

Design, Fabrication and Performance Analysis of a Parabolic Trough Solar Collector Water Heater

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ABSTRACT: The energy is always a need to continue the life cycle with low cost and high efficiencies at the end of the day output. And engineering is always in the hunt of the new and best technology to furnish the vast and clean output which should be obviously friendly to the nature. So, it is intended to build a machine which can give more efficient and clean energy with low cost, powerful and also friendly to the nature, for that it is simple to switch the solar energy system. As everyone knows that the solar energy is enormous and abundant in nature and some thousand watts of heat energy is transmitted to our earth from the sun in the form of light every day. The PTSC (Parabolic Trough Solar Collector) technology is very useful as it is used for approximately all solar energy applications such as steam and power generation, water heating, air heating etc. The prototype of the parabolic trough concentrating collector is manufactured using the available materials (plywood, Reflective Aluminium sheet, storage tanks, and copper tube) and equipment in the workshop. An experimental setup has been developed to investigate the performance of the solar parabolic trough collector. Measurements of total direct radiation on the plane of the collector, ambient temperature, wind speed, water flow rate, and inlet and outlet temperatures of the water inside the absorber tube are collected and employed in studying the performance of the parabolic trough.

KEYWORDS: The PTSC, Solar energy, Water heating.

I. INTRODUCTION

Humans always use the rays of the sun to gather their energy needs. Energy needs of today with increasing environmental concern, alternative systems to be investigated to reduce the use of non-renewable and polluting fossil fuels. One such possibility is solar energy, which has become increasingly popular in recent years.

Now-a-days solar energy has been strongly promoted as available energy source. One of the simplest and most direct applications of this energy is the conversion of solar radiation into heat. Hence, the domestic sector can lessen its impact on the environment is by the installation of solar parabolic trough collectors for heating water. Although it should be said that some of these collectors have been in service for the last 40-50 years without any real significant changes in their design and operational principles.

The use of solar energy is centered at present on photovoltaic and thermal solar energy conversion systems. In the first-named, solar energy is converted into electricity directly by a photoelectric cell. The obtainable outputs are, however still limited. Higher outputs can be achieved by solar thermal conversion. In this process solar energy is received and transferred by a collector system to a working fluid.

Today with increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such possibility is solar energy, which has become increasingly popular in recent years. Solar

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energy is the radiation produced by nuclear fusion reactions in the core of the sun. This radiation travels to Earth through space in the form of energy called photons. Even though only 30% of the solar power actually reaches the Earth, every 20 minutes the sun produces enough power to supply the Earth with its needs for an entire year.

Due to the nature of solar energy, two components are required in order to have a functional solar energy generator. These two components are a collector and a storage unit. The collector collects the radiation that falls on it and converts it to other forms of energy (electricity, heat). Whilst the storage unit is required because of the non-constant nature of solar energy, as during cloudy days the amount of energy produced by the collector will be quite small. The storage unit can hold the energy produced during the periods of maximum radiation and release it when it is needed or the productivity drops.

II. MATERIALS AND METHODS

The materials and their measurements used for the development of the parabolic trough solar collector water heater is tabulated below.

Table 1: Materials and their measurements

MATERIAL	DIMENSIONS
Reflectivity of mirror	0.96
Absorber tube material	Copper
Outside Diameter of Cu tube	32.5 mm
Inside Diameter of Cu tube	31.5 mm
Glass cover tubes diameter	38mm
Corresponding Aperture Area	1.545m ²

Methods of collecting and storing solar energy vary depending on the use of the solar generator. The PTSC (Parabolic Trough Solar Collector) technology is very useful as it is used for approximately all solar energy applications such as steam and power generation, water heating, air heating etc. The prototype of the parabolic trough concentrating collector is manufactured using the available materials (plywood, Reflective Aluminium sheet, storage tanks, and copper tube) and equipment in the workshop.

