[Anvesh*, 5(3): March, 2016] ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

CFD ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER FOR HEAT TRANSFER ENHANCEMENT BY USING NANO FLUIDS

Ch. Venkata Anvesh*, Ch. Kiran Kumar, T. Naveen
*M.Tech Thermal Engineering, Sanketika Institute of Technology & Management, India.
Associate Professor, Dept of Mechanical Engineering, Sanketika Institute of Technology & Management, India
Technical Assistant, Dept of Mechanical Engineering, Gayatri Vidya Parishad College of Engineering, India

DOI: 10.5281/zenodo.48366

ABSTRACT
A heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid, between solid particulates and fluid, at different temperatures. Heat exchangers are important engineering devices in many process industries since the efficiency and economy of the process largely depend on the performance of the exchanger. Aluminium Oxide has a more thermal conductivity and is dispersed in water as Base Fluid. Copper Material has a maximum thermal conductivity and is used as a material of Double Pipe Heat Exchanger. The Concentration of the Nano Fluids size is in Base Fluids Plays a major role as its size increases density increases. Heat Exchangers considered to have great potential for heat transfer enhancement and are highly suited to application in heat transfer processes. In recent years, several important research works have been carried out to understand and explain the causes of the enhancement or control of heat transfer using Nano fluids. Nano Particles are expensive so analysis is useful than the experimental investigation of Nano fluid Properties for better heat exchanger. CFD simulations shall be done for three Al_2O_3-water Nano fluid concentrations of 0.1%, 0.2%, and 0.3% by volume.

KEYWORDS: Double pipe Heat Exchanger, Nano Fluid, Al_2O_3-Nano dispersion.

INTRODUCTION
Different types of heat exchangers are extensively used in various industries to transfer the heat between cold and hold stream. The key role of the heat exchanger is to transfer heat at maximum rate. The enhancement in heat transfer rate is possible to achieve by two steps viz. (1) to optimize the design of the heat exchanger and (2) to optimize the operational parameters. A Nano fluid is a mixture of Nano sized particles and a base fluid. Typical nanoparticles are made of metals, oxides or carbides, while base fluids may be water, ethylene glycol or oil. The Nano fluid exhibits different thermo physical properties than the base fluid. Generally thermal conductivity of Nano fluids is higher than the base fluid which increases the heat transfer rate. The heat transfer enhancement using Nano fluid mainly depends on type of nanoparticles, size of nanoparticles and concentration of nanoparticles in base fluid.

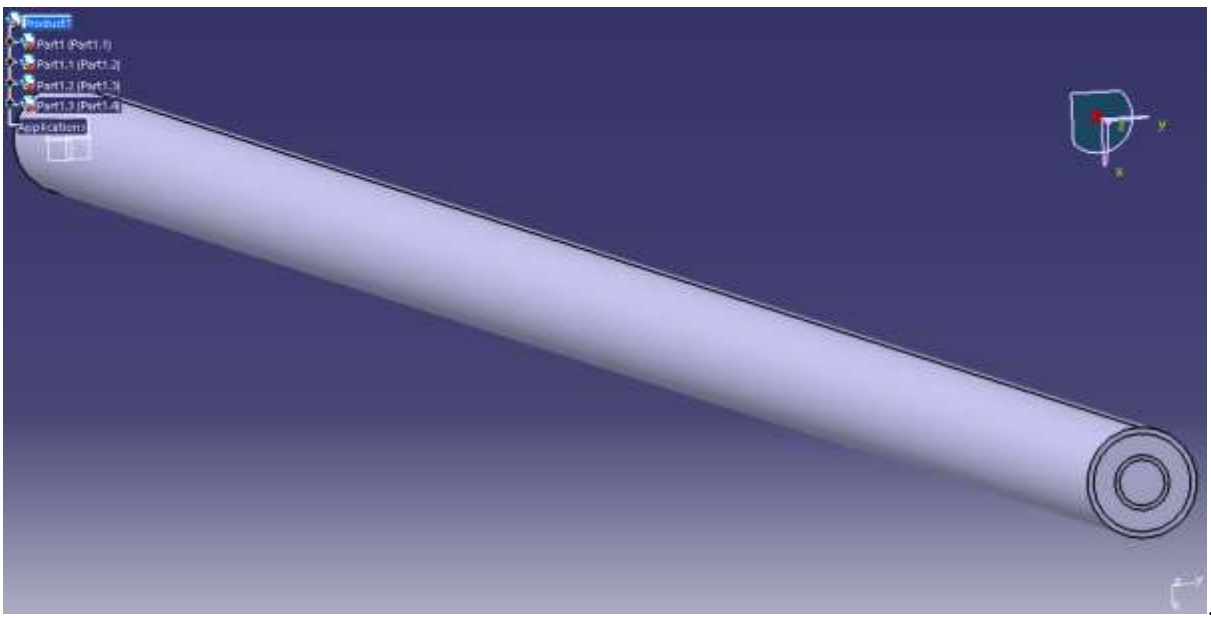
MATERIALS AND METHODS
Material for Double pipe Heat Exchanger
Apparatus for Double pipe Heat Exchanger is shown in the figure 1. The material used for the outer pipe and the inner pipe of the exchanger is Copper material. And the Nano Fluid is aluminium Oxide mixed with water at different concentrations and are passed through the inner pipe and water as base fluid is passed through the outer pipe. The dimendions of the pipe are shown in the table 1.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Table 1 shows the Dimensions of Double pipe Heat Exchanger

