

EXPERIMENTAL INVESTIGATION OF TWISTED TAPE INSERT ON LAMINAR FLOW WITH UNIFORM HEAT FLUX FOR ENHANCEMENT OF HEAT TRANSFER

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ABSTRACT

This paper analyses the experimental and numerical investigation of heat transfer, heat transfer co-efficient and friction factor with twisted tape insert using CFD simulation. An experimental data obtained from the heat exchanger both plain tube and twisted tape inserts. The experimental setup was made with mild steel pipe on outside with 28mm inner diameter and 32mm outer diameter. The inner pipe made on aluminum tube with 18mm inner diameter and 20mm outer diameter. A uniform heat flux condition was set by electric heating coil wire wrapped around the tube section and proper Insulating is used over the entire tube length. The surface temperature of the heating coil tube value measured at four different points. The inlet and outlet temperature of the inner tube cold fluid flow was recorded with two thermocouples. The copper twisted tape were inserted with twist ratio y is 3.90 in the inner tube and takes swirling flow to enhance the heat transfer. The recorded data obtain from the CFD simulations were verified with the experimental assessment of twisted tape insert. The results shows that the considerable amount of heat transfer enhancing with several of heat transfer co-efficient and Reynolds number.

Keywords: Twisted tape, Heat transfer, CFD

INTRODUCTION

Heat exchanger is a device used in many industries to recover the waste heat. Heat exchangers with the convective heat transfer of fluid inside the tubes are frequently used in engineering application. In many industries to augment of heat transfer is utilized many technical methods are used and most one of the method is twisted tape insert in the concentric tube. While, inserting the twisted tape for enhancing the convective heat transfer for take the swirl flow through out of length of the pipe. So that in this present work also used twisted tape for enhancing the heat transfer. Elasma-ard.S studied, the influence of combined non-uniform wire coil and twisted tape in the tube and analyse the performance characteristics of the heat exchange. Elasma-ard.S is investigate the convective heat transfer in a circular tube to carry the augmentation of heat transfer. Monheit.M made an experimental evaluation of the convective characteristics of the tube with twisted tape inserts. Murugesan.P studied the heat transfer and pressure drop characteristics of turbulent flow in a tube fitted with trapezoidal cut tape inserts. Rahimi.M evaluated the heat transfer characteristics and friction factor characteristic in an experimental and CFD simulation in a tube fitted with modified twisted tape inserts. Dat A.W. studied the numerical prediction of laminar flow and heat transfer in a tub fitted with regularly spaced twisted tape elements. Duplesses J.P and Shabanian S.R studied the CFD and experimental study on heat transfer enhancement with different tube inserts. The results shows the heat transfer were increases with varying the pipes. Shivasanmugam P made on experimental work for augmentation of heat transfer and analysis friction factor of laminar flow tube inserted. Heat transfer and pressure drop characteristics of laminar flow with twisted tape inserts were studied through the many literature survey.

EXPERIMENTAL INVESTIGATION SET UP

The experimental set up consists of two concentric tubes with use of outer and inner pipe. The outer pipe of diameter is 32mm OD and 28mm ID and the inner pipe of diameter is 20mm OD and 18mm ID. The water is supplied from the storage tank in the both inner and outer tube. The outer tube with electrical heating coil was wrapped and regularly supplied voltage to the coil. The outer tube temperatures were measured by four different points using thermocouples. The heating coil was connected with 220 V main connection. The water was taken from the tank and supplied to the test section. The mass flow rate of the flow is varied regularly for obtained the different data. Now the heat is transfer from the heating coil to outer pipe then outer pipe to inner pipe. The experimental data occurred for plain tube and twisted tape. The inner tube temperature also gathered at the inlet and outlet of the pipe.

