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ANALYSIS OF SHELL AND TUBE HEAT EXCHANGER USING CFD”

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ABSTRACT
Our paper's main goal is to design the Heat Exchanger by adjusting many variables to improve its performance and efficiency, to find the best solutions, and to prepare it for use in challenging and dangerous situations. The heat exchanger, which involves both fluid flow and heat transfer, is simulated using the CFD technique. Through this procedure, we discover the pressure distributions, velocity vectors, and temperature gradients. This analysis demonstrates that the temperature values between the simulated and experimental values differ.

Keywords: Heat Exchanger, temperature gradients, fluid flow, CFD technique, pressure distributions, velocity vectors

1.Introduction

Heat exchange between the fluids is one amongst the important approaches in engineering [1]. And there are many unique kinds of heat exchangers that are handy for unique sorts of the installations. And the right here one of the vital kinds of heat exchangers is the shell and tube kind heat exchanger, which is used for the building of Petro-chemical plants, system industries, pressurized water reactor power plants, nuclear power stations, building heating, ventilating, and air- conditioning and the refrigeration.
Commonly used kind of heat exchangers are the shell-and-tube heat exchangers[2]. These can be operated at excessive pressures, and their development enables disassembly of heat exchanger for periodic upkeep and cleaning[3]. The defined shell-and-tube heat exchangers which consist of a bundle of tubes enclosed inside a cylindrical kind of shell.

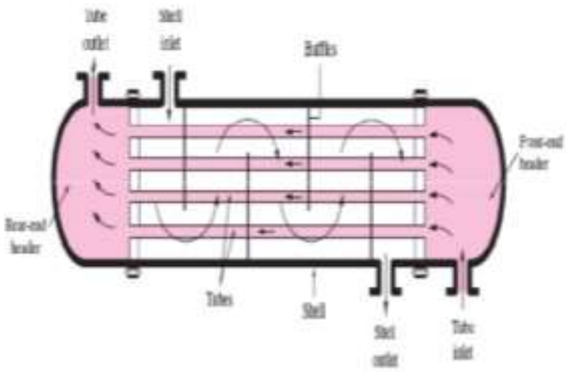

Fig 1. Shell-and-tube heat exchanger

Heat exchanger

These are the mechanical tools that are used to transport heat from one fluid to another, regardless of whether the fluids are being kept apart by a solid wall so that they never mix or are in direct touch. They are widely employed in petrochemical, chemical, and natural fuel processing facilities, as well as in air conditioning, space heating, and refrigeration[4]. The radiator of an automobile is one of the most significant and frequently used examples of a

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heat exchanger. The radiator contains a hot engine cooling fluid, such as antifreeze, which is crucially employed to transfer heat to air passing through the radiator.

2. Material and method

Shell and tube heat exchanger consists of a shell, tubes and baffles, usually for the shell, for economic reasons steel is the most commonly used material and also galvanized iron, cast iron, titanium and other alloys are preferred, as these are having good thermal conductivity [5]. For the Tubes, generally copper, stainless-steel materials are preferred. For the baffles, preferred material is steel, as they have high thermal conductivity

Table.no. 2.1 construction material and dimensions

Specification of shell		Specification of tube	
Material	Stainless steel	Material	Stainless steel
Inner diameter	28mm	Inner diameter	9.5 mm
Outer diameter	33.8 mm	Outer diameter	12.7 mm
Length	500 mm	Length	1000mm
		No. of Tubes	07

Table.no. 2.2 Properties of materials

S. no	Material	Composition	Properties
1.	Water	100%	1.High specific heat capacity.
2.	Al_2O_3	1%,3%,5%	1.Aluminium oxide have good thermal conductivity. 2.it has high specific heat capacity.
3.	CuO	1%,3%,5%	1.High thermal conductivity 2.Easily soluble in water

2.1 Method

In the process of performing thermal analysis on the shell and tube type heat exchanger by using CFD simulation techniques, firstly we have to design the required geometry in the suitable design software such as fusion 360 software. After the required geometry is made in the fusion 360 software with the required measurements, then the designed geometry file will be saved and then next the saved file from the designed software, that is imported into the Ansys software by the file selection. And then next the analysis is performed. Here the CFD techniques or the simulation is performed by the FLUENT preprocessor, which is used to simulate.

