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CFD ANALYSIS OF PARALLEL AND COUNTER FLOW DOUBLE PIPE HEAT EXCHANGER

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ABSTRACT: Heat exchangers are devices used to transfer heat energy from one fluid to another. The temperatures of both fluids may change while flowing through the exchanger. The energy transferred between the streams results in a change in temperature of each fluid stream if neither fluid is undergoing a phase change. As a result of the gradual change in the temperature levels in an exchanger, the temperature difference across the heat transfer barrier vary over the length of the exchanger. There are also economic considerations which include as initial cost of the exchangers, necessary space, and required life of the unit and ease of maintenance

Double pipe heat exchangers are the simplest recuperates in which heat is transferred from the hot fluid to the cold fluid through a separating cylindrical wall. It consists of concentric pipes separated by mechanical closures. Inexpensive, rugged and easily maintained, they are primarily adapted to high temperature, high-pressure applications due to their relatively small diameters

In this thesis calculating pressure and temperature and velocity parameters in two different flow patterns (parallel, counter flow) and finally thesis conclude with which flow or Nano particle will have more hate transfer rate

Tools were used:

Cad tool: solid works

Cae tool: Ansys workbench fluent

1. INTRODUCTION

HEAT EXCHANGERS

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions. Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single-or multi component fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control a process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In many heat exchangers, the fluids are separated by a heat transfer surface, and ideally they do not mix or leak. Such exchangers are referred to as direct transfer type, or simply recuperate. In contrast, exchangers in which there is intermittent heat exchange between the hot and cold fluids—via thermal energy storage and release through the exchanger surface or matrix— are referred to as indirect transfer type, or simply regenerators. Such exchangers usually have fluid leakage from one fluid stream to the other, due to pressure divergences and matrix rotation/valve switching. Common examples of heat exchangers are shell-and-tube exchangers, automobile radiators, condensers, evaporators, air preheaters, and cooling towers. If no phase change occurs in any of the fluids in the exchanger, it is sometimes referred to as a sensible heat exchanger. There could be internal thermal energy sources in the exchangers, such as in electric heaters and nuclear fuel elements.

Combustion and chemical reaction may take place within the exchanger, such as in boilers, fired heaters, and fluidized-bed exchangers. Mechanical devices may be used in some exchangers such as in scraped surface exchangers, agitated vessels, and stirred tank reactors. Heat transfer in the separating wall of a recuperate generally takes place by conduction.

Applications:

The SHE is good for applications such as pasteurization, digester heating, heat recovery, pre-heating and effluent cooling. For sludge treatment, SHEs are generally smaller than other types of heat exchangers.

APPLICATIONS OF HEAT EXCHANGERS:

- Heat exchangers are used in a wide variety of applications such as home heating, refrigeration, air conditioning, petrochemical plants, refineries as well as in natural gas processing.

- In many industrial processes a heat exchanger helps in using the wasted heat from one process to be utilized in another process which saves a lot of money while being efficient at the same time.
- Cooling of hydraulic fluid and oil in engines, transmissions and hydraulic power packs.
- Heat exchangers are used in many industries, including:
  -Waste water treatment

  -Refrigeration

  -Wine and beer making

  -Petroleum refining

- In commercial aircraft heat exchangers are used to take heat from the engine's oil system to heat cold fuel.

NANO FLUID

A Nano fluid is a fluid containing nanometer-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in Nano fluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene glycol and oil.

Applications

Nano fluids are primarily used for their enhanced thermal properties as coolants in heat transfer equipment such as heat exchangers, electronic cooling system (such as flat plate) and radiators. Heat transfer over flat plate has been analyzed by many researchers. However, they are also useful for their controlled optical properties. Graphene based Nano fluid has been found to enhance Polymerase chain reaction efficiency. Nano fluids in solar collectors is another application where Nano fluids are employed for their tunable optical properties

Literature review

Extensive work has been completed on the flow and heat transfer characteristics of heat exchangers. There are a number of published papers and handbooks on this subject, for both hydrodynamic and heat transfer aspects. Kays and Perkins (1973), Berger et al., (1983) and Shah and Joshi (1987) are some of the more complete reviews.

