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Experimental Study of Heat Transfer Parameters Using Pipe in Pipe Fitted With Screw Tape Inserts Of Different Materials

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ABSTRACT

Many heat transfer enhanced techniques have simultaneously been developed for the improvement of energy consumption, material saving, size reduction and pumping power reduction. Screw tape inserts in tubes are a typical technique that offers a higher heat transfer increase and at the same time, only a mild pressure drop penalty. This study investigates the heat transfer characteristics of a horizontal tube-in-tube heat exchanger with a Screw tape of different materials in the inner tube.

Screw tapes have been extensively studied to their advantages of steady performance, simple configuration and ease of installation. Now, the attention on how to optimize the thermal performance of tube fitted with helical screw tape inserts has been increased. To achieve a good heat transfer performance as well as low friction factor, we proposed pipe in pipe heat exchanger fitted with screw tape insert in present work.

The scope for this study would encompass all necessary activities for benchmarking the existing application like solar power plant with the current performance level and performance standards to be set for arriving at the objectives of the dissertation work. Recommendation of the best alternative would follow the comparison of the results. Data over Testing to be shared through a Test report for the experimentation phase.

***Keywords* – screw tape;thermal performance;friction factor**

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I. INTRODUCTION

Heat exchangers are mostly used devices in many areas of the industries. Hence, the using of high performance heat exchangers is very important for saving energy. [1] Thermal performance of heat transfer devices can be improved by heat transfer enhancement techniques. The turbulent generator with different geometrical configurations have been used as one of the passive heat transfer enhancement techniques and are the most widely used tubes in several heat transfer applications, for example, heat recovery processes, air conditioning and refrigeration systems, chemical reactors,food and dairy processes.[1] Heat transfer augmentation using various types of swirl flow generators like twisted tapes, helical screw tapes have been widely reported in literatures. It has been reported that such devices induce turbulence and superimposed vortex motion (swirl flow) causing a thinner boundary layer and consequently resulting in higher heat transfer coefficients.[2] Twisted-tape inserts are, therefore, used to mix the gross flow effectively in laminar flow to reduce the thermal resistance in the core flow through the channel. Integral axial ribs are also tabulators.[3] Twisted tape swirl turbulator is one of the commonly used passive types for heat transfer augmentation due to their advantages of steady performance, simple configurations and ease of installation.[4] S. Suresh et.al.[1]investigated comparison of thermal characteristics of Al2O3/water and CuO/water nanofluids in transition flow through a straight circular duct fitted with helical screw tape inserts was made in this study. The helical screw tape inserts with twist ratios Y = 1.78, 2.44 and 3 were used in the experimental study using 0.1% volume concentration Al_2O_3/water and CuO/water nanofluid. The average enhancements in Nusselt number for water with twist ratios of 1.78, 2.44 and 3 were 156.24%, 122.16% and 89.22% respectively when compared to plain tube. The average increase in Nusselt number corresponding to the twist ratios of 1.78, 2.44 and 3 were 166.84%, 128.67% and 89.22% respectively for Al2O3/water nanofluid. In the case of CuO/water nanofluid, the enhancements in Nusselt number were 179.82%, 144.29% and 105.63% for twist ratios 1.78, 2.44 and 3 respectively. Thermal performance analysis based on the constant pumping power criteria shows that helical screw tape inserts give better thermal performance when used with CuO/water nanofluid than with Al_2O_3/water nanofluids. Subhankar Saha, Sujoy Kumar Saha [2]tested the experimental friction factor and Nusselt number data for laminar flow through a circular duct having integral helical rib roughness and fitted with way strip inserts. The heat transfer test section was electrically heated and uniform wall heat flux boundary condition was imposed. Friction factor and Nusselt number correlations have been developed by log-linear regression analysis. The performance of the present fin geometry has been evaluated. The major findings of this experimental investigation are that the wavy strip inserts in combination with integral helical rib roughness perform better than the individual enhancement technique acting alone for laminar flow through a circular duct up to a certain range of parameters.Sujoy Kumar Saha,et al[3] investigated the experimental friction factor and Nusselt number data for laminar flow through a circular duct having integral axial rib roughness and fitted with center-cleared twisted-tape. Predictive friction factor and Nusselt number correlations have also been presented. The thermohydraulic performance has been evaluated. The major findings of this experimental investigation are that with and without center-cleared twisted tapes in combination with integral axial rib roughness perform significantly better than the individual enhancement technique acting alone for laminar flow through a circular duct up to a certain amount of twisted-tape center-clearance. Subhankar Saha et.al[6] conducted experiment for friction factor and Nusselt number data for laminar flow of viscous oil through a circular duct having integral helical rib roughness and fitted with helical screw-tape insert. Predictive friction factor and Nusselt number correlations have also been presented. The thermohydraulic performance has been evaluated. The major findings of this experimental investigation are that the helical screw-tape inserts in combination with integral helical rib roughness perform significantly better than the individual enhancement technique acting alone for laminar flow through a circular duct up to a certain value of fin parameter. P. Sivashanmugam et al [7] investigated Experimentalinvestigation on heat transfer and friction factor characteristics of circular tube fitted with right-left helical screw inserts of equal length, and unequal length of different twist ratio have been presented. The experimental data obtained were compared with those obtained from plain tube published data. The heat transfer coefficient enhancement for right-left helical screw inserts is higher than that for straight helical twist for a given twist ratio. The effect of right-left helical twist length on heat transfer and friction factor was presented. The empirical relation for Nusselt number, friction relating Reynolds number, twist ratio and right-left distance were formed and found to fit the experimental data within 10% and 20% for Nusselt number and friction factor, respectively. Performance evaluation analysis has been made and the maximum performance ratio of 2.85 and 2.97, respectively were obtained for 300 R and 300 L, and 400 R and 200 L type inserts.