Part name	Inner diameter in mm (ID)	Outer diameter in mm (OD)	Length of the pipe mm (L)
Inner fluid	15	-	3000
Inner pipe	15	18	3000
Outer fluid	18	32	3000
Outer pipe	32	36	3000

Figure 1 shows the design diagram of Doupipe Heat Exchanger



METHODS

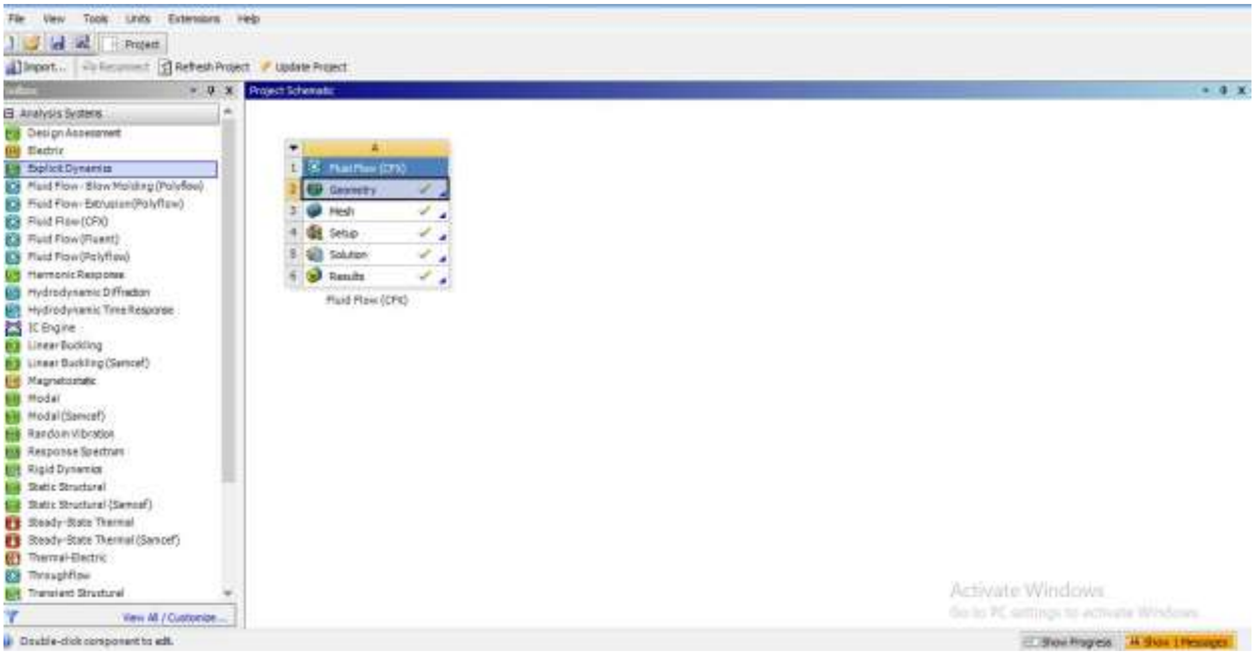
Method to Design Heat Exchanger IN CATIA

Step 1: Open CATIAv5 R20 and Go to Start > Mechanical design > Part design.
Step 2: Open Sketcher module by selecting XY plane > Sketcher.
Step 3: Draw the circle with the 15mm diameter and extrude to a length of 3000mm. The design part is inner fluid part. Save it as a part 1
Step 4: Draw the circles at the same centre with 15mm diameter and 18mm diameter and extrude to a length of 3000mm. The design part is inner pipe. Save it as a part 2
Step 5: Draw the circle with the 18mm diameter and 32mm diameter and extrude to a length of 3000mm. The design part is outer fluid save it as part3
Step 6: Draw the circle with the 32mm diameter and 36mm diameter and extrude to a length of 3000mm. The design part is outer pipe save it as 4.
Step7: Assemble the all four parts by using assemble command by fixing one centre point. Hence the required double pipe heat exchanger is modelled using CATIA.

