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EXPERIMENTAL INVESTIGATION OF INCREASING THE EFFECTIVENESS OF DOUBLE PIPE HEAT EXCHANGER BY THREADED PIPE

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ABSTRACT

Experimental investigation has been carried out to study the effect of overall heat transfer coefficient, heat transfer rate and effectiveness in a smooth copper pipe and two different copper pipes having threads of pitch (p=1.25mm, p=1.5mm) in double pipe heat exchanger by using water as a working fluid. The copper tube (OD=26mm, ID=22mm, t=2mm) was subjected to constant and uniform heat flux. The experimental data obtained from pipes having different surface texture i.e. by threading with different pitches (p=1.25mm, p=1.5mm) were compared with smooth circular pipe. The effect of different surface texture of pipes obtained by threading with varying pitch on overall heat transfer coefficient, heat transfer rate and effectiveness were presented. The effectiveness for pipes having threads was found to be much higher than smooth circular pipe. So by changing the internal surface texture the performance of circular tubeimproved.

Keywords: Effectiveness, Double pipe heat exchanger, Mass flow rate, Parallel flow, Counter flow.

1. INTRODUCTION

Heat exchangers are used to transfer that energy from one substance to another. In process units, it is necessary to control the temperature of incoming and outgoing streams. These streams can either be gases or liquids [1].

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Heat exchangers are the devices that exchange heat between two fluids of different temperatures that are separated by a solid wall. The temperature gradient or the differences in temperature facilitate this transfer of heat. Transfer of heat happens by three principle means: radiation, conduction and convection. In the use of heat exchangers radiation does take place. However, in comparison to conduction and convection, radiation does not play a major role. Conduction occurs as the heat from the higher temperature fluid passes through the solid wall. To maximize the heat transfer, the wall should be thin and made of a very conductive material. The biggest contribution to heat transfer in a heat exchanger is made through convection [2].

The double-pipe heat exchanger is one of the simplest types of heat exchangers. It is called a double-pipe exchanger because one fluid flows inside a pipe and the other fluid flows between that pipe and another pipe that surrounds the first. This is a concentric tube construction. Flow in a double-pipe heat exchanger can be co-current or counter-current. There are two flow configurations: co-current is when the flow of the two streams is in the same direction, countercurrent is when the flow of the streams is in opposite directions. As conditions in the pipes change: inlet temperatures, flow rates, fluid properties, fluid composition, etc., the amount of heat transferred also changes. This transient behavior leads to changes in process temperatures, which will lead to a point where the temperature distribution becomes steady. When heat is beginning to be transferred, this changes the temperature of the fluids. Until these temperatures reach a steady state their behavior is dependent on time.

In this double-pipe heat exchanger a hot process fluid flowing through the inner pipe transfers its heat to cooling water flowing in the outer pipe. The system is in steady state until conditions change, such as flow rate or inlet temperature. These changes in conditions cause the temperature distribution to change with time until a new steady state is reached. The new steady state will be observed once the inlet and outlet temperatures for the process and coolant fluid become stable. In reality, the temperatures will never be completely stable, but with large enough changes in inlet temperatures or flow rates a relative steady state can be experimentally.[3]

a). Problem definition

Heat transfer enhancement is very important in the applications of thermal system such as thermal power plant and industries. Inthermal power plants in order to increase the rate of heat transfer and effectiveness of heat exchanger, leads to the increasing the overall efficiency of the power plant. In order to increase the effectiveness of Double pipe heat exchanger, this project studied and developed.

b). Objectives of the Project work

"Experimental Investigation Of Increasing The Effectiveness Of Double Pipe Heat Exchanger By Threaded Pipe"

1. To study the effect of different water flow rate on heat transfer rate of various pipes
2. To study the effect of water flow rate on effectiveness.
3. To compare the pipes with respect to effectiveness
4. To study the performance of the threaded pipes.

2. LITERATURE REVIEW

Number of investigations has been carried out by using various inserts and tube geometries for heat transfer augmentation. Investigations of various researchers and their findings are as follows.

PaisarnNaphon [1] experimentally investigated the effect of coil- wire insert on heat transfer enhancement and pressure drop of the horizontal concentric tube has been studied. It was observed that as the Reynolds number increases heat transfer rate decreases.

