

DETAILED STUDY AND ANALYSIS OF FLAT PLATE TYPE SOLAR COLLECTOR USING REFLECTOR OF HEXAGONAL TYPE FOR HEATING WATER

HimanshuMandhata¹, Jitendra Raghuvanshi²

M.techScholar , Dept. Of Mechanical Engineering , LNCT Bhopal (M.P.)¹

Professor, Dept.Of Mechanical Engineering, LNCT Bhopal(M.P.)²

Abstract

Solar collectors have been modified over many years to serve the thermal needs of the this time and for time to come. Many designs and innovations have paved their way to invent new ways to succeed in gaining more solar energy in the form of useful heat .Solar thermal collector is one of the major component in any solar thermal application. It soak up the incoming solar radiation (solar energy), and converts it to heat energy, and transfers the heat to a working fluid. Commonly used working fluid are air and water sometimes oil .The Flat Plate solar collector integrated with reflector was used in this experiment for heating water .To increase the reflectivity of this system and to concentrate both direct and diffuse radiation towards collector Hexagonal Reflector was used. Further to get maximum amount of an incident solar radiation the reflector was permitted to changes its angle with suns position.It can be seen in the reading significant improvement of the final temperature of collector and efficiency was obtained using hexagonal type reflector. Therefore flat plate solar collector integrated with hexagonal reflector delivers better thermal performance then the systems present today.

Keywords

Flate Plate Solar Collector, Diffusion, Reflectivity, Emmisivity, Solar Water Heater, Heat Transfer.

1.Introduction

To foster a destitution free world, energy security for all areas should be guaranteed. As the traditional wellsprings of energy are restricted and can't meet the expanding need of the average folks, wide scattering of environmental friendly power innovations is the lone way out. The solar radiation can be an elective wellspring of energy.Because of expanding interest for energy and increasing expense of fossil of all sort. (i.e., gas or oil) Solar power is viewed as the most encouraging among other environmentally friendly power sources, because of its tidiness and wealth in numerous pieces of the world . India is invested with immense sunlight energy which is coming from the sun with india land region with most parts getting 4000Kwh per sq. M each.

Solar thermal collector is an important component in any solar thermal application. It soak up (absorbs) energy (heat) from striking solar radiations and conduct this heat to a working fluid (water is used in this experiment) flowing through.Solar heating is not a new innovation, but advanced techniques to increase the solar absorptivity and output temperature range are increasingly manifesting.

1.1Looking into past of solar energy

The history of using the sun for solar energy goes way back to the Romans and Ancient Greeks as their buildings were constructed such that the rays of the sun can provide them with light and heat for indoor spaces. Earliar it was said that “Houses that look toward south , the sun penetrates entrance in winter.” Romans advanced this particular art by covering the openings to south facing building using glass , to retain the heat in winter.

The history of utilising solar energy dates back to 1861 when Mouchout developed a steam engine powered only by the sun . In 1883 American inventor Charles Fritts constructed the first solar cells made of selenium wafers. In 20th century, the scientists were able to develop large cone-shaped collectors that were able to boil ammonia for refrigeration. In the UN (united states) , John Ericsson designed “parabolic trough collector” a new technology which functions more than a hundred years later on same basic design. Albert Einstein was awarded 1921 Nobel Prize in physics for his research on the photoelectric effect , a phenomenon central to the generation of electricity using solar cells.

1.2Different Types of collector

Numerous numbers of design of solar collector are available but most commonly used are concentrating type or stationery type. The stationery type solar collector are classified as flat plate type solar collector (FPSC) , Evacuated Tube type solar Collectors and Compound Parabolic type solar Collectors. Concentrating type solar collector are classified as Parabolic type ,Cylindrical type Trough Collectors, Parabolic Dish Reflector and Heliostate Field collector.

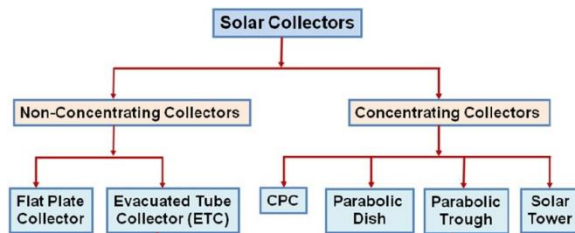


Figure 1 :- Different types of collector

1. Parabolic Dish type solar collector :- In these type the incoming solar radiations which are parallel to axis of dish are transmitted back to its focus point, position of solar rays striking the dish do not matter. Solar radiations from the sun's surface arrives at the Earth's surface almost completely parallel to each other, and the dish is arranged in such way that its axis and position of sun is alligned in parallel which allows all the solar radiations incoming to be pushed back towards the focal point positioned at dish. Losses occur in such collectors are mainly because for imperfections in reflection and the parabolic shape.

