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THE EFFECT OF MASS FLOW RATE ON THE HEAT TRANSFER SOLAR WATER HEATER WITH USING NANO FLUID ON CFD

Gyan Singh[1], Yogesh Tembhurne[2], Vijaykant Pandey[3]
M.Tech Schoalr[1], Assistant Professor[2, 3], Department Of Mechanical Engineering
Bhabha Engineering Research Institute, Bhopal

Abstract
This study was performed in an open environment in bright sunlight. The solar water heater was used for the study of the effect of sunlight on the Nano-fluids. The solar water heater was directly facing the sun. A Nano-fluid was prepared by using Nano-particles of different materials with water. The mass flow rate of the water at the inlet was 1lpm (0.017kg/s). The Nano-fluids were made to flow through the solar heater from the inlet at a temperature of about 320k. The outlet temperature of the Nano-fluid was observed in order to find the Nano-fluid with the highest temperature. The results shows to increase the efficiency and performance of solar heat pipe collector using PbO nanofluids at 0.5% fraction.

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Keyword: flat plate solar collector, ZnO/water nanofluids, flow rate, the outlet-inlet temperatures difference

Introduction

Solar Energy

Sun is the main source of energy in system. It offers us the energy of great potential in terms of activity the world's need. As the primary energy resources are depleting constantly, solar energy draws attention of investigators all through the world. Solar energy is one among the alternative energies that have large potential. It's estimated that the earth receives close to 1000W/m2 quantity of solar irradiation during a day. The radiation incident on the Earth's surface is comprised of two kinds of radiation – beam and diffuse, go inside the wavelengths from the ultraviolet to the infrared (300 to 200 nm), that's characterized by a mean solar surface temperature of approximately 6000°K. The number of this solar power that is intercepted is 5000 times larger than the sum of all totally different inputs – terrestrial nuclear, energy and gravitative energies, and lunar gravitational energy. to place this into perspective, if the energy created by 25 acres of the surface of the sun were harvested, there would be enough energy to provide this energy demand of the world (Bouska, 2004).
When solar radiation incident on a surface then a number of this radiation is absorbed and in turn, increase the temperature of the surface. Because the temperature of the body will increase, the surface loses heat at an increasing rate to the environment. Steady-state is reached once the speed of the solar heat gain is balanced by the speed of heat loss to the close surroundings. The full energy received from the sun, per unit time, on a surface of unit area kept at right angles to the radiation, in universe; just exterior the earth's atmosphere is thought as solar constant. The value of the solar constant is concerning 1350 w/m2.

Extraterrestrial radiation is that the solar radiation that falls on a surface traditional to the rays of the sun outside the atmosphere of the planet. This extraterrestrial radiation at the mean earth-sun distance is called the rate. As a result of the extraterrestrial radiation passes through the atmosphere, a part of its mirrored back to space, part is absorbed by air and water vapour, and a few is scattered. The solar radiation that reaches the surface of the world is thought as beam (direct) radiation, and also the scattered radiation that reaches the surface from the sky is thought as sky diffuse radiation (Bouska, 2004).

Solar Energy Collector

The conversion of solar Thermal Energy into a lot of usable type (e.g. Heat or Electricity) is completed by solar energy collectors. A solar collector may be a device that transmissions the collected solar energy to a fluid passing in dealings with it, accordingly it's always a problem of analysis to know that however with efficiency solar collectors are changing solar energy into thermal energy.

The Classification of solar collectors is:

(i) Non-Concentrating or flat plate type solar collector
(ii) Concentrating type solar collector

Non-Concentrating solar collector:

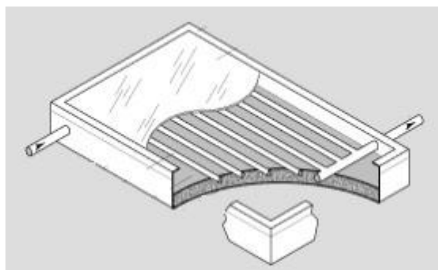

Fig. 1 Cross-sectional view of Flat plate collector

Concentrating Type solar collector:

(Parabolic trough) (Dish type collector)

Fig.2 concentrating solar collector

The most usually used of the solar collectors are the flat plate collectors. Flat plate collectors, technologically advanced by HOTTEL and WHILLIER in the 1950s. Flat plate collector is an isolated box with the glazing (glass or plastic cover) and a dark colored absorber plate. These collectors heat up liquid or air at temperature less than 80˚C. Flat plate collectors are more classified supported fluid used (e.g. Liquid heating collector or solar air hater).

