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EXPERIMENTAL ANALYSIS OF HEAT TRANSFER ENHANCEMENT IN A CIRCULAR TUBE WITH DIFFERENT TWIST RATIO OF TWISTED TAPE INSERTS

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ABSTRACT

An experimental investigation was carried for measuring heat transfer, Reynolds number, and friction factor fitted in concentric tube with twisted tape inserts. The different twist ratio y=2.52, 3.00 and 3.20 were studied for the laminar flow using computational fluid dynamics package. An aluminium inner tube of 18 mm internal diameter and 20mm outer diameter and 220mm length was used for experimental study. The outer tube material is mild steel of 28mm inner diameter and 32mm outer diameter was used for the experimental record. A copper twisted tape of different twist ratio of twist was inserted and the obtained plain tube data were verified with twisted tape inserts and ensure the validation of simulation results. The results are analyzed that the twisted tape accessible high heat transfer with increases in friction factor. In additionally the experimental value of twisted tape as compared with numerical simulation. A CFD package of commercial Ansys Fluent were utilized for simulate the twisted tape.

Keywords: Heat transfer, Twisted tape, Computational Fluid Dynamics.

1. INTRODUCTION

To improve the performance of heat exchanger devices for reducing material cost and surface area and decreasing difference for heat transfer, thereby lot of techniques have been used. Further to increase the heat transfer co-efficient by using the twisted tape inserts and swirl flow generated higher heat transfer co-efficient. Experimental investigation of heat transfer and friction factor characteristic in a double pipe heat exchanger fitted with regularly spaced twisted tape elements were studied by Eiamsa-erd [1]. The Numerical investigation of heat transfer and friction factor characteristic of a circular tube fitted with twisted tape inserts with twist ratio were studied for laminar flow using CFD package were studied by Sami et al [2]. Heat transfer enhancement characteristic in a circular tube fitted with conical ring and a twisted tape swirl generator has been investigated experimentally by Promvonge and Eiamsa [3]. The experimental investigation taken by L. Syamsundar were discussed an experimental study on effect of full length twisted tape inserts on heat transfer and friction enhancement were studied [4]. The Experimental and numerical analyses of heat transfer and friction factor of laminar flow were studied by many literature survey [5-8]. The configuration optimization of regularly spaced short length twisted tape in a circular tube to enhance turbulent heat transfer using CFD by Y.Wang [9][9]. A combined approach to predict friction coefficients and convective heat transfer characteristic in a tube with twisted tape inserts for a wide range of Re and pr by P.K.Sharma [10]. P.sivashanmugam discussed with the Experimental studies on heat transfer and friction factor characteristic of turbulent flow through a circular tube fitted with regularly spaced helical screw tape inserts [11].

2. EXPERIMENTAL SET UP

The schematic diagram of the experimental set up is shown in Fig.1.it consist of a long MS pipe called test section with made of 220mm and inner diameter 28mm and outer diameter 32mm and aluminium inner tube of inner diameter 18mm and 20mm outer diameter were used to analyze the experimental work. A copper twisted tape was inserted with different twist ratio and by twisting 2mm thick, 20mm width for straight strip. The pitch length H was taken 51.2mm, 60mm and 71.2mm and twist ratio Y were taken 2.52, 3.00, and 3.20. Figure. 2 & 3 shows twisted tape 2D and 3D model. The following equations are used to calculate the experimental value of Effectiveness and heat transfer co-efficient.

