Improvement in Efficiency of Solar Evacuated Tube by Using Heat Pipe system and Parabolic Reflector

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Abstract- *In India,there are average 200 clear sunny days,this solar energy is to be used effectively by using solar collectors.One of the domestic application is by flat plate collector. But various limitations are introduced in flat plate collector. This collector has very less exposed area which makes the system less efficient. Also the solar rays incident on the flat plate is less which produces less heat thus requires more time to heat water.All the above drawbacks of flat plate collectors can be overcome by evacuated tube collectors. Hence we decide to take project on evacuated tube solar collector.An attempt is made to improve the efficiency of evacuated tubes collector by using heat pipes and parabolic reflector.Heat pipe increases heat transfer rate while parabolic reflector increases area exposed to sunlight.*

Keywords- Heat pipe, Parabolic reflector, Infrared,Porous materials

I. INTRODUCTION

Evacuated tube solar collectors are extensively and widely usedbecause it's good thermal insulation characteristics and insensitivity to the direction of sun light[1].There are three types of evacuated tube solar collectors viz (a) Water-in glass evacuated tubesolar collector, (b) U-type evacuated tube solar collector and(c) evacuated tube heat pipe solar collector.In this paper we focus on improving the thermal performance of evacuated tube collectorsby using heat pipe. The function of an evacuated tube is to absorb the incident solar radiation over the evacuated tube and totransfer as much of that absorbed energy in the form of heat to theinside heat pipe, which in turns heats up a secondary medium, e.g.water or oil, that is in contact with the tip of the heat pipe.To eliminate unused solar rays passing through gap between tubes a parabolic reflector is mounted on inclined frame below the tubes. Thus performance of overall system increases considerably. By using porous material(mild steel) and oil(vegetable) as a heat transfer medium between evacuated tube and inside heat pipe heat transfer rate is calculated.

II. LITERATURE REVIEW

Manufacturing of these new solar collectors began in 1985.

1. Improving the performance of evacuated tube heat pipe collectors usingoil and foamed metalsM.S. Abd-Elhady⇑, M. Nasreldin, M.N. ElsheikhMechanical Department, Beni-Suef University, Beni-Suef, Egypt

In this paper the effect of different heat conducting materials is studied like copper foam and thermal oil.

2. PERFORMANCE OF HEAT PIPE FOR DIFFERENT WORKING FLUIDS AND FILL RATIOS A. K. Mozumder1,*, A. F. Akon1, M. S. H. Chowdhury1 and S. C. Banik2

In this paper properties of various materials that used in heat pipes are given and also effect of filling ratio on heat pipe performance is studied.

III. PROBLEM DEFINITION & SCOPE

India along with the world is facing 'Energy Crisis'. There is a significant gap in the demand and supply for electricity. Day by day as our country progresses towards development, this gap is increasing and tackling this situation is very important to continue our country's ascending path. In order to meet this situation a number of options are being considered with a large focus on renewable energy research & development. The options considered are solar energy, biogas, wind energy, geothermal energy to name a few. To support this background it is essential that we acquire indigenous capability to design, develop and install solar thermal plants. Above Crisis arises due to very low usage of renewable resources. This also increases the consumption of non renewable resources. All this limitations motivated us to take a project on solar energy applications.

IV. OBJECTIVES

The objective of this paper is to comparative study of evacuated tube collector with and without using heat pipe system. Also to calculate decrease in time required for heating purpose due to reflector and heat pipes.

V. DESIGN AND EXPERIMENTAL SETUP

Components

1. Frame

Frame like structure is manufactured to withstand all the components such as tubes and container. It is made with an inclination angle of 27^0. It should be easy to install with attachment options.

2. Glass tube

A 3 layered glass tube is installed with vaccum inside. Outer glass is installed with radiant shield type and infrared. Tubes should have high absorptivity and less reflectivity.

3. Manifold

It is made of light weight alumium alloy that is folded to form a strong protective encasing**.**

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4. Insulatingmaterial

Puffing is used as the insulating material in the tank to prevent the flow of heat outside the tank.

5. Heat pipe

Copper vacuum pipe that transfers the heat from within the ET up to the manifold.The influence of oil and foamed copper on the thermal performanceof the evacuated tube heat pipe has been examined underthe Sun. Three evacuated tubes with heat pipe have been examined at the same time, such that all tubes are subjected to the same ambient conditions of solar irradiance and ambient temperature. The three evacuated tubes are identical and are similar.

Heat pipe assembly inside glass tube with fin
(At SSPM's COE, Kankavli, 10/04/2018)

- Material = copper
- Working fluid = methanol
- Wickless type
- Length = 300 mm

VI. PARBOLIC REFLECTOR

It is mounted on inclined frame and has following specifications,

- Focus = 29 cm
- Material = Aluminium
- Inclination with horizontal = 27 ^{o}
- Parabola length 300 mm
- Parabola width 300 mm
- Parabola depth 290 mm
- Focal height 290 mm_
- Evacuated tube outer dia 0.05 m
- Evacuated tube length 400 mm

VII. EXPERIMENTAL CALCULATION

Input

$$= I \times A \times \Delta t$$
$$= 951 \times \pi \times 0.058 \times 1.69 \times 30$$
$$= 4422.15 \text{ W}$$

Output

$$= m \times c_p \times \Delta T$$
$$= 0.03 \times 4185.5 \times (311.1\text{-}308.6)$$
$$= 313.9 \text{ W}$$

Efficiency,

$$\eta = \frac{mc_p\Delta T}{IA\Delta t}$$

$$\eta = \frac{0.03 \times 4185.5 \times (311.1 - 308.6)}{951 \times 0.155 \times 30}$$

$$\eta = 0.0709$$

$$\eta = 7.09\%$$

Overall Efficiency:

The energy efficiency based on first law is defined as ratio of collector output (increase in temperature of water) to the energy input (energy of solar radiation).

