ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Experimental investigation on convective heat transfer characteristics in a circular tube fitted with perforated twisted tape and wire coil

E. Kannan*, C. Balasuthagar, S. Ponsankar, M. sivashankar
Department of Mechanical Engineering, SRM University, Kattankulathur,
Chennai, Tamil Nadu – 603203.
***Corresponding author:kannan4028@gmail.com**

ABSTRACT

Enhancing the heat transfer is one of the techniques to increase the performance of the heat exchanger system. Among the enhancement methods, passive techniques attract the researchers due to its lower power requirement. Literatures particularly indicate that insertion of tape is the economical method to enhance the heat transfer rate. Here, the heat transfer from circular cross section tube fitted with pierced twisted tape and wire coil are experimentally studied. A plain brass tube having 60 mm outside diameter, 1000 mm length is insulated with the glass wool and asbestos rope to avoid the heat dissipation to surrounding. This tube is fitted with pierced twisted tape of twist ratio 2,3,4 and wire coil of diameter 50 mm. Experiments were conducted by varying twist & wire coil ratio. The result indicates nusselt number varies inversely to the twist ratio. The thermal factor is more than 1.44 while using the pierced twisted tape with lower twist ratio and wire coil.

Keywords: Heat transfer enhancement, twisted tape, twist ratio, wire coil ratio

1. INTRODUCTION

Among the various insertion techniques twisted tape attract the various researchers for the following reason. The heat transfer can be varied by varying the twist pitch of the device. Typical twist pitch ratios possible to manufacture (360° twist pitch / tape width) are between 6 and 18. The width of the tape is specified between the tape and the tube wall. Large clearances between tube wall and twisted tapes can cause bypass flow and thermal underperformance.

Shyy Woei Chang et al. have experimentally understood the compound heat transfer improvement in a tube with serrated twisted tape; they found that the tube with serrated twisted tape is an effective measure for further heat transfer development.

Jian Guo et al. have studied numerically the laminar flow in a circular tube with twisted tape. They observed that for short width twisted tapes, the heat transfer and thermo hydraulic performance are declined by cutting off the tape edge.

Bhuiya et al. have studied experimentally the effect of triple helical tapes on heat transfer improvement. The triple helical tapes with diverse helix angles, α=9°, 13°, 17°,and 21° were observed for Reynolds number from 21,000 to 50,000. The experiment revealed Nusselt number, effectiveness, friction factor for the insertions were found to be 4.5, 3.45 and 3.0 times, respectively, over the plain tube. The highest improvement achieved was 3.7 for the insertions.

2. EXPERIMENTAL SET-UP

The experimental rig consists of an inlet section, test section, Electric blower and a heater. The tube shaped inlet section 533 mm length was prepared to avoid flow disturbances. The test section was made of brass tube having 56 mm inside diameter, 60 mm outside diameters and 1000 mm long. The triple twisted tapes were made of mild steel with four unlike twist ratios, TR = 2,3,4. Nichrome wire of resistance 1.2 Ω/m was used as an electric heater. The heat transfer and pressure drop tryouts were carried out separately. The heat transfer experiment was made under a constant heat flux condition. The pressure drop test was carried under an isothermal condition without heater.

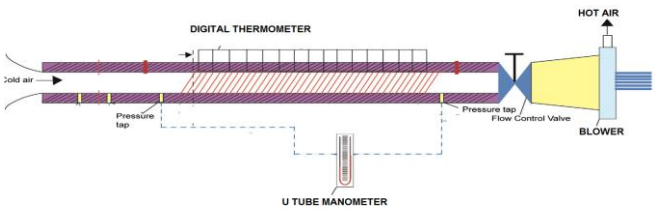

Figure.1.Schematic diagram of the experimental set-up

Experimental details:

Brass tube length (L) = 1000 mm

Brass tube diamete (d_i) = 55 mm

Insulation material = Glass wool, Asbestos rope

Heating element = Nichrome wire

Twisted tape material = Mild steel
Twisted tape width = 45 mm
Twist ratio TR = 2,3,4
Blower = 1.8 A, 230V

3. RESULTS AND DISCUSSION

TABULATION

Table.1.Thermal performance factor for twist ratio 2 with coil pitch ratio 12

Mass flow rate Kg/min	Reynolds number Re	Nusselt number Nu	Friction factor f	Thermal performance factor η
0.24	26600	200	0.35	1.6
0.29	32300	210	0.32	1.54
0.33	35720	216	0.31	1.46
0.38	41800	225	0.28	1.40

Table.2.Thermal performance factor for twist ratio 3 with coil pitch ratio 12

Mass flow rate Kg/min	Reynolds number Re	Nusselt number Nu	Friction factor f	Thermal performance factor η
0.24	26600	180	0.31	1.42
0.29	32300	185	0.29	1.40
0.33	35720	195	0.27	1.38
0.38	41800	200	0.26	1.32

