CFD ANALYSIS OF Fe_3O_4 NANOFLUID FLOW IN AN ELLIPTICAL TUBE INSIDE A CIRCULAR TUBE WITH INSERTS

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***Abstract*—There is a continued research to increase heat transfer rates in many engineering applications. Particularly at moderate Reynolds numbers in pipe flow the augmentation methods are divided into two types viz., passive techniques and active techniques. Placing different types of inserts in tubes serve as passive techniques. Active techniques, in which external power input is used, such as power work, are less preferred. The main aim of this thesis is to analyze the heat transfer in turbulent flow to horizontal tube using different types of inserts. The Reynolds number at 12000 and two different fluids are used such as water and water 95%+ Fe3O4- 5%. Furthermore, the three different types of inserts used. 1) Twisted tape 2) Perforated Twisted Tape3) Double Counter Twisted Tape .The data from ANSYS is used to calculate Friction factor and Nusselt number in the presence of inserts 3D models of the horizontal tube with inserts is done in Pro/Engineer and analysis is done in ANSYS. Using nano fluid further improved heat transfer.**

***Keywords*— Nanofluid, Return Bend, Wire Coil Inserts, CFD, Heat Transfer**

I. INTRODUCTION

Turbulent heat transfer and pressure drop in a horizontal tubes with strip-type inserts experimentally done to get heat transfer enhancement for 6500⩽Re⩽19500. [1]. Techniques (passive and active) have been discussed to enhance compound heat transfer enhancement amng them using inserts is one of the goo idea[2]. The heat transfer characteristics and the pressure drop in the horizontal double pipes with twisted tape insert are investigated. The majority of the data falls within ±15%, ±10% of the proposed correlations for heat transfer coefficient and friction factor, respectively [3]. Experimental investigation of heat transfer and friction factor characteristics in a double pipe heat exchanger fitted with regularly spaced twisted tape elements, were studied. The inner and outer diameters of the inner tube are 50.6 and 25.8 mm, respectively and cold and hot water were used as working fluids in shell side and tube side [4]. An extensive experimental study on three wire coils of different pitch inserted in a smooth tube in laminar and transition regimes. Isothermal pressure drop tests and heat transfer experiments under uniform heat flux conditions have been carried out. The friction factor increases lie between 5% and 40% in the fully laminar region [5]. The thermohydraulic performance of turbulent flow of air through rectangular and square ribbed ducts with twisted-tape inserts has been experimentally studied. The short-length twisted-tape performance is worse than the full-length twisted tapes [6]. Nanofluids, i.e., well-dispersed (metallic) nanoparticles at low- volume fractions in liquids, may enhance the mixture's thermal conductivity, knf, over the base-fluid values. New theories as well as useful correlations have been reviewed [7]. Flow friction and heat transfer behavior in a twisted tape swirl generator inserted tube are investigated experimentally. The twisted tapes are inserted separately from the tube wall. The effects of twist ratios (y/D=2, 2.5, 3, 3.5 and 4) and clearance ratios (c/D=0.0178 and 0.0357) are discussed in the range of Reynolds number from 5132 to 24,989, and the typical one (c/D=0) is also tested for comparison. Consequently, the experimental results present that the best operating regime of all investigated twisted tape swirl generator inserts is detected at low Reynolds number, leading to more compact heat exchanger. The empirical correlations based on the experimental results of the present study are also given for prediction the heat transfer (Nu), friction factor (f) and heat transfer enhancement (ζ) [8]. The heat transfer performance and friction factor characteristics in a circular tube fitted with twisted wire brush inserts were investigated experimentally. Heat transfer and friction factor data in tubes were examined for Reynolds number ranging from 7,200 to 50,200. The results indicated that the presence of twisted wire brush inserts led to a large effect on the enhancement of heat transfer with corresponding increase in friction factor over the plain tube. Finally, correlations were developed based on the data generated from this work to predict the heat transfer, friction factor, and thermal performance factor for turbulent flow through a circular tube fitted with the twisted wire brush inserts in terms of wire density (y), Reynolds number (Re), and Prandtl number (Pr) [9]. The Experimental investigation of heat transfer and friction factor characteristics of horizontal circular pipe using internal threads of pitch 100mm, 120mm and 160mm with air as the working fluid. The transitional flow regime is selected for this study with the Reynolds number range 7,000 to 14,000. The heat transfer coefficient enhancement for internal threads is higher than that for plain pipe for a given Reynolds number. The use of internal threads improved the performance of horizontal circular pipe. Keywords - Enhancement, internal threads, heat transfer and turbulent flow. Angirasa performed experiments that proved augmentation of heat transfer by using metallic fibrous materials with two different porosities namely 97% and 93%. The experiments were carried out for different Reynolds numbers (17,000-29,000) and power inputs (3.7 and 9.2 W). The improvement in the average Nusselt number was about 3-6 times in comparison with the case when no porous material was used. Fu et al. experimentally demonstrated that a channel filled with high conductivity porous material subjected to oscillating flow is a new and effective method of cooling electronic devices. The experimental investigations of Hsieh and Liu

