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Performance Evaluation Of Direct Absorption Solar Flat plate Collector Using Thermic Fluid

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***Abstract* —— This paper Due to the growing demand of energy and lesser availability of fossil fuels, it shifts our concern towards Renewable energy sources. From all of the sources available to us solar energy is the best option with minimum environmental impact. But the problem lies in efficiently collecting and converting this energy into something useful form. The present study has been carried out to increase the efficiency of the solar collector by using new type of solar collector (DASC-Direct absorption Solar collector) and different class of fluids called (Thermic fluids). In conventional type of flat plate solar collectors we get more resistances whereas in DASC these resistances are reduced . In the present work we have evaluated the collector efficiency using water and Thermic fluid with different volume concentration.**

At different mass flow rate of the thermic fluid and water the efficiency of the direct absorption solar flat plate collector is to investigate and compare the efficiency of the flat plate collector by using thermic fluid and by using water. And the efficiency of the system by using the thermic fluid is to be compared with the literature.

I. INTRODUCTION

In the modern era the use of solar energy is increasing day by day. Due to depletion of fossil fuels and increasing demand of energy sources, we have to focus on renewable energy sources like solar energy. So collecting of solar energy and the use of that energy is a Challenging task for the people. The best way of collecting of solar energy is by using the different types of collectors. The solar flat plate collector now a days used for collecting of solar energy. So it is required to enhance the efficiency of the solar flat plate collector. Heat transfer Thermic fluids are used in many fields of applications and often play a key role to define the performance of an energy system[1]. Efficiency of the collector is increased by using the Thermic fluid as the working fluid. The aim of this paper is to investigate the effect of Thermic fluid on the efficiency of the flat plate collector. Thermic fluid gives the better efficiency as compared to the water which is used as the working fluid in the conventional solar flat plate type collector. Thermic fluid is also used in the other solar systems like solar cells and ponds. The study shows that the efficiency of the flat plate collector is increased by using Thermic fluid as the working fluid.

Flat plate solar collectors are the common type of solar collectors for solar water heating systems and are the simplest device in this category. In a flat plate collector , the solar radiation energy is absorbed by a flat conductive plate and is transferred to the working fluid inside the tubes which are attached on the absorber plate. [2-4] Due to environmental issues and limited fossil fuel resources , more and more attention is being given to renewable energy sources. A new government study shows that Americans are using less energy overall and making more use of renewable energy resources. The strongly promoted and viable energy sources in the current years is the solar energy. The one of the most common application of solar energy is converting the solar energy into heat. After this heat energy is used in the various industries for heating purpose.The most common use of solar energy is the heating of the water in the hot water systems. The heat energy absorbs from the sunlight is converted into the electrical energy by using the solar panel. Heating of the water by using the solar energy is not a new concept it is also used in ancient time.

In the ancient time black painted tanks are used for the heating purpose of water. In the recent times the water heating technology greatly improved. However in this days there are lots of solar collectors are used around the globe.In this paper the tests of the efficiency of the direct absorption solar flat plate collector at different flow rate carried out. The measured efficiency is then compared with the water is used as working fluid for the direct absorption solar flat plate collector.

Nomenclature

Q_o	Heat loss by solar collector (J)
Q_i	Solar radiation received by the collector (J)
Q_U	Useful heat gain by collector (J)
A_c	Collector area (m^2)
m'	Mass flow rate of the working fluid (kg/sec)
T_o	Outlet temperature of the working fluid (°C)

T_i	Inlet temperature of the working fluid (°C)
C	Specific heat (J / kg°C)
G	Global solar radiation (W/m^2)
η	Efficiency of solar collector.

II . EXPERIMENTS

2.1 Experimental set up

The specification of the solar flat plate collector :

Specifications	Detail
External Diameter	2000×1000×95 mm
Riser tube material	Aluminium
Absorber material	Aluminium
Cover material	Low iron glass
Cover thickness	4 mm
Tiltangle of plate	22.5°
Gap spacing	25 mm

The experimental set up used in the experiment is as shown in fig 1. In this design the glass cover is made from the toughened glass and the support is made from the aluminium section. The absorber plate is made from aluminium plate And it is attached to the plywood sheet. Plywood sheet used for supporting the aluminium plate and also reducing the conduction losses the inlet is given to the collector by the aluminium pipe. On the absorber plate there is a finned type passage is used. Finned type passage is used for guide the flow and increasing the heat transfer area. The size of the collector is 200×100 cm . the fins are placed at the 10 cm apart from each other on the absorber plate. Fins are made of aluminium material. Fins are shown in fig 2.