Table.3.Thermal performance factor for twist ratio 4 with coil pitch ratio 12

Mass flow rate Kg/min	Reynolds number Re	Nusselt number Nu	Friction factor f	Thermal performance factor η
0.24	26600	140	0.27	1.2
0.29	32300	147	0.24	1.17
0.33	35720	152	0.23	1.10
0.38	41800	162	0.20	1.0

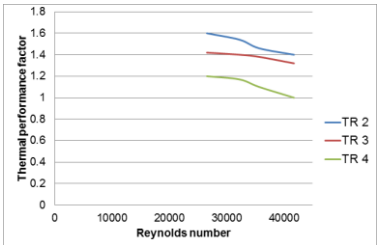

Figure.1.Relationship between Reynolds number and thermal performance factor for various twist ratios

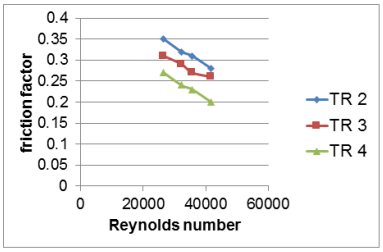

Figure2.Relation between Reynolds number and friction factor for various twist ratio

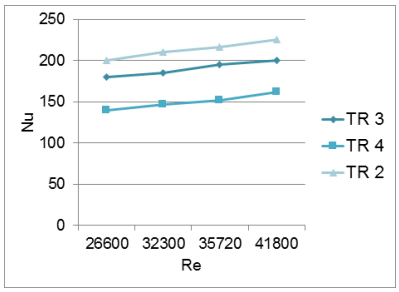

Figure.3.Relation between nusselt number and Reynolds number for various twist ratio

From the fig 3.1, 3.2, 3.3 it is understood that the twisted tape and wire coil increases the nusselt number considerably. The influence of using the pierced twisted tape and wire coil on heat transfer is significant for all Reynolds number. With increase in twist ratio the performance factor decreases. With increase in coil pitch ratio the thermal performance decreases.

4. CONCLUSION

Studies on the heat transfer characteristics in a circular tube fitted with pierced twisted tape and wire coil for various twist ratio has been done experimentally. The results indicate that the nusselt number increases with decrease in the twist ratio. The thermal performance factor is more than 1.44 while using the pierced twisted tape with lower twist ratio and lower wire coil ratio.

REFERENCES

Bhuiya MMK, Ahamed JU, Chowdhury MSU, Sarkar MAR, Salam B, Saidur R, Masjuki HH, Kalam MA, Heat transfer enhancement and development of correlation for turbulent flow through a tube with triple helical tape insert, International Communications in Heat and Mass Transfer, 39, 2012, 94–101.

Bhuiya MMK, Chowdhury MSU, Ahamed JU, Khan MJH, Sarkar MAR, Kalam MA, Masjuki HH, Shahabuddin M, Heat transfer performance for turbulent flow through a tube using double helical tape insert, International Communications in Heat and Mass Transfer, 39, 2012, 2012, 18–825.

Bhuiya MMK, Chowdhury MSU, Shahabuddin M, Saha M, Memon LA, Thermal characteristics in a heat exchanger tube fitted with triple twisted tape inserts, International Communications in Heat and Mass Transfer, 48, 2013, 124–132.

Chang SW, Yu KW, Lu MH, Heat transfers in tubes fitted with single, twin, and triple twisted tapes, Experimental Heat Transfer, 8, 2005, 279–294.

Eiamsa-ard S, Nivesrangsan P, Chokphoemphun S, Promvonge P, Influence of combined non-uniform wire coil and twisted tape inserts on thermal performance characteristic, International Communications in Heat and Mass Transfer, 37, 2010, 850–856.

Jian Guo, Aiwu Fan, Xiaoyu Zhang, Wei Liu, A numerical study on heat transfer and friction factor characteristics of laminar flow in a circular tube fitted with center-cleared twisted tape, International Journal of Thermal Sciences, 50, 2011, 1263-1270.

Pongjet Promvonge, Somsak Pethkool, Monsak Pimsarn, Chinaruk Thianpong, Heat transfer augmentation in a helical-ribbed tube with double twisted tape insert, International Communications in Heat and Mass Transfer, 39, 2012, 953–959

Shyy Woei Chang, Ming Hui Guo, Thermal performances of enhanced smooth and spiky twisted tapes for laminar and turbulent tubular flows, International Journal of Heat and Mass Transfer, 55, 2012, 7651–7667.

Shyy Woei Chang, Yih Jena Jan, Jin Shuen Liou, Turbulent heat transfer and pressure drop in tube fitted with serrated twisted tape, International Journal of Thermal Sciences, 46, 2007, 506–518.

Smith Eiamsa-ard, Chinaruk Thianpong , Pongjet Promvonge, Experimental investigation of heat transfer and flow friction in a circular tube fitted with regularly spaced twisted tape element, International Communications in Heat and Mass Transfer, 33, 2006, 1225–1233.

Smith Eiamsa-ard, Chinaruk Thianpong, Petpices Eiamsa-ard, Pongjet Promvonge, Convective heat transfer in a circular tube with short-length twisted tape insert, International Communications in Heat and Mass Transfer, 36, 2009, 365–371.