PaisarnNaphon ,TanaponSucana[2] in 2011 changes the geometry of insert, it was found that the swirl flow is generated as fluid flowing through the plain tube with twisted wire brush insert the presence of swirl flow the convective heat transfer obtained is higher.

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Smith Eiamsa-ard, PongjetPromvonge [3] experimentally investigated the heat transfer characteristics in a tube fitted with helical screw-tape with/without core-rod inserts. It was observed that the heat transfer rate obtained by using the tape without core-rod is found to be better than that by one with core-rod around 25–60% while the friction is around 50% lower.

Smith Eiamsa-ard, ChinarukThianpong [4] in 2008 used double pipe heat exchanger with different arrangement of louvered strip inserts, experimental results showed that the forward louvered strip arrangements can promote the heat transfer rate by approximately 150% to 284%, while the backward arrangements could improve the heat transfer by approximately 133% to 264%. It was observed that Louvered strip insertions can be used efficiently to augment heat transfer rate because the turbulence intensity induced could enhance the heat transfer.

SmithEiamsa- ard,PongjetPromvonge [5] in 2010 changed the geometry of insert in a heat exchanger tube and observed that the presence of novel alternate C–CC twisted-tapes, the periodic change of swirl direction And also the strong collision of the recombined streams behind the changing location, lead to superior chaotic mixing and to better heat transfer, compared with the typical twisted-tape.

3. EXPERIMENTAL SETUP

Figure (1) shows photograph of experimental set-up. Test section consist of copper tube (O.D=26mm, I.D=22mm, t=2mm) of length 800mm. four J type thermocouples were placed at inlet and outlet of the fluids to measure their temperature. The required heat input was given by the electric heater. Rota meters are used to measure the flow rate of the fluids. The length of copper tube L=800mm.Two threaded pipes of pitch 1.25 and 1.5 mm are used for this experiment.

