Enhancement of Overall Heat Transfer Coefficient by using Twist Tape – A Passive Augmentation Technique

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Abstract: In this paper, studied overall heat transfer coefficient in fabricated of double pipe heat exchanger in laboratory scale by using smooth pipe and twist tape experimentally for affecting parameters friction factor, Reynold number, pressure drop along the mass flow rate range between 0.02 Kg/sec – 0.033 Kg/sec. Basically, passive technique is focused to increases the overall heat transfer coefficient without increases the area of heat exchanger. In this technique increases the heat transfer coefficient to disturbing the boundary layers of flow, flow becomes more turbulent, mean velocity of flow and temperature gradient through generation of swirl flow in heat exchanger. Here present the effect on Reynold number, pressure drop and friction factor at the low pumping power and area using heat transfer augmentation technique that is passive technique using twisted tape having twist ratio y = 7.7.

Keywords: Double pipe heat exchanger, Overall heat transfer coefficient, Passive technique, Twist tape, Swirl flow.

I. INTRODUCTION

Heat exchangers have several industrial and engineering applications. The design procedure of heat exchangers is quite complicated, as it needs exact analysis of heat transfer rate and pressure drop estimations apart from issues such as long-term performance and the economic aspect of the equipment. The major challenge in designing a heat exchanger is to make the equipment compact and achieve a high heat transfer rate using minimum pumping power. Techniques for heat transfer augmentation are relevant to several engineering applications. In recent years, the high cost of energy and material has resulted in an increased effort aimed at producing more efficient heat exchange equipment. Furthermore, sometimes there is a need for miniaturization of a heat exchanger in specific applications, such as space application, through an augmentation of heat transfer. Augmentation if heat transfer is a subject of considerable interest to researchers as it leads to savings in energy and cost. There exist numerous applications of heat transfer in channels in process industries and engineering system. The conventional heat exchangers are improved by means of various augmentation techniques with emphasis on many types of surface enhancement. Augmentation surface can one or more combination of the following conditions that are favorable for the increase in heat transfer rate with an undesirable rise of friction [1]:-

1) Disruption of the development of boundary layers and increase of turbulence intensity,
2) Increase in heat transfer area,
3) Generation of swirling/rotating /secondary flow.

II.METHODOLOGY

Existing enhancement techniques can be broadly classified into three different categories [10]:
1. Active techniques
2. Passive techniques
3. Compound techniques

1) Active techniques- In this technique applicable some external power to increases the heat transfer rate in heat exchanger. Complexity in this technique is less as passive and compound technique e.g. Mechanical aids, Surface vibration, Fluid vibration, etc.
2) Passive techniques- In this technique change the flow pattern without any external power only by available power in system. This change of flow pattern leads to disturbing thermal boundary layer and pressure drop to enhance the heat transfer rate in heat exchanger e.g. rough surface, Swirl flow, etc.
3) Compound techniques- In this technique application of both active and passive techniques. Compound technique is more complexity which increases the pressure drop e.g. Rough tube with twisted tape, finned tubes in Fluidized bed, etc.

2.1 Passive Techniques:

In this 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 surfaces. Heat transfer augmentation by these techniques can be achieved by using; Treated Surfaces, Rough surfaces, extended surfaces, displaced enhancement devices, coiled tubes and swirl flow devices.
Swirl flow devices: The devices produce and superimpose swirl flow or secondary recirculation on the axial direction flow in a tube. These include twisted tapes, helical strip or cored screw type tube inserts. They can be used for single phase and two-phase flows.

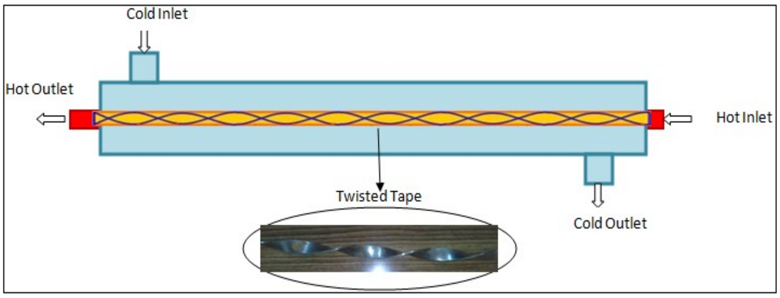

Figure 2.1: Swirl flow device inserted in double pipe heat exchanger

III. EXPERIMENTATION

3.1 About the inserts:

An insert used for the experiment are mild steel twisted tapes. While much literature can be found about passive heat transfer The augmentation using twisted tapes as mentioned earlier, twisted tap are a new kind of insert where no such experiments have been done thus giving us ample room for experimental studies. The present work deals with finding the friction factor and the heat transfer coefficient for the twisted tapes with twist ratios (y=7.7) and comparing those resultswith that of smooth tube and among themselves.

