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Experimental Study of Heat transfer and friction factor in Double pipe Heat Exchanger using twisted tape with V-cut of different depth

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Abstract: *The utilization, conservation and conversion of energy in every domestic, commercial and industrial application involve a heat exchange process. Some industrial applications are utilized in condensation and steam generations in power plants; sensible cooling and heating of viscous media in thermal processing of agricultural, chemical and pharmaceutical products, liquid and air cooling of engine and turbo machinery systems, and cooling of electronics devices and electrical machines, Improved heat exchange, over and above that in general practice, can significantly increase the thermal efficiency in such applications as well as the economics of their operation and design.*

In the present work, Experimental Study of Heat transfer and friction factor in Double pipe Heat Exchanger using Twisted tape with V-cut of different depth of 2mm,4mm and 6mm at constant temp is carried. A comparative study was done to evaluate the effects of twisted tape inserts with respect to plain tube on the values of heat transfer rate, Nusselt Number and friction factor through a circular tube using water as testing fluid with a range of Reynolds number between 5600 and 10000. In the double pipe heat exchanger (DPHE), hot water was cooled in the inner tube and cold water was used as cooling fluid between the inner tube and the outer tube. The results showed that the heat transfer characteristics of DPHE were enhanced with twisted tape while frictional resistance also increases at the same time. The maximum increase in heat transfer rate was found to be 31% for 6 mm V cut depth,29% for 4mm V cut depth,27% for 2 mm Vcut depth and 19% for without V cut with respect to plain tube. Friction factor was varied from 0.10 to 0.37 for the tube fitted with V cut twisted tape as compared with inserted twisted tape on plain tube.

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I. INTRODUCTION

Heat exchangers are devices which is used to transfer the heat between two or more fluid, Depending on the type of heat exchanger employed, the heat transferring process can be gas-to-gas, liquid-to-gas, or liquid-to-liquid and occur through a solid separator, which prevents mixing of the fluids, or direct fluid contact. It is a type of equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and running costs. The temperature of each fluid changes as it passes through the exchanger and the temperature of the dividing wall between the fluids also changes along the length of the exchanger. Present work involves a novel configuration of twisted tape to comparatively study heat transfer and friction characteristics of circular tube with V-cut twisted tape depth of 2 mm, 4 mm and 6 mm at constant angle . Heat transfer data pertaining to proposed configuration will be collected and compared with plain strip.To improve the performance of heat exchanging devices for reducing material costs and surface area and decreasing the difference for heat transfer thereby for reducing external irreversibility, lot of techniques have been used. To increase heat transfer coefficient, twisted tapes are promising. The twisted tapes effects the fluid flow across the tube promotes higher heat transfer coefficient. Numerical analysis on a double pipe heat exchanger with twisted tape induced swirl flow on both sides by Ranjitha ,Shaji Kb in 2015. Experimental Investigation of Heat Transfer Rate Using Twisted Tape with Elliptical Holes by K. R. Gawande 1 , A. V. Deshmukh* 2 in 2017. Experimental Investigation of Heat Transfer Characteristics in a Circular Tube Fitted with Triangular-Cut Twisted Tape (TCTT) Inserts by Sivakumar K1* and Rajan K2 in 2018. Experimental study on thermal performance and exergy analysis in an internally grooved tube integrated with triangular cut twisted tapes consisting of alternate wings by C. Nithiyesh Kumar 1 & M. Ilangkumaran2 in 2018. Experimental Augmentation of Heat Transfer in a Shell and Tube Heat Exchanger using Twisted Tape with baffles and hiTrain Wire Matrix Inserts – A Comparative Study by Raman Bedi1 , Kiran K1 , A M Mulla2 , Manoj3 , Gurumoorthy S Hebbar1 in 2018. V-cut Twisted Tape Insert Effect on Heat Transfer Enhancement of Single Phase Turbulent Flow Heat Exchanger by Indri Yaningsih1,2,4 a), Agung Tri Wijayanta2 b), Takahiko Miyazaki3,4 c), and Shigeru Koyama3,4 d) in 2018. Thermal performance of double pipe heat exchanger with V-cut twisted Tape inserts by a) Sumitkumarsingh b)Jahar Sarkar in 2019. Study the effect of Nano fluid on Heat Transfer in Finned Pipe with

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Validation of experiment setup

Experimental set-up is validated against the standard correlations as suggested by various authors to check correctness of the data obtained through the experiments. The values of Nusselt number and friction factorthe experiments of plain tube are compared with the Gnielinski and Filonenko correlations respectively. The results reveal that the experimental values are within the permissible limits. The maximum deviation found is ±7% for Nusselt number and ±7.5% for friction factor.