Methodology

Step of working

- Collecting information and data related to the flat plate solar heater.
- A fully parametric model of the flat plate solar heater is generated using CATIA V5 Design Modeler.
- Model obtained is analyzed using ANSYS 15 (FLUENT).

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- Manual calculations are done.
- Finally, we compare the results obtained from ANSYS.

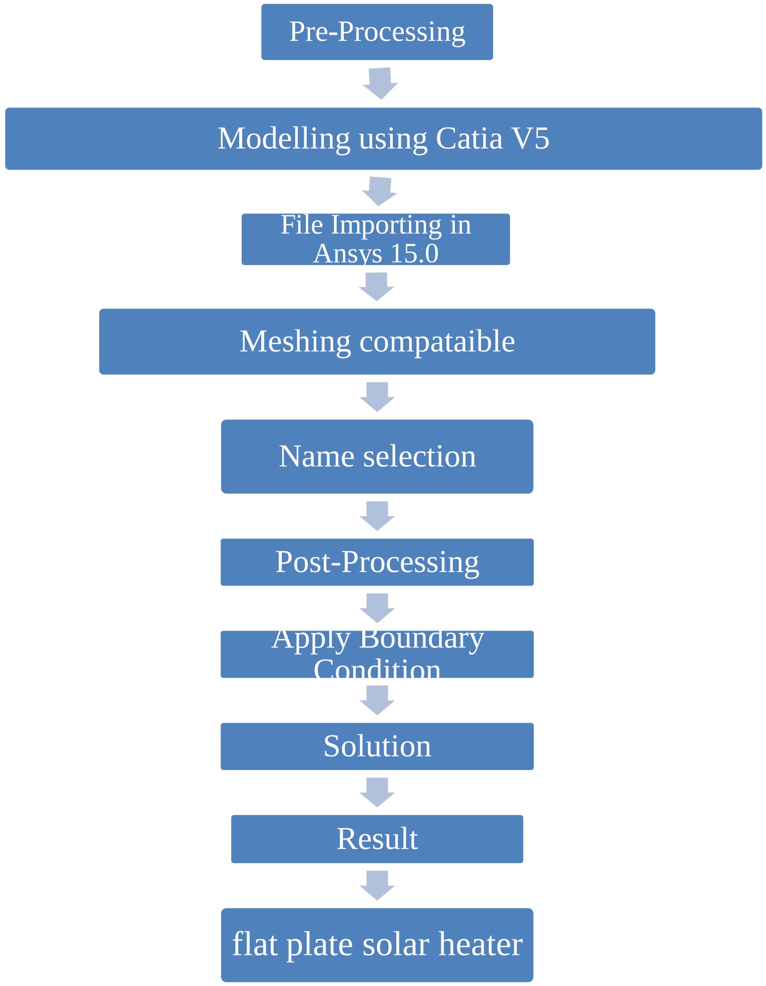

Fig.3 Setup of working

Flat Plate Solar Collector

Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar area heating. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark-colored absorbent plate. These collectors heat liquid or air at temperatures but 80°C.

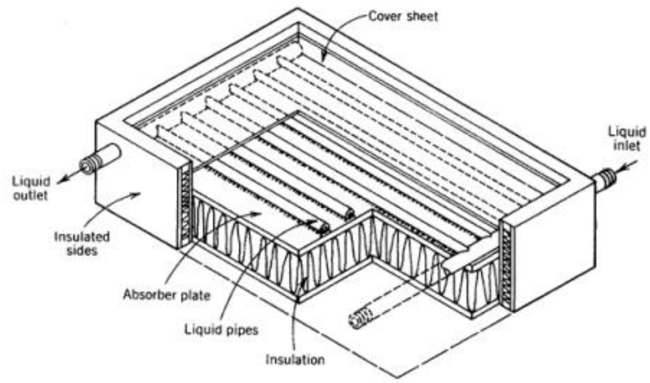

Fig.4 A typical liquid Flat Plate Collector

For design proposed model some specifications are shown in table 1.

Table 1 The specifications of solar collector.

