MIGRATION OF BOILER DRUM TEMPERATURE (BDT) INTO ASPEN DYNAMICS ENVIRONMENT FOR TEACHING AND RESEARCH PURPOSES

NUR HASNIENA BINTI MOHD ROSLI

Universiti Sains Malaysia

2017

MIGRATION OF BOILER DRUM TEMPERATURE (BDT) INTO ASPEN DYNAMICS ENVIRONMENT FOR TEACHING AND RESEARCH PURPOSES

By

NUR HASNIENA BINTI MOHD ROSLI

Thesis is submitted in partial fulfilment of the requirements for the degree of Bachelor of Chemical Engineering

June 2017

ACKNOWLEDGEMENT

I would like to make my deepest appreciation and gratitude to my supervisor, Associate Professor Ir. Dr. Zainal bin Ahmad for all his guidance and consultation during my completion of this project. He was very supportive throughout the project and was always guide me to complete this project.

I would also extent my gratitude to my family who always giving their support and motivation for me to finish this project. I greatly appreciate their unconditional love and support all the time.

Apart from that, I would also like to thank to all my colleague who always supported me throughout this four years. They are willing to sacrifice their time to share their knowledge and motivate me in finishing my final year project.

NUR HASNIENA BINTI MOHD ROSLI

May 2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

	Symbol	Unit
PB	Proportional band	%
T_I	Integral time	s
T_D	Derivative time	s
K_C	Gain	%%

LIST OF ABBREVIATIONS

BDT	Boiler Drum Temperature
P&ID	Piping and instrumentation Diagram
IAWPS-95	The International Association for the Properties of Water and Steam Formulation 1995
T11	Tank that represents the boiler drum
T12	Preheated feedwater tank
LCV11	Level control valve at a feed water inflow pipeline to T11
TCV11	Control valve for heat exchanger
Z-N	Ziegler-Nichol method
PI	Proportional Integral Controller
PID	Proportional Integral Derivative Controller
OP	Controller Output
PV	Process Variable

PENGHIJRAHAN DANDANG SUHU DRUM KEPADA PERSEKITARAN ASPEN DYNAMICS UNTUK PENGAJARAN DAN PENYELIDIKAN

ABSTRAK

Permodelan simulasi dinamik telah menjadi satu keperluan untuk jurutera proses kawalan. Ini adalah disebabkan oleh kajian dinamik dan keadaan mantap selaras dengan objektif proses kawalan untuk mengekalkan proses kepada keadaan operasi yang dikehendaki. Dalam kajian ini, penghijrahan dandang suhu drum dilakukan menggunakan Aspen Plus untuk keadaan mantap. Analisis sensitiviti telah dilakukan untuk menganalisis kesan perubahan masukan kepada keluaran daripada proses. Kemudian, simulasi itu tukar ke platform Aspen Dynamic untuk mengkaji sistem dinamik proses tersebut di mana gelung kawalan ditambah dan dikaji. Prestasi kawalan keseluruhan juga telah dinilai dengan memperkenalkan gangguan dalam aliran suapan proses dan memperkenalkan parameter penalaan. Pengesahan simulasi telah dilakukan dengan data eksperimen yang sebenar. Prestasi simulasi lebih cepat untuk kawalan suhu berbanding dengan proses sebenar tetapi sebaliknya untuk kawalan paras. Tambahan pula, prestasi pengawal ditingkatkan lagi dengan penalaan menggunakan kaedah Z-N. Prestasi simulasi menjadi lebih cepat untuk mencapai produk yang diingini berbanding PID yang normal.

MIGRATION OF BOILER DRUM TEMPERATURE (BDT) INTO ASPEN DYNAMICS ENVIRONMENT FOR TEACHING AND RESEARCH PURPOSES

ABSTRACT

Dynamic simulation and modelling has turned into a need to process control engineers. This is due to dynamics and steady state study are in line with the primary objective of process control which is to maintain a process at the desired operating conditions. In this study, migration of the Boiler Drum Temperature was done using Aspen Plus for steady state condition. Sensitivity analysis was done to analyse the effect of input changes on the output of the process. Then, the simulation was exported to Aspen Dynamic platform to study the dynamics of the system, whereby control loops are added and studied. The overall control performance was also evaluated by introducing disturbances in the feed streams of the process and introducing the tuning parameter. Validation of the simulation was done with the actual experimental data. The performance of the simulation for the temperature is much faster compared to the actual process but for level it has slower response. In addition, the controller performance is improved by tuning using Z-N. It became faster to get to the desired set point compared to normal PID.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This study will focus on the migration of Boiler Drum Temperature (BDT) to Aspen Dynamics environment for research and teaching purposes. The experimental equipment that will be used is this study is the Boiler Drum and Heat Exchanger Process Control Training System, Model BDT921. The Piping and Instrumentation Diagram (P&ID) is obtained from laboratory manual from Process Control Laboratory EKC 493 School of Chemical Engineering Universiti Sains Malaysia Engineering Campus.

1.2 Introduction of dynamic simulation and control

Dynamic simulation and modelling has turned into a need to process and control engineers, along these lines dynamic simulation software are being utilized for the evaluation of control and optimization study (Restrepo et al., 2014). Steady state simulators for plant model behaviour using continuous, time interval based and steady state approximations require the least effort to set up and calibrate. Further, dynamic simulation can also be considered as a series of steady state simulations. Dynamic simulators are based on real time or accelerated dynamic simulation principles and can provide a true representation of the plant behaviour, including retention times and thermal lags. It also can be used for operational plant troubleshooting, control loop tuning and real time optimisation. In the other hand, the continuous steady state with varying throughput, start up, shutdown, feed and composition change, can all be studied. However the dynamic simulations require more information and are more difficult to set up (Edwards et al., 2014).

This dynamics and steady state study are in line with the primary objective of process control which is to maintain a process at the desired operating conditions, safely and efficiently, while satisfying environmental and product quality requirements (Seborg et al., 2010). In this study, the focus will be on the level and temperature control based on BDT 921. There are three methods to control which feedback control, feedforward control and cascade control.