reported that Nusselt numbers were between four and two times the bare values at low Re and high Re [10]. An experimental investigation was carried for measuring tube-side heat transfer coefficient, friction factor, heat transfer enhancement efficiency of water for turbulent flow in a circular tube fitted with rectangular-cut twisted tape insert. Nusselt numbers obtained from smooth tube were compared with Gnielinski correlation and errors were found to be in the range of -6% to -25% with r.m.s. value of 20%. At comparable Reynolds number, Nusselt numbers in tube with rectangular-cut twisted tape insert were enhanced by 2.3 to 2.9 times at the cost of increase of friction factors by 1.4 to 1.8 times compared to that of smooth tube. Heat transfer enhancement efficiencies were found to be in the range of 1.9 to 2.3 and increased with the increase of Reynolds number [11]. This work deals with the experimental investigation on Nusselt number, friction factor and thermal performance factor in a circular tube equipped with perforated twisted tape inserts with four different porosities of Rp=1.6, 4.5, 8.9 and 14.7%. The experimental results revealed that both heat transfer rate and friction factor of the tube fitted with perforated twisted tapes were significantly higher than those of the plain tube. Over the range investigated, Nusselt number, friction factor and thermal performance factor in the tube with perforated twisted tape inserts was found to be 110 –340, 110 –360 and 28–59% higher than those of the plain tube values, respectively. In addition, the empirical correlations of Nusselt number, friction factor and thermal performance factor were formulated from the experimental results of tape inserts [12]. The present study explored the effects of the double counter twisted tapes on heat transfer and fluid friction characteristics in a heat exchanger tube. The double counter twisted tapes were used as counter-swirl flow generators in the test section. The experiments were performed with double counter twisted tapes of four different twist ratios (y=1.95, 3.85, 5.92 and 7.75) using air as the testing fluid in a circular tube. In addition, the empirical correlations for the Nusselt number, friction factor and thermal enhancement efficiency were also developed, based on the experimental data [13]. An experimental forced convective heat transfer analysis is done on magnetic micro fluid flowing through a copper tube in the presence of magnetic field for different mass fractions of magnetic particles, different Reynolds numbers and different Hartmann numbers. An increase in flow rate (Reynolds number) or Magnetic Field (Hartmann Number) or mass fractions of magnetic particles resulted in increase in the rate of convective heat transfer (Nusselt Number) for both the cases [14]. The convective heat transfer, friction factor, effectiveness and number of transfer units (NTU) of Fe3O4/water nanofluids flow in a double pipe U-bend heat exchanger and with twisted tape inserts were estimated experimentally. Finally the effectiveness and NTU of heat exchanger is enhanced for nanofluids flow in a double pipe heat exchanger with twisted tape inserts [15]. Below are some of the inserts used for augmentation commonly.

Fig. 1 Classic twisted tape

Fig. 2 Perforated twisted tape

Fig 3 Notched twisted tape

Fig 4 Jagged twisted tape

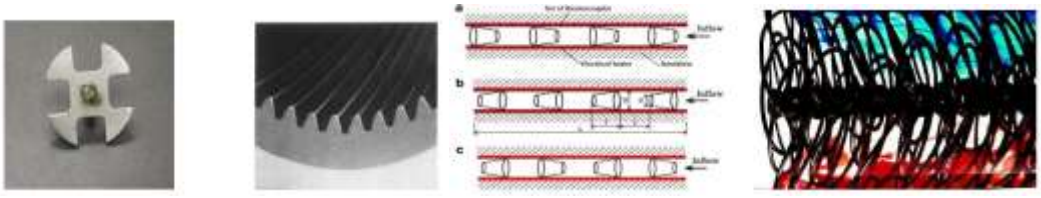

Fig. 5 Square cut circular ring insert, Micro-fins incorporated in a tube, Conical ring inserts, Wire insert

II. MODELING AND ANALYSIS

Pro/ENGINEER Wildfire is used for drafting as shown below.

