

PERFORMANCE CHARACTERISTICS OF SOLAR WATER HEATING SYSTEM WITH HALOGEN BULB UNDER DIFFERENT RADIATION INTENSITY

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Abstract - Performance characteristic of a solar water heating system with halogen bulb is used to determine the efficiency of the system and the impact of heat removal factor and heat loss transfer coefficient on the system efficiency. At different intensity level from a minimum value to a maximum value the efficiency has been calculated at an angle when the plate is tilted at 60°. The above procedure will be carried out when the wind speed is kept to a minimum value and when the wind speed is at a maximum value. And to determine the best efficiency of the solar water heating system by comparing the efficiency at different intensity radiation and also the best plate tilted angle at which solar water heating system efficiency is optimal.

Key Words: Solar water heating system, Non-conventional energy, LPG.

1. INTRODUCTION

As we know that from past that fossil fuels will be over around 2 decades. So the world will be fully depended on non-conventional energy sources. From non-conventional energy solar energy is most prominent and number of research work is going on to improve is overall production that is to increase its efficiency. As we know that the efficiency of solar energy is very less say around less than 10 percent. A solar water heating system is the device that uses solar energy for the production of hot water. Solar water heating system is renewable energy technology that are being used in many countries around the world. This type of energy is absolutely free and produce less pollutant and are much economical. A solar water heating system is very much environment friendly. In residential area most energy is required for the production of hot water and also for space heating. Hot water is very important for bathing and for washing utensils in urban as well as rural areas. Heating of water is usually done by firing wood in rural areas and with the help of kerosene oil, LPG, Coal and electricity in urban areas. For this heating purpose solar water heating system can be used for heating hot water. Many different types of solar water heating system are available and are much used in wide

application. Typically there are two types of solar water heating system based upon types of circulation: natural circulation and force circulation. Natural circulation ability of a fluid in a system to circulate continuously with gravity and with possible changes in heat energy. Forced circulation is a different phenomenon as it largely depends on pumps instead of natural density differences. Suitable design of solar water heating system is required which will give maximum efficiency. For this solar water heating system performance characteristics at different intensity level is carried out so that utilization will be optimal.

1.1 Objectives

- Performance characteristics of solar water heating system with halogen bulb under different intensity.
- Performance characteristics when plate is tilted at 60 degree.
- Performance characteristics when intensity is minimum wind speed are constant and tilt angle 60 degree.
- Performance characteristics when intensity is minimum wind speed are maximum and angle is 60 degree.
- Performance characteristics when intensity is maximum wind speed are constant and tilt angle is 60 degree.
- Performance characteristic when intensity is maximum wind speed is maximum and tilt angle 60 degree.

2. SOLAR WATER HEATER

A solar water heating system with tilted flat plate solar collector with water as a transfer fluid is used. The heated water of the collector rises up to the hot water tank and this hot water replaces an equal quantity of cold water and this cold water enters the collectors and the cycle continues. And further all water gets heated due to the movement of water. When hot water is taken from the hot water outlet tank, the same amount of amount of cold water is replaced by cold water make up tank which is fixed just above the hot water tank. This scheme is known as passive heating scheme as water is circulated naturally in the loop due to thermo siphon action. When the collector is fixed above the level of the hot water tank so in this case a pump is required to induce circulation of the

water and this is known as active circulation. This is also known as forced circulation. In solar water heater with halogen bulb only difference is the input energy as halogen bulb provides sufficient intensity radiation and the rest all the function are same. For better working the hot water temperature must be within 60 to 80° c.

3. TYPES OF SOLAR WATER HEATING SYASTEM

A There are two types of solar water heating system they are as follows.

3.1 Natural Circulation System

In natural circulation system the phenomenon involved is natural tendency of a less dense fluid to rise above a denser fluid can be used in solar water heating system to cause the fluid motion through the collector. The difference in density is created within the solar collector where heat is added to the liquid. When the water gets heated up it rises to the tank and cold water from the tank moves to the bottom of collector which results in natural circulation method. This type of water Heaters does not use a pump this type of heater is called passive water heater. For a passive water heating system the storage tank must be above the collector.

3.2 Forced Circulation System

When a passive solar water heating system cannot be used during to climatic or structural reason a forced circulation system is used. For accommodating the thermal expansion of water from heating a pressure relief valve and a expansion tube of small capacity is used. Here in this system water always stay in the collector, antifreeze that is propylene glycol or ethylene is required for location when freezing condition occurs. In summer the temperature in the collector is high and it cause the pressure in the loop to increase. This phenomenon can cause leak in the loop some fluid is to be allowed to escape through a pressure relief valve.

