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HEAT TRANSFER ENHANCEMENT IN TUBE USING CIRCULAR SQUARE CUT INSERT-REVIEW

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Abstract:

Heat transfer augmentation techniques are used to increase rate of heat transfer without affecting much the overall performance of the system. Heat transfer augmentation techniques are commonly used in areas such as heating and cooling in evaporators, air-conditioning equipment, thermal power plants, space vehicle, automobile, etc. Researchers have done several researches on heat transfer enhancement in tube by inserting various inserts in past few years. There is need to increase the thermal performance of heat exchangers, thereby reducing size of heat exchanger and saving of material, effecting energy & cost led to development & use of heat transfer augmentation techniques. This paper contains literature survey of enhancement techniques in heat transfer using inserts.

Keywords — Circular square cut insert, Dimensional analysis, Heat transfer augmentation, Nusselt no, Reynolds no.

INTRODUCTION

Heat transfer occurs due to temperature difference between the two systems. In daily life, there are lots of engineering systems in which heat transfer plays very important role. Heat exchangers, boilers, condensers, radiators, heaters, furnaces, refrigerators, solar collectors etc. are the equipments of engineering systems in which heat transfer occurs. In past few years various researchers research on heat transfer augmentation. Heat transfer augmentation techniques are used to improve performance of heat exchangers. Improving the performance of heat exchangers led to saving of energy. Therefore total energy required to the system decreases. So, heat exchanger becomes compact and material required for heat exchangers is low. Energy efficient heat exchanger gives high performance. The techniques used to improve performance of heat exchangers are called as heat transfer augmentation or heat transfer enhancement techniques. Various researchers used different techniques like passive, active, compound etc.

A) Passive Techniques:
Heat transfer augmentation achieved by using inserts or introducing additional devices. External power input is not required in passive techniques. There are various passive techniques as given below:
(a) Treated Surfaces: Treated surfaces are used in condensing and boiling and this technique includes application of coating.
(b) Extended Surfaces: Fins are the example of extended surfaces and fins are used in heat exchanger to enhance heat transfer.
(c) Displaced Enhancement Devices: These devices are used in forced convection. Various inserts are inserted to displace fluid from core to surface side.
(d) Swirl Flow Devices: Rotating type of flow generated by using these devices. Inlet Vortex Generators, Twisted Tape Inserts are the different types of swirl flow devices.

B) Active Techniques:

For heat transfer enhancement, there is external power input is required. This technique is more difficult to design and there are very less applications. Mechanical Aids, Injection, Surface Vibration and Electrostatic Fields are different examples of active techniques.

C) Compound Techniques:
Combination of active techniques and passive techniques is called as compound techniques. Its purpose is to improve thermo hydraulic performance of a heat exchanger.

Inserts have been utilized as one of the enhancement techniques and are widely utilized in heat transfer equipments. They show several advantages in relation to other enhancement techniques:
1) Easy installation and removal.
2) Simple manufacturing process with low cost.
3) Preservation of original plain tube from mechanical strength.
4) Possibility of installation in an existing smooth tube heat exchanger.

LITERATURE SURVEY

Suvanjan Bhattacharyya, Subhankar Saha, presented Laminar flow heat transfer enhancement in a circular tube having integral transverse rib roughness and fitted with centre-cleared twisted-tape and the experimental friction factor and Nusselt number data for laminar flow through a circular duct. Centre clearance c=0, 0.2, 0.4, 0.6, Rib pitch (P/e) =2.0437, 5.6481and rib height (e/D) =0.07692, 0.1026. Predictive friction factor and Nusselt number co-relations are also presented. They have evaluated the thermo-hydraulic performance and the major findings of their experimental investigations are that with and without centre cleared twisted tape in combination with integral axial rib. They worked within the Reynolds number range of 10-1000, got friction factor in the range of 0.017-1.2 and Nusselt no. in the range of 3-15. The friction factor and Nusselt number both decreases with increase in the value of centre clearance initially however, after c=0.4 and with further increase of c, no appreciable changes in the friction factor and Nusselt number occur.

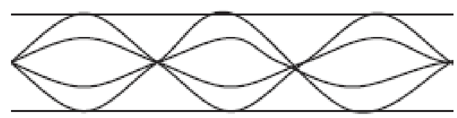

Figure 1.1 Centre Cleared Twisted Tape

M.M.K. Bhuiya, M.S.U. Chowdhury, M. Saha,proposed heat transfer and friction factor characteristics in turbulent flow through a tube fitted with perforated twisted tape inserts. The experiments were conducted in a turbulent flow regime with Reynolds number ranging from 7200 to 49,800 using air as the working fluid under uniform wall heat flux boundary condition. They got the Nusselt no. values in the range of 20-100 and friction factor in the range of 0.017-0.15. It has been found that the perforated twisted tape inserts enhanced the heat transfer rate significantly with corresponding increase in friction factor in comparison to that of the plain tube.