The collector glazing is low reflectance glass which acts as transparent to the incoming short wavelength solar radiations but becomes opaque for high wavelength radiations emitted by the Absorber plate. In this collector we are using Direct Absorption system in which the solar radiations are directly allowed to strike the working fluid. so, the conduction and convection losses are eliminated in this collector.

In this experiment first of all water is used as the working fluid at different flow rate of 7,8 and 9 l/min. and the efficiency is measured at different flow rate of water. Then hytherm 500 thermic fluid as the working fluid at different flow rate of 7,8, and 9 l/min. and the efficiency is measured at different flow rates. The experiments are conducted between 9 am to 4 pm. The inlet temperature is taken constant at 28°C.

Fig 1 Finned type passage

Fig 2 Experimental Setup

III RESULTS AND DISCUSSIONS

3.1 Solar Collector Instantaneous Efficiency Calculations:

The instantaneous efficiency of the solar flat plate collector using water can be calculated as follows :

The useful heat gain is ;

$$Q_U = m' c (T\_o - T\_i)$$

$$\eta = Q_U / A_c G$$

Fig 3 shows that the variation of the global solar radiation w.r.t. time for the different days.

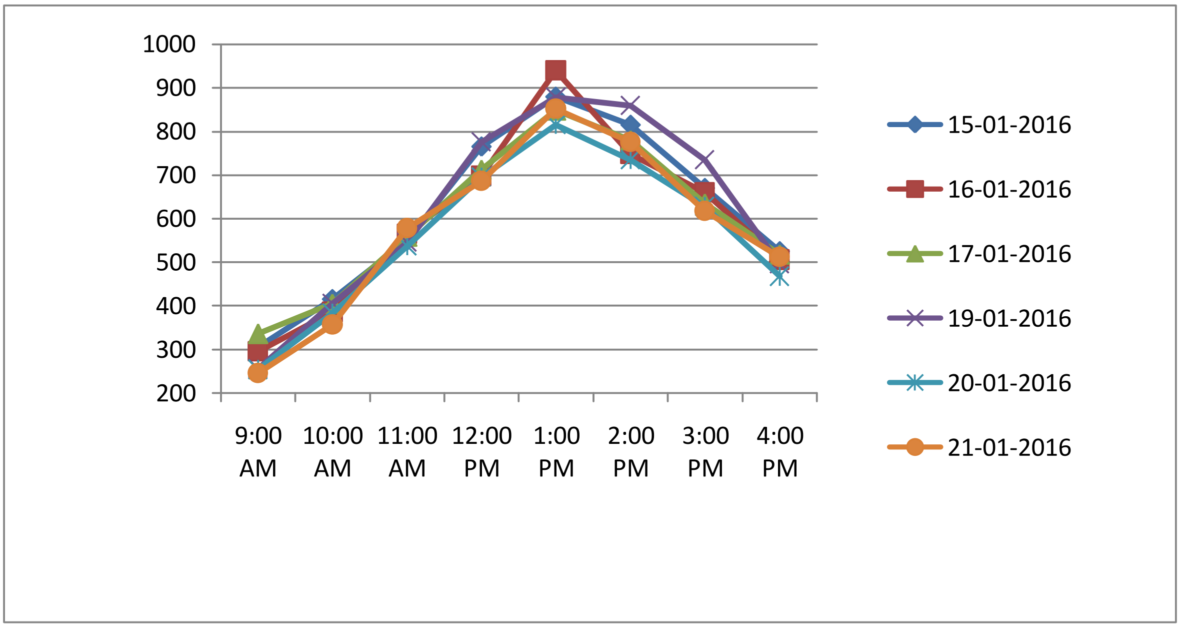

Figure 3 : Global solar radiation v/s Time

Area of the Solar collector= 2 m^2

Total radiations intercepted by the solar collector =A × G_T (W/m^2)

a) Inlet temperature of the working fluid is assumed to be constant for all the experiments. i.e. 28^0C.

b) The Experiments are performed in the Solar noon i.e. from 9 am to 4 pm.

