DUAL AXIS PARABOLIC SOLAR TROUGH COLLECTOR'S PERFORMANCE ANALYSIS FOR VARIOUS REFLECTING MATERIALS

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Abstract - *The technology Dual Axis Parabolic Solar trough Collector is very helpful because it is used for nearly all applications of solar energy like water steam and hydro power generation, solar water heating, solar air heating, etc. In this research work, the dual axis parabolic solar trough collector's performance analysis is performed using various reflecting materials. A Dual Axis Parabolic Trough Solar Collector for hot water production system is analyzed by using various reflecting materials. Here, water is used as a working fluid and is recirculated through the copper tube with the help of a water pump from the storage tank to the absorber tank. The main objective of the work is to increase to a maximum value the temperature of water in the storage tank. An assessment focuses primarily on the material of the reflector. The values of helpful heat gain, system hourly thermal efficiency are estimated and graphically represent their variability with time and solar intensity. Starting with acrylic reflecting mirror sheet is used as a reflector and the use of aluminum mirror sheet and silver foil as a reflector is compared with both the performance. Solar power meter calibrated with a pyranometer is used to measure solar intensity.*

Key Words: Parabolic solar trough, reflecting materials, heat gain, efficiency.

1. INTRODUCTION

With the growing population and rapid development pace, energy is becoming more costly to produce and our towns and cities are facing a major power crisis. The truth is that resources such as coal, oil and natural gas are not going to be around forever. Today we all realize that we need renewable energy alternatives. The source of renewable energy is natural resources such as sunlight, wind energy, tides and geothermal heat. Solar energy as a reflector is one of the most promising future sources of renewable energy.

Solar energy in the form of electromagnetic radiation consists of light and heat generated by the sun. Today's technology helps capture this radiation and turn it into usable solar energy forms-like heating or electricity.

The literature review is conducted on the different fields of dual axis parabolic solar trough collector research aimed at improving the performance of dual axis parabolic solar trough collector.

Kulal et al. [1] developed a Parabolic Dish Solar Collector is very useful because it is used in nearly all applications of solar energy such as steam and power generation, water heating, air conditioning, etc. In this paper work, the parabolic solar dish collector's output study is performed using various reflecting materials. **Lifang Li et al. [2]** A new concept has been developed for the design and manufacture of large parabolic dish. The dish mirror was formed with highly reflective surfaces from several optimally shaped thin flat metal petals. Attached to the mirror petals ' rear surface were several thin layers whose shapes were designed for reflective petals to form a parabola as cables or rods pushed their ends towards each other.

Ibrahim et al. [3] The design and development of a parabola solar water heater for domestic hot water applications was reported. He found that the heater provides a family of four members with 40 liters of hot water a day, assuming that every family member requires 10 liters of hot water a day. He initially expected the model to achieve 50 percent thermal efficiencies, but he achieved 52 percent-56 percent thermal efficiencies and this range of efficiencies is higher than the planned designed quality.

Fareed. M. Mohamed et. al [4] The Portable Solar Dish Concentrator was studied and the development and manufacture of 1,6 meter diameter solar dish concentrations for water heating and solar steam was recorded. The dish is constructed from galvanized steel metal and its interior surface is coated by a reflective film with reflectivity up to (76%) and is fitted with a focal point receiver (boiler). The device is fitted with monitoring system and temperature and solar power measurement.

Yadav et al. [5] The solar-powered air heating system was tested using different reflectors and parabolic trough collectors. The reflected solar radiation in this experiment focused on the absorber tube that was placed at the focal length of the parabolic trough. Air was used as working fluid in this system to capture the heat from the absorber duct. For research, he used three different reflectors and they found that Aluminum sheet quality is excellent compared to steel sheet and Aluminum foil as a reflector.

