CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

In the present work, the performance of an annulus as a simple reactor is compared with an identical annulus to which some turbulence creators are fixed. These turbulence creators are in the form of twisted helical elements, fitted alternatively in the form of left and right handed elements on the outer surface of inner tube. Residence time distribution studies performed.

Reactor is the key piece of equipment in all hydrometallurgical digestion process. In the current study, an innovative tubular reactor having annulus with static mixer is examined, and it is possible that such a reactor would have many applications. The reaction kinetics and the yield are, to a great extent, decided by the type and the size of the reactor, and thus the selection, design, calculation and the optimization conditions are of importance in the chemical and metallurgical production.

A motionless mixer is simply added to the traditional tubular reactor. These mixers have the function of strengthening the mixing effects. In this study, a Ricker model is used to simulate the tubular reactor with inlet mass flow at various volumetric flow rates, and the residence time distribution (RTD) and flow field were investigated. The objective of the present study is to characterize the flow behavior of tubular reactor. Ricker model's predictions are validated with experimental RTD curves. The Ricker model analysis can improve the performance of the reactor and reduce testing in experiments.

The experimental C(t) curves were used to obtain information about the mean fluid residence time, the variance of distributions, σ^2, and the RTD distribution functions at the reactor exit, inclusively in normalized form E(θ).

The flow and concentration fields in a tubular flow reactor were simulated by simulating the fluid dynamics, in which Ricker model is used. The various values of volumetric flow rate (40-120 l/hr) are adopted. Simulations are validated with experimental residence time distribution (RTD) determination. It is shown that the fluid flow is very turbulent and the flow pattern approaches to the plug flow. Comparison between RTD curves shows that motionless mixture can improve the performance of reactor.

As the volumetric flow rate increases, the variance of RTD is enlarged, but the mean residence time has no obvious change. It can be seen from Table 6.3, 6.4, as the volumetric flow rate increases in the tubular reactor without BHE, the mean residence time and the variance of RTD decrease proportionally. As the brazed helical elements are inserted in the tubular reactor, the variance increases sharply, indicating that the fluid flow deviates from the ideal plug flow.

There are several influencing factors of mean residence time. In Ricker model prediction, as the brazed helical elements are inserted in to the tubular reactor, there is no evident effect on the mean residence time. But in experiments, the result shows that the mean residence time decreases with inserting brazed helical element.

The E(θ) curves show the presence of stagnant zones, When the maximum of E(θ) appears at $\theta < 1$, it indicates the presence of short-circuits;

while the maximum of E(θ) appears at θ>1, it indicates the presence of the back mixing. The width of RTD curve is an appropriate measurement to determine the approach to plug flow. Figure 6.2 to 6.31 shows the comparison of the RTD curves by simulations with experimental data, in which the two are accordant, especially at low volumetric flow rate, indicating that Ricker model approach used in this work is reliable for simulating the RTD curves of the tubular reactor.

By comparing with no motionless mixer, the RTD curve is narrow with motionless mixer, where the flow is shown to approach to plug flow conditions. The maximum of the curve E(θ) appears near θ=1 at various volumetric flow rate (40 – 120 l/hr), and flow pattern tends to ideal plug flow.

Table 6.5 shows the comparison between simulated and experimental data of mean residence time and variance. For existing error and model simplification, numerical prediction is a little lower in mean residence time.

1) The Ricker model simulation of flow field and RTD in a tubular reactor with brazed helical element was investigated. The RTD curves predicted with Ricker model show good agreement with experimental data.

2) The distribution of velocity shows that the flow field is very turbulent and the fluid flows along brazed helical element.

3) The tubular reactor without brazed helical elements can improve the flow profile by narrowing the RTD curve, decreasing mean residence time and avoiding back mixing, but a brazed helical element broadens the RTD curve drastically.

4) The RTD functions demonstrate that the profiles of flow approaches to plug flow. As the flow rate increases in the tubular reactor with BHE, there is no evident effect on the mean residence time, whereas the variance is enlarged greatly.

5) Residence time distribution (RTD) studies were performed in tubular flow reactor with motionless mixing elements. In this work, Ricker model simulations for the prediction of RTD of mixer have been performed. The theoretical RTD results obtained from the application of the Ricker equation have been compared with the results obtained by performing the experiments in Static mixer. The experimental and computational evidence of RTD in Static mixer is provided in this work. The comparison is commonly scaled to the minimum standard error which yields the result that the Ricker equation simulated results are good fit to the experimental data. The comparison validates our synthetic modelling and shows that the Ricker equation is the best model to predict RTD for Static mixer. Also the experimental and computational evidence in relation to variance, mean and maxima scaled to minimum standard error yields the result that at the maximum value of RTD the errors between the experimental and calculated values are minimal. The fact proves that the model is best suited for our target applications.

7.2 FUTURE WORK

Steady mathematical simulations could possibly be used to extract first-order estimates of the large scale stirring due to the organized flow structures within the mixer and even to estimate the contribution of small-scale turbulent mixing from the calculated distributions of the Residence time and its rate of dissipation. Such an undertaking is beyond the scope of this paper and will be left as a subject for future research. The present research work is motivated by interest in using static mixers in drinking water treatment plants; however, the method and results presented here are applicable to any of the variety of environmental engineering applications where static mixers are used.