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Improve the Performance of Heat Exchanger: Twisted Tape Insert With Metallic Wiry Sponge

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Abstract-- Enhancing heat transfer surface are used in many engineering applications such as heat exchanger, air conditioning, chemical reactor and refrigeration systems, hence many techniques have been investigated on enhancement of heat transfer. One of the most important techniques used are passive heat transfer technique. These techniques when adopted in Heat exchanger proved that the overall thermal performance was improved significantly. This experiment works taken by researchers on this Augmentation Technique such as Twisted Tape. So, Researchers tried to increase the effective surface area Contact with fluid to increases the heat transfer rate in the heat exchanger. We work on Double tube type Heat Exchanger and fabricate the Experimental setup & make Comparative Study with twisted tape Flat Type Rectangular section, Simply Twisted Tape and Twisted Tape insert with Wiry Metallic Sponge. From this experiment it has been observed that the twisted tape insert with metallic wiry sponge gives more heat transfer as compared to the plain tube and twisted tape insert in the counter flow heat exchanger. Also very small difference of friction factor has been observed between twisted tape and twisted tape with sponge inserts at higher Reynolds number.

***Keywords*:** Double pipe heat exchanger, Augmentation techniques, twisted tape, sponge.

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INTRODUCTION

Heat exchangers are devices that can be used to transfer heat from a fluid stream (liquid or gas) to another fluid at different temperatures. Heat Exchanger is a device in which the exchange of energy takes place between two fluids at different temperature. A heat exchanger utilizes the fact that, where ever there is a temperature difference, flow of energy occurs. So, That Heat will Flow from higher Temperature heat reservoir to the Lower Temperature heat Reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them.

Heat exchangers are used in different processes ranging from conversion, utilization & recovery of thermal energy in various industrial, commercial & domestic applications. These include power production, process, chemical and food industries, electronics, environmental engineering, and waste heat recovery, manufacturing industries and air conditioning, refrigeration and space applications. Examples of heat exchangers that can be found in all homes are heating radiators, the coils on your refrigerator and room air conditioner and the hot water tank.

Augmentation Techniques of Heat Transfer: Twisted Tape Insert

The augmentation techniques of heat transfer are widely applied to improving the performance of heat exchangers in chemical industries and air conditioning systems to reduce the size and costs of the heat exchangers, these techniques are classified as active and passive techniques. The active techniques require external forces, e.g. electric field, surface vibration or Jet impingement. The passive techniques require special surface geometries or swirl/vortex flow devices. Many of experimental works on heat transfer augmentation using twisted tape as swirl/vortex flow devices have been reported in the literature.

LITERATURE REVIEW

Bodius Salam et al. [1] experimental investigation was carried for measuring tube side heat transfer coefficient of water for turbulent flow in a circular tube fitted with twisted tape insert of 5.3 twist ratio. Watcharin Noothong et al. [2] influences of the twisted tape insert of twist ratio 5 and 7 on heat transfer and flow friction characteristics in a concentric double pipe heat exchanger have been studied experimentally. Veeresh fuskele et al. [3] does investigation on the double pipe heat exchanger with new kind of insert called twisted wire mesh. They make experimental set up with copper pipes and use twisted tape wire mesh of twist ratio 5.0 and 7.0. A. rahul Kumar et al. [4] do experimental analysis of heat transfer augmentation by using twisted tapes of different twist ratio as flow arrangement inside the tubes. Maughal Ahmed Ali Baig et al. [5] perform twisted tapes with holes and with baffle plates are carried out to find the suitable design for the heat transfer augmentation. Prof. Naresh B. Dhamane et al. [6] presents an experimental study of heat transfer and friction characteristics in turbulent flow generated by a helical strip inserts with regularly spaced cut passages, placed inside a circular pipe across the test section. The experiments were conducted for water flow rates in the range of Re 5000 to Re 30000.

Aim of this paper is to improve the heat transfer rate of double pipe heat exchanger by insert twisted tape with metallic wiry sponge. It

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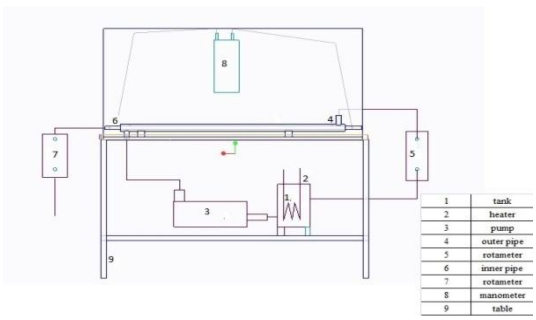
will helpful to increase the rate of heat transfer in tube. Increase the heat transfer rate with metallic wiry sponge which is very low expensive and easily available. Sponge is an industrial waste and it will helpful to increase the heat transfer rate. Twisted tape with spiral section, Spiral section has large surface and good contact area with fluid. So, it will increase the heat transfer rate.

