Parabolic Water Heater

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Abstract- *Solar radiation reaches the Earth's upper atmosphere with the power of 1366 watts per square meter (W/m2). Many technologies have been developed to make use of solar radiation. Some of these technologies make direct use of the solar energy (e.g., to provide light, heat, etc.), which helps us to generate electricity. But in order to generate higher temperatures with good efficiency a solar collector in the form of a parabolic trough reflector can be productive. The parabolic trough reflector is a solar thermal energy collector designed to capture the sun's direct solar radiation over a large surface area and focus, or more generally "concentrate it" onto a small focal point area increasing the intensity of solar energy received at the focal point. The project studies on parabolic through collector with header absorbers, and reflecting surfaces as well as maintains to cultivate interpretation with different flow rates as to predict the best form of efficient source. The absorber design is header copper tubes whereas the reflecting surfaces are taken as one being aluminium and the other as reflecting mirror. Another objective of the project is to understand various relations and equations related to the solar parabolic collector and to interpret the results from the tabulated values taken from observations. The experiment is conducted with water as the working fluid and readings are taken for different flow rates and reflecting surfaces.*

Keywords- Pyrheliometer, Linear Fresnel Collector (LFC), Evacuated tube collector (ETC), Parabolic collector.

I. LITERATURE REVIEW

- Kalogirou, S.A. et.al (1994) presented a comparison of advantage and disadvantage of concentrating collectors against conventional flat plate collector. Due consideration is given to collector- aperture and rim angle optimization, together with the receiver-diameter selection. The design of the system is accomplished by considering their parameters: the optimized collector aperture and rim angle, and the receiver diameter.

- They found concentrating collectors exhibit certain advantage as compared to conventional flat plate type:
  a) Higher thermodynamic efficiency can be achieved.
  b) The thermal efficiency is greater because of the smaller heat loss are relative to receiver area.
  c) Reflecting surface require less material and are structural simpler.
- Groenhout, N.K. et.al (2001) performed an experiment where the experimental rig was a full-scale model, located in a small temperature-controlled room. The collector they designed was constructed from timber ply and uses low iron, anti-reflective glass, of the type used in a standard flat plate collector, for the glass cover. Three 1KW element type heaters, sandwich between two sheets of 2mm thick aluminium plate, are used to model the absorber plate. The heaters were connected to variable voltage power supply through Al-go due UPM30 digital power meters that measure the power input to the heaters. The power meters were connected in turn to a computer via RS232 connection. Thirty T-type thermocouples were used to measure:
  a) the surface temperature on the heater plates,
  b) the surface temperatures on the walls of the concentrators,
  c) the temperature gradient across the glass cover, and
  d) the ambient temperature.

- Kalogirou, S. (1994) tested collector's performance according to Ashore Standard. The design of the collector employed by Kalogirou in this system is based on previous work on the optimization and design of a PTC. The collector has an aperture area of 3.5 m2. The 7-concentration ration is of 21.2 used gives a receiver diameter of 22mm (standard pipe size). The system designed to operate with the requisite accuracy of tracking consists of a small motor which rotates the collector via a speed reduction gearbox. A control system is used to detect the sun's position and operate the motor. Three sensors are used in this system. In this design of a parabolic trough collector system, the experimentally calculated value of optical efficiency found out by the researchers varied only by 0.8% from the theoretically calculated value.

- Valan Arasu, A. and Rajkumar, T. (2007) gave emphasized on the keywords for Fibreglass reinforced parabolic trough, Parabolic surface error, Wind load test, Wind orca. The mould is constructed with plywood ISI BWR-IS-303, which is manufactured using high-density timber from selected hard wood veneers of uniform thickness for good strength and stability. The fibreglass reinforced parabolic trough was manufactured by hand layup method (kalpak Jian, 1995). A wax parting compound called was polish was applied on the wooden mould in order to separate the casting from the mould. The polyvinyl alcohol (PVA) resin was applied onto the mould surface and was given sufficient curing time to set. The PVA resin was given to get a smooth inside surface of the parabola, the surface on which the reflective material will be glued. Next, a layer of polyester resin and chopped strand fibreglass cloth were laid on top of the PVA resin and allowed to set and this process of lying has been repeated until a 3mm thickness fibreglass reinforced laminate was obtained.

