

Effect of Strip Insertion on Thermal Performance Evaluation in Evacuated Tube Solar Water Heater with Different Inner Tube Diameter

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Abstract

Solar energy is a form of all energy, and it is abundantly available. Solar energy is not only environmentally friendly, but it also reduces consumption of fossil fuels for energy production. Solar energy can be used for a variety of purposes, including power generating, water heating, and drying. The current research focuses on using solar energy for water heating with evacuated tube solar water heaters by introducing turbulence strip in evacuated tubes with inner diameters of 18 mm and 20 mm without twisted tape, respectively, and studying the effect of the same on the thermal performance of evacuated tube solar water heaters.

Key-word: Solar Energy, Fossil Fuels, Evacuated Tube Solar Water Heater, Turbulence Strip.

1. Introduction

Because production and manufacturing can be fulfilled solely through energy use, energy availability is critical in economic activity. Nowadays, low-cost energy is required for any country's economic development; however, because the majority of energy is still extracted from fossil fuels, countries with insufficient amounts of such fossil fuels face numerous issues related to unemployment. Renewable forms of energy such as solar energy, wind energy, and biomass, on the other hand, can help solve the energy dilemma. However, renewable energy sources such as solar energy, wind Solar energy is abundant and it is responsible for all of the light and the majority of the heat that we experience on Earth. Energy from sun i.e., solar can also be used to heat water through absorption and conduction in solar thermal collectors. It may be intensified with mirrors to cook meals and used to heat rooms

with strategically positioned windows. Photovoltaic cells can even convert photons (light) from the sun into electricity.

The effects of the tilt angle of solar collectors were studied by **Foued Chabane, Nourddine Moumami, and Said Benramache** [1]. The optimum angle is found by calculating the numbers at which overall sunlight on the solar collector is highest for a specific day or timeframe. **U. K. Nayak, S. C. Roy, M. K. Paswan, and A. K. Gupta** [2] concentrated their efforts. The friction factor and heat transmission properties of a thermosyphonic solar water heater with a flat plate solar collector and a full-length baffle with a 10cm pitch have been investigated experimentally. For this investigation, the flow regime is laminar, with Reynolds numbers ranging from 124 to 258. Work on twisted-tape began with its application in circular ducts, but it was eventually expanded to include non-circular ducts. **S.Rajasekaran, M.Chandrasekar, and T.Senthil Kumar** [3] investigated the influence of various materials used for water tubes in solar water heaters, such as steel, copper, and aluminium. Despite the limited thermal conductivity of stainless steel and aluminium, this study aims to introduce heating system with a flat plate collector that gives effective performance at a reasonable cost.

R. Meenakshi Reddy, N. Nallusamy, and K. Hemachandra Reddy [4] summarize the major experimental data of a combination sensible and latent heat thermal energy storage (TES) system integrated with such a variable (solar) heat source. Variable HTF flow rates and various sizes of spherical capsules are investigated in the TES system for distinct phase change materials (paraffin and Stearic acid) (68, 58, and 38mm in diameter). **Hussain Al-Madani** [5] conducted an experiment on a cylindrical solar water heater and calculated the efficiency of the device. During the trial, the greatest value was discovered to be 41.8 percent. This demonstrates the system's ability to transform solar energy into heat that can be used to heat water. When compared to the flat plate collector, the cylindrical solar water heater is more cost effective, according to an economic analysis. **Chii-Dong Ho, Tsung-Ching Chen, and Cheng-Jung Tsai** [6] investigated the absorber efficiencies of a recycled flat-plate solar water heater with rectangular conduit cross - section both theoretically and practically. The recycle-effect notion entails increasing the rate of convective heat transfer. On collector efficiency, the impact of flow conduit aspect ratio, incoming solar radiation, inlet water temperature, number of conduit pairs, recycling ratio, and water mass flow rate is studied. **Anand Patel** [7,8,9] reported experimental results in a solar water heater using helical and serpentine shaped tubes, as well as a solar water heater using phase change material (PCM).