J.S. Jayakumara et al., [1] conducted an experimental study on Computational Fluid Dynamics (CFD) of helically coiled heat exchanger. In this paper, after validating the methodology of CFD analysis of a heat exchanger, the effect of considering the actual fluid properties instead of a constant value is established. Heat transfer characteristics inside a helical coil for various boundary conditions are compared. It is found that the specification of a constant temperature or constant heat flux boundary condition for an actual heat exchanger does not yield proper modelling. Hence, the heat exchanger is analyzed considering conjugate heat transfer and temperature dependent properties of heat transport media. An experimental setup is fabricated for the estimation of the heat transfer characteristics. The experimental results are compared with the CFD calculation results using the CFD package FLUENT 6.2. Based on the experimental results a correlation is developed to calculate the inner heat transfer coefficient of the helical coil.

M.H. Saber, et al., [2] conducted a study the on the simulation and CFD analysis of Heat Pipe Heat Exchanger using fluent, to increase the thermal efficiency. In this paper, a heat pipe heat exchanger is considered and computational fluid dynamics (CFD) is used to analyses its evaporators performance and based on it, it was tried to increase the thermal efficiency and optimize the distribution of fluid flow in this type of heat exchangers. The numerical computations are achieved using Fluent (the CFD solver program).

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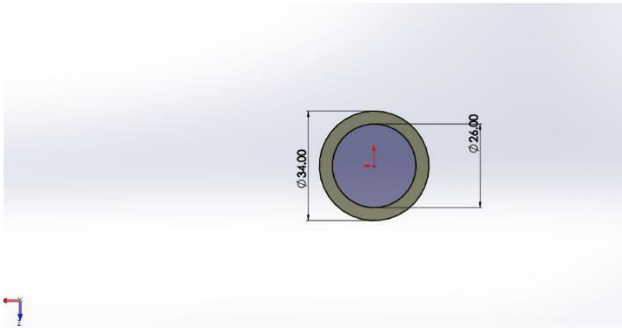
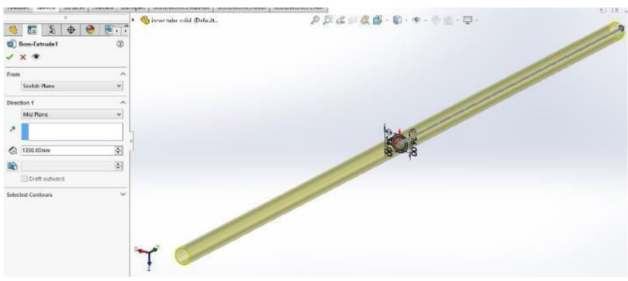
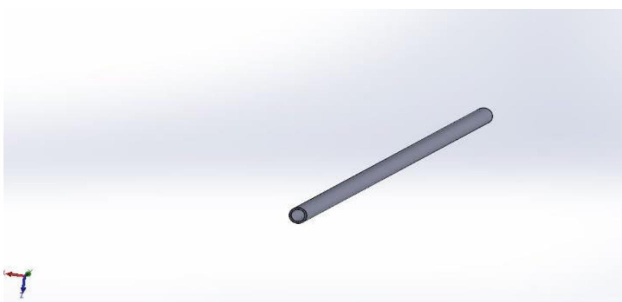
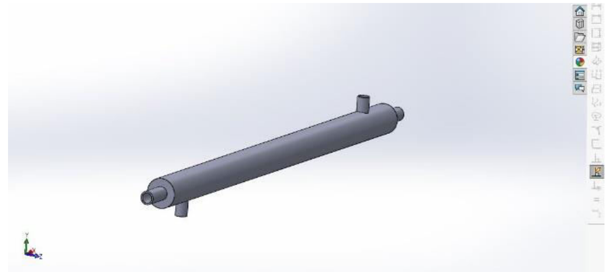
Designing process step by step