- Sandeep, H.M. and Arunachal, U.C. (2017) performed the experiment where the Parabolic Trough Collectors (PTC) with non-evacuated receiver delivered lower thermal efficiency even with use of reflector having best optical characteristics due to convection and radiation losses. Hence heat transfer enhancement in PTC became essential to transfer maximum heat to Heat Transfer Fluid (HTF), which can further reduce the system size. The new study focused on review and feasibility of various heat transfer augmentation techniques for PTC receiver. These include the use of evacuated receivers, nanofluids with/without inserts and use of inserts with base fluids. PTC with evacuated receivers have thermal efficiency in the range of 65–70% which is about 10% higher than PTC with non-evacuated receiver. They found out that enhancement in heat transfer by nanofluids is due to the combined effect of increase in effective thermal conductivity and decrease in thermal boundary layer thickness.

1. SOLAR ENERGY MEASURING DEVICES

1.1 Pyrheliometer

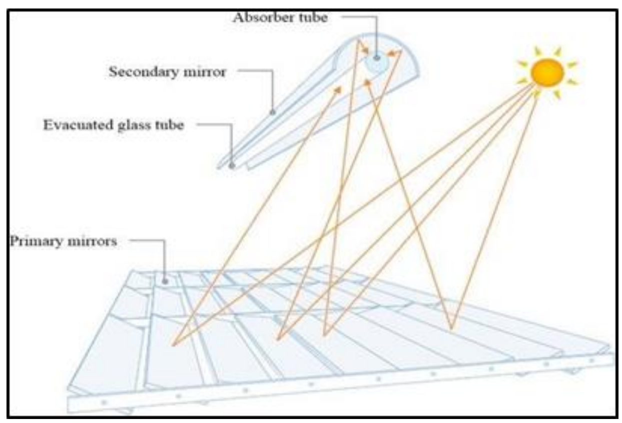
A pyrheliometer is an instrument for measurement of direct beam solar irradiance. Sunlight enters the instrument through a window and is directed onto a thermopile which converts heat to an electrical signal that can be recorded. The signal voltage is converted via a formula to measure watts per square metre.[2] It is used with a solar tracking system to keep the instrument aimed at the sun. A pyrheliometer is often used in the same setup with a pyranometer. Fig. represents a Pyrheliometer.

Figure 1.1: Pyrheliometer

2. Brief Description About Solar Collectors

1) Linear Fresnel Reflector (LFR)

Linear Fresnel Reflector (LFR) technology relies on an array of linear mirror strips which concentrate light on to a fixed receiver mounted on a linear tower. The LFR field can be imagined as a broken up parabolic trough reflector as shown in the Fig. 4.1. But unlike parabolic troughs, it doesn't have to be of parabolic shape, large absorbers can be constructed and the absorber does not have to move.



2) Evacuated Tube Collector (ETC)

Evacuated heat pipe solar collectors (tubes) consist of a heat pipe inside a vacuum sealed tube, as shown in the fig. Evacuated tube collectors have demonstrated that the combination of a selective surface and an effective convection suppressor can result in good performance at high temperatures. The vacuum envelope reduces convection and conduction losses so the collector can operate at higher temperature (150oC). Both direct and diffuse radiation can be collected. Evacuated tube collectors use liquid vapour phase change materials to transfer heat at high efficiency.

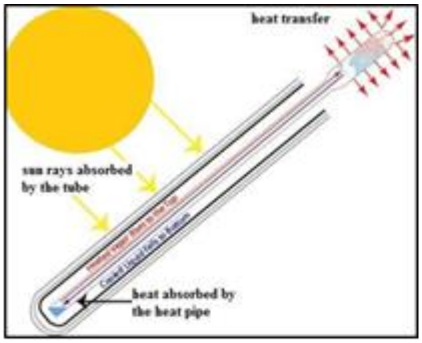
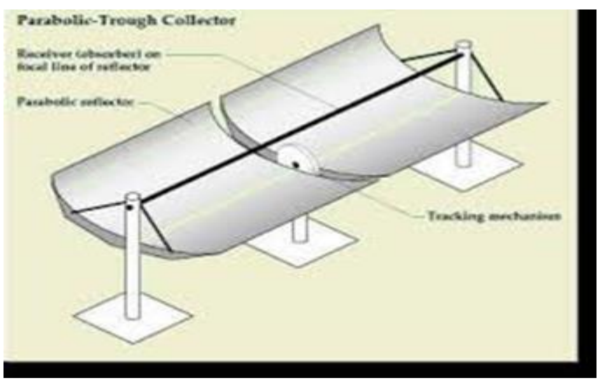