EXPERIMENTAL SETUP & PROCEDURE

Outer pipe: material- copper (OD: 38mm, ID: 34mm, length: 1050mm)
Inner pipe: material- copper (OD: 19mm, ID: 17mm, length: 1200mm)
Water at room temperature was allowed to flow through the inner pipe while hot water flows through the annulus side in the counter current direction.



Experiment Procedure

Fig. 1 shows the experimental setup. It is counter flow double pipe heat exchanger. Insulation of glass wool is provided on outer side of outer pipe to reduce the heat loss. Tank contains fluid (water) which is heated with the help of heater. The hot fluid from the tank is going to the annuals between two pipes by means of pump providing between tank and outer pipe. Outlet of fluid of outer pipe is connected to the rotameter and then to the tank. Another fluid (water) passing through inner pipe and outlet is also connected to another rotameter. Temperature of both pipes at inlet as well as outlet is measured with help of thermocouple. Rotameter at outlet of both pipe measure flow rate. Pressure of fluid in inner pipe can be measured with the help of manometer.

Readings are being taken for following types of inserts and noted in the observation table. 1. Without any insert (plain tube) 2. Twisted tape inserts 3. Twisted tape with metallic wiry sponge inserts (by removing ¼ length of twisted tape).

DATA REDUCTION EQUATIONS

Heat transfer from hot water can be calculated by

$$Q_h = m_h * Cp_h * (Th_i - Th_o)$$

Heat transfer to cold water can be calculated by

$$Q_c = m_c * Cp_c * (Tc_o - Tc_i)$$

The average heat transfer rate can be calculated by

$$Q_{avg} = \frac{Q_c + Q_h}{2}$$

The overall heat transfer coefficient U, can be calculated from

$$Q_{avg} = U * Ai * \Delta T_m$$

Where, $Ai = \pi * di * l$

$$\Delta T_m = \frac{(Th_i - Tc_o) - (Th_o - Tc_i)}{\ln\left(\frac{(Th_i - Tc_o)}{(Th_o - Tc_i)}\right)}$$

Reynolds number $Re = \frac{\rho * V * d}{\mu} = \frac{4 * m}{\pi * d * \mu}$

Prendtl number $Pr = \frac{\mu * C_p}{k}$

Tube side heat transfer coefficient h_i can be calculated from

$$Nu_i = 0.023 * Re_c^{0.8} * Pr_c^{0.4} = \frac{h_i * d_i}{k}$$

Tube side heat transfer coefficient h_o can be calculated from

$$Nu_o = 0.023 * Re_c^{0.8} * Pr_c^{0.4} = \frac{h_o * d_h}{k}$$

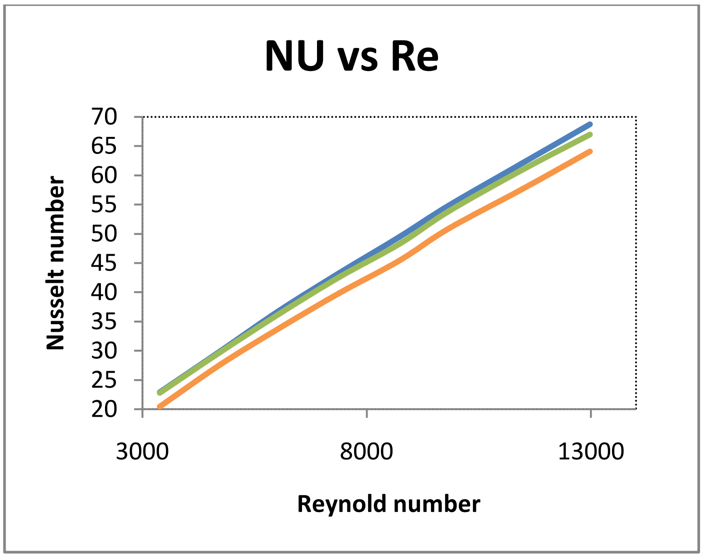
The overall heat transfer coefficient U, can be calculated from (by neglecting thermal resistances of copper tube wall), can be calculated from

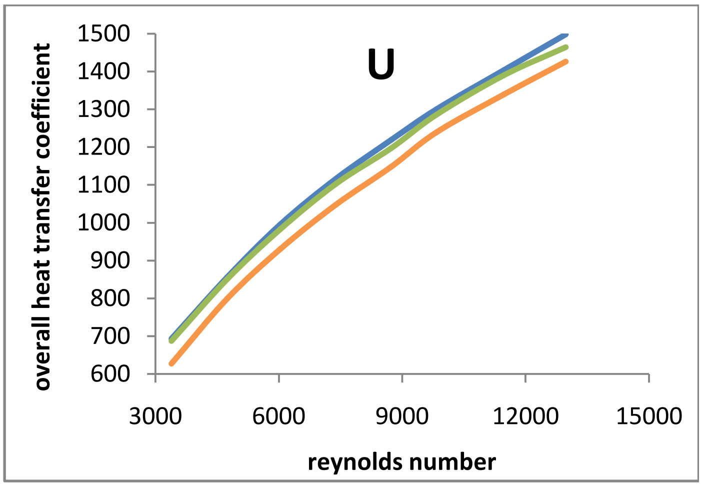
$$\frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_o}$$