The goal of such performance evaluations, according to **Sharad B. Parekh and Ripen Shah** [10], is to find new materials as solar thermal absorbers and build workable technology. Another motivation to go from polycarbonate to a copper tube-based flat plate collector is to save money. By

selecting the suitable shape and measurement of fins, **Sethuraman Ramasamy and Pakkirisamy Balashanmugam [11]** discussed the experiment with the goal of maintaining velocity at the output and improving exit water temperature. The major goal of this experiment is to maintain the pressure drop while increasing the heat transfer rate by increasing the tube area. **Vimal Dimri, et al. [12]** focuses on an attempt to analyze the inner and outer glass temperatures and their impacts on yield. Due to increased operational temperature variations between water and the inner glass cover, an active solar distillation system yielded more than a passive system. **P.P.Patil et al. [13]** analyses the design of solar water heaters to provide hot water for home and industrial purposes.

Because the design of a solar water heating system is critical to ensuring optimum benefit to consumers, they focus on and assess absorber plate materials, absorber and glazing coatings, as well as design adjustments. When constructing a solar water system, the right selection for every component of the needed capacity and installation site for a solar water heater to provide hot water is essential.

2. Experimental Methodology

In the present work first of all three evacuated tubes made from 20 mm inner diameter and 40 mm outer diameter glass with 1 m length are fabricated. These three tubes are connected with water tank made from mild steel with black coating having dimension s of 6” diameter and 15” length from where cold and hot water is recalculated in the system as per the principle of convective current. The twisted stripes with 1 m 950 mm length and 18 mm diameter with pitch of 1.5” are inserted in the evacuated tubes of another set up with same all other dimension to make flow turbulent. The ‘K’ type thermocouples are used to measure the temperature of water temperatures at inlet and outlet as well as body temperature too. The measuring flask with capacity of 1000 ml is used to measure mass flow rate water.

