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HEAT ENHANCEMENT THROUGH CIRCULAR PIPE USING TWISTED TAPES

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Abstract:

The heat generated within the system must be dissipated to the surrounding in order to maintain the system at recommended working temperature and functioning effectively and reliably. The used of twisted tapes, ribs are generally employed in order to improves the heat transfer rate. In this research work the different types of twisted tapes was used in order to improve the heat transfer within the concentric circular pipes. In this study, attempt is made to reduce the problem by using the twisted tapes. This inclination provides high degree of turbulence and reduces the pressure loss to a large extent. Twisted tapes are not directly attached to the surfaces, but the space is provided between the surfaces and tapes. Through this space, air is flowing which avoids the formation of eddies at the back side of the twist tapes.

Keywords: Twisted Tapes, Heat Transfer, Double pipe heat exchanger

1. Introduction:

Heat exchangers are used in different processes ranging from conversion, utilisation & recovery of thermal energy in various industrial, commercial & domestic applications. Some common examples include steam generation & condensation in power & cogeneration plants; sensible heating & cooling in thermal processing of chemical, pharmaceutical & agricultural products; fluid heating in manufacturing & waste heat recovery etc. Increase in Heat exchanger's performance can lead to more economical design of heat exchanger which can help to make energy, material & cost savings related to a heat exchange process. Use of Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop. So, while designing a heat exchanger using any of these techniques, analysis of heat transfer rate & pressure drop has to be done. Apart from this, issues like long term performance & detailed economic analysis of heat exchanger has to be studied. To achieve high heat transfer rate in an existing or new heat exchanger while taking care of the increased pumping power, several techniques have been proposed in recent years and are discussed in the following sections. Lokanath and Misal [1] studied twisted tapes in shell and tube heat exchanger for different fluids. Their study revealed that twisted tapes of tighter twists are expected to give higher overall heat transfer coefficients. K. Shivakumar [2] investigated heat transfer, friction factor, and pressure drop characteristics in a pipe fitted with the Al twisted tape and Cu twisted tape inserts with different twist ratio for laminar flow. The experimental results reveal that for the different material of inserts the Reynold number various from 2570 to 7891 for same twist ratio y= 4.3 of both the material. Manglik and Bergles [3] experimentally studied effect of twisted tape in laminar flow. They concluded that the main reason for heat transfer augmentation by twisted tape inserts are partitioning of tube flow resulting in higher flow velocities, reduction in hydraulic diameter increasing the heat transfer coefficient, helically twisting fluid motion increasing flow path and secondary fluid motion improving convective heat transfer. Gaikwad and Kundlik Mali [4] investigated the heat transfer enhancement by using twisted wire brush inserts in double pipe heat exchanger. In this review The Nusselt number obtained for the tube with twisted wire brush inserts varied from 1.55 to 2.35 times in comparison to those of the plain tube S.D.Patil et al. [5] work on the passive augmentation techniques to increase the rate of heat transfer and from this review they found that twisted tape inserts mixes the bulk flow well and therefore performs better in laminar flow. Because of laminar flow Thermal resistant was not limited to thin region. The result also shows twisted tape insert is more effective, if no pressure drop penalty is considered. They also concluded that twisted tape insert is not effective in turbulent flow, because it blocks the flow and therefore pressure drop increases. S. Darewar [6] investigated heat transfer enhancement by using twisted tape of three different twist ratios (y=3.0,4.0 and 5.0) in his experiment and concluded that for rotary twisted tape inserts at higher RPM, heat transfer rate increases as compared to fixed twisted tape. Smith et. al. [7] investigated the effect of single twisted tape, full length dual and regularly spaced dual twisted tape on heat transfer rate and result showed that full length dual twisted tape yield higher heat transfer enhancement than regularly spaced twisted tape. Smith Eiamsa-ard [8] shown in his experiment that full length helical tape with rod provide highest heat transfer rate than without centered rod.

