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# Effect of V-Cut out Ratio on the Performance of Flow and Heat Transfer Enhancement in a Horizontal Pipe

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***Abstract*** **-In this work, forced convection heat transfer through a horizontal pipe built-in with/with out twisted tape-inserts is numerically studied under a uniform heat flux condition. Water is used as a working fluid. The governing equations are numerically solved in the domain by a finite volume method (FVM) using the Realizable κ–ε (RKE) model. The computational results are performed for a range of the Reynolds number (4000≤ Re≤ 12000), the twisted ratio 4. Two type of twisted tape which inserts across a circular pipe(P-TT) and (V-cut) are carried out. The influence of these parameters on the local, average Nusselt Number and the thermal performances were examined with plain pipeunder similar conditions. The results show that the average Nusselt number and friction factorrise as the twisted ratio rise for any value of Reynolds number. Furthermore, thermal performance factor tended to increase with increasing Re and decreasing tape twist ratio. Obviously, the (V-cut) twisted- tape and (P-TT) twisted tape with TR = 4 gave a higher mean thermal performance factor (1.974 and 1.745) than that with TR = 4, respectively. In the proposed work we used three different cut ratios are 0.6, 0.8, 1, and 1.25 and get the better heat transfer factor on 1.25 cut ratio.**

***Keywords*****- twisted pipe, finite volume method, V-cut, twisted ratio**

## I. INTRODUCTION

The development of high performance thermal systems has excited interest in strategies to enhance heat transfer. The study of improved heat transfer performance is said as heat transfer improvement, augmentation or intensification. Heat transfer improvement is that the method of up the performance of a heat transfer system. It's a subject of considerable interest to researchers because it ends up in saving in energy and value.

As a result of the fast increase in energy demand altogether over the world, each reducing energy consumption connected with ineffective use and improvement of energy within the context of heat became an increasingly important task for design and operation engineers for several systems. Within the past few decades varied analysis are performed on heat transfer improvement. These researchers centered on finding a method not only increasing heat transfer however additionally achieving high efficiency. Achieving higher heat transfer rates through numerous improvement techniques may result in substantial energy savings, development of additional compact and less expensive equipment with higher thermal efficiency.

Device may be a device facilitating heat transfer between 2 or additional fluids. It's extensively utilized in many industries, like thermal power plants, chemical process plants, air conditioning equipments, refrigerators, and radiator for house vehicles yet as automobiles. Until date large number of tries has been created to reduce the dimensions and prices of the heat exchangers. The high performance heat exchangers are obtained by utilization of heat transfer improvement techniques. In passive technique no external power is needed and inserts are utilized in the flow passage to enhance the heat transfer rate, that are benefits compared with active techniques, as a result of the insert producing method is straightforward and these techniques is simply used in an existing device. within the style of compact heat exchangers, passive techniques of heat transfer augmentation plays a vital role if a correct passive insert configuration is elect consistent with device operating condition.

The passive strategies additionally uses techniques like surface coating, rough surfaces, extended surface, swirl flow devices, convoluted (twisted) tubes, additives of liquids and gases etc. The compound technique is that during which over one passive or active technique are used at the same time for augmentation of heat transfer. The work according in thesis is concerning the employment of compound technique i.e., dimpled tube equipped with often spaced twisted tape insert. This found to be a promising heat transfer augmentation technique in terms of improvement of heat transfer performance characteristics of fluid flow.

## II. TWISTED TAPE

The Twisted Tape Turbulat or albeit simple is extremely effective. The fact that its design parameters are well known and built into major heat transfer software is what makes it the most widely used turbulator there is. It consists of a metal strip formed with a precise twist count and profile to deliver turbulation by redirecting the fluid

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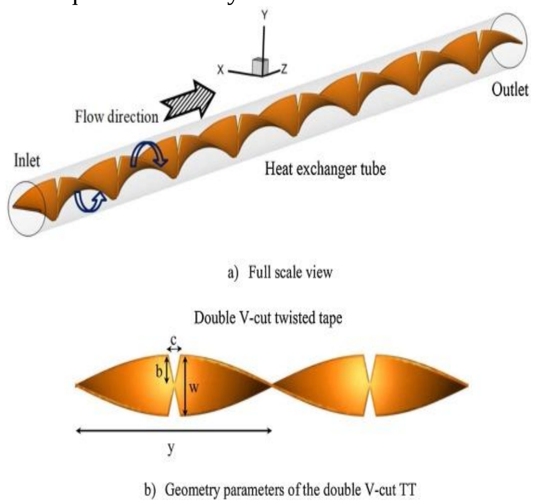
in a concentric path. This is often the ideal turbulator for retrofitting existing equipment to improve heat transfer efficiency.

