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EXPERIMENTAL STUDY AND ANALYSES OF FLAT PLATE COLLECTOR USING HEXAGONAL REFLECTOR IN SOLAR WATER HEATING

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ABSTRACT

The paper describes performance of solar water heating on Flat plate solar collector using Hexagonal reflector. Solar collector is main component of a solar water heating system. The collector gather sun's energy and convert this radiation into heat and then transfer the heat into a Fluid (water) which has many household or industrial applications .The solar Hexagonal type reflector used here with the solar collector to increase the reflectivity of the collector. Thus, the reflectors concentrate both direct and diffuse radiation of the sun toward the collector. To maximize the intensity of an incident radiation the reflector was allowed to changes its angle with day time. The radiation comes from sun's energy was converted into heat , and then heat was transferred to the collector Fluid (water). A prototype of a solar water heating system was constructed and obtained the improvement of the collector temperature and efficiency by using Hexagonal type reflector. Thus, the present solar water heating system has a best thermal performance compared to available system.

KEY WORDS: Solar energy, solar water heating system, flat plate collector, Hexagonal reflector.

1. INTRODUCTION

Energy have found on planet in a variety of forms, some of which are immediately useful to do work, while others require the process of transformation. The sun is a primary energy source in our lives. Besides, water, fossils fuel such as coal, petroleum products, nuclear power plants are sources of energy. A most available source of renewable energy on earth is solar energy as the earth receives a millions of watts of energy everyday comes from solar radiation. However, only a fraction of it in a form of day lighting and photosynthesis is used by the natural world, one third is reflected back into space and the rests is absorb by land, oceans and clouds. Thus, it is very feasible to collect solar energy and utilize it efficiently to generates electric power , heat and also for cooling purposes in a possible way. The effect of using solar energy on the environment for the variety of applications is minimal as it produces no harmful pollutants. Due to increasing demand for energy and rising cost of fossil type fuels (i.e., gas or oil) solar energy is becoming an important source of renewable energy. Solar water heating systems are the cheapest and consume about 20% of the total energy consumption of a family **(vishal et al. 2015).**[1] considering the heating requirements and environmental conditions three types of solar thermal collectors are employed, such as flat plate collector, evacuated tube solar collector and concentrated solar collector. Due to the simplicity of design, the flat plate collectors are

extensively used for water heating. It requires very little maintenance and can collect both direct and diffuse radiation.**[2] Siva Kumar et al. (2012)** and[3] **Vijay et al. (2013)** were review various types of flat plate solar collectors with a variety of applications. They also discussed the design parameters, construction, arrangement, and sizing of various solar collectors and their performances.

[4]Himangshu Bhowmik et al. In the paper we studied that it works on the performance of the solar thermal collectors by using Flat plate collector. It used Flat plate type collector using two reflectors to maximize the intensity of incident radiation. This reflector was allowed to change its angle with day time. In this way a solar water heating system was constructed and obtained the improvement of collector efficiency around 10% by using reflector.

[5] TABET et al. In the paper studied that it work on Flat plate collector using reflector. Here it shown that can increase of 23% for solar radiations incident on the collector surface with the addition of planer reflectors in the day of may so, increases the fluid temperature with an average of 5% and this may causes an improvement of the performance of the collector.

[6] M.A.Sabiho et al.:- In the paper we studied that it used the evacuated collector for water heating, solar cooker, swimming pool heating purpose. It has been found that an evacuated tube collector has higher than other collector. An evacuated tube collector is also very efficient to be used at higher operating temperatures.