Paisarn Naphon et. al [8] presented study the heat transfer characteristics and the pressure drop of the horizontal concentric tube with twisted wires brush inserts are investigated. The inner diameters of the inner and outer tubes are 15.78 and 25.40 mm, respectively. The twisted wire brushes are fabricated by winding a 0.2 mm diameter of the copper wires over a 2 mm diameter of two twisted iron core-rod with three different twisted wires densities of 100, 200, 300 wires per centimeter. The plain tube with full-length twisted wires brush and regularly spaced twisted wires brush with 30 cm spacer length inserts are tested. Cold and hot water are used as working fluids in shell side and tube-side, respectively. The test runs are performed at the hot water Reynolds number ranging between 6000 and 20000. The inlet cold and hot water temperatures are 15, 20 °C, and between 40 and 50 °C, respectively. Effect of twisted wires density, inlet fluid temperature, and relevant parameters on heat transfer characteristics and pressure drop are considered. Twisted wire brushes insert have a large effect on the enhancement of heat transfer, however, the pressure drops also increase.

II. EXPERIMENTATION

The experimental set up consists of a test section, calming section, pump, cooling unit, and a fluid reservoir. Calming and test sections are made of straight copper tube and MS tube with the dimension 1000 mm long, 10 mm ID and 12 mm OD. The calming section is used to eliminate the entrance effect. The test section tube is uniformly heated by ceramic beads coated electrical SWG Nichrome heating wire of resistance 120 W wound on it. Over the electrical winding a thick insulation is provided using glass wool to minimize heat loss. The terminals of the Nichrome wire are attached to an auto-transformer, by which heat flux can be varied by varying the voltage. The fluid and wall temperatures are measured by using calibrated RTD temperature sensors. The pressure drop across the test section is measured using a differential pressure transducer mounted across the test section which is able to read up to 1 cm of water. A differential u-tube manometer is also fitted across the test section to validate the pressured drop shown by the pressure transducer. The fluid after passing through the heated test section flows through a riser section and then through the cooling unit which is an air cooled heat exchanger and finally it is collected in the reservoir. A peristaltic pump is used to circulate the fluid through the circuit. The pump discharge is varied by adjusting the speed of rotation. The pump gives a maximum discharge of 2.55 l/min. The peristaltic pump was calibrated by weighing the mass of water collected in a measured time interval and comparing this measured flow rate with calculated flow rate. As the flow rate is controlled by varying the rotational speed (N) of the pump, the calculated flow rate can be obtained from 13 _ N/60 ml/s. A plastic container of 5 l capacity is used as the fluid reservoir.

Figure no.1: Experimental setup

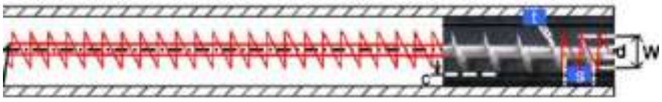

Figure 2: Helical Screw Tape Insert

III. RESULT AND DISCUSSION

Results were discussed on the basis of heat transfer performance different types Material used for screw tape. The experimental system was validated by performing experiments using pure water. The following results were obtained for different Materials i.e. copper And M.S. shown as graphically.Following graph indicates variation of Nusselt Number Vs Reynolds Number for cold water flow rate which is constant at 60,120LPH for Copper Screw tape with 15cm pitch.