Component	Dimensions	Remarks
Absorber Plate	(0.95x0.526x0.003)m	Material: stainless steel
Glass cover	Thick (4 mm)	Window glass
Collector area	(1.04x0.64x0.12)m	
header pipes	Inner diameter (16) mm,outer diameter (20) mm Length (60) cm	Copper
Riser pipe	Inner diameter (8) mm, outer diameter (10) mm, Length (80) cm, centre to centre distance (7.5 cm)	copper Number of tubes: six

Material Property

Table 2: Material property of nanoparticles

Material	Density (Kg/m3)	Heat Capacity(J/kg.k)
ZnO	5606	376.8
CuO	6500	535.6
PbO	9530	205.2

Table 3: Properties of water

Heat capacity (J/Kg.K)	4185.5
Viscosity (Kg/m.s)	0.001054
Thermal conductivity (w/mK)	0.6

Mass flow rate (kg/s)	0.017 (1 lpm)

Properties of Nano fluid

Table 4: Material property of nanoparticles

Material	Density (Kg/m3)	Heat Capacity(J/kg.k)
ZnO+Water	1023.03	2281.15
CuO+Water	1027.5	2360.55
PbO+Water	1042.65	2152.75

Model of solar pipe

Component	Dimension	Material
Header pipe	Length – 60 cm, Outer diameter – 20 mm, Inner diameter – 16 mm	Copper
Riser pipe	Inner diameter -8 mm, Outer diameter -10 mm, Length -80 cm	Copper

Table 5: Material properties of the copper solar plate heater

Density (Kg/m3)	8978
Specific heat(Cp) (J/kg.K)	381
Thermal conductivity (w/mK)	387.6

CAD Model of the solar heater

The above figure 5 shows the CAD Model of the solar heater.

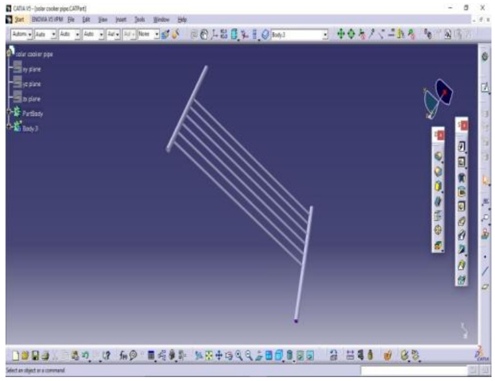

Fig.5 CAD Model of the solar heater

Meshing

Table 6: Nodes and Element of Solar Heater

Nodes	Element
857890	2282934

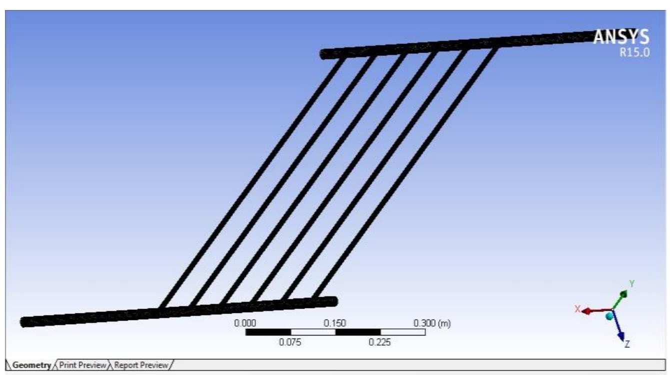

Fig.6 meshing of Solar Water heater

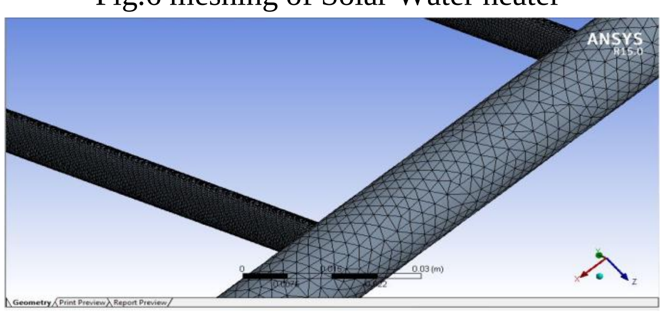

Fig.7 Zoomed view of the meshing of solar water heater

Boundary Conditions and Assumptions

In this analysis rate of flow (1, 2 and 3) with numerous inlet temperatures was introduced and also the pressure outlet condition is carried at the exit. The thermo- physical properties of the operating fluid (water and ZnO/water, CuO/water, PbO/water) assumed constant at mean bulk temperature. Impermeable boundary and no-slip wall conditions was performed on the channel walls.