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FLUENT which is a preprocessor of Ansys used to simulate the heat exchanger with the aid of the extruding a range of components of the heat exchanger and additionally used to function thermal analysis of heat exchanger.

2.2 Generate a grid

In order to perform the thermal analysis, in order to mesh the heat exchanger, the designed object is extracted into the Ansys software program and then the file is to be processed in order to mesh to perform thermal analysis.

In the procedure of performing the meshing, the designed object is split into the a number of factors and then the temperature variants are utilized in order to perform thermal analysis.

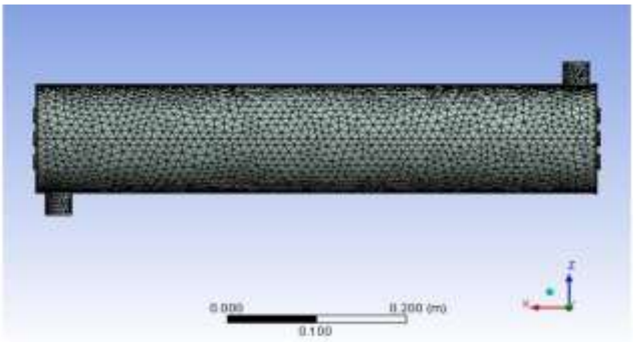

Fig.no. 2.1. Meshing of shell and tube heat exchanger

2.3 Methodology

A solid geometry of shell and tube type heat exchanger is to be designed using fusion 360 software

Then it is imported into Ansys software for simulation using CFD techniques

The computed values are then compared with the experimental values.

2.4 Boundary Conditions

We can set the or fluctuate the boundary conditions in Fluent however we can additionally do it in CFD, in fact, it is little bit complex. in the OPERATION menu; click on Zones button. Under the phrase ZONES two buttons will be appeared: Specify Boundary Types and do Specify Continuum [6]. Click on the Specify Boundary Types button. A floating window known as Specify Boundary Types will appear.

Change the Entity pop down menu to the edges. Select the edge that will be the speed of inlet and down the Type pop down menu select Velocity Inlet. It is used that you label will be the exceptional edges. This will assist you to hold track of them in the Fluent output reports. The labels ought to be one word, i.e. no areas or the tabs. To end the developing the simulate the BC click on Apply. Now pick the edge that being will be the flow rate outlet and select Outflow. The upper and lower edges of the airfoil and manage quantity are the walls. There is a listing at the pinnacle of this window that must mirror the two BC's that we have created.

3.Modelling of shell and tube heat exchanger

Fusion 360 users get the concept of the entry to the perfect productiveness for the need which is to be the precise superior methods with targeted solutions[7]. The software can be the lead professional engineering and add innovation, primarily for the major based on special and very specialized that which also integrates the product and procedure expertise.

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Fig 3.1. 3D Modeling of shell and Tube heat Exchanger (Fusion 360)

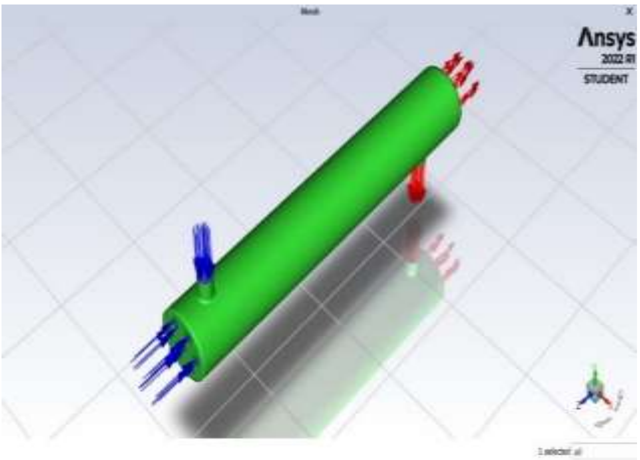

Fig 3.2. 3D Modeling of shell and Tube heat Exchanger (Fusion 360)

Fig 3.3. 3D Modeling of shell and Tube heat Exchanger (Fusion 360)

4 .Result and discussion

Based upon analysis results, it has been concluded that the shell and tube heat exchanger with CuO 5% nano fluid have high net heat transfer rates comparatively, as copper is high thermal conductive material. When compared with water and Al_2O_3 as nano fluids for shell and tube heat exchanger, Al_2O_3 5% have high net heat transfer rates.

