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Effects of Inserts Coil-Spring Turbulator on Thermal Efficiency of Solar Flat Plate Liquid Collectors

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Abstract- The efficiency of the solar flat plate collector is improved by swirling the flow of liquid in the absorber tube. The turbulator in the absorber tube hindrance the flow of fluid and increase the efficiency of the collector. There are various type of heat transfer technique which is used in the solar flat plate collector and is mainly classified as active and passive technique. The efficiency of solar flat plate collector is increased by either of these two technique. The passive technique does not required any external source of power and for that's reason this technique do not harms the structure of the tubes neither weaken the strength of the tube material. For that reason the passive technique is most widely used for the augmentation of heat transfer rate. The various turbulator is used for the increased efficiency of the solar collector. In our present work we used the two turbulator the first one is coil-spring turbulator and the second is twisted tape turbulator. The experiment is done on these two turbulator with two different experimental setup. The experimental reading is compared with each other and see which one is most effective for the augmentation of heat transfer rate. Wire coil inserts are relatively less used and less experimented passive technique. Presence of well-established correlation of design parameters does not mean that twisted tapes are the best heat transfer augmentation device. These passive devices enhance the heat transfer, but due to increased friction, pumping power requirement of the heat exchanger is also increased. The present study is therefore focused on coiled wire inserts as heat transfer enhancement device in solar liquid collectors. The effect of dimensionless parameters such as pitch of coil to tube diameter and coil wire diameter to tube diameter on thermal efficiency of the solar collector was studied under changing flow rates in the study.

KEYWORDS-Solar flat plate liquid collectors; heat transfer enhancement; coiled spring inserts, twisted tape turbulator insert, thermal efficiency of solar collectors etc.

INTRODUCTION

The application for the installation of turbulator into the absorber

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tube for heat transfer augmentation is very commonly practice in heat exchanger process. The solar energy is one of the most capable of the alternative energy sources of energy. Due to increasing Demand for energy and rising cost of fossil type fuels (i.e., gas or oil) solar energy is considered an attractive source of renewable energy that can be used for water hearing in both homes and industry. Heating water consumes nearly 20% of total energy consumption for an average family. Solar water heating systems are the cheapest and most easily affordable clean energy available to homeowners that may provide most of hot water required by a family. The continuous increase in the level of greenhouse gas emissions and the climb in fuel prices are the main driving forces behind efforts to more effectively utilize various sources of renewable energy. In many parts of the world, direct solar radiation is considered to be one of the most prospective sources of energy. Sunlight is mainly used in Thermal and photovoltaic forms water heating, but the real scope of using hot water system is in the domestic section. Hence solar water is applicable for the use of the solar radiation falling on the Flat plate Collector is transformed into the heat energy, which is used to heat water in the range of 60˚C to 75˚C. This device makes direct use of sunlight available in abundance most part of India for most of the time.

Solar heater is a device which is used for heating the water, for producing the steam for domestic and industrial purposes by utilizing the solar energy. Solar energy is the energy which is coming from sun in the form of solar radiations in infinite amount, when these solar radiations falls on absorbing surface, then they gets converted into the heat, this heat is used for heating the water. This type of thermal collector suffers from heat losses due to radiation and convection. Such losses increase rapidly as the temperature of the working fluid increases.

Turbulator

Turbulator is a device that convert the laminar flow into turbulence flow. Turbulator create the hindrance in the passage of fluid flow. It helps to destruct the boundary layer formation on the inner surface of absorber pipe. The main purpose here for the installation of turbulator in the absorber tube is that, the fluid

Figure1 represent: Coil-Spring turbulator

when flow inside the absorber tube it takes time to flow from inlet to outlet. Time consuming of fluid flow gain the heat from the wall of absorber tube the temperature of fluid increased. In our experimental setup we use the two turbulator coil-spring and twisted tape turbulator and see the heat transfer enhancement during experiment.

EXPERIMENTAL SETUP

The experimental setup consist of a flat plate collector and the dimension of the setup is 72.96 × 72.96 cm connected with well insulated storage tank having capacity 10 liter. The cold water from the lower header is evenly distributed in the riser tube and the outlet of the tube is well connected to the the hot storage tank. Finally hot water is collected from the outlet of the tube and is collected in the insulated storage tank. The temperature difference in the storage tank accelerates the driving force and the cycle is

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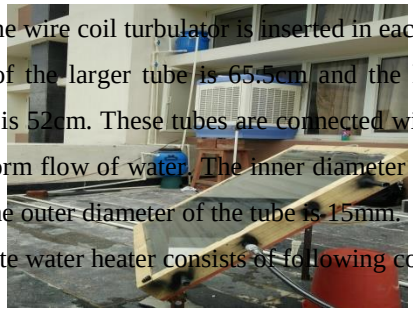
repeated until the temperature between inlet and outlet of the water is zero. A single transparent glass cover of 5mm thickness transmit the solar energy to the absorber plate. The collector and the pipe are well insulated to minimize the heat losses. Absorber plate and riser tube are made of aluminum. Taps are provided to measure the inlet and outlet temperature of water, Absorber plate temperature, Riser tube temperature and pressure drop in each riser tube. The wire coil turbulator is inserted in each of the tube. The length of the larger tube is 65.5cm and the length of the smaller tube is 52cm. These tubes are connected with U-bend to make a uniform flow of water. The inner diameter of the tube is 12mm and the outer diameter of the tube is 15mm.