**1. Swirl Action Flow for continuous antifouling action.**
Heat transfer apart, the twisted tape has a unique tumble effect of the fluid within the tube where in a "swirl flow action" it churns the fluid from the center of the tube to the wall. This action prevents and maybe removes scale buildup on the walls.To give you an idea of the scale of this action, consider a fluid with a flow rate of 1.5 metres per second. If the twisted tape has 10 turns per meter this equals a speed of 1.5 x 10 x 60 = 900 revolutions per minute. You can think of it as 900 RPM. We have used this technique successfully at refineries.




## III. METHODOLOGY

**1. Physical Model**
The schematic drawing of this study is shown in Fig. 2a. 5 styles of twisted tapes (p-TT and V-cut) inserts within a circular pipe with twisted ratios of 4.0 are performed as shown in Fig. 2. The length of the test pipe is 80 cm with AN inner and outer diameter of 2.8 cm and 3.2 cm, severally. The twisted tape material is aluminium of full length, the thickness of 0.3 cm, the width of 2.5 cm, the width ratio (WR) capable 0.34 and also the depth ratio (DP) equal to 0.43. The tape dimension is smaller to it of the inner diameter of the pipe.

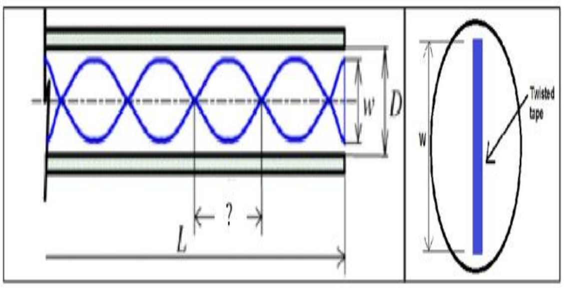
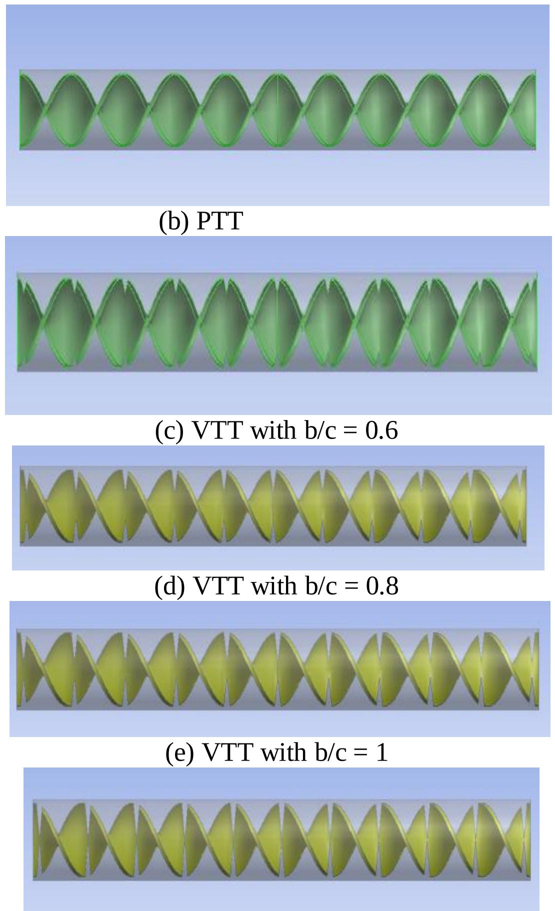



Fig. 2 Schematic drawing of the present study



(b) PTT

(c) VTT with b/c = 0.6

(d) VTT with b/c = 0.8

(e) VTT with b/c = 1

(f) VTT with b/c = 1.25

Fig. 3 PTT and different VTT cut inserts with different cut ratio.