III. OBJECTIVE

The proposed work has the following objectives and contributions in the field of parabolic trough solar collector system:

- To propose a methodology by which the design and selection of parabolic trough solar collector system can be made comprehensive and easy.
- The above model is to be used in modelling and analysis for in depth study of the whole system.
- Optimization of PTSC system with respect to the performance i.e. thermal efficiency, collector efficiency, quality, liability, durability and most importantly the cost of different materials constituting the PTSC system.
- Complete analysis, evaluation, and comparison of the different PTSC system available in the global market, and also the ranking and optimum selection of the PTSC system.
- To design and fabricate the Prototype Parabolic Trough Solar Collector system for hot water generation and its feasibility in other applications.
- To fabricate a cost efficient parabolic trough solar collector system with the use of different alternative materials.

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- To calculate the performance of the PTSC system for the hot water production in terms of useful heat gain, temperature of water in the storage tank, instantaneous efficiency and overall thermal efficiency.
- Experimental analysis, performance evaluation and comparison of glass cover tubes of a copper pipe diameter in terms of efficiency and selecting the best result for improved efficiency of the fabricated PTSC system.

To calculate the values of performance parameters of the optimum design thus obtained from the experimental analysis.

IV. EXPERIMENTAL SETUP



Fig -1: The Parabolic Trough Solar Collector

The design of Parabolic trough collectors are structurally simpler than other types of concentrated collectors but it requires continuous tracking so as to make sure that solar radiations are concentrated on the absorber tube throughout the day. The design of a PTSC should be precise and the dimensions on x,y directions must be accurate to ensure the better optical efficiency of the PTSC design and hence to improve the overall thermal efficiency of the system.

The equipment is made up of a reflector surface, reflector support, absorber pipe, absorber stand. The reflector surface-an optical concentrator is a parabolic trough (curved) mirror designed to concentrate radiant energy from the sun and its support is made with plywood; absorber pipe, a copper pipe.

V. EXPERIMENTAL PROCEDURE

The stepwise experimental procedure which is followed during the experiment is as follows:

Step 1: Cleaning of the reflector surface and absorber tube to remove dust particles. The fresh water is filled in the storage tank. The collector is exposed to the sun at least 60 min before start of the experiment.

Step 2: Setting and tracking of the reflector towards the sun. The pump is started at 10:00 A.M.

Step 3: In each experiment, for 60 min duration, the water flow rate passing through the absorber was maintained constant rate.

Step 4: Start taking readings of inlet and outlet temperatures of the working fluid from temperature from 11:00 A.M onwards.

Step 5: The readings shown in below table are taken after every hour up to 3:00 P.M and are noted down in a tabular form.

Step 6: The whole set up is covered up. This procedure is repeated again for the next readings. The experimental procedure explained above is followed during the whole experiment.

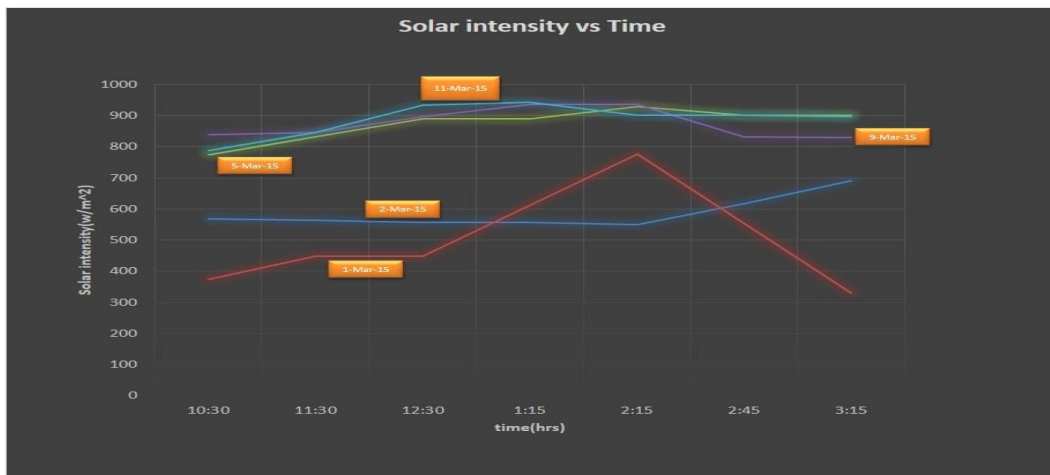
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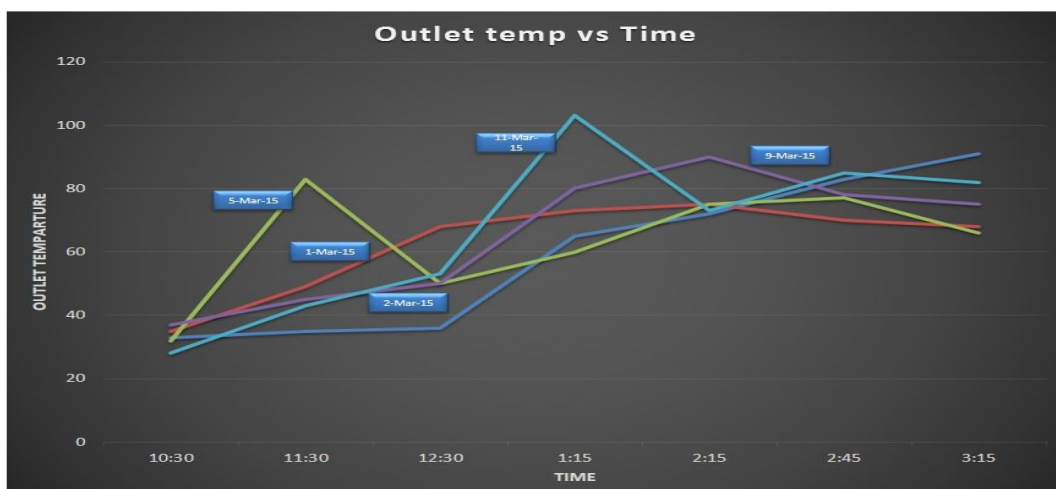
VI. EXPERIMENTAL RESULTS