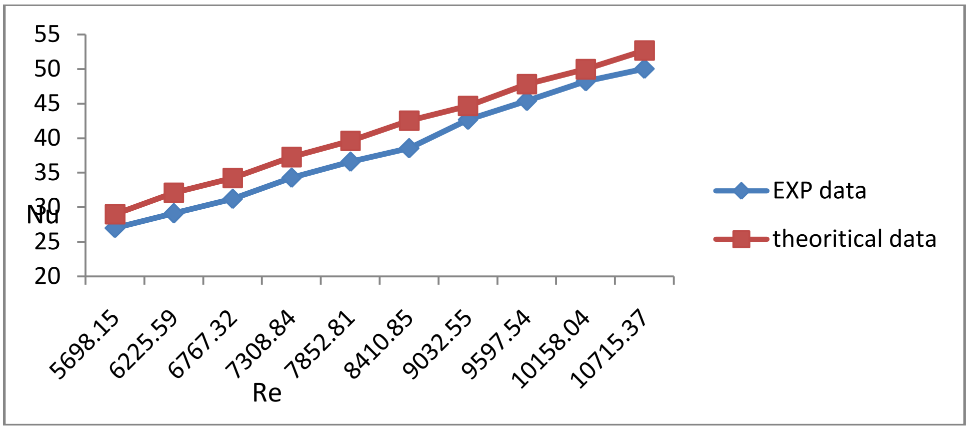

Fig.1. Comparison of the experimental Nusselt number and theoretical Nusselt number for the plain tube.

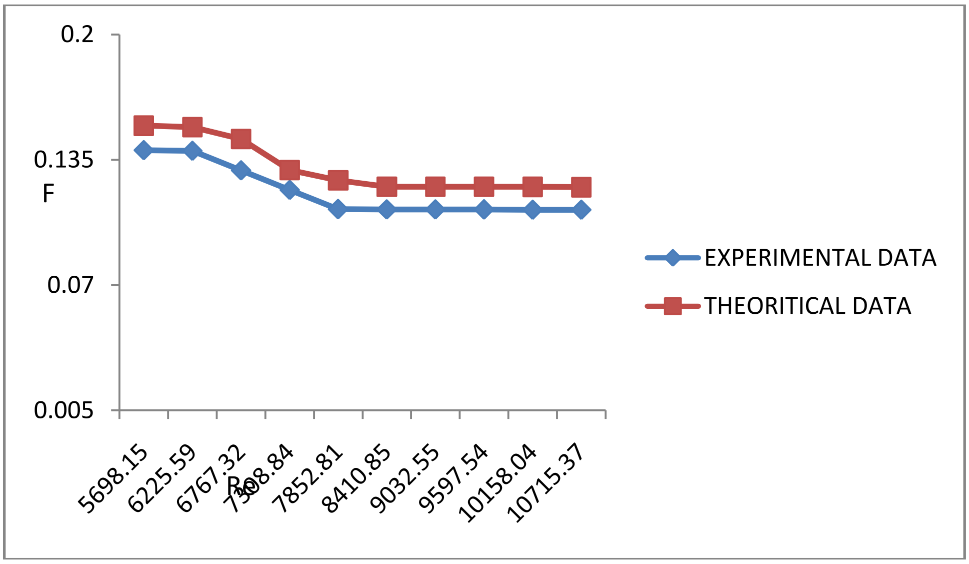

Fig.2 Comparison of the experimental friction factor and theoretical friction factor for the plain tube

Experiment setup

This chapter includes the assembly of Practical setups used to generate the sufficientdataforexperimental investigation on heat transfer and friction characteristics of double-pipe heat exchanger for single-phase forced convective flow. Sufficient data were obtained by varying different parameters over predetermined ranges. The equipment's used and the data compilation methodology adopted are also discussed in this chapter.

