Analysis of Heat Transfer and Friction Factor Characteristics of Circular Tube Fitted Heat Exchanger Using Nano Fluids

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***Abstract*: The experimental investigation of heat transfer and friction factor characteristics of double pipe heat exchanger using aluminum oxide water based nanofluid. In this present study the double pipe heat exchanger for a plain tube the heat transfer from hot water to cold water was experimentally investigated. This investigation also to find the Nusselt number, heat transfer coefficient, and Reynolds number. The experimental value of plain tube with water and Al_2O_3 was obtained from the experimental work and these two statistical data were compared with the results. The results shows that the heat transfer rate enhancement of induced with the nanofluids water based flow has give more heat transfer compared to the plain water. The Reynolds numbers were varied in the range of 5710 to 18366. The data obtained from the experimental value were compared with CFD simulation analysis. The performance of heat transfer characteristics of aluminum oxide nanofluids was enhanced compared with smooth plain water used. The experimental value of the heat transfer and friction factor characteristics was well bonding with simulation value of CFD analysis.**

***Keywords:* Heat transfer, Nanofluid, computational fluid dynamics**

I. INTRODUCTION

Heat exchangers have used for several industrial and engineering applications to improve the performance of heat exchanger devices for enhancement of heat transfer. A majority of heat exchangers used in chemical processing plants, air conditioning equipment, thermal power plants, etc. The heat transfer augmentation techniques are generally classified into three categories namely, Active techniques, and Passive techniques and compared techniques. Sami et al. [1] have investigated in a circular tube fitted with Quadrant – cut twisted tape inserts by using CFD analysis of the heat transfer and friction factor characteristic. Al Amin et al.[2] investigating the heat transfer enhancement using a rotating twisted tape insert. Date and Saha [3] investigated in a tube fitted with regularly spaced twisted tape elements of the heat transfer. Salam et al. [4] discussed the heat transfer enhancement using twisted tape insert in a tube. Bodius salam et al [5] have studied the heat transfer enhancement using rectangular- cut twisted tape insert in a tube. Pratik and Warkhedkar [6] were studied about the Heat Transfer Enhancement using Elliptical-Cut Twisted Tape Inserts in a Tube. Durga Prasad et al.[7] investigated the trapezoidal-cut twisted tape insert using Al_2O_3/water nanofluid in a double pipe u-tube heat exchanger. Sami et al. [8] have discussed with V – cut twisted tape inserts of the numerical investigation of heat transfer and friction factor characteristic in a circular tube. Naga Sarada et al [9] have analyzed the enhancement of heat transfer using twisted tape inserts varying width, were correlation are developed for friction factors and nusselt number for a fully developed turbulent swirl flow. Chang et al [10] have predicting the pressure drop and heat transfer in tube with broken twisted tape inserts with varying twist ratio.

II. EXPERIMENTAL INVESTIGATION

The configuration of geometry of the tube with a thickness (t) 0.075cm, length (L) 220cm is used for experimental investigation. In a double pipe heat exchanger as the heat transfer test section to minimize heat loss to the surrounding this is insulated. It consists of two concentric tubes in which hot water flows through the inner tube and cold water flows outer tube in flow through annulus. The outer tube is made of a cast iron having inside and outside diameters of 28mm and 32mm respectively. The inner tube made of an aluminum having inside and outside diameters of 20mm and 18mm respectively. Water is supplied to the pipe from the water loop, an electrical heater controlled by adjusting the voltage, a stirrer and flow meter is placed in the path of the water supply. The temperature sensors were used to measure the outlet temperature of hot and cold fluid and Four thermocouples were used T_1, T_2, T_3, T_4, to find the surface temperature of heat exchanger and data was recorded using data acquisition unit. The cold water is supplied from storage tank into the outer tube and hot water is supplied in the inner tube. The flow meter and pressure gauge were used to measure the mass flow rate of hot fluid and cold fluid flow. The volumetric flow rates of the hot and cold fluid were adjusted by control valves, situated before the inlet ports and experimental reading was taken with different flow rates for obtained the different experimental data. The experimental data were occurred for both plain twisted tape and triangular-cut twisted tape (TCT). The temperature of the inlet and outlet of hot and cold water data's were gathered. The experimental configuration illustrated in Figure 1. The experimental set-up consists of

1. Electrical heater
2. Pressure gauge
3. Temperature indicator
4. Flow meter
5. Display unit
6. Double pipe heat exchanger with twisted tape