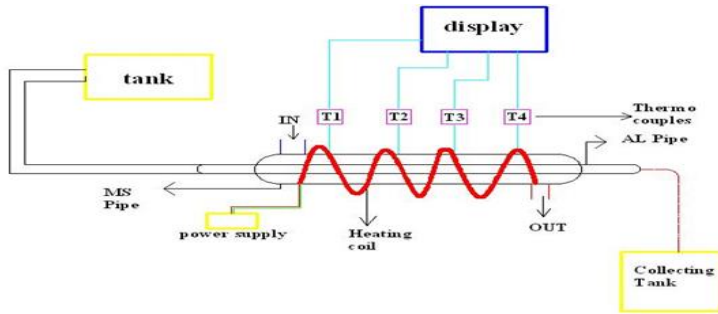


Fig 1 Experimental set of Heat Exchanger

Heat transfer can be calculated with the following equation

$$Q = m C_p [T_{out} - T_{in}]$$

Reynolds number can be calculated with

$$Re = \frac{UD}{\nu}$$

Nusselt number and friction factor

$$Nu = \frac{hD}{K}$$

$$f = \frac{16}{Re}$$

Q-Heat transfer rate, W

m-flow rate, m/s

h-Heat transfer coefficient, w/m²K

f-Friction factor

Re- Reynolds number

ρ - Density, kg/s

COMPUTATIONAL FLUID DYNAMICS ANALYSIS

The geometrical configuration of twisted tape inserts thickness t is 8mm and width is 14mm with twisted ratio 3.90 was used for CFD simulation. The commercial CFD package was used in 3D model simulation. Here the Ansys modelling and meshing were taken and import in to the fluid flow fluent analysis. During the CFD simulation physical model of the pipe and boundary condition were also consider for simulation. The material properties were selected for aluminium tube and mild steel and copper twisted tape insert. In Ansys fluent user interface 3D double precision 3dd and segregated solution method are to be used. The boundary condition for the inlet, outlet, wall and types of fluid for the mesh volume were incorporated. The CFD tool for this study to solve the governing equation with boundary condition. The single first order scheme and pressure –velocity coupling method were selected for simulation. Fig shows the 3D model for the twisted tape grid. Table 1 shows the physical parameters of analyses of tube material.

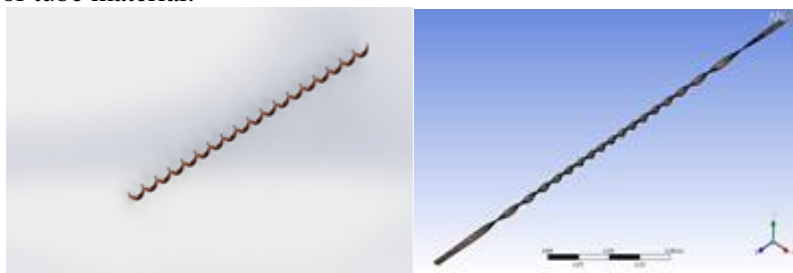


Fig 2. Grid for twisted tape

RESULT AND DISCUSSION

Heat transfer and Nusselt number data was calculated for plain tube and these data were taken to check the heat transfer with twisted tape inserts. The results show, the twisted tape inserts of heat transfer was enhanced more compare with plain tube with increases of Reynolds number and validate the experimental twisted tape data CFD simulation value. Fig 3 shows the variation of mass flow rate and exit temperature of fluid flow and the results shows with experimental value of twisted tape well agreement with the simulation value. The exit temperature was increases with vary of different mass flow rate increases. Fig 4 shows the variation of flow rate and heat transfer. Fig 5 shows the Re with heat transfer, the heat transfer for both plain tube and twisted tape inserts were enhanced with the increase of Re and heat transfer of plain tube were found to be 25 to 30% higher than the twisted tape insert heat transfer. These higher of twisted tape due to the high swirl flow caused by the twisted tape. Fig 6 shows

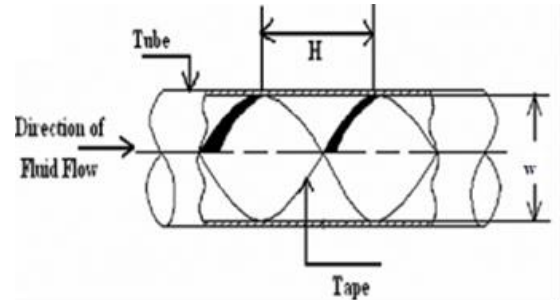


Fig 1A Twisted insert model

the variation of Re with Nu, the results analyses with the Reynolds number increases the Nusselt number also increased. fig 7 shows the variation of friction factor with Re, the friction factor for plain and twisted tape insert were decreased with increases of Re. And friction factor for experimental were found to be very good bonding with the simulation predicted values. Fig 8 shows the comparison of Re and exit temperature. Table 2 & 3 shows the comparison of Mass flow rate with Heat transfer and Exit temperature.

