To investigate the effect of insert on heat transfer in heat exchanger

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Abstract

Heat transfer enhancement has been always a significantly interesting topic in order to develop high efficient, low cost, light weight, and small heat exchangers. The energy cost and environmental issue are also encouraging researchers to achieve better performance than the existing designs. The various effective ways to achieve higher heat transfer rate in heat exchangers are using different kinds of inserts and modifying the heat exchanger tubes.

The present work is on the heat transfer enhancement in a circular tube. In the present work emphasis is given to works dealing with analysis of different inserts and their effects on heat transfer rate because according to the recent studies, these are known to be economic in the field of heat transfer enhancement. The inner and outer diameters of the copper tube are 25 mm and 26.5 mm respectively. The twisted tapes were made of the copper and aluminium strip with thickness of 2mm and the length of 1220 mm. The effects of other three types of tapes including, The copper twisted tape with twist ratio (y) of 6.6 and 8.26 , (2) The aluminium twisted tape with twist ratio (y) of 6.0, are also studied for comparison. All twisted tapes used are twisted at constant twist length(y). Heat Transfer enhancement techniques are used to increase rate of Heat transfer. The heat transfer coefficient increases with Reynolds number. The experimental data obtained are compared with those obtained from plain tube. The heat transfer coefficient increases with twist ratio. The empirical correlations developed in terms of twist ratio, Reynolds number, Nusselt number and friction factor. Heat transfer techniques are mostly used in areas such as thermal power plants, air-conditioning equipment, radiators for space vehicles, automobiles, power sector, process industries, Industrial heat recovery, Electronics cooling, Aerospace.

INTRODUCTION

1.1 INTRODUCTION:

Heat transfer enhancement is a subject of considerable interest to researchers as it leads to saving in energy and cost. Because of the rapid increase in energy demand in all over the world, both reducing energy lost related with ineffective use and enhancement of energy in the meaning of heat have become an increasingly Significant task for design and operation engineers for many systems. In the past few decades numerous researchers have been performed on heat transfer enhancement. These researches focused on finding a technique not only increasing heat transfer, but also achieving high efficiency. Achieving higher heat transfer rates through various enhancement techniques can result in substantial energy savings, more compact and less expensive equipment with higher thermal efficiency. Heat transfer enhancement technology has been improved and widely used in heat exchanger applications; such as refrigeration, automotives, process industry, chemical industry, etc. One of the widely-used heat transfer enhancement technique is inserting different shaped elements with different geometries in channel flow. There exist numerous studies on heat transfer enhancement by inserting fins, twisted tapes baffles and coilwires. The literature survey on investigations of different type of tube inserts indicates that these inserts are generally attached on the tube walls in order to enhance the heat transfer by not only disturbing the laminar sublayer and discontinuing the development of boundary layer, but also increasing the effective heat transfer area.This work differs from those in the literature by attaching the ring inserts separated from the tube wall, thus the effective heat transfer area was not increased and heat transfer enhancement was achieved by only disturbing the laminar sub-layer. Furthermore it is known that attaching the inserts on the tube wall may cause contamination in time, thus there will occur an additional resistance against to heat transfer. Therefore, attaching the inserts near the wall will be convenient in the meaning of preventing the formation of contamination. In this work, the circular cross sectional rings were preferred, because in practice these rings are relatively easy to manufacture, less expensive and also relatively easy to insert and remove from the tube, thereby validating their use in heat transfer enhancement.

LITERATURE REVIEW

PaisarnNaphon,ParkpoomSriromruln studied the heat transfer characteristics and the pressure drop of the horizontal double pipes with and without coiled wire insert are investigated. The inner and outer diameters of the micro-fin tube are 8.92 and 9.52 mm, respectively. The coiled wire is fabricated by bending a 1-mm-diameter iron wire into the coil wire with coil diameter of 7.80 mm. Cold and hot water are used as working fluids in shell side and tube side, respectively. The test runs are performed at the cold and hot water mass flow rates ranging between 0.01 and 0.07 kg/s and between 0.04 and 0.08 kg/s, respectively. The results obtained from the micro-fin tube with coiled insert are compared with those from the smooth tube and micro-fin tube without coiled wire insert. We found that the coiled wire insert has a significant effect on the enhancement of heat transfer. However, the friction factor of the tube with the coiled wire insert also increases.