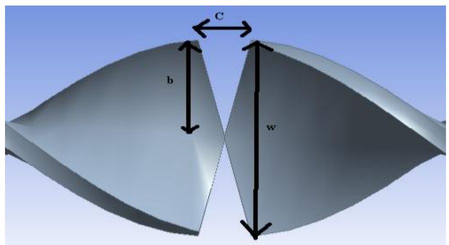



Fig. 4 Geometry parameters of the double V-cut TT

Table 1 Parameters of model.

| | | |
|---|---|---|
| V-cut depth (mm) | b | 3, 4, 5, 6 |
| V-cut width (mm) | c | 5 |
| Cut ratio | b/c | 0.6, 0.8, 1, 1.25 |

## IV. RESULTS

The numerical results of heat transfer (Nusselt number, Nu), pressure drop (friction factor, f) and enhancement performance factor in a tube with twisted tapes (P-TT) and (V-Cut) are reported in the present section. The

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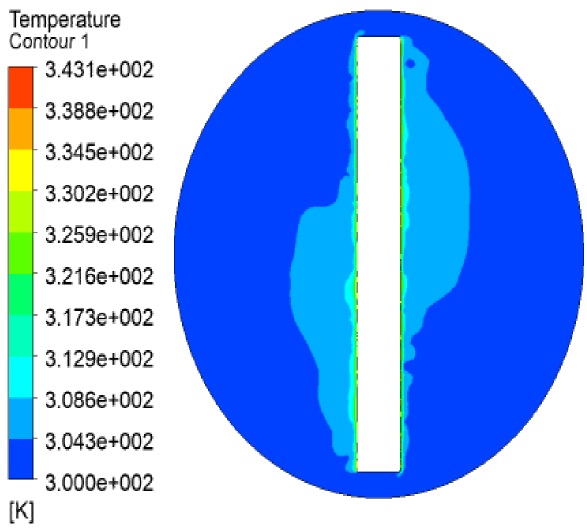
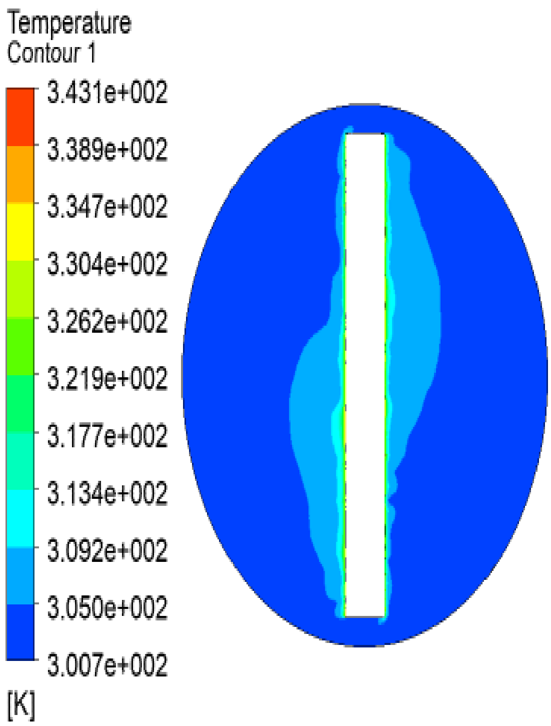
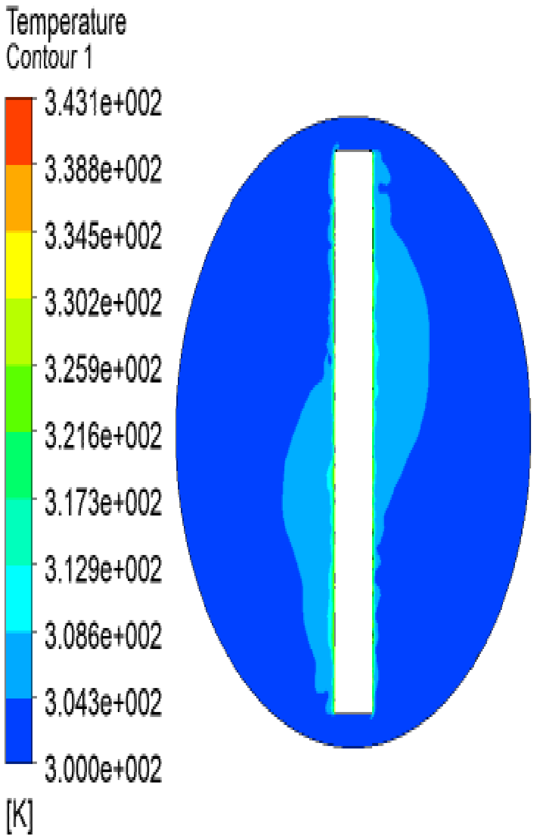
effects of cut-out ratio with (V-Cut) twisted of the tapes in a turbulent region of Reynolds number has been analyzed.

