



Comparative study and experimentation of simple solar water heater using heat pipe concept

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Abstract: In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy; solar water heating is the prime application of solar energy. The problem faced by the existing solar water heating system is periodic inspections, maintenance, time to time component may need repair or replacement and also sufficient quantity of hot water is not available during cloudy/rainy days. Hence to overcome the above problem by the use of heat pipe concept which utilizes the low boiling temperature fluid to increase the heating efficiency, the objective of present work is to increase the heating efficiency solar water heater using low boiling temperature fluid.

Keywords: Solar water heater, concept of heat pipe, low boiling temperature fluid (working fluid).

I. Introduction

Solar water heating is the conversion of sun light into the conversion of sun light into renewable energy for water heating using solar thermal collector. Solar water heating system comprises various technologies that are used worldwide increasingly. A heat pipe is a sealed container, a wick structure, a small amount of working fluid that sufficient to saturate the wick and it is in equilibrium with its own vapor. The operating pressure inside the heat pipe is the vapor pressure of its working fluid. A heat pipe is a device that transports thermal energy from its one point to the other by using low boiling temperature fluid. It utilizes the latent heat of the vaporized working fluid instead of the sensible heat. As a result, the effective thermal conductivity may be several orders of magnitudes higher than that of the good solid conductors.

By the use of concept of heat pipe, which utilizes the low boiling temperature fluid as the working fluid, this working fluid is used in solar water heater to increase the heating capacity of solar water heater. Usually a working fluid is selected on operating temperature band, several possible fluids may exist and a variety of characteristics must be examined in order to determine most acceptable of these fluids for the application considered,

The prime requirements of working fluids are

- ❖ Compatibility with wick and wall materials.
- ❖ Good thermal stability.
- ❖ Wet ability of wick and wall material.
- ❖ High latent heat.
- ❖ High thermal conductivity.
- ❖ Low liquid and vapor viscosities.
- ❖ High surface tension.

The other major component includes are HDPE (High density polyethylene) pipe and copper material as a collector material.

II. Materials and Methodology

A. Materials

HDPE pipe is used as an outer pipe because it has a density of 0.93 to 0.97 g/cm³, can also withstand higher temperature (110 °C to 120°C). It can also observe the heat effectively. In the HDPE pipe working fluid is filled and sealed at both inlet and outlet. Copper pipe is inserted in a HDPE pipe where the water flows inside the copper pipe. The copper pipe is used because it has high thermal conductivity compared to other materials.

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Different types of working fluids are used for the effective heating of water are:- Air, Water, Methanol and Ethanol.

Table1: Properties of working fluid.

Sl.no.	Working fluid	Melting point K at 1atm	Boiling point K at 1atm	Useful Range K
1.	Water	273.1	373.1	303-550
2.	Air	273	90.6	423-673
3.	Methanol	175.1	337.8	283-403
4.	Ethanol	158.7	351.5	273-403

B. Methodology

In process of operation simple solar water consist of an overhead tank (inlet), copper pipe as a collector and a reservoir. The HDPE and copper pipe is arranged in a conical form and is mounted on a conical stand. The inclination angle of collector stand is 25° to the horizontal plane. The cold water is supplied from overhead tank is then circulated through the copper pipe and heat transfer take place in copper pipe because the working fluid in the HDPE pipe is heated more by observing sun light and heat transfer process take place, and the hot water through the outlet gets collected in storage tank. Different types of working fluids are used for the effective heating of water are: - Air, Water, Methanol and Ethanol.

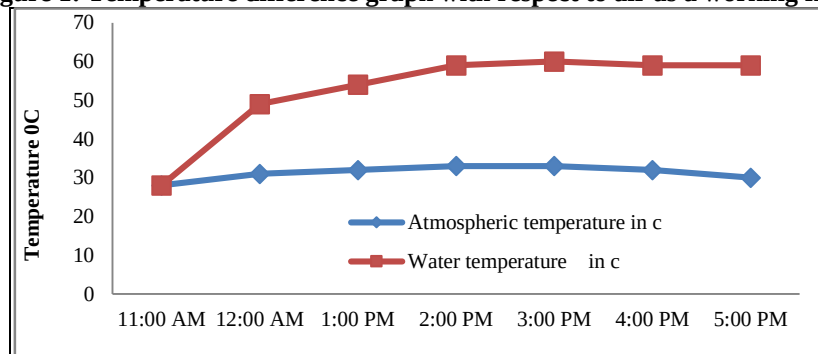
III. Results and Discussion

The experimental setup was tested under various condition for consecutive days for ambient temperature, outlet water temperature, and weather condition. The reading are tabulated in the following tables, corresponding graphs depict the variation of water temperature.

