iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** III **Month of publication:** March 2018

DOI: http://doi.org/10.22214/ijraset.2018.3356

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Performance Improvement in Solar Evacuated Glass Tube Collector

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Abstract: Generally heating system finds its application in domestic use for water and room heating. Also few of the commercial sector rely on water heating system. This appliance requires more of the input energy with less efficient setup available. Thus in order to significantly increase the efficiency of existing setup by reducing thermal losses like conduction, convection and radiation by providing absorber back of the collector and by the top cover to reduce convection and radiation heat losses.
The work carried out on experimental investigation of the performance of evacuated solar collector by adding absorber. It was found that the use of the suggested configuration can result in a 07 to 10 ^{o}C advantage in the stored hot water temperature over extended periods of time.
Keywords: Evacuated Glass Tubes, Absorber Sheet, and Acrylic sheet. etc.

I. INTRODUCTION

According to the Renewable Heating and Cooling European Technology Platform around 50% of the energy consumption in Europe is due to heating and cooling used for domestic, tertiary and industrial purposes. Looking at the industrial and commercial 2/3 of the final energy consumption is spent for heating applications. At present solar thermal systems are mainly used for domestic hot water heating. Through solar energy is widely distributed it is dispersed and available only at the rate 500-1000 w/m^2. Hence solar thermal concentrating collector are required for capturing and directing the energy to target for producing medium and high temperature Solar collector such as flat plate collector are non-concentrating type which typically heat the target only up to 60^{o}C with the maximum reachable efficiency of 30% and are hence use full for only low temperature application. However, glass tube collector can me made efficient enough to raise the temperature of water around 80 ^{o}C thus increasing efficiency till 50% which is rolls around of 40% for normal glass tube collector. These collectors are usually made of parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin is covered with a coating that absorbs solar energy well. Air is evacuated, from the space between the two glass tubes to form a vacuum, which eliminates conductive and convective heat loss. In this type water circulation is due to density difference as shown in figure 1.

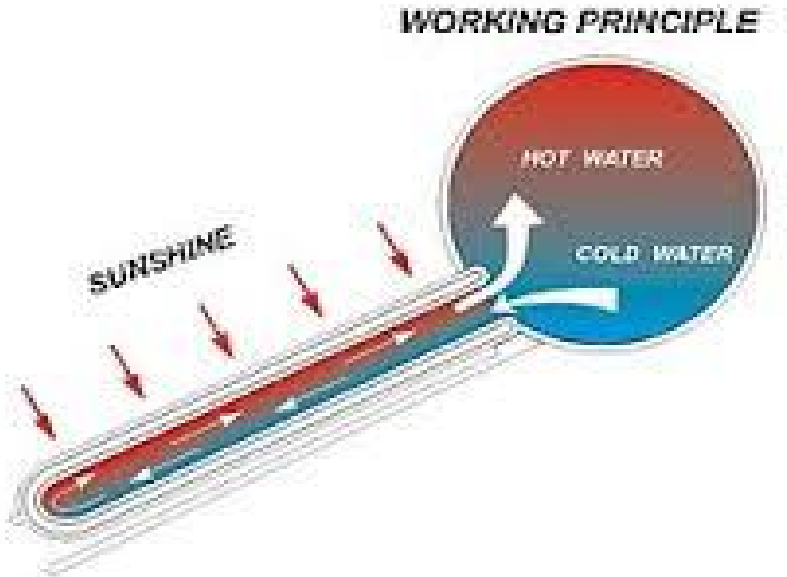

Fig. 1 Evacuated Tube Collector (Natural Circulation)

II.PROBLEM STATEMENT

The most efficient and commonly used solar water heater is evacuated tube collector type heater still it has maximum efficiency of 46%.This efficiency can be enhanced by 7%to 10% with simple mountings to the existing setup. Thermal losses can be reduced significantly by installing absorber and reflector set up.

A. Concept

By introducing a low cost machine was to overcome various limitations with the current manual traditional method. The concept of the work is,

1) Study different types of solar collector
2) Find out the most efficient type of solar collector.
3) To identify various losses.
4) Investigate all areas to improvise efficiency.
5) Produce a specification for higher efficient system.

B. Objective

The main objective of this project is

1) To Analysis the thermal performance of solar collector by inserting the Reflector below the Evacuated glass tube collector.
2) To determine the variation in solar system efficiency for three different conditions.
3) To reduce the heat loss by inserting the absorber at back of the Evacuated glass tube collector.
4) Thermal analysis of evacuated solar collector with glass.

