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HEAT TRANSFER ENHANCEMENT ON DOUBLE PIPE HEAT EXCHANGER BY WIRE COILEDAND PIN WIRE COILED TURBULATOR INSERTS

J. KALIL BASHA[1],M.RAJA[2] L. NARASIMMAN[3], KUMARAVEL[4],

Asst.Professor , Dhanalakshmi Srinivasan Engg College

Asst.Professor , Government College Of Engineering,

Asst.Professor , Dhanalakshmi Srinivasan Engg College

Asst.Professor , Arul Murugan Engg College

Email id: kalilbashajs@gmail.com

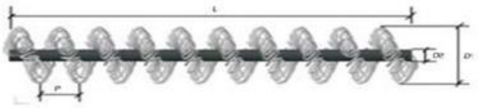
Abstract

This paper presents the effect of wire coiled coil matrix turbulator, taper wire coiled turbulator, and pin wire coiled turbulator on the heat transfer for a fully developed turbulent flow. Tests are conducted at various mass flow rates by controlling the flow control valve, tests are conducted for the following valve opens (25%, 50%, 75%, 100% valve open). Tests are performed on three different wire coiled coil matrix turbulators of different pitches of 5, 10, and 15 mm without bonding of the turbulator, taper wire coiled turbulator and pin wire coiled turbulators. Results have indicated that the heat transfer rate enhances inversely with the pitch of the wire coiled coil matrix turbulator directly proportional to the mass flow rate.

Keywords: Plain Tube, Wire Coiled Turbulator, Taper Wire Coiled Turbulator, Pressure Drop, Friction Co-Efficient.

1. Introduction

Heat transfer can be increased by active and passive techniques. In the active techniques external power is required to increase the heat transfer. For the passive technique method no external energy is required for the enhancement of heat transfer. Wire coiled coil matrix turbulator (WCCMT), taper wire coiled coil matrix turbulator, and pin wire coiled turbulators are falls under the category of passive techniques.In this experimental work, turbulators are used to increase the heat transfer. Three different types of wire coiled turbulators (shown in figs. are used to increase the heat transfer. Due to the insertion of turbulators there is increase in pumping power due to the pressure drop. But when compared to enhancement in heat transfer the increase in pumping power is very less.



L = length of the wire coiled turbulator (1500 mm)

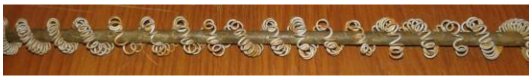
P = pitch (5mm, 10mm, 15mm)

D1 = Outer Diameter of the wire coil turbulator (18mm)

D2 = inner Diameter of the wire coil turbulator (6mm)

Wire coiled turbulator 5mm pitch

10 mm pitch



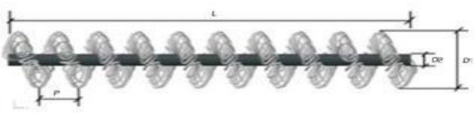
15 mm pitch

Taper wire coiled turbulator: 5mm pitch

10mm pitch

15mm pitch

Pin wire coiled turbulator:



EXPERIMENTAL DETAILS:

SPECIFICATIONS:

(1) Inner Tube of the double pipe:

i. Material - Copper
ii. Inner diameter - 33 mm
iii. Outer diameter- 38 mm
iv. Length - 1550 mm

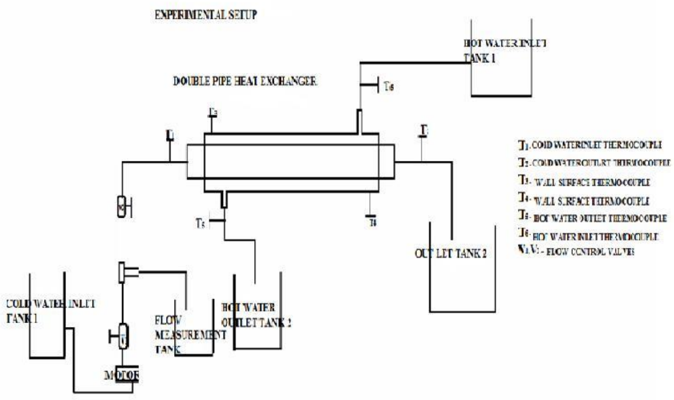
(2) Outer pipe of the double pipe:

i. Material - Mild steel
ii. Inner diameter - 63.5 mm
iii. Outer diameter- 66.5 mm
iv. Length - 1450 mm
v. Insulationmaterial- Asbestos