2. Parabolic Trough :- These type of reflector works in a way that it can concentrates most of the sunlight on an heat pipe or insulated tube located at the focal point, containing the coolant which transfers heat energy from the solar collectors to the boilers present in power station. Reflector shaped as Parabolic trough are employed in solar power plants.

3. Solar Tower :- A solar tower is a large tower which is surrounded by tracking mirrors called as heliostats. Heliostats rearrange themselves such that focus of solar beam on the receiver is at the top of the tower, accumulated heat energy is conveyed to a power station present below. This design has the ability to reach high temperatures which is suitable for generating electricity using methods like chemical reaction at high temperature such as liquid salt or steam engine.

4. Evacuated Tube Collector :- Evacuated Tube Collector generally consist of a heat pipe present inside a glass tube which is vacuum sealed. As the area of one of the tube is kept small so to increase the heat collection area a number of tubes are connected to one manifold. Both (Conductive and convective) heat energy losses are eliminated as no air is available to transfer heat through conduction or by convection. But still there can be heat loss by radiation as heat energy can also flow in vacuum given sufficient temperature difference, even across a vacuum, it should be noted that magnitude of such kind of loss of energy is very little when compared to

the magnitude of heat energy transmitted to the working fluid in the absorber tube.

5. Flat plate collector :- The flat plate type collectors is an important part of any solar energy collection system constructed to operate at the low temperature range, from ambient to 60 degree or the medium temperature, from ambient to 100 degree. A perfectly designed flat plate type solar collector is able to transfer heat at minimum cost for long duration of time. The flat plate type collectors is basically a type heat exchanger which transfer the radiant heat energy to increase the temperature of working fluid-liquid or air.

Below are the main components of a typical flat plate type solar collector :-

1. Supporting framework for protection of the components and to hold them together.
2. Blackend surface - absorbent surface for the incoming solar radiation.
3. Copper Tubes - working fluid flowing through to conduct the solar heat energy from the collector.
4. Glass cover (glazing cover) - a see-through layer made up of glass that transfers solar radiations to the absorber area, but restricts heat losses caused by radiation and convection.
5. Insulation is applied such that it covers all sides and bottom of the collector to reduce loss of heat energy.

1.3 Working of flat plate solar collector

A flat plate solar collector is constructed in such a way that it consists of a very large heat absorbing plate, usually an oversized of aluminium or copper as they are known for their capacity to conduct heat easily. This sheet is chemically etched or painted completely black to soak maximum amount of solar radiation as possible to get maximum efficiency of system. This blackened sheet act as heat absorbing surface which has some pipes overlapped parallelly over one another made up of mostly copper known as risers. These copper pipes are joint together by soldering, bonding or brazing directly to the blackend absorber plate so that maximum surface of contact can be maintained which results further in maximum heat transfer. Solar radiation heats the absorbing surface which increases its temperature. When temperature of absorber plate is increased further heat energy is transferred through the risers and absorbed by the working fluid mostly water flowing through the pipes is then taken in house hold for domestic uses.

2. Experimental Setup

To complete a test investigation, the flat plate solar collector utilizing hexagonal sort of reflector was used. The frame utilized in this experiment contains hexagonal type reflector having 5 of piece of glass mirror that were attached all around the iron structure. Hexagonal reflector was attached in such a way that it was able to change its position with the situation of the sun. Setup also consist of three glasses of rectangular type and two glasses were three-sided type.

Dimension of rectangular type of glass was 0.6*0.4 meter which was attached at the middle of the casing. Further 2 kind of four-sided and three-sided type of glass/mirror were attached in an iron structure which looks like a Hexagonal sort reflector. Two rectangular glasses of measurements 0.7*0.3 and two three-sided glasses of size 0.4*0.3.



Figure 2 :- Hexagonal type reflector

Reading were taken in different time of the day for 5 days which are plotted in result section. The reflectivity of mirror glass used in the setup was taken to be 0.9 and it was assumed that the incident solar radiation on the collector surface were 70 to 80 % of total solar radiations. The total reflector area of setup is 0.78 meter square. The area of the flat plate collector is 0.145 meter square. It can also be observed that during sunny days the tilt angle of the reflector was kept at 45 degree to get maximum output temperature with respect to its Horizontal axis.

3. Readings

Setup was organised in such a way that the between 11pm to 2 pm only four reflectors were working. Two reactangular shaped reflector glasses were adjusted at 60° and one triangular shaped glass was setup at 75°. Between 2pm to 4pm all five reflectors were working and they were adjusted in such that two rectangular shaped mirror/glasses were fixed at 45° and two triangular mirror adjusted at an angle of 30°.