3.1.1 Performance evaluation of the collector using water as the working fluid :

For water,
Density $\rho = 1000$
Specific Heat = 4.184 kj/kgK
Mass flow rate $m = \rho \times V$

Table 1 : Mass flow rate

Volume flow rate (l/min)	Mass flow rate (kg/sec)
7	0.1166
8	0.1333
9	0.15

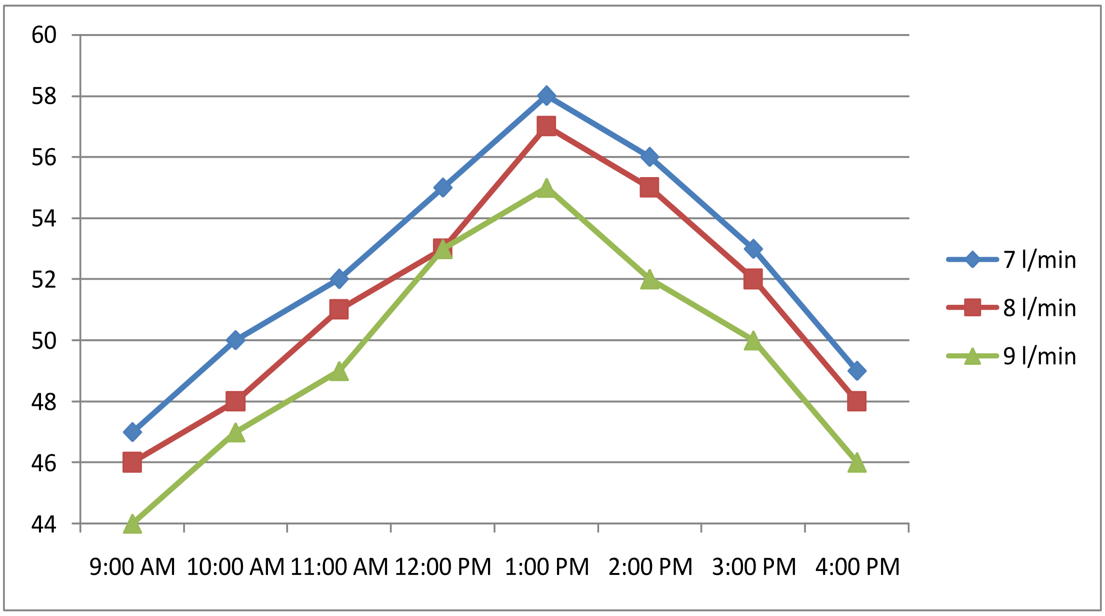

Fig 4 : variation of outlet Temperature of water v/s Time at different mass flow rate

From fig 4 it is observed clearly that as the mass flow rate is decreasing the temperature is increasing and this may be due to the reason that at lower mass flow rate more amount of heat is being absorbed by water.

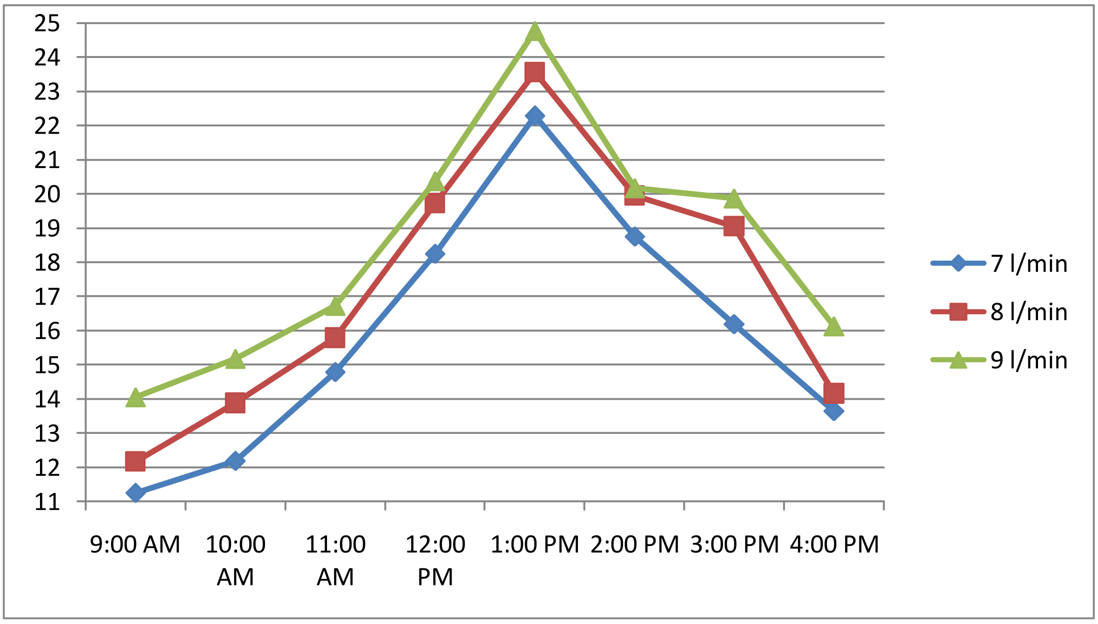

Fig 5 : Collector efficiency (%) for water w.r.t. time at different mass flow rates

