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RESEARCH ARTICLE OPEN ACCESS

CFD Study of Heat Transfer and Fluid Flow of Solar Water Heater Employing Different ProfileTubes

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Abstract:

Solar water heat system is a device that helps to heat water using energy from the SUN. This energy is completely free. Solar energy (solar radiation) is used to heat water. Water is easily heated to a temperature of 60-80o C. Solar water heater Solar water heater (SWHs) 100-300 liters of energy suitable for home use. Larger systems can be used in restaurants, bars, guesthouses, hotels, hospitals etc. A capacity of 100 liters SWH can replace an electric geyser for residential use and can save about 1500 units of electricity per year. The use of 1000 SWHs at a capacity of 100 liters each can contribute to the saving of a maximum load of about 1 MW. The 100-liter SWH can prevent the release of 1.5 tons of carbon dioxide per year. Various solar technologies have been developed to utilize natural and sustainable solar radiation. New ways to use free energy in different energy use processes continue to be created. In this project we will compare the effect of using different shape tubes on a flat solar collector. This project undertakes a flexible fluid analysis of the impact of tuberculosis on the efficiency and temperature of the outflow water.

Keywords —Solar Water Heater, Solar Collector, Collector Panels, Storage Tank, flat-plate collector panels, integrated collector/storage systems and evacuated tube collectors

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I. INTRODUCTION

Solar Water Heating (SWH) to heat water with sunlight, using a solar thermal collector. A variety of configurations are available at different costs to provide solutions for different climatic conditions and environments. SWHs are widely used in residential and industrial areas. The solar water heater is a tool that helps to boil water or keep it warm. Solar water heaters use free solar energy available. And solar power is the most widely available. A solar water heater can provide hot water for over 605 household chores. Solar heaters are very cheap and can help you save 20% energy. Depending on the weather the heater helps with water heating. There are two basic types of solar water heaters, namely, active and passive.

II. METHODOLOGY

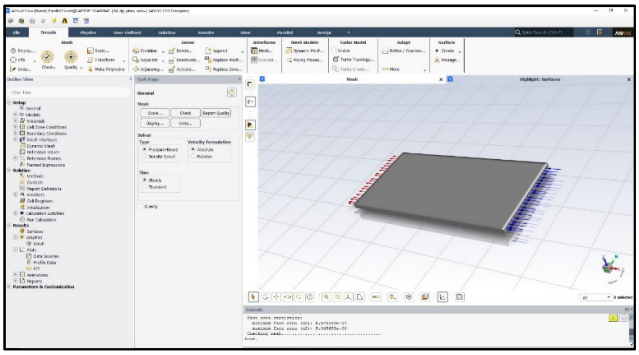
Active systems-Operating systems can be direct rotation or indirect rotation. Direct circulation systems circulate domestic water through collectors and storage tanks. These are especially good for cooler climates where temperatures often drop below freezing. Indirect circulation systems circulate the heat transfer fluid by cooling the collectors and then by the temperature change in the storage tank. These are preferred in cold climates where pipes in a straight-line system may freeze.

Passive systems are usually less expensive but less efficient. It can be collection/storage systems or thermosyphon systems. Combined storage/storage type is usually used to preheat water with a standard water heater and is best suited to weather conditions where temperatures are rarely below freezing. Thermosyphon systems rely on natural convection to circulate water, so the tank should be higher than the collector panels - hot water from the panels flows to the top of the tank and cooled water returns to the collector for warmth.

Computational Fluid Dynamics (CFD):

Computational Fluid Dynamics (CFD) is a scientific discipline dedicated to predicting fluid flow, temperature transfer, mass transfer, chemical reactions, and related conditions by solving mathematical models that control these processes using a numerical process. CFDs are used to analyse numbers and data structures to analyse and solve problems involving fluid flow Computers are used to perform calculations needed to simulate the free flow of fluids, as well as interactions with fluids (fluids and gases) and surface areas. border conditions are defined with high-speed supercomputers better solutions can be reached, and they are often needed to solve big and very complex problems. The history of Computational Fluid Dynamics, or CFD for short, began in the early 1970's. At the time, it was a summary of a combination of physics, mathematical equations, and, to some extent, computer science used to mimic fluid flow. The onset of CFD was due to the availability of powerful mainframes and advances in CFD are still strongly linked to the emergence of computer technology.