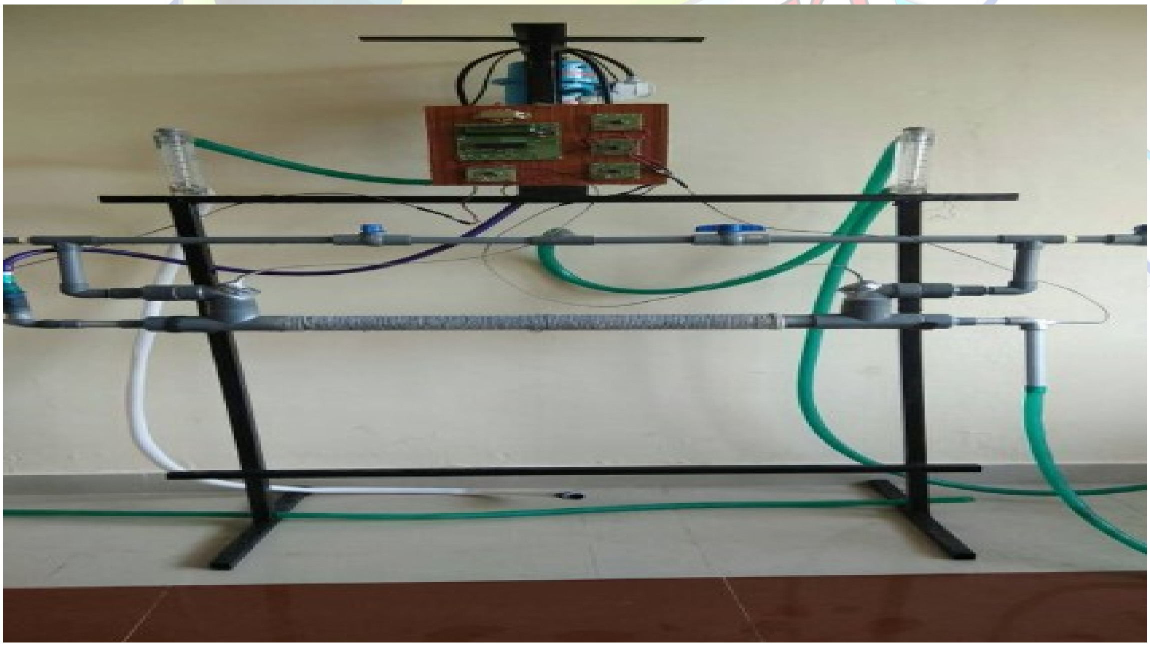

Fig: 1 Double Pipe Heat exchanger Test Rig

4. METHODOLOGY

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In this double pipe heat exchanger system, hot water is supplied by the electric heater. The ball valves are used to control the flow rate of fluids into the system. With the help of rota meters, we can measure the flow rate of hot and cold fluid s into the test section. The parallel flow and counter flow arrangements are made by using the ball valves by opening and closing the appropriate valves. The thermocouples are used to measure the temperature of fluids at inlet and outlet. Initially the hot water flow rate kept constant and cold low rate is changed after every set of readings. Then cold-water flow rate is kept constant and hot water flow rate is changed. The same sets of operations are carried out for counter flow arrangements. Initially plain pipe is used as the test section and readings are taken for different hot and cold flow rates for parallel and counter flow arrangements. Then the treaded pipes with pitch 1.25mm and 1.5 are used as the test section and the same steps are taken to take reading.

5. DATA REDUCTION

1. Heat transfer from hot water

$Q_h = m_{fh} cp_{hot} (T_{h\,in} - T_{h\,out})$ watts ...(1)

C_{ph} = specific heat of hot water = 4186.8 J kg/K

2. Heat gain by the cold fluid

$Q_c = m_{fc} cp_{cold} (Tc_{out} - Tc_{in})$ watts....(2)

C_{pc} = specific heat of cold water = 4186.8 J kg/K

3. $Q = \frac{Q_h + Q_C}{2}$ watts...(3)

4. $$\text{LMTD} = \frac{\theta 2 - \theta 1}{\ln(\theta 1 / \theta 2)}$$ ....(4)

Where $\Theta_1 = T_{h\,in} - T_{c\,in}$ & $\Theta_2 = T_{hout} - T_{c\,out}$ for parallel flow heat exchanger

$\Theta_1 = T_{h\,out} - T_{c\,in}$ & $\Theta_2 = T_{hin} - T_{c\,out}$ for counter flow heat exchanger

5. **Overall Heat Transfer Coefficient based on outside surface area of inner tube**

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$$U_0 = \frac{Q}{A_0 * LMTD} \quad W/m^2K \qquad \text{….(5)}$$

Where $A_0 = \pi d_0 l \quad m^2$

6. $$NTU = \frac{U_0 * A_0}{Cmin} \qquad \text{…(6)}$$

7. **Effectiveness of parallel flow heat exchanger**

$$\varepsilon = \frac{1-e^{-NTU(1+(Cmin/Cmax))}}{1+(Cmin/Cmax)} \qquad \text{….(7)}$$

8. **Effectiveness of counter flow heat exchanger**

$$\varepsilon = \frac{1-e^{-NTU(1-(Cmin/Cmax))}}{1-(Cmin/Cmax)\, e^{-NTU(1-(Cmin/Cmax))}} \qquad \text{…(8)}$$

