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REVIEW ARTICLE

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REVIEW OF HEAT TRANSFER AUGMENTATION TECHNIQUES

MANOJ HAJARE, CHETAN DEORE, KAVITA KHARDE, PUSHKAR RAWALE, VIVEK DALVI
Department of Mechanical Engineering, SITRC, NASHIK

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CHETAN DEORE

ABSTRACT
The article presents a study of Heat transfer augmentation techniques that are used for increase the heat transfer rate in thermal power plant, refrigerators, radiator in vehicles, air-conditioning equipment, process industries, heating and cooling in evaporators, automobile etc. These techniques can be classified broadly as passive, active, compound methods of heat transfer. Passive techniques, where insert is used in the flow passage to augment the heat transfer rate, the advantages of the method is manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger. While designing of compact heat exchanger passive techniques plays an important role. Different insert configuration can be selected according to heat exchanger working condition. Active techniques, tha method involve some external power input to enhancement of heat transfer, including mechanical aids, fluid vibration, surface vibration, electrostatic fields, injection, suction, jet impingement technique to enhance the heat transfer rate. Compound techniques, in this the combination of the two or more active or passive techniques of heat transfer, this technique gives greater value of heat transfer as compared to individual technique of heat transfer.
Keywords: Heat transfer augmentation, Passive techniques, Active technique, Enhancement, Insert Configuration

INTRODUCTION

Heat exchangers have various industrial applications. The design & manufacturing procedure of heat exchanger is complicated and it requires exact analysis of heat transfer rate and pressure drop. Major challenge in heat exchanger is achieve a high heat transfer rate using minimum pumping power and compact design. The high cost of materials and energy has resulted in an increased effort to producing more efficient heat exchanger. To increase the efficiency of heat exchanger some techniques has been used this technique are called heat transfer augmentation technique. To achieve desired heat transfer rate with economical pumping power and reducing the cost of equipment heat transfer augmentation techniques has been used. This technique used for increase overall performance of heat exchanger.

HEAT TRANSFER AUGMENTATION:

Some kinds of inserts are placed in the flow passage to augment the heat transfer rate, and this reduces the hydraulic diameter of the flow passage. Heat transfer enhancement in tubular flow by inserts such as twisted

tapes, ribs, wire coils and dimples is mainly due to flow blockage. Flow blockage is used for partitioning of the flow and secondary flow. Flow blockage increases the pressure drop and leads to increased viscous effects because of a reduced free flow area and increases pumping power. Blockage also increases the flow velocity and in some situations leads to a significant secondary flow. This flow further provides a good thermal contact between the surface and the fluid because secondary flow creates swirl and the resulting mix of fluid improves the temperature gradient, which ultimately gives a high heat transfer coefficient.

2. Classification of augmentation techniques:

This heat transfer enhancement techniques are classified on the basis of external power supply used or not and also the combination of different heat transfer techniques. This classification gives brief idea about which method should be used for better heat transfer rate in heat exchanger device.

Heat augmentation techniques can be broadly classified into three different categories

(a) Passive method,

(b) Active method,

(c) Compound method.

The active and passive methods are described with examples in the following subsections. A compound method is a hybrid method in which both active and passive methods are used in combination. In complex design we use compound method and hence have limited applications.

Passive techniques:

Passive heat transfer augmentation a method to enhance heat transfer without external power. Twisted tapes, dimples, fins wire coils, ribs, etc., are the most commonly used passive heat transfer augmentation tools. Among the techniques used, insertion of twisted tape in a circular tube is one of the most effective approaches The inserted twisted tape generates swirling flow an decreases turbulence intensity which is major influencing factors for heat transfer enhancement.

1. Treated Surfaces:

Such surfaces have a fine scale alteration to their finish or coating which may be continuous or discontinuous. They are applicable primarily in two-phase heat transfer, And they consist of a variety of structured surfaces, The alteration could be continuous or discontinuous, where the roughness is much smaller than what affects single-phase heat transfer, and they are used primarily for boiling and condensing duties. The experiment is carried out by P. Bharadwaj, A.D. Khondge in this The experiment water is used as a working fluid and spirally grooved tube is used for increase the heat transfer rate of heat exchanger shown in fig.1. This The experiment required Constant pumping power comparison with smooth tube shows that the spiral grooved tube without twisted tape yields maximum heat transfer enhancement of 400% in the laminar range and 140% in the turbulent range.