From fig 5 it is observed that as the mass flow rate increases efficiency increases, this may be due to the higher value of the mass flow rate and maximum efficiency is reported at 1:00 pm because at that time the value of global solar radiation is maximum.

3.1.2 Performance evaluation of the collector using hytherm 500 as the working fluid:

For hytherm 500 ,
Density $\rho = 973$
Specific Heat = 3.762 kj/kgK
Mass flow rate $m = \rho \times V$

Table 2 : mass flow rate

Volume flow rate (l/min)	Mass flow rate (kg/sec)
7	0.1135
8	0.1297
9	0.1459

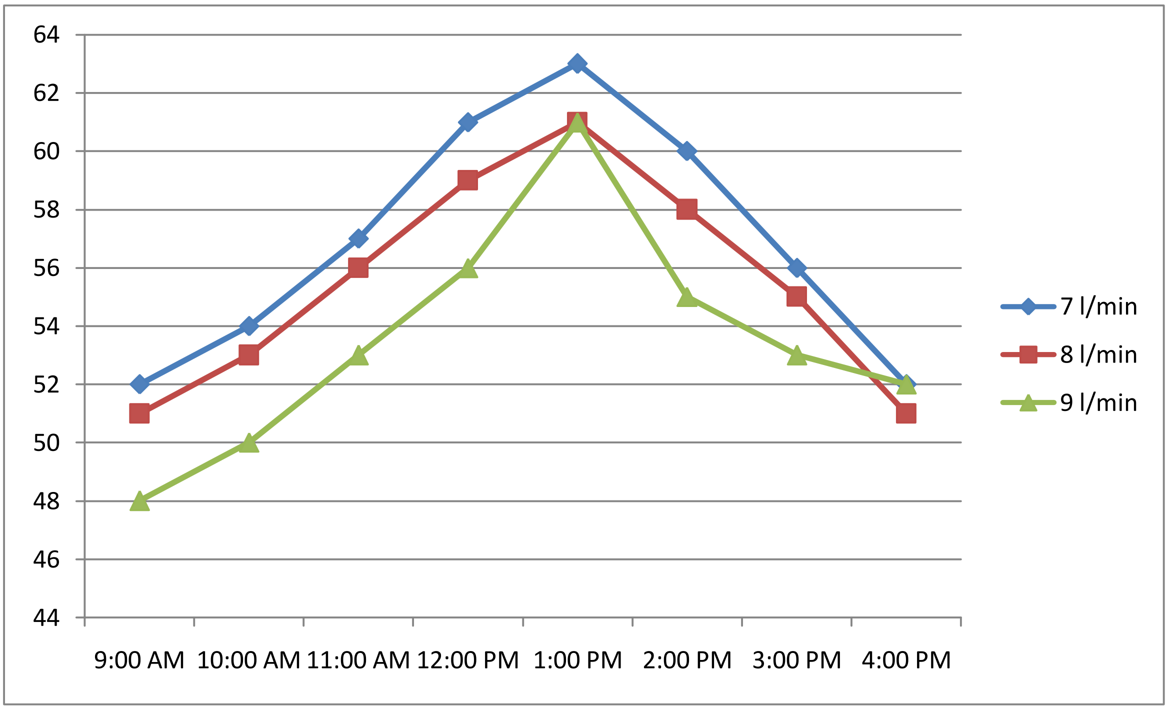

Fig 6 : Variation of outlet Temperature of thermic fluid v/s Time at different mass flow rate

From fig 6 it is observed clearly that as the mass flow rate is decreasing the temperature is increasing and this may be due to the reason that at lower mass flow rate more amount of heat is being absorbed by thermic fluid.