Table 1. Physical properties of Material

Material	Density kg/m ³	Specific heat [J/kgk]	Thermal conductivity [w/mk]	Viscosity [Nm/s]
Water	999.1	4186	0.6	0.0010
Aluminium	2718	870	201.6	-

Table.2.Comparison of Mass flow rate and Exit temperature

S.N	Mass flow rate kg/s	Exit Temperature [plain tube]	Exit Temperature [Twisted tape]	Simulated data[CFD]
1	0.05	34	37	37
2	0.065	35	38	40
3	0.07	35	39	40
4	0.08	36	40	41
5	0.09	39	42	43

Table.3.Shows the variation of Mass flow rate with Heat transfer

Mass flow rate kg/s	Heat transfer Kw [plain tube]	Heat transfer KW[Twisted tape]	Heat transfer KW [CFD]
0.05	1.3	1.63	1.85
0.065	2.2	2.65	2.8
0.07	2.85	2.93	2.76
0.08	2.9	3.36	3.93
0.09	3.4	4.90	4.32

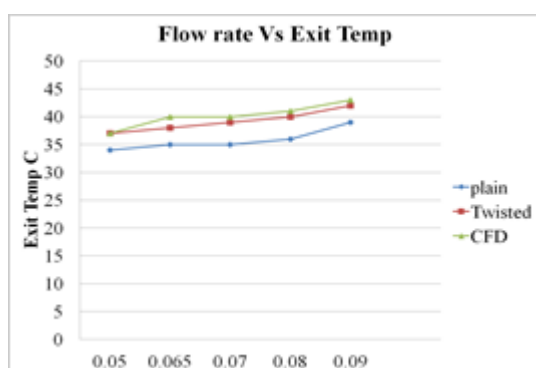


Fig 3 the variation of Mass flow rate with Exit temperature

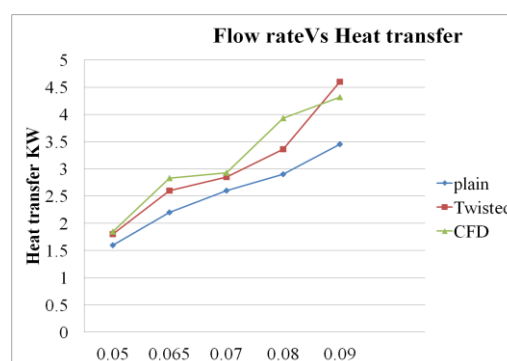


Fig 4 shows the comparison of Mass flow rate and Heat transfer

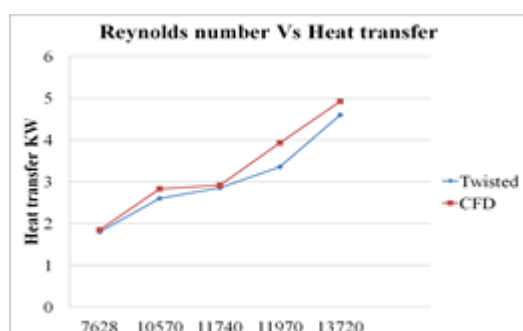


Fig 5 shows the variation of Re with Heat transfer

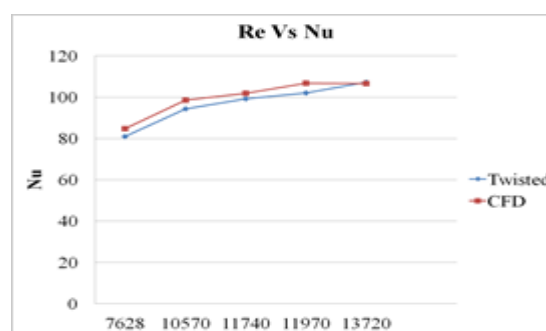


Fig 6. Shows the comparison of Re with Nu



Fig 7. Shows the variation of Reynolds number with friction factor

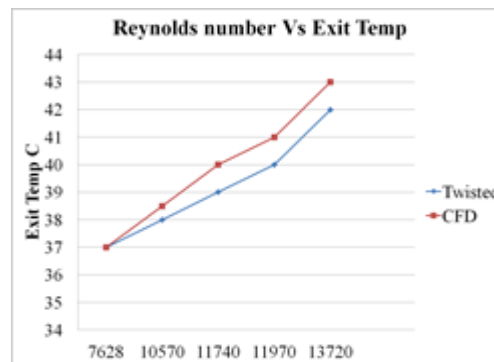


Fig 8. Reynolds number and Exit temperature

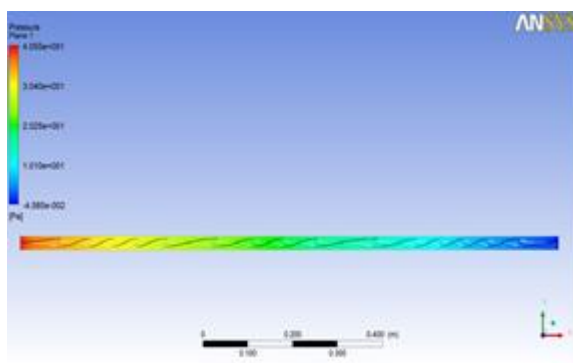


Fig 9 Shows the simulation for pressure contour

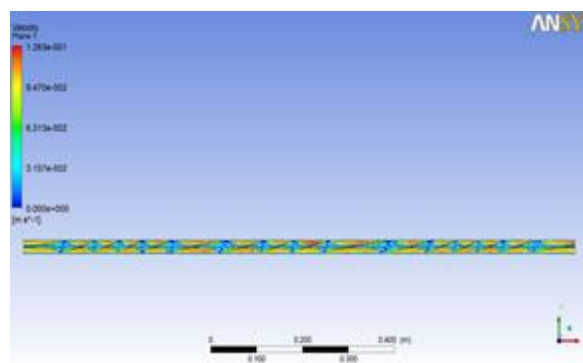


Fig 10 Twisted tape velocity profile

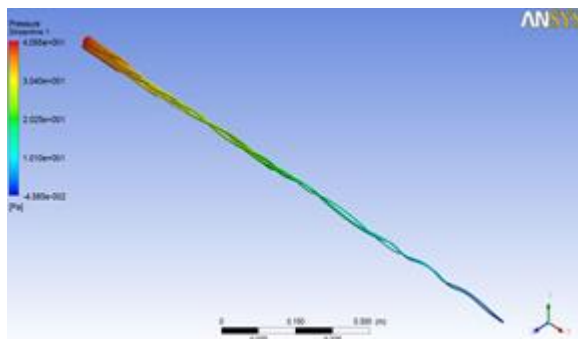


Fig 11 Shows the pressure streamline

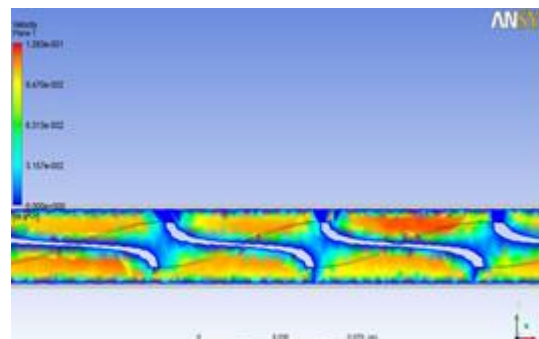


