UNIVERSITI TEKNOLOGI MARA

MODEL INPUT AND STRUCTURE SELECTION IN MULTIVARIABLE DYNAMIC MODELING OF BATCH DISTILLATION COLUMN PILOT PLANT

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AUTHOR'S DECLARATION

I declare that the work in this thesis/dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

In the wake of fast soft computing processing, advances in hardware interface provisioning and demand over cost efficiency, a substantial acquiesce over the interests in nonlinear control and optimal process operation can been seen in recent academic and industrial study particularly in multivariable control processes. Among such are the distillation processes which are susceptible to various operation perturbations that would directly influence the desired end product outcome. There are several recorded control approaches that have been successfully employed to meet with the end product quality requirement however the current study put the bulk of its focus on a control approach performed based on the reflux ratio as manipulated variable with the top tray temperature as the controlled variable. It is recognized that there is a need to have an offline representation of the pilot plant to allow for anticipation of experiment results to reduce operation error, hence, the main purpose of this study. The pilot plant used as reference process platform in this study is a binary mixture, batch process bubble cap distillation column that suffers from the time-varying nature of its process. It is established that a valid nonlinear multivariable case study is presented by the process plant via a systematic experiment conducted to justify the adopted nonlinear system identification. The implementation of Nonlinear Auto-Regressive with eXogenous input (NARX) technique was then explored in this study to prove its reliability as a comprehensive system identification approach which has been cited across various recorded process identification platforms. The present work further investigates the effectiveness of Orthogonal Least Squares (OLS) and Error Reduction Ratio (ERR) as a model structure selection technique to represent a system that is heavily afflicted with intrinsic noise and poor operating conditions. Pre-screening method based on Correlation Coefficient analysis was elaborated to reduce the searching pool and comparison studies are presented to seek out the best process output conformity with the reference process dynamics using various well established model selection criteria. Ultimately, the developed identified model is designed and tested such that it can function extensively as an emulation of the plant in an offline environment. Comparison results have shown that the pre-screening method has an essential role in determining an effective process representation especially in real-time multivariable identification framework where *a priori* knowledge is not available and would help in resultant model generalization performance as opposed to simply using all available model input variables. Further, after a careful investigation into the OLS algorithm, it was shown that the ERR technique which is an essential part of the algorithm to reach model parsimony, has led the resultant model to select an incorrect model terms albeit some improvement in model selection criteria and validation method adopted in this study. This is made apparent when the resultant model was found not being able to generalize a process that deviates from its training parameters.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND STUDY

Distillation column in general is an apparatus in which a chemical mixture is separated through subjugation of temperature and pressure involving the manipulation of the liquid and vapor reactions of each component involved to obtain a purified version of its feed mixture. Among its popular application in the modern world is the separation of crude oil process that by its own has limited application compared to the rich distilled, median and bottom products which have been subjected onto temperature, pressure, composition, phase and state temperament in distillation column [1]. Due to its pivotal role in product separation, the subject has been widely approached by various studies among that were pioneered by [2-5] with the goals of ultimately improving the process control and identification of the controlled variables. These works have paved the way for researchers in efforts to explore further into distillation column modeling and control among such as [6-9].

Fundamentally, a distillation column is operated such that the mass and heat transfer of both the uprising vapor and downcomer liquid in the tower achieve heat transfer through conduction with each other. This is done to observe equilibrium on both of the phase and is therefore essential that each phase come into intimate contact with each other and is operated at essentially the same temperature and pressure for the coexisting zone during a given distillation run. This is the basis of the equilibrium stage concept which is central in distillation and can be defined as a stage where perfect mixing at each phase exists [10, 11].

Given an example of two different temperature and pressure phases of vaporizing liquid and condensed vapor molecules that is in contact with each other in a given distillation operation, an equilibrium stage can be identified when all changes in temperature and pressure between the two phases cease to exist resulting in the rate of condensation and evaporation to be equal. Theoretical equilibrium concept allows for analytical expressions over the distillation operation dynamics that is made possible by assuming vapor-liquid equilibrium (VLE) on each stage. These