Thermal Performance Analysis of Helical Solar Water Heater

Anand Patel, Divyesh Patel, Sadanand Namjoshi

Abstract: The alternative energy sources are new option in front of world to overcome energy crisis and pollution related issues. The solar energy, wind energy and bio mass are three major sources and out of these three energy sources solar energy is the easiest source to extract useful energy because the wind energy can be useful particularly in coastal area where there is high wind velocity and energy extraction bio mass needs either chemical conversion or thermo chemical conversion process. The objective of present work is to carry out thermal performance the proposed helical solar heater by using K type thermocouple at appropriate location of the experimental set up; using thermocouple the change in water temperature for 20 lt water capacity will be carried out.

Keywords: Alternative Energy Sources, helical Solar Water Heater

I. INTRODUCTION

All forms of energy on the earth are derived from the sun. However, the more conventional forms of energy, the fossil fuels received their solar energy input eons ago and possess the energy in a greatly concentrated form. A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the hat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and are delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80 C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system. Broadly, the solar water heating systems are of two categories. They are: closed loop system and open loop system. In the first one, heat exchangers are installed to protect the system from hard water obtained from bore wells or from freezing temperatures in the cold regions. In the other type, either thermo syphon or forced circulation system, the water in the system is open to the atmosphere at one point or other. The thermo syphon systems are simple and relatively inexpensive. They are suitable for domestic and small institutional systems, provided the water is treated and potable in quality. The forced circulation systems employ electrical pumps to circulate the water through collectors and storage tanks. The choice of system depends on heat requirement, weather conditions, heat transfer fluid quality, space availability, Annual solar radiation, etc. The solar water heating systems are economical, pollution free and easy for operation in warm countries like ours. Solar water heating systems for domestic, industrial and commercial application are at present available. Except in the hilly regions and in the northern latitudes, the potential for domestic water heaters is somewhat limited. In commercial establishments however, there is great potential especially in hotels, hospitals, guest, tourist bungalows, Canteen etc. For industrial applications, solar water heating system can meet the low and medium temperature process heat requirement hot water up to 90^0 C, hot air up to 110^0 C and low pressure steam up to 140^0 C. These are especially useful in engineering, textile, chemicals, pharmaceutical, food processing, and sugar, dairy and other industries. Hot water systems have relevance for many agricultural and village industries also, such as for handloom fabrics, seri-culture, leather tanning and handmade paper [1]. The main objective of the present research work is to evaluate thermal performance of helical solar water heater. Budihardjo, G.L. Morrison [2] studied the thermal performance of water-in-glass evacuated tube solar water heaters and is evaluated using experimental measurements of optical and heat loss characteristics and a simulation model of the thermo syphon circulation in single-ended tubes. Y. Taheri, BehroozM .Ziapour, K. Alimardani [3] investigated a new techniques for solar water heater using black coated sand and all experiments results, the collector averaging daily efficiencies achieved higher than 70%. N.M. Nahar [4] focused on effect of selective surface on the performance of solar water heater the overall efficiency of the heater is 57%. The predicted performance at various Indian stations revealed that hot water is required at most places for domestic use only during winter season and it can provide 100 l of hot water at an average temperature of 50–70 ^{0}C, which can be retained to 40–60 ^{0}C till next day morning use. K.K. Chong, K.G. Chay, K.H. Chin [5] studied solar water heater using stationary V-trough collector. Integrating the solar absorber with the easily fabricated V-trough reflector can improve the performance of solar water heater system. In this paper, optical analysis, experimental study and cost analysis of the stationary V-trough solar water heater system are presented in details. Rakesh Kumar, MarcA.Rosen [6] carried out thermal performance of integrated collector storage solar water heater with corrugated absorber surface. In this investigation, the surface of the absorber is considered to be corrugated, with small indentation depths, instead of plane. The modified surface has a higher characteristic length for convective heat transfer from the absorber to the water, in addition to having more surface area exposed to solar radiation. The corrugated surface based solar water heater is determined to have a higher operating temperature for longer time than the plane surface.

Revised Version Manuscript Received on August 11, 2015.

Anand Patel, Department of Mechanical Engineering LDRP Institute, Gandhinagar, Gujarat Technological University, Ahmadabad, Gujarat, India.

Prof. Divyesh Patel, Assistance Prof. Department of Mechanical Engineering SVIT-Vasad, Gujarat Technological University Gujarat India.

Dr. Sadanand Namjoshi, Academician and Energy Consultant, Vadodara, Gujarat India.

Hussain Al-Madani [7] performed experiment on cylindrical solar water heater the efficiency of the cylindrical solar water heater was calculated. The maximum value during the experimental period was found to be 41.8%. This reveals a good capability of the system to convert solar energy to heat which can be used for heating water. An economic analysis has reveals that the cylindrical solar water heater compared with the flat plate collector is cost effective.

