IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
ISSN (e): 2278-1684, *ISSN (p):* 2320–334X, *PP: 33-36*
www.iosrjournals.org

A Review on Heat Transfer Augmentation using Twisted Tape inserts inAbsorber/Receiver of PTC

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ABSTRACT: *Heat Transfer Augmentation techniques refer to different methods to enhance rate of heat transfer without affecting much the overall performance of the system. These techniques are used in various applications such as solar power plants, thermal power plants, refrigeration and air conditioning, process industries, radiators for automobile systems etc.These techniques are of three types which are active, passive and compound techniques. The present paper is review of passive augmentation technique used in recent past.*

Keywords –*Heat transfer augmentation, Tapeinserts Passive methods*

I. INTRODUCTION

Nowadays, the high cost of energy and material has resulted in an increased effort aimed at producing efficient heat transfer equipment's. The heat transfer rate can be enhanced by introducing the disturbance in the fluid flow (making and breaking thermal boundary layers) but in process industries pumping power may increase significantly and ultimately the pumping cost becomes high .Therefore to achieve the desired heat transfer rate in an existing heat exchange equipment's at an economic pumping power, several techniques have been proposed in recent years and are discussed in further sections.

II. HEAT TRANSFER ENHANCEMENT

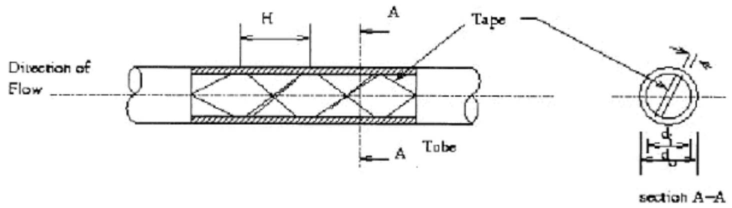
The Heat transfer enhancement in tube flow by inserts such as twisted tape, coil inserts/spirals, ribs and dimples is mainly due to flow blockages, partitioning of the flow and secondary flow. The flow blockages increase the pressure drop and leads to increased viscous effect because of reduced fluid flow area. The blockages also increase flow velocity and in some situations it leads to a significant secondary flow. The secondary flow further provides a better thermal contact between surface and fluid as secondary flow creates swirl and the thisresultsin mixing of fluid that enhances the thermal gradient which ultimately enhances the heat transfer coefficient.
The twisted tape develops a spiral flow along the tube length. A wire coil inserts consists of helical coiled spring which act as non-integral roughness. Fig 1 shows three typical configuration of twisted tape with 180˚ twisted pitch. Fig. 2 shows typical configuration of wire/spiral coil inserts. In turbulent flow, the dominant thermal resistance is limited to thin viscous sub layers. The wire /spiral coil inserts are more efficient in turbulentflow compared with twisted tape inserts because wire coil mixes the flow in viscous sub layers near the wall quite effectively whereas twisted tape cannot properly mix the flow near the viscous sub layers. For a laminar flow, the dominant thermal resistance is limited to thicker region compared with turbulent flow. Thus wire coil inserts are not effective for laminar flow because it cannot mix the bulk flow well and reverse is true for twisted tape inserts. Thus twisted tape inserts are efficient in laminar or transition flow. Cost and performance are important factors that play important role in selection of any passive technique for enhancement of heat transfer. In general, twisted tape inserts and wire coil inserts are more widely applied and have been preferred in recent past than other technique probably because methods such as extended surface inserts suffer from a relatively high cost and mesh inserts suffers from high pressure drop and fouling problems.

Laminar and Turbulent Flow in Tube:

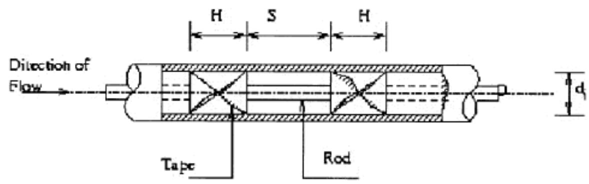
For fully developed laminar flow in a circular tube without any inserts the Nussult number has constant value under the condition of constant wall temperature Nu =3.657 and friction fraction for this flow is given as, f =16/Re .for fully developed turbulent flow in a smooth circular tube the Nussult Number can predicted by;

Dittus-Boelter correlation; $Nu = 0.023Re^{0.8}Pr^{0.4}$ (1)

And friction factor can be calculated by the correlation $f = 0.079Re^{-0.25}$ (2)



(a)



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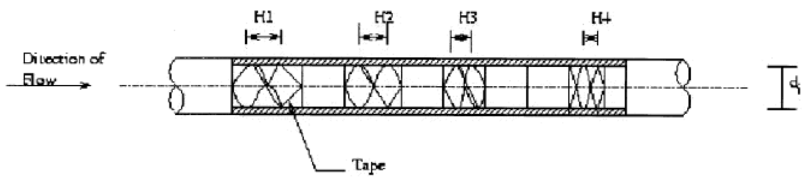

(c)

Fig. 1 (a) Full length twisted tape (b) Regularly spaced twisted tape and (c) Smoothly varying (gradually decreasing) pitch full length twisted tape

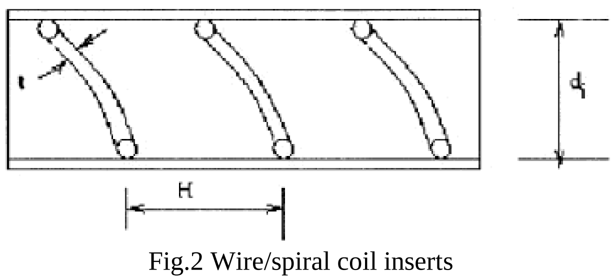

Fig.2 Wire/spiral coil inserts

III. CLASSIFICATION OF ENHANCEMENT TEQUNIQUES

Heat transfer Enhancement Techniques are classified in three broad categories which are as follows:

1. Active method
2. Passive method
3. Compound method

The active and passive methods are described with examples in following subsections. A compound method is hybrid method in which both active and passive methods are used in combination. The compound method has complex design and hence has limited applications.

