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MODELING AND ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER WITH DIFFERENT NANO FLUIDS AT DIFFERENT VOLUME FACTORS

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Abstract: Heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. In this project, glycerin (40%) fluid is mixed with base fluid water (60%) are calculated for their combination properties. The nano fluid is titanium carbide, magnesium Oxide and silver nano particle for volume fractions (0.1, 0.2 & 0.25) Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs for analysis. hair pin heat Exchangers are available in single tube (Double Pipe) or multiple tubes within a hairpin shell (Multitude), bare tubes, finned tubes, U-tubes, straight tubes (with rod-thru capability), fixed tube sheets and removable bundle. 3D model of the hair pin heat exchanger is done in Solid work parametric software. CFD analysis is done on the hair pin heat exchanger with TiC, MgO& silver nano particle at different volume fractions (0.1, 0.2 & 0.25)

Key words: CFD analysis, HEAT EXCHANGER

INTRODUCTION

Heat exchangers are one of the mostly used equipment in the process industries. Heat Exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Process fluids, usually are heated or cooled before the process or undergo a phase change. Different heat exchangers are named according to their application. For example, heat exchangers being used to condense are known as condensers, similarly heat exchanger for boiling purposes are called boilers. Performance and efficiency of heat exchangers are measured through the amount of heat transfer using least area of heat transfer and pressure drop. A better presentation of its efficiency is done by calculating over all heat transfer coefficient. Pressure drop and area required for acertain amount of heat transfer, provides an insight about the capital cost and powerrequirements (Running cost) of a heat exchanger. Usually, there is lots of literature and theories to design a heat exchanger according to the requirements.

1.1 Heat exchangers are of two types:-

Where both media between which heat is exchanged are in direct contact with each other is direct contact heat exchanger, where both media are separated by a wall through which heat is transferred so that they never mixindirect contact heat exchanger.

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1.2 TUBULAR HEAT EXCHANGERS

A tubular heat exchanger can either consist of a smaller-diameter tube mounted inside a larger diameter tube ("double-pipe exchanger", see Figure 1) or, more commonly, a tube bundle inside a shell ("shell-and-tube exchanger", see Figure 1.1). Thus, heat transfer surfaces are plain or enhanced tubes. Additionally, shell-and-tube heat exchangers can contain multiplepass tube bundles, i.e., for double-pass we have a bundle of U-tubes, for triple-pass the tubes in the bundle bend twice, etc. Multiple-pass shells are common as well. Baffles, either segmental or doughnut and disc ones, present in the shell direct fluid flow in shell-side, support the tubes, and limit possible tube vibrations.

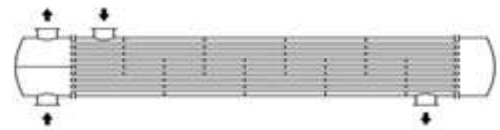

Figure 1: Countercurrent double-pipe heat exchangerFigure 1.1: Segmentally baffled one-pass shell and two-pass tube shell-and-tube heat exchanger

2. LITERATURE SURVEY

2.1 DESIGN AND ANAYSIS OF DOUBLE PIPE HEAT EXCHANGER USING COMPUTATIONAL METHOD

Heat transfer equipment is defined by the function it fulfills in a process. On the similar path, Heat exchangers are the equipment used in industrial processes to recover heat between two process fluids. **2.2 DESIGN AND EXPERIMENTAL ANALYSIS OF PIPE IN PIPE HEAT EXCHANGER**

Pipe in pipe heat exchanger are used in industrial process to recover heat between two process fluids. The project carried out design of pipe in pipe heat exchanger having tube with fin and without fin.

2.3 CFD ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER

Heat exchangers are used in industrial processes tore cover heat between two process fluids. All the heat exchangers are designed based on the function it fulfills in a process. Although the necessary equations for heat transfer and the pressure drop in a double pipe heat exchanger are available, using these equations the validation of the design is laborious.

2.4THERMAL ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER BY CHANGING THE MATERIALS USING CFD

Heat Exchanger is a device used to exchange the heat energy between the two fluids by which increases the operating efficiency? These Efficiencies plays a major role for cost effective Operations in the process industries.

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3. METHODOLOGY

In all of these approaches the same basic procedure is followed.