II. HELICAL SOLAR WATER HEATER

A helical type flat-plate solar collector is basically a black surface which is called collector that is placed at a convenient angle to the daily motion of the sun for collecting maximum solar radiation, and provided with a transparent cover for trapping the heat; appropriate insulation for reducing heat losses around the sides, top and rear can quite effectively act as an energy converter. Water is used as heat transfer fluid which moves through the tubes due to density gradient caused by temperature differences. In this experiment, a helical type thermo syphon flat-plate solar water heater has been constructed and fabricated. It has a helical collector coated with ordinary black coating. This system is a passive natural circulation heating system or non-pump system which works using heat transfer technique, designed on a thermo syphon mechanism.

Fig 1 Helical Solar Water Heater

Fig 2 Experimental Set up

III. DETAILS OF EXPERIMENTAL SET UP

In the present experimental setup following parts are used:

- Copper pipes of 1/2 inch diameter, 20 gauge thickness and 1 m length. (3 nos.) as Risers in serpentine shape.
- Copper pipes of 1/2 inch diameter, 20 gauge thickness and 0.5 m length. (2 nos.) as Headers
- 0.5 mm thick MS sheet of dimensions 0.75m X 0.5 m as Solar absorber.
- Plain glass with above mention size and 3 mm thick
- K type thermocouple (3 nos)
- Digital Temperature indicator
- Wooden box of above mentioned dimension will be used as a insulation box as well as structure box.
- 2 mm thick wooden sheet will be attached at the bottom of MS sheet to reduce heat leakages from the bottom of absorber plate.

The cold water tank for the solar water heater was filled with water. The tap was opened slightly to allow water flow to the circulating pipes through the inlet pipe. The water temperature in the tubes increases as it is heated up from the heat supplied by the absorber plate. By virtue of density difference the cold water goes down, while the hot water comes up and a flow is initiated. The hot water flow for both the SWHs was measured using stop watch and flask. Temperature was measured at three different locations.

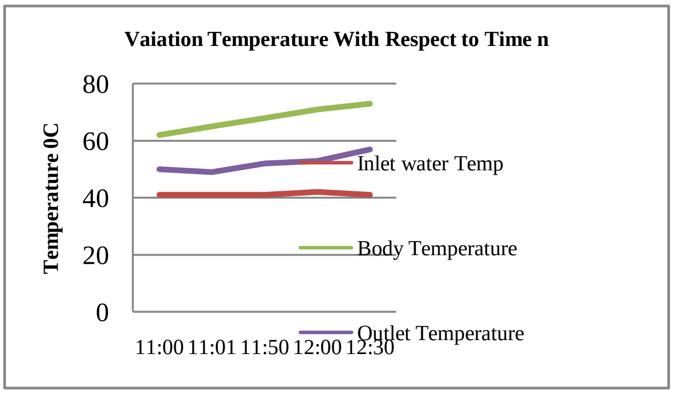
IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

The experimental readings are for the time period of 11:00 to 12:00. The maximum temperature in serpentine Solar Water Heater is 53 °C at 12:00 which was the highest temperature attained by the system at the hot water outlet mass flow rate of 0.003kg/s. The helical solar water heater is compact kind of solar water heater and the appreciable temperature value of hot water can be obtained.

Table I: Experimental Readings

Date: 8 May 2015 ṁ = 0.003 kg/s				
TIME (hh:mm)	**Time for 1000 ml Flask**	**T1in (°C)**	**T2 b (°C)**	**T3out (°C)**
11:00	292	41	62	50
11:20	294	41	65	49
11:40	297	41	68	52
12:00	300	42	71	53

Fig 3 Temperature Variation W.R.T Time



V. CONCLUSION

Experiments have been performed during the months of March, April and May and the efficiency is found highest in the month of May as the atmospheric temperature is high in May compare to other months. The maximum temperature attained by the system is 53°C.

As it is a conceptual design there is further scope of improvement in efficiency by designing a helical tube for optimization.

REFERENCES

1. Rai G.D. Solar Energy Utilisation, 5th edn. Khanna Publishers Delhi, India, 2005
2. Budihardjo, G.L. Morrison, "Performance of water-in-glass evacuated tube solar water heaters", Solar Energy 83 (2009) 49–56
3. Y. Taheri, Behrooz M. Ziapour, K. Alimardani, "Study of an efficient compact solar water heater", Energy Conversion and Management 70 (2013) 187–193
4. N.M. Nahar, "Year round performance and potential of a natural circulation type of solar water heater in India"Energy and Buildings 35 (2003) 239–247
5. K.K. Chong, K.G. Chay, K.H. Chin, "Study of a solar water heater using stationary V-trough collector", Renewable Energy 39 (2012) 207-215
6. Rakesh Kumar, MarcA.Rosen**, "**Thermal performance of integrated collector storage solar water heater with corrugated absorber surface", Applied Thermal Engineering 30 (2010) 1764-1768
7. Hussain Al-Madani, "The performance of a cylindrical solar water heater", Renewable Energy 31 (2006) 1751–1763