1.3 Introduction of Boiler Drum Temperature (BDT)

Boilers are used in most of the process and power plants to generate steam for the process heating and electricity generation. There are two basic process control systems found in any boiler plant: (i) Boiler drum level control and (ii) combustion control. Model BDT921 allows the study of the boiler drum level control system using water which is mimicking the level of the liquid in the boiler. This liquid level control is very important in the boiler to prevent any liquid carried over to steam system and can create hammering to the system.

In addition to that, the boiler also should be able to control temperature in the boiler as what has been set in BDT 921 where it has a temperature control system in a shell and tube heat exchanger. The Model 921 allows the study of control of the process variables such as level, flow and temperature. In this study, the controllers include simple ON/OFF controller for the heater to supply the heat for the process utility, PID single-loop feedback controller, PID cascade controller and PID feedforward controller for the flow, level and temperature control. The single loop controller is for the level, level and temperature while for cascade control are for level/flow and temperature/flow. As for the feedforward controller, its only applies for the level control.

1.4 Aspen Simulation

In the present study, Aspen Plus steady state and dynamics simulations are utilized to study the BDT 921 in simulation environment. Aspen Dynamics is a dynamic simulator regularly used to study the dynamics of the process and part of it to study the process control of continuous processes around the steady-state operating point. Aspen Plus enhances the study of the process by building and running the process simulation accurately and adding a comprehensive system of offline process modelling. Aspen Plus and Aspen Dynamics developed a very sophisticated simulation process that involves a multiple complex steps and scripts in a very lengthy design and analysis procedure. Researchers have combined the steady-state and dynamics simulator to study comprehensively the control strategies for certain processes like in model predictive control (MPC). One can easily predict the behaviour of any process by using fundamental and engineering relationship such as mass and energy balance, phase and chemical equilibrium in block oriented kind of approach. Thus, one of the advantageous of the process simulation is, it can run different cases like "what if" analysis, sensitivity analysis and to do optimization runs without considering the time and consumables like in the laboratory. The simulator will be able to model/design and optimized the plants and consequently in economics perspective, is able to study the profitability of existing plant offline (Taqvi et al., 2016).

1.5 Problem Statement

In chemical and environmental engineering, process modelling and simulation are fundamental representations of a real physical-chemical or economic process by alternative mathematical or physical form that fits for a specific purpose. The main advantages of utilizing process modelling and simulation is to minimise the time and resources consumed in conventional experimentation courses. Conventional experiment has many disadvantages as compared to visual experiment using simulator. Conventional experiment is time consuming with the additional procedure for examples to prepare the consumables or to follow the procedure for start-up and shutdown. The maintenance sometimes can be very costly especially when dealing with the process control equipment like control valves and the sensors. Therefore, some of the equipment needs to be replaced for maintenance purposes and it takes times. These challenges can be overcome by using simulator software such as Aspen.

The main challenge in simulator development is to develop accurate model that can really represent the process or system properly.

1.6 Research objectives

The main objectives of this study are:

i. To study boiler drum flow and heat exchanger process control.
ii. To simulate boiler drum temperature using Aspen Plus and Aspen Dynamic.
iii. To validate Aspen and experimental data

1.7 Scope of studies

To achieve the objectives of the research project, the scope of study is firstly being identified the unit operations and operation parameters of Boiler Drum Temperature and heat exchanger. Then, by using Aspen Plus and Aspen Plus Dynamics, the steady-state and dynamics simulation will be done. Finally, validation data between Aspen data and experimental data to ensure the accurate model was developed.

1.8 Organization of thesis

This thesis consists of five main chapters and each chapter contributes to the sequence of this study. The following are the contents for each chapter in this study:

Chapter 1 introduces the dynamic simulation and control, Boiler Drum Temperature (BDT), Aspen simulation, problem statement, research objectives and organization of thesis.

Chapter 2 discusses the literature review of this study. An understanding of Aspen as teaching and research tools, discussion on process simulation using Aspen and Aspen as a process control tools.

Chapter 3 covers details of methodology. It discusses on the BDT Temperature Control, BDT Level Control, Aspen software development and finally is Aspen validation.

Chapter 4 discusses the results and discussion of the simulation for the steady state and dynamics state of the process.

Chapter 5 concludes the research. Suggestions for future research are also presented in the chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Aspen has been widely used for several types of tools. Nowadays, simulation by using Aspen is already commercial as a teaching tool. For research and process control tools, usually Aspen Plus and Aspen Dynamic is used to simulate steady state and dynamic simulation. Furthermore, it is also can be apply for process simulation such as separation system, gasification etc. In this section, all the application using Aspen simulator will be discuss in detail.

2.2 Aspen as a teaching tool

As mentioned in Komulainen et al. (2012), dynamic simulation was found to be very useful teaching tool for a wide range of chemical engineering courses. Demonstration and testing for various kinds of processes and equipment, control algorithms and safety procedures can be done by using software simulation. Student can increase their understanding for practical operation of complex chemical process by test runs with the simulation model. Its shows successful integration of dynamic simulation into the chemical engineering curricula in both undergraduate and graduate courses based on the survey that being done. Three undergraduate and graduate courses had experienced themselves on the dynamic simulation in this study (Komulainen et al., 2012). The feedback has been positive for both students and teacher. The experiences confirm that commercial dynamic simulators provide realistic training and can be successfully applied into undergraduate and graduate teaching, laboratory courses and research.

It is importance to encourage a closer relationship between the engineering computer programs offered by companies like Aspen Technology Inc., and the chemical engineering students (Castrellón et al., 2011). The main objective is the development of high interactive academic guides, which instructs students about design and control of distillation columns, using Aspen Plus and Aspen Dynamics. Castrellón et al. (2011) use three case studies before developing academic interactive guide for the student. The cases studies are being selected to develop different skills and tools in students learning with increasing order of complexity. After that, academic interactive guide was evaluated. Based on the survey results, it shows that this guide is a useful tool with a high interactive content which allows students to improve their knowledge and to introduce the use of specialized software like Aspen Plus and Aspen Dynamics.

Commercial packages simulation software such as Aspen can be useful tool for operator training because this simulator can replicate process dynamic behaviour over a wide range of operations. As mentioned in Patle Dipesh et al. (2014), operator training simulation (OTS) has been successfully used in many chemical industries. In addition to that, Patle Dipesh et al. (2014) also discuss the important aspects of OTS such as its need, its applications in chemical industry, issues related to its development and implementation, its salient features, training configurations and related issues, and future directions. Basically, OTS is cost-effective and risk-free training method. Systematic development and appropriate use of OTS are essential so that the desired objective can be achieved. OTS should be maintained to reflect changes in the plant. Available commercial tool is a very convenient option for OTS development.