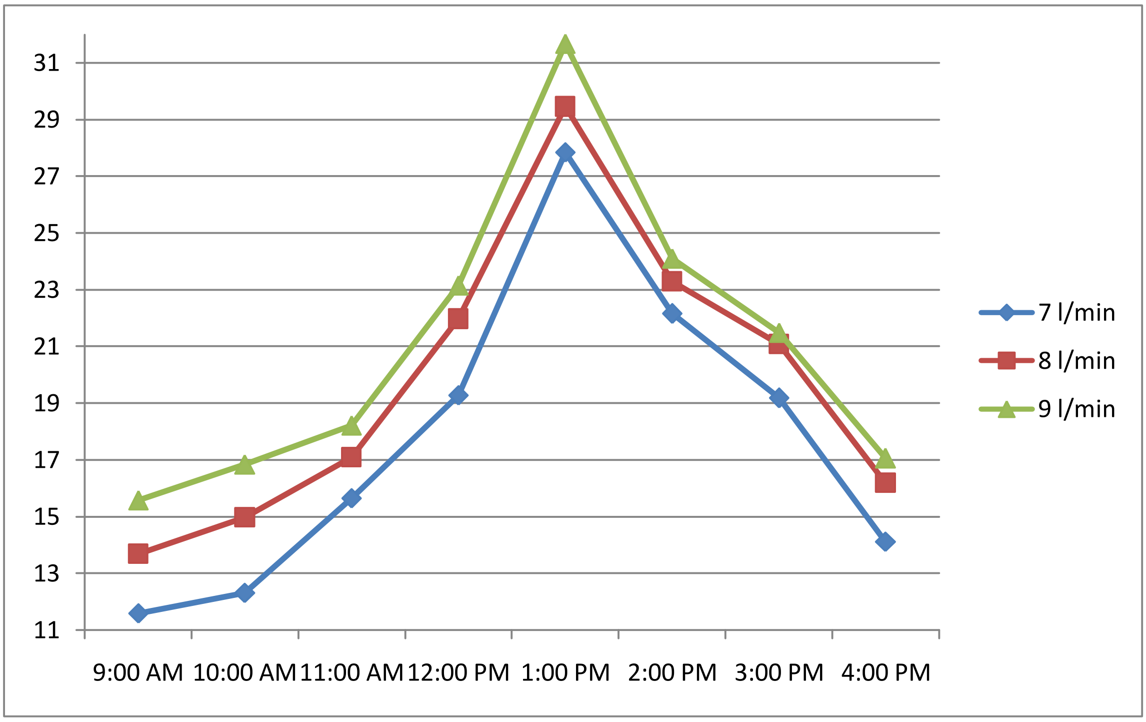

Fig 7 : variation of collector efficiency w.r.t. time at different mass flow rates of thermic fluid

From fig 7 it is observed that as the mass flow rate increases efficiency increases, this may be due to the higher value of the mass flow rate and maximum efficiency is reported at 1:00 pm because at that time the value of global solar radiation ismaximum.