Fig. Evacuated tube collector (ETC)

3) Parabolic Concentrator

Parabolic concentrating systems use parabolic dish shaped mirrors to focus the incoming solar radiation onto a receiver that is positioned at the focal point of the dish, like it's illustrated in the Fig. 4.3. The fluid in the receiver is heated to very high temperatures of about 750oC. This fluid is then used to generate electricity in a small Stirling engine, or Brayton cycle engine, which is attached to the receiver. Parabolic dish systems are the most efficient of all the solar technologies, at approximately 25% efficient, compared to around 20% for other solar thermal technologies. Fig. 4.3 represents a parabolic collector.



3. EXPERIMENTAL AND CONSTRUCTIONAL DETAILS OF THE SETUP

Construction of the Trough Collector

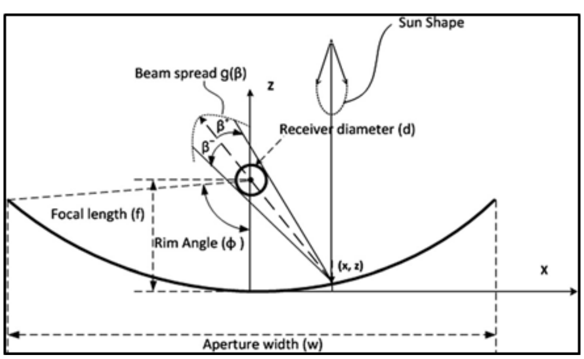


Figure .Parabolic through collector picture

Dimensions required for making of experimental Model:

1. Focal Length(f)
2. Rim Angle (Φ)
3. Receiver diameter (d)
4. Beam spread g(β)

• **Components:**

The main component of the experimental setup and the constructional detail of the setup are described below:

1. Parabolic Trough
2. Collector Plates
3. Copper Tubes
4. Reflective film
5. Fresnel lances
6. Reservoir

1. Parabolic trough

The trough is fabricated with FRP (Fibre Reinforced Plastic) plate in parabolic shape, FRP material is preferred to withstand wind force and also extended life of setup. The setup is mounted on a stand which is fabricated with mild steel angles. The trough is mounted on the support in such way that the trough can be tilted over a wide range of angle, this is for manual tracking to the sunlight angle. Fig.5.2 represents a parabolic trough.

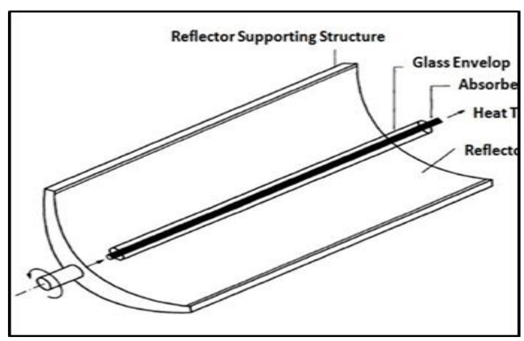


Figure Parabolic trough

2. Collector plate

A rectangular shaped collector plate is fabricating for the experimental setup, providing a larger surface area for solar rays enhance the workability of the collector. Fig. represents a collector plate.

