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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.

Keywords: *Friction Factor; Flat Plate Collector; V-Trough Solar Water Heater; etc*

1.0 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.

2.0 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.

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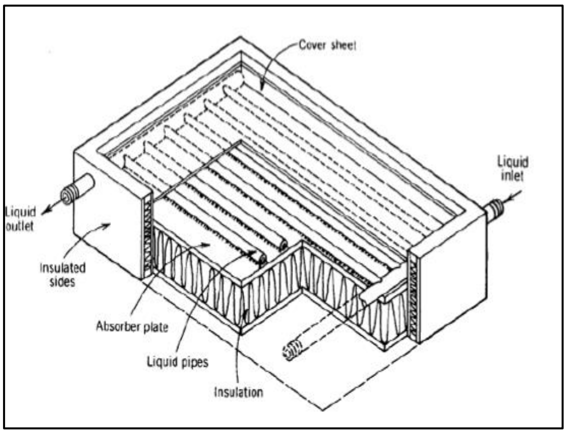
Fig 1: Flat Plate Collector



3.0 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 syphon 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= θ = 60º, can fully map all the vertical rays from the inclined reflector to the absorber plate purely based on geometrical optics.

From Study of a solar water heater using stationary V-trough collector [1] water heater is also done.

Fig 2: V– Trough Solar Water Heater

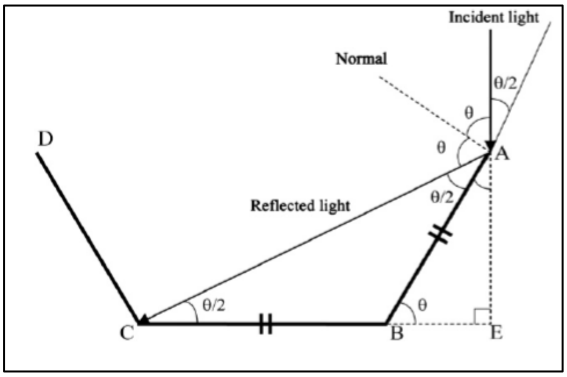


Table 1: Specification of Water Heater

Tilt Angle	12º
Collector glazing	Single transparent glass of 3 mm thickness
Dimension of each mirror	14 cm (width) ×110 cm (length) ×0.4 cm (thickness)
Total number of mirrors per V-trough reflector	2
Inclined angle of each mirror	60º
Dimension of each glazing	28 cm (width) × 110 cm (length) × 0.4 cm (thickness)
Dimension of each absorber plate	14 cm (width) ×100 cm (length) × 0.3 mm (thickness)
Total sets of V-trough collector	5
Lower header	ID 25.4 mm
Upper header	ID 25.4 mm
Riser tubes	OD 12.5 mm, ID 11 mm ,length 1010 mm
Total aperture area, AC	1 m2
Bottom insulation	50 mm extruded polystyrene
Reflector insulation	15 mm extruded polystyrene
Tank type	Horizontal
Tank volume	100 liters
Tank wall thickness	3 mm
Tank insulation thickness	50 mm

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

Fig 2(a) : Modeling Of Absorber Plate Using Catia V5 Software

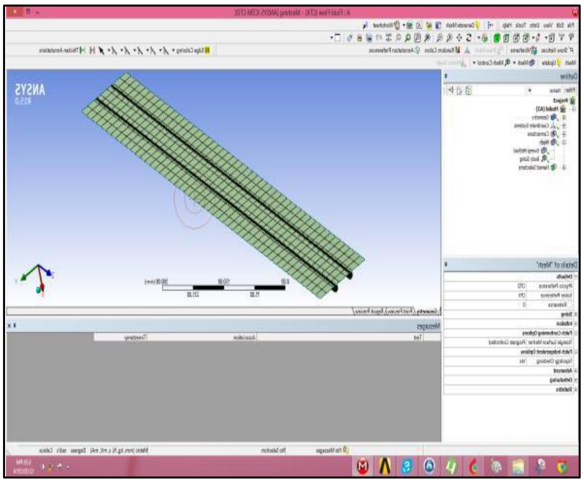
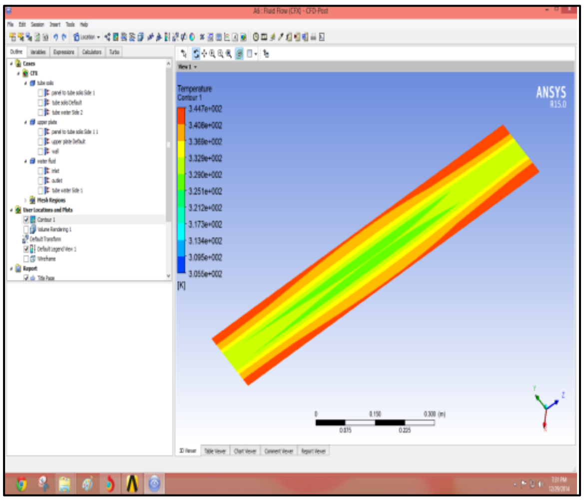


Fig 2 (b) : Modeling of Absorber Plate Using Catia V5 Software



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.