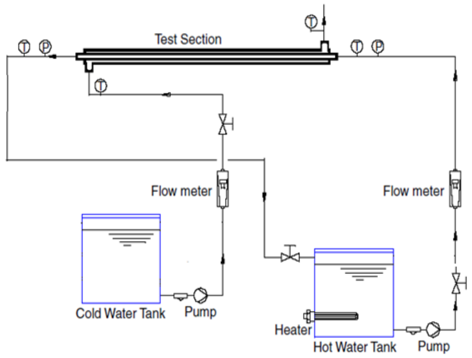

Figure 1. The experimental setup for heat exchanger

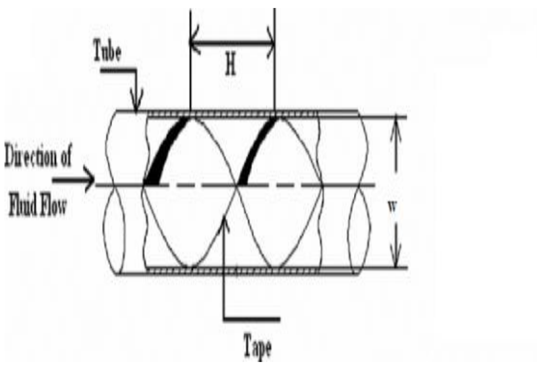

Figure 2. Twisted tape model

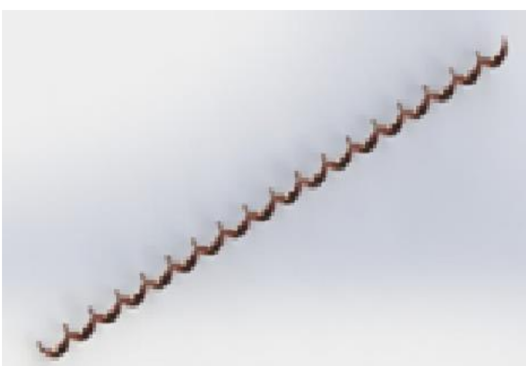

Figure 3. Copper twisted tape

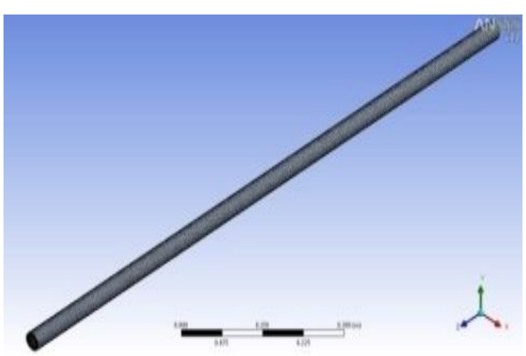

Figure 4. Grid for plain tube

Heat transfer rate [w]
$Q = m\ Cp\ [T_{out}-T_{in}]$

Effectiveness = Q_{max} / Q

Reynolds number
$Re = UD/ \upsilon$

Nusselt number
$Nu = hD/k$

Heat transfer co-efficient [w/m^{2}k]
$h = q\ [T_w - T_b]$

Friction factor
$$F = \frac{64}{Re}$$

3. NUMERICAL SIMULATION

CFD modeling is one of the methods to find the flow process of fluid mechanics that uses numerical methods and algorithm to solve and analyze the problem that used in flows of fluid. CFD methods consist of numerical solutions of the momentum, mass and vary conservation with other equation like transport species. In the present work analyze the concentric pipe heat exchanger solved for the cold fluid flow outer side and hot flow inner side to record the data using experimental work. Three dimensional momentum equation and continuity equation are practices in the numerical significance. In this work Ansys fluent version are used to simulate the heat exchanger and also to calibrate the experimental assessment. The modeling and meshing of the twisted tube was takes place and then enter in fluid flow CFD solver program to solve the heat exchanger analyze. In Ansys fluent user interface 3D double precision (3dd), to simulate the Computational analysis segregated solver methods were used. Figure 4 shows the modeling and meshing of heat exchanger concentric tube with twisted tape.

4. RESULT AND DISCUSSION

4.1 Mass flow rate and exit hot fluid temperature

The variation of mass flow rate and exit hot fluid temperature for plain tube and twisted tape insert tube is shown in figure 5. The exit temperature of hot fluid was decreases with increase of mass flow rate and more temperature were obtained in the twisted tape insert. The mean temperature of twisted tube was increased from 2 to 4% compared to plain tube.

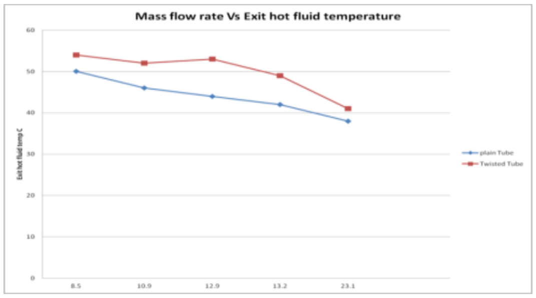

Figure 5. Variation of Mass flow rate and Exit hot fluid temperature

4.2. Mass flow rate and heat transfer

The variation of mass flow rate and heat transfer for straight twisted tape insert is shown in figure 6 and discussed with plain tube, twisted tube and CFD simulation. While consider the twisted tape inserts the heat transfer was enhanced more compared with the plain tube data obtained from the experimental record.