III. EXPERIMENTAL SETUP

The Following Figure 2 represents a proposed solar water heating system.

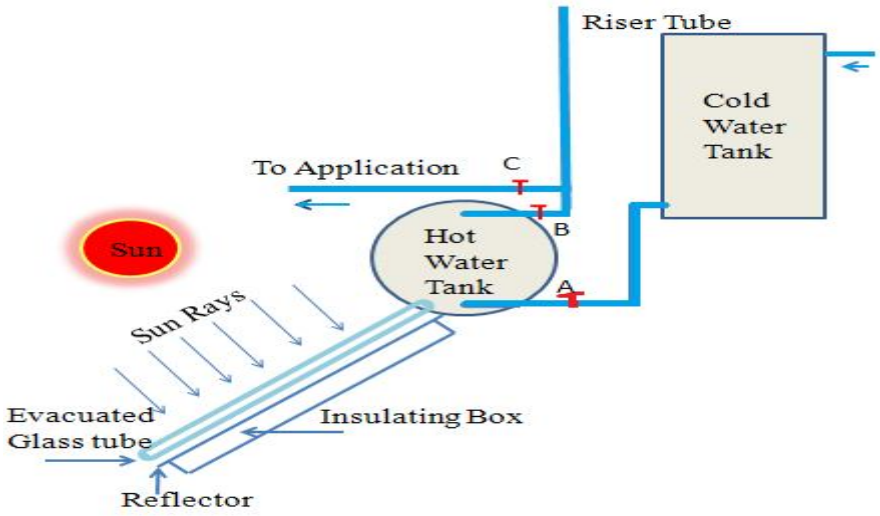

Fig. 2 Experimental Set Up Of Evacuated Glass Tube Solar Collector.

The proposed system has components: a) A Evacuated solar collector unit, b) a well-insulated water storage tank. In this present study thermal analysis of solar collector and thermal energy storage unit was studied experimentally.

IV. TESTING RESULTS AND ANALYSIS

Efficiency of the setup can be calculated for setup without reflector and with reflector as

$$\eta_h = \frac{m * c_p * (T_o - T_i)}{A * I_T} \qquad (1.1)$$

Where,

m = mass of water in hot water tank = 100 liter.

C_p = specific heat of water= 4187 kJ/Kg K.

D = External diameter of Evacuated Glass tube = 58 mm= 0.058 m.

L = length of Evacuated Glass tube = 1700 mm= 1.7 m.

N = Number of evacuated tubes = 11 No.

A = area of Receiver Tubes (without reflector) = Tube diameter * Length of tube* No. of Tube.

= D*L*N = 0.058*1.7*11= 1.09 m^2

A = area of Reflector (with reflector) = width of reflector * Length of reflector.

= b*L = 0.860*1.7 = 1.436 m^2

I_T = Intensity of Solar Radiation at 8:00 am (without reflector)
= 234 W/ m^2

I_T = Intensity of Solar Radiation at 8:00 am (with reflector)

= 226 W/ m^2

The following result table is obtained for efficiency and heat gain at an hourly interval for setup at different cases

Table 1 Heat Gain & Efficiency of EGTSC with Reflector.

Time	q_u (W)	η_h (%)	η_o(%)
8:00 AM	116.31	35.84	48.71
9:00 AM	314.03	48.6	
10:00 AM	558.27	58.2	
11:00 AM	755.99	62.38	
12:00 PM	883.92	63.66	
1:00 PM	942.08	65.47	
2:00 PM	697.83	50.25	
3:00 PM	511.74	41.44	
4:00 PM	325.66	33.2	

Table 2 Heat Gain & Efficiency of EGTSC without Reflector

Time	q_u (W)	η_h (%)	η_o(%)
8:00 AM	81.414	31.92	45.69
9:00 AM	209.35	41.39	
10:00 AM	407.07	54.36	
11:00 AM	546.64	58.38	
12:00 PM	674.57	63.34	
1:00 PM	732.73	65.58	
2:00 PM	511.74	47.47	
3:00 PM	372.18	38.8	
4:00 PM	244.24	31.69	

Graphical representation of various parameters are concluded for differential analysi analysis the inlet & outlet temperature of water with the help of thermocouple on hourly basis and plot a graph temperature verses time as shown in figure 3 and figure 4 for setup without reflector and with reflector respectively. From this graph it's observed that maximum temperature difference obtain,

when the value of intensity of radiation is maximum. In this case location of temperature sensor is inside the inlet and out let pipe of the hot water tank.