2. Experimental Setup:

Fig. 2.1 shows the schematic diagram of the experimental setup. It is a double pipe heat exchanger consisting of calming section, test section, control panel, flow measuring devices, nichrome heater wire and blower fan with speed regulator. Control panel consist of measuring instruments like voltmeter, ammeter, temperature indicator and control devices such as dimmer stat and regulator etc.The circular channel is used for this investigation and made up of copper. An exhaust fan is used to draw the air from entrance to exit section. The flow developed through smooth copper pipe with dimension of 1100 mm in length, inner pipe-25 mm ID and 28 mm OD. Outer PVC pipe dimensions are 900 mm in length, 58 mm ID and 61 mm OD. The outer pipe is well insulated using 10 mm dia. of asbestos rope to reduced heat losses to atmosphere. The uniform flux plate type heater is fabricated from nichrome wire to heat the air. This heater is connected in series with dimmer stat in order to supply the same amount of heat to heater. A blower fan is used to inject the air through the copper pipe. The air is passed over the nichrome wire heater and after getting heated this air is flow through copper pipe. The velocity of air is controlled by using regulator which is fixed on control panel. Two pressure taping one just before the test section and the other just after the test section for pressure measurement. Thermocouples are used to measure the inlet and outlet temperatures of water and air, which is indicated on temperature indicator.

Fig.2.1 Experimental Setup

3. Results and Discussion

3.1. Heat transfer

The experiments were conducted on the test rig initially without using any twisted tapes and the different heat transfer characteristics are calculated. Similarly heat transfer characteristic are found out for twisted tapes of twist ratio of 5.0 and 7.0. Fig.2.1 shows the comparison of heat transfer rate for different types of twisted tapes at input 180 W. From the fig.3.1, it is observed that the heat transfer rate of twisted tapes with y=5.0 is increased drastically from mass flow rate 0.0733 kg/s to 0.0913 kg/s. For further increase in mass flow rate, heat transfer rate of twisted tapes y=5.0 increases steadily. Heat transfer rate of twisted tape with twist ratio of y=7.0 increases steadily with mass flow rate. Initially, difference between heat transfer rate of twisted tapes with twist ratio of 5.0 and 7.0 are found to be more. Heat transfer rate of without twisted tapes is less than with twisted tapes inserts for the all range of mass flow rate.