The performance of this fabricated PTSC hot water generation system is determined by obtaining the values of collector instantaneous efficiency, overall thermal efficiency, and for combinations of solar intensity of radiations, ambient temperature and the inlet water temperature. The storage tank water temperature, ambient temperature, and collector water outlet temperature were recorded with the help of dial thermometer. All parameters are measured as a function of time over one hour period under steady state conditions.



Graph1: Solar intensity verses Time

The above Graph shows the change in solar intensity with time. The maximum solar intensity occurred every day around 1 pm. The heat gain was increased depending on time and solar intensity. The solar intensity is approximately constant throughout the day and was varied by the type of the day just as sunny day or rainy day.



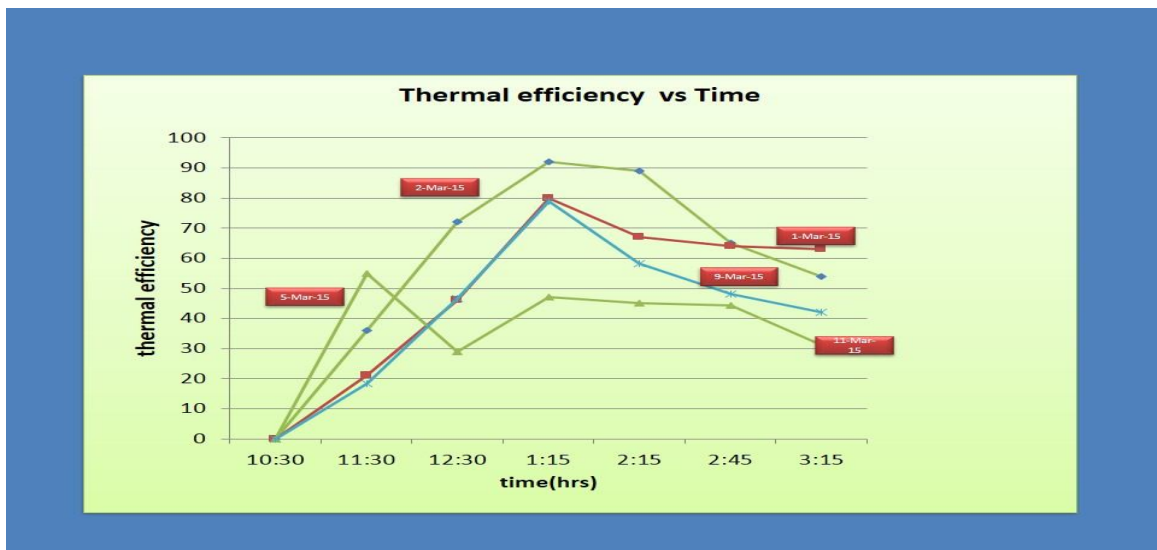
Graph2: Outlet Temperature verses Time

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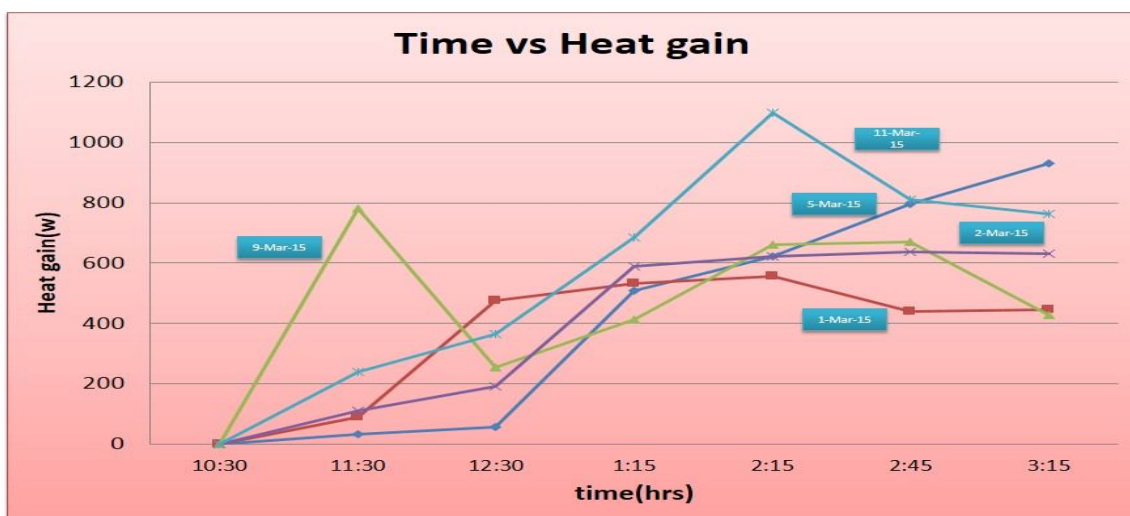
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High temperature at 103°C is observed due to high solar intensity. The lowest temperature was observed as 60°C at 3:15pm on a sunny day. This was the least temperature observed on a sunny day. Minimum outlet temperature during the rainy day is very low of 83°C at 2:00 pm.



Graph3: Thermal Efficiency verses Time

High thermal efficiency at 98% is observed due to high solar intensity. By this a PTSC gains heat more effectively and gives high performance. In the mid-noon, we observe 63% of thermal efficiency. The performance of PTSC will have high during the sunny day.



Graph4: Heat gain verses Time