Table2: Results of Air as a working fluid

Sl.no	Time	Atmospheric temperature in °c	Water temperature in °c for air	Water temperature in °c for bare copper tube
1.	11:00 AM	28	28	28
2.	12:00 PM	31	40	34
3.	1:00 PM	32	42	36
4.	2:00 PM	33	45	39
5.	3:00 PM	33	47	40
6.	4:00 PM	32	45	41
7.	5:00 PM	30	45	40

Figure 1: Temperature difference graph with respect to air as a working fluid.

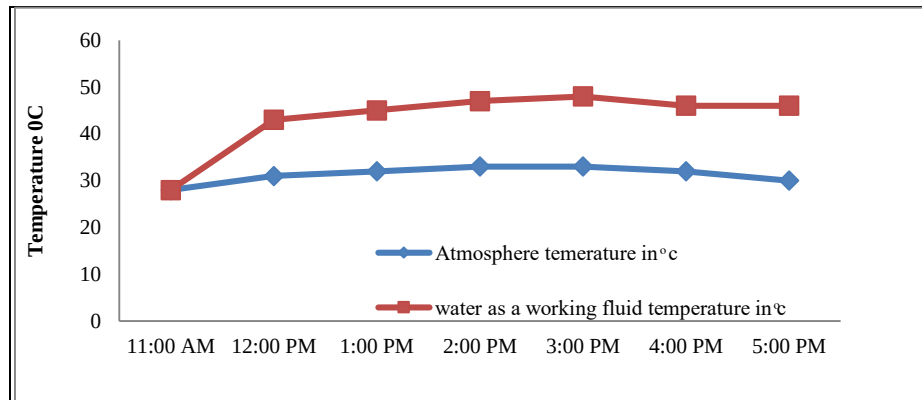


As shown in the table 2, the maximum temperature reached by using air as a working fluid is 47°C whose value is 15% greater than that of bare copper tube.

Table 3: Result of Water as a working fluid

Sl.no	Time	Atmospheric temperature in °c	Water temperature in °c
1.	11:00 AM	28	28
2.	12:00 PM	31	43
3.	1:00 PM	32	45
4.	2:00 PM	33	47
5.	3:00 PM	33	48
6.	4:00 PM	32	46
7.	5:00 PM	30	46

Figure 2: Temperature difference graph with respect to water as a working fluid

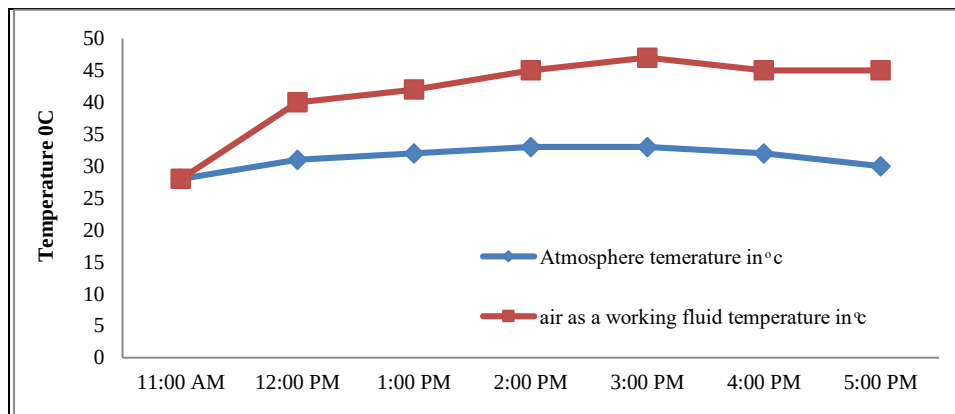


As shown in the table 3, the maximum temperature reached by using water as a working fluid is 48°C whose value is 17% greater than that of bare copper tube.

