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Bottle - Neck in Solar Flat Plate Collector: An Experimental Investigation and Feasibility Study of Usage of Evacuated Tube Solar Collector for High Salinity Area

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Abstract —Today the solar energy plays a vital role in various sectors. Even though the solar flat plate collector technology has been matured but in filed the technology failed because of salt deposition of raisers. Hence the present paper investigates the failure analysis of 500 LPD solar water heater installed in 2010. The main cause of failure is the salt deposition. Further in depth study on flow distribution inside the solar flat plate collector revealed that there is a non-uniformity in the flow of each raiser. The same has been ascertained with a collector on a standard test bed condition. The collector performance characteristics have been estimated for the decade year solar flat plate collector. Detailed comparison chart has been proposed and reported. To overcome this effect a new Evacuated Tube collector has been proposed. A 10-year-old evacuated tube collector installed for domestic application has been taken for study and reported.

Keywords: *Solar Energy, Flat plate Collectors, Evacuated Tube Collectors*

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I.INTRODUCTION:

Solar energy is freely available prominent energy of the future as the fossil fuels diminishes day by day. The sun generates its energy by nuclear fusion of hydrogen nuclei to helium. The total energy from the sun is $3.8*10^{20}$ which is equal to $63MW/M^2$. But our earth receives only small fraction of total radiation from sun, it is estimated that 84 min of solar radiation falling on earth which is equal to one-year world energy demand. Solar thermal energy is free and therefore one of the most cost effective technology. With the solar thermal, you can reduce your water heating bill by 50 to 75% from the energy bill and can supplement space heating as well! According to Renewable Energy Policy Network data (2010), more than 70 million people requires hot water for their day today lifestyle. By using various solar thermal system, solar energy can be directly converted into heat. In our project the solar energy is used to heat water. The solar water heating system can be either active or passive, but the active system is most commonly used. Active system relies on pumps to move the liquid between storage tank and collector while passive system rely on gravity and the tendency for water to naturally circulate as it is heated.

II.LITRATURE REVIEW:

M.S. Hossain [1]describes about the various forms of heat losses in circulating pipes of the solar water heaters due to the salt deposition in the circulating pipes, which causes a major problem in the circulation of the water through the pipes.

III.FLAT PLATE COLLECTOR:

Solar flat plate collector is active system which pump the water between the storage and collector. It consists of transparent sheet cover (glazing) and absorber plate in the insulation box. The absorber plate is integrated with tubes, which is usually made of metal sheet of high thermal conductivity such as copper and aluminium. Its surface is coated with selective material (black colour) to get high radiation absorption. The insulation box is used to reduce the heat loss from the back side of the collector. The water is inlet to tube, the heat transfers from the absorber plate to water and it gets heat, then the hot water is given to the tank as cyclic process. Due to the water circulation the salt will be deposits ontubes which reduces the water flow and the efficiency also reduced while comparing to other collectors.

This is the major drawback of the flat plate collector and one more drawback is life time of the insulation material is minimum.

IV.FLAT PLATE COLLECTOR –WITH SALT DEPOSITION:

Flatplate collector system is mainly having the potential of generating the hot water, using this system the analysis of efficiency has to be carried out in future. The efficiency of the flat plat is very less, due to the ageing effect and problems shown below,

The Problems of the fat plate collector system is

1.Salt formation in the riser tubes

2.Absorber paint peeling effect

3.Damaging of insulation

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Fig:4.1 Salt formation problem

Fig:4.2 Paint Peeling Effect

Fig:4.3 Damage of Insulation

Efficiency analysis:

All the readings are taken for every 15 minutes of time interval. The readings are plotted in the graph.