In Kong et al. (2006), Aspen Dynamics can be applied to Web-based learning. Web-based learning is independent type of learning whereby the student hands on learning directly and facilitated by an instructor is not required. Web-based course is creating using software. To model chemical process plants and their control systems, students employ dynamic process simulation using dynamic simulator such as Aspen Dynamics. The student then creates disturbance toward the feed composition, flow, system temperatures and/or pressure and then study the effect of the disturbance on the plant operation. This study can allow the student to evaluate the strengths and weakness of a given process control scheme.

Aspen Plus and Aspen Dynamics create steady state and dynamic simulation. Thus it can be applied in various type of plant simulator as mentioned by Li et al. (2007). The process simulation can act as a platform for refinery plant simulation and its application. Based on the simulation of a crude oil distillation process, they provide a detail analysis of Flexible Multi-Case Data-drive Simulation (FMCDS), which employs the idea of distinct event simulation and would be helpful for the improvement of simulation accuracy and efficiency. The FMCDS platform in virtual plant laboratory introduced in this paper is based on dynamic simulation, static simulation and discrete event simulation, which take the demand of experiment teaching and comprehensive researches into consideration.

In addition, Dahm et al. (2002), show the effectiveness of process simulation to include in the chemical engineering curriculum. One of the courses in chemical engineering, like process dynamics and control, are computer intensive and it can benefit from the process simulators packages such as Aspen software. Without truly understand the physical phenomena within each unit operation, it is possible for students to successfully construct and use models. Dahm et al. (2002), also, conducted a survey about the role of computers in chemical engineering education and practise. The results show that process simulators are used essentially in all design courses. However, the roles of simulators can be beneficially expanded in their curriculum are being acknowledged by many respondents.

From Zapata and Agudelo (2015), simulation for limonene epoxidation in a batch reactor using a Langmuir-Hinshelwood-Haugen-Watson (LHHW) kinetic expression is shown step by step with the detailed described. Simulated data and laboratory data is close to each other. Thus, it makes the model is valid tool for studying and analysing the conceptual design and scale-up for the reaction system. This model usually used in chemical reaction engineering course to improve the fundamental knowledge and understanding of the students.

2.3 Aspen as a research tool

Aspen is the most popular modelling software package for both steady sate and dynamic modes respectively. This statement was supported by the review in Castrellón et al. (2011). This paper focusing on the two currently significant low-carbon energy processes; namely, bioenergy and post-combustion carbon capture (PCC) processes. Main software simulations are being reviewed and the most popular modelling software packages are identified and their use in the literature is analysed. The result from this review is the modular packages Aspen Plus was found to be dominant for modelling both bioenergy and PCC process at steady-state with both 75% and 46% of total research papers respectively.

Further in Ignat and Kiss (2013), Aspen Plus and Aspen Dynamics is used as computer aided process engineering (CAPE) tools to perform the steady-state and dynamic simulations, as well as the optimization of the new reactive dividing wall column (R-DWC) based biodiesel process. This study is among the first to tackle the optimal design, dynamics and control of such an integrated unit and proposes an efficient control structure for a biodiesel process based on reactive DWC technology using Aspen simulation. In Ignat and Kiss (2013), its clearly shows the superiority of Aspen Plus as a research tool.

As mentioned in Luo et al. (2014) dynamic simulation platform is a key and helpful device as a supplement of experimental research. It is generally recognized that the transition process from air-firing mode to oxy-fuel combustion is a key procedure in accomplishing successful operation for oxy-fuel combustion power plants. In Luo et al. (2014), a control strategy for how to lead the transition process was discussed. To better comprehend the impacts of transition operation on process parameters, a dynamic model was created utilizing the facility as a model by Aspen Dynamics. Moreover, comparable operations of the transition process conducted in the test were reproduced and the performance of the transition operations was then analysed and evaluated based on the simulation results. The outcomes demonstrated that the proposed control strategy was effective and could be connected to other huge scale pilot plants or business control plant. The experience acquired from this study could be utilized as reference for other oxy-fuel control plants. Dynamic simulation platform, which could spare a lot of time and cash, is a vital and valuable device and ought to be broadly created as a supplement of experimental research.

Furthermore, in Galbe and Zacchi (1992), Aspen Plus was used to simulate ethanol production process based on enzymatic hydrolysis of lignocellulosic materials. It is used to study the effects of water recycling required to decrease the amount of water and to find a way of rise the ethanol concentration in the feed to the distillation for various process configuration. Galbe and Zacchi (1992) also state that Aspen software can be useful tool for the analysis, design, and economic evaluation of the individual process steps, and for comparing and optimizing various process alternatives. Simulation also can be used to aid future research and development.

From Wooley et al. (1999), it shows the upgraded biomass-to-ethanol process model and the utilization of the model and the latest biotechnology tools to establish their future technology performance target. Aspen Plus is used as a process simulator to model bioethanol process technology. This process was analysed to estimates the current and projected costs of bioethanol. As mentioned in Wooley et al. (1999), Aspen Plus is widely used in the chemical and petroleum industries. It offers ability for carrying out thermodynamically rigorous material and energy balances for complex process.

2.4 Process simulation using Aspen

Process simulation technology whose main purpose is to provide an environment close to reality has been developed for decades. Therefore, for this study, its clearly shows that Aspen software be able simulate almost all types of plant and process. In this section, various type of process simulation using Aspen is reviewed.

2.4.1 Separation system

Aspen can be used to simulate various type of unit operation such as distillation. This section will review different type of separation system being simulate using Aspen.