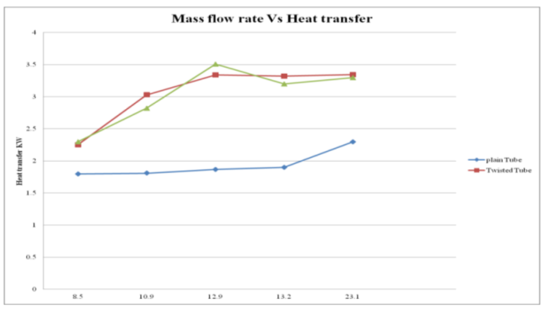

Figure 6. Comparison of mass flow rate and heat transfer

4.3. Reynolds number and heat transfer characteristic

The comparison of Reynolds number and heat transfer characteristics were shown in figure 7 and the heat transfer was increases with increase of Reynolds number. The predicted value of heat transfer in CFD simulation with twisted tape inserts were well bonded with experimental value of heat transfer.

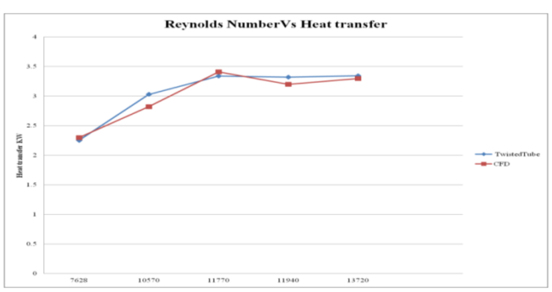

Figure 7. Variation of Reynolds number with heat transfer

4.4. Reynolds number and Nusselt number

Figure 8 shows the correlation between the Reynolds number and Nusselt number, which results shows the Reynolds number increases, the Nusselt number also increases. The relations between the experimental data of twisted tape were good agreement with simulation record.

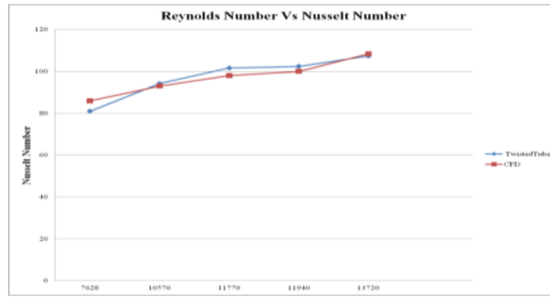

Figure 8. Correlation between the Reynolds number and Nusselt number

4.5. Reynolds number and heat transfer co-efficient

The comparison of Reynolds number and heat transfer co-efficient shows in figure 9. The heat transfer co-efficient were increases with various with the Reynolds number. The heat transfer co-efficient of experimental twisted tape records was well coincide with simulation value.

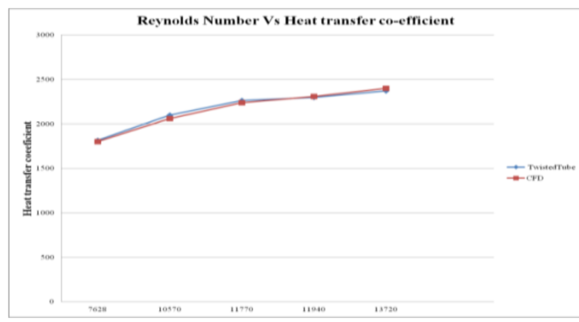

Figure 9. Reynolds number with Heat transfer co-efficient

4.6. Reynolds number with friction factor:

Figure 10. Shows the correlation between the Reynolds number and friction factor, which results analyses with friction factor was decreases with increases of Reynolds number.