Fig .1. Window for Fluent solution set-up for Flat Plate Solar Collector



III. MODELLING AND ANALYSIS

Flat plate Solar water heater selected for Study This project is a Non-pressurized Solar Water heater with soft water and a $2m^2$ suction area with a total size of 2030x1030x100mm and a capacity of 150 litres. The Absorber has a dark chrome colour to retain heat and not let the rays escape. Collector Frames are made of Aluminium and are coated with Powder.

I. ***Absorber Plate:*** The collector or absorber plate is usually the most complex and expensive part of the collector. Flat-plate collectors include a black holding plate, floor where pipes or channels are installed. Solar energy is absorbed into the dark environment and provides heat to the liquid that is distributed through pipes or channels. The absorber plate is made of copper, stainless steel, or plastic.

II. ***Box or Enclouser:*** The complete set of collectors is locked in a box that holds all components for protection. The combination of box and frame as a unit has many important functions. The combination of the box and the frame must be weatherproof and must withstand constant exposure to objects. The unit must be able to withstand daily temperatures of up to 500 "Fahrenheit and temperature fluctuations up to 100" Fahrenheit in a few minutes.

III. ***Glass cover plate:***Conduction, convection, and other losses from the surface of the suction plate are minimized by using closing plates. Cover plates are usually made of fiber, glass, or plastic. The glass cover can be transparent, hard, or nanostructured.

IV. ***Insulations:*** Insulation is made up of fiber, glass, rock wool, or glass wool that is placed at the back and sides of the collector to eliminate any heat losses

V. ***Tubes or Flow Passages:***The flow passages conduct the working fluid across the collectors.

material is water the tube-like structure is constructed in the moving pathway and the tube is well attached to the absorber plate.

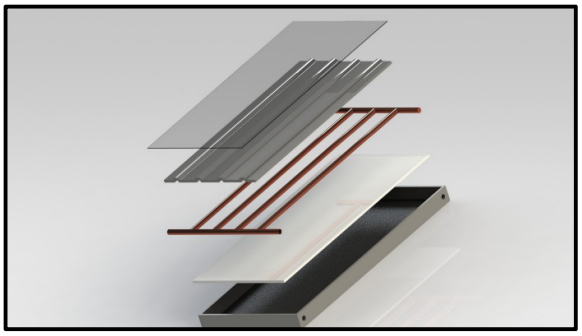


Fig .2.Exploded View of FPC Solar water heater

VI. RESULTS AND DISCUSTIONS

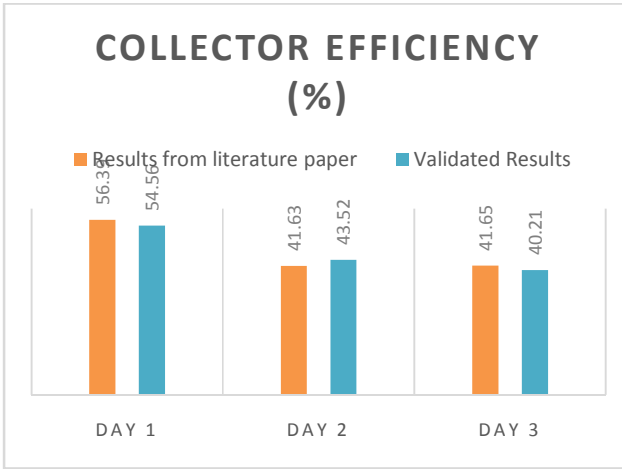
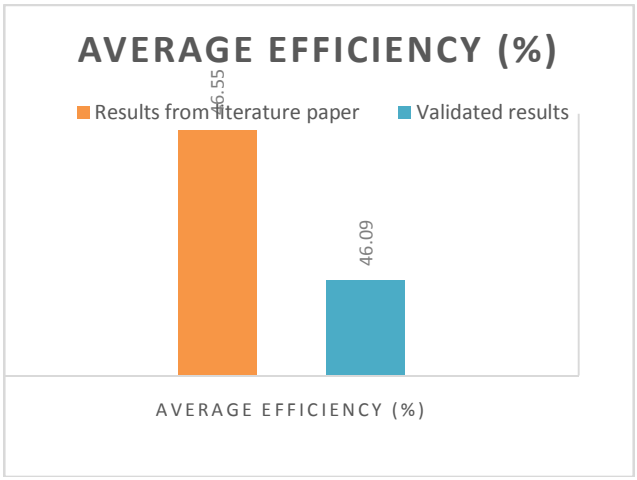
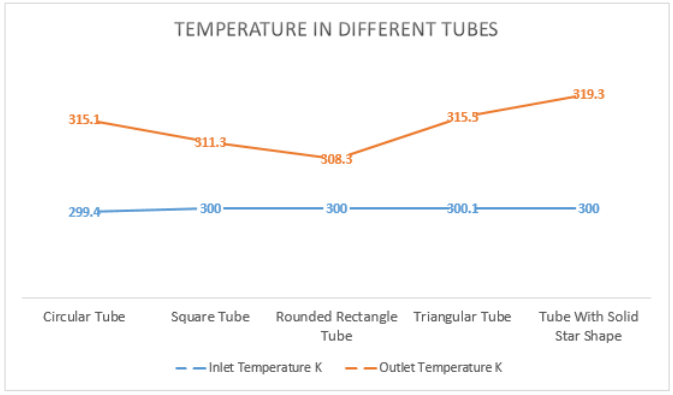