After performing analysis on shell and tube heat exchanger with water as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K. it is observed

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that the cold outlet temperature is around 308.42K and hot outlet temperature is around 313.6K and the net heat transfer rate is around 418 (w/m^2 K).

After performing analysis on shell and tube heat exchanger with Al_2O_3 1% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K, it is observed that the cold outlet temperature is around 308.77K and hot outlet temperature is around 31.82K and the net heat transfer rate is around 421.98 (w/m^2 K).

After performing analysis on shell and tube heat exchanger with Al_2O_3 3% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K, it is observed that the cold outlet temperature is around 309.17K and hot outlet temperature is around 312.15K and the net heat transfer rate is around 428.07 (w/m^2 K).

After performing analysis on shell and tube heat exchanger with Al_2O_3 5% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K, it is observed that the cold outlet temperature is around 309.55K and hot outlet temperature is around 311.54K and the net heat transfer rate is around 435.27 (w/m^2 K).

After performing analysis on shell and tube heat exchanger with CuO 1% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K, it is observed that the cold outlet temperature is around 308.96K and hot outlet temperature is around 312.69K and the net heat transfer rate is around 420.45 (w/m^2 K).

After performing analysis on shell and tube heat exchanger with CuO 3% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K, it is observed that the cold outlet temperature is around 308.71K and hot outlet temperature is around 311.75K and the net heat transfer rate is around 424.19 (w/m^2 K).

After performing analysis on shell and tube heat exchanger with CuO 5% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K, it is observed that the cold outlet temperature is around 310.49K and hot outlet temperature is around 310.99K and the net heat transfer rate is around 429.85 (w/m^2 K).

4.1 Heat Transfer Rate

$Q = m * Cp * \Delta T$

M = Mass flow rate

Cp = Specific Heat of Water

ΔT = Temperature Difference Between Tube Side

4.1.1 Heat transfer rate for water

The observed heat transfer rate for water as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 418 (w/m^2 K).

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4.1.2 Heat transfer rate for Al_2O_3 1%

The observed heat transfer rate for Al_2O_3 1% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 421.98 (w/m^2 K).

4.1.3 Heat transfer rate for Al_2O_3 3%

The observed heat transfer rate for Al_2O_3 3% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 428.07 (w/m^2 K).

4.1.4 Heat transfer rate for Al_2O_3 5%

The observed heat transfer rate for Al_2O_3 5% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 435.27 (w/m^2 K).

4.1.5 Heat transfer rate for CuO 1%

The observed heat transfer rate for CuO 1% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 420.45 (w/m^2 K).

4.1.6 Heat transfer rate for CuO 3%

The observed heat transfer rate for CuO 3% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 435.27 (w/m^2 K).

4.1.7 Heat transfer rate for CuO 5%

The observed heat transfer rate for CuO 5% as nano fluid with cold inlet temperature of 301K and hot inlet temperature of 333K have net heat transfer rate of 429.85 (w/m^2 K).

4.2. Problem setup

Simulation has been carried out in ANSYS software. In the Fluent solver was once chosen, absolute velocity formation and steady time was once chosen for the simulation is made. In this type of heat exchanger (shell and tube type) the is model optionally an available energy calculation was once on and the viscous used to be set to a standard k-e, general wall characteristic (k-epsilon two eqn). In cell zone region fluid water-liquid was once selected [9]. Water-liquid and the copper, aluminum ha been chosen as substances for simulation. Boundary conditions used to be chosen for inlet and outlets.

In the inlet and the outlet 1kg/s velocity and temperature was once set at 353k. Across every tube 0.05 kg/s velocity and 300k temperature was once made [10]. Mass flow used to be chosen in every inlet. In reference Value Area set as 1m2 ,Density 998 kg/m3 ,enthalpy

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229485 j/kg , size 1m , temperature 353k, Velocity 1.44085 m/s , Ration of specific heat 1.4 was once made [11].