As mentioned by Taqvi et al. (2016), the paper present the optimization and dynamics of distillation column for acetone production unit. This paper shows how an acetone manufacturing process can be conveniently simulated first to get temperature, pressure and composition profile followed by application of optimization techniques to enhance performance. It was performed by using a simulator Aspen Plus. An appropriate control structure can be modelled from Aspen Dynamics control model library to develop a realistic scheme that will be helpful to understand physical reality. It can be witnessed that Aspen Plus and Aspen Dynamics is a comprehensive tool which can be used to optimize the column and can be used to develop different control strategies. In using Aspen simulation, the first step is to set up a simulation in Aspen Plus that has the required pieces of equipment to size the column and auxiliary equipment of desired capacity. It should be noted that in Aspen Plus flow sheet must be a continuous process with the feed and product stream. Systematic and realistic modelling has been done to develop an understanding about distillation column parameters variation to maintain product quality. The model developed in Aspen Plus is exported to Pressure-Driven simulation in Aspen Dynamics. Before exporting to Aspen Dynamics, the size and the initial specification for each of equipment must be identified that includes valve pressure drops, pumps suction or discharge pressure etc.

Based on Huang et al. (2016), an innovative ethylene glycol diacetate (EGDA) synthesis process in a single reactive distillation column has been investigated. In this paper, to achieve optimal process design in steady state simulation, important parameter has been investigated which is number of theoretical stage, feed position, reflux ratio, rate of distillation and operating pressure on the purity of EGDA, energy consumption, conversion, selectivity and yield. Huang et al. (2016) also does the comparison between steady state simulation and dynamic state simulation results. From the comparison, the dynamic state simulation by Aspen Dynamics has achieved an innovative process to produce EGDA without ethylene glycol (EG) feed based on steady state basis.

However, in Smejkal and Šoóš (2002), comparison for simulation results between Aspen Plus and Hysys software was done for reactive distillation. The objective is to show the relevance of the Aspen Plus and Hysys to solve the problem of reactive distillation problem. Based on the result, an excellent agreement between experimental data and simulation results was achieved. In comparison, both software needed the same computation time for the same type of computer for reactive distillation simulations but Hysys is cheaper than Aspen Plus.

As mentioned in Raimondi et al. (2015), atmospheric distillation of crude oil is being used in petroleum industry to separate main petroleum product such as naptha, kerosene, fuel oil and diesel oil. Priority for oil refinery process is to improving performance and reduces operational cost. Adaptive Predictive (AP) control strategy was introduced to overcome this challenge. By using ADEX and MATLAB simulation, AP controller was simulating. The controllers' performance is tested on a crude oil atmospheric distillation process simulator developed in Aspen Plus v7.1 and Aspen Dynamics v7.1. The simulation of the proposed AP strategy results is compared against a PID based control strategy. From the comparison, we can see the improvement of operational stability.

Next, in Sajjad and Rasul (2015), the performance of small scale of solar desalination plant can be simulate by using Aspen software. The model is validated with experimental results found in the literature. The validated model is used to optimize the functional parameters of a desalination plant and in turn, enhance the recovery rate and product quality of the system. The outcomes of the study are a validated process simulation model of a small scale solar desalination plant, optimization of this model for better utilization of current technologies and methods of improving performance, efficiency and recovery and reducing operational limitations. To develop a validated model against the design data, the Aspen Plus model adopted the single to triple membrane series arrangement progression as illustrated in Figure 2.1. The model was tested as each membrane was added to the system to ensure validation of the simulation was achieved.

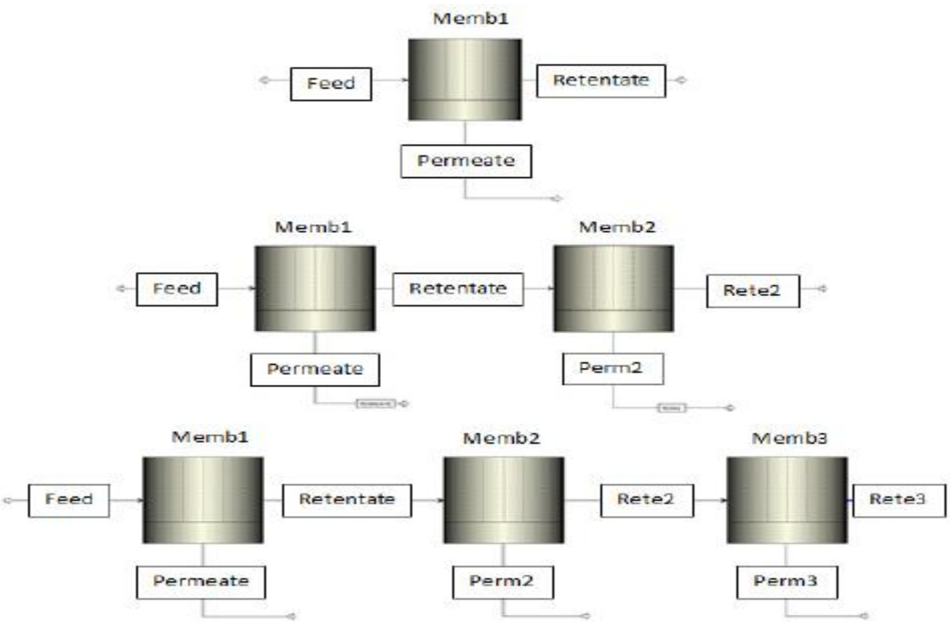

Figure 2.1: Membrane series model development schematic (Sajjad and Rasul, 2015)

From Haydary and Pavlík (2009), Aspen simulation can simulate steady state and dynamic simulation of Preflash and Atmospheric column (Pipestill) in a real crude oil distillation plant. Simulation data and experimental ASTM D86 curves of various products were compared. It shows that steady state simulation results were in good agreement with experimental data. Haydary and Pavlík (2009) also, state that Aspen Plus and Aspen Dynamics can do the simulation of very complex distillation systems like petroleum fractionators. For Aspen Dynamics, dynamic simulation of very complex system is possible but required detail properties of the system, careful setting of controller parameters and long calculation time.

In addition, Aspen software can simulate membrane gas separation systems. As mentioned in Sharifian et al. (2016), this paper explained a mathematical model and numerical solving technique for an asymmetric hollow fibre membrane gas separation module for separation of multicomponent mixtures and how to implement in an Aspen Plus. At different operation conditions, a comparison between the model and the experiment cases shows that calculated values are in good agreement with measured values. It proves that this model, for future developments is appropriate as well as design and performance analysis of multicomponent gas permeation systems prior to experimental realization.