3.1 Day 1 Readings

TABLE 1 DAY 1 READING

TIME IN HOUR	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM
AMBIENT TEMPERATURE IN DEGREE CELSIUS	30.5	32.4	36.1	37	37.9	39.2
OUTLET TEMPERATURE IN DEGREE CELSIUS	32.1	35.8	39.7	42	43.5	47.7

TIME (HR) VS TEMPERATURE(°C)

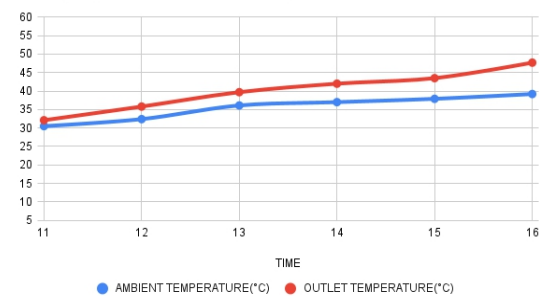


Figure 2 :- Day 1 graph

3.2 Day 2 Readings

TABLE 2 DAY 2 READING

TIME IN HOUR	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM
AMBIENT TEMPERATURE IN DEGREE CELSIUS	32.9	37.1	38.2	39	40.3	39.1
OUTLET TEMPERATURE IN DEGREE CELSIUS	36.1	38.9	43	44.6	49.4	52.4

3.3 Day 3 Readings

TABLE 3 DAY 3 READING

TIME IN HOUR	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM
AMBIENT TEMPERATURE IN DEGREE CELSIUS	36.9	38.2	40	41.2	39.5	39
OUTLET TEMPERATURE IN DEGREE CELSIUS	39.1	43.5	49.2	51.4	53	54.5

TIME (HR) VS TEMPERATURE (°C)

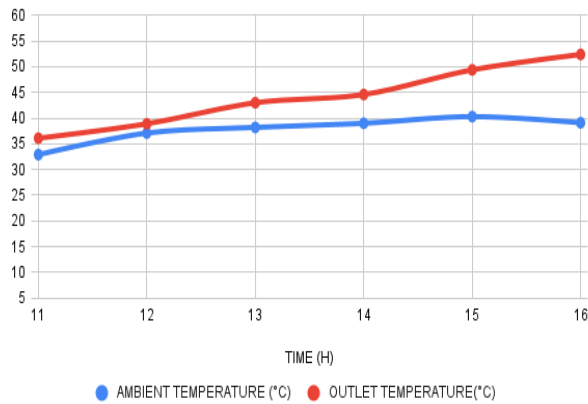


Figure 3 :- Day 2 graph

TIME (HR) VS TEMPERATURE (°C)

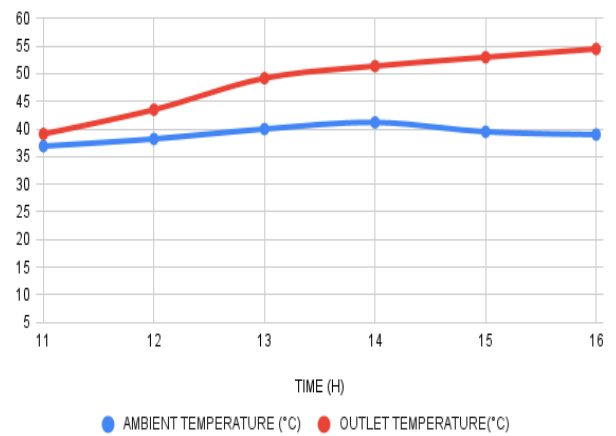


Figure 4 :- Day 3 graph

3.4 Day 4 Readings

TABLE 4 DAY 4 READING

TIME IN HOUR	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM
AMBIENT TEMPERATURE IN DEGREE CELSIUS	38.3	39.9	41.6	42.2	43	42
OUTLET TEMPERATURE IN DEGREE CELSIUS	39.3	45.2	50.2	54.8	58.4	59.5

3.5 Day 5 Readings

TABLE 5 DAY 5 READING

TIME IN HOUR	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM
AMBIENT TEMPERATURE IN DEGREE CELSIUS	32.9	37.1	38.2	39	40.3	39.1
OUTLET TEMPERATURE IN DEGREE CELSIUS	36.1	38.9	43	44.6	49.4	52.4

TIME (HR) VS TEMPERATURE (°C)

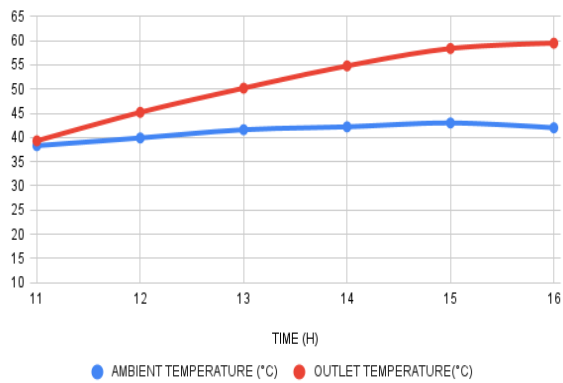


Figure 5 :- Day 4 graph

TIME (HR) VS TEMPERATURE (°C)