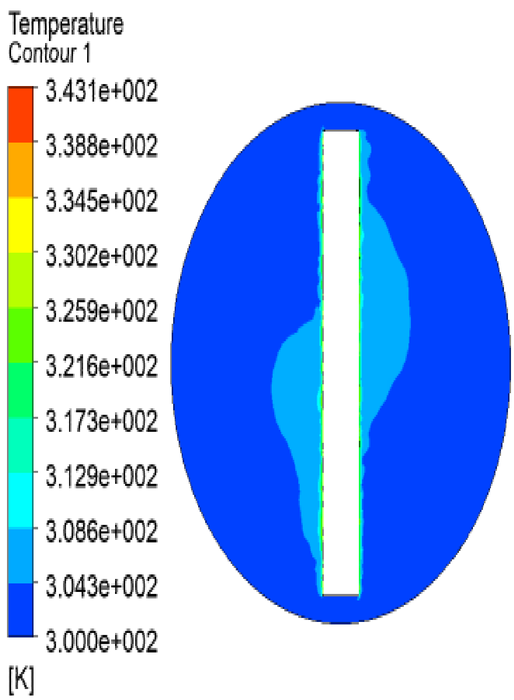
**1. Effect of Twist Tape Insert**




(a) Re = 4000
(b) Re = 6000




(c) Re = 8000
(d) Re = 10000

Fig. 5 Temperature contours for P-TT twisted tape at different Reynolds numbers

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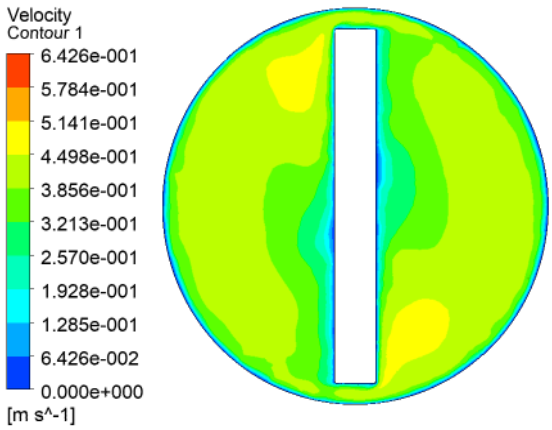
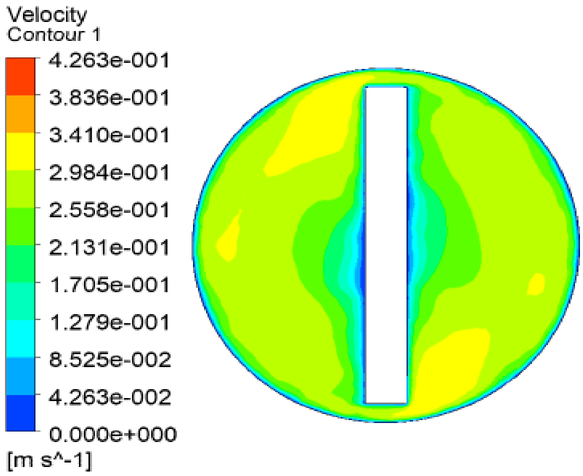
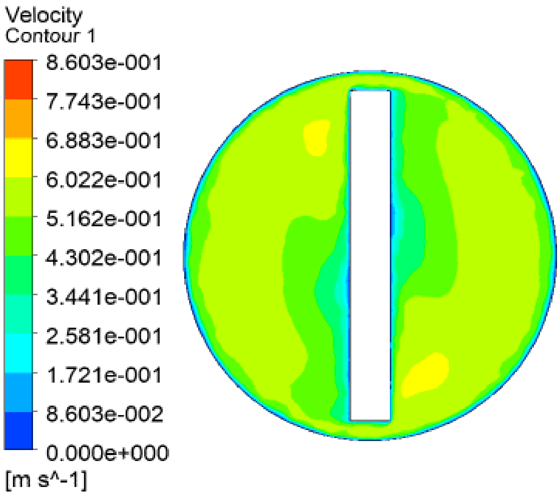
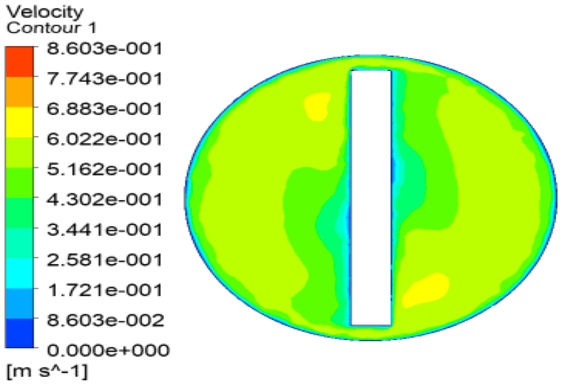
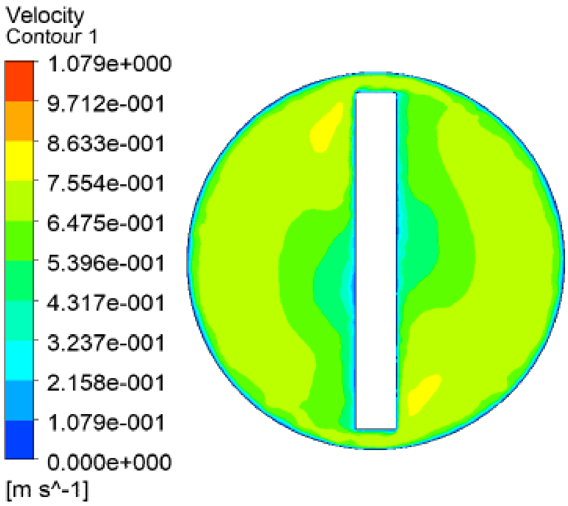