Method of Analysis for Double Pipe Heat Exchanger

Analysis for double pipe heat exchanger is done by Ansys CFX (Fliud Flow)

Figure 2 shows the start page for analysis setup



In this Analysis which has 5 steps which are Geometry, Meshing of system,Setup,Solution and Results

In the geometry the heat exchanger.igs is imported and meshing of the setup is meshed in mesh step.

Setup is done for the heat exchanger and in puts are created with boundary conditions. In the Solution step the setup file running will be done by edit and run calculations. The final step in the Analysis is Results, which will be shown in results step by editing results.

Geometry

Step 1: Open Ansys Workbench 15.0 and select CFX Solver in the display window.

Step 2: Go to Geometry > Select import geometry and browse heat exchanger.igs

Step 3: In the design modeler window right click on Import1 and click on Generate.

Step 4: Close the design modeler window.

Meshing

Step1: In the workbench module right click on Mesh and click edit.

Step2: Click on Expand the model >expand Geometry> Go to part1>right click on part1> go to named selection > name as OP (Outer Pipe)

Step3: Go to part2>right click on part2> go to named selection > name as OF (Outer Fluid)

Step4: Go to part3>right click on part3> go to named selection > name as IP (Inner Pipe)

Step5: Go to part4>right click on part4> go to named selection > name as IF (Inner Fluid)

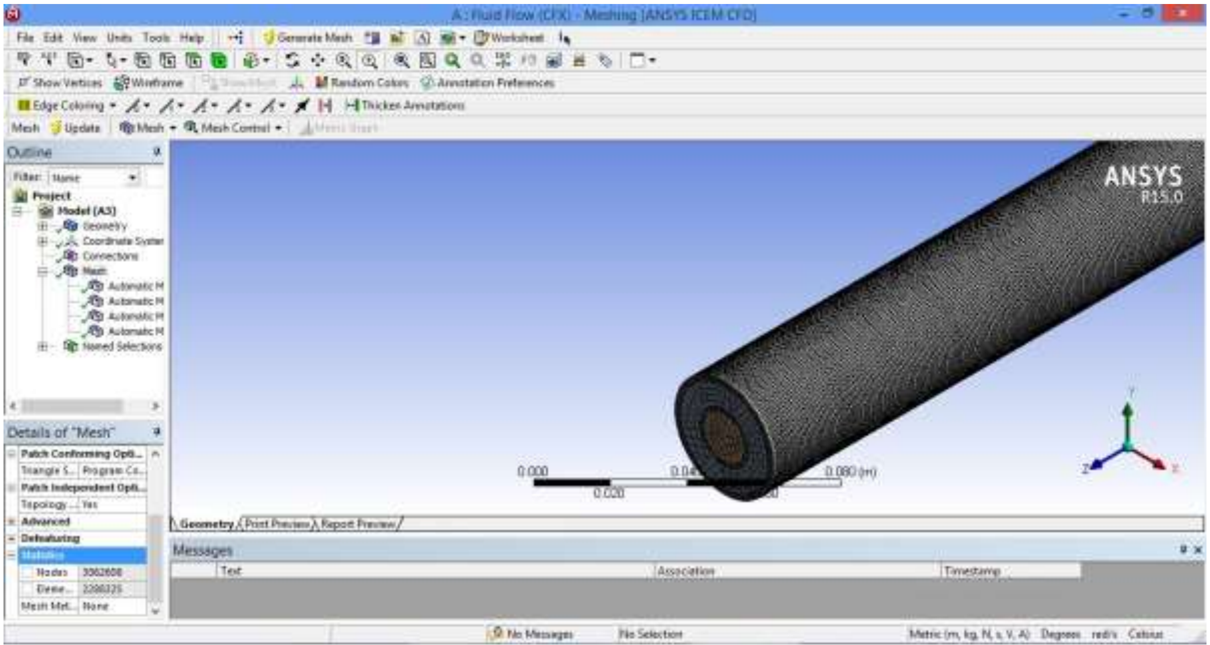
Step6: Go to model > Geometry> Hide parts 2, 3, 4 by right clicking and select hide body

Step7: Go to body> right click> Create Name selection name as OP WALL_1 (Outer Pipe Wall 1)

Step8: Repeat the steps to complete all the input parameters as discussed above steps.

