Thermal performance of Co-current & Counter current Flow Double Pipe Heat Exchanger Using Different Nano Fluids

[1]T. Meenakumari, [2] C. Neelima devi,
[1]Mtech, [2]Asst.Professor,
[1] Department of Mechanical Engineering,
[1]JNTUK-UCE Viziangaram, Andhra Pradesh, India.

Abstract: In heat exchanger heat is transfer from the higher to lower temperature difference and transfer of heat is an important aspect of the heat transfer application. The efficiency is depending upon the amount of transfer heat and mode of heat transfer. Heat is transfer from hot to cold fluid through wall max heat can transfer based on the heat transfer coefficient of transferring medium and the thermal conductivity of material. To increase efficiency heat transfer between small temperatures should be increased; this can be done by increasing the efficiency of the working fluid. In this experiment, heat transfer from hot fluid to cold fluid by Double pipe heat exchanger is experimentally investigated by using different Nano particles like Al2O3, CuO, SiO2, Ethylene-glycol and Water to get better heat transfer, the same thing is validated in CFD analysis. The experiment is performed at Laminar flow under different flow arrangements like Parallel flow and Counter flow. Same flow variations are validated in CFD analysis.

***Keywords* – heat exchanger, forced convection and ANSYS.**

I. INTRODUCTION

Heat transfer is the term used for transfer of thermal energy from a hot to a colder body. Theoretically on a microscopic scale, thermal energy is related to the kinetic energy of molecules. . Heat transfer always occurs from a hot body to a cold one, a result of the second law of thermodynamics

Moreover, heat exchanger is defined as a device used to exchange heat from one medium to another often through metal walls, usually to extract heat from a medium flowing between two surfaces. In automotive practice, radiator is used as heat exchanger to cool hot water from engine by air surrounding same like intercooler which used as heat exchanger to cool hot air for engine intake manifold by air surrounding. Usually, this device is made from aluminum since it is lightweight and good thermal conductivity.

II. SCOPE OF THE WORK

It is observed from the literature that the experimental data for different fluids in laminar and turbulent flow conditions are available. Although, CFD and experimental simulation results are not available for different nano-fluids in turbulent and laminar flow conditions. In this paper I find out the thermo physical properties in addition additives of nano particles to water. The heat transfer rate is enhanced by using different fluids. Similarly by using CFD simulation software, it can reduce the operation cost and time compared to experimental calculations, in order to measure the optimum parameter and the behavior of this type of heat exchanger.

III. METHODOLOGY AND APPROACH

The experiment is carried under different flow arrangements i.e. turbulent flow and laminar flow which are further carried out in parallel and counter flow using different nano fluids like Al2O3, Cuo, SiO2, Ethylene-glycol, and Water keeping as base fluid and by varying only hot fluids.

The inlet flow conditions like mass flow rate are varied maintaining the temperature constant i.e. at inner inlet 312°K and at outer inlet 300°K, the mass flow rates in laminar flow for inner inlet& outer inlet is taken as 0.0133, 0.0166, 0.02 kg/s and 0.01, 0.0133, 0.0166 kg/s similarly in turbulent flow the mass flow rates for inner inlet & outer inlet are taken as 1.2, 1.8, 2.4 kg/s&1.166, 1.66&2.166 kg/s.

Physical parameters like Materials properties and baffle segmental were introduced into the double pipe heat exchanger fluent model as the properties cannot be varied in experimental setup heat exchanger.

IV. EXPERIMENTAL SETUP

The experiment is carried out under laminar flow by using nano-fluids in inner pipe side and water in outer pipe side fluid. The water is feed through outer pipe side from the tank and nano-fluid is passing through inner pipe side as a hot fluid. By using electrical heater the nano-fluid is heated with control device. By using flow meters the flow rate is measured and governed by adapting valves. By attachment of thermocouples at inlet and outlet, temperatures of fluid are measured. Fig1 shows the experimental setup.

