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An Analysis Of Flow Capacity Variation and Distance Between Louvered Strip Constant Angle 25° Of Heat Transfer and Pressure Decrease On The Heat Exchanger

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Abstract. This study aims to determine the effect of variations in flow rate and the louvered strip inclination angle on heat transfer in a double-pipe heat exchanger and the impact of variations in flow rate and inclination angle of the louvered strip on the inner tube pressure drop in a double-pipe heat exchanger. Three pieces of louvered strips at 50 mm, 70 mm, 90 mm are inserted into the inner tube of the heat exchanger with a constant tilt angle of 25°. Cold and hot water are used at a constant value where the cold-water flow rate is 600 liters/hour and V = 900 liters/hour, while the hot water flow rate is 1200 liters/hour. The inlet and outlet temperatures of both hot and cold water are measured, and the heat transfer characteristics of the heat exchanger are calculated as a result of the pressure drop that occurs in the inner tube due to the difference in height on the U-tube manometer used.

Keywords. Flow Capacity Variation, Louvered Strip, Heat Transfer, Heat Exchanger,

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1 Introduction

The science of heat transfer or heat transfer not only tries to explain how heat energy is transferred from one object to another but also can predict the rate of displacement that occurs under certain conditions. This completes the first and second laws of thermodynamics by providing several forms of experimentation that can be utilized to determine energy transfer. As in thermodynamics, the experimental rules used in the heat transfer problem are sufficiently simple and expanded to various practical situations. (J.P. Holman, 1988).

Pankaj, N.S., Rajeshkumar, U.S., Pradip, R.B. (2013) conducted experiments on the mean Nusselt number, friction factor and heat gain factor characteristics in circular tubes with various types of deep threads with a pitch of 120 mm under uniform wall heat flux boundary conditions. In this experiment, measured data were taken at the Reynolds number ranging from 7,000 to 14,000 with air as the working fluid. Experiments were carried out on circular tubes with three different types of threaded threads, namely. The data obtained from heat transfer and friction factor were compared with data obtained from plain round tubes under similar geometric and flow conditions. The variations in heat transfer and pressure loss were in the form of Nusselt numbers (Nu) and the friction factor (f) are determined and depicted graphically, respectively. It was observed that at all Reynolds numbers, Nusselt numbers and thermal performance increased for circular tubes with deep-threads compared to plain round tubes. This is due to the increased strength and intensity of the vortices emitted from the deep-threads.

Murugesan (2009), conducted research on heat transfer and friction factor characteristics of a heat exchanger pipe by installing a trapezoidal type twist plate turbulator with a Reynolds number range of up to 12000. Double tube heat exchanger used in this study, where the diameter the inner pipe is 28.5 mm long and 2000 mm long, the inner and outer pipe materials used are copper and stainless steel respectively. The hot water fluid is supplied to the trapezoidal section inner tube for testing. Meanwhile, cold water flows through the outer pipe wrapped in asbestos and glass wool to reduce heat loss to the environment. The turbine is made of thick aluminum and has a width of 1.5 mm and 23.5 mm respectively with a length of 2000 mm. The twist ratio is determined from the ratio of one strand length or twist pitch length to the twist diameter y = 6.0 and y = 4.4. The dimensions of the trapezoidal cut are 8 mm deep, 8 mm base, 12 mm long. These strips are located above and below the center of the twist to break up and increase the turbulence of the flow near the pipe wall.

Research on the heat transfer characteristics in pipes with the installation of a threaded barrier (with core) and a barrier (without core) (Eiamsa, 2006) examined the effect of installing this barrier on a turbulator into an inner tube flowing hot water on a double tube heat exchanger with a helical screw tape diameter of 17 mm and a core diameter of 5 mm with a clearance of 4 mm in the pipe. When compared to plain tube installation with helical screw tape inserts can increase the rate of heat transfer. This is due to the effect of the swirling generated by the helical screw turbulator, so that the pressure gradient in the radial direction and the temperature increase. This flow eddy increases the turbulence so that it will increase the convection heat transfer, as well as the Reynolds number will be high which is indicated by the high rate of heat transfer. The results showed that the helical screw with core rod has a greater Nusselt number than the Nusselt number of a heat exchanger without a turbulator, namely 230% ($Nu = 0.0094\, Re^{0.96}\, Pr^{1/3}$). The friction factor is also increased by the presence of a helical screw turbulator which is 4.9 times larger than a plain tube.