Double pipe heat exchanger final assembly model

Ansys process

Material selection

Steel

Young's modulus: - 2.0*10^11 Pa

Poison ratio: 0.29

Density: 7850 Kg/m^3

Yield strength: 250Mpa

EN9

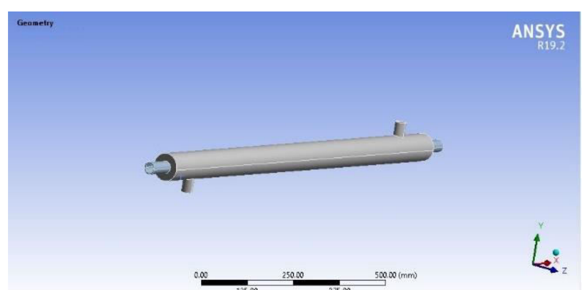
Ex: - 210*10^9 pa

Poison ratio: 0.29

Density: 7850 kg/m^3

Yield strength: 355*10^6 mpa

Import



Meshing

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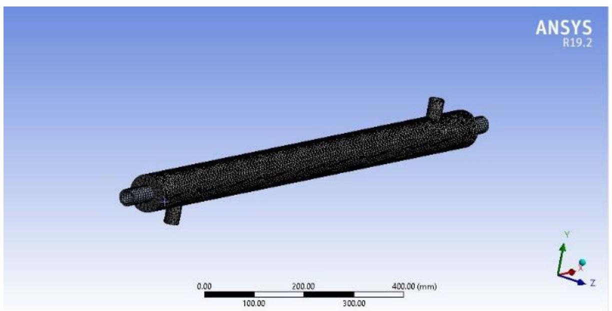
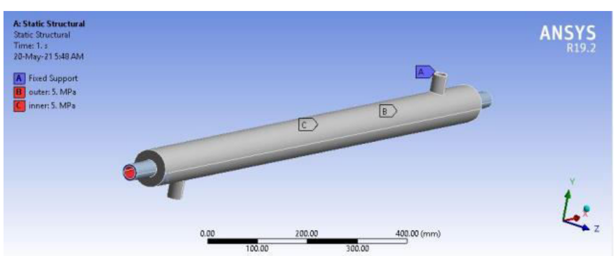
After completion of material selection here we have to create meshing for each object meshing means it is converting single part into no of parts. And this mesh will transfer applied loads for overall object. After completion meshing only we can solve our object. Without mesh we cannot solve our problem. And here we are using tetra meshing and the model shown in below.



Boundary conditions



Static structural →supports→fixed support→inlet outlet areas

Pressure →5 Mpa

After completion of boundary conditions here we have to check results by solving. Just click on solve option and select results like deformation, strain, stress and safety factor values for the object.

