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DESIGN AND CFD SIMULATION OF HAIR PIN HEAT EXCHANGER WITH DIFFERENT NANO FLUIDS

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Abstract *A heat exchanger is a machine used to switch heat between or more liquids. The beverages can be isolated via a stable wall to prevent mixing or they can be in direct contact. Bullet heat exchangers are applicable for unmarried cylinder (double tube) or single cylinder in a mounting shell (massive capacity), exposed tube, finned tube, U-tube, directly cylinder (with pour-thru ability), solid tube plate and removable PC.*

In this project, a nanofluid is mixed with a base fluid and its mixing traits are decided. The nanofluids are magnesium oxide and silver nanoparticles in ratios of 0.35%, 0.45%, 0.55%, 0.65% and at different velocities (0.5, 1, 1.5, 2 m/s). Hypothetical calculations are performed to decide the properties of the nanofluid and these houses are used as enter for the assessments.

3D variations of the hairpinheat exchanger (with and without the winding band model) are created with parametric programming CREO. CFD evaluation is accomplished for the hairpinheat exchanger with different quantities of nanofluid. The CFD evaluation goals to determine the stress drop, Reynolds range, heat go with the flow coefficient and Nusselt number.

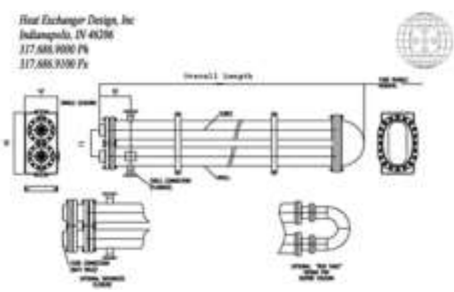
Key words:nano fluid, heat exchanger, CFD, stress drop, Reynolds range

1. INTRODUCTION

Heat exchangers are one of the most typically used pieces of device in method flowers. They are used to move heat between cycle streams. Their use can be understood because any cycle that entails cooling, heating, accumulation, effervescent, or dissipation calls for a heat exchanger for this purpose. The technique fluid is usually heated or cooled earlier than being handled or present process a level trade. Heat exchangers are given numerous names depending on their utility. For instance, a heat exchanger used for awareness is referred to as a condenser and a heat exchanger used for brewing is known as a boiler. The overall performance and efficiency of a heat exchanger is calculated based totally on the amount of cutting-edge which can glide via it the use of the minimum flow course and stress drop. Calculating the overall flow coefficient gives a very good representation of the efficiency. The expected strain drop at a specific drift degree and the vicinity will come up with the capital cost and strength requirement (utilization) of the heat exchanger. In trendy, there are loads of documents and theories to layout a heat exchanger as per your necessities.

Heat Exchanger

Heat Exchanger Projects, Inc. Gives a complete line of hairpin exchangers. These heat exchangers provide actual countercurrent flow and are particularly applicable for extreme temperature transfer, high strain, high temperature, and low to mild floor necessities. Our hairpin exchangers are to be had as single cylinders (double tube) or separate cylinders in a shell (multi-tube), uncovered tubes, finned tubes, U-tubes, instantly cylinders (with non-stop rod capacity), non-stop tube plates, and removable elements. Surface regions range from 1 sq. Ft. To 6000 sq. Feet. (finned tube). Pressure capacities range from full vacuum to over 14,000 PSI (confined by way of duration, fabric and creation). Hairpin exchangers are designed and built according with ASME Code and TEMA pointers.



Double-pipe Bare and Multi-tube

Advantages of -Style Heat Exchangers

Hairpin heat exchangers are suitable for applications requiring high thermal performance and low impact.Shell and Barrel Heat Exchangers are available in a ramification of styles and sizes with additives and housings handcrafted for a ramification of applications. Hairpin heat exchangers are encouraged for quit-use systems with difficult space situations and stringent thermal requirements.

Hairpin Heat Exchangers, with their twist configuration and precise cease styles, can solve a variety of problems related to heat exchangers for programs requiring high thermal overall performance and low impact.