Step9: Click on the generate mesh and wait until the mesh was generated.

Figure 3 Shows the generated mesh file



Setup:

Step1: Go back to workbench module > Right Click on Setup and Click Edit.

Step2: Go to CFX.cdmb > In Principal 2D Regions check all the named selection inputs Given at the time of meshing to generate the faces.

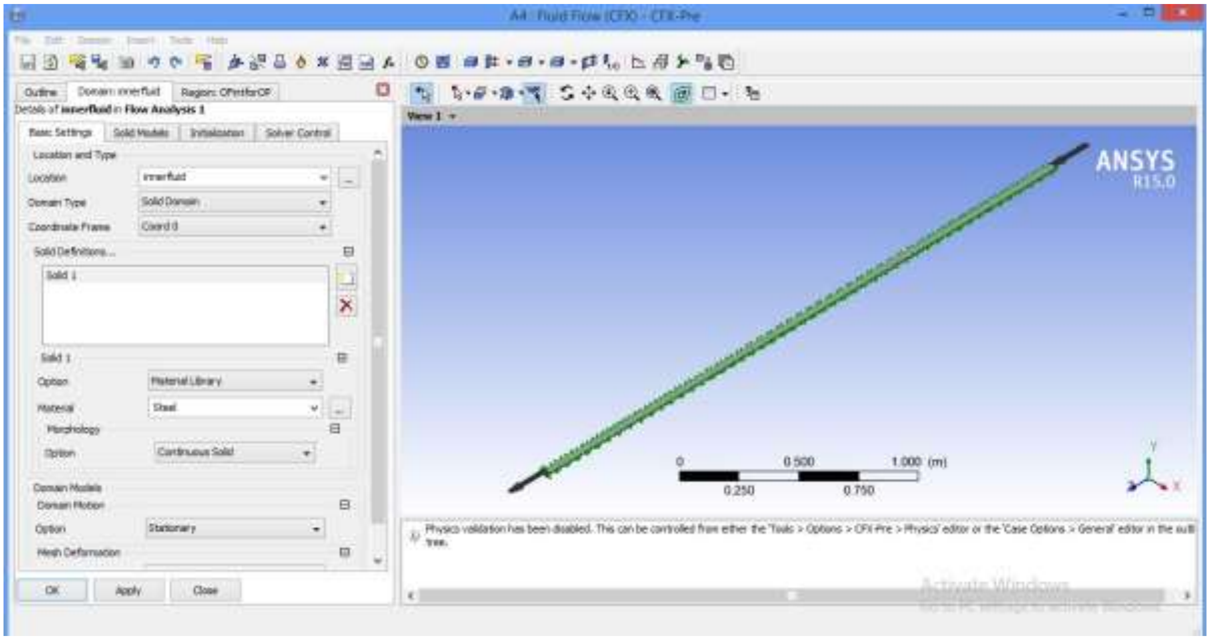
Step3: Go to IFintforIP > Insert > Boundary > inlet

Step4: Go to Inner fluid_ inlet 1 > Insert > Boundary > inlet

Step5: Go to Inner fluid_ outlet 1 > Insert > Boundary > outlet

Complete the steps for all the inlet and outlet conditions for the all Inner pipe, Inner fluid,Outer pipe, Outer Fluid.