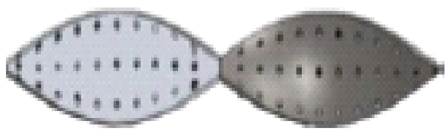

Figure 2.1 Perforated Twisted Tape

K. Wongcharee, S. Eiamsa-ard investigated Friction and heat transfer characteristics of laminar swirl flow through the round tubes inserted with alternate clockwise and counter-clockwise twisted-tapes. The thermo-hydraulic characteristics of the circular tubes equipped with alternate clockwise and counter-clockwise twisted-tapes (TA) for the Reynolds number ranging from 830 to 1990, are reported. In the experiments, the twisted tapes with three different twist ratios (l/W=3, 4 and 5) were inserted individually into the uniform wall heat flux tubes where water was utilized as the working fluid.

The obtained results reveal that, Nusselt number, friction factor and thermal performance factor associated with alternate clockwise and counter clockwise insert was greater as compared to simple twisted tape. They worked in the Nusselt number range of 800-2000. They got Nusselt number in the range of 10-55 and Friction factor in the range of 0.2-0.6.

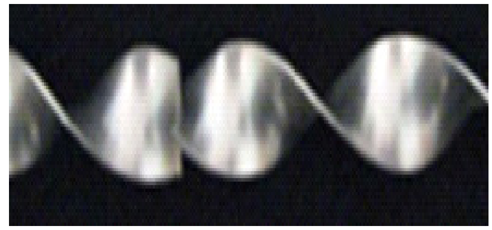

Figure 3.1 Alternate Clockwise and Counter-Clockwise Twisted-Tapes

S. Eiamsa-ard Studied thermal and fluid flow characteristics in turbulent channel flows with multiple twisted tape vortex generators. This research has been performed to study the influences of multiple twisted tape vortex generators on the heat transfer and fluid friction characteristics in a rectangular channel. The experiments conducted using the twisted tapes with three different twist ratios (y/w=2.5, 3.0 and 3.5) for generating different swirl and turbulent intensities in the channel.The experiments were conducted within the Reynolds number range of 2700-9000using air as the working fluid. Nusselt number range was within 8-55 and the friction factor range was within 0.05-0.3. The channel with the smaller twist ratio provides higher heat transfer rate and pressure loss than those with the larger of the twist ratio under similar operating conditions.

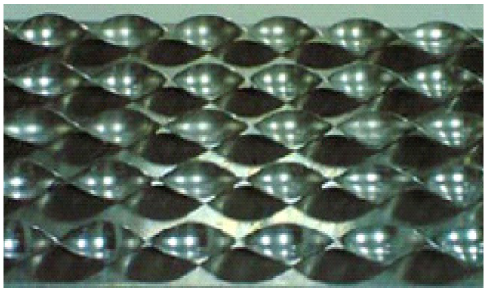

Figure 4.1 Multiple Twisted Tape

1. M.M.K. Bhuiya, M.A. Kalam,studied Heat transfer enhancement and development of correlation for turbulent flow through a tube with triple helical tape inserts. Influence of triple helical tapes inserted for turbulent flow through a tube on heat transfer enhancement was studied experimentally. The triple helical tapes made of mild steel with different helix angles, α=9°, 13°, 17°, and 21° were examined for Reynolds number ranging from 22,000 to 51,000.The experiment showed that the Nusselt number, effectiveness and friction factor for the inserts were found to be up to 4.5, 3.45 and 3.0 times, respectively, over the plain tube. The highest enhancement efficiency achieved was 3.7 for the inserts based on constant blower power. Finally, new correlations for predicting heat transfer and friction factor for turbulent flow through a circular tube fitted with the inserts were proposed.

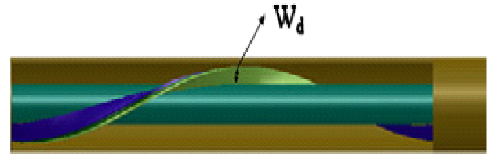

Figure 5.1 Test Section Fitted with Triple Helical Tape Insert with a Core-Rod

CONCLUSION

We will further analyze the heat transfer enhancement using square cut insert in convective heat transfer. While the findings show that the incorporation of the inserts in the flow passage enhances the heat transfer rate, the characteristics of the flow in the transitional and the fully turbulent flow regimes induced by the effect of inserts are distinct. Experimentation will be done on cases with and without using square cut insert in the turbulent flow passage, and evaluating the change in Nusselt no. from the previous researches and comparing the importance of the pressure drop and temperature rise.

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