Thus efficiency is given by,

$$\eta = \frac{mc_p(T_h - T_c)}{IA\Delta t}$$

$$\eta =$$

calculations it can be observed that the efficiency of evacuated tube $\frac{334.4}{5\times420}$

0.0655

$\eta =$ 6.55%

Hence from above 5 glass tubes and the tubes are inclined at an angle of 27^0C and inlet temperature of water is 29^0 C and the outlet temperature of water is 61.4^0C.

Heat Losses [8]

By Conduction (Inner Glass)

$$Q_{cond} = \frac{\ln(D_{gi} \div d_{gi})}{2 \times \pi \times L \times K}$$

$$= \frac{\ln(0.047 \div 0.045)}{2 \times \pi \times 1.8 \times 1.14}$$

$$= 3.37 \times 10^{-3} \text{ W}$$

By Conduction (Outer Glass)

$$Q_{cond} = \frac{\ln(D_{go} \div d_{go})}{2 \times \pi \times L \times K}$$

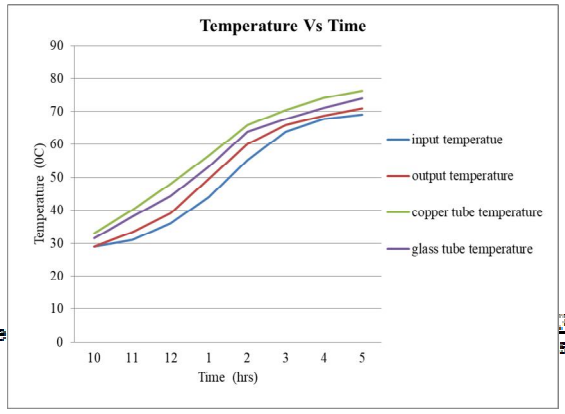
$$= \frac{\ln(0.058 \div 0.056)}{2 \times \pi \times 1.8 \times 1.14}$$

$$= 2.17 \times 10^{-3} \text{ W}$$

By Convection (Outer Glass)

$$Q_{conv} = \frac{1}{h \times A_c}$$

$$= \frac{\ln(0.058 \div 0.056)}{1.14 \times \frac{31.20}{0.058} \times 0.058 \times 1.8 \times \pi} = 4.97 \times 10^{-3} \text{ W}$$



VIII. EXPERIMENTAL RESULT TABLE WITH HEAT PIPE

Sr. No	Time (hr)	T_i temp(0C)	$T_o$temp(0C)	HPT temp(0C)
1	10.00	29	29	33
2	11.00	31	33.4	40.2
3	12.00	36	39.1	48
4	13.00	44	49.6	56.7
5	14.00	55.3	60.1	65.8
6	15.00	63.8	65.9	70.4
7	16.00	67.8	68.8	74.2
8	17.0	69	70.9	76.3

Where T_i = inlet temperature,
T_o= outlet temperature,
HPT =Heat Pipe Tip

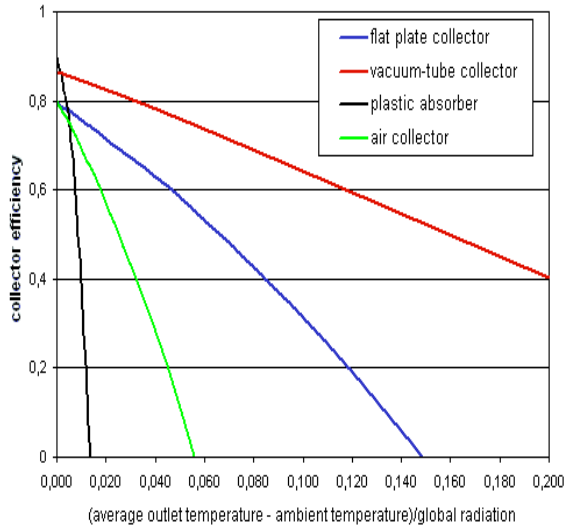
IX. EXPERIMENTAL RESULT TABLE WITHOUT COPPER TUBE

Sr. No	Time(hr)	T_i temp(0C)	T_o temp(0C)
1	10.00	29	29
2	11.00	30.8	31.9
3	12.00	33.4	35.6
4	13.00	38.1	41.3
5	14.00	44	48.1
6	15.00	50.7	53.1
7	16.00	55.3	57.4
8	17.00	59.6	61.4

X. CONCLUSION FROM EXPERIMENTAL RESULTS

1. Time required to heat the water inside tank decreases with heat pipes in evacuated tubes.
2. Thus, heat pipe increases heat transfer rate from evacuated tube to the fluid to be heated at tip of heat pipe(in this case Water)
3. By using methanol in heat pipe max. temperatureupto 110 to 120 ℃ can be reached.

4. Following graph shows greater efficiency of evacuated solar tube collectors,



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