Objectives of the project

The main objectives of this study are:

1. To design the joint heat exchanger for different nano fluids with different calculations, for example with and without curved bands;
2. To determine the deep flow coefficient, pressure, velocity and deep flow rate using CFD analysis;
3. To identify the appropriate fluid to be used, since the results are obtained from a limited factorial analysis;

2. LITERATURE REVIEWS

P.V. Durga Prasad et al. carried out experimental assessments to improve the heat waft the use of low volume concentration alumina nanofluid and trapezoidally cut curved ribbons. The outcomes showed that the usage of nanofluids significantly improves the heat glide, even as the bottom fluid and trapezoidally reduce complex ribbons boom the disturbance, which results in an increase within the rate of heat go with the flow.

B. Raei et.al. Estimation of typical depth glide coefficients and friction elements of water-based totally γ-Al_2O_3 nanofluids in double tube heat exchangers. Results show that increasing nanofluid ratio, flow charge, and reactor temperature will increase the general depth go with the flow coefficient and go with the flow price.

V. Murali Krishna et al. Conducted exams to determine the intensity flow charge of Al_2O_3-water nanofluids at diverse drift fees and volumetric concentrations in a concentric tubular heat exchanger. A thorough observe between nanofluids and base fluids has been performed.

Hiregowder Y et al. finished CFD evaluation using four exclusive nanofluids (magnesium oxide water, copper oxide water, titanium oxide water, and iron oxide water). The effects acquired found out that magnesium oxide-water primarily based nanofluids have better go with the flow speed in depth as compared to different nanofluids.

3. METHODOLOGY USED

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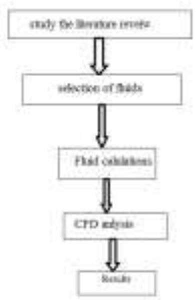
The following chart shows the methodology of project used in this research



Dimensions of designed double tube Hair-pin heatexchanger:
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 istaken
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 coppertube through which heattransfer could take place= 45cm
Total length of the copper tube = straight part (51cm) + U-shaped bend part (9cm) =60cm
Twisted tape length =400mm
Pitch =180mm

3d model hair pin heat exchanger (without twisted tape)

CFD

CFD stands for Computational Fluid Dynamics, and it is a branch of fluid mechanics that uses numerical methods and calculations to study and solve problems of fluid flow. Computers are used to carry out the calculations necessary to simulate the exchange of liquids and gases with surfaces characterized by boundary conditions.

Calculations to determine properties of nano fluid by changing volume fractions

MATERIAL PROPERTIES

MAGNESIUM OXIDE

Density = 3580 kg/m^3
Thermal conductivity =60W/m-k
Specific heat = 1030J/kg-k
TITANIUM DIOXIDE (TiO_2)
Density = 5400 kg/m^3
Thermal conductivity =28.84 W/m-k
Specific heat = 330 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

Fluidflow of hair pin heat exchanger

Imported Model

The model is created using CREO and then imported into ANSYS for grid analysis and analysis. The pressure profile and temperature distribution are determined using CFD analysis. The liquid ring is divided into two connected volumes at the cross section. The edges are then merged, at this point 360 degrees and at all thicknesses. The cross section is based entirely on a tetrahedral structure.

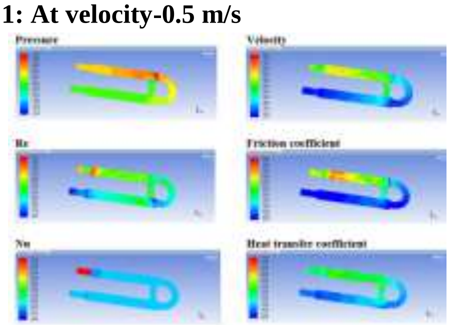
Meshed Model

The model is created using CREO and then imported into ANSYS for grid analysis and analysis. The pressure profile and temperature distribution are determined using CFD analysis. The liquid ring is divided into two connected volumes at the cross section. The edges are then merged, at this point 360 degrees and at all thicknesses. The cross section is based entirely on a tetrahedral structure.