The set-up consisted of the following components:

1. AC power supply
2. Heater

3. Electrical heater fired hot water boiler
4. low measuring devices
5. Plane Steel Tube
6. Externally Helical Copper Wire Wound Steel Tube
7. Twisted Inserts Outer tube [G.I]
8. Thermocouples
9. Cold water source

Hot water flow from top placed hot tank to the inner steel tube where it lose heat by cold water which is flowing through the outer tube. The outlet and inlet of cold water in outer tube positioned at top so that outer tube should be filled completely and inner tube must be fully immersed in water. The flow of cold water is regulated by rota-meter at the inlet in the outer tube, this cold water then takes away heat to drainage. Mass flow rate of hot water is governed by rota-meter at the inlet of inner tube and the hot water outlet is circulated to hot water boiler for re-utilising of that hot water. By taking his hot water into boiler we conserved the wastage draining of hot water at outlet. Now in the hot water boiler placed at bottom we use a heater of higher capacity of 9KW power, which provides hot water of ranges 60º-90ºC in sometimes so we can save waiting time for upper hot tank's hot water. In bottom placed boiler we also have a pump of 0.5 HP capacity which pumps the hot water onto hot water tank placed at top for further utilisation. Four thermocouples are used to note down temperature at inlet outlet of cold and hot water flows respectively.

In my experiment, we use T shape 8mm width and 1.5m long Aluminium strip and water as a Fluid. With the help of Lathe, these Aluminium strip formed into flute face like twisted tape shape of 1.5m long with depth of 2 mm,4 mm and 6mm at constant angle 45 degree by using of twisting movement technique. Twisted tape is illustrated in the fig. 3.