(a) Re = 4000
(b) Re = 6000




(c) Re = 8000
(d) Re = 10000
Fig. 6 Velocity contours for P-TT twisted tape at different Reynolds numbers.

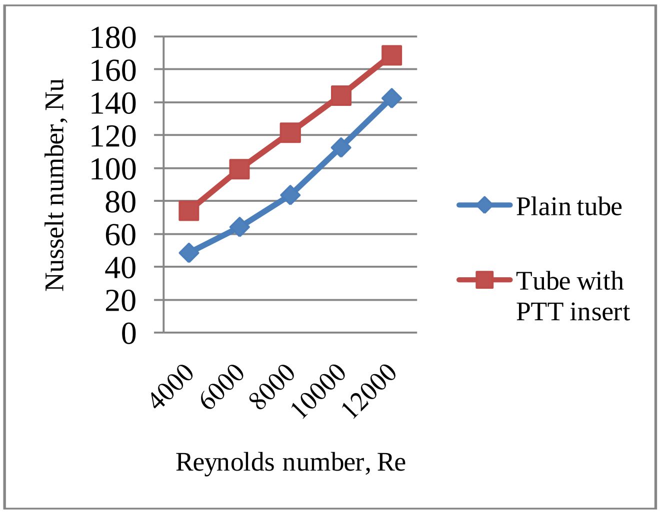



Fig. 7 Nusselt number vs Reynolds number for plain and P-TT insert

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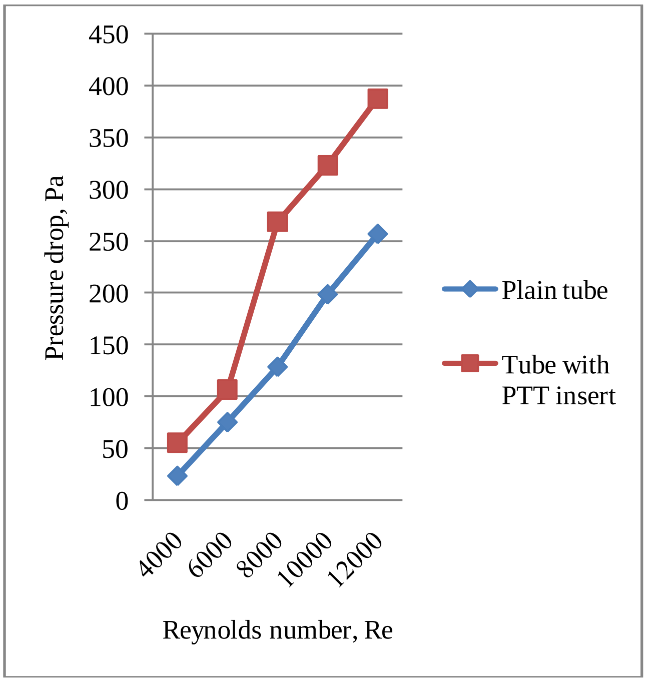


Fig. 8 Pressure drop vs Reynolds number for plain and P-TT insert.