[7] Prasad et al. (2010) classified solar collectors into two types: water-type (hydraulic), used water as the heat transfer fluid, and air-type used air as the heat transfer fluid. It was noted that air-type having the low heat transfer coefficient and low thermal efficiency was employed water-type collector for high thermal performance. To obtain the highest solar intensity on the collector, in summer, the inclination angle of the Reflector was maintained at 45◦ with respect to the Horizontal axis **(Tabaei and Ameri, 2015).[8]**

It is observed from the literature review that the various studies were available for the improvement of the performance of solar collectors. No studies were found based on the improvement of temperature by using the Hexagonal solar reflector. A flat plate solar collector using hexagonal reflector in solar water heating design and constructed in such a way that the temperature and performance was improve. . The reflector is introduced here to concentrate both the direct and diffuse radiation of the sun on the collector, which will increase the temperature. To observe the improvement of performance of solar water temperature by using the Hexagonal reflector is obtained in this analysis. The results are also compared with the results available in the literature.

2. Experimental set- up and procedures

2.1 Theoretical analysis

The experiment was conducted at LNCT COLLEGE OF ENGINEERING AND TECHNOLOGY, Bhopal (Madhya Pradesh) India on 18th march 2019. The collector was faced toward the sun and changed its positions with time or the position of sun. However, the system was testing in several times in the day and the collector was changed its position with the position of the sun in a day.The experiment was conducted to study the performance of the solar thermal collector with the reflector. A solar energy collector is used to collect direct radiant energy having parallel paths and diffused radiant energy from sun. The maximum concentrations of solar energy collectors collect diffuse and direct solar radiation. A reflector focuses direct radiation onto a first or movable collector and reflects a substantial portion of the diffused radiation onto the Flat plate collector position near a focus of reflector. The Flat plate collector was oriented in a

such a way that it receive both the direct and diffused radiation during the day time.

2.2 Practical Experiment and Design method

To carry out an experimental analysis, the Flat plate solar thermal collector using Hexagonal type reflector as shown in fig.2.2. The Flat plate solar thermal collector was made up of iron plate .Here, the frame is used which consist of Hexagonal reflector having Five piece of mirror or mercury glass that were mounted all around the frame as shown in fig2.2. The reflector was mounted un such a way that it can change its position with the position of the sun. In Fact, the earth moves one revolution about its axis in every 24h, gives a rotation of about 15 degree in 1 hour that means the solar ray deviates around 2.5 degree in 10min.[4] Here, three glasses are rectangular type and two glasses are triangular type. One Rectangular glass whose dimension is 0.6*0.4 m which are mounted on the middle of the frame. Another two type of rectangular and triangular type of frame where we insert glass are mounted in a frame which seen as a Hexagonal type reflector as shown in fig.2.4. Here, the two rectangular glasses dimensions are 0.7*0.3 m and two triangular glasses dimension is 0.4*0.3 m. The absorber plate of the collector was placed at a height of 3ft with the help of stand .The stand height are 3ft.

The absorber plate of the collector was painted black. In the experiment while taking Five reflected mirror used, these reflected mirror are set manually with changing the position of the sun . Here in the day time , the between 10 am to 12 pm there are four reflected glass is working and the angle of these four reflected glass are; two rectangular reflected glass angle is 60 degree and one triangular reflected glass angle is 75 degree which will we set manually by tracking the sun position. While the time between 12 pm to1 pm there is also four glass working whose angles are; two rectangular reflector glasses angle is 45 degree and one triangular reflector glass angle is 60 degree shown in fig2.2.

Another while the time between 1 pm to 4 pm there are five reflected glass which was working and seen as a Hexagonal type reflector. The angle of these reflected glasses which was set manually by tracking the sun position are; two rectangular reflected glass is 45 degree and two triangular reflected glass angle is 30 degree as shown in fig.2.1. while working these Hexagonal type reflector , results shown that at this angle maximum reflected light can fall on the collector that leads to increasing the transfer of heat to the water that are present in the collector. In Fact , the inclination angle affect strongly on the heat transfer rate of flat plate solar collector.

It also noted that in summer the inclination angle of the reflector was maintained at 45 degree with respect to the Horizontal axis.[4] The reflectivity of mirror glass was taken as 0.9 and assumes that the incident radiation on the collector surface was around 70 to 80 %[4] . The total reflector area is 0. 78 m^2. The area of the collector is 0.145 m^2.