Solar flat plate water heater consists of following components:

1) Absorber plate
2) Glazing
3) Insulation
4) Absorber tubes
5) A wooden box or housing enclosing whole assembly.

Figure 2 : Flat plate solar water heater

Performance Investigation

The first step before starting the experiments that had any inclusions of varying pitch turbulators was to measure plain tube readings keeping several parameters in mind to be calculated. Nusselt number was one of such parameters which, sequentially is thought to be measured under an unvarying or constant condition of heat flux. Then compared the obtained results for convective heat transfer coefficient and Nusselt number vis-à-vis the results that were obtained from the fundamental equations given by Dittus- Boelter. The main motive behind conducting the plain tube experiments was the experimental validation of plain tube. From fig. it can be concluded that the results obtained from plain tube experiments, for heat transfer i.e. the trend followed by the graph representing the variation of Nusselt number with Reynolds number lies well within the agreement depicted by the graphical trends formed by equations .

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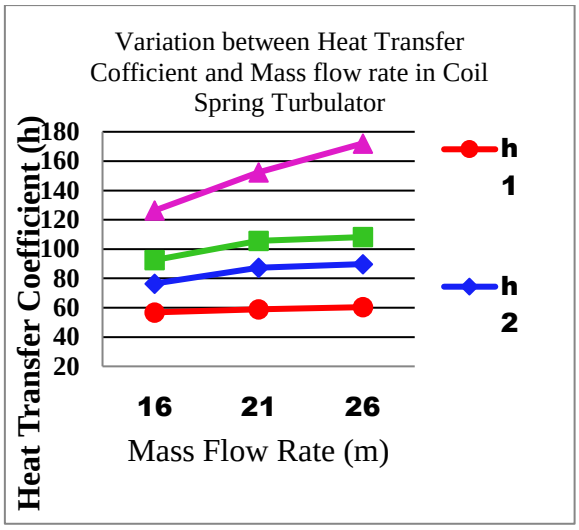

Figure 3: Variation between Heat Transfer Coefficient and Mass flow rate in Coil Spring Turbulato

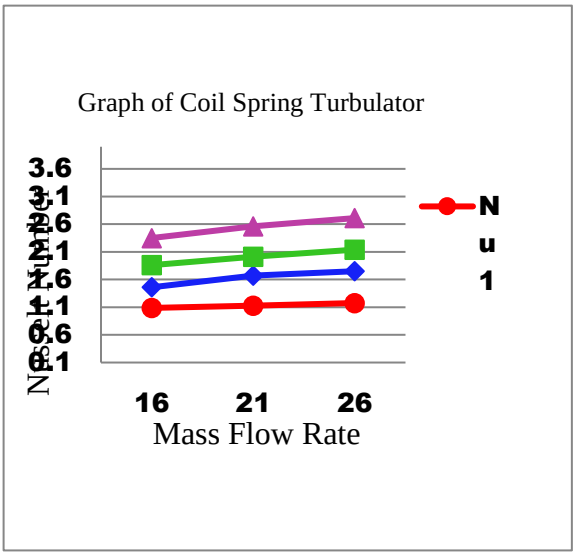

Figure 4: Variation between Nusselt number and Mass flow rate in Coil Spring Turbulator.

Experiments were performed under the unvarying mass flow rate and with the help of this we see the effect of variation in heat transfer coefficient. To obtain how much heat transfer coefficient is increased or decreased by varying the mass flow rate we calculate the Reynold number and Nusselt number. Calculation obtained were compared with each other and see how much effect is takes place in temperature.

As shown in the figure there occurs a significant change in Nusselt number and mass flow rate,when mass flow rate is kept constant there is little variation in nusselt number .It was observed that Nusselt number increase by increase in flow rate. Calculation of variation of parameter in plain tube and compared it with other other tube having turbulator, then see how much effect is produced by comparing with each other.

Concluding Remarks

The most significant concluding remarks obtained from the present study are:

The highest outlet temperature, useful heat gain and the heat transfer coefficient are achieved using twisted tape turbulators as compared to coil spring turbulators. The higher value of each of the parameters investigated is as a result of higher value of turbulence generated compared to other turbulator shape investigated. The highest value of efficiency obtained from the investigated system is 63%.

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