Heat rejected in hot water (Qh) = mh*cph*(Thi-Tho) in watts:

Heat taken by cold water (Qc) = mc*cpc*(Tco-Tci) in watts

Logarithmic mean temperature difference

LMTD = (θ2 – θ1)/ In (θ2/θ1)

Where $\theta 2 = Thi - Tci$, $\theta 1 = Tho - Tco$

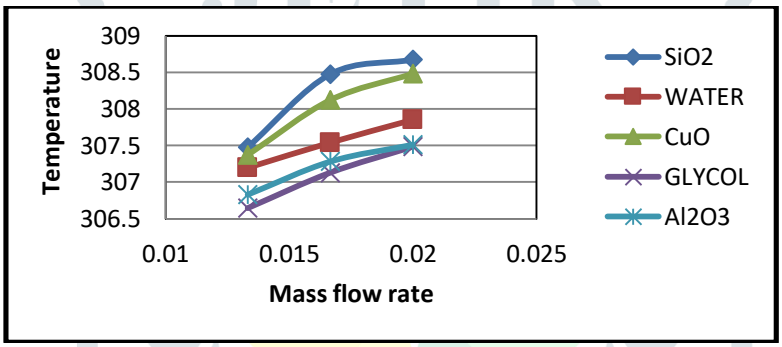
Overall heat transfer coefficient: $U0 = Qs / (Ao * LMTD)$.

Fig.1 Double pipe heat exchanger

IV.1 Hot Fluid Temperature Variation

From the below figure the hot fluid inlet and outlet temperatures is directly proportional to mass flow rate i.e. on increasing the mass flow rate the temperature of hot fluid increases.

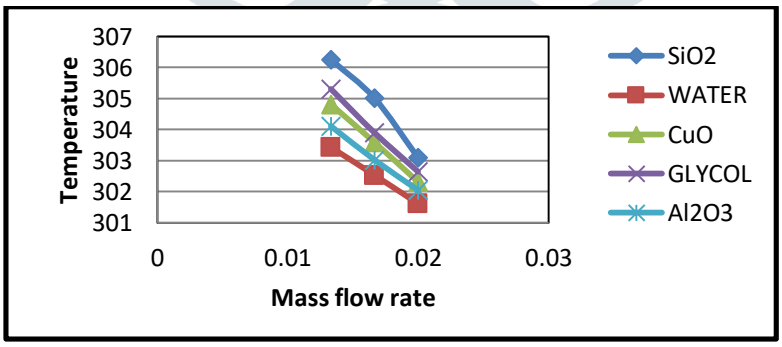
Graph1: Hot Fluid Temperature Variation



IV.II Cold Fluid Temperature Variation

From the below figure the cold fluid inlet and outlet temperatures is inversely proportional to mass flow rate i.e. on increasing the mass flow rate the temperature of cold fluid decreases.

Graph2: Cold Fluid Temperature Variation



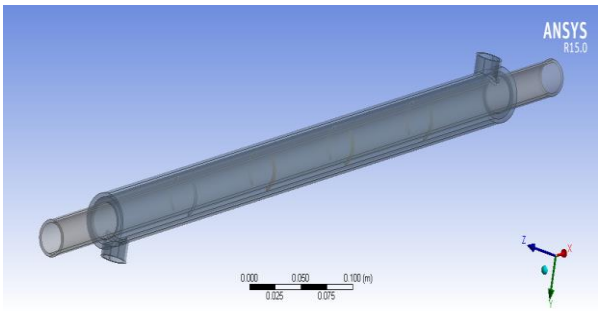
V. SIMULATION

V.I Problem Description and Modeling

For numerical analysis By using CATIA software the model is created. The analysis is done by using finite volume method.