Smith Eiamsa-ardstudied heat transfer and turbulent flow friction characteristics in a circular wavy-surfaced and constant heat-flux tube with a helical-tape insert using hot air as a test fluid. The experimental results shows that apart from the friction factor, the heat transfer rate can be substantially improved by using both the wavy-surfaced wall and the helical tape. The maximum increase in heat transfer rate and friction factor are found to be about 4.2 and 110 times the plain tube for the flow range studied.

S.NagaSarada and A. V. Sita Rama Rajuinvestigate the augmentation of turbulent flow heat transfer in a horizontal tube by means of varying width twisted tape inserts with air as the working fluid. In order to reduce excessive pressure drops associated with full width twisted tape inserts, with less corresponding reduction in heat transfer coefficients, reduced width twisted tapes of widths ranging from 10 mm to 22 mm, which are lower than the tube inside diameter of 27.5 mm are used. Experiments were carried out for plain tube with/without twisted tape insert at constant wall heat flux and different mass flow rates. The twisted tapes are of three different twist ratios (3, 4 and 5) each with five different widths (26-full width, 22,)

OVERVIEW OF INSERTS

TYPES OF INSERTS USED

- **TWISTED INSERTS:**

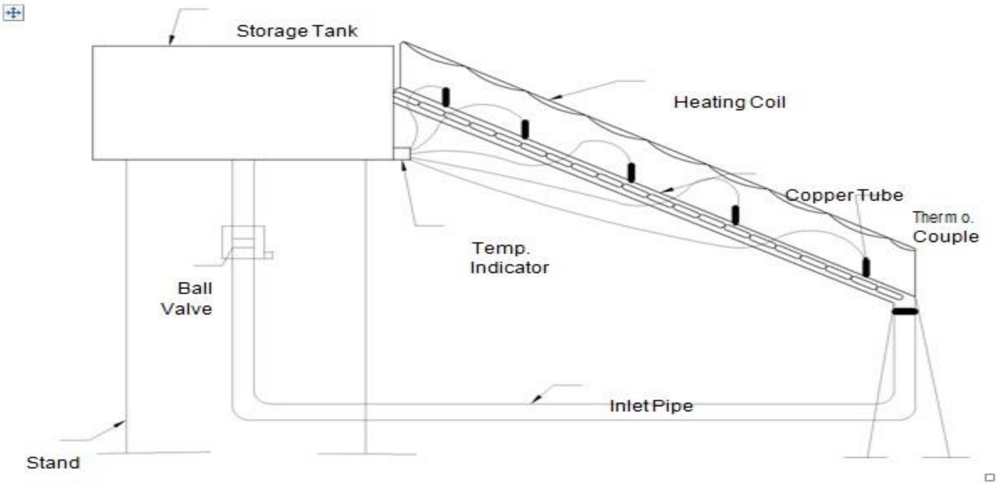
Copper Twisted tape:
This type of strip is made by copper material. It is having its thermal conductivity is 353 W/mk. Its total length is 4 ft and out of which test section is 4 ft. Its thickness is 2 mm and width is 20 mm
.

Fig. 3.12

Aluminium Twisted Tape:
This type of strip is made by Aluminium material. It is having its thermal conductivity is 204.3 W/mk. Its total length is 4 ft and out of which test section is 4 ft. Its thickness is 1 mm and width is 20 mm.

Fig. 3.12

EXPERIMENTAL SETUP



4.4 CONSTRUCTION AND WORKING

The experi mental setup for experiment as shown in above fig. It consists of a rigid stand which is made by a metal bar. It consists of a 2.5*1.75 ft base on which the storage tank is fixed. At the one side of reservoir the outlet pipe is attached. One end of this pipe is connected to the reservoir and another end is connected to the copper tube. This inlet pipe has one flow control valve for controlling the flow of water. The copper tube is main experimental part which is having 4 ft length from which we are using the 4 ft section for the experiment purpose. The five thermocouples are fixed on this 4 ft section at equally distance. These thermocouples are connected to the temperature indicator which indicates the temperature of each thermocouple. At another end of the copper pipe, the pipe is attached for making the outlet of water. This water is collected in a collective tank.