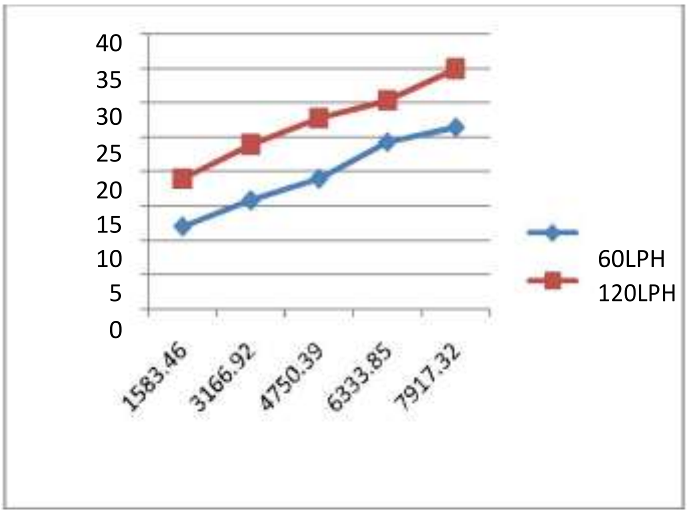

Fig 3: Variation of Nusselt Number Vs Reynolds Number.

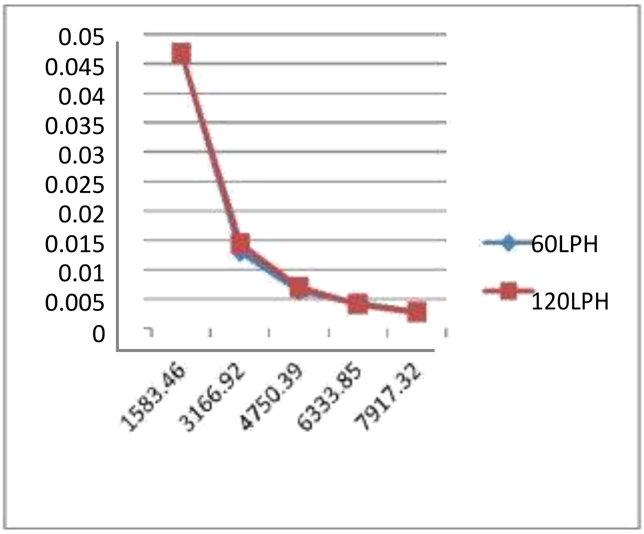

Figure 4 Variation of Friction factor Vs Reynolds Number.

Above graph indicates variation of Friction factor Vs Reynolds Number for cold water flow rate which is constant at 60,120LPH for Copper screw tape with 15cm pitch.

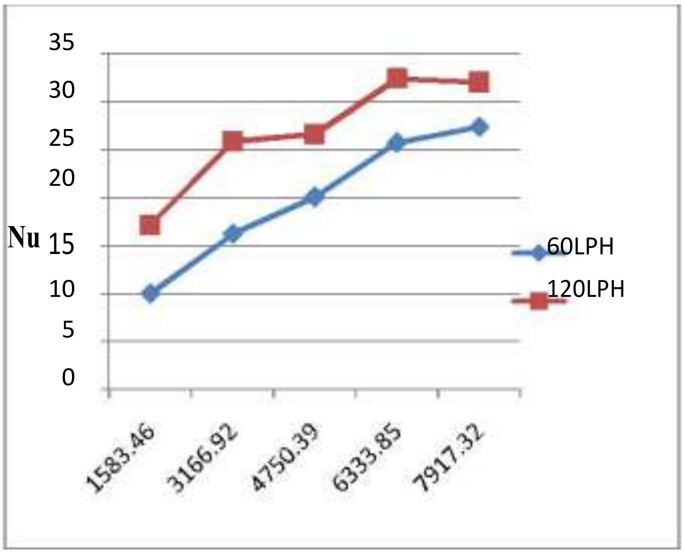

Figure 5: Variation of Nusselt Number Vs Reynolds Number

Above graph indicates variation of Nusselt Number Vs Reynolds Number for cold water flow rate which is constant at 60,120 LPH for Steel screw tape with 15cm pitch.

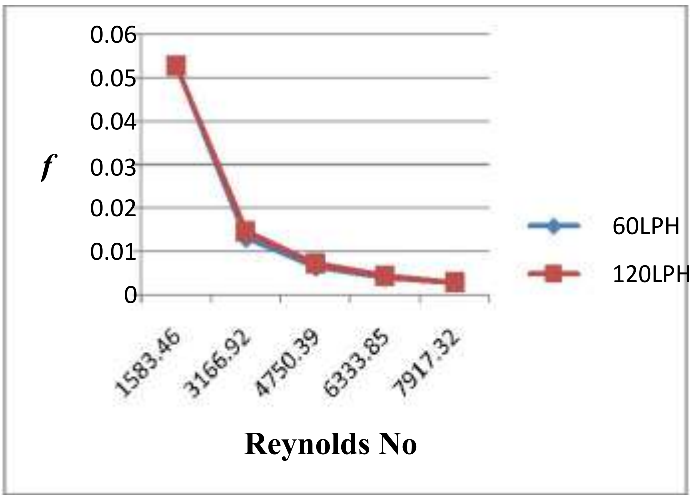

Figure 6:Variation of Friction factor Vs Reynolds Number.

