CHAPTER 1

INTRODUCTION

1.1   Introductions

Liquid-liquid extraction has become a common subject to be discussed not just among chemical engineers, but mathematicians as well. Liquid-liquid extraction is a process with many applications in pharmaceuticals, petrochemicals processing, industrial chemical production and metals extraction and recovery [1]. This process is a technique to separate two liquids product. The principle of liquid-liquid extraction process entails the transfer of one elements of a solution to another liquid phase which is relatively immiscible in the first solution [2].

There are many types of equipments used for the processes of liquid-liquid extraction. The one that will be considered in this research is the column extractor type called Rotating Disc Contactor (RDC) column. In the RDC column, there are two phases that were involved in extraction process which called the dispersed phase (drops) and the continuous phase. Mathematical model on the mass transfer process that occurred in RDC column were already completed by previous researchers. However, there are still some weaknesses on the latest mass transfer model that can be improved.

In RDC column, chemical substances will be used in order to complete the extraction process. Therefore, molarity is a proper method to determine the

concentrations on the chemical substances. Molarity will be embedded in the former model in order to reform it. Then, the suitable algorithm is determined so that the solutions of the improved model can be achieved.

1.2   Problem Statement

Quite a lot of models on RDC column have been developed. The modeling in drops distributions and mass transfer process are the most important factors for the column performance [3]. Therefore, a more realistic mathematical model is presented.

There are a number of researchers in this field such as Ghalehchian [3], Talib [4], Arshad [5], Mohamed [6] and Maan[3]. Talib [4] has presented the mass transfer models which are Initial Approach of Mass Transfer (IAMT) and Boundary Approach of Mass Transfer (BAMT). These two models were said unsteady-state model. According to Maan [3], Ghalehchian has developed a new model by applying the idea of axial mixing into the simulation of the mass transfer process. Arshad [5] also has developed a steady state model for hydrodynamics process. Then, Mohamed [6] has modified a model developed by Talib which is the BAMT model which is called Simultaneous Discrete Mass Transfer (S-DMT) model. Meanwhile Maan [3] has developed an inverse model of mass transfer where it can determine the value of the input while the value of output is known.

However, the research that was being concentrated on this study is the S-DMT model [6]. Some weaknesses have been detected in this model. As mention before, the concentration of a chemical substance is better being determined by using molarity. Molarity is a method used by chemists to calculate the molar concentration of the chemical substances by using the volume and the number of mole for the substances. Therefore, molarity will be embedded into some of the steps in the S-DMT model. Improvements of this model will be explained further in Chapter 4. Then, the

concentration for both dispersed and continuous phases obtained in this research will be compared with the SSPS data as cited in Talib [4].

1.3   Objective of the Research

The main goals of the research are to model a mass transfer process by using molarity that happen in the RDC column and compare the data obtained from this model with the experimental data obtained in SSPS as cited in Talib [4]. To achieve these goals, the following objectives are the working strategies. The objectives of the study are:

1. To formulate a new model for the mass transfer process for drops and continuous phase in the RDC column.
2. To incorporate the new mass transfer model in the existing algorithm.
3. To develop a programming to simulate the concentration of drops and continuous phase in the new mass transfer model.

1.4   Scope of Study

In this study, the geometrical properties for RDC column with the height 1.75 meters will be used. The RDC column is modeled into 23 stages. Each stage is between two consecutive stator rings. Let say the stage and stator ring are labeled as i where $i = 1, 2, \ldots, 23$. Then, the stage i is between the ith stator ring and $i + 1$th stator ring. This situation continues along the column. However, stage 23 will be between 23rd stator ring and the top of the column. This is as given in Figure 1.1 below.
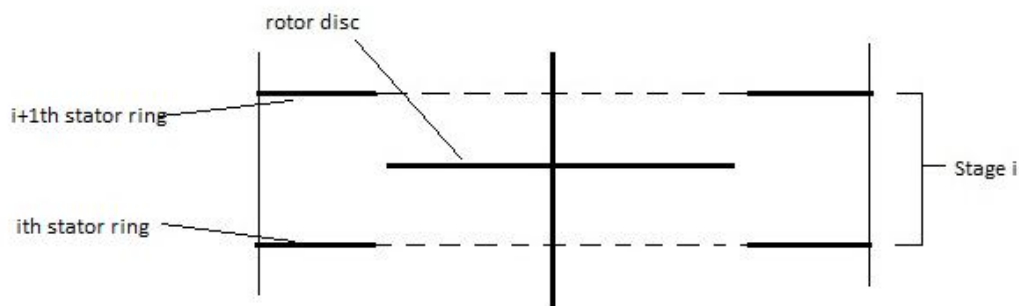
Figure 1.1 : The illustration for stage i located between 2 stator rings next to each other.