4. EXPERIMENTAL SETUP



Fig -1: Insight solar water heater



Fig -2: Arrangement of halogen bulbs

An insight solar water heater comprises of

- Halogen bulbs- to provide the required radiation (21 bulb)
- Anemometer-to measure the air velocity.
- Radiation meter – to measure intensity
- Insulated piping – for regulating flow of water
- Insulated hot water tank – the function of hot water tank is to store water
- Pump – the function of pump is to deliver water from suction head to delivery head
- Collector plate- the function of collector is to absorb intensity

Overall system specification is given in the Table-1 below

Table -1: Specifications of experimental setup

COMPONENTS	SPECIFICATION	REMARKS
Water heating system(collector and water tank)	Collector area:0.716 m ² Tank capacity : 50 L	Collector flat plate To collect and transfer heat Tank: non pressurized aluminium tank To store water
Halogen system	Halogen fixtures area :0.72m ² Number of halogen lamp: 21 Power :150 watt each Regulator :5000 w	Halogen: To supply the required intensity on the collector. Regulator: To adjust the intensity at the desire level.
Radiation meter	Range :0 to 1999 w/m ² Power supply : DC	To measure the radiation level on the collector
External water tank	Capacity : 80 L	To supply cold water to the heating system
Water pump	Power supply : AC POWER : 0.5 hp	To lift water upto the desire level To facilitate the forced mode operation
Water flow meter(for forced mode)	Sensor: Flow range :0.5 to 25 LPM Working voltage :4.5 to 24 VDC Maximum pressure :17.5 bar Working pressure : 0 to 10 bar Max rated current :8mA Withstand current :15mA Working temp: 80 c Storage temperature : 25 to 65° C Accuracy :1%fsd Supply voltage - 230 V AC	Mini turbine wheel based technology To measure the water flow rate during the forced mode operation
Fan	Range : 0 to 5 m/sec Power supply: AC with regulators	To supply the wind at different

Anemometer	Air velocity: Range : 0.4 to 45 m/sec Resolution : 0.1 m/sec Accuracy : $(\pm\% + 0.1 \frac{m}{sec})$ Air temperature : Range :14 to 60 c Resolution : 0.1° C Accuracy :0.5° C Power supply : DC 4*1.5 AAA size	The anemometer can measure the air velocity and the ambient air temperature The air flow sensor is a conventional angled vane arms with low friction ball bearing.
Pressure gauges	Sensor: Range : 0 to 6 bar Accuracy ± 3 KPA Output : 4 to 20mA (± 3) Input : 4 to 20mA DC Power : 220 VDC	Semiconductor thin -film based technology Works on the principle of generation of electrical signal due to exertion of pressure To measure the inlet and outlet pressure
Thermometers	Sensor: class A Range : -200 to 650° C Accuracy ± 15 to .002*(t) Where t is absolute value of temperature in °c Supply voltage : 230 AC	Sensor is RTD based platinum probe Works on the principle of variation of resistance with temperature To measure the inlet , outlet ,plate and tank water temperature

4. PROCEDURE OF CONDUCTING EXPERIMENT

- Keep all valves closed
- Fill cold water tank no 1
- Open the valves 1 and 2 and fill cold water tank 2 by using the pump
- Once the cold water tank 2 is full, open valve 3 and 4 and allows the water to flow into the hot water tank and the collector by gravity.
- Once the cold water tank 2 overflows and water comeback to the cold water tank 1 close the valve 1,2 and 3
- Switch on the wind generating fan.
- Measure the win speed at different locations of the collector by using the anemometer. use average value for calculation
- Similar to the wind speed measure the ambient air temperature by using the same anemometer at different locations around the experimental setup. Use an average value for calculation
- Note all the readings
- Switch on the halogen system and set the regulator for different intensity radiation
- Measure the radiation level at different locations on the collector glazing by using the radiation meter. To get the radiation levels at the desired value apply the regulator. Use an average value for calculation.
- Note down the readings after every 15 minutes
- To know the mass flow open rate open the three ways valve and note down the time required to fill a desire amount of water in a beaker.

5. RESULTS AND DISCUSSION

After conducting the experiment heat removal factor (F_R), heat loss coefficient (U_L) and efficiency (η) were calculated using following formulas.

1. HEAT REMOVAL FACTOR

$F_R = \frac{\text{Actual useful energy gain}}{\text{useful energy gain if the entire collector were at the fluid inlet temperature}}$

$$F_R = \frac{\dot{m} C_p [T_{fo} - T_{fi}]}{A_c [I_t \tau_o \alpha_o - U_L (T_{fi} - T_a)]} \dots \dots \dots (1)$$

2. HEAT LOSS COEFFICIENT

$$U_L = U_t + U_b + U_e \dots \dots \dots (2)$$

$$U_t = \left\{ \frac{\frac{1}{N}}{\frac{C}{T_p} \left[\frac{T_p - T_a}{N + f} \right]^{1/3} + \frac{1}{h_a}} \right\} + \left\{ \frac{\sigma (T_p + T_a)(T_p^2 + T_a^2)}{(\epsilon_p + 0.05N(1 - \epsilon_p))^{-1} + \frac{2N + f - 1}{\epsilon_g} - N} \right\} \dots \dots \dots (3)$$

$$U_b = \frac{K_b}{X_b} \dots \dots \dots (4)$$

$$U_e = U_b \left(\frac{A_e}{A_c} \right) \dots \dots \dots (5)$$

3. EFFICIENCY

$$\eta = F_R [(\tau_o \alpha_o) - \frac{U_L (T_i - T_a)}{I_t}] \dots \dots \dots (6)$$

Where,

$$C = 365.9x (1 - 0.00883\beta + 0.0001298\beta^2)$$

$$i^2 = (1 + 0.04h_a - 0.0005h_a^2) X (1 + 0.091N)$$

$$h_a = 5.7 + 3.8V$$

The heat removal factor (F_R), heat loss coefficient (U_L) and efficiency (η) were calculated using above formulas for radiation intensity of 449w/m², 270 w/m² and 170 w/m². The calculated readings are shown in the following tables.

