Experimental Analysis of Heat Transfer Augmentation for Flow of Liquid Using Twisted Angles and Tapes: A Review

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Abstract - For the optimization of heat transfer, the devices used in industries and household application must be design very carefully. The enhancement in the heat transfer is the major challenge in design of heat exchanger. Heat transfer augmentation techniques (passive, active or a combination of passive and active methods) are commonly used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc. Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger.

Keywords: Heat transfer augmentation, Thermo hydraulic performance, Twisted tape, Wire coil.

1. INTRODUCTION

A heat exchanger is a device, which used to transfer thermal energy between two or more fluids or between a solid object and a fluid. The fluids may be separated by solid wall to prevent mixing fluids, or they may be in direct contact. Heat exchangers are used in various applications, like refrigeration and air conditioning, power stations and space heating, chemical plants, and petrochemical plants and petroleum refineries, natural gas processing, and sewage treatment. The elegant example of a heat exchanger in an internal combustion engine is radiator. In which circulating fluid known as engine coolant flows through radiator coils and air is used to cool the coolant. Another example is the heat sink, which is transfers heat generated by an electronic or a mechanical device to a fluid medium, like air or a liquid coolant.

Energy and materials saving considerations, as well as economic incentives, have led to efforts to produce more efficient heat exchange equipment. Common thermo hydraulic goals are to reduce the size of a heat exchanger required for a specified heat duty, to upgrade the capacity of an existing heat exchanger, to reduce the approach temperature difference for the process streams, or to reduce the pumping power.

The study of improved heat transfer performance is referred to as heat transfer augmentation, enhancement, or intensification. In general, this means an increase in heat transfer coefficient. Attempts to increase “normal” heat transfer coefficients have been recorded for more than a century, and there is a large store of information.

1.1 ENHANCEMENT TECHNIQUES IN HEAT EXCHANGER

Enhancement of heat transfer using various techniques has received strong attention over the years in order to reduce the size and cost of heat exchanger. Many techniques have been developed for enhancing heat transfer rate in heat exchanger as the effective ones: (1) Nano fluids (2) Inserting fluid turbulators and (3) Roughening heat exchanger surfaces. Although for better heat transfer, combination of all the three or any two techniques can be used**.**

Heat exchanger using nano fluid is a device in which the heat transfer takes place by using nano fluid. In this the working fluid is nano fluid. Nano fluid is made by the suspending nano particles in the fluid like water, ethylene glycol and oil, hydrocarbons, fluorocarbons etc.

1.1.1 Nano fluids

Nanofluid, a suspension of nanoparticles in a continuous and saturated liquid, has been found capable to get considerably higher thermal conductivity than their respective base fluids resulting in better overall heat transfer coefficient. Fluids have higher specific heat compare to metals, and metals have higher thermal conductivity compare to solids. So when we added a small amount of nanoparticle to base fluid it will increase the thermal conductivity of base fluid.

1.1.2 Fluid turbulators

Heat transfer can also be enhanced by using rotating inserts in a round tube. These rotating inserts acts as a swirl generator. The use of the swirl generator is expected to create the tangential velocity or swirling flow to prolong residence time of the flow and to enhance the tangential and radial fluctuation, therefore leading to increase in heat transfer inside the test tube .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. In these cases, external power is used to facilitate the desired flow modification and the concomitant improvement in the rate of heat transfer. Augmentation of heat transfer by this method can be achieved by:

1.1.2.1 Mechanical Aids:

Such instruments stir the fluid by mechanical means or by rotating the surface. These include rotating tube heat exchangers and scrapped surface heat and mass exchangers.

1.1.2.2 Surface vibration:

They have been applied in single phase flows to obtain higher heat transfer coefficients.

1.1.2.3 Fluid vibration:

These are primarily used in single phase flows and are considered to be perhaps the most practical type of vibration enhancement technique.

1.1.2.4 Electrostatic fields:

It can be in the form of electric or magnetic fields or a combination of the two from dc or ac sources, which can be applied in heat exchange systems involving dielectric fluids. Depending on the application, it can also produce greater bulk mixing and induce forced convection or electromagnetic pumping to enhance heat transfer

1.1.2.5 Injection:

Such a 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.

1.1.2.6 Suction:

It involves either vapor removal through a porous heated surface in nucleate or film boiling, or fluid withdrawal through a porous heated surface in single-phase flow.

1.1.2.7 Jet impingement:

It involves the direction of heating or cooling fluid perpendicularly or obliquely to the heat transfer surface.

1.1.3 Geometrical modification (by roughening heat exchanger surfaces)

These techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior (except for extended surfaces) which also leads to increase in the pressure drop. In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. These techniques do not require any direct input of external power; rather they use it from the system itself which ultimately leads to an increase in fluid pressure drop. They generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior except for extended surfaces. Heat transfer augmentation by these techniques can be achieved by using;

1.1.3.1 Treated Surfaces:

Such surfaces have a fine scale alteration to their finish or coating which may be continuous or discontinuous. They are primarily used for Boiling and condensing duties.