Then, each stage is also modeled into 10 cells with the same width. The cell is labeled as j where $j = 1, 2, \ldots, 10$. Each cell is said to have its own range of drops diameter where this range will be explain further in Chapter 2. The cells can be illustrated as in Figure 1.2. Figure 1.3 shows an RDC column being modeled into 23 stages and 10 cells in every stage.
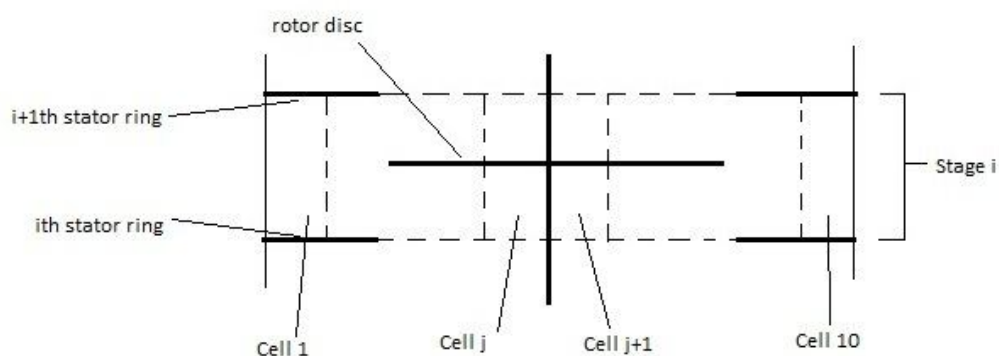

Figure 1.2 : Illustration of stage i being divided into cell with the same width.

The chemical substances that were taken into consideration are cumene in isobutiric acid as the dispersed phase and isobutiric acid in water as continuous phase. The physical properties for the system are obtained from the experiments done by Bahmanyar as cited by Talib[4]. The same applies to the geometrical properties of the RDC column. Both the geometrical properties and the physical properties are given in Appendix A.
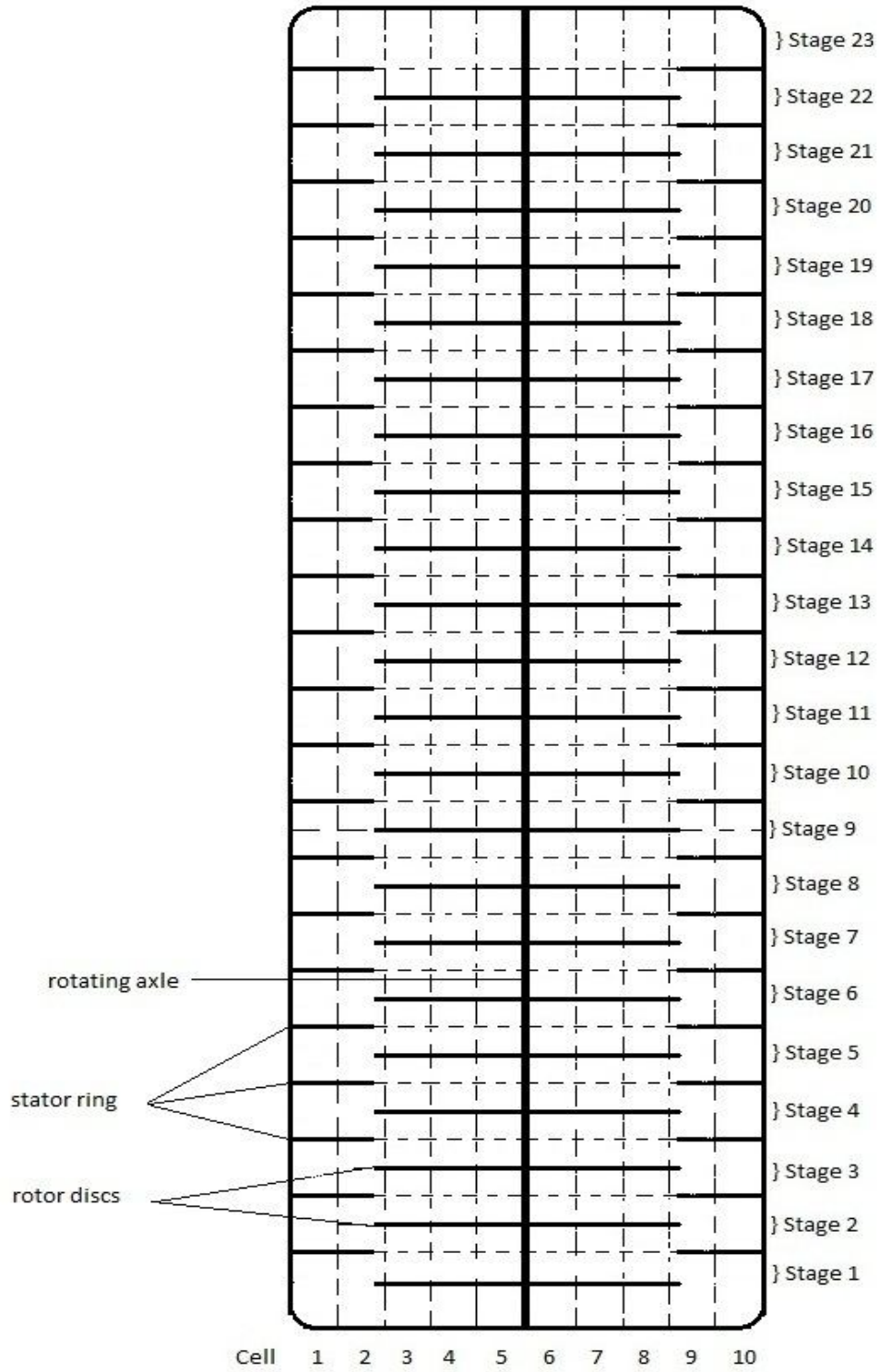
Figure 1.3 : The RDC column that was modeled into 23 stages and 10 cells in each stage.