Fig3: Graphical Comparison of Reynolds Number with Heat Transfer Coefficient (Hi)

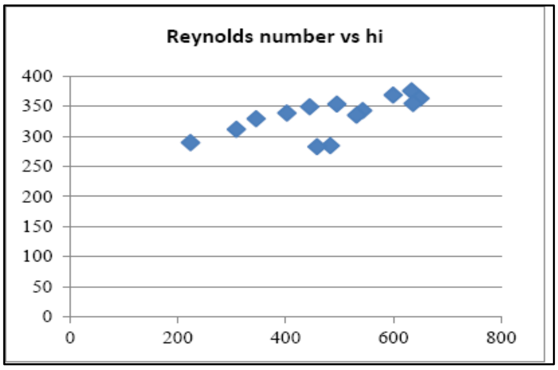


Fig 4: Graphical Comparison of Reynolds Number with 1/Hi

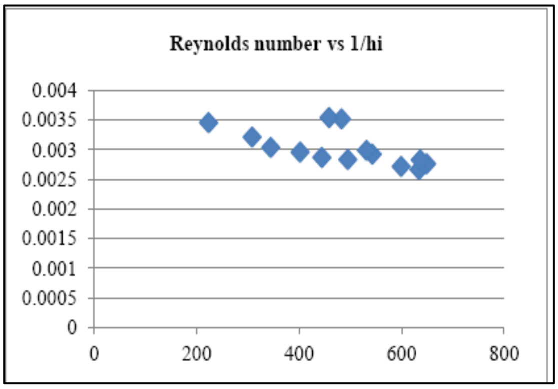


Fig 5: Graphical Comparison of Standard Time with Intensity

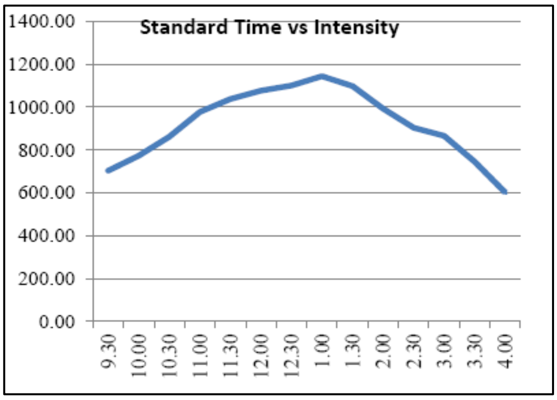


Fig 6: Graphical Comparison of Mass flow Rate with Reynolds Number

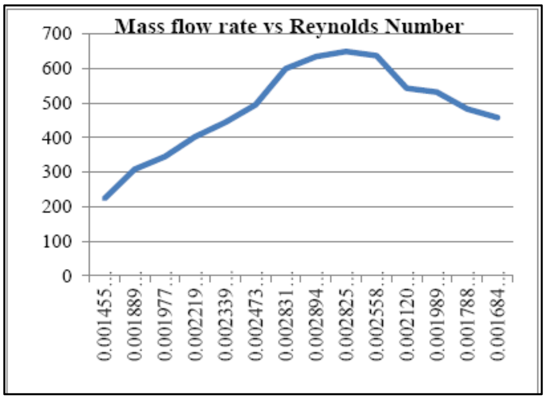
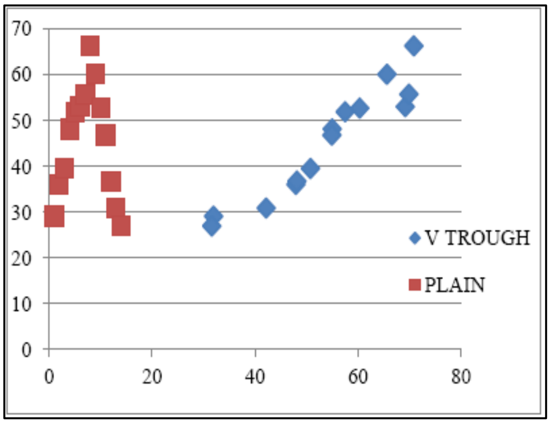


Fig 7: Graphical Comparison of Efficiency of Flat Plate Solar Water Heating System with V-Trough Solar Water Heating System



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.

5.0 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.

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