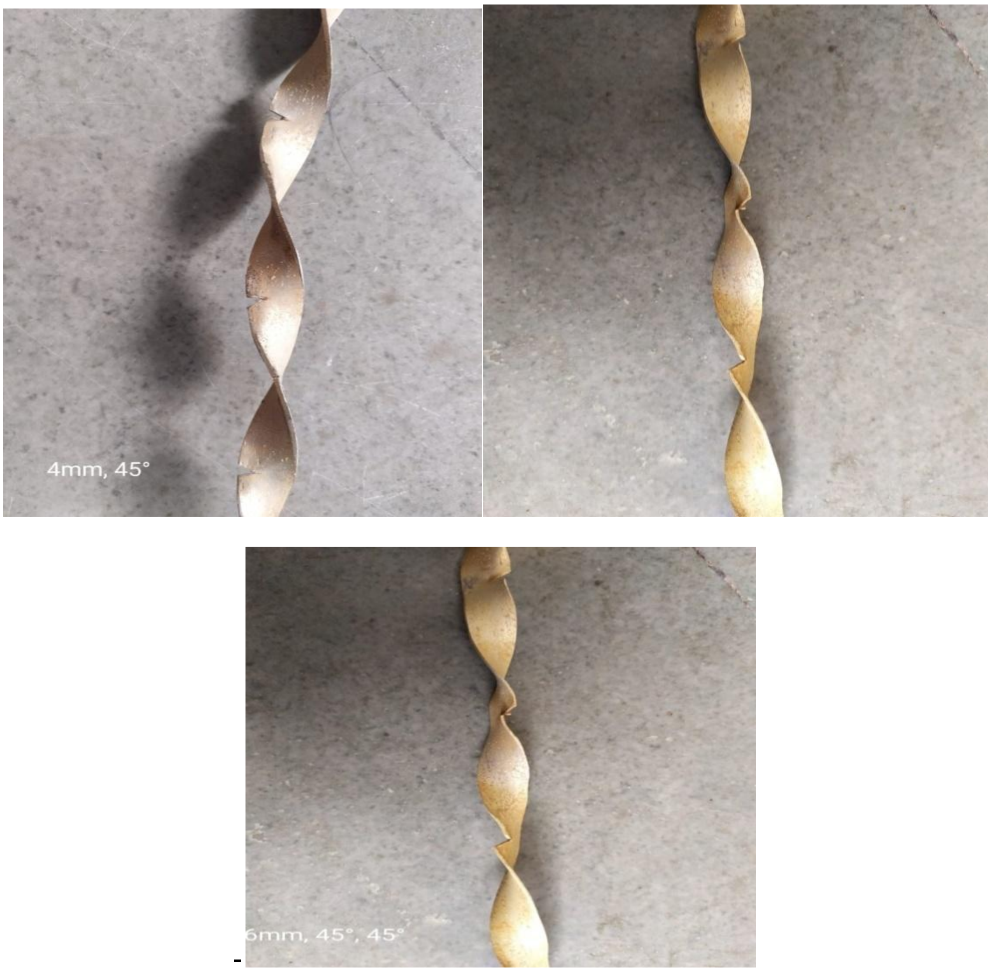

Figure:3 – showing twisted inserts with V-cut

II. RESULT AND DISCUSSION

Nusselt number increases in the tube with inserted twisted tape when depth of V cut is increases from 2 mm to 6mm at constant angle.. As discussed, Nusselt number is found to be maximum (50.04 at Re 10715.37 and 26.98 at Re 5698.15) for plain tube (no twisted tapes insert), (63.84 at Re 10606.28 and 32.72 at Re 5616.03) for plain tube with twisted tapes insert
(67.96 at Re 10666.95 and 33.084 at Re 5585.68) for depth of V cut 2 mm at constant angle.
(71.10 at Re 10616.31 and 35.94 at Re 5574.41) for depth of V cut 4 mm at constant angle.
(74.92 at Re 10762.93 and 36.93 at Re 5617.51) for depth of V cut 6 mm at constant angle as shown in fig 3.

This highest value of Nusselt number of (twisted inserts is 1.26 times greater than the values for Nusselt number for plain tube, twisted tape insert with depth of V cut 2 mm is 1.35 times greater than the values for Nusselt number for plain tube, twisted tape insert with depth of V cut4 mm is 1.42 times greater than the values for Nusselt number for plain tube and twisted tape insert with depth of V cut 6 mm is 1.49 times greater than the values for Nusselt number for plain tube at constant angle.

Highest value of Nusselt number is obtained for V cut depth 6 mm at constant angle 45. as it induces maximum increase in the secondary flow vis-à-vis plain twisted tape and twisted tape with other configurations used for the experiments. This results in a reduction in the formation of boundary layer and increases the overall fluid velocity consequently; maximum value of Nusselt number is obtained for the given range of parameters.