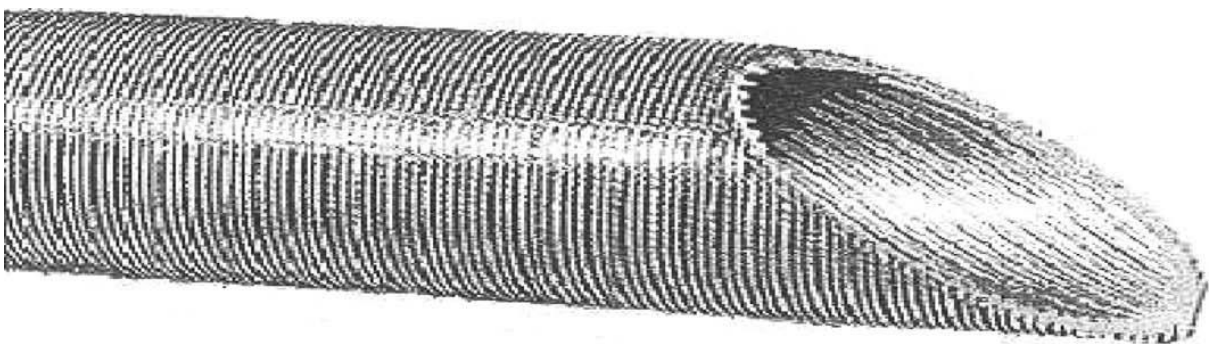

Fig.1 Spirally Grooved Tube

2. Rough Surfaces:

These are the surface modifications that promote turbulence in the flow field in the wall region, primarily used in single phase flows, rather increase in heat transfer surface area.

One of the earliest and perhaps simple and yet highly effective technique is the use of surface roughness in turbulent single-phase flows. In laminar flow, small-scale surface roughness tend to have little effect. It very necessary to disturb the viscous sub layer in the near wall turbulent flow structure to promote higher momentum and heat transport The experiment is carried out by S. Pethkool, S. Eiamsa-ard, S. Kwankaomeng, P. Promvongein this The experiment water is used as a working fluid and Corrugated Tube is used for increase the heat transfer rate of heat exchanger shown in fig.2.Because of this tube Nusselt no, friction factor &Thermal heat performance increase with pitch ration.

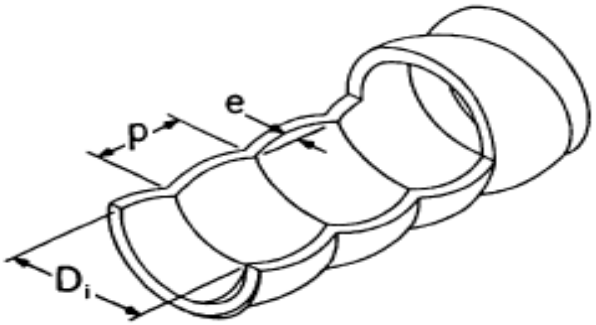

Fig.2 Corrugated Tube

3. Extended surfaces:

Extended or finned surfaces are the most widely used and researched of all enhancement techniques. Their applications cover the broad spectrum of heat exchange devices, which include finned tubes for shell-and-tube exchanges. The advanced developments have led to modify finned surfaces that also improve the heat transfer coefficients by disturbing the flow field in addition to increasing the surface area. This technique is most widely used for improving the heat transfer rate. The experiment is carried out by Leonard D. Tijing, Bock Choon Pak in this The experiment water is used as a working fluid and Star shape Fin insert is used as heat transfer rate enhancement device of heat exchanger shown in fig.3.Heat Transfer Enhance by 51%.

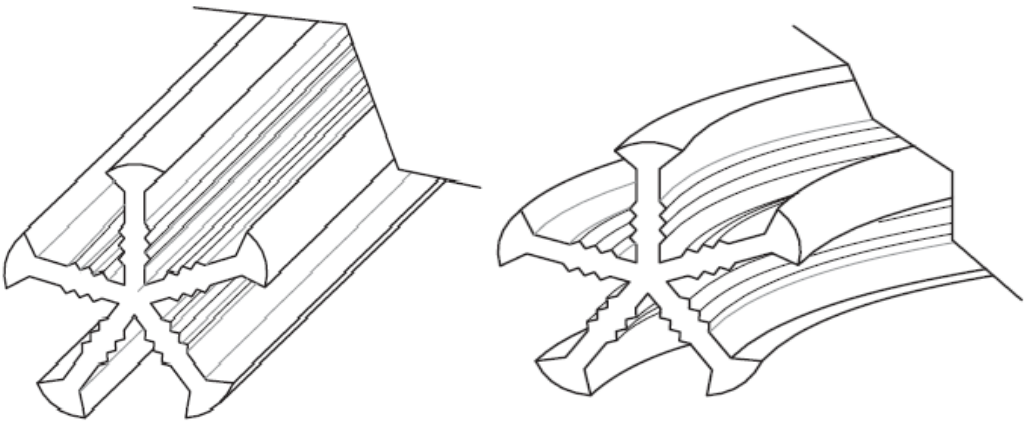

Fig. a) Straight Fin

Fig. b) Twisted Fin.