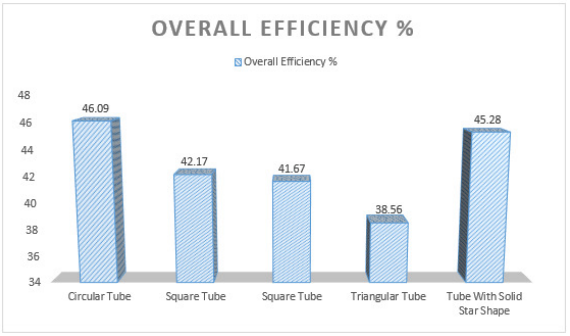
Fig .3. Comparison of Results for Validation Case for Collector Efficiency

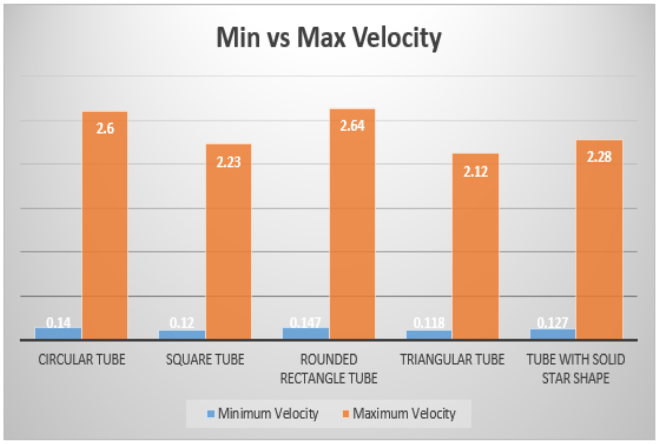


Parameters	Circular tube	Square tube	Rounded Rectangle tube	Triangular tube
Inlet Temperature K	299.4	300	300	300.1
Outlet Temperature k	315.1	311.3	308.3	315.5
Velocity m/s	0.14 to 2.60	0.12 to 2.13	0.127 to 2.64	0.118 to 2.12
Overall Efficiency %	46.09	42.17	41.67	38.56

Table ;Results Obtained from CFD analysis







VI. CONCLUSION

Based on the CFD analysis it is to be state that, the root cause of decrease in efficiency of Solar Flat Plate Water Heater is turbulence with high pressure difference but it also increases the outlet temperature as there is more heat transfer due to increase in Heat Transfer Coefficient due to Turbulence. Results show the temperature counters on Solar Flat Plate Water Heater which illustrate the increase in outlet temperatures as the turbulence Increases Conducting thermal and flow mapping by CFD tool provides extensive information about changes in Temperature and Velocity by changing the Tube Profiles. It gives better approximate solutions with material saving. It can be implemented where the direct contact thermal mapping techniques cannot be applied. The following observations can also conclude accordingly.

- Solar water heaters typically only use circular profile tubes and there are possibilities for enhancement of heating capacities of Solar Water heaters by using different tube Profiles.
- Pressure difference affects the overall Efficiency of the Solar Flat Plate Water Heater as it effects the pumping power requirements.
- Turbulence in Water due to tube shape leads to increase in Heat Transfer Rates.
- CFD tools are best for thermal and flow mapping of Solar Flat Plate Water Heater and are also reliable.

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