# PREDICTION OF TOTAL CONCENTRATION FOR SPHERICAL AND TEAR SHAPE DROPS BY USING NEURAL NETWORK

**NORHUSNA BINTI SAHARUN**

**UNIVERSITI TEKNOLOGI MALAYSIA**

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NORHUSNA BINTI SAHARUN

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*Special dedicated to*

*My beloved father, Saharun Abdul Aziz and my beloved mother, Nadrah Hj Noorwawi*

*My beloved husband, Mohd Izlan Mohd Ali Nor Piah and*

*Thank you very much to those people who have guided and inspired me throughout my journey of education*

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# ABSTRACT

In this study, the development of an alternative approach based on the Artificial Intelligent technique called Artificial Neural Network (ANN) was carried out. This report presents a new application of ANN techniques to the modeling of prediction total concentration of drops in the Rotating Disc Contactor Column (RDC). The ANN was trained with the simulated data based on spherical and tear-shaped drops, which consider ten classes volume of drops. The comparison result between Neural Network output and Mathematical Model output is presented. With 4 hidden nodes, the Neural Network models are able to generate the smallest MSE for each ten classes volume of drops. Then the neural network model is then being applied to the combination for all shape drops, which are spherical and tear shape drops as the inputs. The Neural Network models are able to predict 400 simulated data for combination spherical and tear shape drops with MSE error value $6.8482E-6$. The results with the smallest MSE presented in this paper shows that the Neural Network Model works successfully in prediction total concentration of multiple shape drops in ten classes volumes.

# ABSTRAK

Dalam pembelajaran ini telah membincangkan satu aplikasi baru bagi kaedah kepintaran buatan yang dinamakan teknik Rangkaian Artificial Neural (ANN). Laporan ini membincangkan aplikasi baru bagi teknik ANN untuk memodelkan ramalan bagi jumlah kepekatan bagi titisan di dalam turus pengekstrakan dalam turus berputar (RDC Column). ANN telah dilatih menggunakan data simulasi berdasarkan bentuk sfera dan titisan air yang mempertimbangkan sepuluh kelas isipadu titisan. Bandingan antara output Rangkaian Neural dan Model Matematik ditunjukkan di sini. Dengan nod tersembunyi sebanyak empat, model rangkaian neural ini mampu menghasilkan nilai ralat MSE terendah untuk setiap sepuluh kelas isipadu titisan. Kemudian, model rangkaian neural ini diaplikasikan untuk menggabungkan semua bentuk titisan iaitu sfera dan titisan air untuk dijadikan sebagai input. Model rangkaian neural ini mampu meramal 400 data simulasi yang menggabungkan titisan berbentuk sfera dan titisan air dengan ralat MSE sebanyak $6.8482E-6$. Keputusan ralat yang sangat kecil terhasil dalam kertas ini menunjukkan keberkesanan model rangkaian neural ini dalam meramal jumlah kepekatan bagi pelbagai titisan dalam sepuluh kelas isipadu.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Neural network is the powerful and useful artificial intelligence technique that has been demonstrated in several applications including medicine, diagnostic problems, mathematics, finance and many other problems that fall under the category of pattern recognition. Neural network is being chosen in this study because its ability able to derive meaning and extract pattern from complicated data that are too complex to be described by humans or computer techniques.

In this research, the focus is on the predicting the total concentration for drops in Rotating Disc Contactor (RDC) Column by using the artificial intelligence neural network techniques. RDC Column is one of the equipments in the extraction of liquid. Liquid–liquid extraction is a method to separate compounds based on their relative solubility in two different immiscible liquids, usually water and an organic solvent (Kertes, 1975). It is an extraction of a substance from one liquid phase into another liquid phase. For certain liquids that cannot withstand the high temperature of distillation, liquid extraction is more effective to be used to separate the compounds of liquids.

Liquid-liquid extraction equipment can be classified as mixer settlers and column extractor. For the latter classification, two types of column are non-agitated and agitated columns. The agitated columns such as Rotating Disc Contactor Column are widely used for liquid-liquid extraction. For the purpose of this research, the main concern is only on Rotating Disc Contactor Column (RDC).

There are several models that had been developed for the modeling of RDC columns. The modeling shows that the important factors for the column performances are the drop size distribution and the mass transfer processes. Several researchers (Talib, 1994; Mohammed, 2000; Arshad, 2000) had been working successfully in the area of modeling of mass transfer in RDC column based on the assumption of spherical drops. Most of these models are considered spherical coordinate system when dealing with spherical drops. In many situations, the shape of the drops contained in a liquid or porous media is not perfectly spherical and may be classified as oblate and prolate spheroids (Delgado, 2007).