(3) Digital temperature indicator:

i. thermocouple - k type
ii. Number of sensors - 8 no's
iii. Range - 0-199.9 °C
iv. Displayunit - digitalthermometer

EXPERIMENTAL SETUP:



6.2.4 WORKING PRINCIPLE OF EXPERIMENTAL SETUP:

1. The hot and cold water tank is filled with the required level water.
2. The three heaters are switched on through the main power supply of the setup.
3. The RDT (Relational Temperature Detector) is set with the required temperature of hot water inlet.
4. In this experiment there are two flow control valves are used in that two initially one flow control valve is closed and another one is open this allow the fluid to fill in the container by using this we measure the flow rate.
5. After that both the flow control valves are open the cold water is entered into the inner pipe of the setup.
6. The hot water is entered into a inner tube of the heat exchanger through flow control valve,

7. The sensor measures the hot water and inlet and outlet temperature and indicates in the temperature indicator.
8. After taking the required readings the gate valves is adjusted to the initial position.
9. Finally the heater and main power is switch OFF and the water is drained.

DATA REDUCTION EQUATIONS:

1. Heat Transfer Rate (Q) = Q = m Cp $(T_0 - T_i) = h_i A_i (\Delta T_i)m$
2. Nusselt number , friction factor,pressure drop equations (plain tube):

   $Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$ f =
   $0.046\ (Re)^{-1/5}$
   $\Delta p = \frac{4fLVc^2}{2\ D_2}$

3. Nusselt number , friction factor,pressure drop equations (plain tube):

   $Nu = 0.459 Re^{0.606} / Pr^{0.073}$
   $f = 26.43/(Re)^{0.268}\ (Pr)^{0.189}$
   $\Delta p = \frac{4fLVc^2}{2D_2}$

Results and discussion:

The present experimental results on heat transfer and friction characteristics in a plain tube are first validated in terms of Nusselt number and friction factor. It is important to compare the experimental results obtained for the fully developed turbulent flow for various turbulator inserts.At 25% valve open, with a pitch of 5 mm, the wire coiled turbulators without bonding have resulted in almost 2 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.75 times and 1.5 times, respectively. At 50% valve open, with a pitch of 5 mm, the wire coiled turbulators without bonding have resulted in almost 1.83 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.66 times and 1.33 times, respectively. At 75% valve open, with a pitch of 5 mm, the wire coiled turbulators without bonding have resulted in almost 1.75 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.63 times and 1.37, respectively. At 100% valve open, with a pitch of 5 mm, the wire coiled turbulators without bonding have resulted in almost 1.63 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.45 times and 1.27 times, respectively.

At 25% valve open, with a pitch of 5 mm, the taper wire coiled turbulators without bonding have resulted in almost 2.25 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 2 times and 1.75 times, respectively. At 50% valve open, with a pitch of 5 mm, the taper wire coiled turbulators without bonding have resulted in almost 2 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.83 times and 1.5 times, respectively. At 75% valve open, with a pitch of 5 mm, the taper wire coiled turbulators without bonding have resulted in almost 1.87 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.63 times and 1.5 times, respectively. At 100% valve open, with a pitch of 5 mm, the taper wire coiled turbulators without bonding have resulted in almost 1.72 times enhancement when compared with plain tube. On the other hand, for pitches of 10 mm and 15 mm the enhancement were 1.45 times and 1.18 times, respectively. On other hand the Nusselt number, friction factor, and pressure drop are indirectly proportional to the pitch.