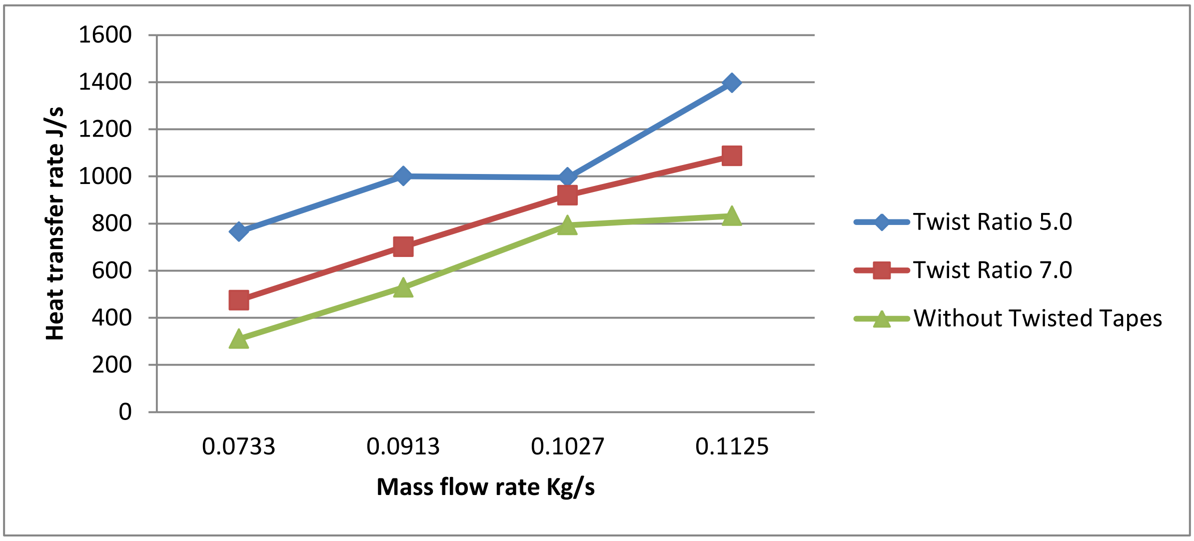

Fig.3.1: Heat Transfer rate Vs Mass flow rate for Input 180 W

In the area of heat transfer, Nusselt number has more importance as it is directly proportional to heat transfer coefficient. The Nusselt number is varying with the different velocity of flow through the pipe which shows the enhancement. Fig.3.2 shows the comparison of heat transfer rate of different twisted tapes for the input 252 W. From the fig.3.2, heat transfer rate of twisted tape y=5.0 is increased from mass flow rate 0.0733 Kg/s to 0.1125 kg/s. In case of twisted tape y=7.0, heat transfer rate is less as compared to without twisted tape up to mass flow rate 0.0913 Kg/s and it increased again from mass flow rate 0.1027 Kg/s to 0.1125 Kg/s. Heat transfer rate is increased due to formation of turbulence. Heat transfer rate of tube without twisted tapes is steadily increases with increase in mass flow rate..

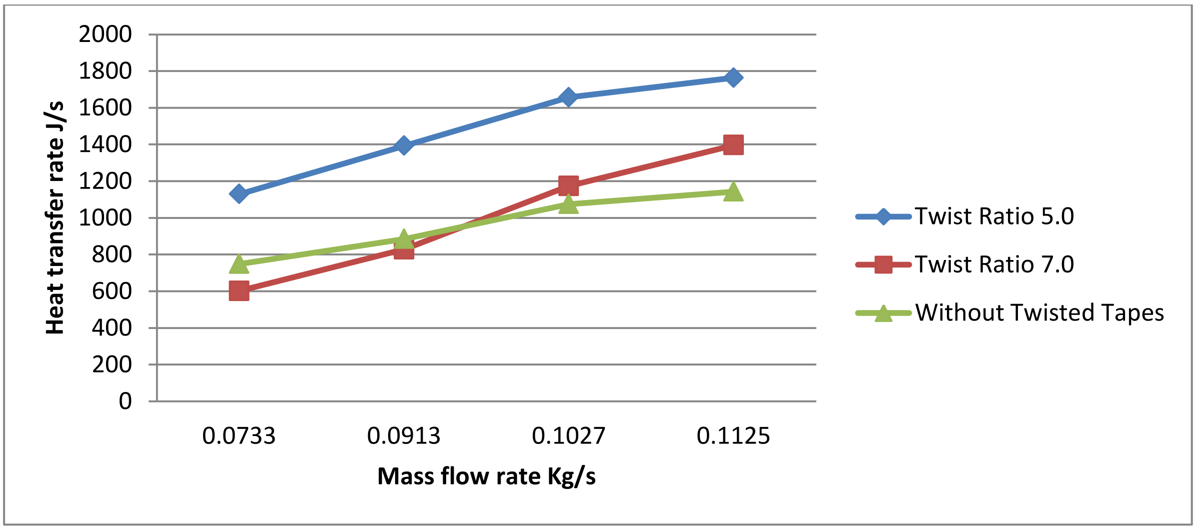

Fig.3.2: Heat transfer rate Vs mass flow rate for input 252 W

Nusselt number and Reynolds number is dimension less number which imparts the rate of heat transfer through the duct. Reynolds number shows the degree of turbulence which is directly proportional to the heat transfer rate. As the Reynolds number increases, the turbulence increase which results in enhancement of heat transfer. Fig.3.3 shows the comparison of heat transfer rate of various twisted tapes for the input 320 W. Heat transfer rate of twisted tape y=5.0 is more than other two cases. The value of heat transfer rate of twisted tape y=5.0 and y=7.0 having very less difference at mass flow rate 0.733 Kg/s and 0.1027 Kg/s. Heat transfer rate of twist ratio 7.0 and without twisted tapes are having near about same difference up to mass flow rate 0.0913 Kg/s, then the value of twist ratio 7.0 are found to be increases gradually. As mass flow rate increases, the air flow will cause more turbulence so definitely the heat transfer rate will increase. It is observed that, the circular channel without any inserts gives least heat transfer coefficient. Use of twisted tapes inserts increases the heat transfer rate. Twist ratio 5.0 gives maximum value of heat transfer rate as compared with other two.