4. RESULTS AND ANALYSIS

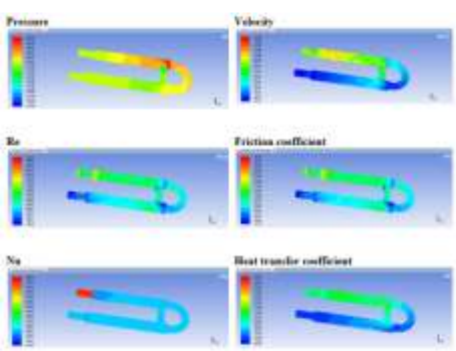
Fluid - Water

Case 1: At velocity-0.5 m/s



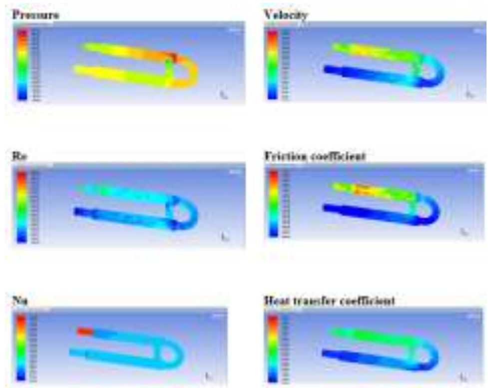
Variations of Pressure, Temperature, Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m/s

Case 2: At velocity-1.0 m/s



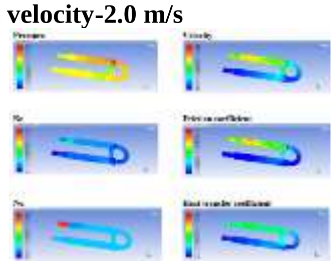
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

Case 4: At velocity-2.0 m/s

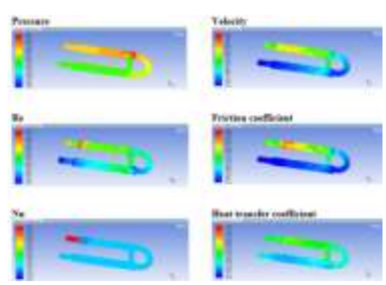


Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

Fluid - magnesium oxide

At volume fraction-0.35

Case 1: At velocity-0.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.0 m/s

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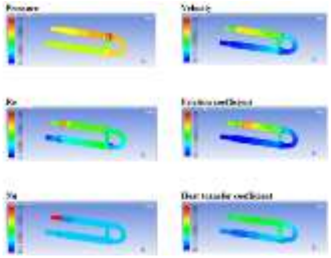
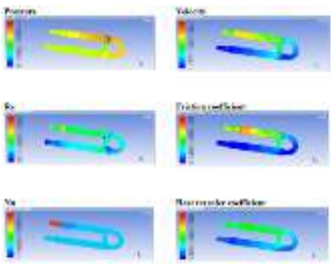


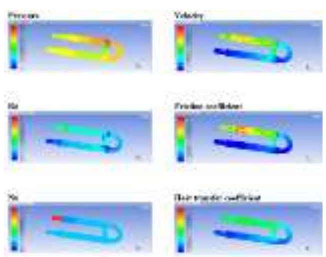
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



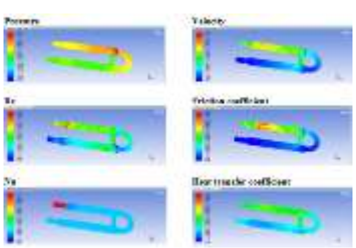
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

At velocity-2.0 m/s



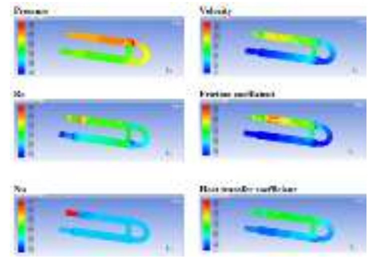
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

At volume fraction-0.45
Case 1: At velocity-0.5 m/s



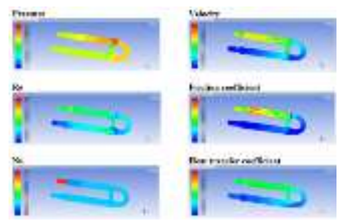
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.0 m/s