Fig 12 Shows the velocity plane of insert tube

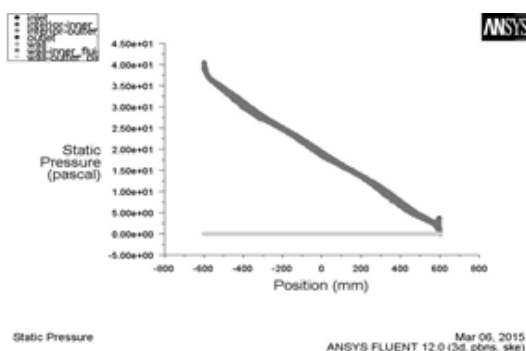


Fig 13 Static pressure with position

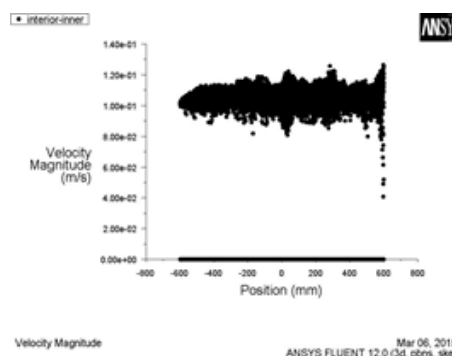


Fig 14 Velocity magnitude with position

CONCLUSION

An experimental investigation were carried out for measuring the heat transfer, Reynolds number, Nusselt number and friction factor of water for laminar flow in a circular tube fitted with twisted tape insert. The Reynolds

number varied from 7628 to 13720. The effects of parameters such as modified twist ratio, heat transfer and Reynolds number were studied. The enhancement of heat transfer with twisted tape inserts as compared to plain tube varied from 25 to 30% of heat transfer. The heat transfer enhancement of experimental record was validating with simulated record and the results gave the good agreement with experimental and predicted values. The Reynolds number increased with reduction of friction factor. These reductions caused due to more swirl flow takes between the different twist ratios. The Nusselt numbers were increases with increase of Reynolds number. The experimental value of Nusselt numbers were increased with 2 to 2.5 times of twisted tape inserts as compared to plain tube. An average of 25% enhancement of heat transfer was observed for the twisted tape insert than that of the plain tube. The correlation for the Reynolds number and exit temperature are proposed on present experimental work and the much more relation between the experimental and simulated values.

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