At 25% valve open, with a pin wire coiled turbulator without bonding have resulted in almost 2.5 times enhancement when compared with plain tube. At 50% valve open, with a pin wire coiled turbulator without bonding have resulted in almost 2.16 times enhancement when compared with plain tube. At 75% valve open, with a pin wire coiled turbulator without bonding have resulted in almost 2 times enhancement when compared with plain tube. At 100% valve open, with a pin wire coiled turbulator without bonding have resulted in almost 1.81 times enhancement when compared with plain tube. On other hand the Nusselt number, friction factor, and pressure drop are indirectly proportional to the pitch.

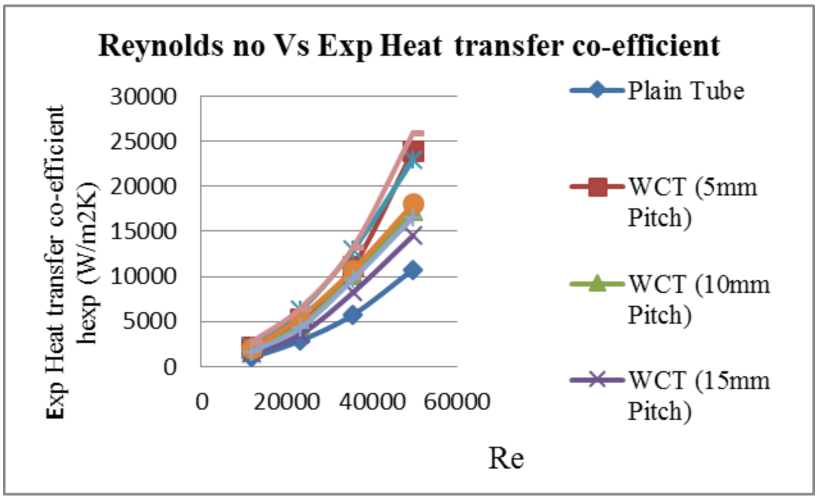


Fig 10. Reynolds number Vs Experimental Heat transfer co-efficient

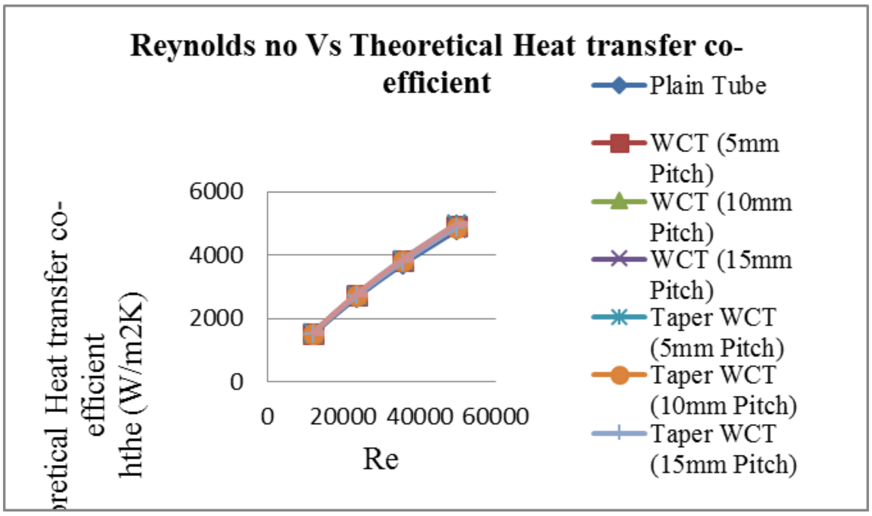


Fig 11. Reynolds number Vs Theoretical Heat transfer co-efficient

Figures 10and 11 shows variation of Nusselt number with Reynolds number for the different cases like plain tube, wire coiled turbulator, taper wire coiled turbulator,and pin wire coiled turbulator.

It is observed that the heat transfer rate is higher for pin wire coiled turbulator while compare with other turbulators.