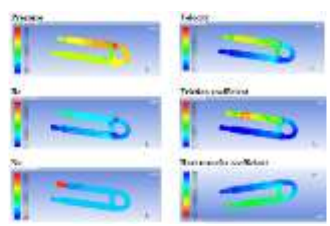
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

At velocity-2.0 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

At volume fraction-0.55
Case 1: At velocity-0.5 m/s

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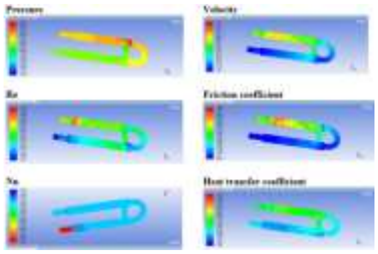
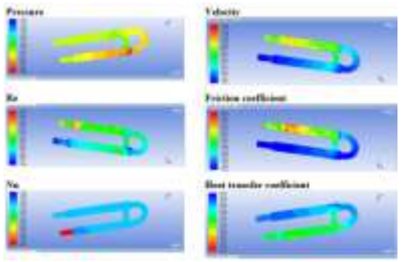


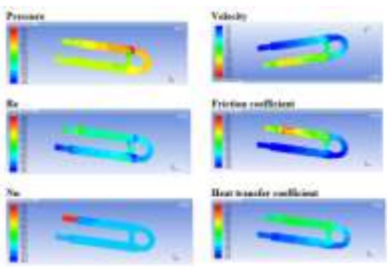
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.0 m/s



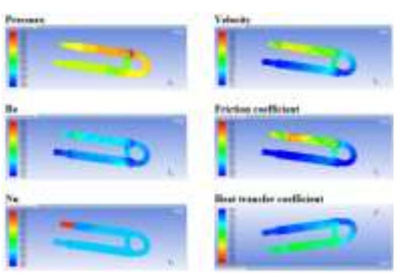
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

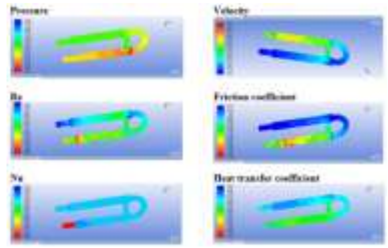
At velocity-2.0 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

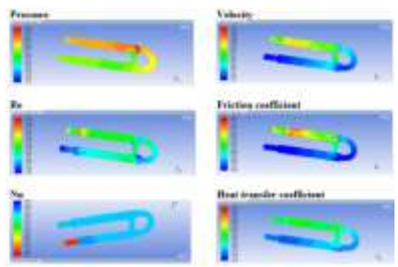
At volume fraction-0.65

Case 1: At velocity-0.5 m/s



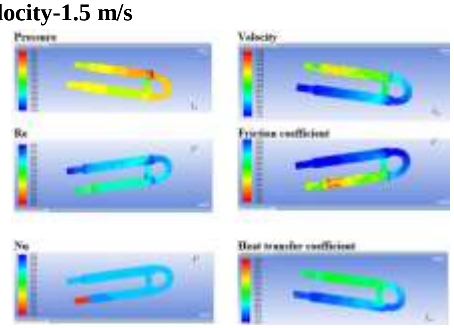
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.0 m/s



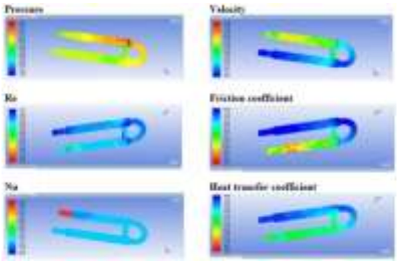
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