This study aims to determine the effect of variations in flow rate and the louvered strip inclination angle on heat transfer in a double-pipe heat exchanger and the impact of variations in flow rate and inclination angle of the louvered strip on the inner tube pressure drop in a double-pipe heat exchanger. Three pieces of louvered strips at 50 mm, 70 mm, 90 mm are inserted into the inner tube of the heat exchanger with a constant tilt angle of 25°

2 Research Method

In this study, the independent variables consisted of three variations of flow rate, namely, 600 L/hour, 900 L/hour, and 1200 L/hour, for three variations of the distance between louvered strips, namely, 50 mm; 70mm; and 90 mm (with a constant inclination angle of 25o louvered strips) inserted in the hot water tube in a counter-flow double-pipe heat exchanger.

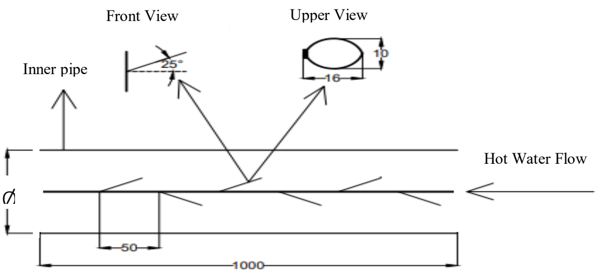
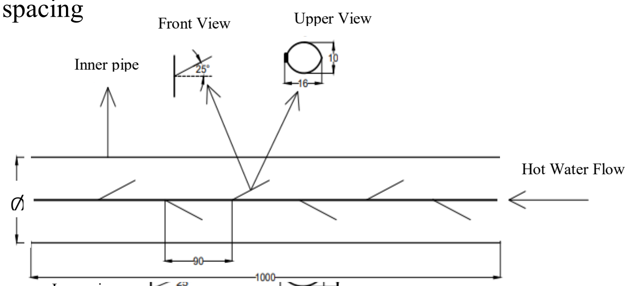


Fig.1 louvered strip test specimens with 50 mm spacing



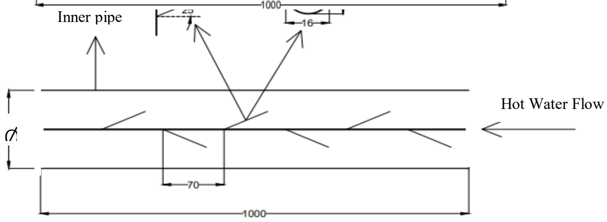


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Fig.3 Louvered strip test specimens with a spacing of 90 mm

B = Ball Valve
C = Centrifugal Pump
D = Double Pipe
F = Flow Meter
M = Manometer U
T = RTD
CW = Cold Water
HW = Hot Water
HT = Heater

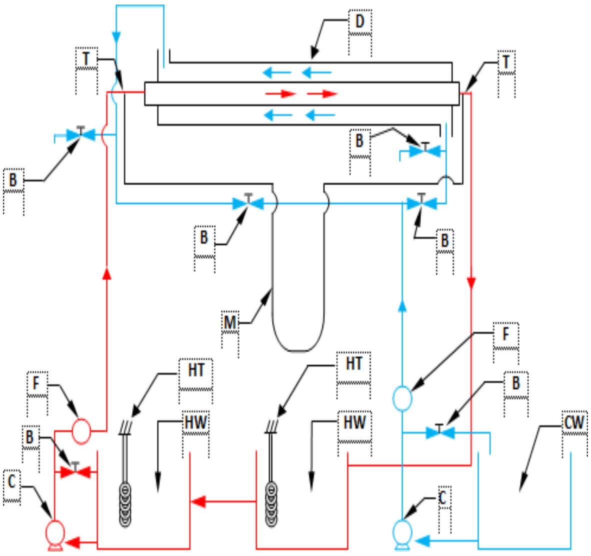

Fig.4 Installation of research tools

3 Result and Discussion

3.1 Relationship between hot water discharge variations and the distance between louvered strips to the Reynolds number (Re)