Fig. 1 - Experimental Set Up; Fig. 2 - Evacuated Tube with Twisted Tape



3. Result and Discussion

Fig. 3 - Temperature Variation for Low Flow Rate

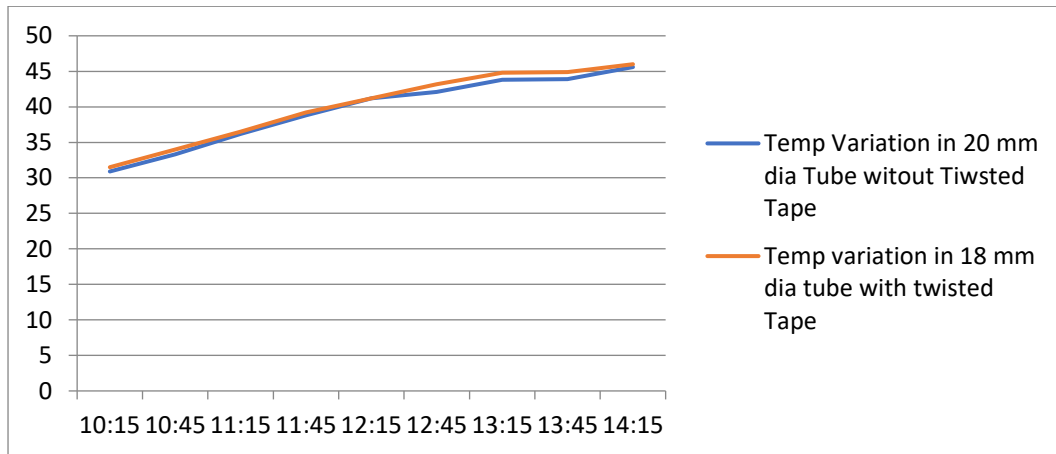


Fig.4 - Temperature Variation for Medium Flow Rate

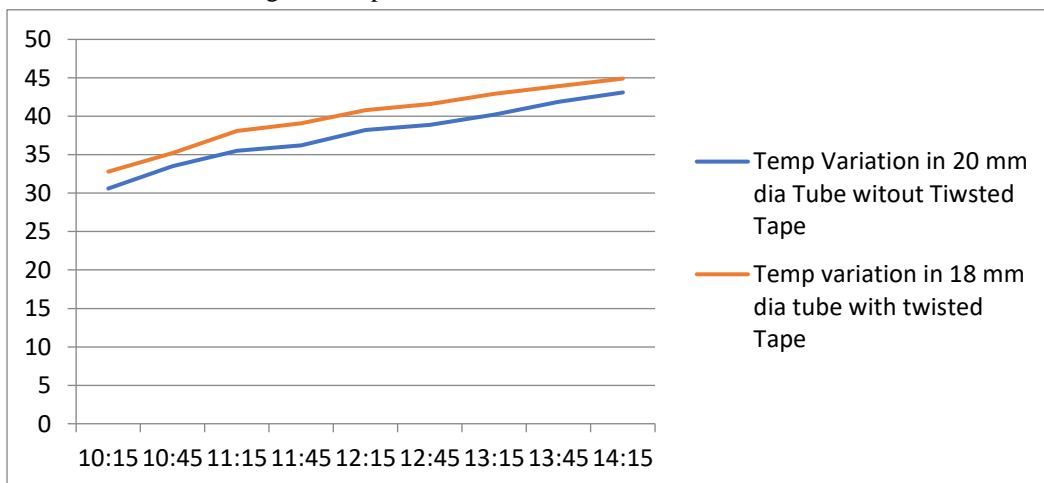


Fig. 5 - Temperature Variation for High Flow Rate

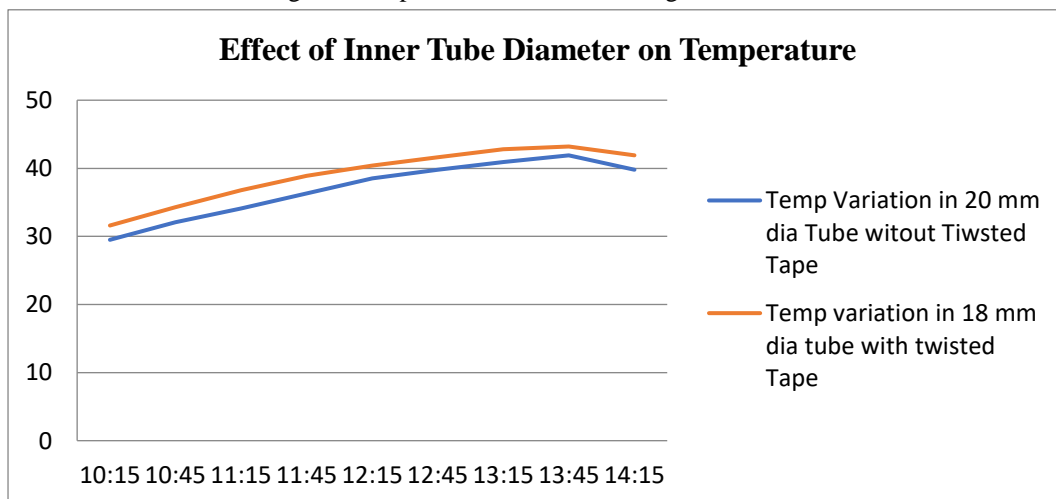


Table 1 - Mass Flow Rate of Water for Solar Water Heater

Flow	Time Required to fill 1000ml Flask (s)	Flow Rate (lps)
Low	735	0.00136
Medium	695	0.00144
High	617	0.00162

1. It is obvious from observation that the temperature gain of H₂O at low and mid flow rates is greater in both the circumstances than at high flow rates, owing to the longer retention period, which raises the temperature of the water.
2. Because this is a small experimental model of 10 lt capacity and has no protecting glass sheet and no black coating, the temperature gain is almost 1 to 1.5 °C in all circumstances.
3. In comparison to without twisted tape, higher temperature rise will be obtained with twisted tape due to turbulence in the flow and tiny inner diameters, which improve heat transfer area.

4. Conclusion

- Heat will be collected more efficiently via the evacuated tube.
- Because the evacuated tube generates a vacuum in the annular space, the solar water heater must not waste heat from the water to the air due to convection.
- There will be higher heat transmission due to the inclusion of twisted tape because water going via swirling action creates turbulence in the flow.

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