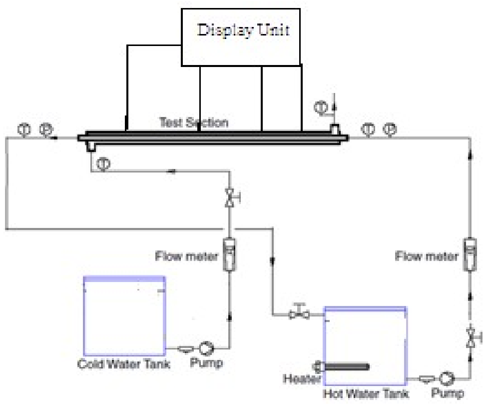

Fig. 1. Experimental setup

Heat transfer rate was calculated

$$Q = m\ Cp\ (T_{out} - T_{in}) \quad \text{---- (1)}$$

Heat transfer coefficient can be calculated

$$h = q / (T_w - T_b) \quad \text{---- (2)}$$

Reynolds number was calculated

$$Re = UD/_{v} \quad \text{---- (3)}$$

Nusselt number can be obtained

$$Nu = h\ D / K \quad \text{---- (4)}$$

III. NUMERICAL INVESTIGATION

The commercial CFD package was used to perform 3D numerical calculation of the twisted tape of triangular cut and plain twisted tape using the governing equation. The solid flow simulation engineering fluid dynamics is a new breed of computational fluid dynamics software that enables mechanical engineers to simulate fluid flow and heat transfer application. The solid work modeling and meshing was taken and import in to the fluid flow analysis. Numerical values of the mass flow arte and heat transfer used for simulation. In this study, aluminum pipe material were used. The boundary condition for the inlet and outlet of fluid for mesh volume were incorporated. The behavior of the fluid flow in the pipe plain water was studied and the approach by the fluid flow was completely different. Figure 4 shows the numerical simulation for temperature distribution of different flow rates. Figure 5 velocity profiles.