V.I.I Geometry Modeling and Material Properties for the Analysis

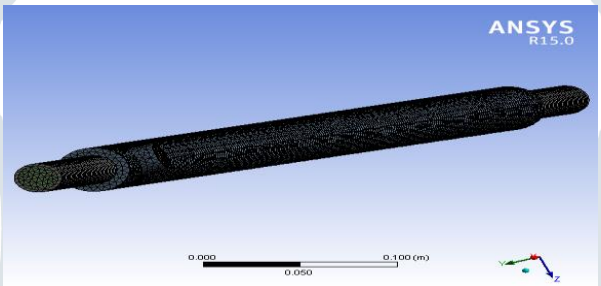
Fig2: Shell and tube heat exchanger model



V.I.II Mesh Generation

Initially a relatively coarser mesh is generated. This mesh contains mixed cells (Tetra and Hexahedral cells) having both triangular and quadrilateral faces at the boundaries. Care is taken to use structured hexahedral cells as much as possible. It is meant to reduce numerical diffusion as much as possible by structuring the mesh in a well manner, particularly near the wall region. Later on, a fine mesh is generated. For this fine mesh, the edges and regions of high temperature and pressure gradients are finely meshed.

Fig3: Grid generation



V.I.III Defining Material Properties

Table1. Properties of materials

Different material properties	Density (ρ) kg/m^3	Thermal conductivity(K) W/mk	Specific heat C_P j/kgK
Copper	8978	387.6	381
Aluminum	2719	203.2	871

Table2. Fluid properties

FLUIDS	DENSITY (Kg/m^3)	VISCOSITY (Ns/m^2)	SP.HEAT (Kj/kgk)	THERMAL CONDUCTIVITY (W/mk)
ACETONE	791	0.00033	2160	0.180
BENZENE	876.5	0.00058	1821	0.167
GLYCERIN	1261	0.799	2813	0.285
GLYCOL	1116	0.0157	2200	0.258
WATER	998.2	0.001003	4174	0.6

V.II Numerical Solution

At inlet as velocity inlets and pressure outlets at outlet as boundary conditions are applied. The inlet flow conditions like mass flow rate are varied maintaining the temperature constant i.e. at inner inlet 312°K and at outer inlet 300°K, the mass flow rates in laminar flow for inner inlet& outer inlet is taken as 0.0133, 0.0166, 0.02 kg/s and 0.01, 0.0133, 0.0166 kg/s similarly in turbulent flow the mass flow rates for inner inlet & outer inlet are taken as 1.2, 1.8, 2.4 kg/s&1.166, 1.66&2.166 kg/s. The parameters are remaining calculated by the software FLUENT. Finally we have to run the calculations after giving the boundary conditions to the inner and outer fluid.

V.III Results and Discussions

By monitoring of CFD simulation results are talk over below for the given boundary conditions. To find out the best fluid for double pipe heat exchanger.

i. The results will be analyzed by using ANSYS software.
ii. Experimental results will be done to use as a cross check.
iii. For modelling laminar flow heat transfer ANSYS FLUENT is a use full tool.

VI Experimental validation for parallel flow:

The temperature, pressure & velocity variation in a parallel flow double pipe heat exchanger of copper material performed for laminar flow is as shown in below profiles.

VI.I Temperature, pressure & Velocity Profile for parallel flow Heat Exchanger:

At mass flow rate 0.02 (Plane representation)