Aspen software can also simulate hydrogen production via steam methane reforming with in situ hydrogen separation in fluidized bed membrane reactors (Ye et al., 2009). In this case, a sequential modular approach was implemented because fluidized bed membrane reactor (FBMR) operation does not exist in the simulator. As shown in Figure 2.2, the FBMR was separated into successive steam methane sub-reformers and membrane sub-separators. Thus, model predictions on reactor performance exhibit good agreement with experimental results.

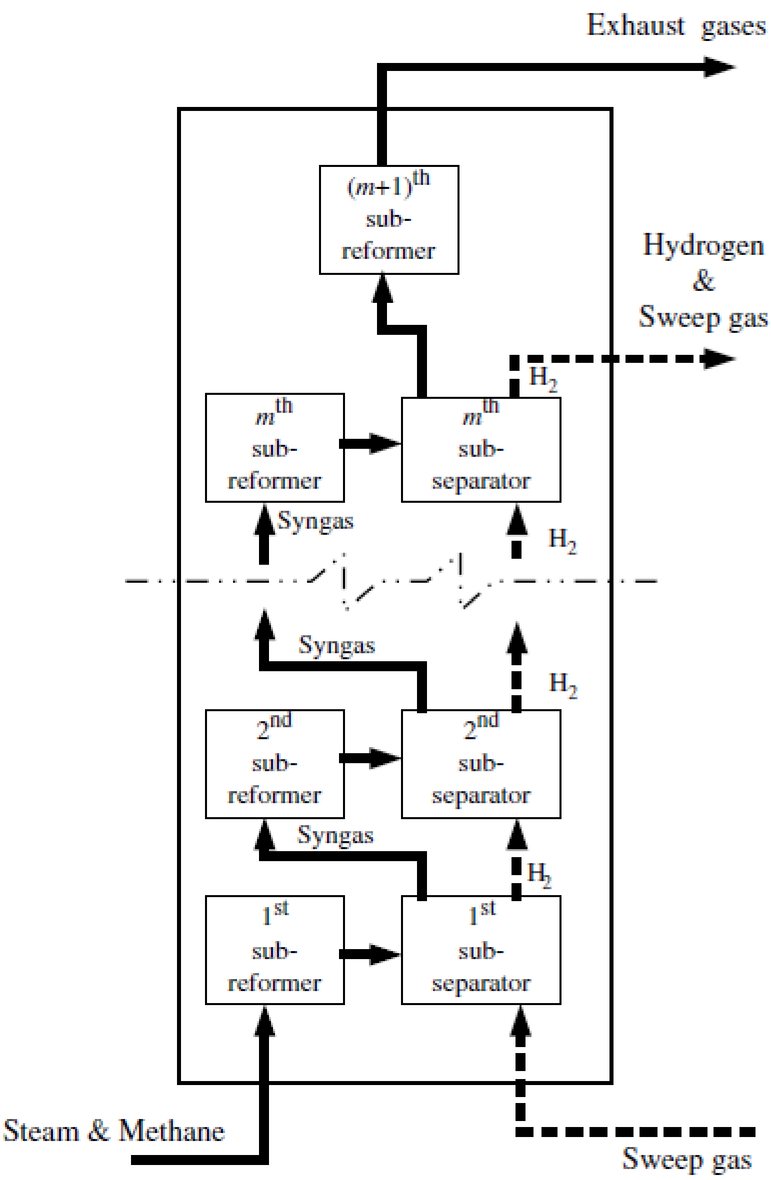

Figure 2.2: Sequential modular simulation diagram of FBMR with Aspen Plus (Ye et al,2009)

2.4.2 Power Plant

Model simulation for combined cycle cogeneration plant fuelled by natural gas was developed using Aspen software. The mode was divided into three main parts which is gas turbine, heat recovery steam generation (HRSG) and steam turbine. The simulation flow sheet for the commercial cogeneration plant has been developed and compared with a set of data from the operation. The key results generated by this model were found to be in good agreement with the operating data. Based on these findings, it is concluded that the developed model is suitable for simulation of commercial cogeneration plants (Zheng and Furimsky, 2003).

Not every complex chemical reaction can be simulating by using Aspen. To solve this problem, self-defined model can be developing and then connect it with Aspen Plus as a user module. One example of complex chemical reactions cannot be simulated properly on Aspen is catalytic reforming reactions. To overcome this problem, modified kinetic model is developed as mentioned in Hou et al. (2006). By connect this self-defined model with a user module, a whole commercial continuous catalytic reforming process is simulated on Aspen Plus platform.

According to Nikoo and Mahinpey (2008), by using Aspen simulator, a model was developed for the gasification of biomass in an atmospheric fluidized bed gasifier as illustrate in Figure 2.3. In this case, some Aspen unit operation blocks were combined. Based on the literature, kinetic expressions and hydrodynamic models were developed. The purpose of this simulation is to predict the results of lab-scale gasification of pipe with water and steam and then compared the result with experimental data.

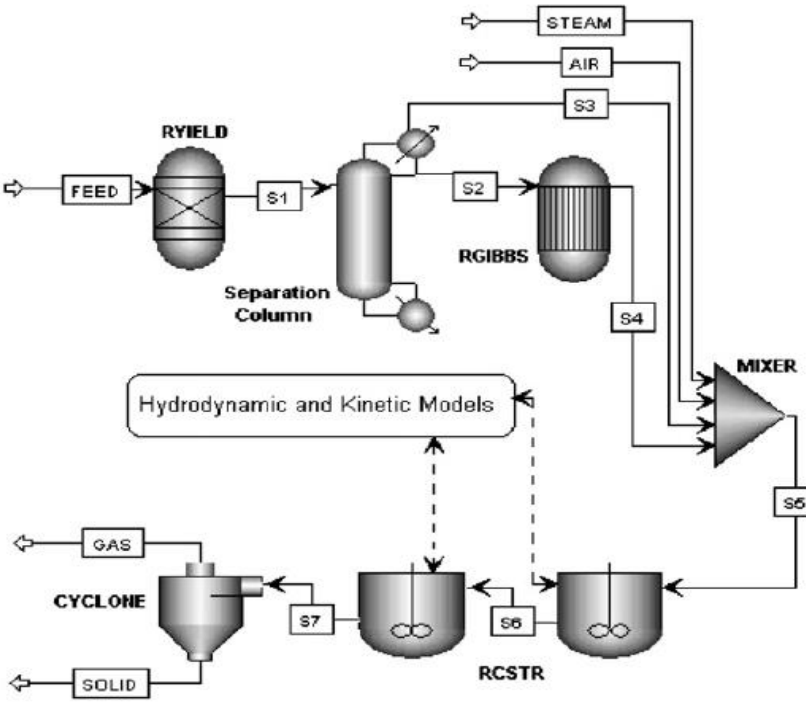

Figure 2.3: Comprehensive simulation diagram for the fluidized bed gasification process (Nikoo and Mahenpay, 2008)