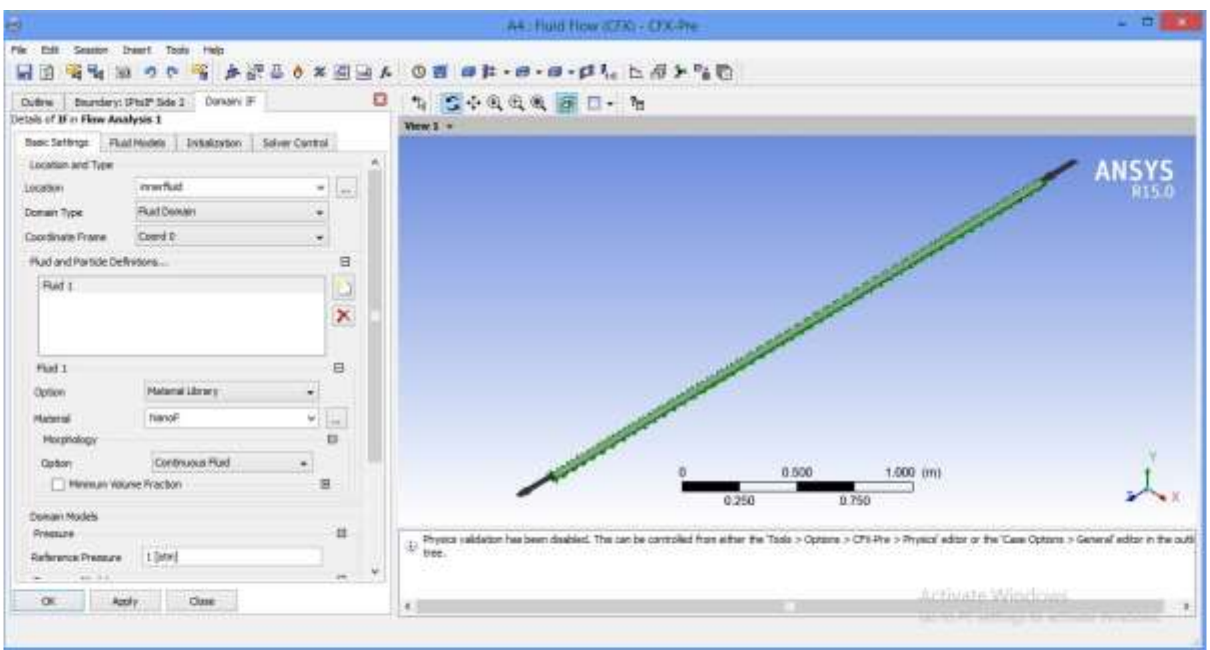
Figure 4 shows the setup



Simulation

In the simulation process flow analysis is carried out with giving input parameters as boundary conditions

Figure 5 shows the start page for simulation



Solution:

Step1: Go to Solution in Workbench Module and Click on Edit.

Step2: Select Run Mode > Platform MPI local and parallel in CFX solver Manager

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Step3: Click on Double Precision
Step4: Click on Start Run
Step5: Now the Iterations will start and wait until the Pop Up window appears Showing Results are Normally Completed.

RESULTS AND DISCUSSION

Analysis using Ansys CFX is done on double pipe heat exchanger has been carried out as per methodology. The results for parallel flow presented in Table and Table respectively. The overall heat transfer coefficients obtained analysis and temperatute distribution of fluids are shown in the figures.