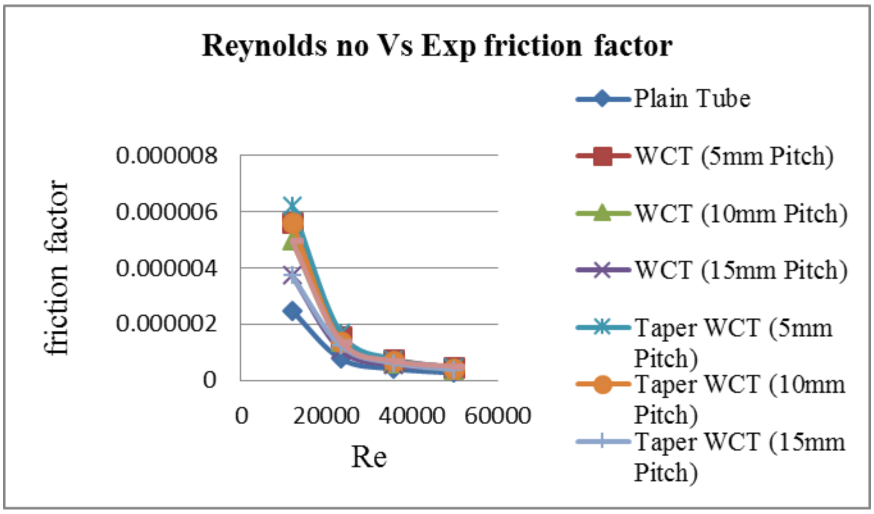


Fig 12. Reynolds number Vs Experimental friction factor

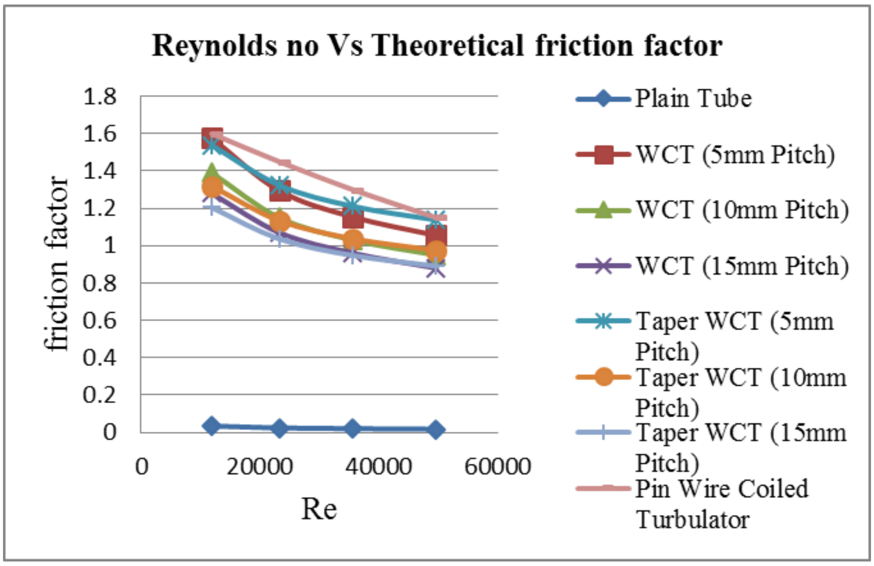


Fig 13. Reynolds number Vs Theoretical friction factor

Figures 12and 13 shows variation of friction factor with Reynolds number for the different cases like plain tube, wire coiled turbulator, taper wire coiled turbulator,and pin wire coiled turbulator.

It is observed that the friction factor is higher for pin wire coiled turbulator while compare with other turbulators.