Efficiency of the flat plate collector is calculated using the formula:

Efficiency= $mc_{p\,[T2-T1]}/(H*A)$

Where,

m = mass flow rate of water (lt/min),

C_p = Specific Heat of water (J/Kg),

C_p = 4187 J/Kg,

T_2 = Outlet temperature (degree C)

T_1=Inlet temperature (degree C)

H = Intensity of solar radiation (W/m^2),

A= Area of the collector (m^2)

V.FLAT PLATE COLLECTOR – TEST RIG:

The Fig 5.1 shows the schematic diagram flat plate collector test bed,which is made up of standard test flat plate solar water heating system. The system is made of sensors and actuators for measuring the values, and displayed using the display. Then it comprises of two cool water storage tanks and one hot water storage tank for the water circulation. Here we can do the experiments in two modes of operation thermosiphon and forced circulation method. This forced circulation method of heating can be achieved using a pump. Halogen bulb setup are used to supply the required radiation level through their illumination. The radiation can be controlled using a controller. Air pressure is created using a blower located at the bottom of the test flat plate collector.Then check for the initial conditions and start the experiment.

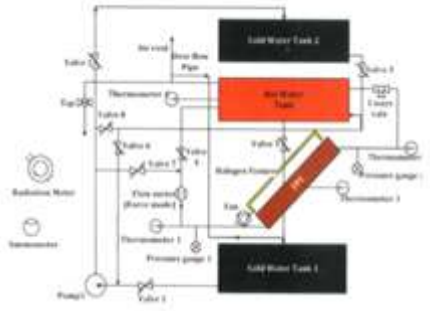

Fig:5.1 Schematic diagram of Test Rig

XI.TESTING OF FLAT PLATE COLLECTOR:

Parameters to be measured:

1.Solar Radiation flux meter

2.Ambient temperature thermometer

3.Water inlet temperature

4.Water outlet temperature

5.Mass flow rate

6.Wind speed using Anemometer

7.Plate and cover temperature

All the readings are taken for every 1 hour of time interval. The readings are plotted in the graph. Efficiency of the flat plate collector was calculated. The performance curve graph for the flat plate, test rig is plotted.

VII.EVACUVATED TUBE COLLECTOR:

The construction of the solar evacuated tube collector is mainly made up four main parts, evacuated tube (ET), Heat Pipe (HP), manifold, mounting frame.ET is the tube which is used to absorbs solar energy and converts it to usable heat. A vacuum between the two glass layers

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insulates against heat loss. The Heat Transfer Fin helps to transfer heat to the Heat Pipe. Copper vacuum pipe that transfers the heat from within the ET up to the manifold. Insulated box containing the copper header pipe. The header is a pair of contoured copper pipes with dry connect sockets that the heat pipes plug into. Strong and easy to install with a range of attachment options. The efficiency of the evacuated tube collector is calculated using the formula and finally the performance curve is plotted.

Fig:7.1 Evacuated Tube Collector

Efficiency= $mc_{p\,[T2-T1]\,/(H*A)}$

Where,

m = mass flow rate of water (lt/min),

C_p = Specific Heat of water (J/Kg),

C_p = 4187 J/Kg,

T_2 = Outlet temperature (degree C)

T_1 = Inlet temperature (degree C)

H = Intensity of solar radiation (W/m^2),

A= Area of the collector (m^2)

VIII.RESULTS AND DISCUSSIONS:

Table 8.1 Performance details of Test Rig

Time (Hrs)	T_a °C	T_{fi} °C	T_{fo} °C	Efficiency %	$(T_{fi} - T_a)/ I$
9	31	36	83	59.3	0.008
11	31	36.5	77.5	51.7	0.009
12	31	37	72	44.2	0.01
14	31	39.2	63.3	30.4	0.014
16	31	43	49.2	7.8	0.02
17	31	45.9	49.8	4.9	0.025

Table 8.2 Performance details of Flat Plate Collector-without salt

T_{ime} (Hrs)	T_a ° C	T_{fi} ° C	T_{fo} ° C	Efficiency	$(T_{fi} - T_a)/ I$
9.00	32	30	36	30.01	0.00147
1.00	34	30	33	12.44	0.00366
5.00	31	30	31	7.82	0.0046

Table 8.3 Performance details of Evacuated tube collector

T_{ime} (Hrs)	T_a ° C	T_{fi} ° C	T_{fo} ° C	Efficiency	$(T_{fi} - T_a)/ I$
9.00	32	32	40	30.01	0.00147
1.00	34	40	55	12.44	0.00366
5.00	31	42	48	7.82	0.0046