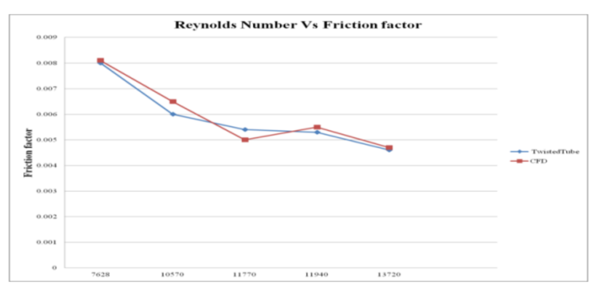

Figure 10. Comparison of Reynolds number with friction factor

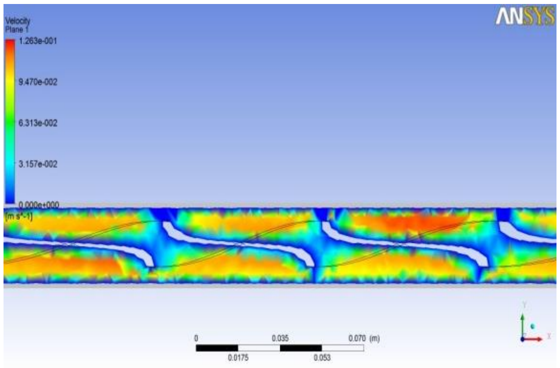

Figure 11. Velocity profile for the twisted tape

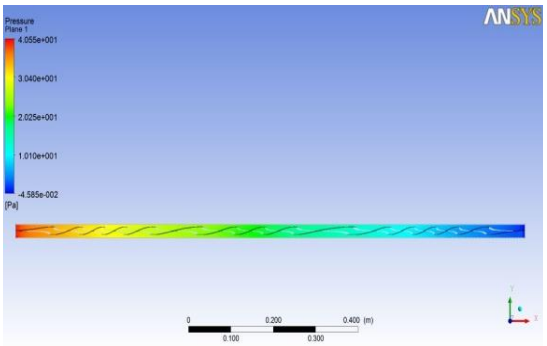

Figure 12. CFD simulation for pressure variation

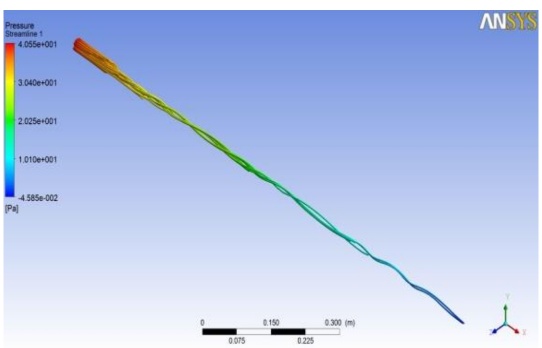

Figure 13. Fluid flow pressure variation

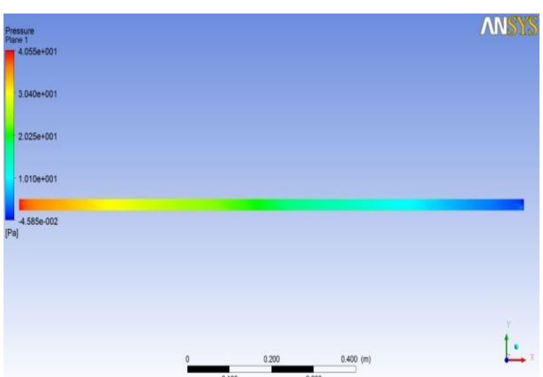

Figure 14. Twisted tape with inner pressure variation

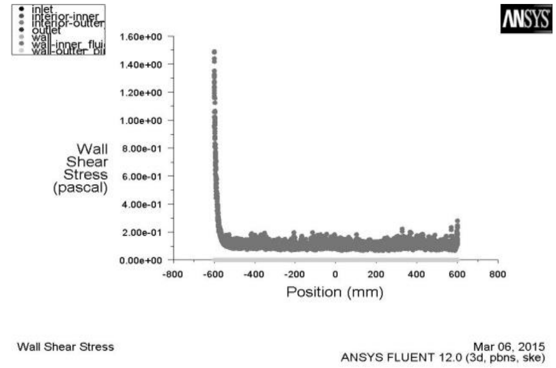

Figure 15. The simulation result

5. CONCLUSION

The value of heat transfer and friction factor was investigated with the laminar flow in a circular tube fitted with twisted tape inserts. Experimental investigation of enhancement of heat transfer, heat transfer co-efficient, Nusselt number and friction factor characteristics of circular tube fitted on different twist ratio with twisted tape inserts has been studied. The heat transfer enhancement was takes place with increase of Reynolds number. Heat transfer can be observed with plain smooth tube records were enhanced from 7% to 10% of the twisted tube heat transfer of fitted in the concentric circular tube. The data obtained from the experimental value of twisted tape friction factor was decreased 2% to 6% as compared to the plain tube. The experimental values with twisted tape of friction factor were good agreement with CFD simulation assessment. The Nusselt numbers also were increased with increases of Reynolds number. The enhancements heat transfer twisted tape was achieved by due to the swirl flow action obtained with concentric tubes. The experimental values of heat transfer and friction factor were investigated with the laminar flow in a circular tube fitted with twisted tape inserts.

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