3.2 Comparison charts between water and hytherm 500 thermic fluid :

3.2.1 Outlet temperature comparison

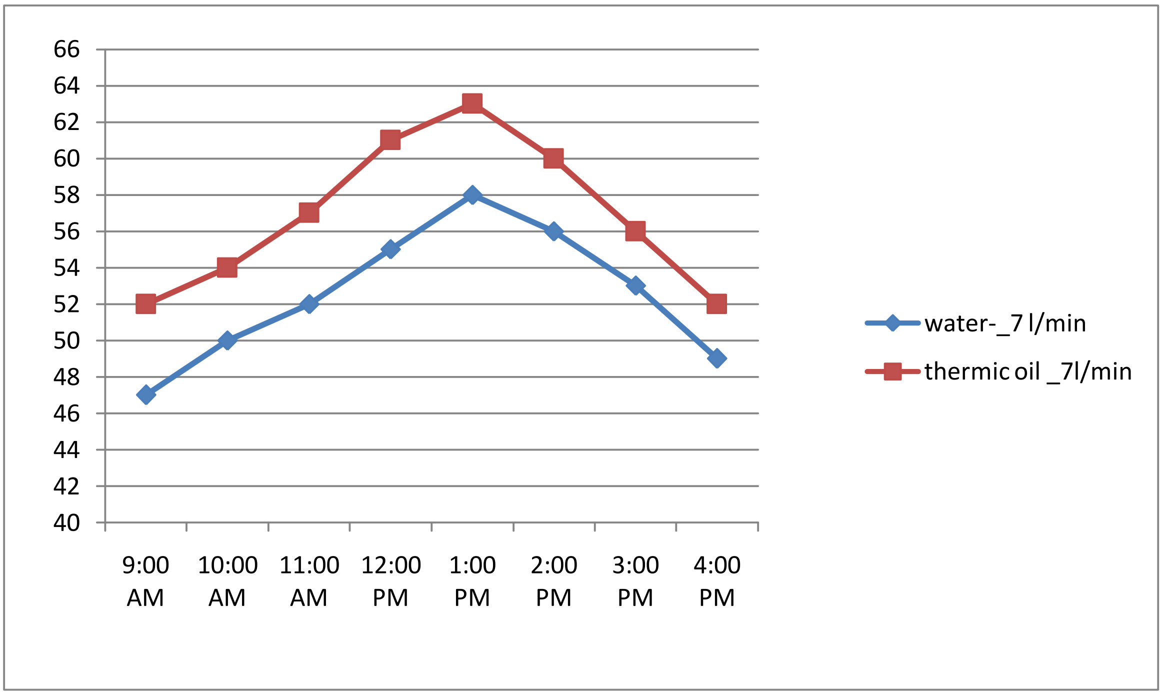

Figure 8: variation in outlet temperature w.r.t. time

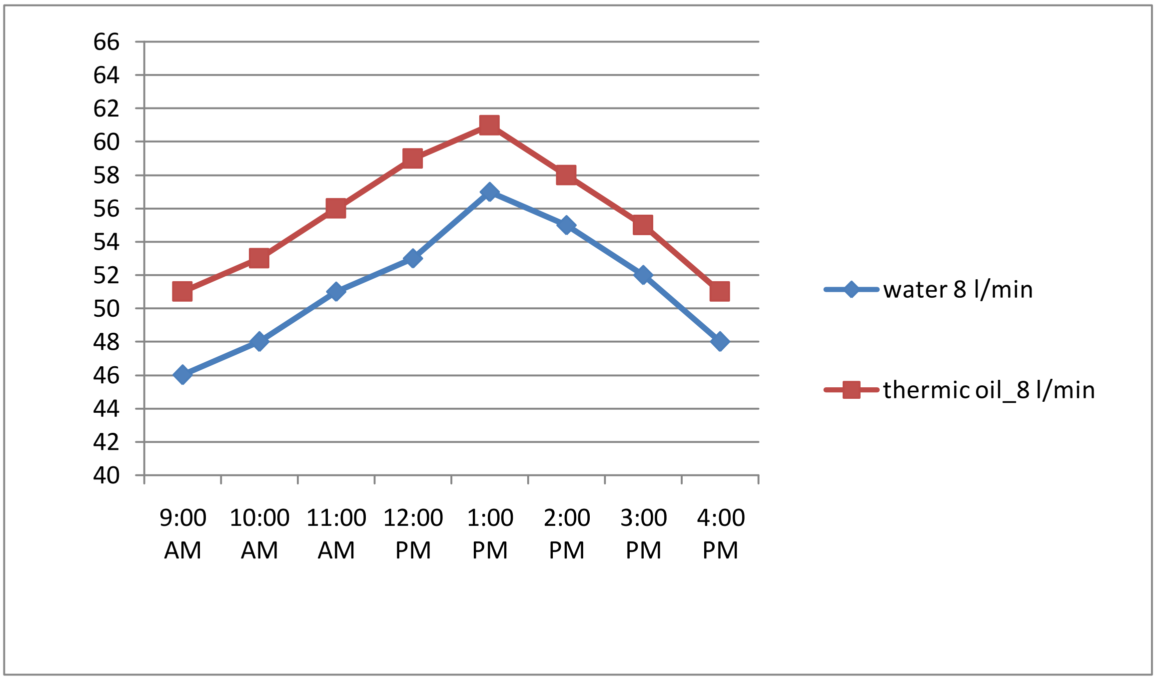

Figure 9 : variation in outlet temperature (°C) w.r.t. time