- During preprocessing
  - The geometry (physical bounds) of the problem is defined.
  - The volume occupied by the fluid is divided into discrete cells (the mesh). The mesh may be uniform or non-uniform.
  - The physical modeling is defined – for example, the equations of motion + enthalpy + radiation + species conservation
  - Boundary conditions are defined. This involves specifying the fluid behaviour and properties at the boundaries of the problem. For transient problems, the initial conditions are also defined.
- The simulation is started and the equations are solved iteratively as a steady-state or transient.
- Finally a postprocessor is used for the analysis and visualization of the resulting solution.

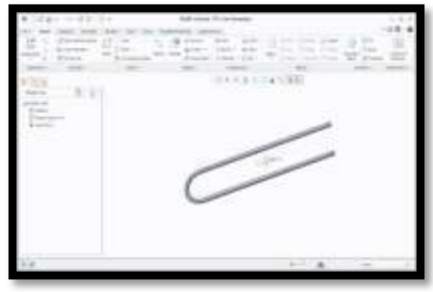
3.2 DIMENSIONS OF DESIGNED DOUBLE TUBE HAIR-PIN HEAT EXCHANGER:

Outer pipe specification Inner tube specification

Copper tube of U bends
I.D. of shell= 19.05 mm
I.D. of tube = 8.4 mm
Copper tube of U bends
I.D. of shell= 19.05 mm
I.D. of tube = 8.4 mm
O.D. of shell = 22 mm O.D. of tube = 9.5 mm
Center to center distance is taken
Wall thickness= 0.55 mm
1.5 - 1.8 times of outer dia. ofshell.
Thermal conductivity of wall= 385 w/m2K
Length of each G.I. pipe =
22.86cm
Effective length of copper tube through which heat transfer could take place= 45cm
Total length of the copper tube = straight part
(51cm) + U-shaped bend part (9cm) =60cm

3.3 3D MODEL OF DOUBLE PIPE HEAT EXCHANGER





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3.11INTRODUCTION TO CFD

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows.

CALCULATIONS TO DETERMINE PROPERTIES OF NANO FLUID BY CHANGING VOLUME FRACTIONS

Volume fraction= 0.4 & 0.5(taken from journal paper)

MATERIAL PROPERTIES

ALUMINUM OXIDE

Density = 3880 kg/m^3

Thermal conductivity =40 W/m-k

Specific heat = 910J/kg-k

TITANIUM CARBIDE

Density = 4930 kg/m^3

Thermal conductivity =330 W/m-k

Specific heat = 711 J/kg-k

WATER

Density = 998.2 kg/m^3

Thermal conductivity = 0.6 W/m-k

Specific heat = 4182 J/kg-k

Viscosity = 0.001003kg/m-s

NOMENCLATURE

ρ_{nf}= Density of nano fluid (kg/m^3)

ρ_s= Density of solid material (kg/m^3)

ρ_w = Density of fluid material (water) (kg/m^3)

ϕ = Volume fraction

C_{pw} = Specific heat of fluid material (water) (j/kg-k)

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C_{ps} = Specific heat of solid material (j/kg-k)

μ_w = Viscosity of fluid (water) (kg/m-s)

μ_{nf} = Viscosity of Nano fluid (kg/m-s)

K_w = Thermal conductivity of fluid material (water) (W/m-k)

K_s = Thermal conductivity of solid material (W/m-k)

NANO FLUID PROPERTIES

FLUID	Volume fraction	Thermal conductivity (w/m-k)	Specific heat (J/kg-k)	Density (kg/m^3)	Viscosity (kg/m-s)
ALUMINUM OXIDE	0.4	2.647	1809	2150.92	0.002006
	0.5	4.17	1570.9	2439.1	0.002256
TITANIUM CARBIDE	0.4	2.625	5357.01	2570.92	0.002006
	0.5	4.12	4069.1	2964.1	0.002256