4.3 Solution initialization

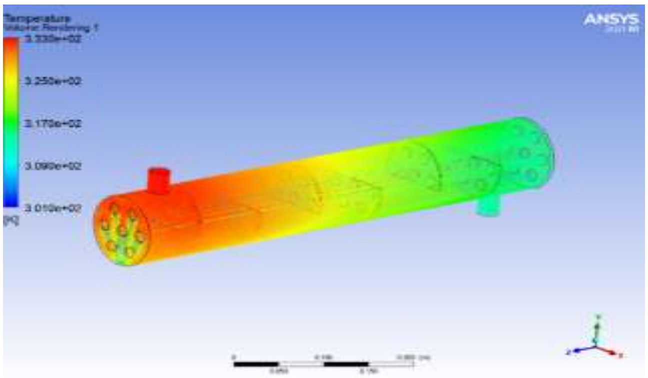
The SIMPLEC connection for pressure velocity was selected. Correction for skewness was set to zero. Pressure, first order upwind momentum, and turbulence were the conventional settings for the spatial discretization area's gradient, respectively. Energy was originally established as the First order Upwind in addition to Kinetic electricity, which was set at First order Upwind. Pressure, Density, Body Pressure, Momentum, Turbulent Kinetic and Turbulent Dissipation Rate, Power, and Turbulent Viscosity were all set to 1 in Solution Control [8]. The solution initialization was the concept that was employed, and the response was initially initialised from the inlet using the around 300k temperature.

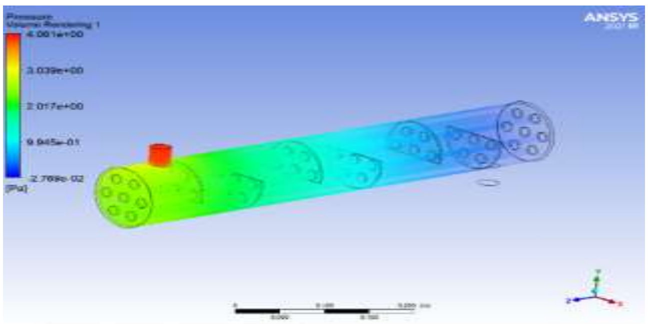
Under the Above mentioned conditions or the boundary circumstance and answer initialize circumstancesimulation used to be set for a hundred iterations.

Here, Analysis is performed on the shell and tube heat exchanger with different Nano fluid such as water, Al_2O_3 1%, Al_2O_3 3%, Al_2O_3 5%, CuO 1%, CuO 3%, CuO 5% and the following results were obtained.

4.4.1 For water as nano fluid

Variation of Temperature, Pressure and Velocity





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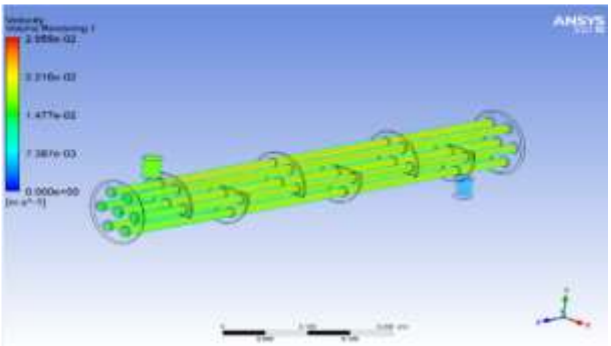


Fig 4.1.Temperature, Pressure and Velocity distribution

4.4.2 For Al_2O_3 1% as nano fluid

Variation of Temperature, Pressure and Velocity

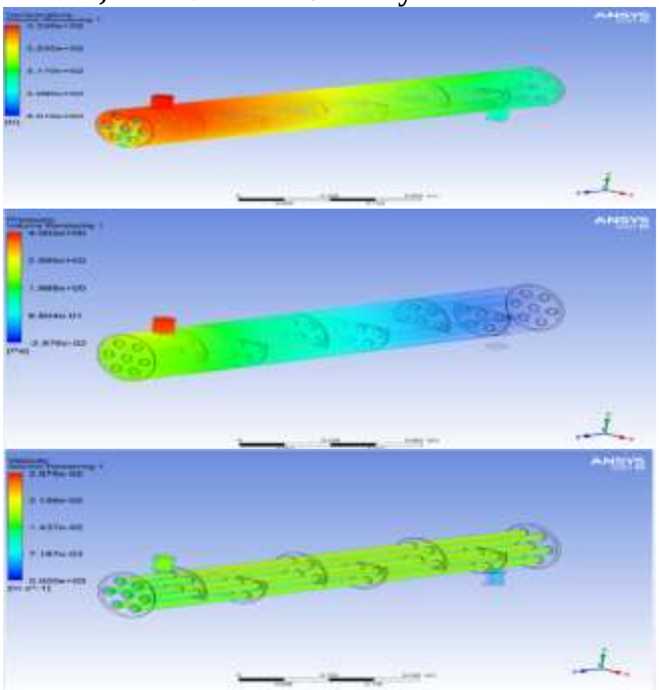
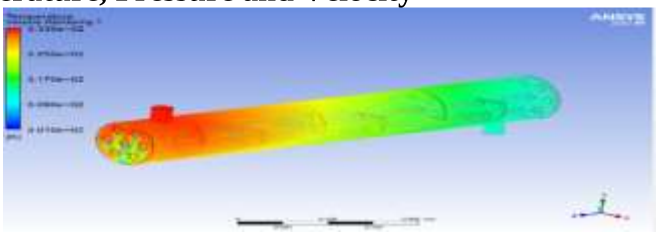