Fig4: Temperature variation

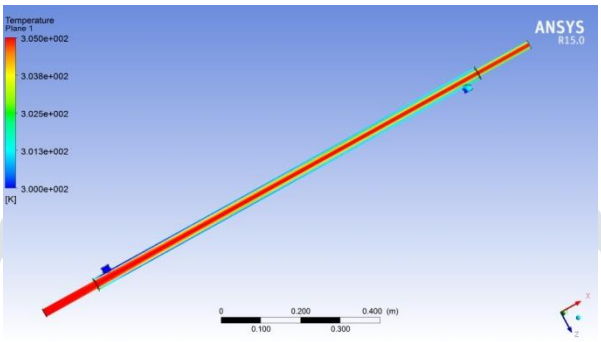


Fig5: Pressure variation

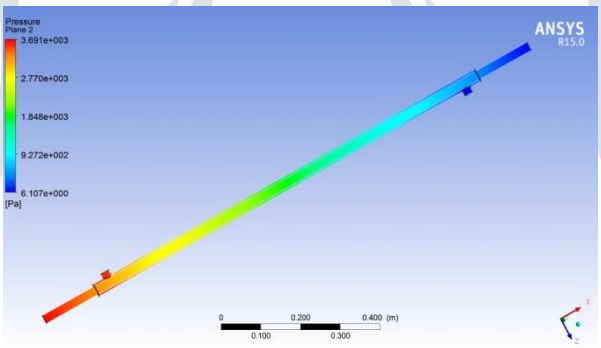
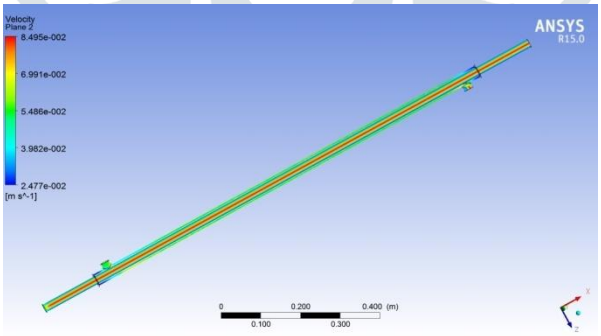


Fig6: Velocity variation



VII Experimental validation for counter flow:

VII.I Laminar Flow in a Counter Heat Exchanger FLUENT model:

The temperature, pressure & velocity variation in a counter flow double pipe heat exchanger of copper material performed for laminar flow is as shown in below profiles.

Temperature, pressure & Velocity Profile for counter flow Heat Exchanger

Fig7: Temperature variation

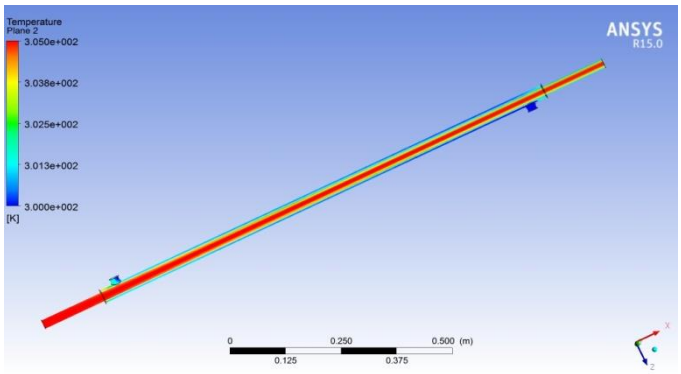


Fig8: Pressure variation

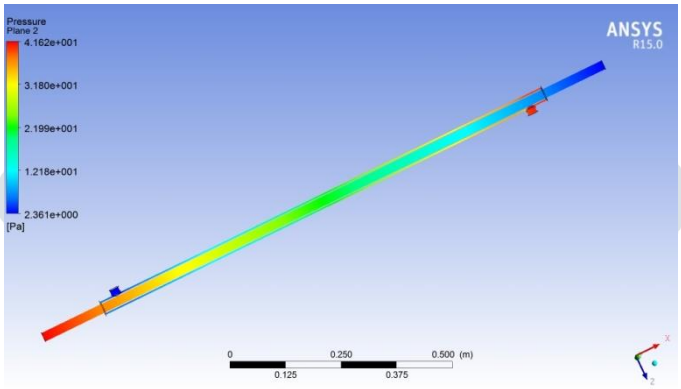
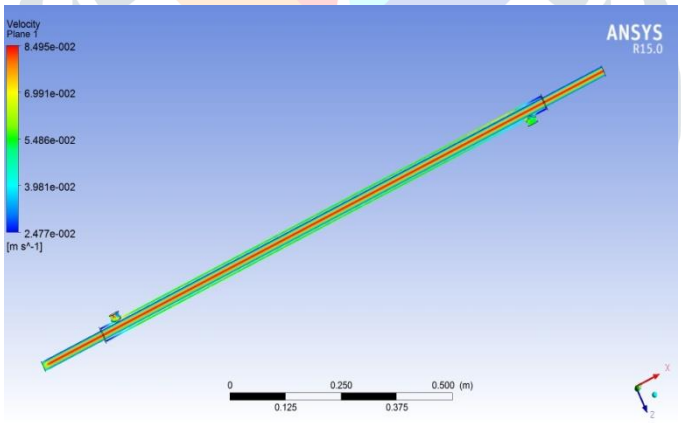