However, in Ramzan et al. (2011), Aspen Plus was used to simulate hybrid biomass gasifier. This process involved three stages as shown in Figure 2.4. Firstly, moisture content of the fuel is lowered before proceeding to the reactor. After that, biomass is decomposed into volatile components and char. For the final stage models, the partial oxidation and gasification reactions by minimizing Gibbs free energy.

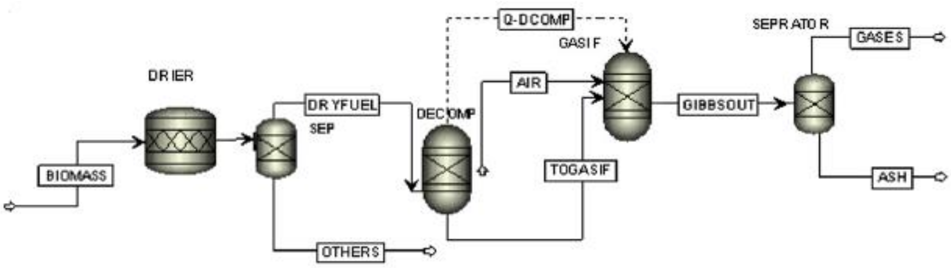

Figure 2.4: Simulation of hybrid biomass gasifier (Ramzan et al., 2011)

Besides that, Aspen Plus can be used to simulate combustion of coal in a circulating fluidized bed reactor (CFBC). Since CFBC model is not exist in Aspen Plus, four Aspen Plus reactor models and several subroutines are used to represent CFBC model as stated in Sotudeh-Gharebaagh et al. (1998). Based on the validation of the data, the model is proven to represent a CFBC unit in various process simulation flowsheet such as power generation plants.

2.5 Aspen as a process control tools

From the literature in Gil et al. (2012), process control of extractive distillation column is simulated by using Aspen software. To maintain stable operation for large feed disturbances, a control scheme is developed. For this process, there were two control structures that being developed and tested which is effective quality and production rate control. First control strategy uses the entrainer makeup flow rate to control the base level in the recovery column. Whereas the second control strategy uses the entrainer makeup flow rate to control the entrainer feed flow rate to the extractive columns. Second control strategy is recommended for the extractive distillation of ethanol compared to control strategy one because it is allowing to attain a soft-regulating control with minimal changes in the temperature profile for both columns and maintaining the high purity.

However, in Luyben (2006b) refractive distillation was developed but for isopropyl alcohol dehydration process. By using Aspen software, temperature control in the extractive column and the solvent recovery column, as well as flow rate of the extractive solvent to the feed flow rate has been simulated. The difference of this process form other process is the unique control scheme as shown in the Figure 2.5. This scheme will play around with the amount of the solvent in the feed.

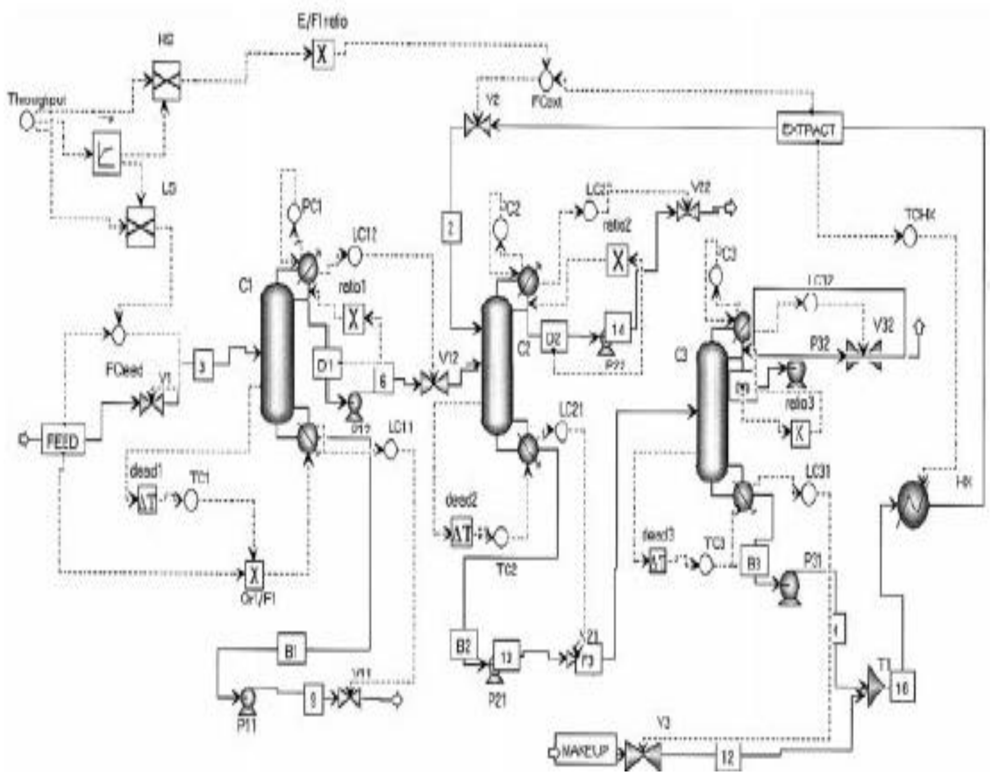

Figure 2.5: Modified control system (Luyben, 2006b)

Further in Luyben, (2006a), Aspen is used to study of the control of a two-column heterogeneous azeotropic system to separate ethanol and water using benzene as the light entrainer. For the steady state design and dynamic simulation, the commercial simulator which is Aspen Plus and Aspen Dynamics has been used. Steady state flowsheet was having difficulty to converge because it consists two recycle streams as illustrated in Figure 2.6. This problem is can be overcome by converging to a dynamic simulation as shown in Figure 2.7.