Figure 6 shows the results for 0.1 concntration

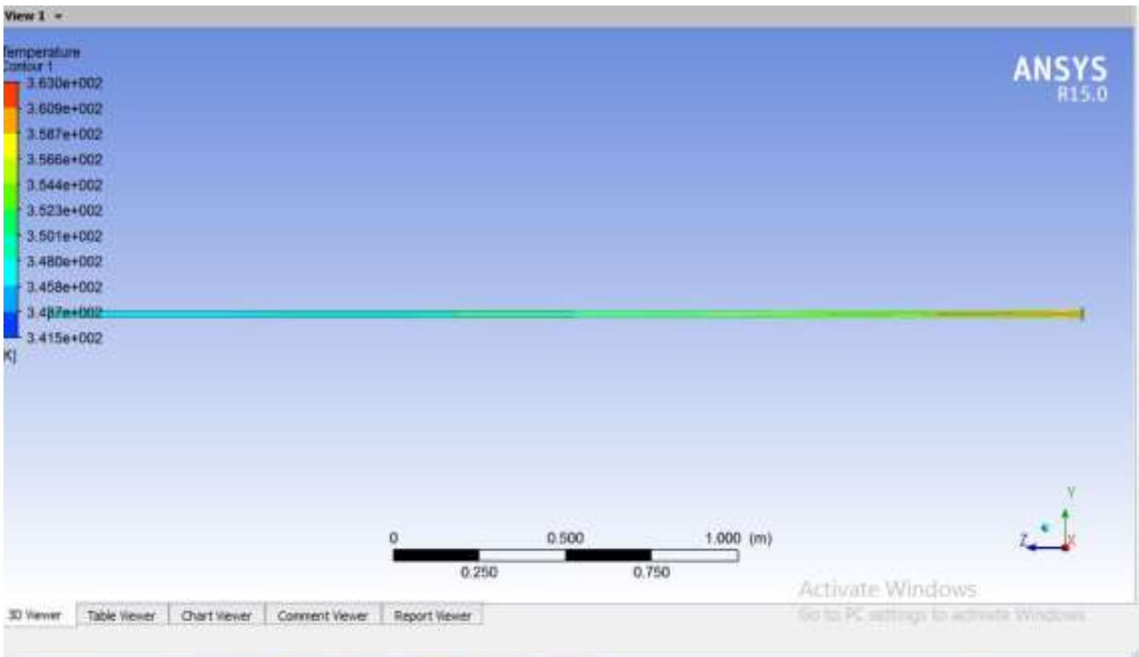


Figure 7 shows the results for 0.2 concntration

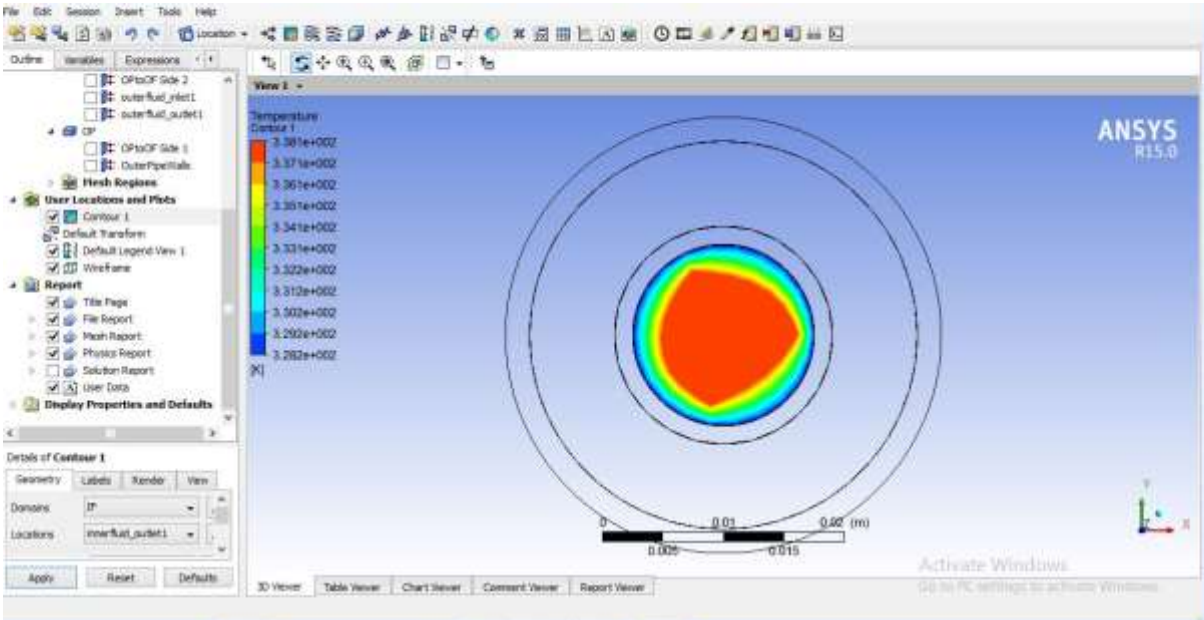
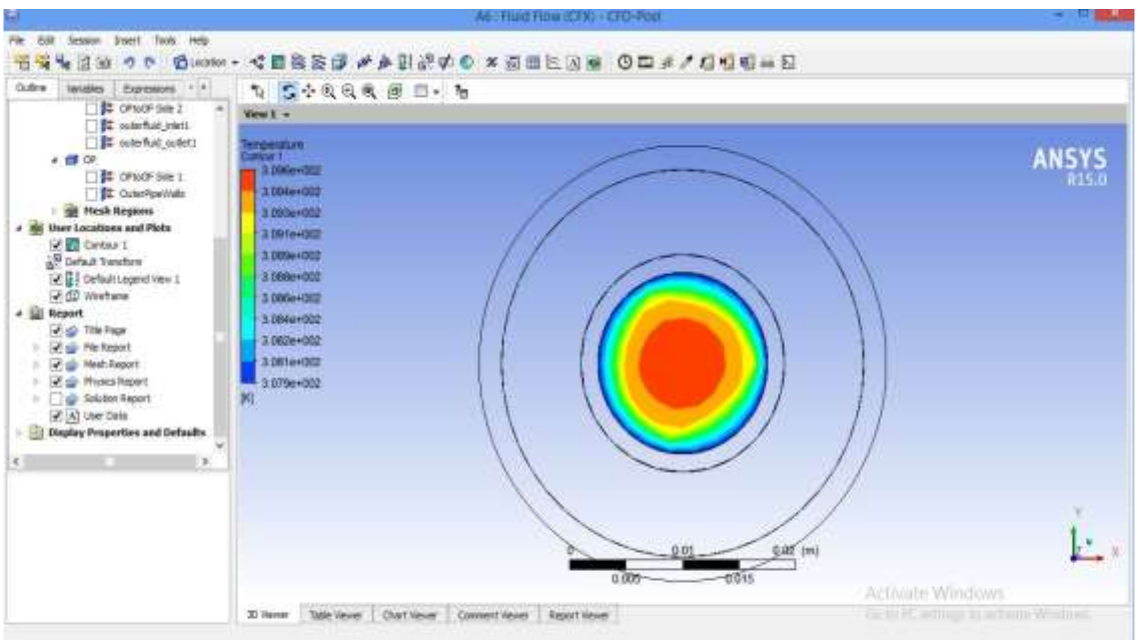