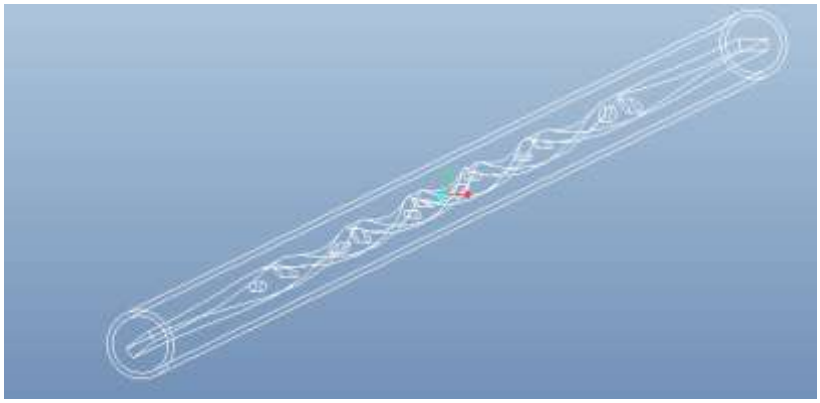

Fig. 6 Perforated twisted tapes in Pipe

Computational fluid dynamics, usually abbreviated as CFD is used as tool for Analysis. Pre programmed commertial CFD software ANSYS is used for meshing and analysis.

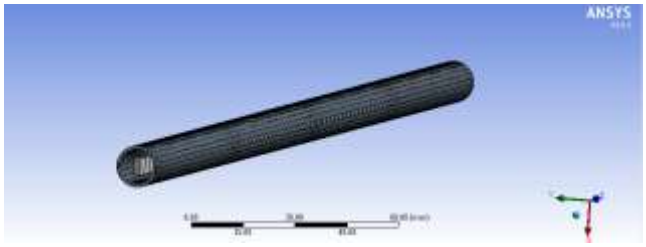

Fig 7. Meshed model

Steps involved in fluent as follows.

Update project>setup>edit>model>select>energy equation (on)>ok

Materials> Materials > new >create or edit >specify fluid material or specify properties > ok

Table 1: Thermo physical properties of fluids

Properties	Water	Water 95%+ Fe3O4 5%
Density(kg/m3)	998.2	344.829
Thermal conductivity(W/mk)	0.6	1.107
Specific heat(J/kg-k)	4182	3429.394
Viscosity(kg/m-s)	0.001003	0.001128

III. RESULTS AND DISCUSSION

In post processing following results are obtained.