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The above graph shows that the highest heat gain was observed as 1500W on a sunny day, and the lowest heat gain was observed in rainy day 450W. The heat gain was increased depending on time and solar intensity. We observe the steam produced at 103°C of outlet temperature and here the thermal efficiency is 83% and heat gain is 1500 W at a 1:15 pm.

VII. CONCLUSION

The following conclusions are drawn with the experimental analysis of the fabricated PTSC system for hot water generation. This conclusion was stated for the dates of 01th, 02th, 09th, 11st, and 13rd of March month.

1. We observed the high temperature at 103°C and high thermal efficiency at 98% due to high solar intensity. By this a PTSC gains heat more effectively and gives high performance.
2. The lowest temperature was observed as 60°C at 3:15pm on a sunny day. This was the least temperature observed on a sunny day. In the mid-noon, we observe 63% of thermal efficiency.
3. In this the performance is greatly high even in the mid noon. The highest heat gain was observed as 1500W on a sunny day, and the lowest heat gain was observed in rainy day 450W.
4. We observe the steam produced at 103°C of outlet temperature and here the thermal efficiency is 83% and heat gain is 1500 W at a 1:15 pm.
5. The performance of PTSC will have high during the sunny day and the minimum outlet temperature during the rainy day is very low of 83°C at 2:00 pm.
6. The solar intensity is approximately constant throughout the day and was varied by the type of the day just as sunny day or rainy day.
7. The highest temperature during the day is 103°C and the lowest temperature is 40°C.

The heat gain was increased depending on time and solar intensity.

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