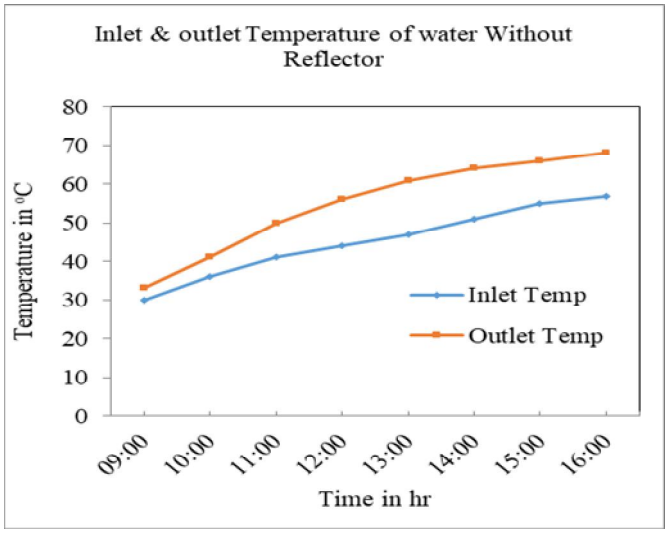

Fig. 3 Variation of water temperature without reflector

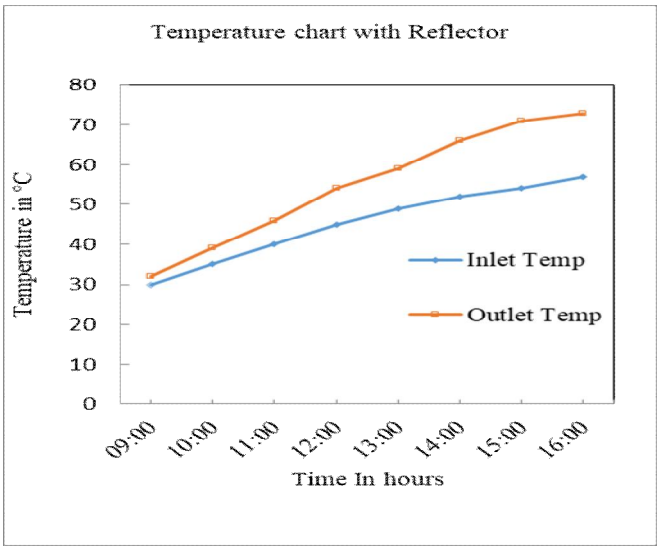

Fig. 4 Temperature chart with Reflector

From the above graphs it can be concluded that by placing the reflector at back of the solar collector it reduced the heat loss and increase the temperature extraction from the solar energy that should be 4 to 6 ^{o}C greater than the solar system without reflector.

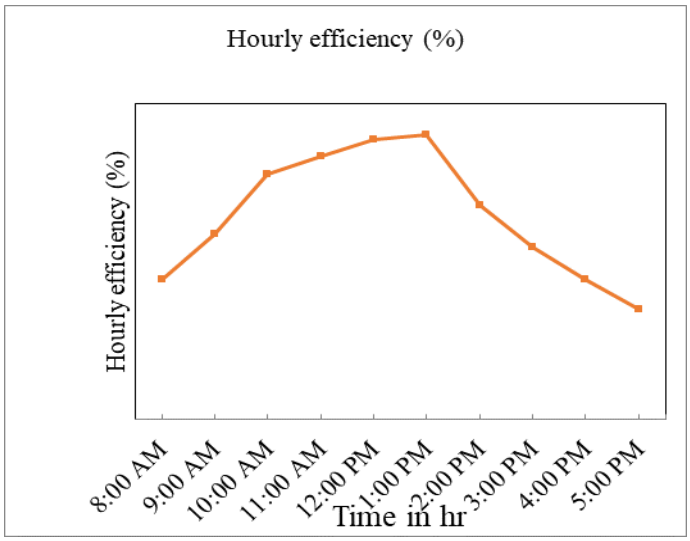

Fig. 5 Variation in hourly efficiency without Reflector.