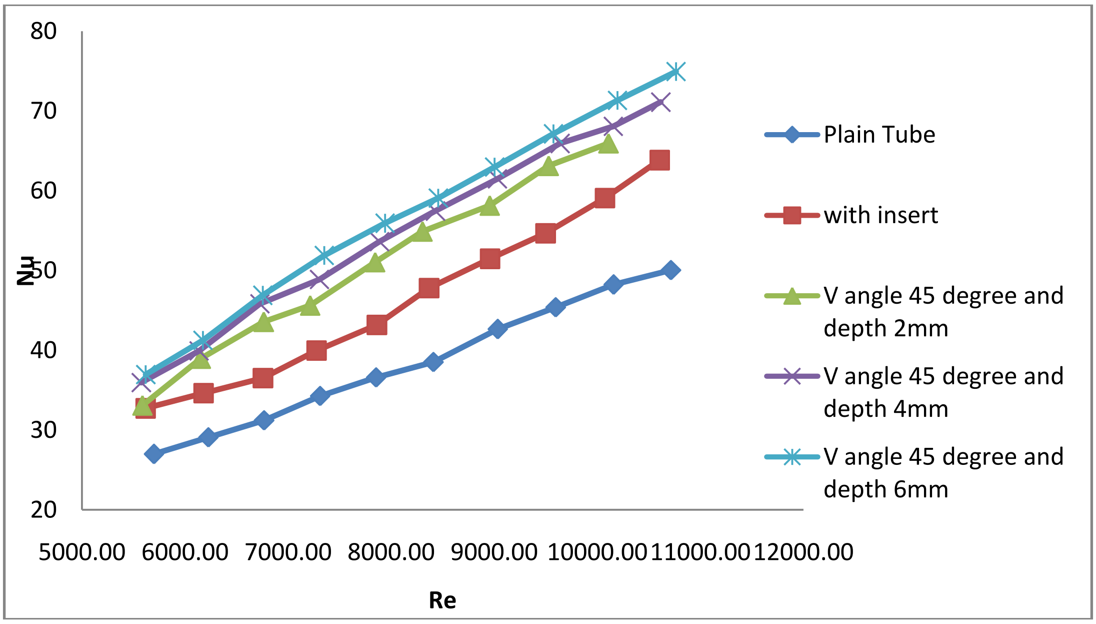

Fig.4. Variation in Nusselt number with respect to Reynolds number for different values (Plain tubes, with twisted tapes insert, twisted tapes insert at Vcut depth 2mm, 4mm and 6mm at constant angle)

Friction factor enhances with an increase in the depth of V cut 6mm. In addition, it increases with an increase in the depth of V cut at constant angle. It is on account of reduction in the flow area which in turn provides more contact surface resistance. Therefore, plain tube is reported to have minimum value of friction factor. Over the range depth of V cut depth increases, friction factor is found to be minimum for twisted tape with no Vcut. The value of friction factor for plain tube is found to be 0.1090 (for Re=10715.37) and 0.1399 (for Re=5698.15),for twisted tape insert is found to be 0.1361 (for Re=10606.28) and 0.1876 (for Re=5616.035), for twisted tape insert with depth of V cut 2mm is found to be 0.177 (for Re=10666.95) and 0.255 (for Re=5585.68),for twisted tape insert with depth of V cut 4mm is found to be 0.199 (for Re=10616.31) and 0.295 (for Re=5574.41),for twisted tape insert with depth of V cut 6mm is found to be 0.21 (for Re=10762.93) and 0.31 (for Re=5617.511).

Friction factor for twisted tape with insert is found to be 1.23-1.34 times whereas twisted tape with V cut depth 2 mm is reported to be 1.62-1.82, 1.83-2.10 (V cut depth 4mm) and 1.99-2.24 (for v cut depth 6mm) times respectively greater than as comparison with friction factor for the plain tube. A graph depicting the variation in friction factor with respect to Reynolds number is depicted in Figure 4.