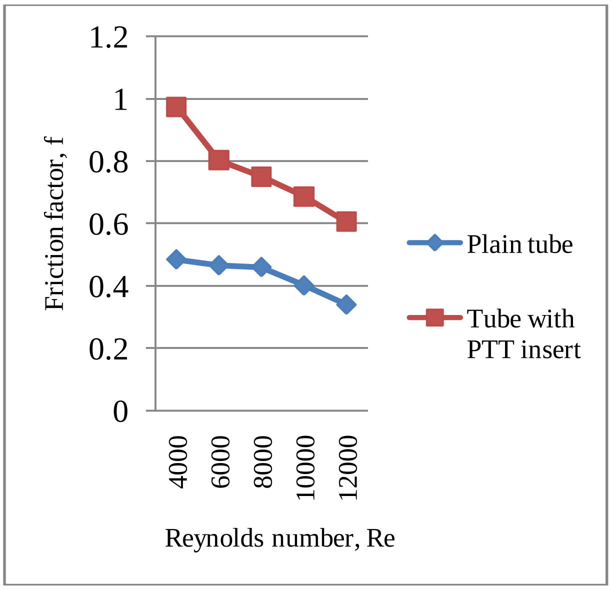


Fig. 9 Friction factor vs Reynolds number for plain and P-TT insert

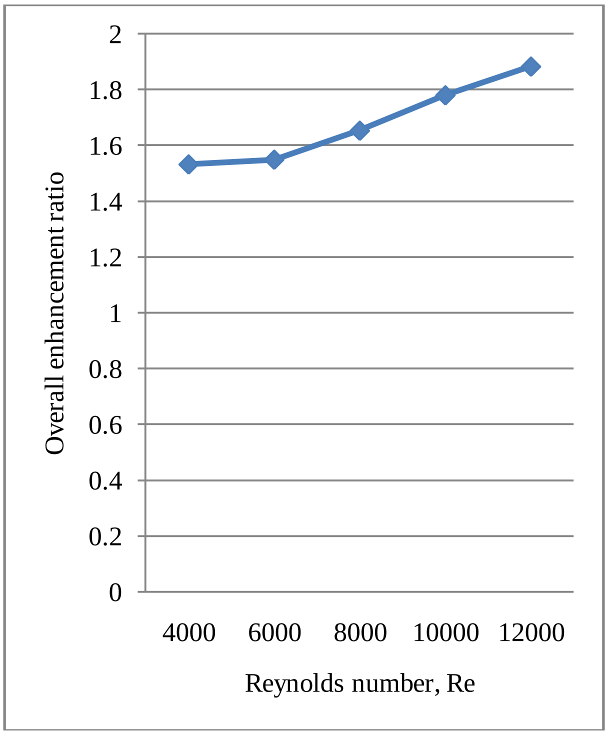


Fig. 10 Overall enhancement ratio vs Reynolds number for P-TT insert.