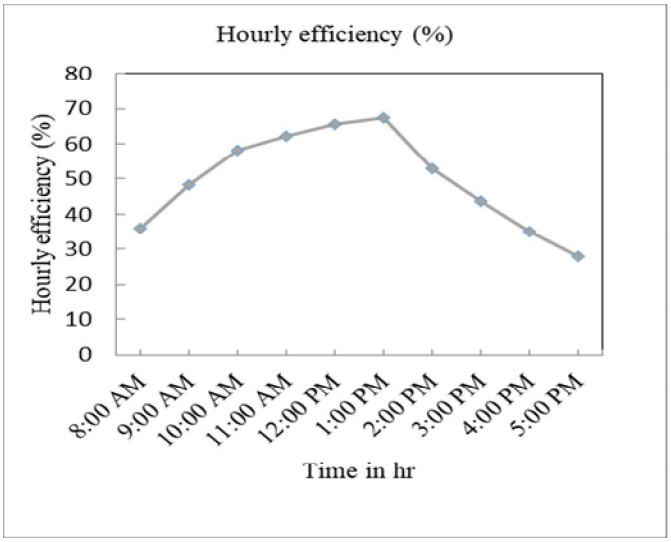

Fig. 6 Variations in Hourly Efficiency with Reflector.

In the analysis of EGTSC the hourly efficiency of EGTSC without reflector and with reflector is studied. The analysis of evacuated glass tube solar collector without reflector, is find out hourly efficiency based on the different input and output parameter as seen from equation (1.1). For EGTSC without reflector some of heat loss takes place due to space between two tubes hence efficiency of this collector less as compare to the EGTSC with reflector which has reflector at back. Temperature of this reflector increases which radiates additional heat to evacuated tubes.

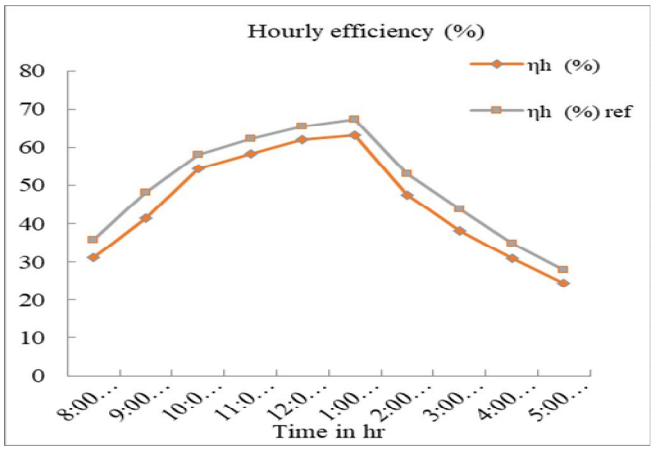

Fig. 7 Variation in hourly efficiency in different cases

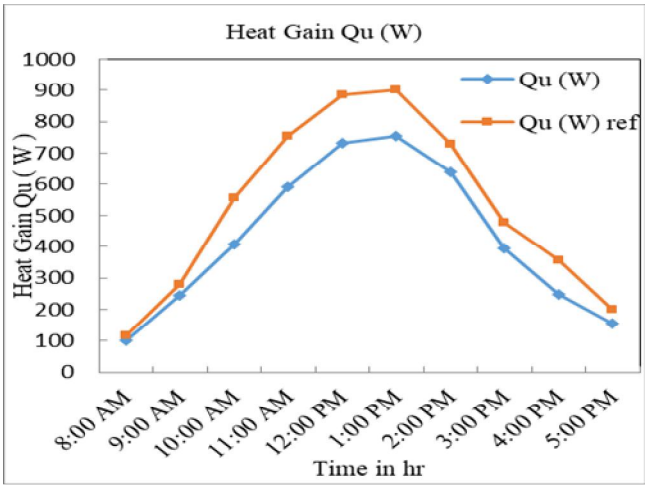

Fig.8 Variation in Heat Gain for different conditions

In the Figure 7 show variation of hourly efficiency with time for different conditions, in which,

1. n_h = represented the efficiency of collector without reflector
2. n_{href} = represented the efficiency of collector with reflector

In the Figure 8 show the variation in heat gain for three different conditions, in which,

1. Q_u= represented the heat gain by water if collector without reflector
2. 2.Q_{uref} = represented the heat gain by water if collector with reflector

V. CONCLUSION

The work presents the installation which increases the efficiency of solar evacuated glass tube collector. Useful heat gain of the system which is depend on the Temperature difference of the fluid can be enhanced by incorporating with Reflector, Absorber with Glass cover. Output of system gives more satisfactory result with respect to time. Also hot water can be made available for longer time.