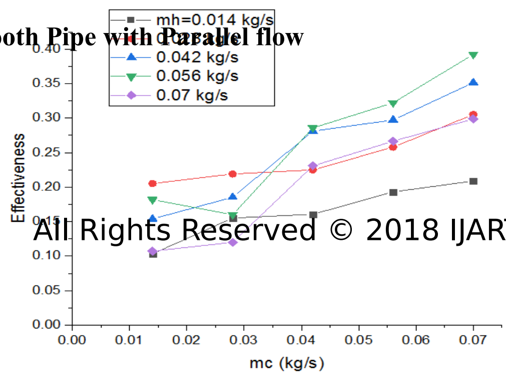
6. RESULTS AND DISCUSSIONS

a). Smooth Pipe with Counter Flow

Figure :2 m_c varies, m_h constant

Figure:3 m_h varies, m_c constant

b). Smooth Pipe with Parallel flow



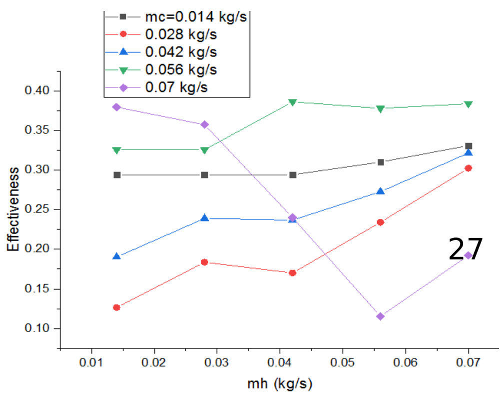


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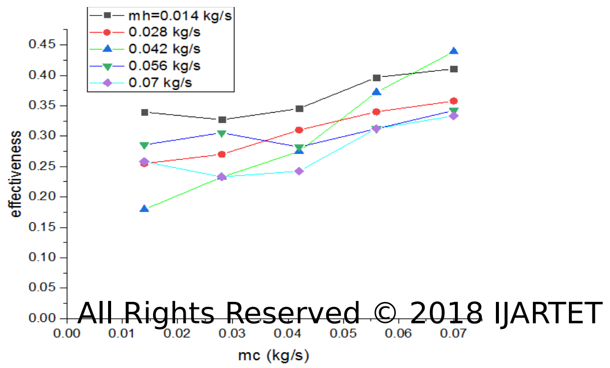
Figure:4 m_c varies. m_h constant **Figure:5 m_h varies. m_c constant**

The figures: 2 to Figure 5 show the graph of counter flow and parallel flow heat exchanger with smooth pipe for various flow rates of hot and cold water configuration. In this by keeping hot water flow rate as constant like 0.014, 0.028, 0.07 kg/sec by varying the corresponding cold water flow rate like 0.014 to 0.07 kg/sec and vice- versa. In this various flow rate got higher effectiveness is Ɛ=0.449 at the combination of m_h=0.07 and m_c= 0.07 kg/sec and also at m_h= 0.056 & m_c= 0.07 kg/sec with Ɛ is 0.4115.And also in parallel flow by varying hot and cold water rate the maximum effectiveness is Ɛ= 0.393 at the flow rate of m_c=0.07 and m_h=0.056 kg/sec and also got Ɛ= 0.379 at m_h= 0.014 and m_c= 0.07 kg/sec.

c). Pipe with 1.25mm pitch For Counter Flow



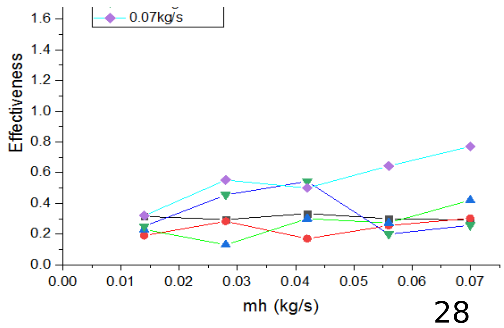


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Figure:6 m_c varies. m_h constant **Figure:7 m_h varies. m_c constant**