CFD ANALYSIS OF HAIR PIN HEAT EXCHANGER

→→Ansys → workbench→ select analysis system → fluid flow fluent → double click

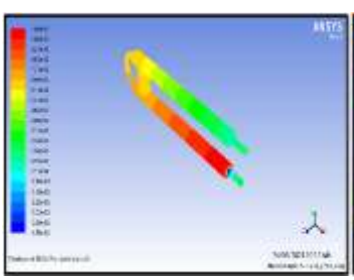
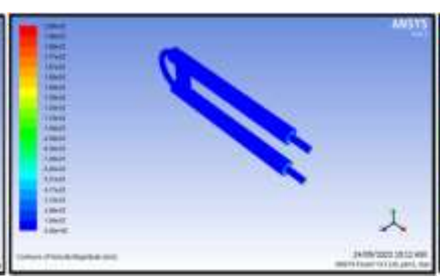
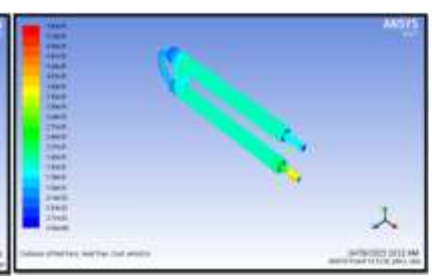
→→Select geometry → right click → import geometry → select browse →open part → ok



FLUID- TITANIUM CARBIDE

AT 0.1%

PRESSURE

VELOCITY, HEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.3%

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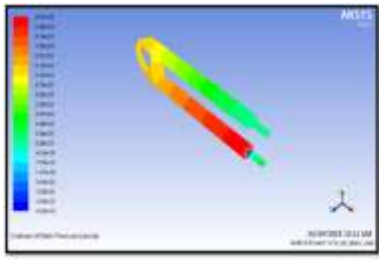
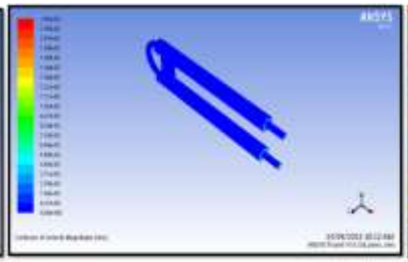
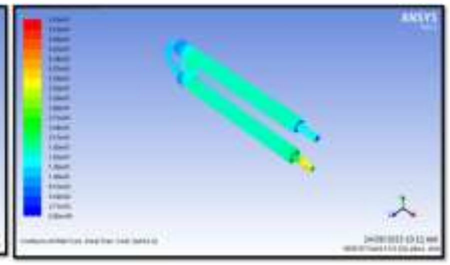
PRESSURE

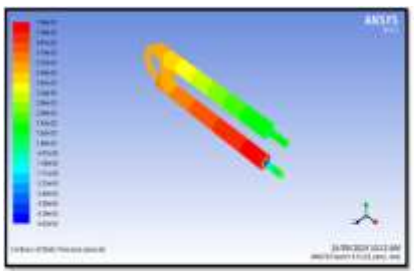
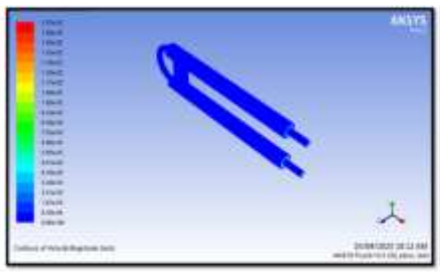
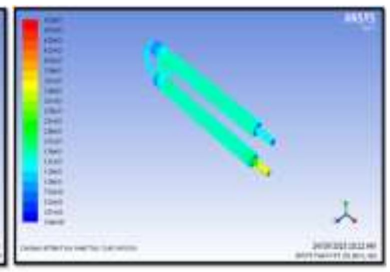




VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.5%

PRESSURE

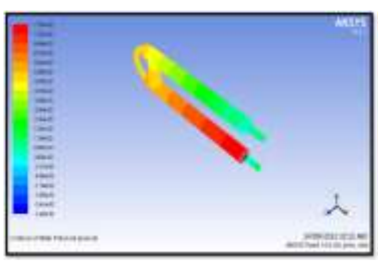
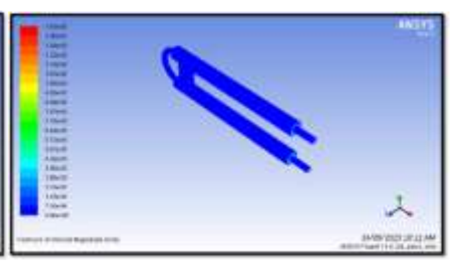
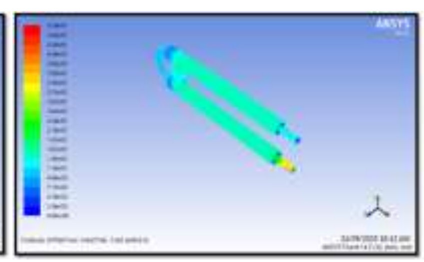




VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.8%

PRESSURE

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HEAT TRANSFER RATE

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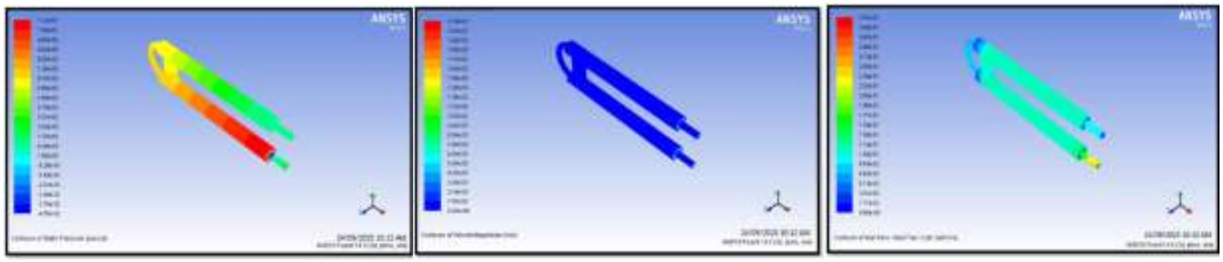
FLUID- MAGNESIUM OXIDE

AT 0.1%

PRESSURE

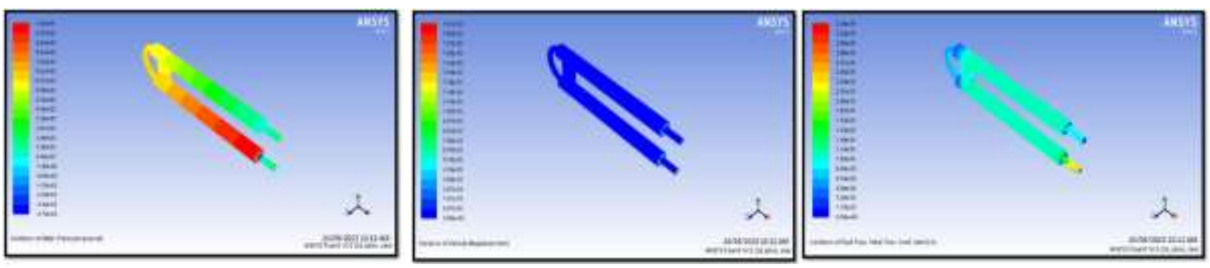


VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.3%

PRESSURE

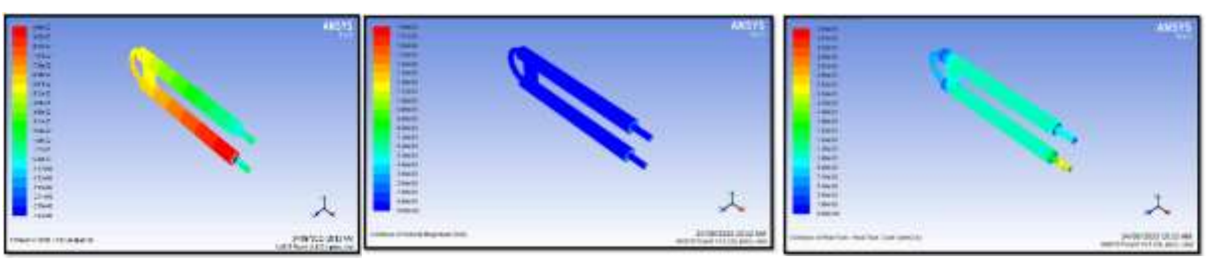


VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.5%

PRESSURE

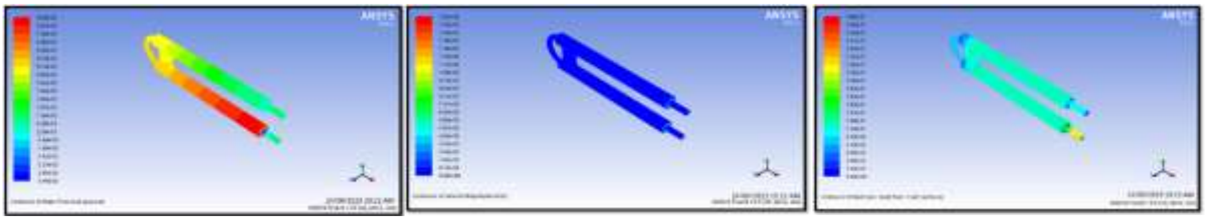


VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.8%

PRESSURE