Assumptions:

a) Water and ZnO/water, CuO/water, PbO/water nanofluids was used as operating fluid, it's incompressible fluid.

b) The flow regime was thought-about to be laminar.

c) The thermal-physical properties of water and absorbent material tube are independent of temperature.

d) The face of the absorbent material plate and also the bottom a part of the absorbent material tube was supposed to be adiabatic.

Result Analysis

CFD SIMULATION OF THE SOLAR WATER HEATER

The study was carried out using ANSYS FLUENT tool.

Case -1 Using the Nano-fluid – ZnO

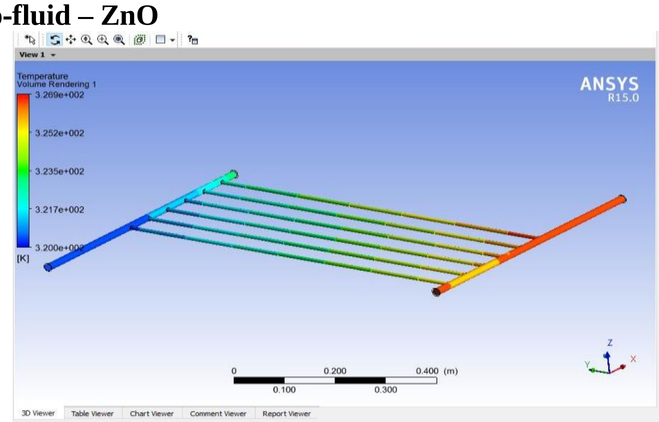

Fig.8 Temperature for using ZnO nanofluid

Case -2 Using the Nano-fluid – CuO

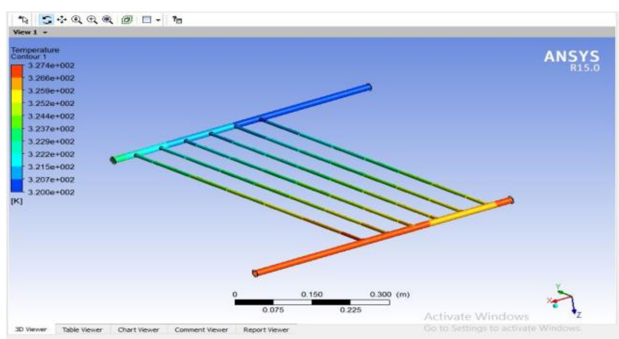

Fig.9 Temperature for using CuO nanofluid

Case -3 Using the Nano-fluid – PbO

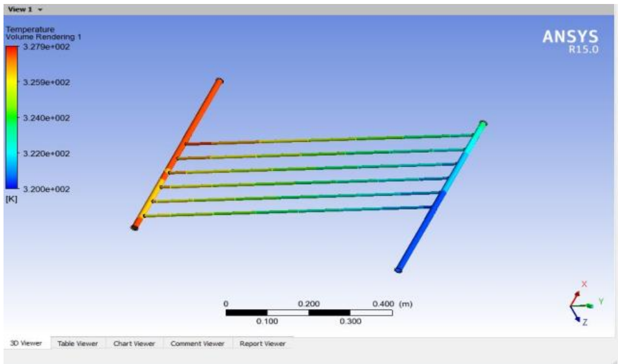

Fig.10 Temperature for using PbO nanofluid

5.2 COMPARISON TABLE

Comparison of the outlet temperature of the nanofluids is shown in below table.

Table 7 All case comparison table

Case	Inlet temp (K)	Outlet temp (K)
1 ZnO	320	326.9
2 CuO	320	327.4
3 PbO	320	327.9

Conclusion

The concluded points of this work are as follows:

- In this work studied three simulation of the flat plate solar heater. There are three nanofluids ZnO, CuO and PbO are used at 0. 5%.
- To increase the performance of solar heat pipe collector, we are using the PbO nanofluids with water.
- In this observed that the Nano-fluid containing PbO+water reach the highest temperature at the outlet of the solar water heater. Thus, using the nanofluid of PbO is most suitable for absorbing heat energy.
- PbO nanofluids with 0.5% volume fraction of efficiency is increase.
- One of the main causes of receiving higher efficiency is the very small particle size, which improves the absorption capacity of nanofluids so; improvement in efficiency could be obtained by using various particle size distributions.
- Comparison of three cases at outlet temperature of the nanofluids.

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