At velocity-2.0 m/s

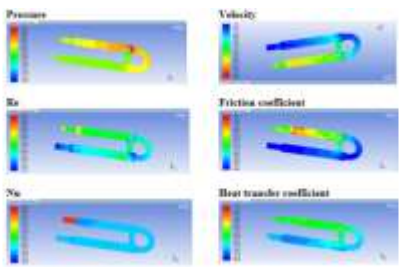


Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

Fluid-Titanium dioxide Fluid

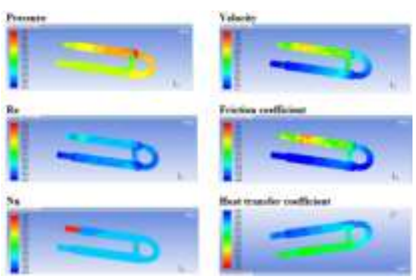
At volume fraction-0.35

Case 1: At velocity-0.5 m/s



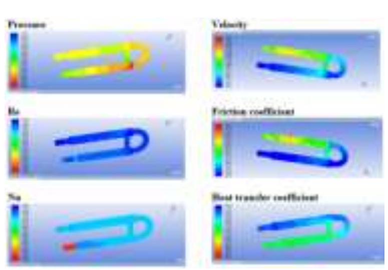
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.0 m/s



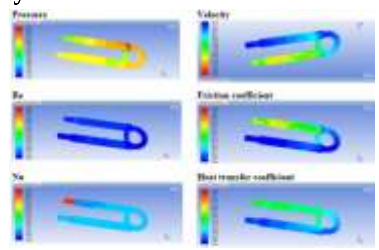
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

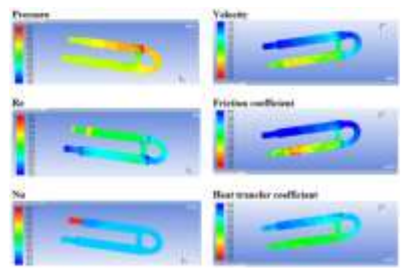
At velocity-2.0 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

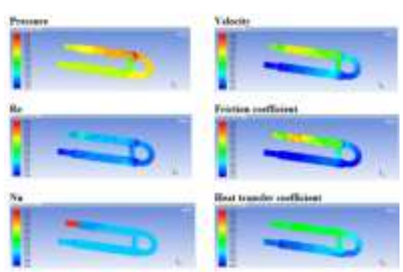
At volume fraction-0.45

Case 1: At velocity-0.5 m/s



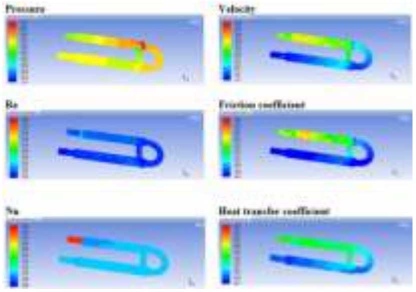
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.0 m/s



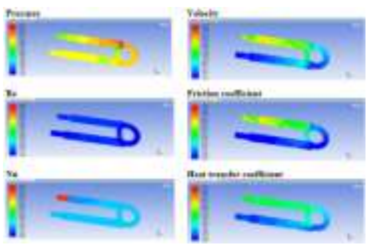
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

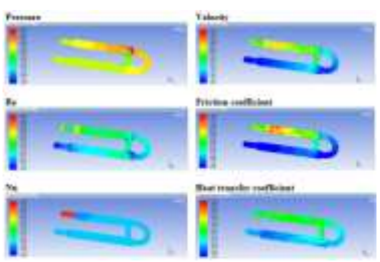
At velocity-2.0 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

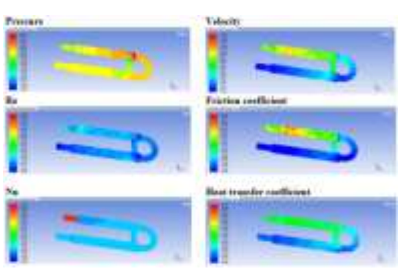
At volume fraction-0.55

Case 1: At velocity-0.5 m/s



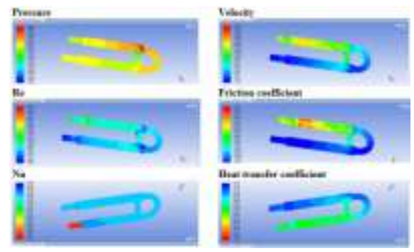
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