Solution→solve→deformation

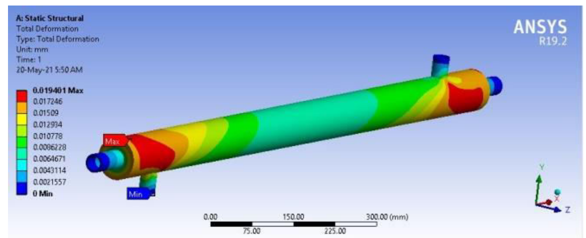
Solution→solve→safety factor

Solution→solve→stress

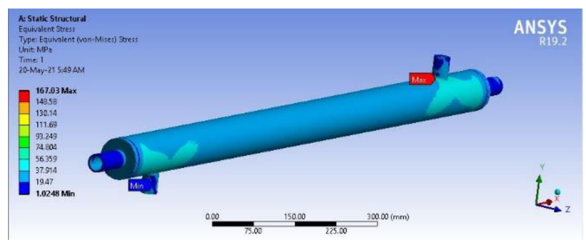
Results

Steel

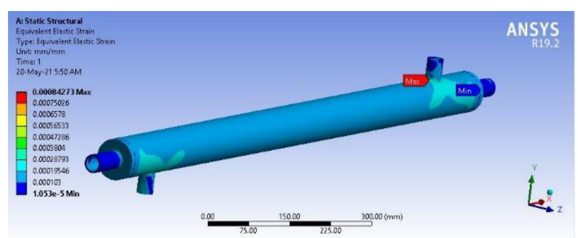
Deformation



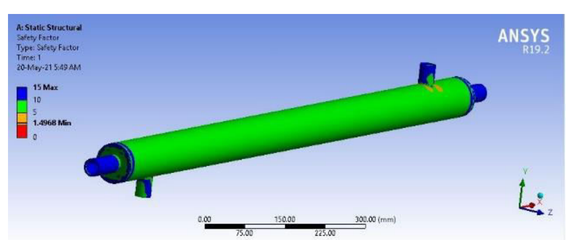
Stress



Strain



Safety factor



Tables

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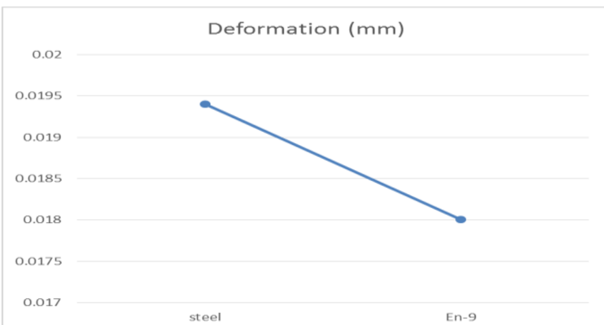
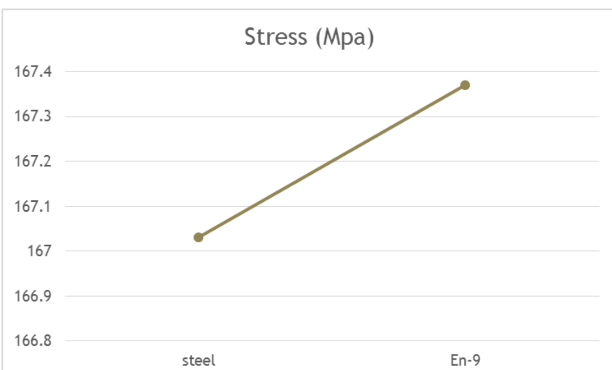
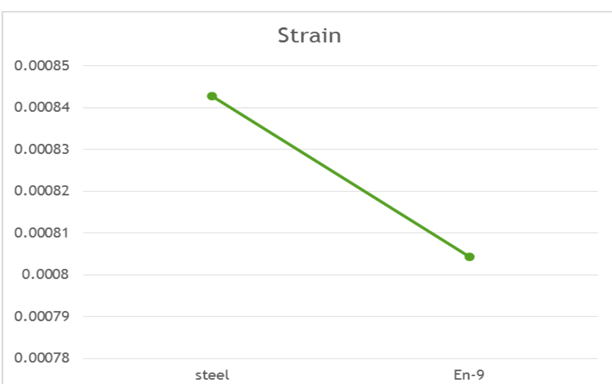
	steel	En-9
Deformation (mm)	0.019401	0.018008
Stress (Mpa)	167.03	167.37
Strain	0.00084273	0.00080434
Safety factor	1.4968	2.121

Graphs



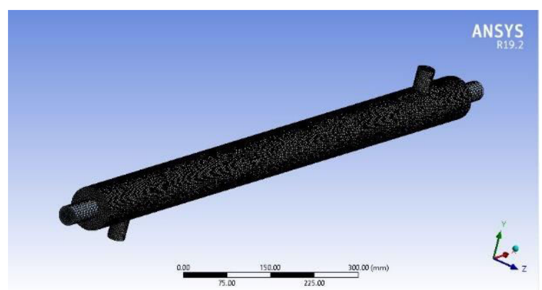




Cfd analysis results

Meshing

After completion of material selection here we have to create meshing for each object meshing means it is converting single part into no of parts. And this mesh will transfer applied loads for overall object. After completion meshing only we can solve our object. Without mesh we cannot solve our problem. And here we are using tetra meshing and the model shown in below.