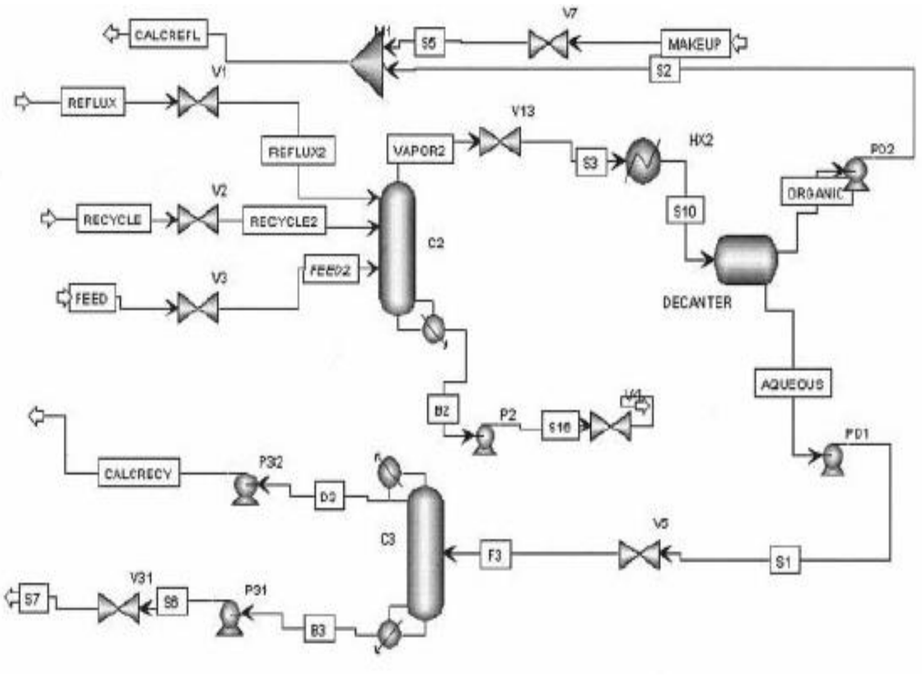

Figure 2.6: Aspen Plus flowsheet with recycles not closed (Luyben, 2006a)

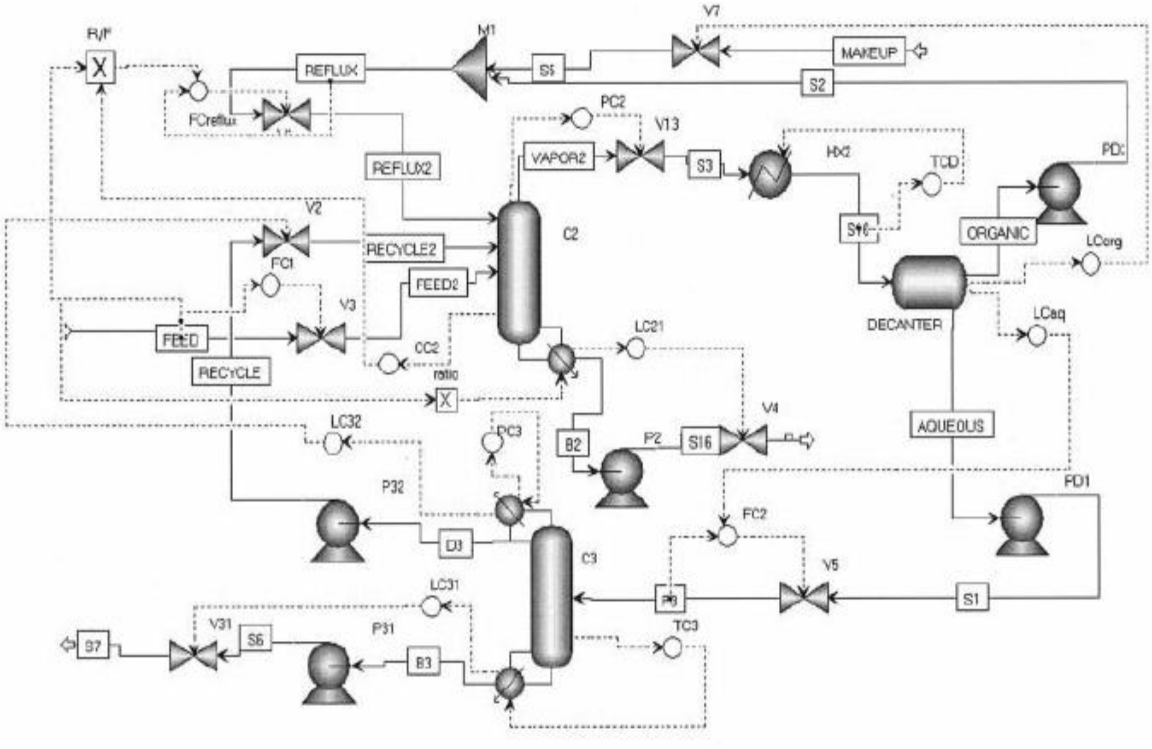

Figure 2.7: Aspen Dynamics flowsheet with recycles connected (Luyben, 2006a)

Next, for the divided-wall column dynamic control, it has been explored in a relatively small number of papers. As mentioned in Ling and Luyben (2009), control is much harder than with a conventional two-column separation. This is because more interaction between controlled and manipulated variables since the four sections of the column are coupled. Thus, a new control structure for divided wall distillation columns was introduced as illustrated in Figure 2.8. This new scheme can simultaneously controlling product compositions and minimizing energy consumption in a practical way.