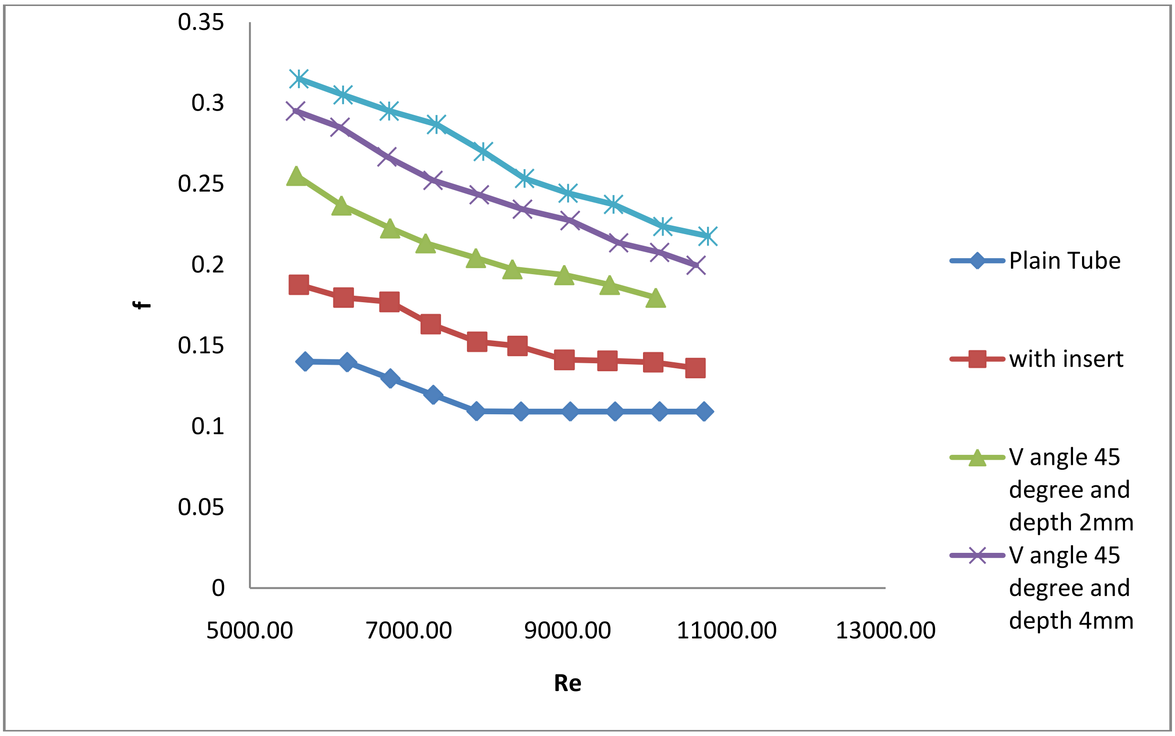

Fig.5. Variation in friction factor with respect to Reynolds number for plain tube, with insert angle 45 degree with depth of 2mm,4mm and 6mm respectively

The variations in performance evaluation criteria (PEC) with Reynolds number in the plain tube and in tubes fitted with twisted tapes with V cut depth 2mm,4mm and 6mm respectively is presented in Figure 5. It can be emphatically deduced from the Figure that the performance evaluation criteria decreases with an increase in Reynolds number for all cases which reflects when Reynolds number increases, the impact of friction factor becomes more and more significant in comparison to Nusselt number. The ratio of Nusselt number decreases with an increase in Reynolds number which means twisted tape gives better result in weak turbulence. Over the range of Reynolds number investigated, maximum PEC is found at V cut depth of 6 mm with a value of 1.13 (Re=5617.51) and 1.07 (Re=10762.93) and it is 1.12-1.06 times for without V cut twisted tapes. On the other hand, maximum value of performance evaluation criteria is 1.03-1.018 for V cut depth of 2mm,1.09-1.03 for V cut depth of 4 mm is greater than without V cut inserted twisted tapes.