d). Pipe with 1.25 mm pitch For Parallel Flow

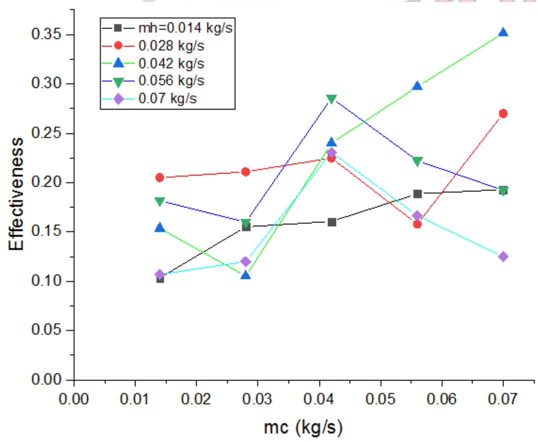

Figure:8 m_c varies. m_h constant

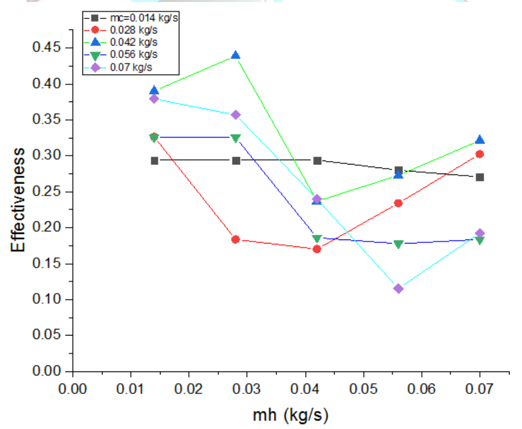

Figure:9 m_h varies. m_c constant

The figure:6 to Figure:9 shows the counter and parallel flow pipe with threads of pitch 1.25mm on the outer surface of the pipe conduct the same experiment for varying flow rates of hot water and cold water flow rate varies form 0.014 kg/sec to 0.07 kg/sec for counter flow heat exchanger effectiveness Ɛ= 0.439 at the flow rate of m_h= 0.042 & m_c= 0.07 kg/sec and also by increasing the flow rate the both hot 7 cold water to m_c=m_h= 0.07 kg/sec achieve the effectiveness of 0.77 because of the rate of production of turbulence is more. Hence the effectiveness of heat transfer is more compared to parallel flow heat exchanger. Counter flow heat exchanger gives the better effectiveness for all flow conditions.