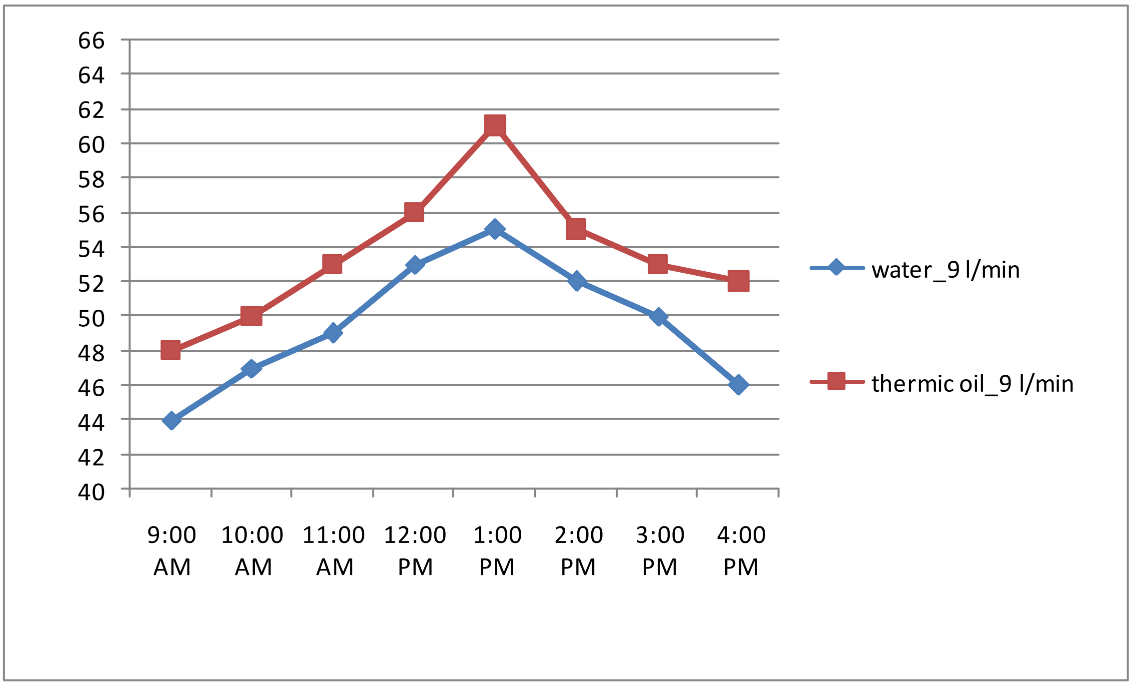

Figure 10 : variation in outlet temperature (°C) w.r.t. time

From fig 8 , 9 ,10 it is clearly seen that the outlet temperature in case of a Thermic oil is higher than that of a water as a working fluid. This is due to that more amount of heat is being absorbed by the Thermic fluid.