Working

Firstly water is collected in a tank which is called as reservoir for continuous flow of water. Then it is passed towards the copper tube through a flow control valve and pipe assembly. The flow control valve is used for regulating the flow of water at a various rate. The copper tube is of 4 ft length and having both end open. The various types of inserts are placed in copper tube. When water enters it changes its flow when get in contact with insert and make maximum contact with the copper tube. Which cause the increase in temperature of water this temperature is measured by five thermocouples and indicated on digital indicator. Then this water is collected in storage tank. From this arrangement we can calculate in how much time what amount of water is collected in tank. Thisexperiment work on the mode of convection heat transfer.

OBSERVATION TABLE AND CALCULATIONS

Calculation for without insert

Following are the calculations and readings for copper tube without insert, we have calculated nusselt number, Reynold number, Friction factor etc.

- The calculation are stand for full opening valve.

1] For calculation of Nusselt number,

$$\mathrm{Nu} = \frac{\mathrm{hi} \times \mathrm{Di}}{\mathrm{k}}$$

Where,

$$\mathrm{hi} = \frac{\mathrm{mcp(Tw - Ti)}}{\mathrm{Ai(Tw - Tb)}}$$

$$\mathrm{Tb} = \frac{\mathrm{To} - \mathrm{Ti}}{2}$$

$$\mathrm{hi} = \frac{45 \times 1.103(33.6 - 29)}{\frac{\pi}{4} \times 0.025^2 \left(33.6 - \left(\frac{33.6-29}{2}\right)\right)}$$

= 14860.43

Hence,

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$$Nu_1 = \frac{14860.43 \times 0.025}{0.680}$$

= 546.339

2] For friction factor calculation,

$$h = \frac{fLV^2}{2 \times g \times D}$$

Where, $V = \frac{Q}{3600 \times \pi \times (\frac{d}{2})^2}$

$$V = \frac{13.3}{3600 \times \pi \times (\frac{0.025}{2})^2}$$

V = 7.52 $\frac{m}{s}$

Therefore,

$$0.9 = \frac{f \times 1.20 \times 7.52^2}{2 \times 9.81 \times 0.025}$$

friction factor f,

f = 6.50×10^{-3}

3] For Reynold number calculation,

$$Re^{0.25} = \frac{0.0791}{\text{Friction factor}}$$

$$Re^{0.25} = \frac{0.0791}{0.00650}$$

Re = 21930.7

Table 5.1 For without insert

5.2 Calculation for copper twisted tape insert (y = 6.6)

Following are the calculations and readings for copper twisted tape insert, with twist ratio 6.6 we have calculated nusselt number, Reynold number, Friction factor etc.

- The calculation are stand for full opening valve.

1] For calculation of Nusselt number,

$$Nu = \frac{hi \times Di}{k}$$

Nu= 654.65

2] For friction factor calculation,

$$h = \frac{fLV^2}{2 \times g \times D}$$

friction factor f,

f = 7.35×10^{-3}

3] For Reynold number calculation,

$$Re^{0.25} = \frac{0.0791}{\text{Friction factor}}$$

Re = 13413.94

Table 5.2 For copper with twisted tape insert

5.3 Calculation for copper twisted tape insert (y = 8.26)
Following are the calculations and readings for copper twisted tape insert, with twist ratio 8.26 we have calculated nusselt number, Reynold number, Friction factor etc.

1] For calculation of Nusselt number,

$$Nu = \frac{hi \times Di}{k}$$

Nu= 686.48

2] For friction factor calculation,

$$h = \frac{fLV^2}{2 \times g \times D}$$

friction factor f,

f = 7.72×10^{-3}

3] For Reynold number calculation,

$$Re^{0.25} = \frac{0.0791}{\text{Friction factor}}$$

Re = 10987.20

Table 5.3 For copper with twisted tape insert

5.4 Calculation for aluminum twisted tape insert

Following are the calculations and readings for aluminum twisted tape insert, with twist ratio 6.0 we have calculated nusselt number, Reynold number, Friction factor etc.