A. Actual picture of the Project

Without accessories-

With accessories-

VI. ACKNOWLEDGMENT

The authors acknowledges the help rendered by Prof. P.K.JAIN, HOD of Mechanical Engineering Department, Jawahar Institute of Technology, Nashik for the help.

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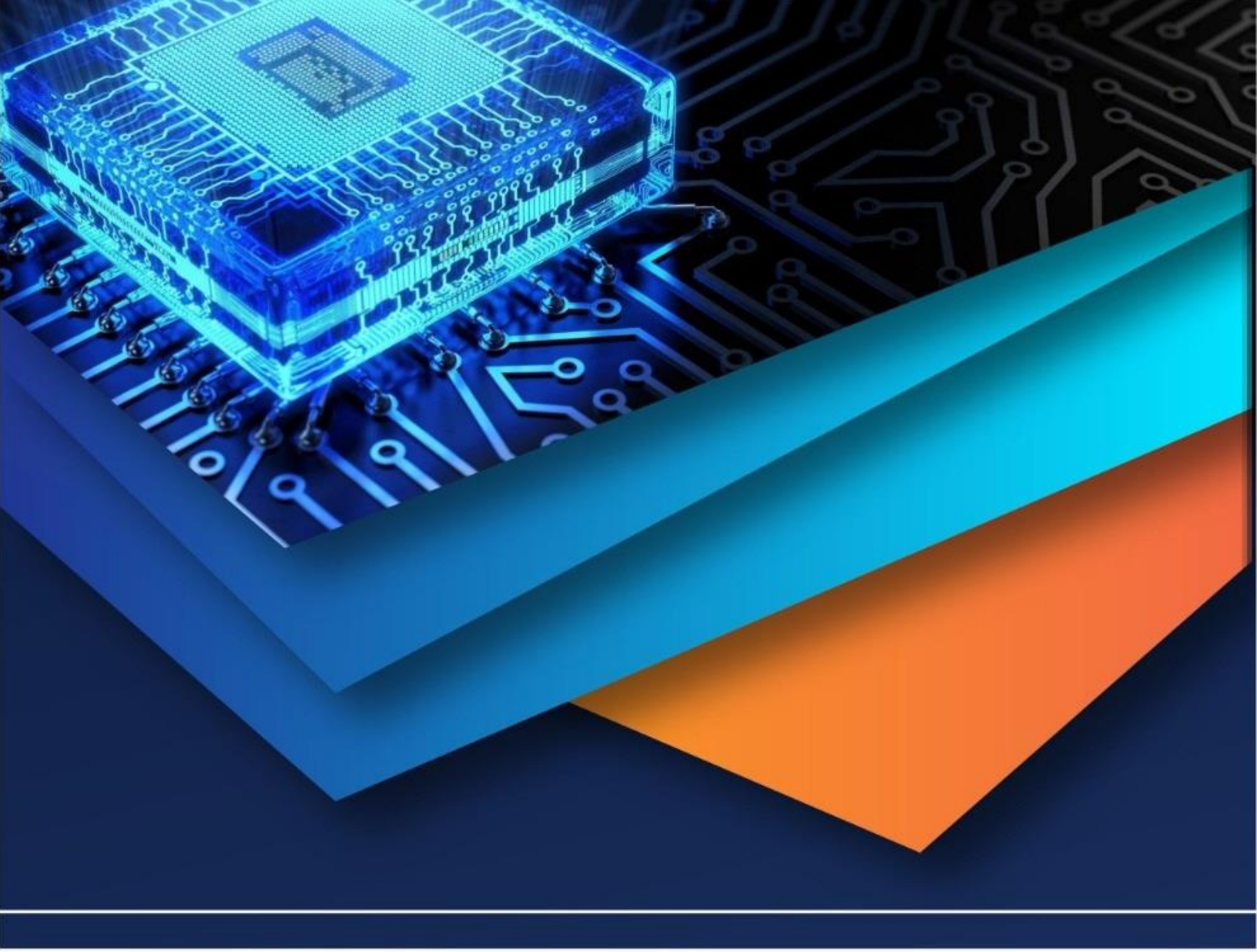

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