2.1 Figure- Image of arrangement of flat plate solar collector using Hexagonal reflector.

2.2 FIGURE - Image of Hexagonal reflector.

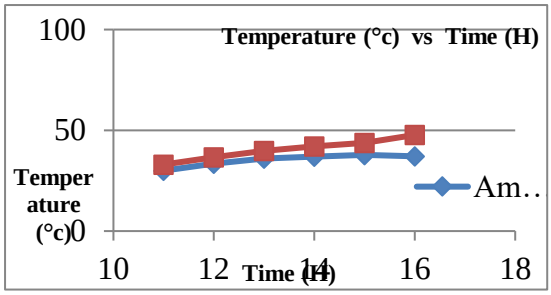
3. Results and analyses

The system was tested in many times in the day and position of a collector was change with position of the sun in a day. As the solar rays always strikes it perpendicular, the solar radiation losses or reflection of energy from a collector surface will be maximize. The collector was painted with black color for which radiation emitted by absorber plate of the collector cannot escape. Thus, increase its temperature. The Hexagonal type reflector on the other hand made of a planar mirror /solar mirror used here to achieved the concentrated solar heat on to the collector surface. All of these help to get highest solar water heating on the collector surface. This heat was absorbed by water which present in the collector. The maximum water temperature was recorded at around 4pm as show in Graph 4.4-. Shows the hourly temperature variation in a day of 9 may 2019.The figure shows the variation of collector water temperature with Hexagonal type reflector. **In Graph .4.1**- shows the hourly temperature variation in a day of 18th march 2019. Here only four reflector mirror glass is working in between 11am to 2 pm and all five hexagonal reflector mirror is working in between 2 pm to 4 pm which is used to reflect the sun radiation and concentrate to the collector. In the 11 am the ambient temperature is 31.5C and water temperature is 33C with working of only four reflector glass mirrors was set in such a way that two rectangular mirrors are set at angle 60 degree and one triangular mirror is set at angle 75 degree. The maximum temperature of water in the collector at 4 pm is 47.7C with working of five mirror of hexagonal reflector and it was set in such a way that two rectangular mirrors are set at angle 45 degree and two triangular mirrors are set at angle 30 degree.

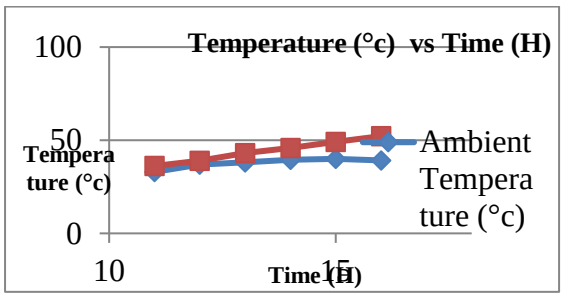
In Graph 4.2- show the hourly temperature variation in a day of 15th April 2019. Here only four reflector mirror glass is working in between 11am to 2 pm and all five hexagonal reflector mirrors are working in between 2 pm to 4 pm which is used to reflect the sun radiation and concentrate to the collector. In the 11 am the ambient temperature is 33C and water temperature is 36.2C with working of only four reflector glass mirror was set in such a way that two rectangular mirrors are set at angle 60 degree and one triangular mirror is set at angle 75 degree. The maximum temperature of water in the collector at 4 pm is 52.2C with working of five mirror of hexagonal reflector and it was set in such a way that two rectangular mirrors are set at angle 45 degree and two triangular mirrors are set at angle 30 degree. **In Graph 4.3**- shows the hourly temperature variation in a day of 3rd may 2019. Here only four reflector mirror glass is working in between 11am to 2 pm and all five hexagonal reflector mirror is working in between 2 pm to 4 pm which is used to reflect the sun radiation and concentrate to the collector. In the 11 am the ambient temperature is 38C and water temperature is 39.1C with working of only four reflector glass mirror was set in such a way that two rectangular mirrors are set at angle 60 degree and one triangular mirror is set at angle 75 degree. The maximum temperature of water in the collector at 4 pm is 59.6C with working of five mirror of hexagonal reflector and it was set in such a way that two rectangular mirrors are set at angle 45 degree and two triangular mirrors are set at angle 30 degree.