1. Radiation intensity = 449 w/m², blade angle = 60 °C Wind speed = 3.8 m/sec

Table -2: Results at 449w/m² intensity

Time	F_R	U_L	η (%)
At 10:15 am	2.15	4.84	1.63
At 11:00 am	2.21	5.44	1.64
At 12:00 am	2.31	5.06	1.71

2. Radiation intensity = 270 w/m², blade angle = 60 °C Wind speed = 3.8 m/sec

Table -3: Results at 270w/m² intensity

Time	F_R	U_L	η (%)
At 10:00 am	0.96	3.61	0.73
At 01:30 pm	2.43	3.74	1.92
At 02:00 pm	3.22	3.71	2.33

3. Radiation intensity = 170 w/m², blade angle = 60 °C
Wind speed = 3.8 m/sec

Table -4: Results at 170w/m² intensity

Time	F _R	U _L	η(%)
At 12:00 pm	2.20	4.58	1.62
At 02:00 pm	5.29	4.77	3.28
At 03:00 pm	5.54	4.83	3.38

From the tables it can be seen that as the efficiency was increased when the radiation intensity was decreased. Also following graphs are plotted to make a comparison between Heat removal factor verses efficiency, Plate temperature verses time and Inlet fluid temp verses efficiency.

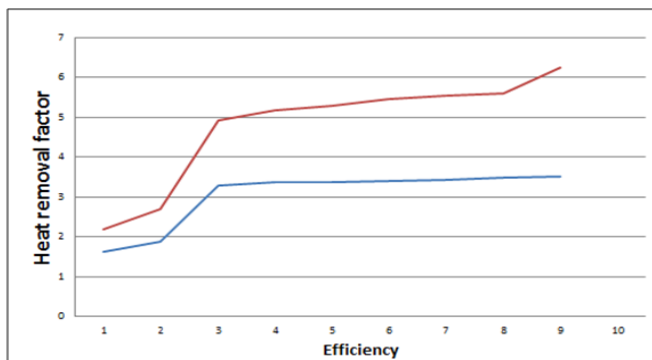


Fig -3: Heat removal factor verses efficiency

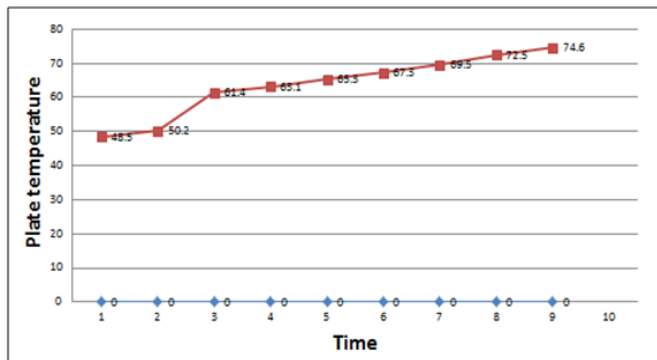


Fig -4: Plate temperature verses time

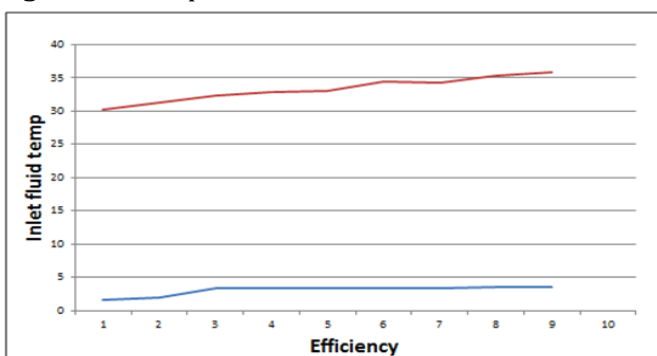


Fig -5: Inlet fluid temp verses efficiency

Fig-3 shows the graph of Heat removal factor verses efficiency where in as heat removal factor increases the efficiency also increases. Fig-4 shows the graph of Plate temperature verses time where in the plate temperature increases with the increase of time. Fig-5 shows the graph of Inlet fluid temp verses efficiency where in the Inlet fluid temperature is increasing slowly with respect to time.

5. CONCLUSION

When intensity is 171.3w/m², Wind speed = 3.8 m/sec Plate tilt = 60 degree following conclusions were drawn from the present work

- With increase in plate temperature efficiency increases.
- Efficiency increase with an increase in heat removal factor.
- Plate temperature increases over a period of time.
- Efficiency decreases with increases with an overall heat loss coefficient.
- Hot water temperature attained so far is 36.5 degree.

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