Fig.3 Star shape Fin insert

4. Swirl flow devices:

Swirl flow devices generally consist of a variety of tube inserts, geometrically varied flow arrangements, and modifications in duct geometry that produce secondary flows. Some examples of each of these techniques include twisted-tape inserts and helically twisted tubes, shown schematically in Fig. They produce and superimpose swirl flow or secondary recirculation on the axial flow in a channel. They can be used for single phase and two-phase flows. Twisted-tape inserts have received considerable attention in the literature, and their thermal–hydraulic performance in boiling, single-phase and condensation forced convection, as well as the design and application issues. The most widely used and effective swirl flow device for single-phase flows is the twisted-tape insert; it has been shown to increase significantly the heat transfer coefficient with a relatively small pressure-drop penalty

i) Helical Screw-Tape Inserts:

The geometry of helical screw-tape inserts with different twist ratio is shown in Fig. 4. The experiment is carried out by P. Sivashanmugam, S. Sureshin this The experiment water is used as a working fluid and helical screw tape insert is used as heat transfer rate enhancement device of heat exchanger shown in fig.4.Heat Transfer coefficient & Friction factor increases with increases in twist ratio.

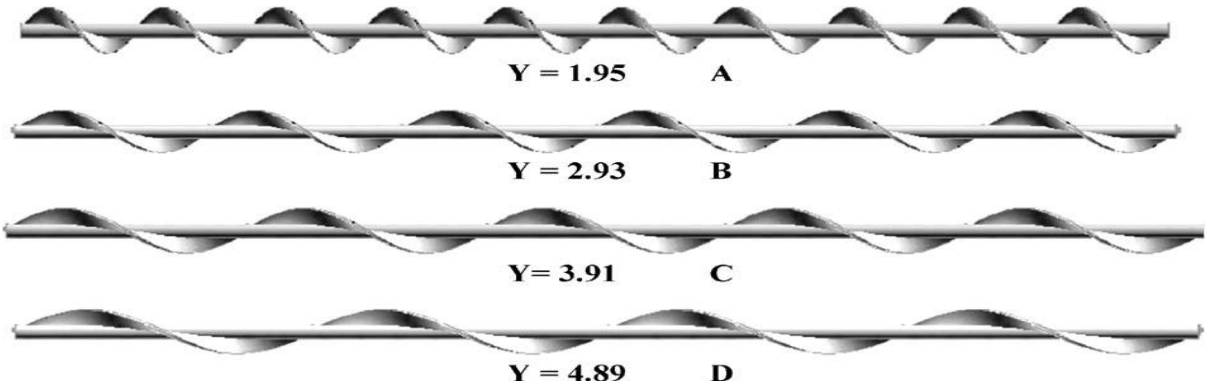

Fig.4 Helical screw tape inserts with different twist ratio

ii) Twisted Tape Inserts:

Twisted tape is most commonly used technique to improve heat transfer rate due to the advantages steady performance, simple design, ease of installation and cost required is Minimum. A twisted tape is the metallic strips twisted with some suitable techniques with desired shape and dimension, inserted in the flow. On air heat exchanger The experiment was carried by Halit Bas, Veysel Ozceyhan using twisted tape and the result of this The experiment is The heat transfer enhancement decreases with Reynolds no increases & it is constant at Reynolds no higher than 15000, twist ratio lower than 3.

Fig.5Twisted tape insert

5. Coiled Wire Inserts:

Heat exchangers lead to relatively more in compact size. Hence it produces secondary flows and vortices which promote higher heat transfer Coefficients in single phase flows as well as in most regions of boiling. Coiled tubes are now used in a wide variety of applications, including domestic hot water heaters, industrial and marine boilers, chemical process reactors, blood oxygenators and kidney dialysis devices, among many others. The thermal augmentation in circular tube with wire coil inserts was The experimentally investigated by Sibel Gunes, Orhan Buyukalaca. The results indicated that the coiled wire inserts are compared to the smooth tube at a constant pumping power, an increase in overall enhancement efficiency is obtained especially at low Reynolds number.

