PERFORMANCE EVALUATION OF POLYCARBONATE COLLECTOR BASED SOLAR WATER HEATING SYSTEM

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Abstract: The Solar Water Heating System having Polycarbonate sheet as a collector has been made and experimental investigation carried out. The aim behind such performance evaluation is to find new material as solar thermal absorber and develop the feasible technology. The Collection system consists of polycarbonate sheet, heat carrier Inflow and Outflow headers, fluid tank and control device i.e. valve, and flow meter, pipe etc., is developed to perform the experiment. The optimum efficiency of the polycarbonate collector was achieved at temperature difference, i.e. the Temperature of outflow fluid and temperature of inlet fluid, 17°C and the mass flow rate of 30 kg/hr. The efficiency of the system reached 18 to 72%, depending on the ambient temperature, solar intensity, Wind speed and Mass flow rate.

Keywords: Solar Water Heater, Polycarbonate Sheet, and Solar Collector.

I. INTRODUCTION

The Increasing need of energy consumption, shrinking resources and rising costs of fossil fuel will have significant impact on our standard of living for future generations. In this situation, the development of alternative, cost effective sources of energy has to be a priority. One of the major renewable energy resources is the solar energy which sun emits to the earth. Since ancient time, the solar energy is always remaining prime source of our uses.

The technology development dependent to solar energy in last few decades, the solar water heater is most commercialize technology Yet, against a technical potential of 45 million sq.km. of collector area only a little over 2.5 million sq. km of collector area has been installed [1].

Solar water heater is a mature technology, but the fact remains that solar water heaters are not cost effective against the current price of natural gas and other fossil fuels. Research and Development can lead to significant advances in materials, design, and manufacturability, which can contribute to lowering the cost of SWHs, improving their performance, and easing installation-both in new construction and in retrofit markets. [2] The Higher Cost, Poor performance and Lesser Reliability are the major reason behind this identified Gap results into the lesser penetration of actual market lead. These are leading us to research and development based technology evolution.

The various technologies have been developed in last few decades. The flat plate collector and evacuated tube collector are widely accepted by the manufacturers and consumers.

A Simple flat plate collector consists of an absorber plate in an insulated box covered with transparent sheets. The most important part of a solar collector is the absorber, which usually consists of several narrow metal sheets aligned side-by-side. The fluid used for heat transfer generally flows through a metallic pipe, which is connected to the absorber strip. In plate-type absorber, two sheets. The outer casing which provides mechanical strength to the equipment is insulated to reduce the heat losses from back and sides of the Collector. [3]

The increasing price of copper and other material uses in existing technology impacts on the manufacturing cost of the Flat Plate Collector. The municipality water quality in many countries like India, Pakistan etc. has high residuals, which results in to two major problems: First Chocking of the tube and second is puncture due to erosion of the copper tube. The Chocking of the tube requires more number of service and the erosion results into the failure of collector much before the expected service life. The Flat Plate collector is also heavy in weight, which results into transportation and handling efforts.

An Evacuated Tube Collector works on the principle of using vacuum as an excellent insulating barrier, preventing heat loss primarily due to convection and conduction. Combining this features with selective surfaces results in a high efficiency collector. [4] In evacuated tube collector the vacuum tube is works as a collector. Solar energy radiation permeates outer glass tubes to heat water in the vacuum tubes. Since cold water has higher specific gravity and hot water has lower specific gravity, cold water flow downwards and hot water rises upwards in the inner tubes, this gradually raises water temperature in the storage tank.

The breakage of glass tube is major issue behind its lesser reliability. The supply of vacuum tube from china at lesser price, increase the competition, which leads the cheap material usages. However its lesser in cost compare to flat plate collector, still it needs further development for higher reliability.

II. REQUIREMENT OF NEW MATERIAL

The current solar water heater technologies faces the major challenges of cost, efficiency and reliability, which acts as a bump in growth 6f the world wide solar market penetration. It is necessary to find some reliable, cost effective material to bridges this gap through technology development.

The one of the solution is to replace flat plate collector with new material such as polymer, glass tube etc.

The favourable properties of polycarbonate when applied to solar collector are: low density, mechanical strength, no special surface treatment required, no corrosion, processing technique adapted to mass production; but it has low thermal conductivity, large thermal expansion and limited surface temperature. Polycarbonate sheet is lighter and tougher with high-light transmission which is useful as solar panel collector purpose. Toughness combined with transparency and high temperature resistance makes polycarbonate a perfect candidate for demanding application. [5]

The one more reason to replace polycarbonate collector with copper tube based flat plate collector is to achieve low cost. This reduces material and manufacturing cost and weight, which can reduce installation costs as well. In addition, polymer materials have not been subject to the skyrocketing price of copper. Copper prices declined to an almost four year low of $1.25/lb in late 2008, but stood at more than $4/lb in December 2010 (Kitco 2012). In contrast, the cost of commodity polymer materials has not risen as high as most metals. In most cases in 2010, the price of polymer materials remainder below $1/lb (Fumoso Industrial 2010) [6].