Figure 1 explains the relationship between variations in the flow rate of hot water and the distance between the louvered strips to the Reynolds number (Re) in a double pipe heat exchanger in the opposite direction, where it can be seen that the Reynolds number (Re) does not change significantly to the variation in the distance between the louvered strip as well as on variations in the discharge of hot water flow. Changes in the Reynolds number that are not significant in variations in the discharge of the hot water flow and the distance between the louvered strips are caused by changes in the density and dynamic viscosity of the hot water, which are also small, which is known that the Reynolds number depends on the density and dynamic viscosity of the fluid. The value of the Reynolds number for variations in the flow of hot water at variations in the distance between the louvered strips can be seen in Table 1

Tabel 1. Reynolds number and Prandtl number on variations of hot water flow discharge and the distance between louvered strips.

Debit (L/hours)	$Pr_{hot, rerata}$				$Re_{hot, rerata}$			
	0 (cm)	50 (cm)	70 (cm)	90 (cm)	0 (cm)	50 (cm)	70 (cm)	90 (cm)
600	3.52	3.676400	3.657200	3.611200	22384.222	21886.072	21985.541	22227.734
900	3.59	3.688800	3.676800	3.653200	33409.387	32668.128	32760.484	32943.703
1200	3.63	3.698800	3.655200	3.687600	44060.618	43411.983	43860.206	43526.218

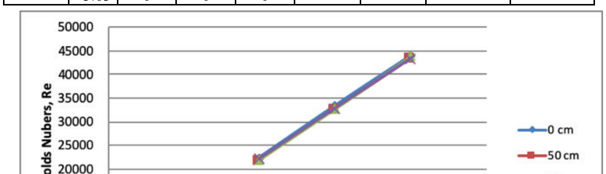

Fig. 5 The average value of the Reynolds number and Prandtl number on the variation of hot water flow discharge and the distance between the louvered strips.

The relationship between the Reynolds number and the Nusselt number for the variation in the distance between the louvered strips can be seen in Figure 4.2, where it can be seen that the Nusselt number increases with the increase in the Reynolds number. However, the increase in the Reynolds number and Nusselt number for the variation in the distance between the louvered strips is not significant. This is because the Nusselt number depends on the Reynolds number, which is known that the Nusselt number is directly proportional to the Reynolds number, so if the Reynolds number increases by itself, the Nusselt number will increase. The change in the Reynolds number and Nusselt number in the variations in the distance between the louvered strips that occur is tiny because the change in fluid properties is also tiny, as shown in Figure 2.

Tabel 2. Reynolds number and Nusselt number in the variations in the distance between the louvered strips

Debit (L/jam)	$Re_{hot, rerata}$				$Nu_{hot, rerata}$			
	0 (cm)	50 (cm)	70 (cm)	90 (cm)	0 (cm)	50 (cm)	70 (cm)	90 (cm)
600	22384.222	21886.072	21985.541	22227.734	101.840	100.807	101.014	101.517
900	33409.387	32668.128	32760.484	32943.703	140.446	139.025	139.203	139.556
1200	44060.618	43411.983	43860.206	43526.218	175.855	174.676	175.492	174.885

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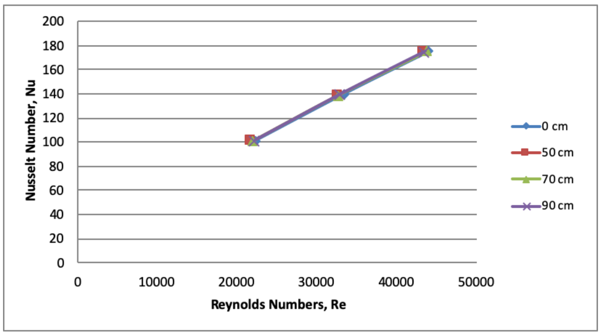