Cold inlet temperature → 298K

Hot inlet temperature→ 333K

Cold fluid mass flow rate → 0.017Kg/s

Hot fluid mass flow rate → 0.0238Kg/s

Results

Water

Pressure

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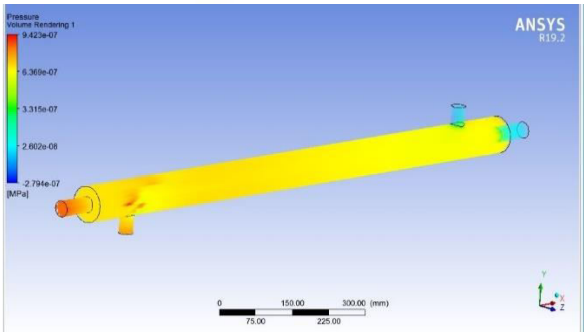
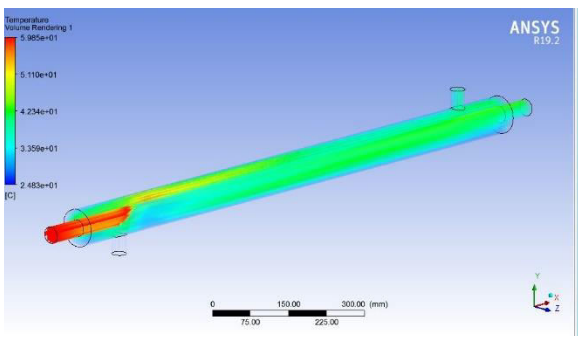
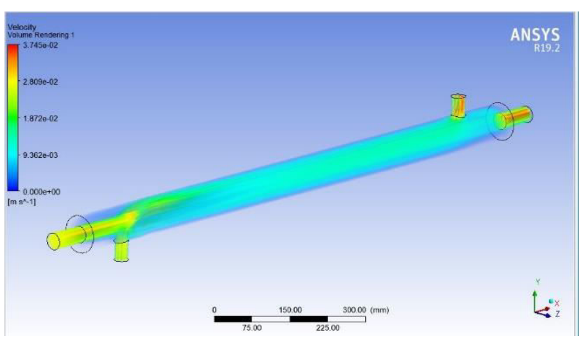


Temperature



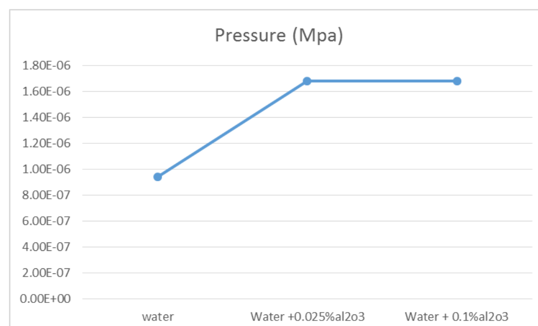
Velocity

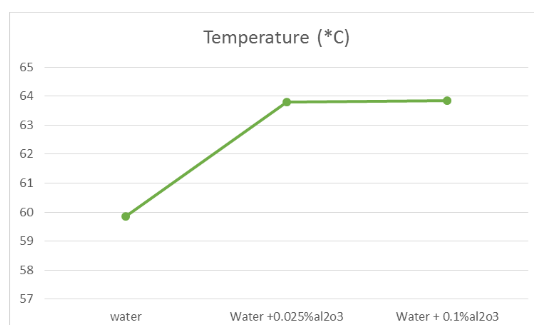


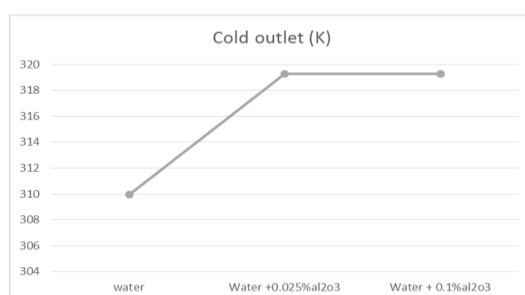
Tables

	water	Water +0.025%al2o3	Water + 0.1%al2o3
Pressure (Mpa)	9.423e-7	1.681e-6	1.680e-6
Temperature (*C)	59.85	63.81	63.85
Velocity (m/s)	3.745e-2	4.221e-2	4.219e-2
Cold inlet (K)	297.999	297.99986	297.99986
Cold outlet (K)	309.972	319.287	319.27634
Hot inlet (K)	332.333	332.999	332.999
Hot outlet (K)	311.932	310.936	310.886
Cold domain heat transfer coefficient (w/m^2-k)	55.924	28.650	29.233433
hot domain heat transfer coefficient (w/m^2-k)	19.1466	19.316	19.312098