Ladan Mohammed (6) Solar thermal parabolic dish cooker has been designed and constructed. For a fairly medium-sized family the cooker was designed to cook food equal to 12 kg of dry rice per day. The model allowed the solar cooker to track the sun constantly for successful efficiency, and for this reason a linear actuator (super jack) was adopted. Preliminary test results indicate that the solar thermal cooker's overall performance was satisfactory. Within 90 – 100 minutes, the cooker was able to cook 3.0 kg of rice, and this strongly correlates with the estimated 91 minute time.

2. EXPERIMENTAL SETUP

Fig -1: Photograph of the experimental setup

Shows the experimental set-up of this project that the experimental set-up consists of a dual axis solar parabolic trough system, an absorber and a heat transfer fluid as water flowing through the water tank system. A pipe is used to transport the water from the tank to the absorber tank and the steel absorber tank is used. It is located at the focal point of the parabolic trough solar trace.

When the rays of sunlight fall on the reflective surface, they are mirrored and transferred to the absorber surface to heat the water. The dual axis parabolic trough made of acrylic mirror sheet, aluminum sheet, and silver foil highly reflective panels. The reflector is cut into small shapes and fixed parabolism that can be easily turned. There is an auto tracking to track the sun.

3. INSTRUMENTS AND MEASURING DEVICES

Temperatures are determined at different points using thermocouples of type k. A digital temperature indicator is connected to the thermocouples that give a 0.10C resolution to the temperature. During the day, the frequency of the solar radiation is measured using a solar power meter.

4. EXPERIMENTATION

The clinical step by step process followed during the test is as follows:

1. Cleaning of the surface of the reflector and the absorber to remove particles of dust. In the storage tank, the fresh water will be filled. At least 30 minutes before the start of the test, the collector is exposed to the sun.

2. The reflector's positioning and tracking towards the sun. The start of the pump.

3. The water flow level going through the absorber is kept constant for 10 minutes in each test.

4. Readings of the solar intensity and inlet are taken from the thermocouples, outlet temperatures of the working fluid.

5. After every 10 minutes, the readings are taken and reported in a tabular form. Within 1 hour, water will be replaced.

6. The pump will be turned off and the whole system will be covered up. For the next readings, this process is repeated again.

For all reflective materials, the same experimental proced ure described above will follow.

5. RESULT AND DISCUSSION

Chart-1 Variation in hourly efficiency with time aluminium mirror sheet reflector

Graph shows diurnal variation with time in the hourly output of the reflector of Aluminium mirror sheet. It is obvious from the above graph that the output initially increases from 9:30 am and at 2.30 pm it reaches its maximum value of 42.82 % and it abruptly decreases after 5.15 pm. It is due to the increase in solar intensity over the same period. At the time period 2 pm to 3 p, due to weather condition black clouds are formed so the efficiency value dropped suddenly.

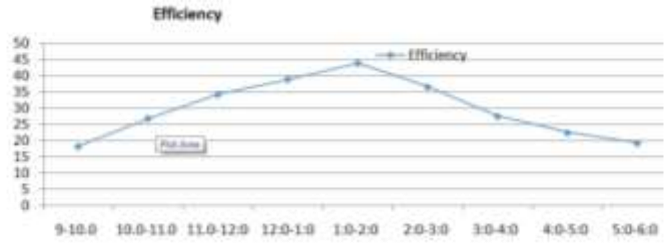

Chart-2 Variation in hourly efficiency with time silver foil reflector

The graph shows diurnal variation in the silver foil reflector's hourly efficiency over time. The plot's essence is like a pyramid. It is evident from the above graph that the output begins to rise from 10.00 a.m to its maximum value of 48.04 % at 1.40 pm and gradually decreases after 1.40 pm. During the same time, it's solar strength.