Fig 4.2.Temperature, Pressure and Velocity distribution

4.4.3 For Al_2O_3 3% as nano fluid

Variation of Temperature, Pressure and Velocity



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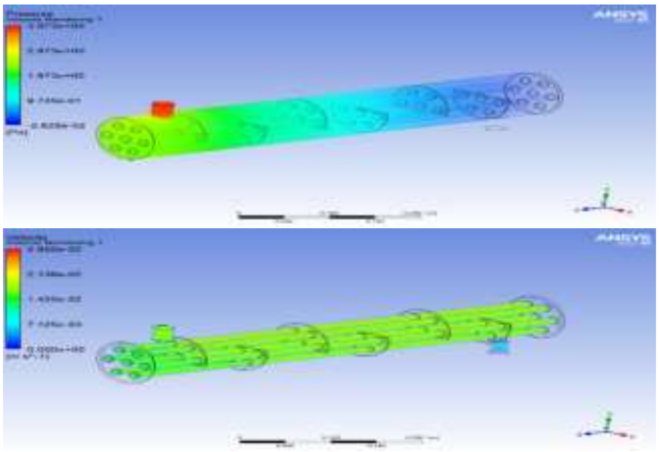


Fig 4.3.Temperature, Pressure and Velocity distribution

4.4.4 For Al_2O_3 5% as nano fluid

Variation of Temperature, Pressure and Velocity

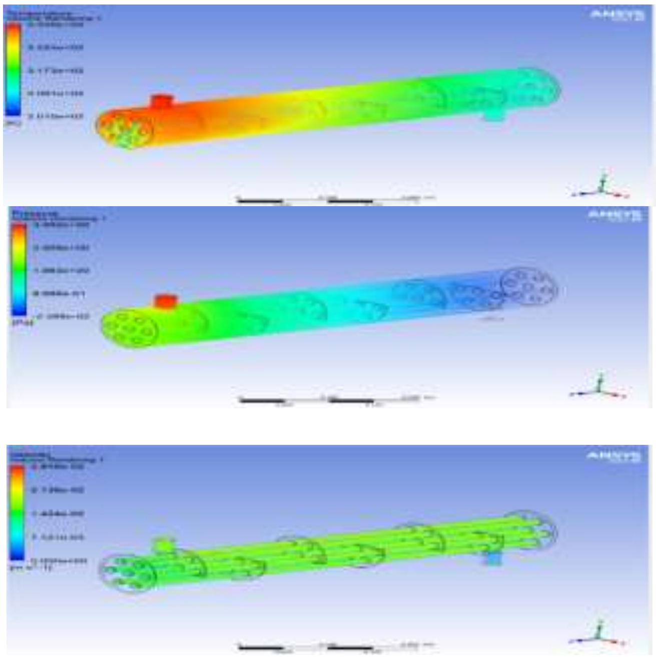
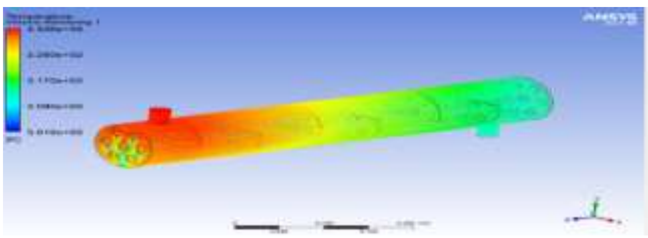