In graph4.4- shows the hourly temperature variation in a day of 9 may 2019. Here only four reflector mirror glass is working in between 11am to 2 pm and all five hexagonal reflector mirror is working in between 2 pm to 4 pm which is used to reflect the sun radiation and concentrate to the

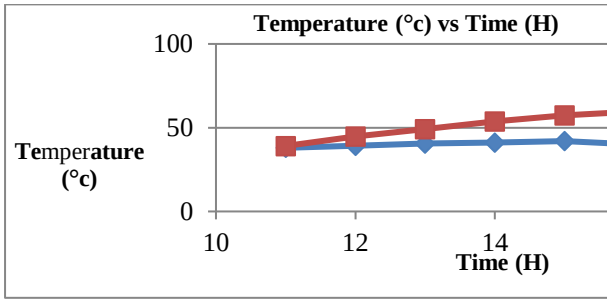
collector. In the 11 am the ambient temperature is 39C and water temperature is 41.3C with working of only four reflector glass mirrors was set in such a way that two rectangular mirrors are set at angle 60 degree and one triangular mirror is set at angle 75 degree. The maximum temperature of water in the collector at 4 pm is 66.2C with working of five mirror of hexagonal reflector and it was set in such a way that two rectangular mirrors are set at angle 45 degree and two triangular mirrors are set at angle 30 degree.



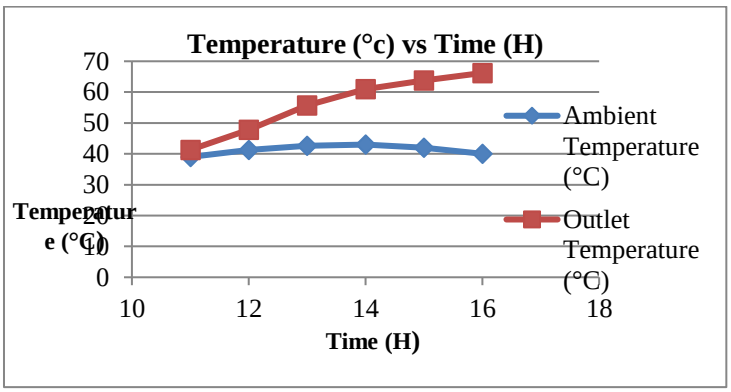
4.1 Graph- The variation of outlet temperature with solar time on 18th march 2019.



4.2 Graph- The variation of outlet temperature with solar time on 15th April 2019.



4.3 Graph- The variation of outlet temperature with solar time on 3rd may 2019.



4.4 Graph- The variation of outlet temperature with solar time on 9th may 2019.

5. Conclusions

A prototype of a Flat plate collector with Hexagonal type reflector was constructed and tested in BHOPAL (MADHAY PRADESH) INDIA on 18 march 2019. Here the Hexagonal type reflector was introduced here to improve the temperature and efficiency of the collector .It is obtained from the observation that the heat transfer rate and a collector efficiency is strongly depends on solar radiation . In Fact, the radiation emitted by the absorber plate of the collector cannot escape through a glass and the reflectors on the other Hand used to concentrate solar heat on a collector surface. Thus, maximize the collector temperature and efficiency. The collector temperature is obtained here with the use of Hexagonal type reflector are 66.2 C. and the efficiency is also increased.

Here, lastly show that when the ambient temperature increased or decreased with change of position of the sun with the time. Thus overall efficiency and temperature of the collector increased with the use of Hexagonal type reflector.

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