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Commentary

Analysis of Fluid Flow and Heat Transfer through Pipe with Twisted Tape Insert

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DESCRIPTION

Increasing demand and fast depleting sources of the energy has received serious attention during last few decades. Continuous attempts are made either to design and manufacture more energy efficient devices or to increase the efficiency of existing devices. Heat exchangers are used on large scale in process industry and for air conditioning and refrigeration applications. The use of heat transfer augmentation techniques will enable to make more compact heat exchangers thus resulting in saving capital and operational cost substantially. Among the various augmentation techniques suggested to enhance the efficiency of heat exchangers, use of twisted tape inserts is a prominent method to improve the thermo-hydraulic performance of it. Twisted tapes are metallic strips twisted along their longitudinal axis at desired dimensions.

Depending on the tube diameter and tape material, inserts of different twist ratio can be employed. Insertion of twisted tape provides simple passive heat transfer augmentation by introducing the swirl to the flow and better mixing of core and boundary layer flow. This results in increased convective heat transfer coefficient between the tube and the fluid. The fluid has to travel greater distance in the helical motion compared to the straight motion. So, for a given mass flow rate, the fluid has to travel with a higher velocity. Secondary flow induced by helical motion ultimately causes greater mixing. The centrifugal force arising from helical flow cause the colder fluid in the core to move outwards and the lighter fluid at the tube surface to move inwards to the core of the tube. Thus, resulting in better mixing of hot and cold fluid.

The augmentation achieved with the use of twisted tape can be utilized either to increase the effectiveness of existing heat exchanger or to reduce the size of the heat exchanger for required performance. However, the rise in the pressure drop and subsequently pumping power may offset the heat transfer advantage. Since late twentieth century many investigations have been carried out to study the heat transfer and pressure drop characteristics of flow through a pipe with full length twisted tape insert. To overcome the pressure drop penalty associated with it, a reduced length twisted tape and regularly spaced twisted tape elements are suggested and investigated. The modified form of full length twisted tape is further investigated to improve the heat transfer.

Despite the comprehensive study of the earlier investigations, it is noted that only few studies have attempted to understand the flow physics of the heat transfer enhancement process. The thermal performance factor is found to be more in laminar regime than the turbulent. Therefore, the earlier investigations were focused either on laminar or turbulent regime of the flow. Rarely the data is available on the performance of twisted tape in transition flow regime. Further, the earlier studies have assumed the critical Reynolds number with the twisted tape same as in the plain tube.

CONCLUSION

There is no evidence of either theoretical or experimental study explaining the laminar to turbulent transition in presence of the twisted tape in the literature reviewed. The present study is the first of its kind explaining the mechanism of heat transfer augmentation using twisted tape and giving detailed explanation of flow transitions and corresponding critical Reynolds numbers.

The findings of this investigation are expected to improve the thermal efficiency of heat exchangers, the other applications of swirling flows including homogenizing liquid metal in casting, mixing in chemical processing and breaking fuel droplets in combustion will also find these findings suitable to enhance their efficiency. The detailed understanding of flow transition will help to identify the flow regimes and the corresponding critical Reynolds numbers.

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