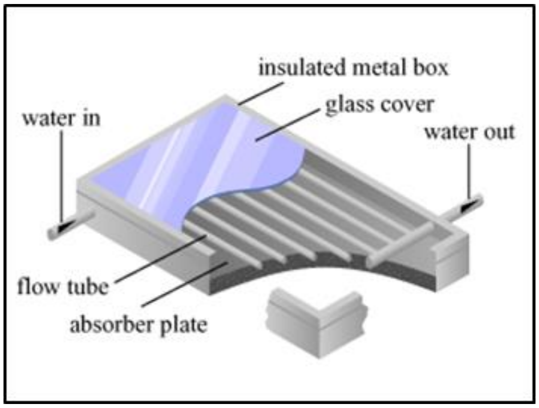


Figure Collector plate

3.Coper tube

A collector plate is made up of copper, since it has high heat transfer coefficient and hence provides better efficiency. Fig 5.4 represents a copper tube.

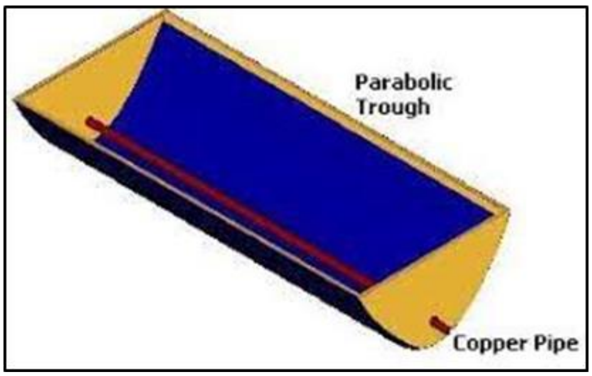


Figure Copper tube

4.Fresnel lances

Fresnel lens, succession of concentric rings, each consisting of an element of a simple lens, assembled in proper relationship on a flat surface to provide a short focal length. The Fresnel lens is used particularly in lighthouses and searchlights to concentrate the light into a relatively narrow beam.

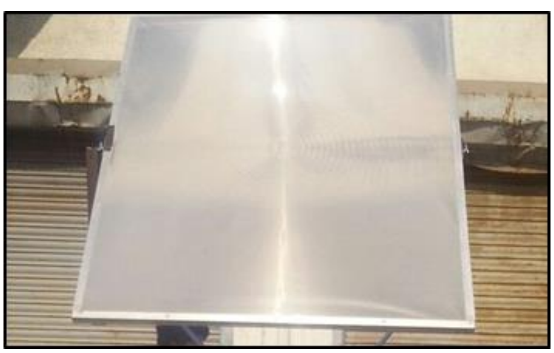


Figure Fresnel lances.

5.Reservoir

It is used to store heated water which is comes from copper pipe after heated. In this project we used water jar as a reservoir.

Figure Reservoir

Pictures of Parabolic Trough Collector

Figure The constructed Trough Collector

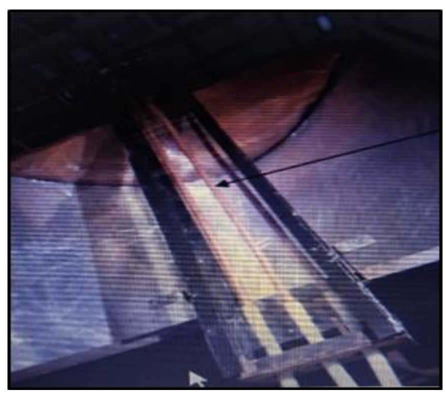


Figure Copper tubes

II. RESULT, CONCLUSION AND FUTURE SCOPE

1. Result

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.
- The efficiency of a parabolic trough collector mainly depends on Solar Intensity, type of fluid used, Reflecting Surface and flow rates.

2. 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.

As the renewable sources of energy is a prime concern in the fulfilment of energy supply in today's world, technical upgradation in the field of design of such technology is a must to gather maximum output. The solar parabolic trough collector is indeed a better alternative to the flat plate solar collector which is widely used today to extract solar energy, modification of the same will surely boost for a better yield.

3. Future Scope

- As the parabolic trough collectors are used for steam generation so they can be used in existing steam power plants for the pre heating of the water and this leads to increase in efficiency of power plant by reducing the fuel consumption.
- Working with different types of fluid as the working fluid to see how the efficiency changes.
- Two similar prototypes of model might be taken into consideration for finding out the comparison simultaneously as to keep the intensity constant as intensity changes day to day

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