OPTIMIZATION OF BIODIESEL PRODUCTION FROM WASTE COOKING OIL (WCO) USING ASPEN HYSYS

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by

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ABSTRAK

Pengoptimuman pengeluaran biodiesel daripada minyak masak sisa (WCO) menggunakan ASPEN HYSYS telah dibentangkan dalam tesis ini. Minyak masak sisa (WCO) dipilih sebagai bahan mentah kerana kira-kira 40,000 tan setahun WCO dihasilkan di negara-negara Asia seperti China, Malaysia, Indonesia, Thailand, Hong Kong, India, dan lain-lain. Cara-cara lain adalah untuk mengitar semula minyak dan menukarnya ke dalam bentuk produk baru iaitu biodiesel yang berguna untuk mengurangkan jumlah sisa dan memberi WCO kehidupan baru. Simulasi ini dijalankan untuk mengkaji kecekapan pengeluaran biodiesel daripada reaktor membran kerana penggunaan artikel rujukan utama untuk projek ini adalah menggunakan reaktor membran yang diambil daripada "Simulasi ASPEN HYSYS untuk Pengeluaran Biodiesel daripada Minyak Masak Sisa menggunakan Reaktor Membran". Projek ini akan mengoptimumkan lagi pengeluaran biodiesel menggunakan reaktor membran. Gambar rajah aliran proses (PFD) juga diambil daripada " Simulasi ASPEN HSYS untuk Pengeluaran Biodiesel daripada Minyak Masak Sisa menggunakan Reaktor Membran" dan digunakan untuk mensimulasikan hasilnya dengan menggunakan ASPEN HYSYS. Metodologi kajian untuk simulasi bergantung pada perisian ASPEN HYSYS. Senarai komponen untuk simulasi boleh didapati dari pangkalan data HYSYS. Pakej cecair untuk simulasi menggunakan kaedah NTRL. Gambar rajah aliran proses (PFD) untuk

simulasi merujuk pada artikel “Simulasi ASPEN HSYS untuk Pengeluaran Biodiesel daripada Minyak Masak Sisa menggunakan Reaktor Membran”. Hasilnya tidak dapat diperolehi kerana banyak kesalahan berlaku semasa melakukan simulasi. Hasil yang diharapkan dari hipotesis ialah hasil biodiesel akan meningkat seiring kenaikan suhu dan tekanan. Hasil biodiesel juga akan meningkat seiring bertambahnya waktu tindak balas. Kajian ini menunjukkan bahawa parameter seperti suhu, tekanan dan masa reaksi memainkan peranan penting yang mempengaruhi hasil biodiesel. Lebih-lebih lagi, ini menunjukkan potensi sebagai proses pengkomersialan baru kerana bahan buangan yang dihasilkan kurang kerana tidak memerlukan air untuk membersihkan produk akhir.

OPTIMIZATION OF BIODIESEL PRODUCTION FROM WASTE COOKING OIL (WCO) USING ASPEN HYSYS

ABSTRACT

Optimization of biodiesel production from waste cooking oil (WCO) using ASPEN HYSYS has been presented in this thesis. Waste cooking oil (WCO) is chosen as the raw material because about 40,000 tonnes per year of WCO produced in Asia countries such as China, Malaysia, Indonesia, Thailand, Hong Kong, India, etc. The other ways are to recycle the oil and convert it into a new form of product which is biodiesel that will be useful to reduce the amount of wastes and give the WCO a new life. The simulation was carried out to study the efficiency of the biodiesel production from the membrane reactor since the main reference article use for this project is using membrane reactor taken from “ASPEN HYSYS Simulation for Biodiesel Production from Waste Cooking Oil using Membrane Reactor”. This project will further optimize the biodiesel production using membrane reactor. The process flow diagram (PFD) is also taken from the “ASPEN HYSYS Simulation for Biodiesel Production from Waste Cooking Oil using Membrane Reactor” and were used to simulate the result by using ASPEN HYSYS. The research methodology for the simulation rely on the ASPEN HYSYS software. The list of components for the simulation can be obtained from the HYSYS databanks. The fluid package for the simulation is using NTRL method. The process flow diagram (PFD) for the simulation is referring the article “ASPEN HSYS Simulation for Biodiesel Production from Waste Cooking Oil using Membrane Reactor”. The result was unable to obtained due to many errors occur during