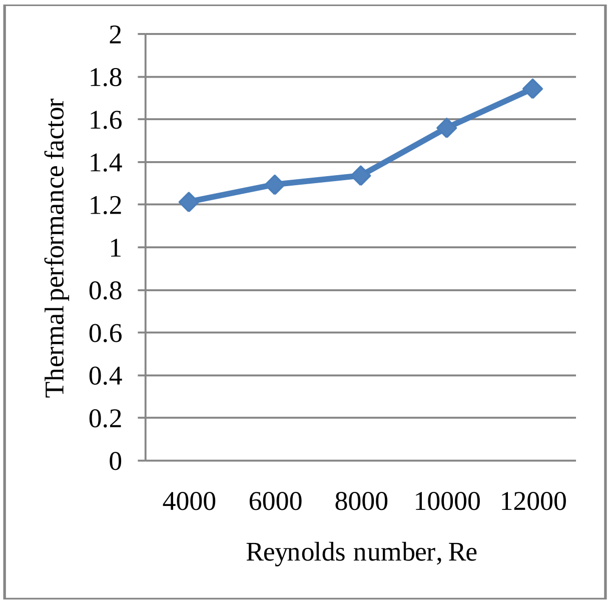


Fig. 11 Thermal performance factor vs Reynolds number for P-TT insert

**2. Effect of Cut Ratio**

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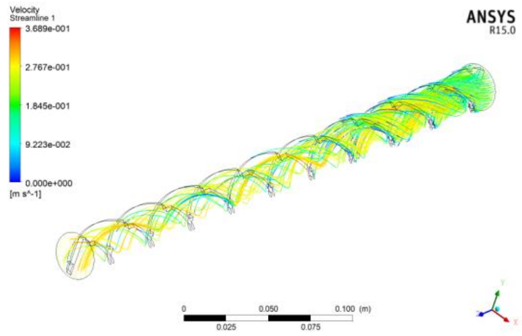


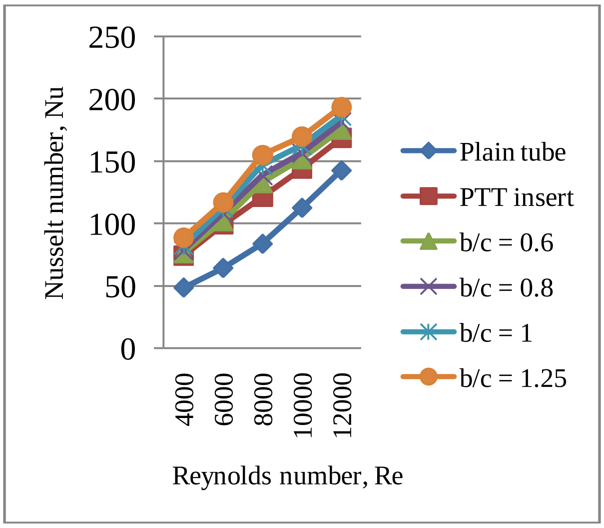


Fig. 12 Variations of Nusselt number against Reynolds numbers for different double V-cut ratios.

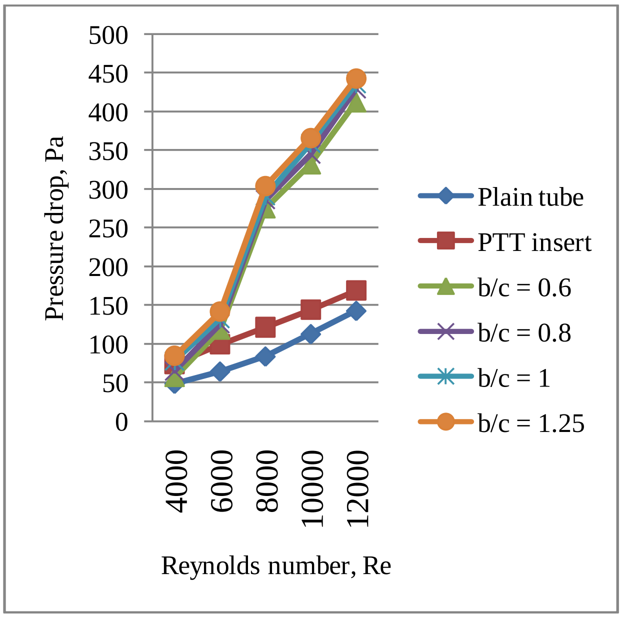


Fig. 13 Variations of pressure drop against Reynolds numbers for different double V-cut ratios.

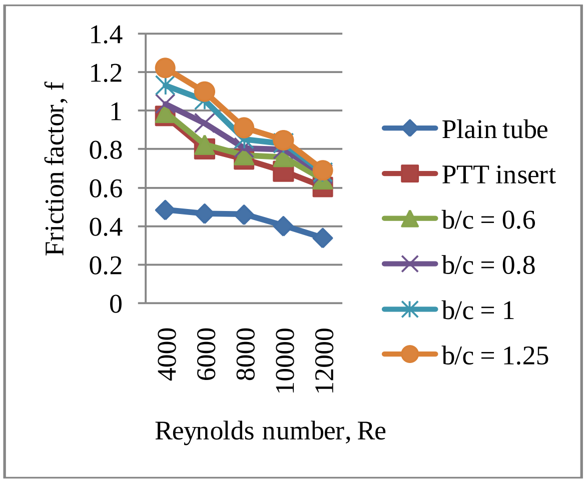


Fig. 14 Variations of friction factor against Reynolds numbers for different double V-cut ratios.