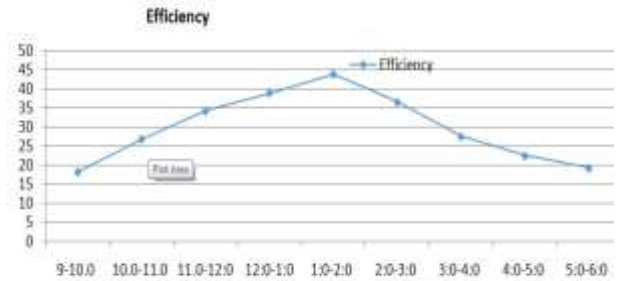

Chart-3 Variation in hourly efficiency with time silver foil reflector

Graph shows diurnal variation in the acrylic mirror sheet reflector's hourly performance over time. It is evident from the above graph that the output was initially gradual increase up to 11:30 a.m. after 1 p.m. it rises and reaches its maximum value of 44.47 % at 1.30 p.m. and is slowly decreasing after 2.30. It is due to the increase in solar intensity over the same period.

Table -1: Result table for Hourly Efficiency

Si. No.	Hourly Efficiency (%)		
	Aluminium mirror sheet	Acrylic mirror sheet	Silver Foil
1	42.82	44.47	48.04

The above table shows the overall efficiencies of different reflecting materials.

6. CONCLUSIONS

In this work, the dual axis parabolic solar trough collector's experimental and performance evaluation was carried out using acrylic mirror sheet, silver foil and aluminum sheet as reflecting materials. Here we analyzed the useful heat gain, instantaneous performance, hourly efficiency of the these three different reflecting materials (shown in the above graph).

When using silver foil as a reflector, the hourly thermal efficiency is 48.04 %, which is the best among all three.

$$\eta_{\text{Silver foil}} > \eta_{\text{Acrylic mirror sheet}} > \eta_{\text{Aluminium mirror sheet}}$$

Where,

$\eta_{\text{Silver foil}}$ = Overall hourly thermal efficiency of silver foil as a reflecting material

$\eta_{\text{Acrylic mirror sheet}}$ = Overall hourly thermal efficiency of acrylic mirror sheet as a reflecting material

$\eta_{\text{Aluminium mirror sheet}}$ = Overall hourly thermal efficiency of aluminium mirror sheet as a reflecting material

Through the comparative study of all three reflecting materials, we find that the overall hourly thermal efficiency of silver foil as a reflecting material is high and has a very good response to solar intensity. The explanation behind this finding is that, relative to other materials, silver foil has better reflection. The silver foil is cost-effective and less material is needed compared to the stainless steel and aluminum foil. It is therefore concluded that the use of silver foil as a reflector for dual axis parabolic solar trough collector is economical.

REFERENCES

[1] Kulal, Patil "Performance Analysis of Dual Axis Parabolic Solar Trough Collector for Various Reflecting Materials", International Research Journal of Engineering and Technology(IRJET), Vol,03, Issue 11, Nov-2016, pp326-329.

[2] Lifang Li, Steven Dubowsky "A new design approach for solar concentrating parabolic dish based on optimized flexible petals", Mechanism and Machine Theory 46(2011) pp 1536-1548.

[3] Ibrahim Ladan Mohammed "Design and development of a parabolic dish solar water heater" International Journal of Engineering Research and Applications (IJERA), Vol. 2, Issue 1, Jan-Feb 2012, pp. 822-830.

[4] Fareed. M. Mohamed, Auatf.S.Jassim, Yaseen. H. Mahmood, Mohamad A.K.Ahmed "Design and Study of Portable Solar Dish Concentrator Fareed" International Journal of Recent Research and Review, Vol. III, September 2012, pp 52-61

[5] Avadhesh Yadav, Manoj kumar, Balram "Experimental study and Analysis of Parabolic Trough Collector with Various Reflectors" International journal of Mathematical, Computational, Physical and Quantum Engineering Vol:7 No:12, 2013 pp1161-1165.

[6] Ibrahim Ladan Mohammed "Design and Development of a Parabolic Dish Solar Thermal Cooker" International Journal of Engineering Research and Applications (IJERA) Vol. 3, Issue 4, Jul-Aug 2013, pp.1179-1186.

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