Fig. 6 The relationship between the Reynolds number and the Nusselt number at various distances between the louvered strips

The effect of variations in the flow rate of hot water on the rate of heat transfer in the variation of the distance between the louvered strips can be seen in Figure 7. The heat transfer rate of the heat exchanger increases as the variation in the distance between the louvered strips decreases and the variation in the flow rate of hot water increases. The magnitude of the value of the heat transfer rate of the heat exchanger on the variation of the hot water flow rate and the distance between the louvered strips can be seen in Table 4.

Table 4. The heat transfer rate for variations in hot water flow rate and the distance between the louvered strips.

Debit	Q_{HE} (W)			
(L/hours)	0 (cm)	50 (cm)	70 (cm)	90 (cm)
600	1521.762	3640.069	2878.984	1743.855
900	2430.441	4826.294	4249.372	3158.879
1200	4073.243	6256.905	5249.475	4539.967

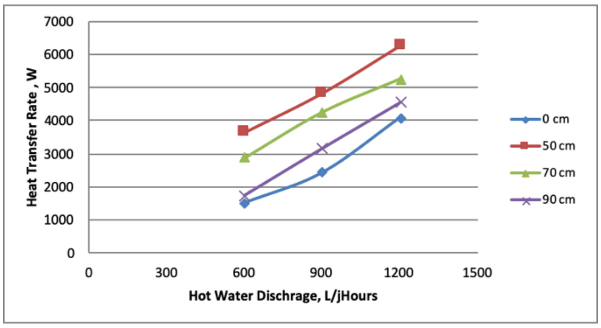

Fig. 7 The relationship between the variations in the flow rate of hot water and the heat transfer rate of the heat exchanger in the variation of the distance between the louvered strips.

3.2 Relationship between variations in the flow rate of hot water and pump power to overcome friction at variations in the distance between the louvered strips

The pump power generated to overcome friction increases with decreasing distance between the louvered strips and the flow rate of hot water (Figure 4.4). The increase in pump power to overcome friction is due to the shorter distance between louvered strips or the greater number of louvered strips which will result in greater resistance. The amount of pump power to overcome friction for variations in the flow rate of hot water and the distance between the louvered strips can be seen in Table 4.

Tabel 4 The average value of the pump power used to overcome friction on variations in hot water flow rate and the distance between the louvered strips.

Debit	W_P			
(L/jam)	0 (cm)	50 (cm)	70 (cm)	90 (cm)
600	0.016	0.041	0.036	0.027
900	0.054	0.118	0.102	0.090
1200	0.097	0.235	0.198	0.190

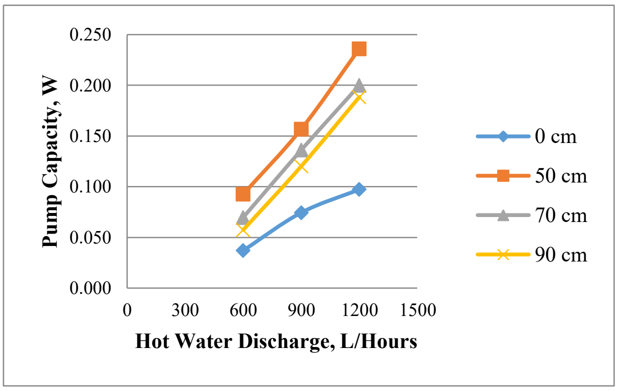

Fig.8 Relationship between hot water discharge variations and pump power

4 Conclusion

After testing and analysing the data obtained, the conclusions can be drawn as follows,

1. The Reynolds number (Re) and Nusselt number (Nu) experience insignificant changes to the variation in the distance between the louvered strips inserted in the inner tube of the double-pipe heat exchanger.
2. The heat transfer rate of the double-pipe heat exchanger increases with decreasing variation in the distance between the louvered strips.
3. The pump power required to overcome the friction losses increases as the distance between the louvered strips decreases.

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