Experimental and Cfd Studies On Heat Transfer and Friction Factor Characteristics of A V-Trough Solar Water Heater
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Abstract
Experimental investigation of heat transfer and friction factor of a modified V-trough solar water heater using thermo siphon has been conducted and the results are compared with flat plate collector for same operating conditions. CFD analyses for the experimental conditions are also made. Results conclude that, heat transfer and friction factor are higher in modified V-trough solar water heating system.

1. Introduction
As we are marching towards sustainable development, our need to tap renewable sources is inevitable. While speaking about renewable energy we can’t neglect solar energy since its basic source for survival of human being in the earth. Renewable energy is generally defined as energy that comes from resources which are naturally replenished in a period of time such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: Electricity generation, Hot water/space heating, Motor fuels and Rural (ofF-grid) energy services.

1.1 Solar Energy
Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as Solar heating, Solar photovoltaic, Solar thermal electricity, Solar architecture and Artificial photosynthesis.

1.2.1 Classification of Solar Technology
Depending on the way they capture, convert and distribute solar energy. Solar technologies are broadly characterized as Active and Passive. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

2. Flat-Plate Collector
Flat-plate collectors are in wide use for domestic household hot-water heating and for space heating, where the demand temperature is low. Many excellent models of flat-plate collectors are available commercially to the solar designer. A discussion of flat-plate collectors is included here because of their use in industrial systems either to supply low-temperature demands or to preheat the heat transfer fluid before entering a field of higher-temperature concentrating, collectors. Flat-plate collectors will absorb energy coming from all directions above the absorber (both beam and diffuse solar irradiance). Because of this characteristic, flat-plate collectors do not need to track the sun. They receive more solar energy than a similarly oriented concentrating collector, but when not tracked, have greater cosine losses.

3. Modified V-Trough Solar Water Heater
To increase the thermal performance of solar water heater. A cost effective and easy fabricated V–trough solar water heater by parallel flow thermo siphon water heater. Integrating the solar absorber with the easily fabricated V-trough reflector improves the performance of solar water heating system. The performance of V – trough solar water heater is compared with flat plate solar water heater at same operating condition. Investigation of heat transfer, friction factor and thermal performance of V- trough solar ABE= 0 = 60º, can fully map all the vertical rays from the inclined reflector to the absorber plate purely based on geometrical
From Study of a solar water heater using stationary V-trough collector [1] water heater is also done.

**Table 1. Specification of water heater**

<table>
<thead>
<tr>
<th>Tilt Angle</th>
<th>12º</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector glazing</td>
<td>Single transparent glass of 3 mm thickness</td>
</tr>
<tr>
<td>Dimension of each mirror</td>
<td>14 cm (width) x 110 cm (length) x 0.4 cm (thickness)</td>
</tr>
<tr>
<td>Total number of mirrors per V-trough reflector</td>
<td>2</td>
</tr>
<tr>
<td>Inclined angle of each mirror</td>
<td>60º</td>
</tr>
<tr>
<td>Dimension of each glazing</td>
<td>28 cm (width) x 110 cm (length) x 0.4 cm (thickness)</td>
</tr>
<tr>
<td>Dimension of each absorber plate</td>
<td>14 cm (width) x 100 cm (length) x 0.3 mm (thickness)</td>
</tr>
<tr>
<td>Total sets of V-trough collector</td>
<td>5</td>
</tr>
<tr>
<td>Lower header</td>
<td>ID 25.4 mm</td>
</tr>
<tr>
<td>Upper header</td>
<td>ID 25.4 mm</td>
</tr>
<tr>
<td>Riser tubes</td>
<td>OD 12.5 mm, ID 11 mm, length 1010 mm</td>
</tr>
<tr>
<td>Total aperture area, AC</td>
<td>1 m²</td>
</tr>
<tr>
<td>Bottom insulation</td>
<td>50 mm extruded polystyrene</td>
</tr>
</tbody>
</table>

**3.1 Specification of Modified V-Trough Solar Water Heater**

Dimensions of absorber plate:
- Length of absorber plate L = 100 cm
- Breadth of absorber plate B = 14 cm
- Thickness of the absorber plate t = 0.3 mm
- Inner diameter of the pipe = 11 mm
- Outer diameter of the pipe = 12.5 mm

Mesh: Sweep mesh
Element type: Hexahedral mesh
Element size: 20 mm
Total Nodes: 56566
Total Elements: 38410

The figure shows the increased heat transfer ability of a modified v trough collector. Here red indicates high temperature value and the blue indicates low...
temperature value. Thus increased heat transfer rate of a modified V-trough solar heating system is clearly observed.

![Reynolds number vs Hi](image1)

**Fig. 3** Graphical Comparison of Reynolds Number with Heat Transfer Coefficient (Hi)

![Reynolds number vs 1/Hi](image2)

**Fig. 4** Graphical Comparison of Reynolds Number with 1/Hi

![Standard Time vs Intensity](image3)

**Fig. 5** Graphical Comparison of Standard Time with Intensity

![Mass flow rate vs Reynolds Number](image4)

**Fig. 6** Graphical Comparison of Mass Flow Rate with Reynolds Number

![Efficiency comparison](image5)

**Fig. 7** Graphical Comparison of Efficiency of Flat Plate Solar Water Heating System with V-Trough Solar Water Heating System

Above graph shows that efficiency of v-trough solar water heating system is higher than the flat plate solar water heating system. The comparative study of flat plate and v-trough solar water heating system reveals that the friction factor and heat transfer rate is more promising in v-trough solar water heating system.

5. **Conclusions**

Efficiency of v-trough solar water heating system is higher than the flat plate solar water heating system. The comparative study of flat plate and v-trough solar water heating system reveals that the friction factor and heat transfer rate is more promising in v-trough solar water heating system. Integrating the solar absorber with the easily fabricated V-trough reflector can improve the performance of solar water heater system.

**References**