3.1 Active Method

This technique involves some external power input for the augmentation of heat transfer and has shown less potential owing to complexity in design. Furthermore external power is not easy to provide in several applications. Some examples of active method are induced pulsation by cams and reciprocating plungers, the use of magnetic field to disturb the seeded light particles in a flowing streams etc.

3.2 Passive Method

This method does not need any external power input and additional power needed to augment the heat transfer is taken from available power in the systems which ultimately leads to fluid pressure drop .The heat exchanger industry has been striving for improved thermal contact (enhanced heat transfer coefficient) and decreased pumping power in order to improve the thermo hydraulic efficiency of heat exchange equipment's. A good heat exchange equipment design should have an efficient thermo hydraulic performance.i.e. minimum generation of entropy or minimum destruction of available work (exergy) in a system incorporating heat exchange equipment. It is almost impossible to stop exergy loss completely but it can be minimized by efficient design.

IV. REVIEW

An extensive literature review of all types of augmentation technique with external inserts till the year 1985 has been discussed by Bergles[1].In the following subsections literature involving recent work on passive methods by employing twisted tape inserts, wire coils etc.as inserts has been reviewed.

4.1 Twisted Tape in Laminar Flow

Twisted tape increases heat transfer coefficient at a cost of rise in pressure drop. Several researcher have studied various configurations of twisted tape such as full length twisted tape, regularly spaced twisted tape etc. This section discusses configurationsthose are suitable for laminar flow.

Shaha and Dutta[2] reported experimental data on twisted tape generated laminar swirl flow friction factor and Nussult number for a large Prandle number (205<Pr< 518) and observed that on the basis of constant pumping power short length twisted tape is good choice because in this case swirl generated by the twisted tape decays slowly down streams which increases the heat transfer coefficient with minimum pressure drop as compared to full lengthtwisted tape.

Manglik and Bergles [3] considered twisted tape with twist ratio (3, 4.5 and 6.0) using water (3.5<Pr<6.5) and proposed correlation for Nussult number and friction factor and reported physical description and enhancement mechanism

Loknath[4] reported experimental data on water (240<Re<2300,2.6<Pr<5.6) of laminar flow through horizontal tube under uniform heat flux condition and fitted with half length twisted tape .He found that on the basis of unit pumping power and unit pressure drop half length twisted tape is more efficient than full length tape

Shaha and Chakraborty[5] found that laminar flow of water (145<Re<1480,4.5<Pr<5.5,tape ratio 1.92<y<5.0) and pressure drop characteristics in a circular tube fitted with regularly spaced ,there is drastic reduction in pressure drop corresponding reduction in heat transfer. Thus it appears that on basis of constant pumping power a large number of turn may yield improved thermo hydraulic performance compared with single turn on twisted tape.

4.2 Twisted Tape in Turbulent Flow

In turbulent flow, the dominant thermal resistance is limited to thin viscous sub layer. This section discusses configuration that is suitable for Turbulent flow.

Royds [6] reported that A tube inserted with twisted tape performs better than plain tube and twisted tape with tight twist ratio provides better heat transfer at a cost of increase in pressure drop for low Prandle number fluid. This is due to the small thickness of thermal boundary layer for low Pradle number fluid and tighter twist ratio disturb entire thermal boundary layer thereby increasing heat transfer with increase in pressure drop.

Date [7] reported that friction and Nu for water flow in tube containing twisted tape deviate 30 percent than experiment with plain tube

Klaczak[8] found usefulness of short length twisted tape with water(1300<Re <8000) than full length twisted tape

Al-fahed et al [9] found that there is an optimum tape width depending upon twist ratio and Re for best thermodynamic characteristics for full length tape with water

Manglik and Bergles[10]developed correlation for both lamina and turbulent flow (3.5<Pr<6.5) with tape but shows that correlation for laminar turbulent transition need to be developed with water

V. CONCLUSION

Twisted tapes mixes with bulk flow and arebetter for laminar flow than any other inserts. However twisted tape inserts performance also depends fluid properties such as Prandtle number .If the Prandtle number is high (Pr>30) twisted tape will not provide good thermo hydrodynamic performance compared with other inserts such as wire coil inserts .Twisted tapes are effective in turbulent flow in certain Reynolds number but not over a wide Reynolds number range. In general, twisted tape inserts and wire coil inserts are more widely applied and have been preferred in recent past than other technique probably because methods such as extended surface inserts suffer from a relatively high cost and mesh inserts suffers from high pressure drop and fouling problems
The literature survey also shows that there is limited work on minimum twist ratio for better heat transfer performance.

VI. ACKNOWLEDGEMENT

We acknowledge our sincere thanks to Dr.Prasad NCL Punehis contribution for synthesis and characterizations of working fluid for our experimental work and BCUD, Pune University for funding for our experimental work.

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