Next, the hydrodynamics of drops, the drops distribution, the range of drops diameter and average of drops diameter that are used in order to achieve the objectives above has been obtained by Talib [4]. The hydrodynamic of drops is used to determine the time taken for drops to travel along the column. The drops distribution is used to calculate the number of drops in every cell in every stage. All these data are used to determine the concentration of dispersed and continuous phases. These data are used in simulating the mass transfer process by using C++ 6.0 software.

1.5 Significant of Study

The purpose of this study is to determine the concentration of dispersed and continuous phases in the RDC column. From the concentrations obtained, the efficiency of the column can be observed. The efficiency of the RDC column will increase if the extraction process that occurs in the column increases. In order to increase the extraction process, improvements can be made to the RDC column such as reducing the speed of the rotor discs in the column so that the drops will break into smaller. This will increase the surface area that was brought into contact with the continuous phase.

These concentrations also help in designing the RDC column by varying the geometric properties of the column. For example, by increase or decrease the radius of the column, the height of the column and etc depends on the extraction process happen, an efficient RDC column will be produce.

1.6 Thesis Organization

This thesis starts with Chapter 2, literature review on the liquid-liquid extraction. It is then followed by the introduction to the Rotating Disc Contactor (RDC) column and

the hydrodynamics of mass transfer process that occurs in the RDC column. Discussion on the hydrodynamic, drop breakage, drop distribution and mass transfer process are also included. The existing models developed by previous researchers are presented.

Chapter 3 reviews on the existing mass transfer models. It discussed on the formulation of the varied boundary function. The details of the exact solution of the Initial Boundary Value Problem (IBVP) with the time depending function boundary condition will be shown and followed by the derivation of a new diffusion equation for sphere.

Chapter 4 discusses the formulation of the mass transfer process in the RDC column by using molarity. The new mass transfer process using molarity is presented. Molarity is a method that will be used to determine the concentration of both drops and continuous phase in the mass transfer process that occurs in the RDC column. Molarity will be embedded in the existing mass transfer model and this process will be explained further in this chapter.

Chapter 5 provided the explanation on the computer program that was build and the simulation data that were obtained from this simulation. The computer program was developed by using C programming. This simulation is then being run until 10000 iterations and the data obtained from this simulation will be compared with the SSPS data as cited in Talib [4]. The concentration error obtained from this comparison is then being compared with the concentration error obtained from the comparison S-DMT model and SSPS data.

The summarization and conclusion on the final findings and suggest areas for further research are given in Chapter 6.

1.7 Summary

In this introduction chapter, general information on the liquid-liquid extraction and the equipment is presented. The weakness of the existing model motivates this research to be done is given in the problem statement. Next, the research objectives and scope, and the contribution of this research are described in this chapter. Finally, the thesis organization is given.