Chapter VII

DISCUSSION

7.1 Effect of Cycle Time Upon the Over all Heat Transfer Coefficients Experimental Results

Experimental results showed in Figure 6.1 and 6.2 indicate that the over all heat transfer coefficient had the highest value at cycle time of 10 second. The curves have similar shapes. According to these curves a conclusion in drawn: when the fraction open increased from 0.5 to 0.7 at both inlet hot water temperatures of 82°C and 72°C, the over all heat transfer coefficients increased. When cycle time increased from 10 to 13 seconds, over all heat transfer coefficients decreased rapidly and approached the value obtained in conventional manner. The over all coefficients were appreciably higher than the values obtained in conventional operation.

Cyclic operation is the cause to form velocity fluctuation. This leads to the formation fo turbulent diffusivity or eddy diffusivity. It is always expressed in term of turbulent intensity or a scale of turbulence. Boundary layer thickness in the conventional manner is relatively thick. As the controlled cycling was applied, the turbulent diffusivity was formed so the boundary layer thickness would be reduced close to the interface. Therefore the resistance of heat transfer of the boundary layer was reduced and the obtained temperature gradient might be increased

It was found that the cycle time of 10 seconds was the optimum point to give the highest value of over all heat transfer coefficients. When the cycle time was short, there was not enough time to develop the turbulent diffusivity in order to reduce boundary layer thickness. So cycle time of 6.1 seconds did not give the high value of heat transfer coefficients. Although, the cycle time was increased to 13 seconds, the over all heat transfer coefficient was not higher; because the higher cycle time gave the lower turbulent intensity that could not reduce boundary layer thickness. From these reasons, the results showed an optimum value of cycle time to yield a maximum heat transfer coefficient.

7.2 Effects of Reynols Number on the Over all Heat Transfer Coefficients

From the experimental results in table 6-2, hot water Reynolds number ranged from 2896 to 7149 and cold water Reynolds number ranged from 1145 to 2346. The plots of these results are shown in figures 6-3 to 6-8.

Reynolds number was the significant factor in measuring the velocity of the fluid flow. The higher Reynolds number, the thinner boundary layer was obtained. It was found that there was only one value of Reynolds number which gave the highest over all heat transfer coefficients in each inlet hot water temperature.

When the controlled cycling operation was applied to laminar flow of fluid, the turbulent diffusivity could reduce significantly the boundary layer thickness. But for turbulent flow, the boundary layer was already thinner. So, the turbulent diffusivity which resulted from controlled cycling operation had little effect in reducing the thickness of boundary layer. Therefore, the increase in the over all heat transfer coefficient for turbulent flow was less than for laminar flow.

The experimental results showed that Reynolds number which were the optimum values were 3620 and 4531 for inlet hot water temperatures of 82°C and 72°C respectively. The values were independent of cycle time and cold water flow rate. From the experimental results, it can be concluded that

i) For the same hot water Reynolds number, over all heat transfer coefficients increased as the cold water Reynolds number decreased.

ii) For the constant line of cold water Reynolds number there was an optimum hot water Reynolds number for each fraction open and each inlet hot water temperature

7.3 Effect of Fraction Open Upon the Over all Heat Transfer Coefficients

The experimental results were shown in Figure 6-11 and 6-12. All the curves had the similar shape. They had the same optimum fraction open of 0.7. For fraction open greater than 0.7 over all heat transfer coefficient decreased and approached to the value obtained for the conventional operation. The optimum value of fraction open was independent of the inlet hot water temperature and cycle time.

Fraction open was the variable which related to the time of fluid flowing in the system. A higher value of fraction open takes a longer time for fluid flow. From the results at fraction open of 0.5, it had a short time so that eddy diffusivity could not be developed extensively in pipes. Hence, the boundary layer thickness could not be reduced greatly as compared to conventional operation, and the obtained over all heat transfer coefficient at fraction open of 0.5 was lower than fraction open of 0.7. At fraction open of 0.7 it had sufficient time to yield significant effect of forming eddy diffusivity. But when the fraction open was greater than 0.7, the operating condition approached that of the conventional one. Therfore, the obtained heat transfer coefficients were lower.

7.4 Effect of Inlet Hot Water Temperature Upon Over All Heat Transfer Coefficient

The inlet hot water temperature had little effect upon the over all heat transfer coefficients. It can be explained in term of viscous force. The effect would have a great role if the viscosity of the fluid had high temperature dependency. For fluid whose viscosity varies greatly with the change of temperature, in varying the fluid inlet temperatures will change the boundary layer thickness greatly. Hence, the temperature difference between the wall and the bulk temperatures will also be changed. The obtained over all heat transfer coefficients will consequently change significantly.

For the present experiments, the fluid used was water which is low viscous fluid. So, the effect of fluid temperature upon the over all heat transfer coefficient was little. Another reason, the experimental runs were operated at 82°C and 72°C which had an insufficiently wide range of temperature to show the effect clearly.

7.5 Experimental Consideration

From the experimental performance some significant points of error which might affect the results, were revealed and they are as follows:

1. The steam-pressure controller of the boiler in the laboratory was not functioning properly. Hence, in order to keep the inlet hot water temperature constant, the steam

Pressure was adjusted all the time. It took a great deal of time in adjusting to the required temperature. The intermittent adjustment of the inlet hot water temperature might have disturbed the cyclic steady-state of the process

2. The measurement of temperatures. There was some error in measuring the temperatures at various point of the equipment. In the conventional manner, it was easy to record these values. However, in the controlled cycling operation, it had a short time to record various temperatures in the same cycle of operation. In the present experiments, mercury thermometers were used. However, for future study, copper-copper constantan thermocouples are recommended to be used.

3. The fluid flow meter readings; Because the cyclic operation caused fluctuation in fluid flow rate, the approximated average values of manometer readings were recorded.

4. Physical properties: viscosity, density and thermal conductivity of pipe wall and water were assumed constant. In fact, these properties are dependent upon the temperature. It would have been precise, if the correction for this temperature effect were included in the calculation.

5. The heat loss: In fact, there were heat losses from the experimental equipment, the double pipe heat exchanger, so the actual temperatures would have been higher than those obtained.

6. The air bubbles in the manometers. In the cyclic manner, automatic control valves were open and closed alternately, and the centrifugal pump used for circulating hot water through the system were the cause to initiate air bubbles in the manometers used in measuring fluid flow rates. It was necessary to stop the operation, quite frequently, in order to eliminate the air bubbles.