Graphs







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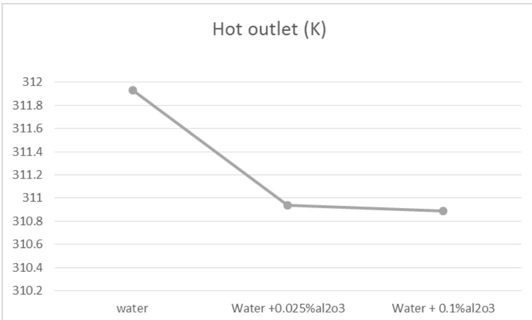
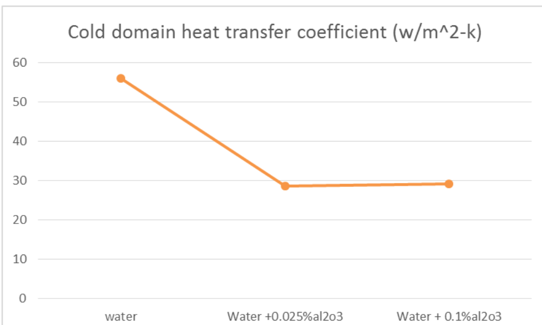
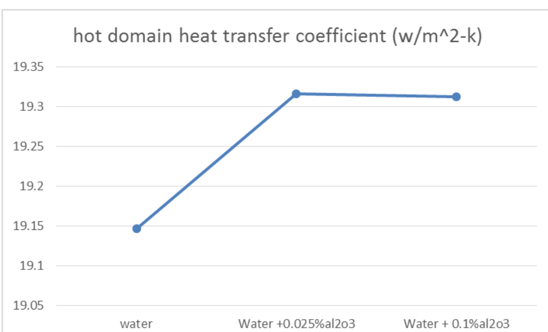






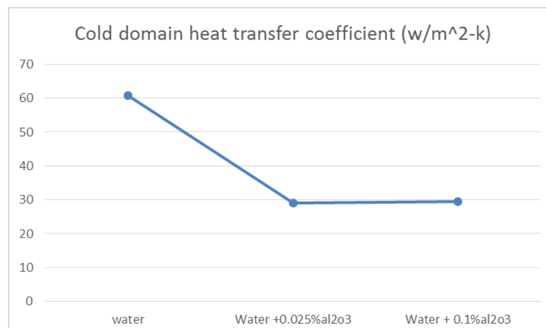
COUNTER FLOW

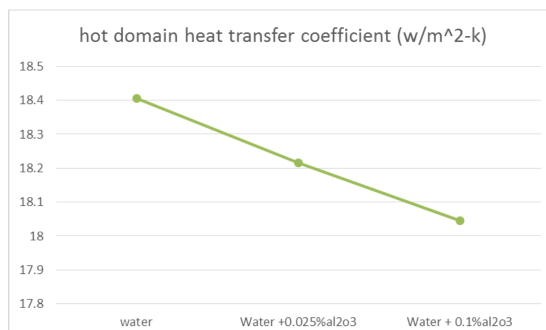
Results

Tables

	water	Water +0.025%al2o3	Water + 0.1%al2o3
Pressure (Mpa)	1.39E-06	1.83E-06	1.82E-06
Temperature (*C)	60.16	64.85	64.91
Velocity	4.00E-02	4.91E-02	4.89E-02
Cold inlet (K)	297.999	297.999	297.999
Cold outlet (K)	325.514	330.946	330.924
Hot inlet (K)	333	332.999	333
Hot outlet (K)	298.579	299.332	299.306
Cold domain heat transfer coefficient (w/m^2-k)	60.714	29.023	29.4023
hot domain heat transfer coefficient (w/m^2-k)	18.405	18.2167	18.0444

Graphs





CONCLUSION

In this thesis here double pipe heat exchanger developed with the help of solid works tool, and analyzing it with 2 different flow (parallel, counter flow) parameters, and calculating results like pressure and temperature and velocity and cold inlet and outlet temperature and hot inlet and outlet temperature values. From analysis results it is observe that Nano particles are increasing the velocity and pressure on walls, but this

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pressure is completely under yield limit values. And when AL2O3 Nano particles mixing with water, the hot outlet temperature we decreasing compare to normal water usage in parallel flow, it means the heat transfer rate increasing by adding this al2o3 Nano particles.

In similar manner heat transfer rate decreasing by adding al2o3 Nano particles to counter flow, and increasing hot outlet temperature values for al2o3 Nano particles compare to water usage.

Finally thesis conclude with these al2o3 Nano particles are increasing heat transfer rate values in parallel flow, and decreasing in counter flow. So 0.025% & 0.10% al2o3 Nano particles are suggested for only parallel flow heat exchanger to enhance the heat transfer rate values.

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