e). Pipe with 1.5 mm pitch For Counter Flow

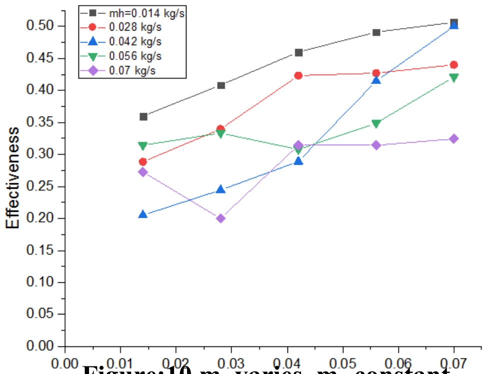

Figure:10 m_c varies, m_h constant

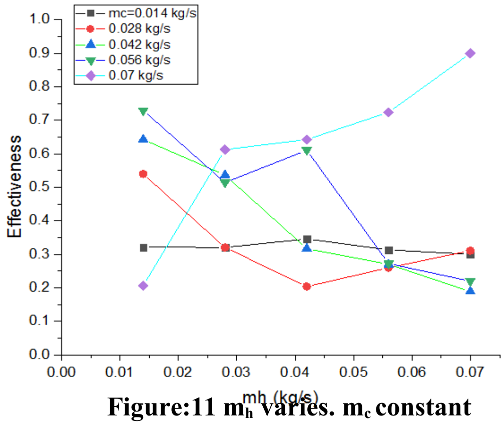

Figure:11 m_h varies. m_c constant

f). Pipe with 1.5 mm pitch For parallel Flow

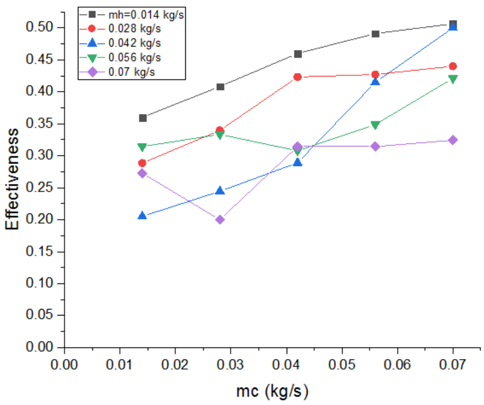

Figure:12: m_c varies. m_h constant

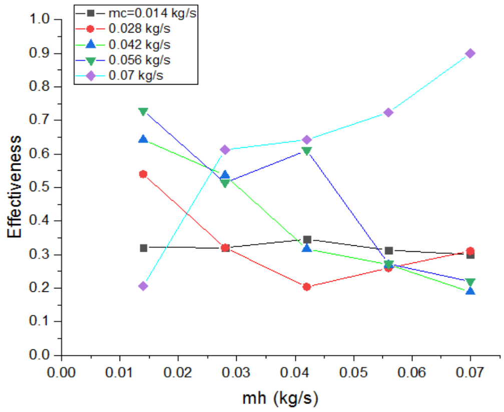

Figure:13: m_h varies. m_c constant

The figure:10 to Figure:11 shows the counter and parallel flow pipe with threads of pitch 1.5 mm on the outer surface of the pipe conduct the same experiment for varying flow rates of hot water and cold water flow rates. In this pitch got effectiveness of Ɛ= 0.506 for m_c= 0.07 &m_h= 0.014 kg/sec, Ɛ= 0.729 for m_c= 0.056 &m_h= 0.014 kg/sec, Ɛ=0.9 for m_c=m_h= 0.07 kg/sec. Compared to pitch of 1.25mm the effectiveness of pitch 1.5mm is increased by 17%. Effectiveness got increased compared to the smooth pipe. Effectiveness of 1.5mm pitch threaded pipe is 100.4% more.

7. CONCLUSION

This project is conducted to Study the effect of the threads of various pitch on to the effectiveness of Double pipe heat exchanger, and concluded are as follows:

- Threaded pipe of 1.25mm pitch the highest effectiveness is 0.77 at m_c and m_h of 0.07 kg/sec for counter flow pipe. But the pumping power required for this corresponding flow rate is higher. Hence low flow rate of m_c=0.056 &$_h$= 0.014 got effectiveness of 0.3965. Hence it is preferable.
- Threaded pipe of 1.5 mm pitch the higher effectiveness is 0.9 at the flow rate of m_c&m_h 0.07 kg/sec. It requires more pumping power & hence consumes more power. But in the flow rate of m_h= 0.014 & m_c=0.056 kg/sec the effectiveness is 0.729. It requires less pumping power and gives better performance.
- Comparing the above two results we can easily conclude the counter flow heat exchanger of flow rate m_h=0.014 & m_c= 0.056 kg/sec gives the better performance of pitch 1.5mm. The increase in the

effectiveness is 83.8%.Threaded pipe counter flow heat exchanger gives better performance compared to parallel flow heat exchanger.

8. NOMENCLATURE

A_0	Area of the heated region of tube (m^2)
A_f	Flow area (m^2)
Cp	Specific heat of water at constant pressure (J/kg.K)
di	Tube inner diameter (mm)
do	Tube outer diameter (mm)
t	Thickness of copper tube (mm)
p	Pitch of threads (m)
h	Heat transfer coefficient (W/m^2 K)
k	Thermal conductivity of water (W/m K)
L	Effective tube length (m)
m_h	Mass flow rate of Hot water (Kg/s)
m_c	Mass flow rate of cold water (Kg/s)
Q	Heat transfer rate (W)
q	Heat flux (W/m^2)
$T_{h\ in}$	Hot Water inlet temperature (^{0} C)
$T_{h\ out}$	Hot Water outlet temperature (^{0} C)
$T_{c\ in}$	Cold Water inlet temperature (^{0} C)
$T_{c\ out}$	Cold Water outlet temperature (^{0} C)
Ɛ	Effectiveness

REFERENCES

[1] PaisarnNaphon, "Effect of coil-wire insert on heat transfer enhancement and pressure drop of the horizontal concentric tubes," International Communications in Heat and Mass Transfer.

[2] PaisarnNaphon, TanaponSuchana, "Heat transfer enhancement and pressure drop of the horizontalconcentric tube with twisted wires brush inserts," International Communications in Heat and MassTransfer.

3] Smith Eiamsa-ard, PongjetPromvonge, "Heat transfer characteristics in a tube fitted with helical screw-tapewith/without core-rod inserts," International Communications in Heat and Mass Transfer.

[4] Smith Eiamsa-ard, ChinarukThianpong, SomsakPethkool, PongjetPromvonge, "Turbulent flow heat transfer and pressure loss in a double pipe heatexchanger with louvered strip inserts," International Communications in Heat and Mass Transfer.

[5] Smith Eiamsa-ard, PongjetPromvonge,"Performance assessment in a heat exchanger tube with alternateclockwise and counter-clockwise twisted-tape inserts," International Journal of Heat and Mass Transfer.

[6] P. Murugesan, S. Suresh, K.Mayilsamy, P.S.S. Srinivasan,"Heat transfer and pressure drop characteristics in a circular tube fitted with and without V-cut twisted tape insert," International Communications in Heat and Mass Transfer