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Design of Solar Parabolic Through Collector for Nano-Fluid Applications

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Abstract—The Section design of "Parabolic Trough Collectors" of the solar thermal energy technology using parabolic trough collectors for the concentration of solar radiation. The implementation of solar collectors depends upon various factors like collector & receiver materials, physical dimensions, solar intensity, nature of working fluid etc.

Keywords: *Parabolic Trough Collectors, Thermal Energy Technology, collector,receiver.*

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I. INTRODUCTION

A parabolic is a form of solar thermal collector. It is in linear dimension has a curve parabola in the other two section. Its interior section is made up of polished metal mirror. As the sunlight struck parallel mirror to the solar collector is focused along focal length. The fluid along the focal length are so focused that it can gained temperature. It consist of elements such as receiver tube which works on focal length of trough collector. The mirror is so placed that it get reflected the source of sunlight that it can able to gain high temperature fluid consist in it. This fluid have various application such as it used in heat engine which is used to drive machinery or to generate the electrical energy.

The shape of parabolic trough collector are curved around and axis in linear parabolic length, which able to connect the sunlight fall on focal length. And long pipe receiver is used for heating the heat exchanger fluid. The heat collector element consist of an copper tube and Metal ceramic glass tube. The glass tube consist of air it can be vacuum out manually and the glass tube make vacuum envelope type. The vacuum in heat collector should be below the conduction band to reduce convective losses in the angular space. The steel tube is intend the property of absorption of solar radiation at low thermal emissivity at the temperature of experiment to reduce heat radiation. The glass cylinder have reflective on its outer side. The different property and the assumption with respect to various property of collector material fluid ambient condition and operation condition determine the performance of solar parabolic trough collector.

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II. OBJECTIVE AND SCOPE OF WORK

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.

. • Complete analysis, evaluation, and comparison of the different PTSC system available in the global market, and also the optimum selection of the PTSC system.

• To design and fabricate the Prototype Parabolic Trough Solar Collector system in which generation of steam from water. And also used for its feasibility in other applications like cooking, as a solar water heater etc.

• To fabricate a cost efficient receiver tube which is available in the global market and it fabricated with the use of different alternative materials.

In the present work, new parabolic trough collector system with manual tracking system which has been developed for steam generation. The proposed methodology is used to obtain optimum parameters and conditions such as operating conditions and parasitic losses. It considers the effects of solar intensity and collector dimensions, material properties, fluid properties, ambient conditions and operating conditions on the performance of the collector for use in steam generation. Fabrication and design of a solar parabolic trough is done using locally available materials. The great advantage of solar trough is that it is clean, cheaper and can be supplied thermal energy without any environmental pollution. It there by directly substitutes renewable energy for fossil-fuels, non-commercial fuel namely- firewood and also helps to cut utility electricity bills. At rural level and remote areas this system can use for hot water generation, crop drying, Laundries, in dairy, Food preparation and service facilities hence low temperature trough will be a better solar thermal device for the rural area.

III. LITRETURE REVIEW

3.1) Experimentation on Nanofluid Based Concentrating Parabolic Solar Collector (Kapilet. Al-2014):Investigated $\eta_i$and η_{ih}experimentally by studying the effect of alumina (Al_2O_3) & copper oxide (CuO) nanoparticles in water, as working fluids. Three mass flow rates (20, 40 & 60) l/hr and particles volume concentrations of 0.01% have been examined.

3.2) Performance Evaluation of Nanofluid (Al_2O_3-H2O-C2H6O2) Based Parabolic Solar Collector Using Both Experimental and CFD Techniques by K. Ajay et. al (2016):To evaluate performance of $Al_2O_3$with water-ethylene as base fluid, for four different concentrations.(0.05, 0.075, 0.1 and 0.125%) . To investigate the thermal performance of PTC by varying the volume flow rates(30 LPH, 50 LPH and 80 LPH)

IV. METHODOLOGY OF WORK

Solar parabolic trough consists of different components which make the whole assembly of it