3.1 Fluid –water 100%+Fe3O4- 0%

CASE: 1 TWISTED TAPE

Pressure

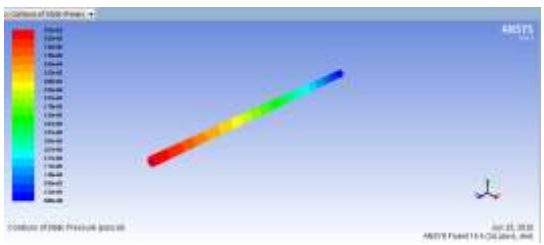

Fig 8. Pressure

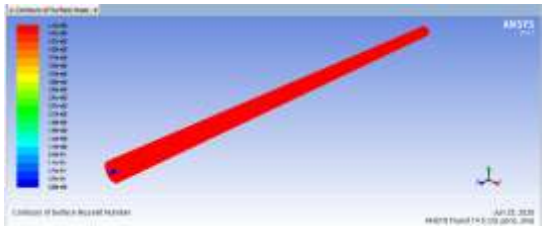

Fig 9. Nusselt number

CASE: 2 PERFORATED TWISTED TAPES

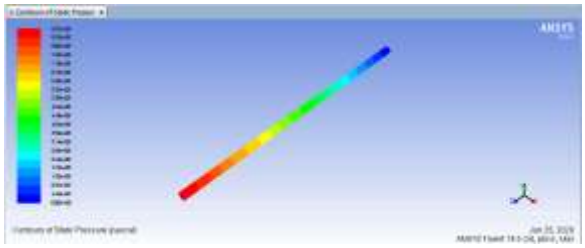

Fig 10. Pressure

Fig 11. Nusselt number

CASE: 3 DOUBLE COUNTER TWISTED TAPES

Pressure

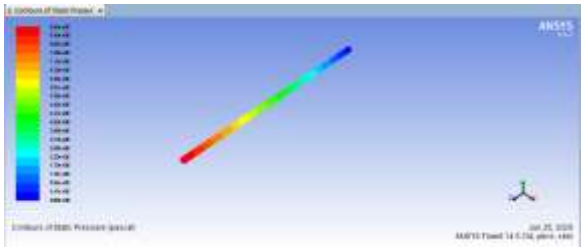

Fig 12. Pressure

Fig 13. Nusselt number

3.2 Fluid –water 95%+Fe3O4- 5%

CASE: 1 TWISTED TAPE

Pressure

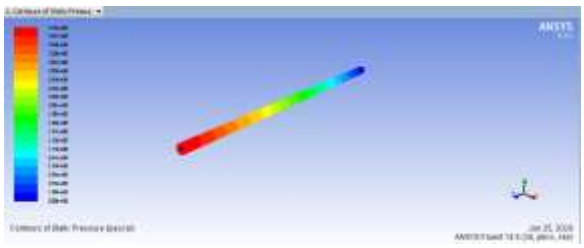

Fig 14. Pressure

Fig 15. Nusselt number

CASE: 2 PERFORATED TWISTED TAPES

Pressure

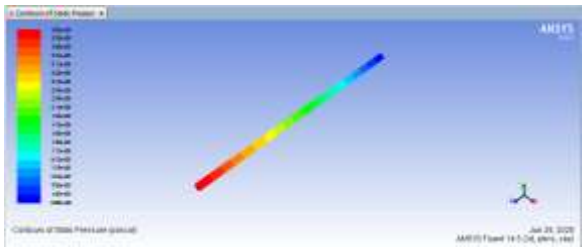

Fig 16. Pressure

Fig 17. Nusselt number

CASE: 3 DOUBLE COUNTER TWISTED TAPES

Pressure

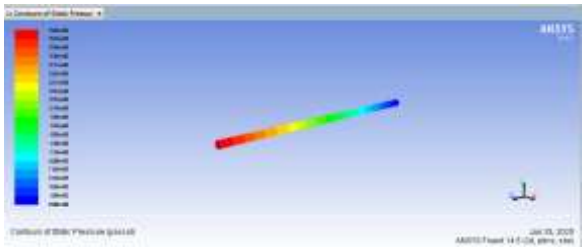

Fig 18. Pressure

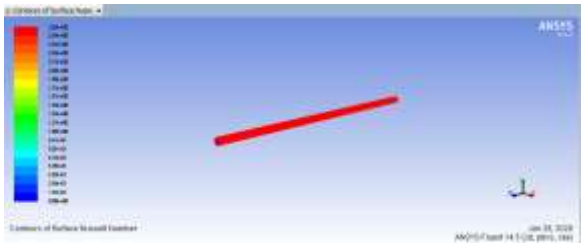