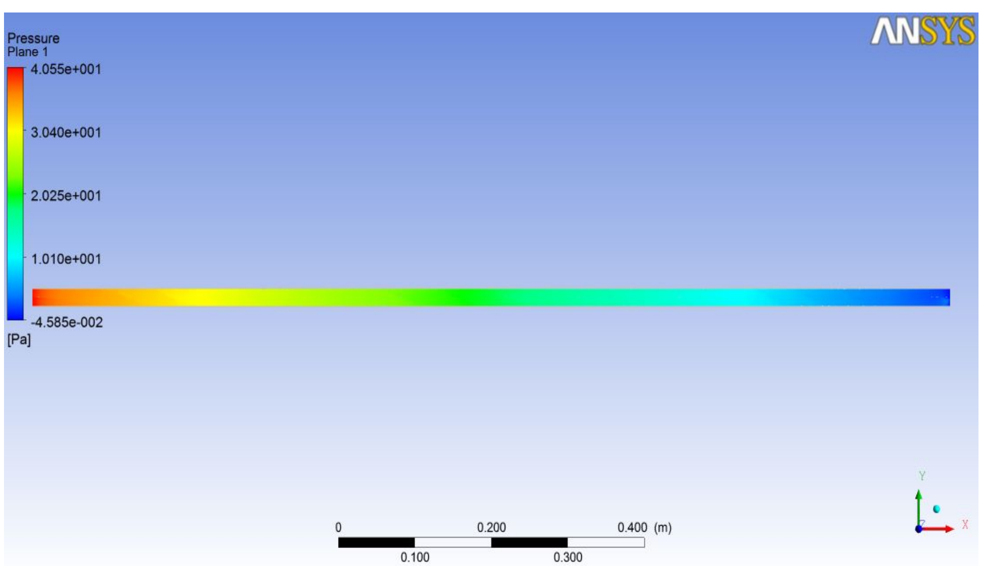

Figure 2 pressure contour

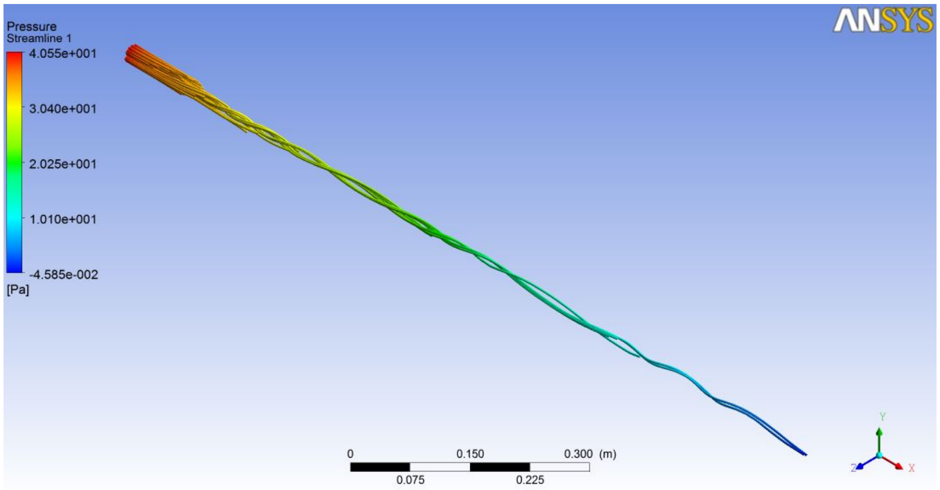

Figure 3 pressure stream line

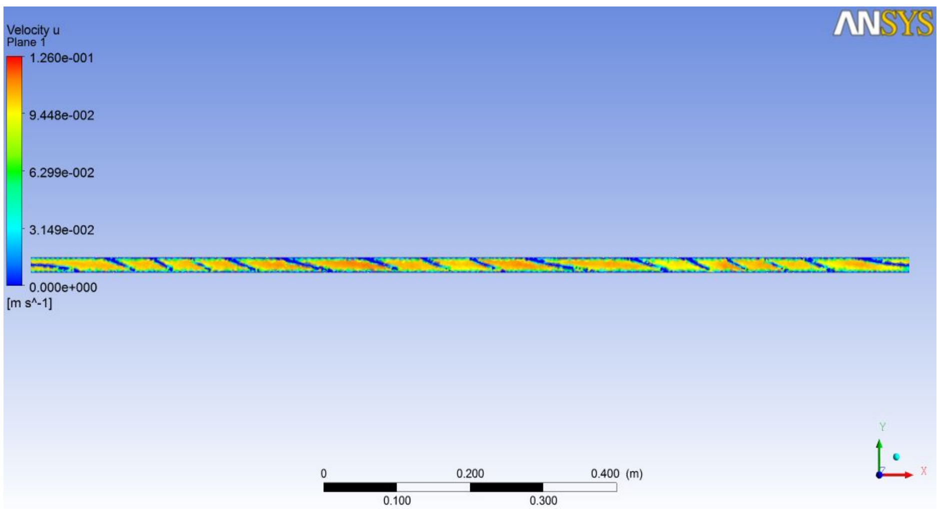

Figure 4 velocity streamline

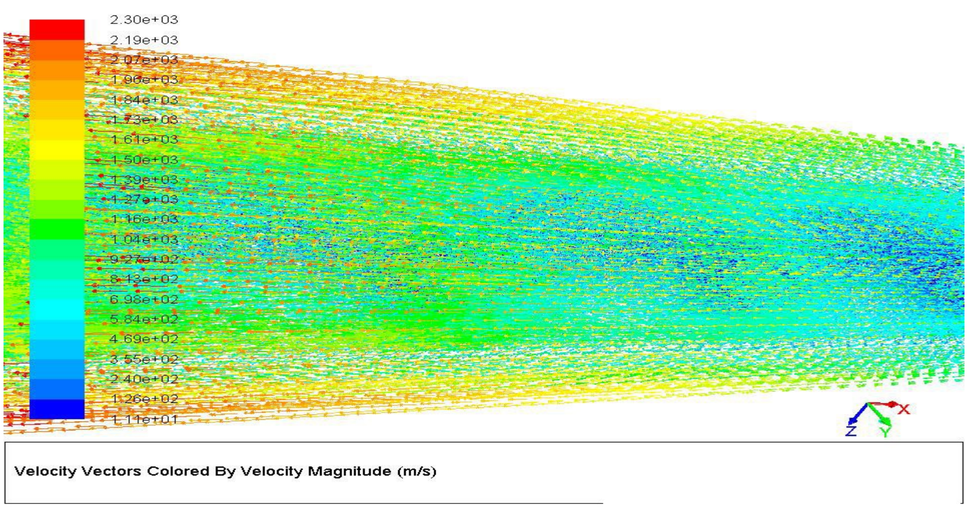

Figure 5 velocity vectors

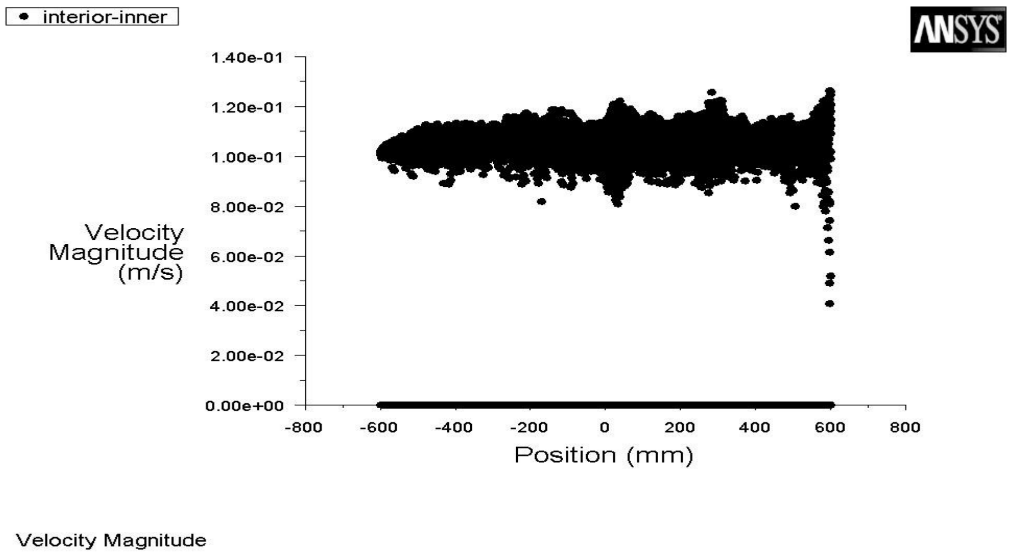

Figure 6 velocity magnitude

IV. RESULT AND DISCUSSION

Heat transfer rate characteristics of experimental value for the plain water and nanofluid were collected and these records were taken to check the validity of the numerical simulation value. The Reynolds varied over the range of 5710 to 18300. The graphical representation of numerical value as shown in graph below. The effect on the heat transfer, Nusselt number, heat transfer coefficient and friction factor were studied numerically. The result of experimental data on the tube fitted with plain water and aluminum oxide are compared with numerical data which is taken from CFD analysis under similar condition. Figure 7 shows the comparison of Reynolds number and Nusselt number of experimental data of plain water and aluminum oxide. It is seen that, the Nusselt number with nano fluids inserts were gives higher values than the plain water inserts. With increases of Reynolds number the Nusselt number also increased. From the observation, the aluminium oxide gives more Nusselt number compared with the plain water used. At the comparable of Re and Nu with nanofluid were improved from 1.02 to 1.19 times compared with the plain water inserts. Figure 8 shows the variation of Reynolds number and heat transfer coefficient, at analogous of nanofluid heat transfer coefficient increased with increases of Reynolds number and gives higher values than the plain water insert. The experimental data of the friction factor and heat transfer of plain water and nanofluids, and these variation with a Reynolds number of nanofluids shown in Figure 9 and 10. It indicates that the heat transfer rate of nanofluid is higher than the plain water insert. For the given Reynolds number, the Nusselt number and heat transfer rate were enhanced with aluminum oxide insert at comparable of plain water inserts.