Figure 8 shows the results for 0.2 concntration



From the results the at the different concentrations the temperatures of Inner Fluid to Outer Fluids Varies as shown in the above figures.

Formulae:

Properties of Nano Fluids:

i) Density of nano fluid (ρnanoparticle):

$$(\rho_{nanoparticle}) = (\emptyset * \rho_{nanoparticle}) + \{(1-\emptyset) * \rho_{water}\}$$

ii) Specific heat of nano fluid (Cpnanoparticle):

$$Cp_{nanoparticle} = \frac{[(\emptyset * \rho_{nanoparticle} * Cp_{nanoparticle}) + \{(1-\emptyset) * \rho_{water} * Cp_{water}\}]}{\rho_{nanoparticle}}$$

iii) Viscosity of nano fluid ($\mu_{nanofluid}$):

$$\mu_{nanofluid} = \{1 + (7.3*\emptyset) + (123*\emptyset^2)\}\, \mu_{water}$$

iv) Thermal conductivity of nano fluid ($K_{nanofluid}$):

$$K_{nanofluid} = \frac{\{K_{nanoparticle}\} + \{2 * K_{water}\} + \{2 * (K_{nanoparticle} - K_{water}) * \emptyset\}}{\{K_{nanoparticle}\} + \{2 * K_{water}\} - \{(K_{nanoparticle} - K_{water}) * \emptyset\}}$$

V) Prandl number of nano fluid ($Pr_{nanofluid}$):

$$Pr_{nanofluid} = \frac{\mu_{nanofluid} * Cp_{nanoparticle}}{K_{nanofluid}}$$

Table 1 shows the properties of Nano Fluid

% of Nano Concentration	Thermal Conductivity (w/ mK)	Viscosity (Centi poise)	Specific heat (J/gK)	Density (kg/ m3)
0.1	0.6	0.7	3.5	1040
0.2	0.65	0.68	2.5	1045
0.3	0.7	0.6	0.45	1060

<u>For 0.1 concentrations:</u>

Mass flow rate of the m = density*velocity*area
= 1040*0.3*0.001018
= 0.317705143 kg/s

Re = density*velocity*diameter of pipe/kinematic viscosity

= 1040*0.03*0.015/0.0007

= 668.5714

Prandtl number = kinematic viscocity*specific heat/thermal conductivity

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

= 0.0007*3.5*0.6 = 0.004083

Dittus boelter Equation

$$Nu_D = 0.023*(Re_D)^{(4/5)}*Pr^{0.4}$$

$$Nu_D = 0.023*(668.5714)^{4/5}*(0.004083)^{0.4} = 0.4634$$

Inner pipe h_i

$h_i = N_U*D_I/K = 0.4634/0.6 = 18.53$

$h_o = N_U*D_2/K = 0.817*61.25/0.036 = 149.91$

Table 2 Shows Reynolds and Prandtl Number Values at three concentrations

Concentration Of Nano Fluid	Reynolds Number	Prandtl Number
0.1	668.5714	0.00147
0.2	691.5441	0.002615385
0.3	795	0.00385714

Table 3 Shows the Nusselt and Overall Heat Transfer Coefficients

Concentration of nano fluid	Valued of Dittus Boltear Equation	Overall Heat transfer Coefficients
0.1	0.463439	16.49759
0.2	3.986401	80.26163
0.3	4.02354	83.36012

CONCLUSION

For the taken input flow condition as the concentration of Nano Fluids is increased the overall effectiveness of the system gets increases.As the input of temperature of outer Fluid pipes is given there is a higher temperature distribution of temperatures to the outer pipes.