Fig 4.4.Temperature, Pressure and Velocity distribution

4.4.5 For CuO 1% as nano fluid

Variation of Temperature, Pressure and Velocity



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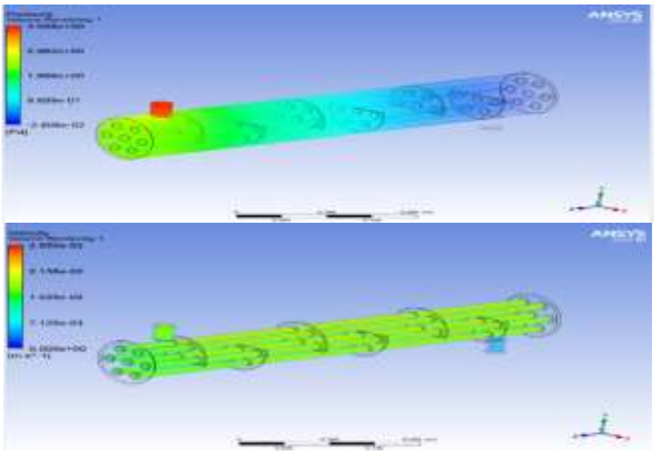
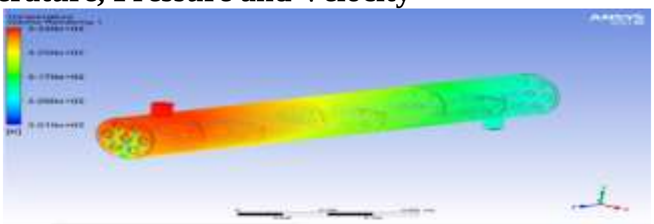


Fig 4.5.Temperature, Pressure and Velocity distribution

Table no.4.1. Inputs and Outputs

S. no	Nanofluid	composition	Hot-inlet temperature(k)	Hot-outlet temperature(k)	Cold-inlet temperature(k)	Cold-outlet temperature(k)	Heat transfer rate w/m^{2-} K
1.	Water	100%	333	313.60	301	308.42	418.03
2.	Al_2O_3	1%	333	312.82	301	308.77	421.98
3.	Al_2O_3	3%	333	312.15	301	309.17	428.07
4.	Al_2O_3	5%	333	311.54	301	309.55	435.27
5.	CuO	1%	333	312.69	301	308.96	420.45
6.	CuO	3%	333	311.74	301	308.71	424.19
7.	CuO	5%	333	310.99	301	310.49	429.85

4.4.6 For CuO 3% as nano fluid
Variation of Temperature, Pressure and Velocity



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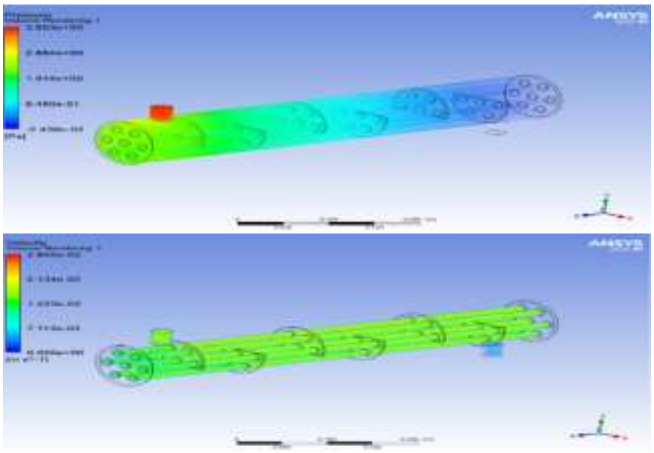