Case 2: At velocity-1.0 m/s



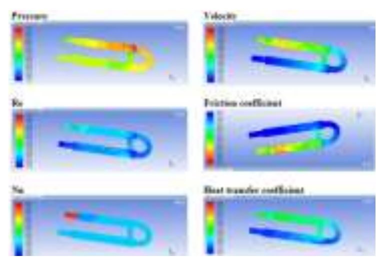
Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

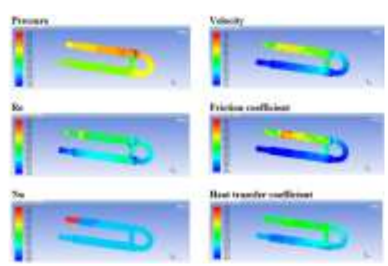
At velocity-2.0 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

At volume fraction-0.65

Case 1: At velocity-0.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 0.5m /s

Case 2: At velocity-1.0 m/s

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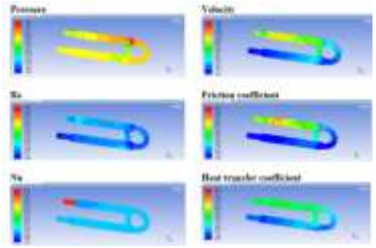
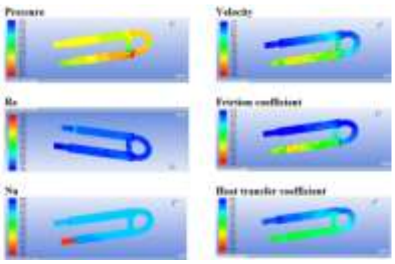


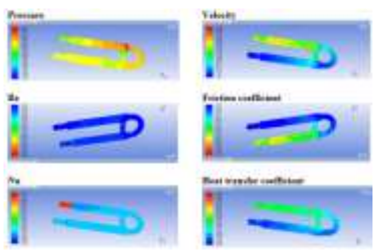
Variations of Pressure, Temperature, Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.0m/s

At velocity-1.5 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 1.5m /s

At velocity-2.0 m/s



Variations of Pressure, Temperature, and Re, Friction coefficient, Nu, Heat transfer coefficient at Velocity 2.0m /s

Results Tables

Results of Hair Pin Heat Exchanger for the fluid water

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m²-k)
Water	0.5	1.78e+02	0.83	1.66e+02	3.02	3.27e+02	5.76e+03
	1	3.33e+02	1.62	2.74e+02	12.74	3.46e+02	1.03e+04
	1.5	1.01e+03	2.40	4.66e+02	1.73e+01	3.32e+02	1.44e+04
	2	1.81e+03	3.22	7.64e+02	2.90e+01	3.55e+02	1.81e+04

Fluid –Magnesium Oxide

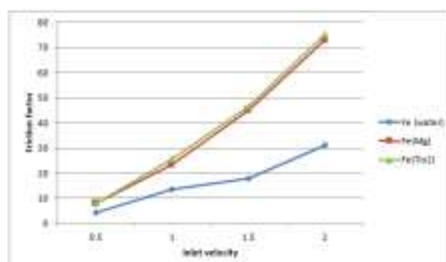
For the fluid Magnesium oxide results of Hair Pin Heat Exchanger

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m²-k)
MgO (0.35)	0.5	3.50e+02	0.831	1.49e+02	6.93	7.31e+01	1.24e+04
	1	1.003e+03	1.622	1.84e+02	2.09e+01	7.48e+01	2.18e+04
	1.5	2.16e+03	2.389	2.72e+02	3.82e+01	7.64e+01	2.98e+04
	2	3.58e+03	3.16	3.88e+02	6.18e+01	7.69e+01	3.75e+04
MgO (0.45)	0.5	3.61e+03	0.8312	1.32e+02	7.33	6.74e+01	1.44e+04
	1	1.34e+03	1.61	1.92e+02	2.17e+01	6.86e+01	2.45e+04
	1.5	2.31e+03	2.37	2.85e+02	4.11e+01	7.02e+01	3.43e+04
	2	4.36e+03	3.23	4.64e+02	6.67e+01	7.07e+01	4.31e+04
MgO (0.55)	0.5	3.68e+03	0.8291	1.35e+02	7.62	6.33e+01	1.39e+04
	1	3.68e+02	1.61	2.05e+02	.26e+01	6.63e+01	2.80+04
	1.5	1.23e+03	2.39	3.25e+02	4.30e+01	6.76e+01	3.81e+04
	2	4.36e+03	3.19	4.90e+02	6.81e+01	6.79e+01	4.78e+04
MgO	0.5	4.38e+02	0.8312	1.57e+02	7.93	5.98e+01	1.82e+04