3.2 Fabrication:

The twisted tap thickness about 2mm and length 90cm, material is used mild steel. First cut into width have 1.2 cm, then fixed on the lathe one end being fixed on the tool part side and the other on the chuck side. The chuck was then rotated slowly by hand, while the angle was being held intension, to give it a desired twist. Two tapes with varying twist ratios were fabricated as shown in fig.3.1 having different twist ratio is (y=7.7). The end portions of the fabricated tapes were cut and drilled to join the tapes by thin high tension wires. Two tapes with the different twist ratio and twist in the same direction was sufficient for the heat exchanger used for the experimental study.

Figure 3.1Twisted Ratio (y=7.7)

3.3 Standardization of smooth tube:

Before starting the experimental study on heat transfer augmentation using inserts, standardization of the smooth tube (without insert) has to be done so that the % difference between the theoretical frictional factor value and the actual value can be obtained.

Figure 3.2: Experimental Set Up

IV. RESULT & DISCUSSION

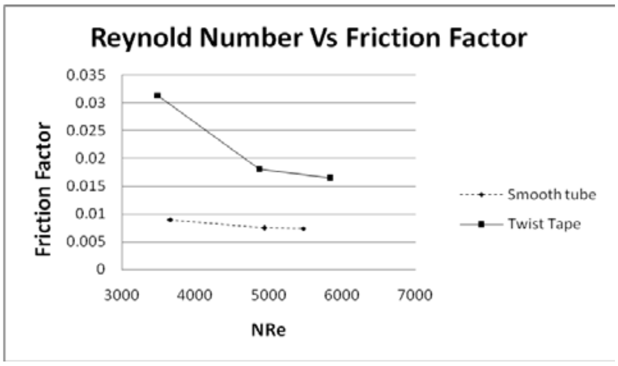

Figure 4.1 Friction Factor Vs N_{Re} for Smooth tube & y = 7.7

Fig 4.1 shows the variation of friction factor (f exp) with Reynolds Number for Smooth tube and twisted tape (y = 7.7). As the twist ratio, a higher degree of swirl is created which leads to higher pressure drop & hence higher friction factor. It has observed that friction factor increases 3.7 times smooth tube for twist tape having twist ration y = 7.7.

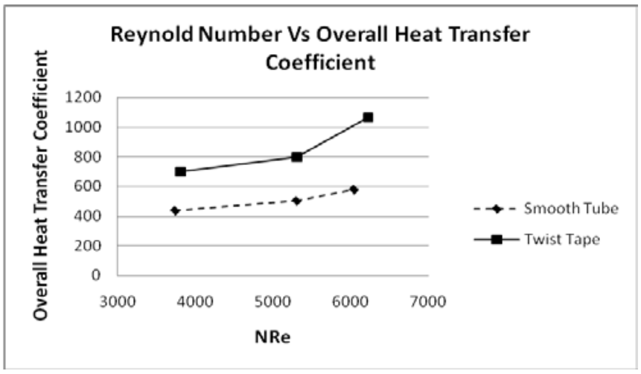

Figure 4.2 Heat Transfer Coefficient Vs N_{Re} for Smooth tube & y = 7.7

Fig 4.2 shows the variation of overall heat transfer coefficient (Ui) with Reynolds Number for Smooth tube and twisted tape (y2 = 7.7). As the twist ratio, a higher degree of swirl is created which increases turbulence & hence the heat transfer coefficient increases. In case of twisted tape(y2 = 7.7), a much higher heat transfer coefficient is observed because of increase in degree of secondary flow created which disturbs the entire thermal boundary layer & hence the heat transfer coefficient increases. The results for overall heat transfer coefficient increases 1.6 times smooth tube for twist tape having twist ration y = 7.7.

CONCLUSION

As the twist ratio, a higher degree of swirl is created which increases turbulence & hence the heat transfer coefficient increases. As experimentation, observed that a much higher heat transfer coefficient as well as higher pressure drop & hence higher friction factor for twist tape as compare with smooth tube. The results for overall heat transfer coefficient increases 1.6 times smooth tube for twist tape having twist ration y = 7.7 as well as friction factor increases 3.7 times smooth tube for twist tape having twist ration y = 7.7.

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