Table 4: Result of Methanol as a working fluid

Sl.no	Time	Atmospheric temperature in °c	Water temperature in °c
1.	11:00 AM	28	28
2.	12:00 PM	31	41
3.	1:00 PM	32	44
4.	2:00 PM	33	47
5.	3:00 PM	33	49
6.	4:00 PM	32	47
7.	5:00 PM	30	47

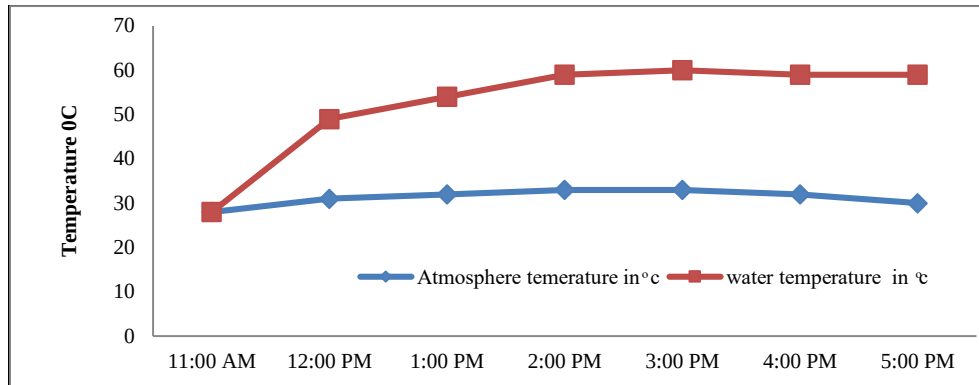
Figure 3: Temperature difference graph with respect to Methanol fluid.



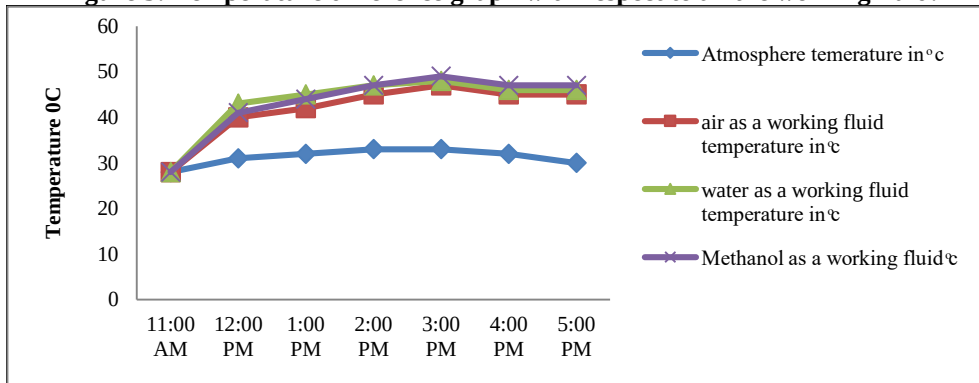
As shown in the table 4, the maximum temperature reached by using methanol as a working fluid is 49°C whose value is 19% greater than that of bare copper tube.

Table 5: Result of Ethanol as a working fluid

Sl.no	Time	Atmospheric temperature in °C	Water temperature in °C
1.	11:00 AM	28	28
2.	12:00 PM	31	49
3.	1:00 PM	32	54
4.	2:00 PM	33	59
5.	3:00 PM	33	60
6.	4:00 PM	32	59
7.	5:00 PM	30	59

Figure 4: Temperature difference graph with respect to ethanol fluid.


As shown in the table 5, the maximum temperature reached by using ethanol as a working fluid is 60°C whose value is 34% greater than that of bare copper tube.

Figure 5: Temperature difference graph with respect to all the working fluid.


IV. Conclusion

The present work carried out to check the feasibility of using the heat pipe concept for increasing the efficiency of domestic solar water heater. Here, low boiling temperature fluid such as air, water, methanol and ethanol are used to increase the efficiency of heating. From the experiment we got the maximum temperature of 47, 48, 49, 60°C respectively. The result of Present study revealed that a use of an ethanol as a working fluid for solar water heater can increase the heating efficiency of domestic solar water heater by 34%.

V. References

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