III. EXPERIMENTAL SETUP

The Polycarbonate sheet of 6 mm is performed as a collector. The area of absorber's working surface $2m^2$, and it's mass about 2.6 Kg. The volume of the heat carrier fluid in to the absorber is about 6 liters. The coefficient of linear expansion (0.071 mm)/(mm 0°C)of the polycarbonate collector was taken in to consideration. The collector works at temperature range from −25°C to 125°C, it was stated that the 2 m long collector will change by 14-16 mm.

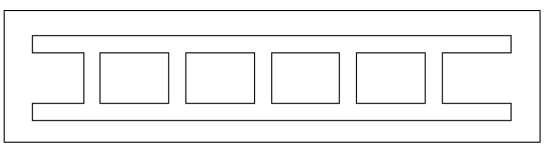

Figure 1: Cross Section of Polycarbonate Sheet

The Collection system consists of polycarbonate sheet, heat carrier Inflow and Outflow headers, fluid tank and control device i.e. valve, flow meter, pipe etc. The system has natural thermo siphon principle is used for water circulation through polycarbonate sheet.

The Polycarbonate sheet will absorbs the electromagnetic waves of solar radiation having length range of 0.4 to 2.4 Âţm. solar radiation transforms into the heat energy in the absorber, which will be transfer to the water through conduction and convection

The measurement of the ambient temperature, solar radiation, Input Fluid Temperature, output fluid temperature and flow rate were performed in the proximity of the collector field.

The Experiment data of solar collector had been recorded to determine the heat energy produced, its coefficient of efficiency, the inflow and outflow fluid temperature to analyze data.

Figure 2: Actual Experimental Setup of Polycarbonate Collector based solar water heating system.

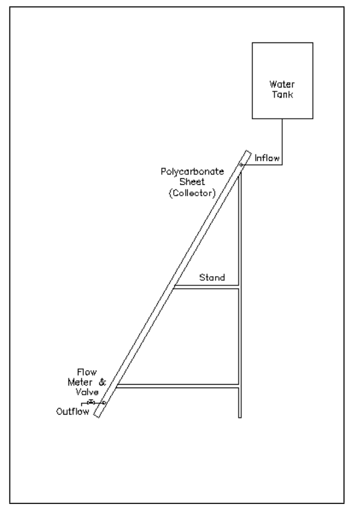

Figure 3: Functional Arrangement of solar water heating system.

IV. TEST RESULT AND DISCUSSION

The obtained experimental results are presented in fig. 4 and fig. 5. Fig. 1 shows the curves of solar irradiance and ambient temperature of April 10th, 2013. The effect of the mass flow rate on the efficiency of the polycarbonate collector is shown in fig. 5. As it seen in the curve the maximum efficiency of 72% is achieved at 830 w/m2 solar radiation, and mass flow rate of 30 kg/hour of water. There is significant loss in the performance by operating the collector at high flow rates. The efficiency of the collector is also reduced by increasing the inlet temperature of the inlet temperature of the fluid. However, the performance of polycarbonate collector was depended on various other parameters like loss of energy due to the wind, the effect of ambient temperature etc.

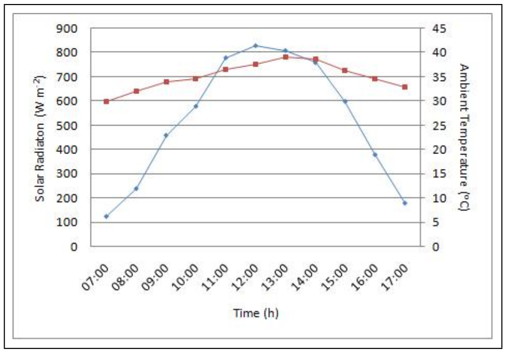

Figure 4: Variation of solar intensity and ambient temperature along the local time.

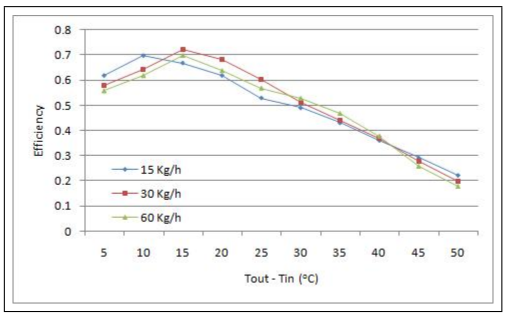

Figure 5: Effect of Mass Flow rate on efficiency of the polycarbonate collector for different temperature difference between Inlet and Outlet Temperature.

V. CONCLUSION

The successful demonstration of heating the water has been done with polycarbonate sheet based collector. However, it needs lots of future work to make it commercialize product in future.

1) During the experimental examination the maximum temperature of the heat carrier reached 72°C at the intensity of solar radiation about 0.830 kW/m2 and ambient air temperature about 37°C.

2) The optimum efficiency of the polycarbonate collector was achieved at temperature difference, i.e. the temperature of outflow fluid and temperature of inlet fluid, 17°C and the mass flow rate of 30 kg/hr.

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