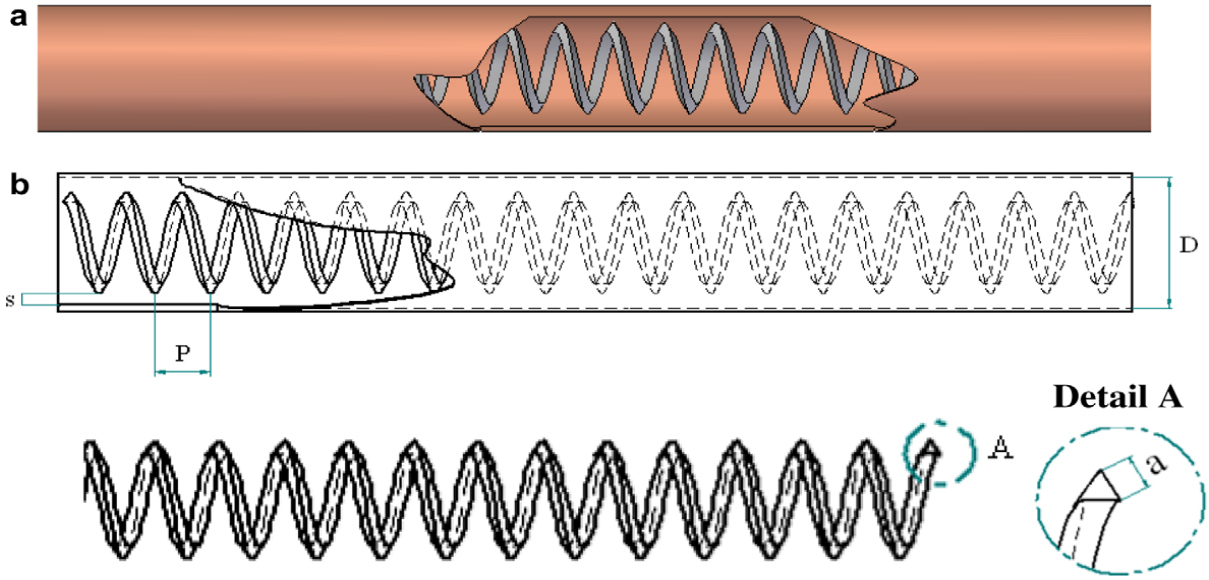

Fig.6 Coiled wire insert

Active Techniques:

These techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in many practical applications. In comparison to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases.

Augmentation of heat transfer by the method can be achieved by

- Mechanical Aids: Such instruments stir the fluid by mechanical means or by rotating the surface. In these include rotating tube heat exchangers and scrapped surface heat and mass exchangers.
- Surface vibration: They have been applied in single phase flows to obtain higher heat transfer coefficients. Vibration on the surface is another active technique that has been applied. The tubes in conventional heat exchangers can vibrate, providing heat transfer enhancement. This technique easily applied on heat exchanger.
- Fluid vibration: fluid vibration is primarily used in single phase flows and is considered to be perhaps the practical type of vibration enhancement technique.
- Electrostatic fields: It can be in the form of electric or magnetic fields or a combination of the two of ac or dc sources, which can be applied in heat exchange systems involving dielectric fluids. Based on the application, it can also produce greater bulk mixing and induce forced convection or electromagnetic pumping to enhance heat transfer.

- Injection: This technique is used in single phase flow and pertains to the method of injecting the same or a different fluid into the main bulk fluid either through a porous heat transfer interface or upstream of the heat transfer section.
- Suction: This involves either vapour removal through a porous heated surface in nucleate, film boiling and fluid withdrawal through a porous heated surface in single-phase flow.
- Jet impingement: Tha method involves the direction of heating and cooling fluid perpendicular to the heat transfer surface.

Combined Techniques: It is combination of active & passive techniques or may be combination of two passive techniques. When any two or more than two of these techniques are employed simultaneously to obtain enhancement in heat transfer that is greater than that produced heat transfer by either of them when used individually. The method gives greater value of heat transfer as compared to individual techniques used alone. Some combined techniques are as follow:

1. Corrugated tube with twisted tape inserts:

Corrugated tubes are used with twisted tape for enhancing the heat transfer rate as compared to these individual passive techniquess. The experiment is carried out by Ventsislav Zimparovin this experiment corrugated tube with twisted tape insert is used as heat transfer rate enhancement device of heat exchanger shown in fig.7. In this the experiment comparing the friction factor in between smooth tube with twisted tape and corrugated tube with twisted tape the result is found for improve heat transfer rate.