1] For calculation of Nusselt number,

$$\mathrm{Nu} = \frac{\mathrm{hi} \times \mathrm{Di}}{\mathrm{k}}$$

Nu= 600.924

2] For friction factor calculation,

$$\mathrm{h} = \frac{fL\mathrm{V}^2}{2 \times \mathrm{g} \times \mathrm{D}}$$

friction factor f,

f = 8.53 ×10^{-3}

3] For Reynold number calculation,

$$\mathrm{Re}^{0.25} = \frac{0.0791}{\text{Friction factor}}$$

Re = 7366.84

Table 5.4 For aluminum with twisted tape insert

RESULT AND DISCUSSION

Enhancement of temperature and length

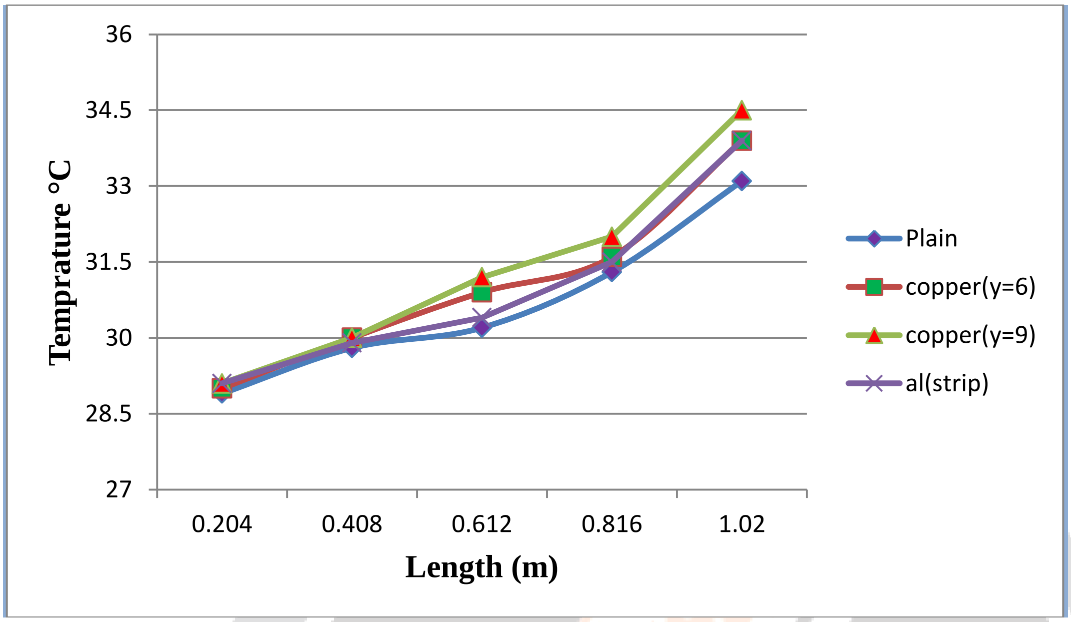

Fig. Temperature vs Length for all inserts

Enhancement of Nusselt number and Reynolds number

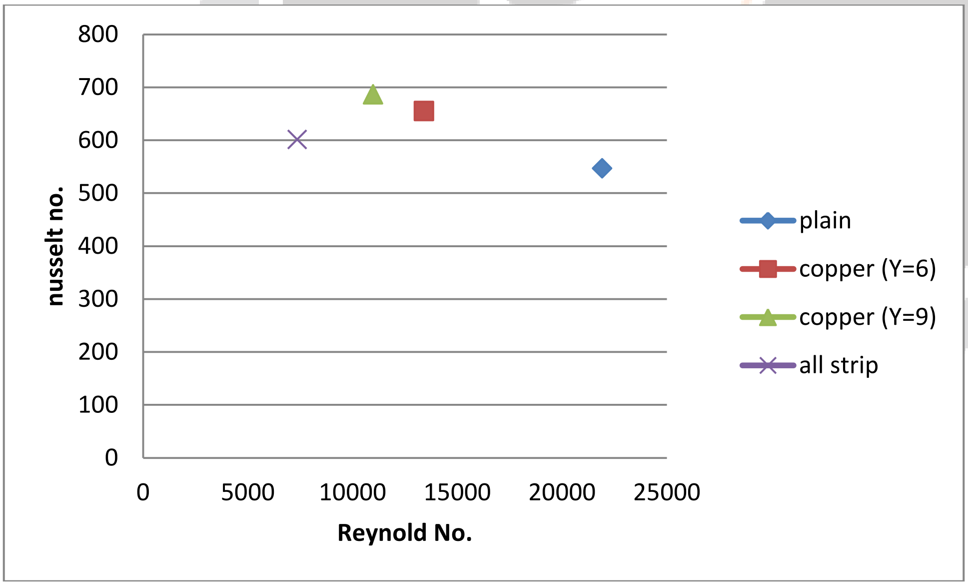

Fig. Reynolds number vs Nusselt no.

Enhancements of Friction factor and Reynolds number

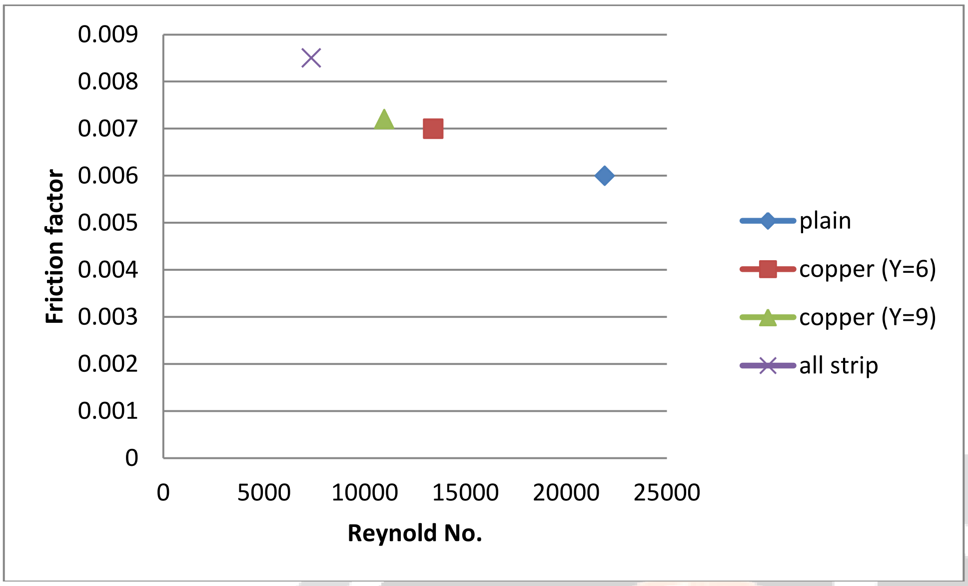

Fig. Variation of friction factor with Reynolds number for various twisted tape inserts

CONCLUSION

Finally The graphs were plotted between Temperature Vs Length as the Reynolds number Vs Friction factor & R_e Vs N_u, R_e Vs f . In all this graph we got result that the more twist ratio tape i.e. y=8.26 was significantly affected by the rise in temperature.

In the present work, an experiment study has been conducted to investigate the heat transfer enhancement of heat exchanger by means of twisted tape inserts with twist ratio 6.6 and 8.26 and different materials in a circular tube under heat flux provided by heating coil. From the experimental results. A twisted tape insert mixes the bulk flow well and therefore performs better in laminar flow, because in laminar flow the thermal resistant is not limited to a thin region. The result also shows twisted tape insert is more effective. Twisted tape in turbulent flow is effective up to a certain Reynolds number range. It is also concluded that twisted tape insert is not effective in turbulent flow, because it blocks the flow and therefore pressure drop increases. Hence the thermo hydraulic performance of a twisted tape is not good in turbulent flow. These conclusions are very useful for the application of heat transfer enhancement.

Hence we conclude that more twist ratio i.e. y=8.26 is superior to other inserts. Use of more twist tape was seen to increase in temperature compared to other inserts.

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