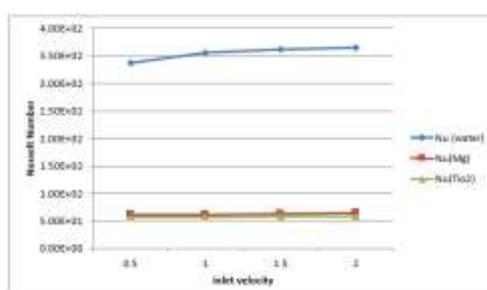
Fluid –Titanium oxide

Results of Hair Pin Heat Exchanger with Silver Nano fluid

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m²-k)
TiO_2(0.30)	0.5	7.84e+02	0.831	2.42e+02	1.28e+01	6.88e+01	1.84e+04
	1	3.71e+03	1.63	6.14e+02	3.84e+01	7.01e+01	2.96e+04
	1.5	5.34e+03	2.41	1.32e+03	7.81e+01	7.06e+01	3.87e+04
	2	8.4e+03	3.21	2.7e+03	1.27e+02	7.10e+01	4.88e+04
TiO_2 (0.45)	0.5	7.95e+02	0.834	2.48e+02	1.30e+01	6.6e+01	2.01e+04
	1	2.73e+03	1.632	6.28e+02	4.03e+01	6.77e+01	3.22e+04
	1.5	5.55+03	2.412	1.43e+03	8.11e+01	6.89e+01	4.05e+04
	2	8.45e+03	3.25	2.82e+03	1.45e+02	7.01e+01	4.95e+04
TiO_2 (0.55)	0.5	8.81e+03	0.837	2.38e+02	1.32e+01	6.27e+01	2.19e+04
	1	2.85e+02	1.619	6.47e+02	4.09e+01	6.41e+01	3.32+04
	1.5	5.85e+03	2.431	1.39e+03	8.13e+01	6.36e+01	4.35e+04
	2	8.48e+03	3.251	2.98e+03	1.321e+02	6.98e+01	5.12e+04
TiO_2 (0.65)	0.5	8.48e+02	0.837	2.63e+02	1.33e+01	5.83e+01	2.42e+04
	1	2.81e+03	1.619	6.72e+02	4.10e+01	5.90e+01	3.91e+04
	1.5	5.88e+03	2.431	1.63e+03	8.14e+01	5.98e+01	4.93e+04
	2	8.51e+03	3.271	3.12e+03	1.42e+02	6.09e+01	5.88e+04



Comparison Graph (Friction Factor vs Inlet Velocity)



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Comparison Graph (Nusselt Number vs Inlet Velocity)

5. CONCLUSIONS

From this study the following conclusions were made

- In this assumption, nanofluids are mixed with base fluid water and their mixing properties are determined. Nanofluids are magnesium oxide and silver nanoparticles with volume fractions of 0.35%, 0.45%, 0.55% and 0.65% at different velocities (0.5, 1, 1.5 and 2 m/s).
- Hypothetical calculations are performed to determine the properties of nanofluids and these properties are used as input to the analysis.
- 3D models of hairpined heat exchanger with and without curved band model are created in CREO parametric programming. CFD analysis is performed for hairpined heat exchanger with different volume fractions of nanofluid.
- CFD analysis is used to determine the stress drop, Reynolds number, heat transfer coefficient and Nusselt number.
- Considering the CFD analysis results, increasing the speed increases the values of friction coefficient and heat transfer coefficient.
- Considering the CFD analysis results, TiO2 nanoparticles (0.65%) have higher friction coefficient and heat transfer coefficient.

Hence, it can be concluded that TiO2 nanofluid (0.65%) is a better fluid for hairpin heat exchanger.

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