Fig 4.1: Experimental Setup

To make the whole system of solar parabolic trough collector components such as receiver tube, storage tank, reflector plate, heat exchanger, piping and other auxiliary parts are required. The receiver tube which is placed on manufactured stand and to mounted on it wisely such that focal length from the reflector plate get focused on the receiver tube. The receiver tube which is the composed of the hollow glass tube and copper tube is totally evacuated i.e. the air present within the glass tube is removed i.e. vacuum is present instead. As we have fabricated this receiver tube by our own the vacuum is generated by attaching one fuel cock at one end of the receiver tube. The vacuum is generated with help of suction manually and at one stage the vacuum is generated the cock is set at off position so that vacuum is locked inside the receiver tube. The storage tank is firstly filled with water to take readings of water; the water is flowed through the piping system connected to the bottom of storage tank. At storage tank the pipe is connected with tap which can be off when not in used another end of pipe is connected to the starting of receiver tube. Then with the help of stopwatch the flow rate of the water is calculated which is needed to calculate the heat transfer rate later on. Then another end of the receiver tube is connected to heat exchanger via T elbow of copper going into the heat exchanger. The glass wool is wrapped up from the terminated end of the copper tube so that there is no heat loss of heated water. Also the heat exchanger is insulated with glass wool. Inside the heat exchanger copper coiling is made so that the coming steam transfer its heat to the surrounding water. Then after losing its heat the steam from the coil is taken again into the storage tank.

The set up was made ready from 10 am for each day; the set up is set such that maximum sunlight should be fall on the reflector i.e. on the stainless steel reflector. Parabolic shape of reflector concentrates more sunlight on the focal length made by it. These solar rays are get incident on the receiver tube so the flowing fluid gets the heat from the receiver tube and gradually as the time passes the temperature of flowing fluid increases. As the intensity on sun increases after noon there is rapid increase of temperature. As the moves from east to west direction the collector plate is capable of collecting the sunlight because of the manual tracking provided to the parabolic cage on which the stainless sheet in mounted. Readings are made on hourly basis i.e. after one hour readings are taken. The temperature is recorded with help of thermometer which push fit at exit side of the copper tube placed on the cork which is of the same diameter of the copper tube. Again as the steam is start generating it reaches at heat exchanger through the copper coiling the at the end again the temperature of the steam is recorded. As the heat exchanger is filled with the water, the coming steam from the coil heat transfer between the fluids is taken place but dramatically at one stage the temperatures of fluid in the coil and the temperature of water in the heat exchanger become equal. So by recording two temperatures and calculating mass flow rate from discharge and specific heat is already known, from this the heat transfer rate is calculated.

V. DETAIL OF DESIGN

5.1 Receiver Tube

Receiver tube is the receiving component, which receives the reflected solar radiations from the parabolic reflector. For proper receiving of the radiations, the receiver tube is placed at the focal length of the parabola. The receiver tube is made up of the two components i.e. copper tube and glass tube together. After extracting all the air within it becomes evacuated type.

Fig 5.1: Receiver Tube

5.2 Copper Tube

The copper tube used in this apparatus of parabolic trough collector is the integral part of the receiver tube. As we know copper is good conductor of heat due to this property of tube it is implemented in the receiver tube. Copper tube also provides the way for fluid to flow from. Copper tube is fitted inside the glass tube in which vacuum is created. Dimensions: Inside diameter = 27 mm Outside diameter = 28 mm, Length = 4 feet long, Thickness=2 mm.

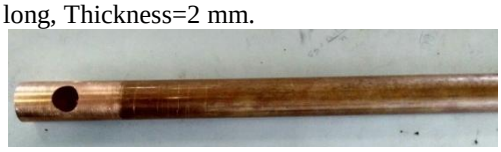

Fig 5.2: Copper Tube

5.3 Glass tube

Glass Tube is the outer covering of receiver tube made up of borosilicate material which highly resistant to heat and also glass is bad conductor of heat which makes it heat proof. So

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this property of glass makes itself sustainable to heat when the apparatus have to stand in the heavy sunlight.

Dimensions:

Inside diameter = 54 mm, Outside diameter= 56 mm Length= 4 feet long Thickness= 2 mm

Fig 5.3 :Glass Tube

5.4 White Cement Fixtures

These are hollow disc which are fitted in the glass tube so as to lift and hold copper tube inside it. The inside diameter of disc is as the outside diameter of copper tube and outside diameter of disc is the inside diameter of the glass tube.Dimension:

Inside Diameter = 28 mm, Outside Diameter = 54 mm.