From theses as the Nano Fluids are using in the Heat Exchanger devices there is more amount of Heat can be Transferred to the other pipes

ACKNOWLEDGEMENTS

The authors are extremely thankful to the staff members of Mechanical Engineering Department, Sanketika Institute of Technology And Management Visakhapatnam for providing the useful resources and the management of the college and.The authors are also thankful to the students of the college for providing their untiring support and efforts wherever needed.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

REFERENCES

1. Rabienataj Darzi, Mousa Farhadi and Kurosh Sedighi, Heat transfer and flow characteristics of AL2O3–water Nano fluid in a double tube heat exchanger, International Communications in Heat and Mass Transfer, Volume 47, October 2013, Pages 105-112
2. Wael I. A. Aly, Numerical study on turbulent heat transfer and pressure drop of nanofluid in coiled tube-in-tube heat exchangers, Energy Conversion and Management, Volume 79, March 2014, Pages 304-316.
3. CFD analysis of enhancement of turbulent flow heat transfer in a horizontal circular tube with different inserts Sajid Hussein Ali Al – Abbasi Lecturer, Department of Mechanical Engineering College of Engineering,University of Basrah, Iraq
4. Mehdi Bahiraei, Seyed Mostafa Hosseinalipour and Mahdi Saeedan, Prediction of Nusselt Number and Friction Factor of Water-Al_2O_3 Nano fluid Flow in Shell-and-Tube Heat Exchanger with Helical Baffles, Chemical Engineering Communications
5. I. M. Shahrul, I. M. Mahbubul, R. Saidur, S. S. Khaleduzzaman, M. F. M. Sabri, and M. M. Rahman, Effectiveness Study of a Shell and Tube Heat Exchanger Operated with Nano fluids at Different Mass Flow Rates, Numerical Heat Transfer, Part A: Applications: An International Journal of Computation and Methodology, Volume 65, Issue 7, 2014, pages 699-713.
6. F.S. Javadi, S. Sadeghipour, R. Saidur, G. BoroumandJazi, B. Rahmati and M.M. Elias, M.R. Sohel, The effects of Nano fluid on thermo physical properties and heat transfer characteristics of a plate heat exchanger, International Communications in Heat and Mass Transfer, Volume 44, May 2013, Pages 58-63.
7. Shahabeddin K. Mohammadian and Yuwen Zhang, Analysis of nanofluid effects on thermoelectric cooling by micro-pin-fin heat exchangers, Applied Thermal Engineering, Volume 70, Issue 1, 5 September 2014, Pages 282-290
8. Y. Vermahmoudi, S. M. Peyghambarzadeh, S.H. Hashemabadi and M. Naraki, Experimental investigation on heat transfer performance of Fe2O3/water nanofluid in an air-finned heat exchanger, European Journal of Mechanics - B/Fluids, Volume 44, March–April 2014, Pages 32-41.
9. Arun Kumar Tiwari, Pradyumna Ghosh and Jahar Sarkar, Heat transfer and pressure drop characteristics of CeO2/water nanofluid in plate heat exchanger, Applied Thermal Engineering, Volume 57, Issues 1–2, August 2013, Pages 24-32
10. Z. Taghizadeh Tabari and S. Zeinali Heris, Heat Transfer Performance of Milk Pasteurization Plate Heat Exchangers Using MWCNT/Water Nanofluid, Journal of Dispersion Science and Technology
11. Shive Dayal Pandey and V.K. Nema, Experimental analysis of heat transfer and friction factor of nanofluid as a coolant in a corrugated plate heat exchanger, Experimental Thermal and Fluid Science, Volume 38, April 2012, Pages 248-256
12. M. Khoshvaght-Aliabadi, F. Hormozi and A. Zamzamian, Effects of geometrical parameters on performance of plate-fin heat exchanger: Vortex-generator as core surface and nanofluid as working media, Applied Thermal Engineering, Volume 70, Issue 1, 5 September 2014, Pages 565-579.