Above graph indicates variation of Friction factor Vs Reynolds Number for cold water flow rate which is constant at 60, 120 LPH for Steel screw tape with 15cm pitch.

Effect of Material

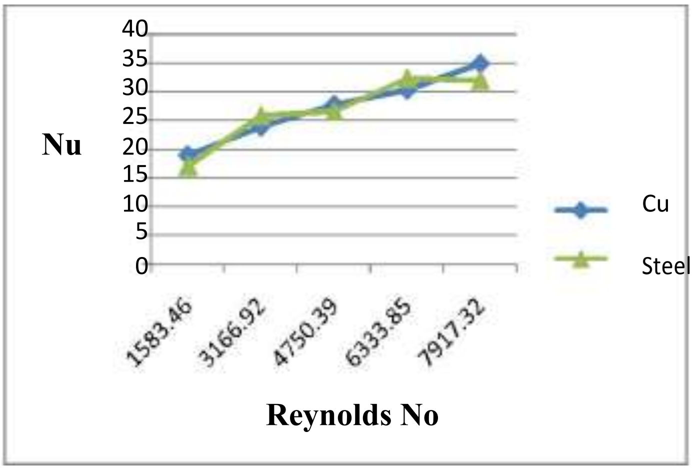

Figure 7: Variation of Nusselt Number Vs Reynolds Number.

Above graph indicates variation of Nusselt Number Vs Reynolds Number for cold water flow rate which is constant at 120 LPH, for Copper and Steel screw tape with pitch value 15cm Above graph clearly indicates that for Copper material Nusselt no is maximum for most of the Reynolds no.So that Copper inserts are more effective than Steel inserts.

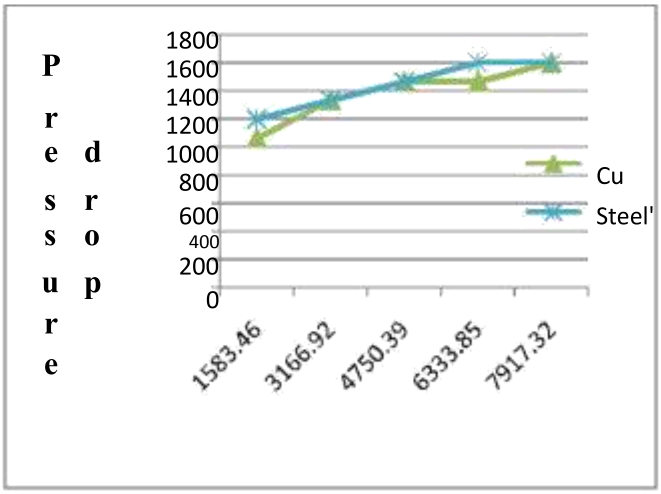

Figure 8:Variation of Pressure DropVs Reynolds Number.

Above graph indicates variation of Pressure Drop Vs Reynolds Number for cold water flow rate which is constant at 120LPH, for Copper, and Steel screw tape with pitch values 15cm.

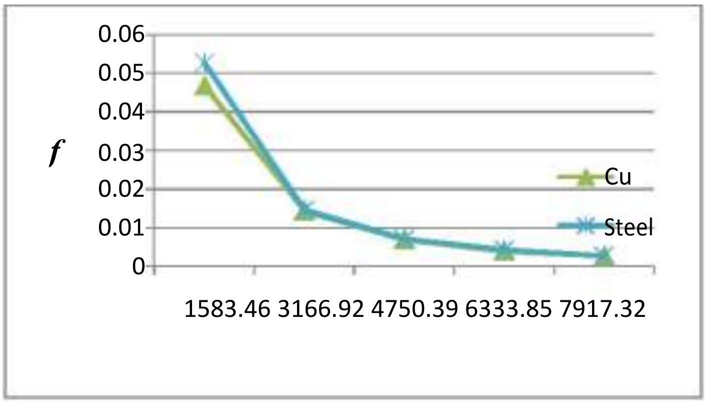

Figure 9:Variation of Friction factor Vs Reynolds Number

Above graph indicates variation of Friction factor Vs Reynolds Number for cold water flow rate which is constant at 120LPH for Copper and Steel screw tape with pitch values 15cm.

IV. Conclusion

It can be found that enhancing heat transfer with passive method using different material screw tape construction in the inner tube of a double pipe heat exchanger can improve the heat transfer rate efficiently. However, the friction factor of the tube with the screw tape insert also increases. The increase in heat transfer and friction can be explained by the swirling flow as a result of the secondary flows of the fluid It is found that pressure drop increases as Reynolds number increases & friction factor decreases with increase Reynolds number.

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