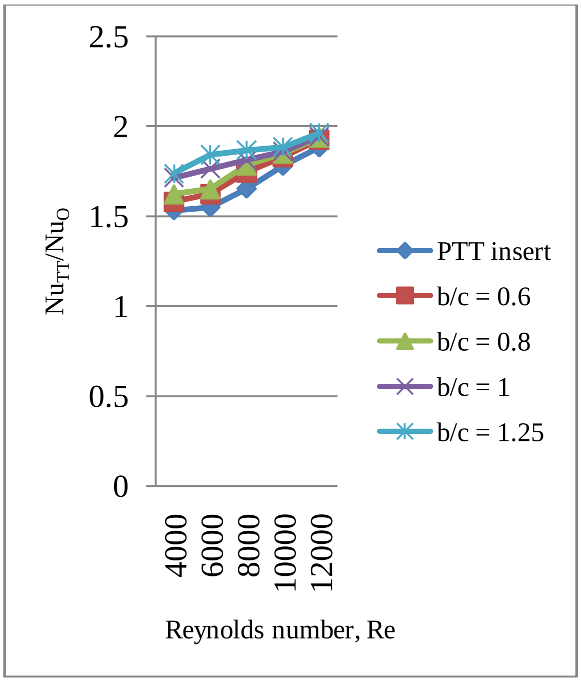


Fig. 15 Variations of overall enhancement ratio against Reynolds numbers for different double V-cut ratios

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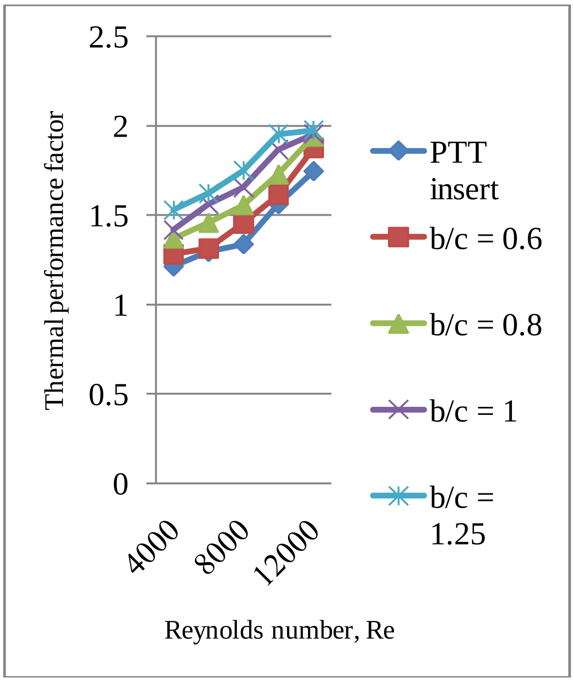


Fig. 16 Variations of thermal performance factor against Reynolds numbers for different double V-cut ratios.

## V. CONCLUSION

The characteristics of heat transfer and friction factor for different twisted tapes (V-cut) and (P-TT) inserted inside a horizontal pipe, with twisted ratios (TR = 4.0) have been studied numerically. Accordingly, the following conclusions are drawn:

- The use of twisted tape increases the heat transfer enhancement. The (V-cut) twisted tape presents a better heat transfer enhancement than that of the (P-TT) with all values of twisted ratio.
- The rates of heat transfer are always higher for the pipe supplied with twisted tapes as compared with the plain pipe, and this occurs due to the strong vortex flow that produced by twisted tapes. Results show that the rate of heat transfer with the twisted ratio (TR = 4.0).
- The friction factor which obtained from the pipe with twisted tape inserts is significantly higher than that of the plain pipe. Moreover, the utility of lower twisted ratio leads to higher tangential contact among the surface of the pipe and swirling flow.
- The maximum enhancement in the heat transfer under the model flow conditions is found when Nusselt number ratio is equal to 193.48 which occur in the (V-cut) twisted tape with the twisted ratio (TR = 4.0) for Reynolds number of around 12000.
- The maximum thermal performance factor is 1.974 for (V-cut) twisted tape with the twisted ratio (TR = 4.0) at Reynolds number (12000).

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