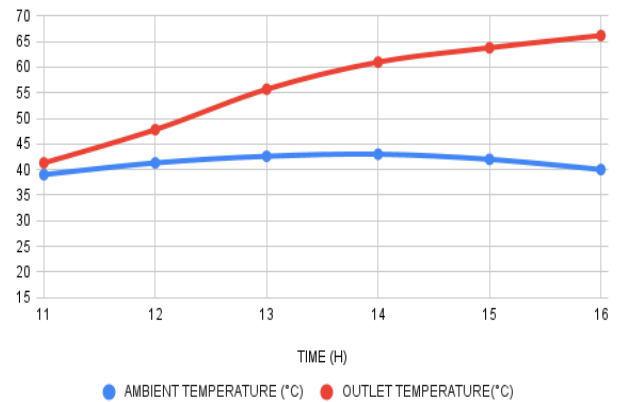


Figure 6 :- Day 5 graph

4. Result

A prototype of flat plate solar collector was made and tested in LNCT Bhopal campus. To improve outlet temperature of water and efficiency of overall system Hexagonal type reflector was introduced in the system. From the observation of reading taken during experimentation it can be observed that overall heat transfer rate and efficiency of the system largely depends upon the magnitude of solar radiations or solar energy. It was also noted that solar radiation passing from the absorber area of solar thermal collector were not able to escape from glass and hexagonal reflector were employed on a purpose to increase final output temperature and efficiency/performance of overall system. The maximum temperature obtained by the flat plate solar collector using hexagonal type reflector was 66.2 degree.

5. Scope for future work

1. Different fluid other than water can be considered for developing better understanding.
2. Size of flat plate solar collector can be increased.
3. Different Phase change material can be used with flat plate solar collector to form thermal storage devices.
6. Cost analysis can also be done to get better cost vs efficiency.
7. Optimization can be done by variation of angle for reflectors.

6. Reference

- [1] Mohammed Mumtaz A. Khana , Nasiru I. Ibrahim , I.M. Mahbulbul , Hafiz Muhammad. Alic, R. Saidur, d , Fahad A. Al-Sulaimanb , : Evaluation of solar collector designs with integrated latent heat thermal energy storage: A review.
- [2] Luca Evangelisti , Roberto DeLieto Vollaro , Francesco Asdrubali: Latest advances on solar thermal collectors: A comprehensive review.
- [3] Ahmad Fudholi , Kamaruzzaman Sopian : Review on Solar Collector for Agricultural Produce.
- [4] JOHAN VESTLUND : Gas-filled, flat plate solar collectors.
- [5] F.A. Sachit1, N. Tamaldin, M.A.M. Rosli1, S. Mishal , A.L. Abdullah : Current progress on flat-plate water collector design in photovoltaic thermal (pv/t) systems: a review.
- [6] Fabio Struckmann : Analysis of a Flat-plate Solar Collector.

[7] M. Faizal , R. Saidur , S. Mekhilef , M.A. Alim : Energy, economic and environmental analysis of metal oxides nanofluid for flat-plate solar collector.

[8] Nurillkmal ShamsulAzha, Hilmi Hussin , Mohammad Shakir Nasif And Tanweer Hussain : Thermal Performance Enhancement in Flat Plate Solar Collector Solar Water Heater: A Review.

[9] Grigorios Jordanou : Flat-Plate Solar Collectors for Water Heating with Improved Heat Transfer for Application in Climatic Conditions of the Mediterranean Region.

[10] Ritvik Dobriyal, Prateek Negi, Neeraj Sengar, Desh Bandhu Singh : A brief review on solar flat plate collector by incorporating the effect of nanofluid.

[11] Basil N. Merzha1 , Majid H. Majeed , Fouad A. Saleh : Experimental study of flat plate solar collector performance with twisted heat pipe.

[12] V. N. Palaskar, S. P. Deshmukh : A Critical Review on Enhancement in System Performance of Flat Plate Hybrid PV/T Solar Collector System.

[13] M.E. Zayed , Jun Zhaoa , Yanping Dua , A.E. Kabeelb , S.M. Shalaby : Factors affecting the thermal performance of the flat plate solar collector using nanofluids: A review.

[14] Elumalai Vengadesan, Ramalingam Senthil: A review on recent development of thermal performance enhancement methods of flat plate solar water heater.

[15] M.A. Alghoul, M.Y. Sulaiman, B.Z. Azmi and M. Abd. Wahab : Review of materials for solar thermal collectors

[16] Mahmut Sami Buker, Saffa B. Riffat : Building integrated solar thermal collectors – A review.