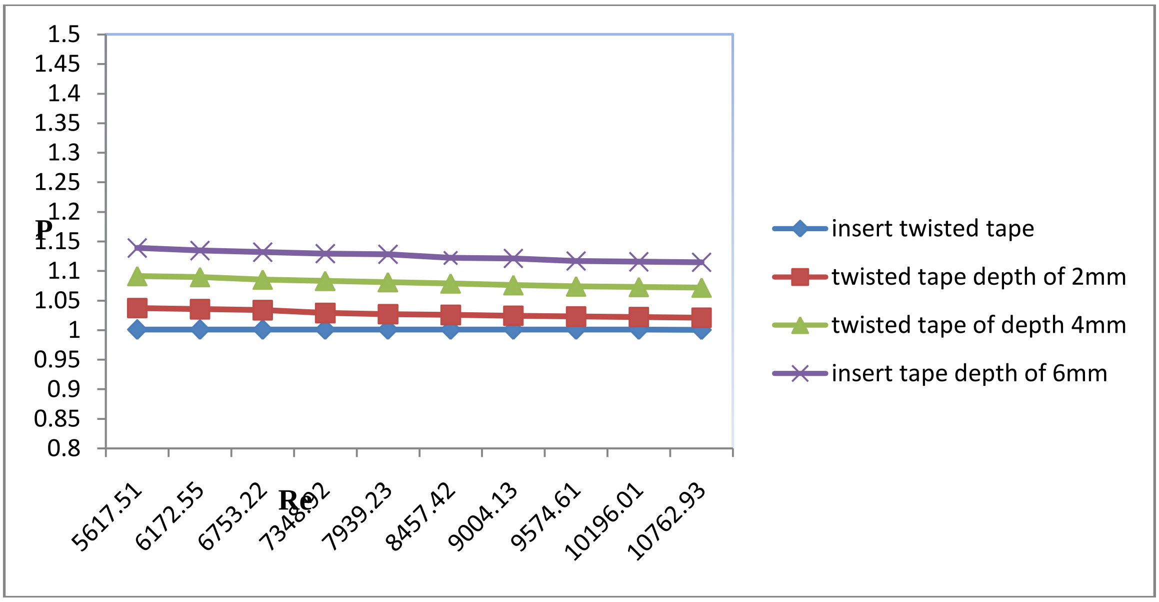

Fig.6.Variation in Performance evaluation criteria with respect to Reynolds number for twisted tapes insert with different values of v cut depth (2,4 and 6mm) at constant angle.

III. CONCLUSION

Heat transfer and pressure drop in a circular tube fitted with inserted twisted tape depth of V cut at 2mm,4mm and 6mm at constant angle 45 degree was experimentally investigated. The effect of twisted tape inserts with V cut of different depth at constant angle on heat transfer and friction factor characteristics has been studied experimentally. The investigations were carried out for water as a working fluid in turbulent flow region. Following conclusions can be drawn from the present work.

I. It is found that over a range of Reynolds number studied, twisted tape inserts depth of V cut give higher values of Nusselt number and friction factor in comparison to twisted tape inserts without V cut and plain tube.

II. This highest value of Nusselt number of (twisted inserts is 1.26 times greater than the values for Nusselt number for plain tube, twisted tape insert with depth of V cut 2 mm is 1.35 times greater than the values for Nusselt number for plain tube, twisted tape insert with depth of V cut4 mm is 1.42 times greater than the values for Nusselt number for plain tube and twisted tape insert with depth of V cut 6 mm is 1.49 times greater than the values for Nusselt number for plain tube at constant angle. Highest value of Nusselt number is obtained for V cut depth 6 mm at constant angle 45. as it induces maximum increase in the secondary flow vis-à-vis plain twisted tape and twisted tape with other configurations used for the experiments.

III. This results in a reduction in the formation of boundary layer and increases the overall fluid velocity consequently; maximum value of Nusselt number is obtained for the V cut depth of 6mm.

IV. The friction factor is found to be directly proportional to the depth of V cut at twisted tape. it increases with an increase in the depth of V cut at constant angle. It is on account of reduction in the flow area which in turn provides more contact surface resistance. As the Reynolds number increases, the effect of twisted tape with V cut depth on friction factor becomes more dominating with respect to Nusselt number. Therefore minimum value of friction factor is reported for plain tube without any twisted tape insert.

V. Furthermore a performance evaluation criterion (PEC) at depth of 6mm at constant angle is maximum which reflects that Nusselt number is predominant over friction factor.

VI. It can be emphatically deduced from the Figure 6 that the performance evaluation criteria decreases with an increase in Reynolds number for all cases which reflects when Reynolds number increases, the impact of friction factor becomes more and more significant in comparison to Nusselt number.

VII. The ratio of Nusselt number decreases with an increase in Reynolds number which means twisted tape gives better result in weak turbulence. Maximum PEC is found at V cut depth of 6 mm with a value of 1.13-1.07 and it is 1.12-1.06 times for without V cut twisted tapes. On the other hand, maximum value of performance evaluation criteria is 1.03-1.018 for V cut depth of 2mm, 1.09-1.03 for V cut depth of 4 mm is greater than without V cut inserted twisted tapes.

IV. FUTURE SCOPE

This study and analysis gives the possibility to investigate many different aspects in double pipe heat exchanger with twisted tape inserts and the following areas of research are identified for future research:

- Experimental study of heat transfer and friction factor in double pipe heat exchanger using twisted tape inserts with V Cut at same depth, multiple angle with nanofluid.
- Experimental study of heat transfer and friction factor in double pipe heat exchanger using twisted tape inserts with V Cut with different depth with nanofluid
- Experimental study of heat transfer and friction factor in double pipe heat exchanger using twisted tape inserts with V Cut at different depth with different twist ratio.
- Experimental study of heat transfer and friction factor in double pipe heat exchanger using using twisted tape inserts with V Cut of different length and at different locations.

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