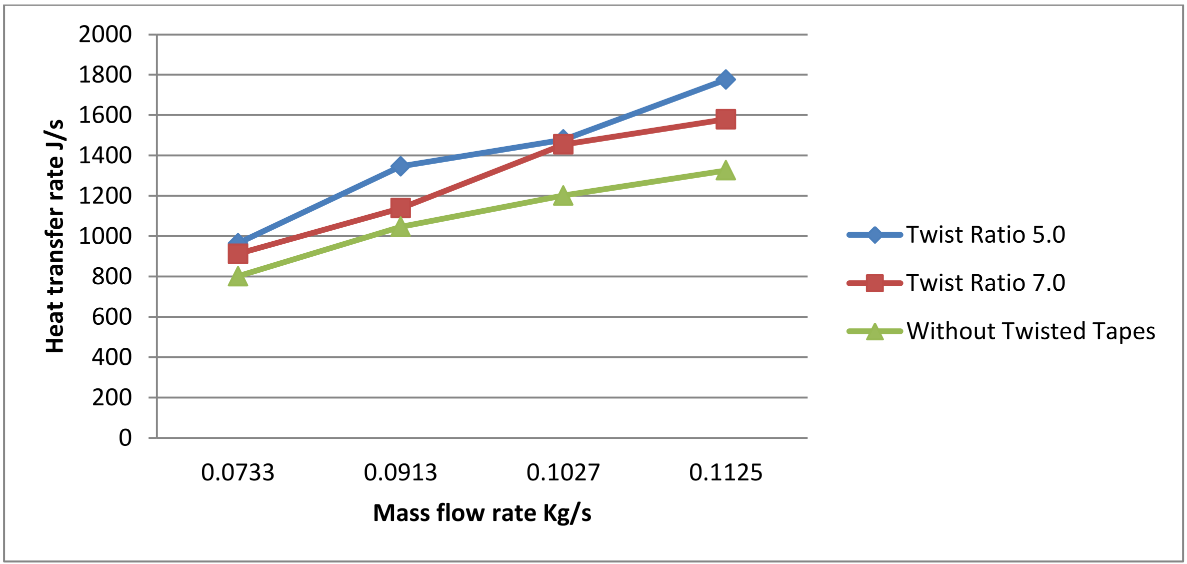

Fig.3.3: Heat transfer rate Vs mass flow rate for input 320 W

3.2. Friction loss in set up

Frictional losses are also important while checking the thermal performance of the system. Optimum performance of twisted tapes is obtained when the friction factor must be low. Fractional loss encounters the problem of pumping power requirement to draw the air flow through the tube. Frictional losses are one of the major areas of studies in heat transfer analysis. Fig.3.4 shows the comparison of friction factors of different twisted tapes for input 180 W. It is observed that as Reynolds number increases there is decrease in friction factor. This is because friction factor is inversely proportional to the velocity. So as the velocity increases (i.e. Reynolds no.) friction factor will decrease. Least friction factor is obtained in tube without twisted inserts and maximum friction factor is observed in case of twisted tapes with twist ratio 5.0. The twisted tape with twist ratio of 5.0 shows the more friction factor and it is reduced at Reynolds number 037545. Friction factor in twist ratio 7.0 is less than twist ratio 5.0 and it is reduced gradually with increased in velocity flow. Fiction factor in without twisted inserts is increased initially and from Re=259590 it is seems to be constant.