FIG 5.4 :White Cement Discs

5.5 Storage tank

Storage tank is the entity which has been used to store water when readings on water are to be taken and similarly it stores glycol as well. Storage tank is kept on tower so that we can obtain gravity feeding so there is no need of pump to circulate the either fluids.

Dimensions: Capacity = 5 liters

5.6Parabolic Collector

Parabolic collector is made up of the stainless steel sheet which is having mirror like finish so that the solar radiations which are colliding are get reflected most of all the radiations to the receiver tube. These reflected solar radiations are get absorb by the receiver tube. Parabolic shape of the reflector focuses all the radiations on the focal length on which the receiver tube is held.

Dimensions:

Length = 1.2 x 0.91 $y2 = 4ax$

Where y = half of the parabolic sheet

x = height of parabola, a = focal length parabola

y = 34.5 cm, x = 22 cm a = 13.52 cm

Fig5.5 Parabolic Trough

5.7 Heat Exchanger

Heat exchanger is kept on cradle and is connected to the end of receiver tube by copper pipe. Heat exchanger is filled with water. Also coiling of copper tube within the heat exchanger is kept at one end and other end is taken out of the heat exchanger.

Dimensions: Capacity = 5 liters

5.8 Fuel Valve

This is the component which is used to create the vacuum inside the glass tube of receiver tube. The fuel valve is of 2 wheeler and can be off and on while creating the vacuum. When the air is sucked from the glass tube it is made on ON condition then after the one stroke of sucking again the fuel valve is made off to maintain the vacuum inside and can be off and on while creating the vacuum.

5.9 Support Structure

All the three components i.e. the receiver tube, parabolic reflector and heat exchanger are mounted on the stand which is basically support structure. This is made up of the iron rods welded together, support structure is rigid and tough as such it bears all the load on it.Dimensions: Length = 6 feet Width = 3 feet Height = 4 feet

Fig. Support Structure

5.10 Tacking System

Tracking system for this set up is kept manual to track at various angles and position of parabolic trough such that it vary with the sun for its various positions in the day time. As the sun rise in east and sets in west so to track, parabolic collector is moved in that way. The system is done by using simple ball bearings which connected at the both end of the supporting shaft of parabolic trough collector which is parallel to the collector tube.

Parabolic trough collectors usually track the sun with one degree of freedom using the N-S axis. Solar tracking by these modes maintains the plane of a solar beam so that it is always normal to the collector aperture. Thus, the solar beam from

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different points of the parabolic trough-reflecting surface is collected on the focal line receiver.

VI. IMPLEMENTATION

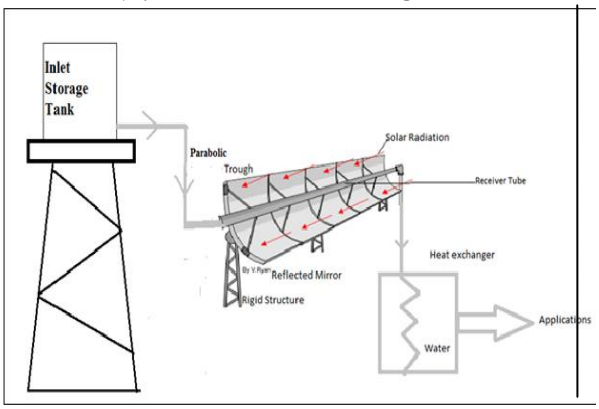

Fig6.1:Block Diagram

As from above figure it is shown that solar radiations are falling on the collector plate. This high intensity radiations getting reflected by the reflector which is at the position so as to absorb more and more solar radiations, then from the pipe at another end of receiver tube passes the heated fluid to the heat exchanger where heat transfer between the heated fluid and the water takes place. Then after again the fluid through coil in the heat exchanger passes into the storage tank.

The block diagram is explained as below:
Solar energy from sun is incident on parabolic collector. The stainless steel sheet which reflects the solar radiation. This reflected radiations are absorb by the receiver tube.
Receiver tube is mounted on the focal line of parabola to trap more radiation.Working fluid flows through this tube , which due to heat transfer receives heat energy.(fluid 1=water, fluid 2=glycol)Then after this fluid is pass forward through piping system which is insulated with superlon material and glass wool.At the end this piping system ends at storage tank .
Storage tank is made insulated through insulating sheets and glass wool in-order to avoid any kind of heat loss.

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