CHAPTER V

DISCUSSION

5.1 The Effect of Important Parameters

5.1.1 Effect of Length to Diameter Ratio (L/D)

The plots in Figs. 6 and 7 show clearly that the extraction efficiency for ε_{90} and ε_{50} increases monotonically with L/D. The increase is larger for small L/D and tends to flatten with increasing L/D. This accord to the fact that the higher L/D, the chance of water to remain separated becomes greater,ie. with a smaller cross-sectional area of the tank, the less area of contact between the hot and the cold water in the adjacent layer.

5.1.2 Effect of Reynolds number (Re_d)

Figs. 8 and 9 suggest that the extraction efficiency for ε_{90} and ε_{50} decreases with increasing Reynolds number. With higher Reynolds number, the jet effects at the entrance becomes more importants and will cause a streng mixing in the entrance region which results in a lower degree of water stratification.

5.1.3 Effect of Tank Diameter to Inlet Diameter Ratio (D/d)

The plots of Fig. 10 shows that ε_{90} decreases with decreasing inlet diameter for a fixed flow rate. The decrease is smaller with small D/d and sharply decreases with larger D/d. The reason is that with a large cross-sectional area of the inlet diameter, the velocity of the inlet water will be lower, which means, the water layer will have time to expand in a large radial direction. This will help in continually separation of the cold water adjacent to the warmer layer above. On the contrary, if the inlet diameter of the storage tank is small, the stream of the cold water with high velocity will shoot upward about the center of the tank while some of the hot water still remain around the edge. This jet effect will cause a higher mixing region and lower the efficient of the storage tank. The effect of D/d ratio is much stronger than the effect of inlet Reynolds number which indicates that the inlet geometry is an important parameter. A well design inlet distributer should aim at reducing jet mixing at entrance.

5.1.4 The Effect of Inlet-Exit Water Temperature Differences (Gr_D)

The temperature difference between the two fluids produces a stabilizing effect. Fig. 11 shows the tendency of the incoming cold water and the stored hot water to remain separated increases with Gr_D. It is seen that ε_{90} increases as Gr_D varies from 8.65×10^9 to 1.52×10^{10} (temperature is in the range of 26 - 59 °C).

The above observations are in agreement qualitatively with the experimental results of Lavan and Thompson (6). The correlation from their experiment has been attempted to fit into our experimental data, and their curve found out to be significantly over estimated. However, a new correlation from this experiment has not been proposed due to the small numbers of data taken. Therefore the graphical and tabulated results are instead, represented here.

5.2 The Effect of Cold Water Inlet Location

The experimental study indicated that the location of the water inlet is very important. Switching the inlet port from the bottom to the top of the tank has changed the extraction efficiency drastically. Fig. 12 shows this great effect where the value of the efficiency (ε_{90}) is only 11% for all flow rates. Clearly, the model described by equation (1) cannot be used to describe such behavior. This is due to the reasons given at length in section 2.2.2. Buoyancy is the predominant effect here. This statement is verified by calculating the residence time (the cold liquid particle entering the tank using Eq. (36)) and compare the time to the drop in the curve of Fig. 12. The calculated time was 0.05 min. corresponded very close to the break of the curve in the figure. The tail of the curve is explained by the inadequacy of the model (section 2.2) to take into account heat transfer phenomena. The entrainment of cold water with the hot water, the mixing of the two fluids, and the heat transfer between the fluid particles, lower the temperature of fluid in the tank and subsequently fluid which enters the tank afterward spent more time in the tank.

5.3 The Effect of Heat Conduction through the Tank Wall

Figs. 13, 14, 15, and 16 show the comparison of the theoretical and experimental output responses. In these figures, the effect of heat conduction calculated from Eq. (24) (Γ varied from 0.2543 - 0.3320) decreases with increasing Reynolds number. This is because the higher flow rate, the heat transfer resistance between the water and the wall in the film region is decreased. The efficiency comparison indicates that the assumption of infinite conduction through the wall under estimates the experimental response significantly. In the conditions of this experiment infinite conduction through wall may contribute to more than 10 % drop in the extraction efficiency. This observation verifies partially the conclusions given by Tanthapanichakoon and Laohakul (11). However, the results discussed in section 5.3 implies that sinusoidal input may fall out of applicable range of the model described by Eqs. (2), (3), and (16). For the materials used under this experiments, fiber glass and fiberglass lined with 1.5 mm. copper, the comparison shows that heat conduction through wall is negligible. In an attempt to fit the experimental data, model describe by Eq. (2), (3), and (17) was used. The responses calculate from Eq. (32) are shown on Figs. (13), (14), (15), and (16) for comparison. The temperature difference between the wall and the water was taken to be -1 when $z/L > \theta$ and +2 when $z/L < \theta$. These values (-1 and +2) were chosen base on a measured experimental data. (See Table 23.1 - 23.4). Curves plotted from calculated values of Eq. (32) is almost exactly that expected from an ideal plug flow (see Figs 13 - 16) which suggests that the effect of heat conduction is negligible.

The experimental values plotted on the same graph was located in the middle of the two theoretical curves. This suggestes that the flow is not a plug flow even though the heat conduction effect should be negligible. There must be another effect which influences this plug flow behavior. The most sensible effect to be considered is the effect of mixing between the adjacent layers of the water. It can be seen from Fig. 13 with Re_d = 3,215 that the efficiency of the experimental curve is lowered by 7 % compared to the calculated values from Eq. (32) and higher by 12 % compared to the calculated values from Eq. (24). Efficiency comparison for other Reynolds number is shown in Table 7. It is to be noted that the experimental curves appear similar to what one would have expected from axial dispersion model (section 2.3.3). And when the dispersion numbers are calculated according to Eq. (37), we find that the higher the Reynolds number, the greater the value of the dispersion number. For Re_d = 3,215, 6,221, 8,993, and 12,325, the value of D/v_mL = 0.0617, 0.0982, 0.0990 and 0.1190 respectively. These values are summarized in Table 8. Figs. 13, 14, 15, and, 16 compare responses from axial dispersion model with the experimental curves. It is to be noted that the model fit the experimental curves relatively well for the lower Re_d cases. The deviation is much larger for the higher Re_d with a noticeable shift towards the left, formation of dead spots inside the tank can explain the behavior qualitatively.