From the previous researches (Herdi and Talib, 2011; Hidayu, 2011; Syarafina, 2012), the researchers were investigating the diffusion equation for drop to find the total concentration of drops in RDC Column numerically or analytically. It was found that no mathematical modeling has been developed to predict the total concentration of drops. In this study, the new applications of Neural Network technique will be introduced to predict the total concentration of the drops. Neural Network will be able to predict the total concentration of drops without using the complex numerical or analytical models that have been developed by the previous researchers.

## 1.2 Background of the Study

From the previous investigations, several researchers developed models of mass transfer in RDC Column based on the assumption of spherical. The shape of drops from the RDC Column is not accurately in spherical shape because there are internal circulation and external distraction in RDC Column. Hence, the behavior and shape of the drops will be distracted and pressurized. It is most likely that the drops will deform into non-spherical. There are also several researchers who have developed models of mass transfer in RDC Column based on the non-spherical shape drop such as tear shape drop (Hidayu, 2011) and ellipsoidal drop (Herdi, 2011).

When there are various shapes of drops, the new diffusion equation will have to be developed in order to find the total concentration of drops. The basic diffusion equation for spherical shape drop, which is developed by Crank, J (1978) has to be investigated in order to develop a new model of diffusion equation of various shapes drops. The analytical or numerical solution that had been modeled by early researchers are quite difficult and complex to be solved.

Therefore, an alternative approach based on the Artificial Intelligent technique called Artificial Neural Network (ANN) is considered to predict and determine the total concentration of drops without using the analytical or numerical solution model. In this study, the ANN will train with the simulated data from Hidayu (2011) based on spherical and tear-shaped drops. It will apply feed forward multi-layers perceptron (MLP) as the technique with different network structure. The training algorithm used to estimate the weights of the neurons is Back-propagation (BP) Levenberg-Marquardt algorithm and the activation functions used are Sigmoid function and Linear transfer function (Purelin).

## 1.3 Problem Statement

This study is going to employ the mathematical modeling of Neural Network. The ability to predict the total concentration of drops in RDC Column accurately is a critical requirement. The method used in predicting the total concentration of drops has great influence in the accuracy of prediction. In ANN, there are many elements to be considered which will affect the convergence of ANN learning such as the number of input, hidden and output node, learning rate, momentum rate, bias, minimum error activation or transfer function. This project examines the questions as below:

1. Does the prediction of total concentration of drops in RDC Column can be modeled accurately using Artificial Neural Network?
2. What is the best architecture of ANN in obtaining the accurate prediction result?

## 1.4 Objective of the Study

This project is done to fulfill the following objectives:

1. To study the structure of the neural network method and understand how the neural network method works in predicting the total concentration of drops.
2. To develop a model for total concentration of drops prediction by using neural network.

3. To simulate data of total concentration drops based on Hidayu (2011), which consider ten classes volume of spherical and tear shape drops at lower stage in the RDC Column.
4. To analyze the performance of accuracy of prediction given by different structures of the developed neural network model.

## 1.5 Scope of the Study

Scopes of the project are:

1. The dataset used is simulated from the experimental data obtained by the researcher Hidayu(2011), which consider ten classes volume of sphere and tear-shaped drops at lower stage in the RDC Column.
2. Feed-forward neural network with back propagation Levenberg-Marquardt learning algorithm is used for total concentration of drops prediction.
3. The activation functions used in this project are Sigmoid function and Linear transfer function (Purelin).
4. This project will focus only on the prediction part of the total concentration of drops on a small medium in RDC, not including the whole process in the RDC Column.

## 1.6 Significance of Study

From this research, the development of understanding on Artificial Neural Network methods will be obtained. Other than that, this study will help the other researchers to predict the total concentration of drop in RDC Column accurately using neural network. Neural Network will be able to predict the total concentration of drops without using the complex numerical or analytical models that have been developed by the previous researchers. Neural Network can also be used to predict the total concentration of multiple shape drops in RDC Column.

## 1.7 Thesis Organization

Chapter 1 introduces the project, problem statement, research objective, scope and the significance of the thesis. Chapter 2 discusses the literature review of RDC Column and Artificial Neural Network that contributed to the success of the project. This includes the background knowledge on the structure of ANN.

Chapter 3 provides the methodology and operational framework. Different network structures are applied to find the best network structure with minimum error. In Chapter 4, the result of the project will be highlight. This project then summarizes the conclusion and discusses the future work in Chapter 5.

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