Fig 19. Nusselt number

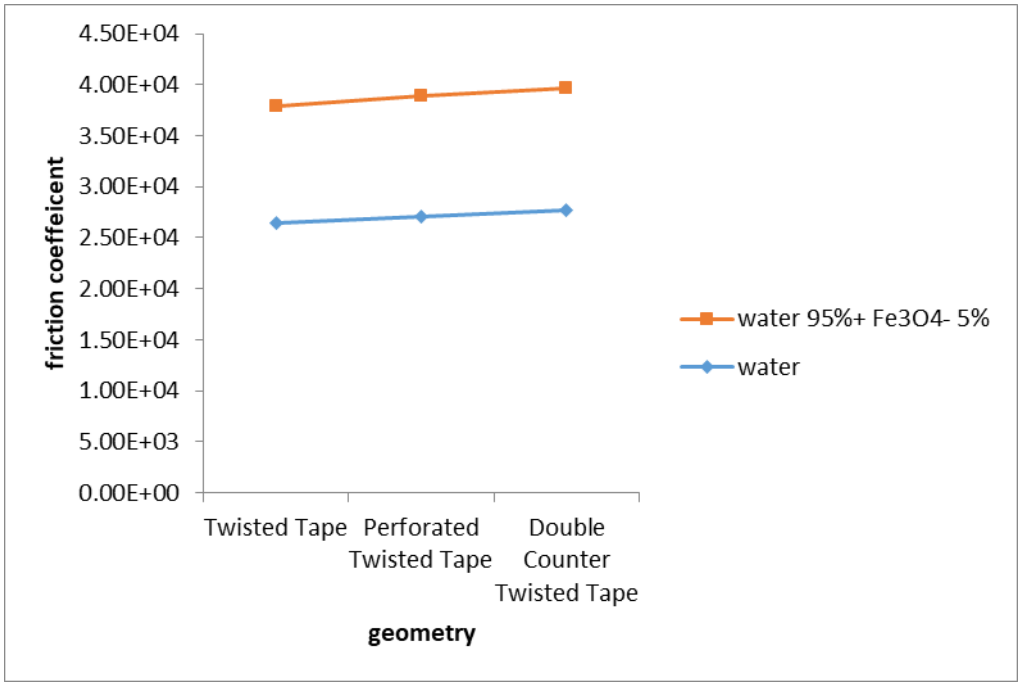

Fig 20. Friction factor in Nanofluid

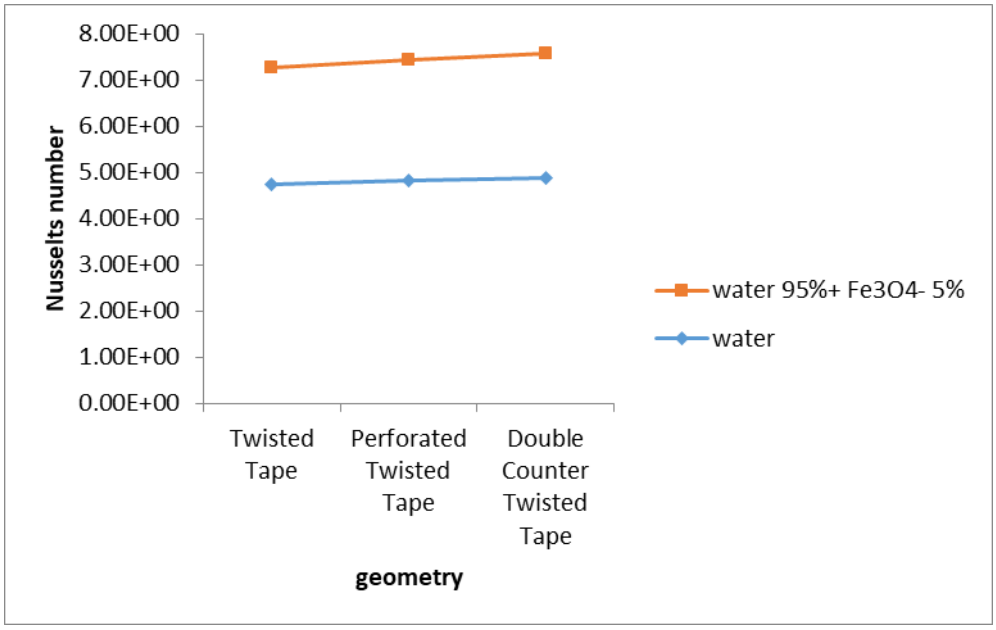

Fig 21. Nusselts Number in Nano fluid

IV. CONCLUSIONS

The Reynolds number at 12000 and two different fluids are used such as water and water 95%+ Fe3O4- 5%. Furthermore, the three different types of inserts used. 1) Twisted tape 2) Perforated Twisted Tape3) Double Counter Twisted Tape .The data from ANSYS is used to calculate Friction factor and Nusselt number in the presence of inserts Form the CFD analysis results; the following conclusions can be made:

The Nusselt number is more for Double Counter Twisted Tape than other inserts, friction factor, and Reynolds number are more for Double Counter Twisted Tape than other inserts.

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