The fig 8.1 shows the various performance curves graphs of the solar water heater collectors. Here it is inferring that the efficiency of the evacuated tube solar water heater is giving more efficiency even after the 10 years of commissioning time. The comparison study makes clear understanding about the performance various types of solar water heater collectors. The readings are tabulated in table 8.1, 8.2 and 8.3

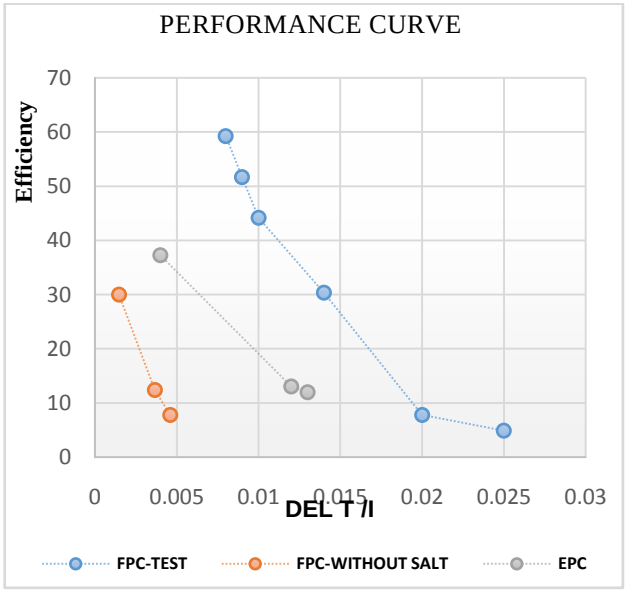

Fig:8.1 Performance curve of water heaters

Fig.8.2 shows the various of inlet water temperature with the time. This shows the exact input water temperature of various collectors. Input water temperature is varying with respect to the circulation of water in flat plate collector and test rig but in evacuated tube collector constant inlet temperature because non-circulation of water.

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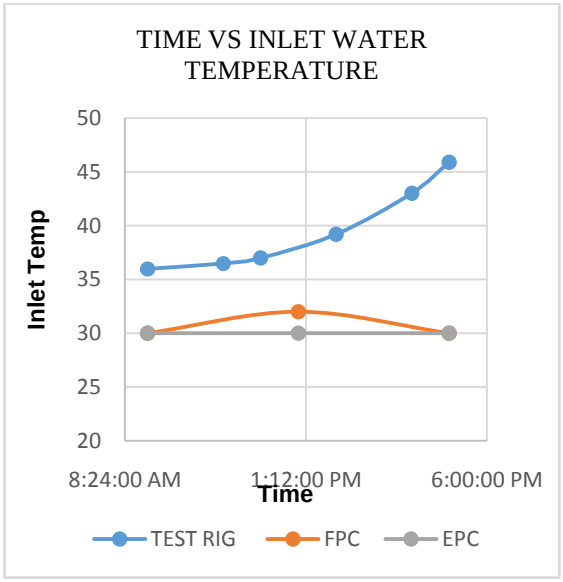

Fig:8.2 Time vs Inlet Water Temperature

Fig:8.3 shows the variation between ambient temperature and inlet temperature of different collectors. Due to the solar radiation, the ambient temperature of water gets change before.

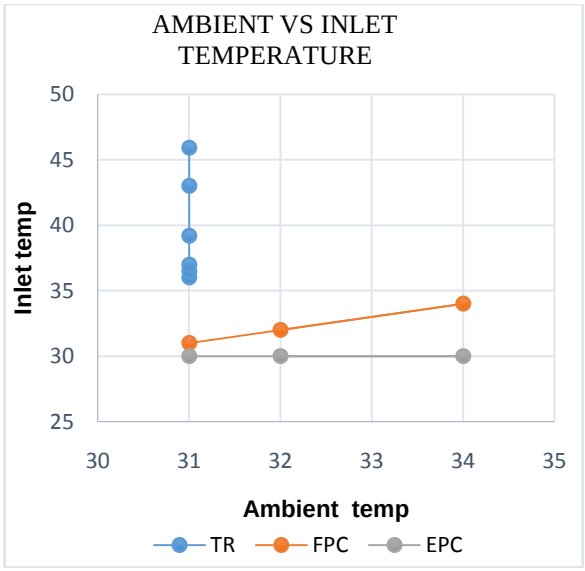

Fig:8.3 Ambient vs Inlet water temperature

Fig: 8.4 shows the output temperature of various collectors with respect to time. The collector plate temperature will vary depend on solar radiation. Due to this changes the output water temperature gets vary time to time