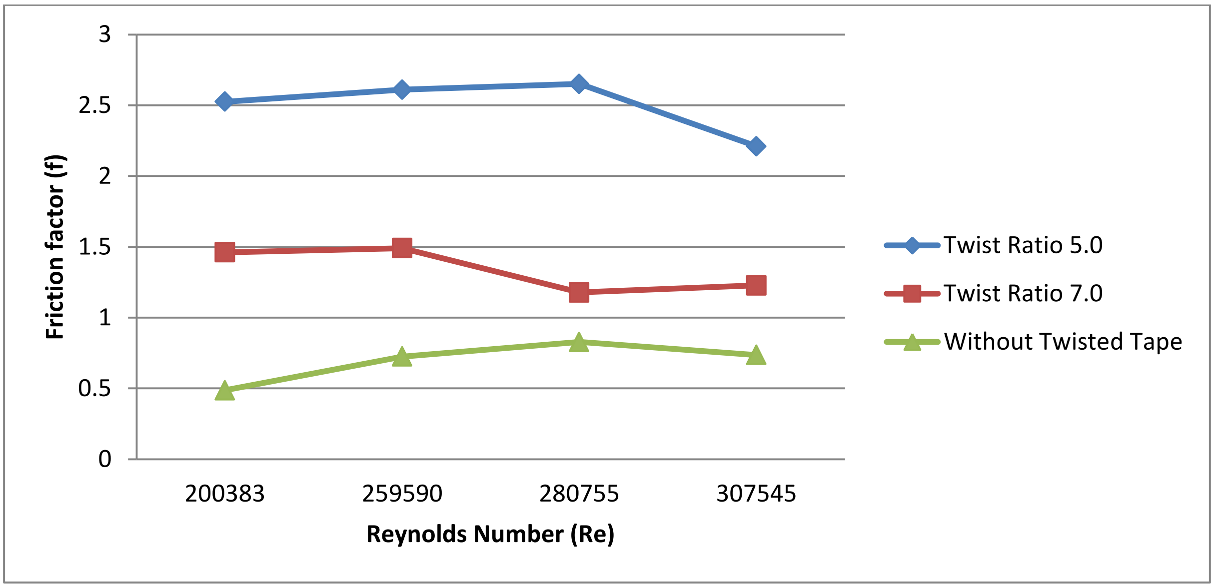

Fig.3.4: Friction Factor Vs Reynolds Number for Input 180 W

Fig. 3.5 shows the same variations in friction factor as the velocity is increase. From fig. it is observed that friction factor is more in case of twisted tape y=5.0 than two other. Initially the friction factor for both twisted tape is reduced gradually up to Re= 259590 and further twisted tape y=7.0 reduced rapidly.

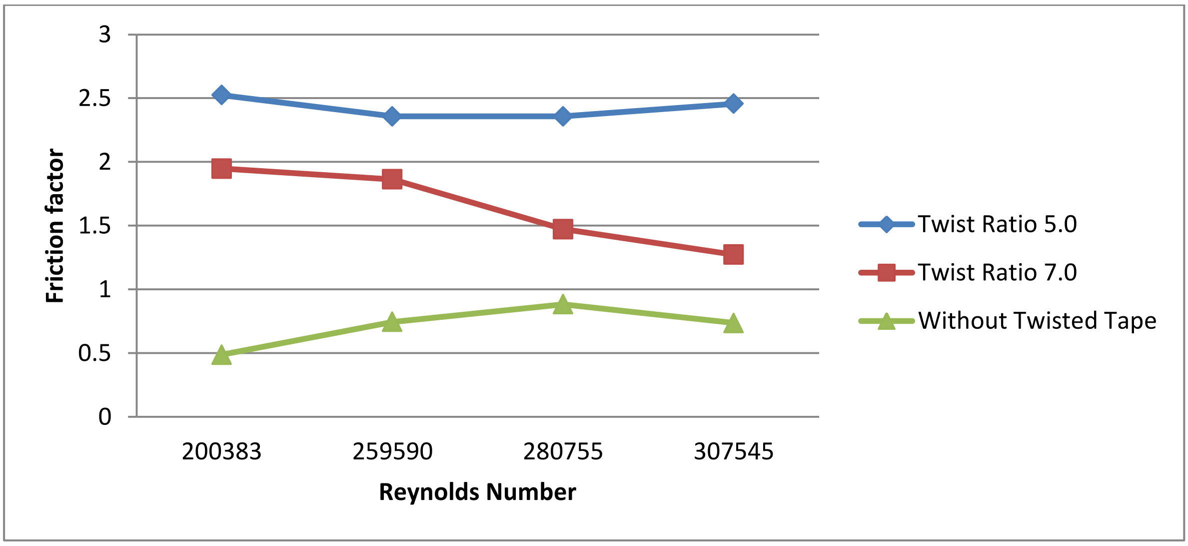

Fig.3.5: Friction Factor Vs Reynolds Number for Input 320 W

4. Conclusion:

- The heat transfer in circular tube with both twisted tapes having twist ratio(y=5.0 and y=7.0) is found to be more as compare without twisted tape in a tube. The increased in heat transfer occurs due to more turbulence is generated within the tube by using twisted tapes.
- Friction factor reduces, as the Reynolds number increases. This is because with increase in Reynolds number, velocity increases. As friction factor is inversely proportional to velocity,

friction factor decreases. This friction factor is found to be more in twisted tapes of twist ratio of 5.0.

- Heat transfer coefficient in a circular tube is near about twice for twisted tape (y=5.0) and 50% for twisted tape (y=7.0) over when no twisted tapes inserts in a tube.

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