Fig 4.6.Temperature, Pressure and Velocity distribution

4.4.6 For CuO 5% as nano fluid

Variation of Temperature, Pressure and Velocity

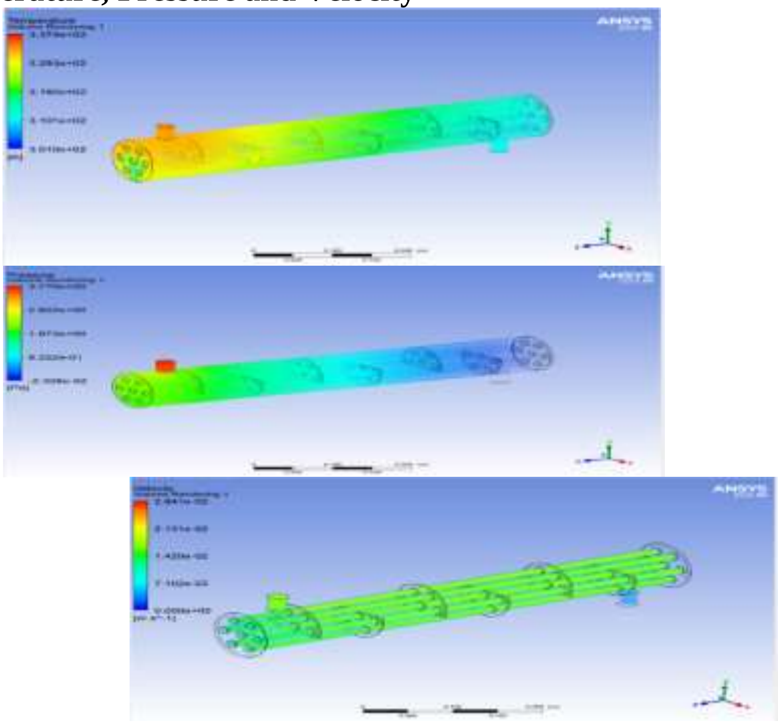

Fig 4.7.Temperature, Pressure and Velocity distribution

5. Unique contribution of research

The main goal of this study was to adjust or execute operations with various nanofluids of varying concentrations in order to increase the heat transfer rate and performance efficiency of the shell and tube heat exchanger.

In this examination of a shell and tube heat exchanger, various nanofluids with varying concentrations are taken into account, including water, Al2O3 at 1%, 3%, and 5%, CuO at 1%, 3%, and 5%, and Al2O3 at 5%. Out of these nanofluids, CuO at 5% provided the best heat transfer rate and efficiency.

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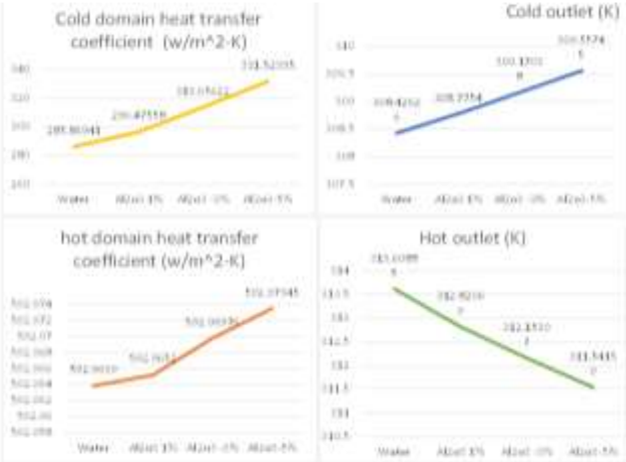

Fig no. 5.2. for Aluminum oxide (1%,3%,5%)

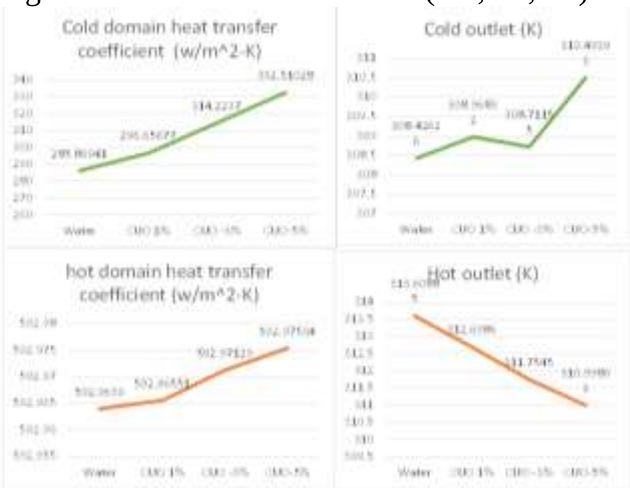

Fig no. 5.3. for Copper oxide (1%,3%,5%)

6. Conclusion

It has been determined that the endeavour to significantly improve the performance of shell and tube heat exchangers under various nanofluids with variable concentrations was successful. Based on the analysis's findings, it has been determined that because copper is a very thermally conductive material, the shell and tube heat exchanger with CuO 5% nano fluid has high net heat transfer rates in comparison. Al2O3 5% has high net heat transfer rates when compared to water and Al2O3 as nanofluids for shell and tube heat exchangers.

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