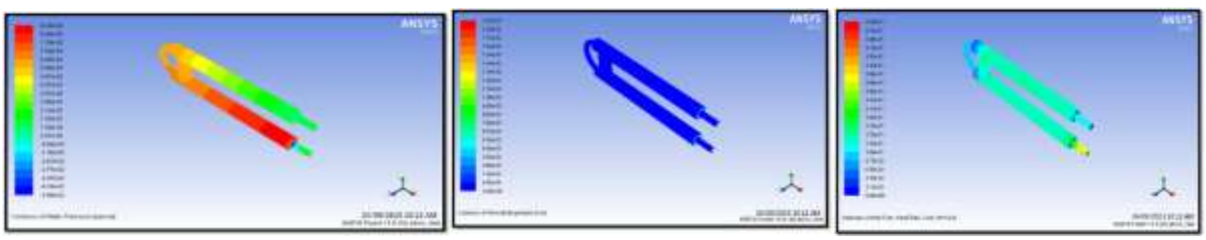
VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

FLUID- SILVER

AT 0.1%

PRESSURE

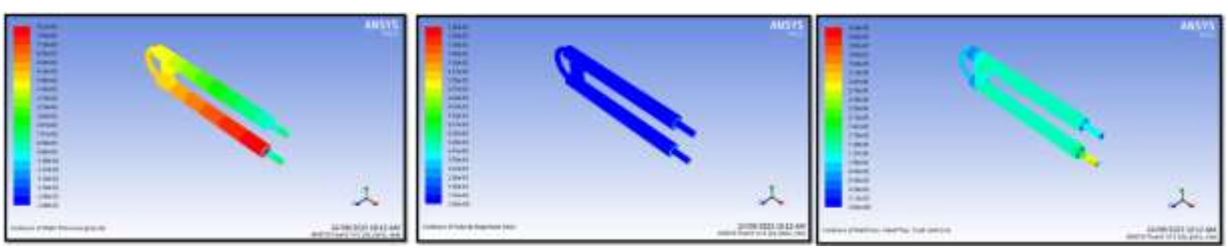


VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.3%

PRESSURE



VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.5%

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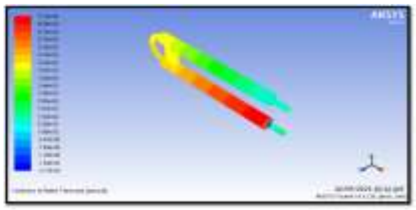
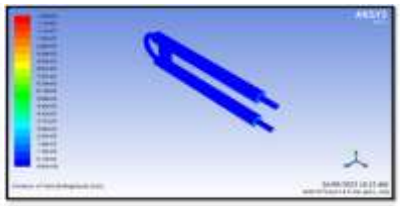
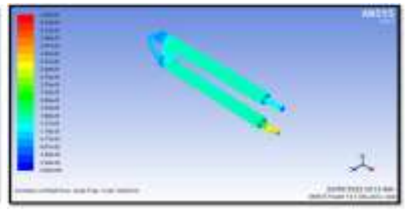
PRESSURE

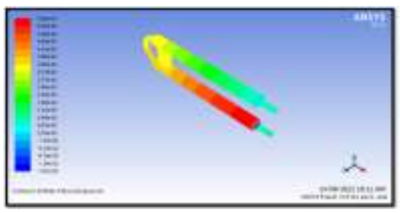
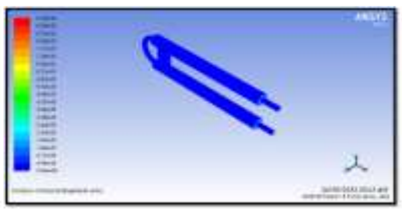
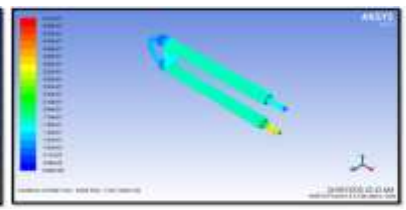




VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

AT 0.8%

PRESSURE

VELOCITYHEAT TRANSFER COEFFICENT MASS FLOW RATE

HEAT TRANSFER RATE

RESULT TABLE&GRAPHS
CFD RESULT TABLES

Fluid	Pressure (Pa)	Velocity (m/s)	Heat transfer coefficient (w/m2-k)	Mass flow rate(kg/s)	Heat transfer rate(W)
Tic (0.1%)	1.08e-01	2.08e-02	5.43e-01	0.0222584	4249.3604
Tic (0.3%)	9.57e-02	1.85e-02	5.42e-01	0.0074508	1501.1453
Tic (0.5 %)	7.66e-02	1.67e-02	5.02e-01	0.004508815	866.03149
Tic (0.8%)	7.76e-02	1.43e-02	4.78e-01	0.015195	2116.966
MgO (0.1%)	1.12e-01	2.14e-02	3.41e-01	0.00857707	1870.842
MgO (0.3%)	1.05e-01	1.91e-02	3.39e-01	0.028222	5086.1448
MgO (0.5 %)	9.86e-02	1.80e-02	3.59e-01	0.024875	5267.2834
MgO (0.8%)	8.82e-02	1.62e-02	3.66e-01	0.0100406	2363.6135
Silver (0.1%)	9.20e-02	1.92e-02	4.37e-01	0.0070454	1194.8652
Silver (0.3%)	8.21e-02	1.50e-02	4.24e-01	0.015154109	2254.1187
Silver (0.5 %)	7.11e-02	1.24e-02	4.58e-01	0.033654	5029.21
Silver (0.8%)	5.69e-02	9.72e-03	5.11e-01	0.0550869	11198.48

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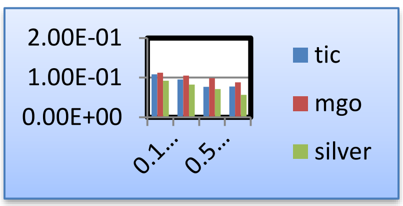
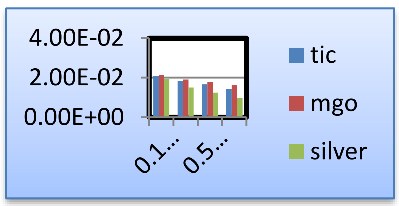
By observing the CFD analysis results the heat transfer rate value more at silver nano particle weight percentage 0.8%.

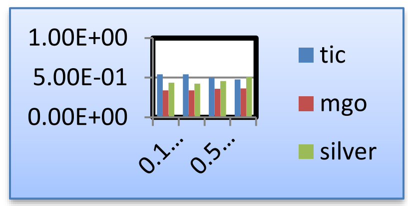
So it can be concluded the silver nano particle nano fluid at weight percentage 0.1% fluid is the better fluid for hair pin heat exchanger.

Graphs

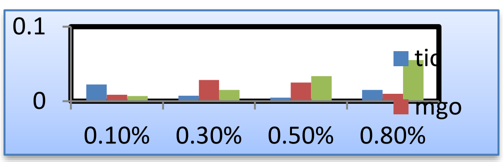
Pressure plot

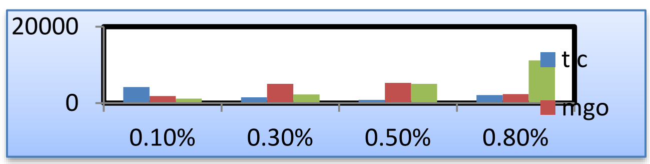






Velocity plot Heat transfer coefficient plot Mass flow rate plot





Heat transfer rate plot

CONCLUSION

In this thesis, glycerin (40%) fluid is mixed with base fluid water(60%) are calculated for their combination properties. The nano fluid is titanium carbide, magnesium Oxide and silver nano particle for weight percentage 0.1%, 0.3%, 0.5% & 0.8%.

Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs for analysis. Hairpin Exchangers are available in single tube (Double Pipe) or multiple tubes within a hairpin shell (Multitude), bare tubes, finned tubes, U-tubes, straight tubes (with rod-thru capability), fixed tube sheets and removable bundle.

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