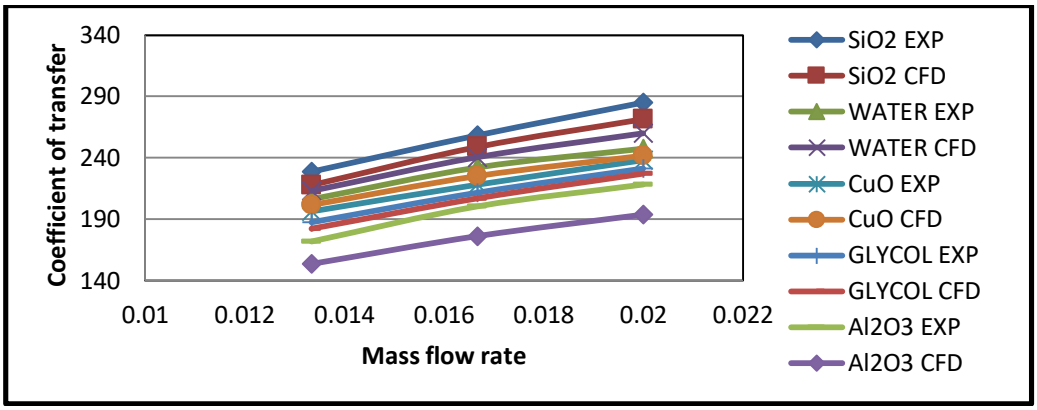
Fig9: Velocity variation



VIII. FLUENT VALUES VS. EXPERIMENTAL VALUES

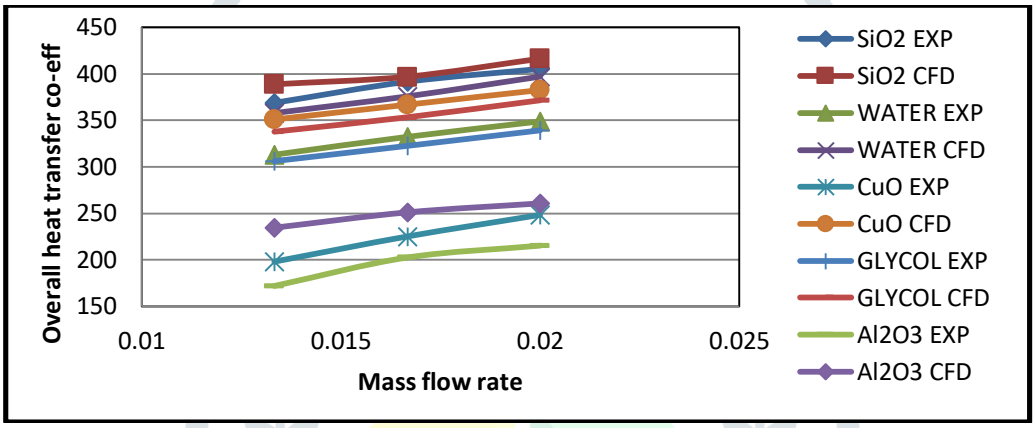
VIII.I Co-efficient of heat transfer (Q_A): The below figure shows that co-efficient of heat transfer directly proportional to mass flow rate i.e. by increasing mass flow rate, the co-efficient of heat transfer increases. As shown in figure, SiO2 EXP acquired better co-efficient of heat transfer compared to other Nano fluids on increasing mass flow rate.