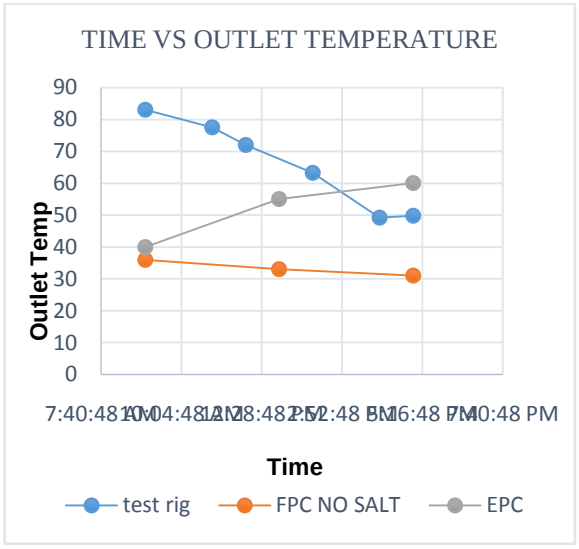

Fig:8.4 Time vs Outlet Water Temperature

TABLE 8.4 Intensity details of Test Rig

Time (Hrs)	Intensity H
9	603
11	603
12	603
14	603
16	603
17	603

TABLE 8.5 Intensity details of Flat plate collector

Time (Hrs)	Intensity H
9	680
11	820
12	435

TABLE 8.5 Intensity details o f Evacuated tube collector

Time (Hrs)	Intensity H
9	200
11	750
12	99

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Fig:8.5 shows the various intensity with respect to time. Table 8.4 shows the intensity details of test rig, we fixed the constant intensity level but in flat plate and evacuated tube collector's intensity varies due to wind flow, cloud formation and rain fall.

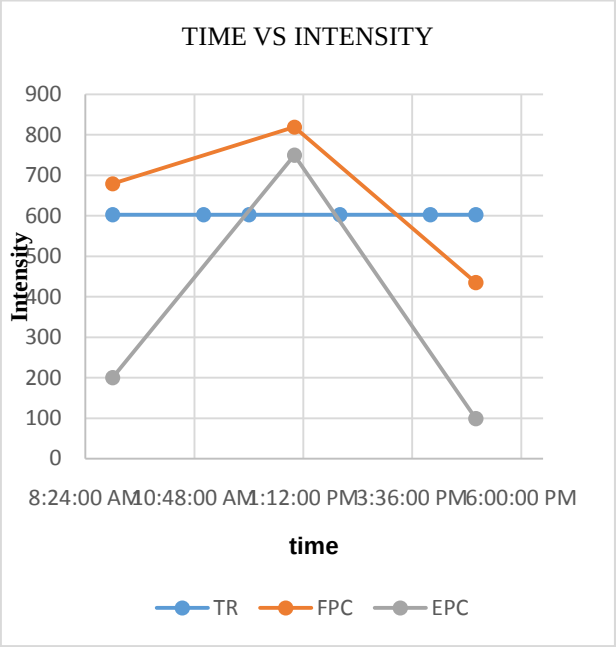

Fig:8.5 Time vs Intensity

XI.CONCLUSION:

Experiments show that there is a difference in the performance of the fresh collector and the aged one. Further after dismantling of aged collector it has been found that more than 5mm salt deposition is there in the header. From the literature it has been proved that the non uniformity exists in the collector due to the header design. The salt deposition in the header further confirmed the above. After removal of salt in the header by scraping there is no flow in the collector shows that deposition of salt in the raisers also. Hence, for high saline area the usage of flat plate collector has a limitation. The experiment has been made for an evaluated tube collector installed in a domestic house for more than 10 years shows that the performance has not been affected. The drop in thermal efficiency is also due to salt deposition in the tank areas which needs further investigation.

X.ACKNOWLEDGEMENT:

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