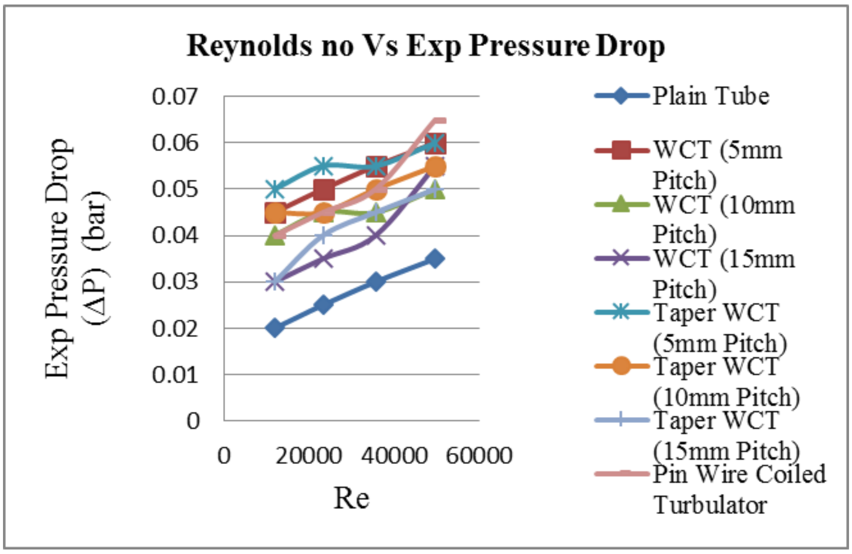


Fig 14. Reynolds number Vs Experimental Pressure drop

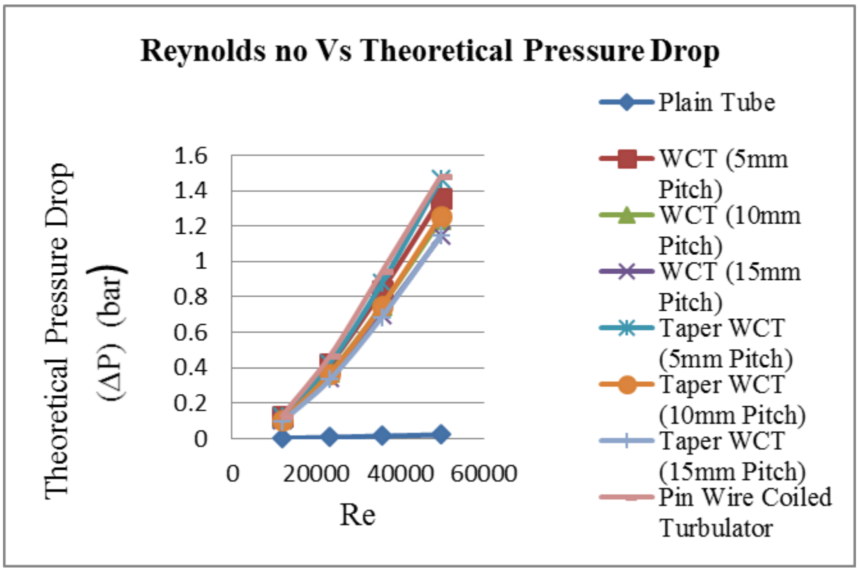


Fig 15. Reynolds number Vs Theoretical Pressure drop

Figures 14 and 15 shows variation of pressure drop with Reynolds number for the different cases like plain tube, wire coiled turbulator, taper wire coiled turbulator,and pin wire coiled turbulator.

It is observed that the pressure drop is higher for pin wire coiled turbulator while compare with other turbulators.

CONCLUSION:

Experimental data obtained were compared with those obtained from the theoretical data of plain tube.

1. The maximum Nusselt number for pitch 5 mm was obtained which indicates that heat transfer coefficient increases with the decreasing pitch of the turbulator.
2. The friction factor also increases with the decreasing pitch.
3. The above findings indicate that the use of wire coiled coil matrix turbulator,taper wire coiled turbulator and pin wire coiled turbulators in the tube-in-tube heat exchanger enhances the heat transfer with considerable pressure drop.
4. The experimental data which indicates the heat transfer rate of pin wire coiled turbulator is higher than the wire coiled and taper wire coiled turbulators.

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