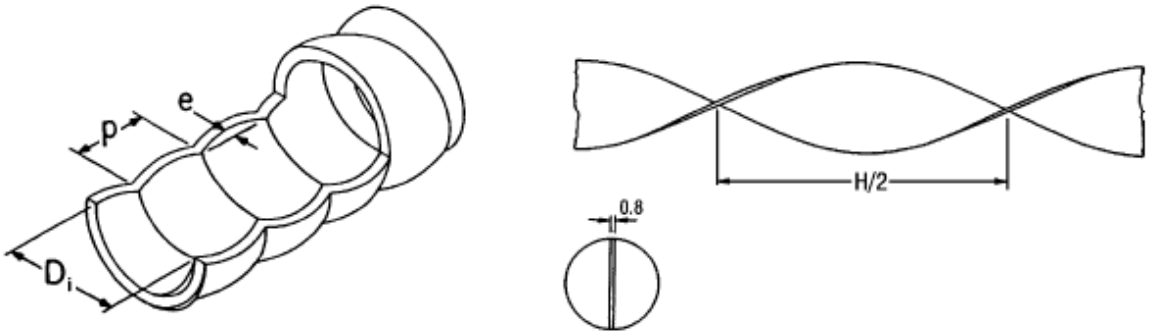

Fig.7 Corrugated tube with twisted tube.

2. Conical Ring with Twisted Tape:

Combination of Conical Ring & Twisted Tape enhances heat transfer by the reverse flow & swirl flow. The experiment is carried out by P. Promvonge, S. Eiamsa-ardin. In this The experiment air is used as a working fluid and conical ring with twisted tape is used as heat transfer rate the smaller twist ratio, the larger the heat transfer and friction factors for all Reynolds numbers.

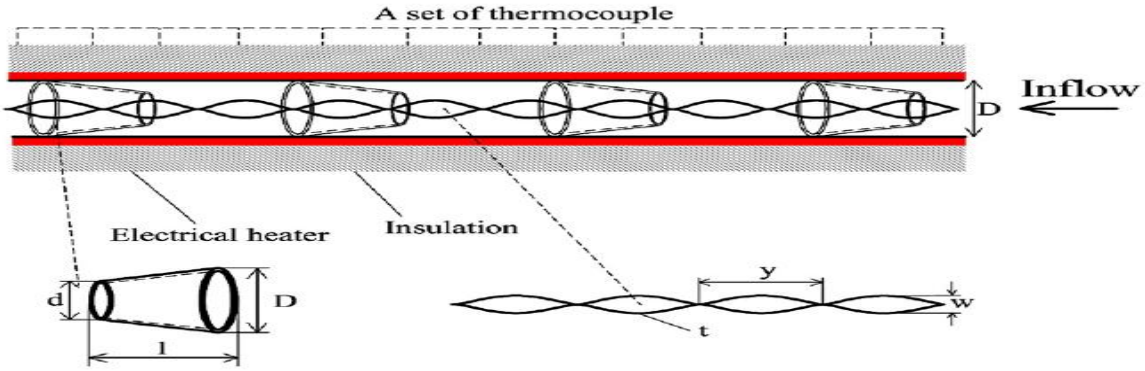

Fig.8 Conical Ring with Twisted Tape

3. Wire coil with twisted tape:

Combination of wire coil insert and twisted tape insert is used for enhancement of heat transfer rate in heat exchanger. Due to the combination of this two insert increases the heat transfer rate. The experiment is carried out by P. Promvonge, in this the experiment combination of wire coil and twisted tape inserts is used the range of reynold number is in between 3000 to 18000. The combined wire coil and twisted tape insert are compared to a smooth tube at constant pumping power, a double increase in heat transfer rate at low Reynolds number. It was found at lower reynold number values for the lowest values of the coil spring pitch and twist ratio.

Fig.9 wire coil with Twisted Tape.

3. CONCLUSION:

From above information the following conclusions can be made:

- Some enhancement techniques can be used for heat transfer augmentation have been reviewed. These Enhancement techniques can be improving the heat transfer rate trough tube.
- From Several techniques studied passive techniquess are commonly used for enhancement heat transfer rate because they do not require external power source.
- Active techniques require external power source therefore a power cost that need to be considered, hence whole cost of system increases.
- This work is expected to serve as a road map for use of techniques in industrial applications.

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