3.2.2 Efficiency comparison for thermic fluid and water :

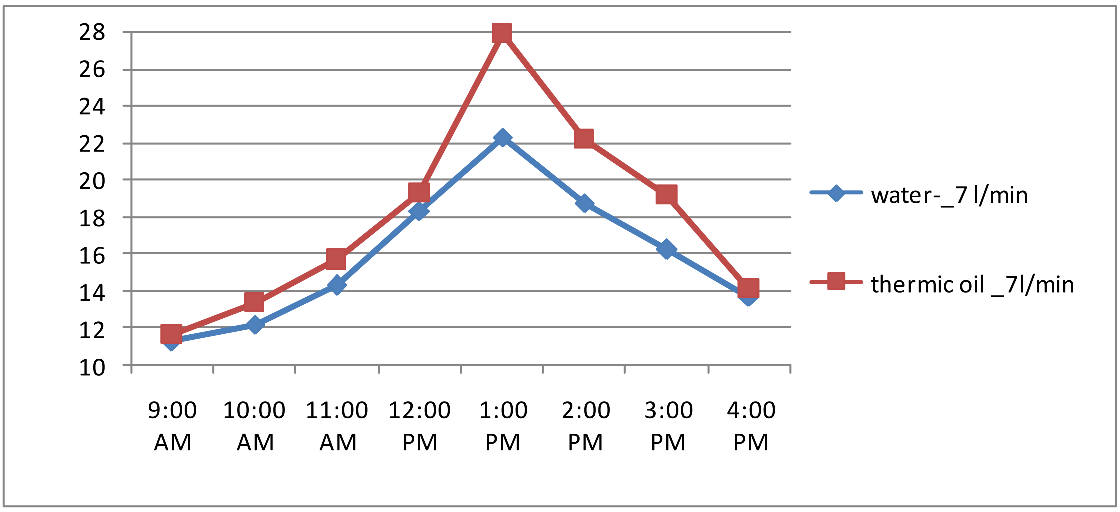

Figure 11: variation of collector efficiency (%) w.r.t. time

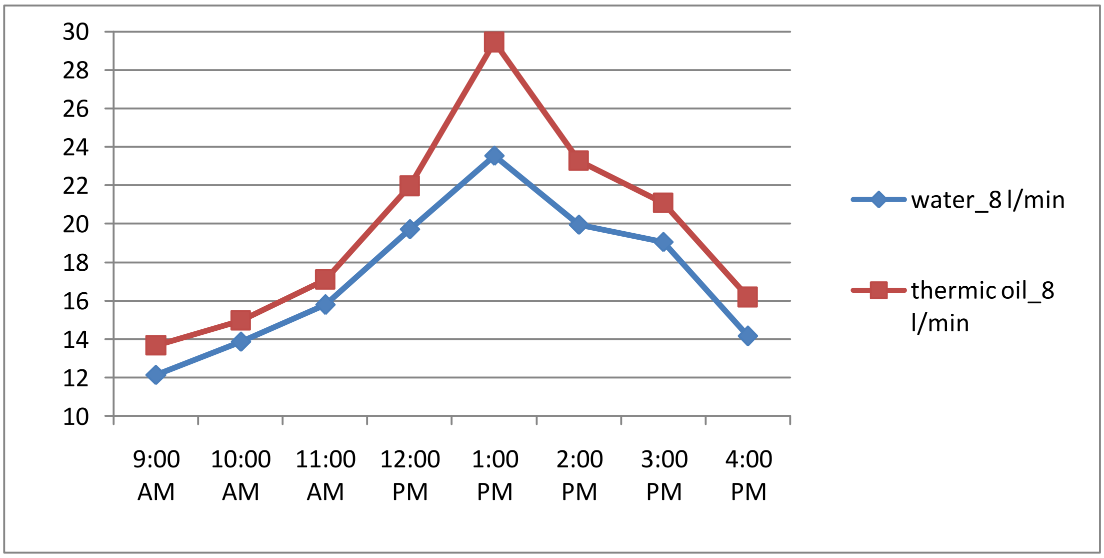

Figure 12: variation of collector efficiency (%) w.r.t. time

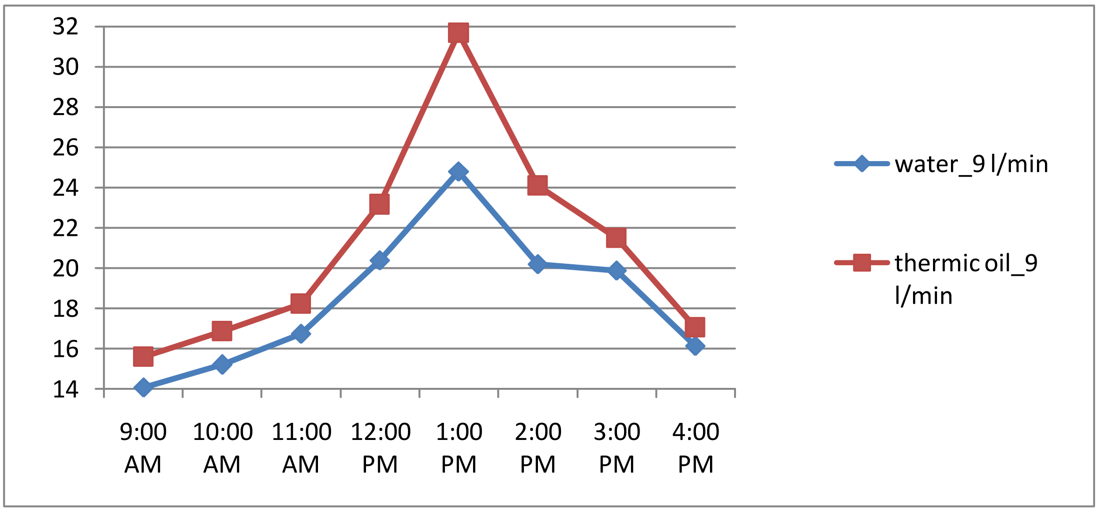

Figure 13: variation of collector efficiency (%) w.r.t. time

From fig 11, 12,13 it is clearly observed that the efficiency of the collector in case of a thermic fluid is higher than that off water because of there is a higher amount of heat is being absorbed thermic fluid as compared to that of water.

IV CONCLUSION

From the results obtained by performing the experiments, this can be concluded that

1. The efficiency of the collector increases upto 4-5% on an average as compared to water. This is due to the high thermal properties of the Thermic fluids.
2. At higher mass flow rate the temperature difference decreases but efficiency increases.
3. The efficiency is found maximum near 1 pm. This is due to the higher value of global solar irradiance.

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