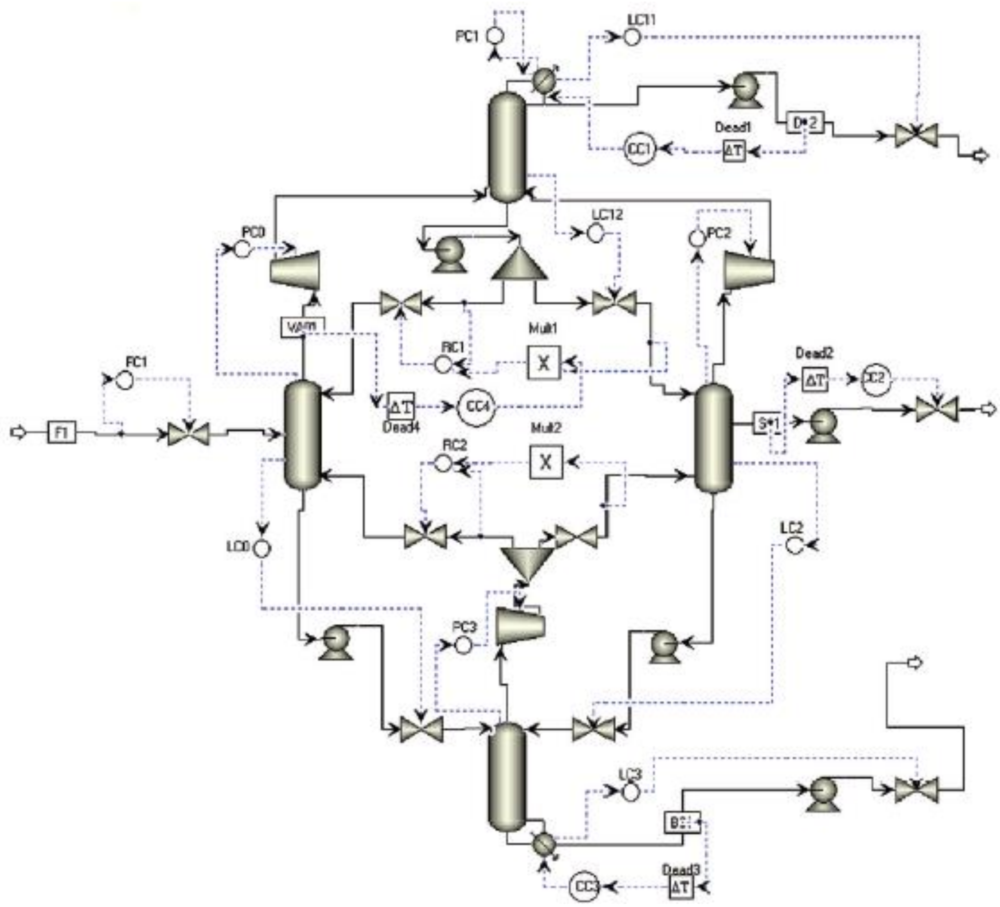

Figure 2.8: Aspen Dynamic implementation (Ling and Luyben, 2009)

Furthermore, one of the process that can be simulated by Aspen software is synthesis of fatty esters. Based on catalytic reactive distillation, heat integrated design was used. Control structure for this plant is illustrated as Figure 2.9. Before using Aspen Dynamics simulator, steady state model must be developed first in Aspen Plus. Dynamic model can be further used for other controllability studied. It is also can be used as a starting point for the development of other control relevant models (Kiss, 2011).

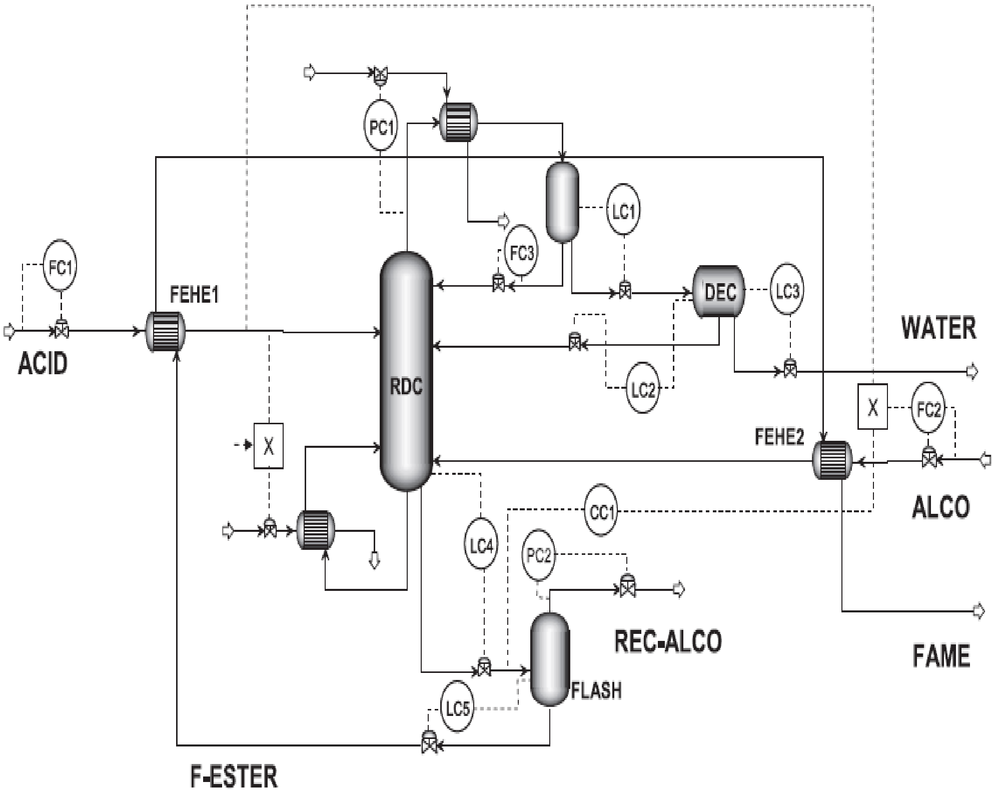

Figure 2.9: Plantwide control structure of the heat integrated RD process (Kiss, 2011)

2.5 Summary/finding from the literature

From the literature review, we can conclude that Aspen software can be a good platform to simulate various type of process especially for chemical engineering system as shown in the section 2.4. Most of the process can be validated from the real experimental data and an excellent agreement between experimental data and simulation results was able to achieved. It clearly shows that the migration of the process or system to the Aspen software can be done with the purpose of easing the burden in experimental exercise as shown on the section 2.2.

Therefore, if an accurate model can really represent the process or system properly, it can be use for teaching,research and process control tools. As mentioned in section 2.2 and 2.3, Aspen model can replace the conventional experiment with a visually experiment which is make it more convenient for research and teaching purposes.