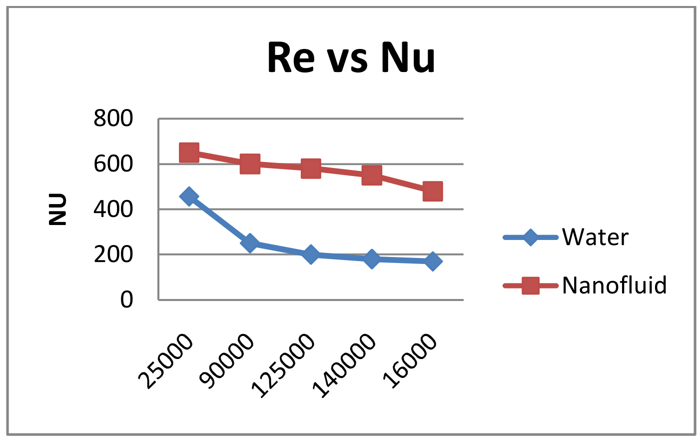

Figure 7.Reynolds number Vs Nusselt number

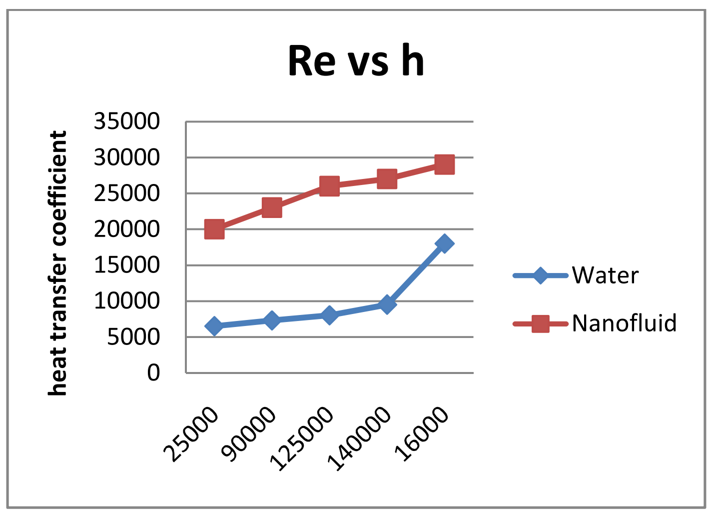

Figure 8.Reynolds number Vs heat transfer coefficient

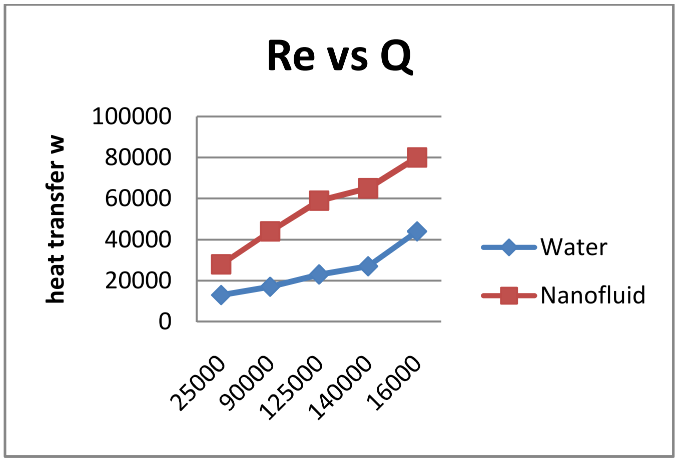

Figure 9. Reynolds number Vs Heat transfer rate

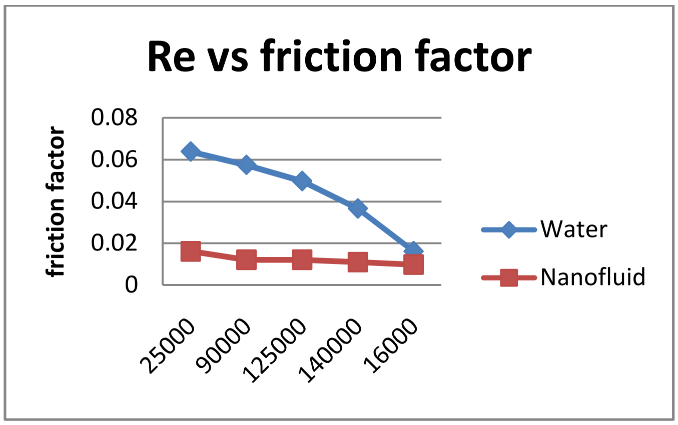

Figure 10. Reynolds number Vs friction factor

V. CONCLUSION

The heat transfer and friction factor characteristics analysis have been experimentally performed on the water based Al_2O_3 nanofluid in the pipe. The Results show that the average nusselt number increase with an increase of Reynolds number and the nanoparticle volume concentration. The heat transfer enhancement in the outlet pipes appears larger than the inlet pipes due to the effect of nanofluids. The friction factor reduced with increase of Reynolds number. The Nusselt number was increased with increases of Reynolds number. The experimental values of Nusselt number was increased with 1.02 to 1.19 times. From the experimental results of the plain water and nanofluid, as the heat transfer rate increases by selecting optimum Reynolds number. The present study of nanofluid aluminum oxide insert yields more heat transfer rate, Nusselt number and friction factor were compared with plain water insert. When The nanofluids offered the better performance of heat transfer characteristics as compared with the plain water used. The comparison of numerical value of nanofluid was as well coinciding with the experimental value of nanofluid.

ACKNOWLEDGEMENTS

The authors would like to thank our Management, principal and Head of the Department and all faculty of the Department Of Mechanical Engineering, for supporting to doing the experimental work in the Thermal Engineering laboratory.

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