Graph3: Co-efficient of heat transfer (Q_A)



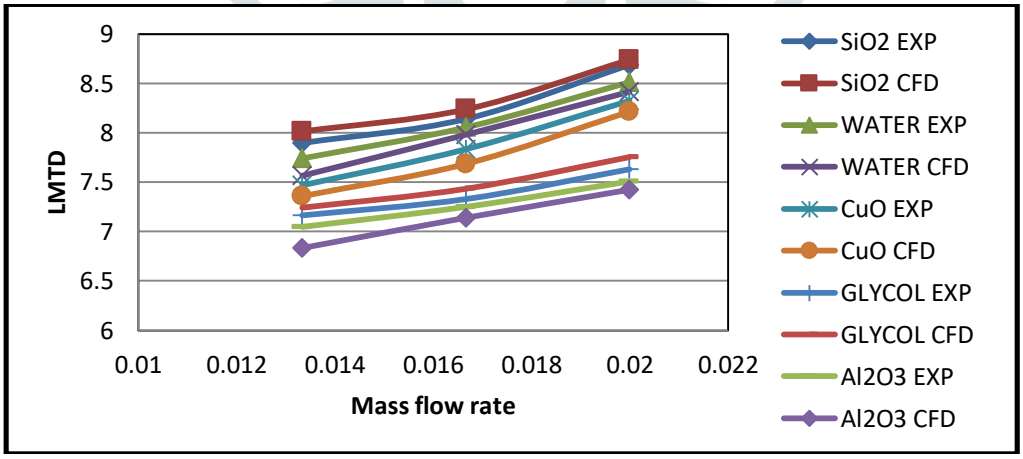
VIII.II Overall heat transfer co-efficient (U_o): The below figure shows that heat transfer co-efficient is directly proportional to mass flow rate i.e. by increasing mass flow rate, the Overall heat transfer co-efficient increases.

Graph4: Overall heat transfer co-efficient (U_o)



VIII.III Log Mean Temperature Difference (LMTD): The below figure shows that LMTD is directly proportional to mass flow rate i.e. by increasing mass flow rate, LMTD increases.

Graph5.LMTD



IX. CONCLUSION

At first, the main objective of this project is to create a validation between Experimental & CFD results which was performed using different nano fluids like Al2O3, CuO, SiO2, Ethylene-glycol and water to check the percentage error, in order to affirm the experimental setup. As the percentage of error is within 6% the experimental setup is validated.

In Parallel flow arrangement, considering laminar flow. At a flow rate of 0.02 m/s by using SiO2 fluid acquired better heat transfer.

In counter flow arrangement, considering laminar flow. At a flow rate of 0.02 m/s by using SiO2 fluid acquired better heat transfer. Hence, SiO2 fluid in counter flow arrangement is better effective.

X. FUTURE WORK

Double pipe Heat Exchanger has a wide range of application in many industries like in thermal power plants, petro chemical plants, for space heating. From the above investigation by changing physical parameters and inlet conditions by using Nano fluids thermal properties of heat exchanger can be calculated

i) By using the angular baffle segmental set, heat transfer augmentation for various fluids can be studied.
ii) The performance of baffle segmental can also be studied under different combinations of depth and width ratios.
iii) Thermal performance of baffle segmental at 45 degree angular orientation can be assessed by introducing the baffle cut.
iv) These variant angular baffles can be used for heat transfer augmentation studies also in refrigeration system.

XI: REFERENCES

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