Friction factor can be written as

$$f = \frac{\Delta p}{\left(\frac{l}{d_i}\right) * \left(\frac{\rho V^2}{2}\right)}$$

RESULTS AND DISCUSSION





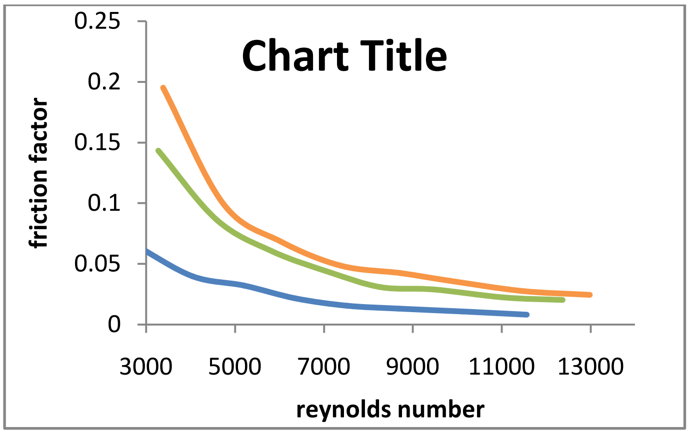


Table 4.1-4.3 gives the Nu results for Plain Tube, With Twisted Tape Insert and with sponge inserts along with the corresponding performance evaluation criteria Re for each of the readings. As depicted in fig.5.1, there is a Nu was drastically increased with twisted tape insert as compared to the plain tube results, and there is increase in Nu, when Twisted tape insert with cutting sponge. At higher mass flow rate of working fluid from the test section difference in Nu between Plain tube, with twisted tape and twisted tape use with sponge was increased. From fig 5.1 we observe that the Nu was increased from 22 to 68 and Re was increased from 2700 to 13000. Maximum value of Nu can be predicted by the twisted tape insert with sponge in the test section. It directly increases the heat transfer rate.

Table 4.1-4.3 gives the U results for Plain Tube, With Twisted Tape Insert and with sponge inserts along with the corresponding performance evaluation criteria Re for each of the readings. As depicted in fig.5.2, U was drastically increased with twisted tape insert as compared to the plain tube results, and there is increase in U, when Twisted tape insert with cutting sponge. At higher mass flow rate of working fluid from the test section difference in U between Plain tube, with twisted tape and twisted tape use with sponge was increased. From fig 5.1 we observe that the U was increased from 620 to 1500 and Re was increased from 2700 to 13000. Maximum value of U can be predicted by the twisted tape insert with sponge in the test section. It directly increases the heat transfer rate.

Table 4.1-4.3 gives the f results for Plain Tube, With Twisted Tape Insert and with sponge inserts along with the corresponding performance evaluation criteria Re for each of the readings. As depicted in fig.5.2, f was increased with twisted tape insert as compared to the plain tube results, and there is increase in f, when Twisted tape insert with cutting sponge. At higher mass flow rate of working fluid from the test section difference in f between Plain tube, with twisted tape and twisted tape use with sponge was decreased. From fig 5.3 we observe that the f was increased from 0.008 to 0.19 and Re was increased from 2700 to 13000. Minimum value of f can be predicted by the plain in the test section.

CONCLUSIONS

This experimental work has been done to increase the heat transfer coefficient of counter flow heat exchanger. From the above experiment we observe that Nu and U was increase with respect to increase in Reynolds Number and friction factor was decreased with respect to Reynolds Number.

Maximum Nusselt Number has been observed in the experiment by twisted tape insert with metallic wiry sponge. Large difference in Nusselt Number has been observed in between plain tube and with twisted tape insert in heat exchanger. Nu for twisted tape insert with metallic wiry sponge and twisted tape was high respectively as compared to plain tube. Also very small difference of friction factor has been observed between twisted tape and twisted tape with sponge inserts at higher Reynolds number.

So that, from this experiment it has been observed that the twisted tape insert with metallic wiry sponge gives more heat transfer as compared to the plain tube and twisted tape insert in the counter flow heat exchanger.

NOMENCLATURE

Q	Heat Transfer Rate, W
Cp	Specific Heat, J/kgK
T_h	Temperature of Hot Fluid, K
T_c	Temperature of cold fluid, K
U	overall heat transfer coefficient, W/m^{2}K
Ai	Area of Inner Pipe, m^2
ΔT	LMTD
Di	Diameter of Inner Pipe, m
Dh	Annulus Diameter, m
L	Effective Length, m
k	Thermal Conductivity Of Fluid, W/mK
V	Velocity Of Fluid, m/s
Δp	Pressure Drop, pa

Dimensional parameters

Re Reynolds Number

Pr Prendtl Number

Nu Nusselt Number

Greek symbols

ρ Density Of Fluid, kg/m^3

μ Dynamic Viscosity, kg/ms

f Friction Factor

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