1.1.3.2 Rough surfaces:

These are the surface modifications that promote turbulence in the flow field in the wall region, primarily in single phase flows, without increase in heat transfer surface area.

1.1.3.3 Extended surfaces(Fins):

They provide effective heat transfer enlargement. The newer developments have led to modified finned surfaces that also tend to improve the heat transfer coefficients by disturbing the flow field in addition to increasing the surface area.

1.1.3.4 Displaced enhancement devices:

These are the inserts that are used primarily in confined forced convection, and they improve energy transport indirectly at the heat exchange surface by displacing the fluid from the heated or cooled surface of the duct with bulk fluid from the core flow.

1.1.3.5 Swirl flow devices:

They produce and superimpose swirl flow or secondary recirculation on the axial flow in a channel. These include helical strip or screw type tube inserts, twisted tapes. They can be used for single phase and two-phase flows.

1.1.3.6 Coiled tubes:

These lead to relatively more compact heat exchangers. It produces secondary flows and vortices which promote higher heat transfer coefficients in single phase flows as well as in most regions of boiling

1.1.3.7 Surface tension devices:

These consist of wicking or grooved surfaces, which direct and improve the flow of liquid to boiling surfaces and from condensing surfaces.

1.1.3.8 Additives for gases:

These include liquid droplets or solid particles, which are introduced in single- phase gas flows either as dilute phase (gas-solid suspensions) or as dense phase (fluidized beds).

1.2 Conclusion

This chapter covers brief summery about the heat exchangers and potential for increasing the heat transfer rate. From the above techniques we find that introduction of Geometrical modification may be the possible methods which can be used at the same time for heat transfer augmentation.

II .LITERATURE REVIEW

The present paper is an attempt for contributes for review of twisted tape and twisted angle tape inserts. The objective of this paper is to review the work carried on twisted tape.

Behabadi et al. [1] experimental investigated the heat transfer coefficients and pressure drop during condensation of HFC-134a in a horizontal tube fitted with TT. The refrigerant flows in the inner copper and the cooling water flows in annulus. Also empirical correlations were developed to predict smooth tube and swirl flow pressure drop.

Eiamsa-ard et al. [2] studied the influences of multiple twisted tape vortex generators (MT-VG) on the heat transfer and fluid friction characteristics in a rectangular channel From the experiment it is revealed that, the channel with the ‘y’ and ‘S’ provides higher heat transfer rate and pressure loss than those with the larger ‘y’ and free-spacing ratio under similar operation condition.

Eiamsa-ard et al. [3] made a comparative investigation of enhanced heat transfer and pressure loss by insertion of single TT, full-length dual TT and regularly-spaced dual TT as swirl generators. The result shows that all dual TT with free spacing yield lower heat transfer enhancement in comparison with the full-length dual TT.

Promvonge and Eiamsa-ard [4] investigated thermal characteristics in a circular tube fitted with conical-ring and a TT swirl generator. The experimental results reveal that the tube fitted with the conical-ring and TT provides ‘Nu’ values of around 4 to 10% and enhancement efficiency of 4 to 8% higher than that with the conical-ring alone.

Mengna et al. [5] investigated experimentally the Pressure drop and compound heat transfer characteristics of a converging-diverging tube with evenly spaced TT (CD-T tube). Swirl was generated by evenly spaced twisted-tape elements which vary in twist ratio and rotation angle.

Eiamsa-ard et al. [6] experimentally investigated on the ‘HTE’ and ‘f’ characteristics in a double pipe heat exchanger fitted with regularly TT insert. By comparing the result with plain tube, it is evident that the heat transfer coefficient increased with ‘y’ and ‘S’.

Saha et al. [7] experimentally investigated the HTE and pressure drop characteristics in the tube with regularly spaced TT element. From the result, it is observed that ‘Pinching’ of tape rather than in connecting the tape element with rods is better proposition from thermo hydraulic point of view.

P.Promvonge[8],conducted experiments by inserting several conical rings as turbulators over a test tube. Conical rings with three different diameter ratios of the ring to the diameter(d/D=0.5,0.6,0.7) were introduced in the tests and for each ratio, the rings were placed with three different arrangements (Converging conical Ring-CR, Diverging conical Ring-DR, Converging Diverging conical Ring-CDR).Cold air at ambient air temperature was passed through the tube .He found out that such inserts lead toahigherheattransferratesthanplanetubesandDRyieldedbe tterheattransferthan the others. The Nusselt number was found to increase by 197%, 333%, 237% in case of CR, DR and CDR array respectively. It leads to a substantial increase in friction factor.

Bergles[8]. The applications of static mixers are generally restricted to chemical processing with heat transfer, where fluid mixing is the primary need.

Spiral brush inserts in short channels with turbulent flows and high wall heat flux have been shown by Megerlinetal.[9] and found out that heat transfer coefficient can be improved as much as 8.5 times that in a smooth tube, but pressure drop was exorbitantly high which restricted its use in practical applications.

III CONCLUSION

High performance heat transfer system is of great importance in many industrial applications. Therefore, the heat transfer enhancement techniques are widely applied in heat exchangers; in order to improve heat transfer coefficient twisted tapes will be the best.

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