency when the flow rates is decreased by 33%

Mirror reflecting surface gives better efficiency compared to that of aluminium reflecting surface.

We mainly see the change in the solar intensity from the morning to the evening as the intensity rises in the morning hours and reaches its peak value between 12:30 PM and 1:30 PM then again decreases in the evening hours.

REFERENCES

1. Grenhout, N.K., Behnia, M. and Morrison, G.L. (2001), Experimental measurement of heat loss in an advanced solar collector, Experimental Thermal and Fluid Science, 26, 131-137
2. Kalogirou, S.A. (1996), Parabolic Trough Collector System for Low Temperature Steam Generation: Design and Performance Characteristics, Applied Energy, 55, Paper 1, 98-132.
3. Kalogirou, S.A., Lyod, S., Ward, J. and Elefteriou, P. (1994), Design and Performance Characteristics of A Parabolic Trough Solar Collector System, Applied Energy, 341-354.
4. Larches, M., Rommel, M., Bohlean, A., Frank, E. and Minder, S. (2013), Characterisation of A Parabolic Trough Collector for Process Heat Applications, ISES Solar World Congress Energy Procedia, 57, 2804-2811.
5. Mace`do-Valenciaa, J., Ramirez-Availaa, J., Acostaa, J., Jaramillob, O.A. and Aguilara, J.O. (2013), Design, Construction and Evaluationof Parabolic Trough Collector as Demonstrative, ISES Solar World Congress Energy Procedia, 57, 989-998.
6. Montesa, I.E.P, Beniteza, A.M., Chaveza, O.M. and Herrerab, A.E.L. (2013) Design and Construction of A Parabolic Trough Solar Collector For Process Heat Production, ISES Solar World Congress, Energy Procedia, 57, 2149-2158.Rai, G.N. (2007), Solar Energy Utilization, Khanna Publishers-2, 120-168.
7. Sandeep, H.M. and Arunachal, U.C. (2017) Solar Parabolic Through Collector: A Review on Heat Transfer Augmentation Techniques, Renewable and Sustainable Energy Reviews, 69, 1218-1231.
8. Sukhatme, S.P. and Nayak, J.K. (2011), Solar Energy, TMH Publications, 240-253.
9. Santosh Kumar Singh Arvind Kumar Singh and Santosh Kumar Yadav, International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 10, December- 2012 ISSN: 2278-0181, Design and Fabrication of Parabolic Trough Solar Water Heater for Hot Water Generation.
10. Patil Digvijay Tanaji, Patil Ashish Anand, International Journal of Advance Research in Science and Engineering, Vol. 2, Issue No. 12 December 16 Parabolic Trough Collector Based Solar Water Heating System Using Forced Circulation.
11. Samia Tabassum, Laila Sharmin, Muhammad Shahrir Bhashar, Mashudur Rahman, Sumon Chandra Debnath, Mahfuza Khanam, Journal of Architectural Environment and Structural Engineering Research, Design and Analysis of Parabolic Through Solar Water Heating System.