conducting the simulation. The expected result from the hypotheses are the yield of the biodiesel will increase as the temperature and pressure increase. The yield of biodiesel will also increase as the reaction time increase. This study has shown that the parameters such as temperature, pressure and reaction time play an important role that affecting the yield of biodiesel. Moreover, it shows a potential as new commercialize process due to the less waste is generated because no water is needed to purify the final product.

CHAPTER 1
INTRODUCTION

Nowadays, the consumption and usage of fossil fuel worldwide has caused the demand for existing fossil fuel to be increased and the current fuel reservoir worldwide will not be able to accommodate the demands for a much longer time. Thus, other alternatives must be found immediately to balance or cover back the existing fossil fuel so that the oil reservoir will not be depleted in the future. One of the promising alternatives is biodiesel due to its abundance of resources such as palm oil, canola oil, rapeseed oil and coconut oil. It also has the same properties as the fossil fuel diesel and can be used in the diesel engine without any modification to the diesel engine (Alternative Fuels Data Center, 2013). It also can be use together with the diesel or pure biodiesel.

Apart from abundance of resources, issues of pollution become another important aspect that need to be considered when choosing alternative energies. Biodiesel that are produced from the waste cooking oil (WCO) is proven to be able to minimize the pollution since it recycled back the waste cooking oil into a new form of energy (The Benefits of Recycling Cooking Oil, 2017). Biodiesel also produces 78% less CO_2 than diesel fuel (Laboratory, 2005). About 40,000 tonnes per year of WCO produced in Asia countries such as China, Malaysia, Indonesia, Thailand, Hong Kong, India, etc (Hanisah, 2013).

The production of biodiesel is typically using transesterification process as the main process but there are also other routes such as supercritical, pyrolysis and hydro-esterification. The process usually starts with the transesterification reaction between the WCO with methanol and sodium hydroxide (NaOH) that acts as catalyst to speed up the reaction (Biodiesel production, 2019). Then, it will undergo purification process to remove any unwanted components and get the final purified product. Although the base catalyst such as NaOH is often used in this process, it has a major setback due to formation of soap which will reduce the yield of the biodiesel. As a result, utilising a heterogeneous acid catalyst in a membrane reactor is proposed for the biodiesel generation from waste cooking oil.

The project is conducted in order to recycle the waste cooking oil generated in Malaysia each year. It also can be as one of the alternatives for a renewable energy to reduce the dependency on the existing fossil fuel. The ASPEN HYSYS software was used in this project. It is one of the most reliable software when dealing with hydrocarbons because it has wide range of database of many processes including the conversion of waste cooking oil to biodiesel. This project is to optimize the data and the efficiency of biodiesel production from waste cooking oil (WCO).

1.1 Research Background

Diesel fuel, commonly known as diesel oil, is a flammable liquid that is used as a fuel for diesel engines. It is often made from crude oil fractions that are less volatile than those used in gasoline. The fuel in diesel engines is ignited by the heat of compressed air in the cylinder, rather than by a spark as in gasoline engines, with the fuel injected as a spray into the hot compressed air (Internal Combustion Engine Basics, 2013). Diesel fuel produces more energy during burning than equal volumes of gasoline, resulting in improved fuel economy for diesel engines. Additionally, because diesel fuel requires fewer refining stages than gasoline, diesel fuel has typically had lower retail pricing than gasoline. Diesel fuel, on the other hand, produces higher levels of some air pollutants like as sulphur and solid carbon particles, and the additional refining stages and emission-control devices implemented to decrease such emissions might lessen the economical benefits of diesel over gasoline. Diesel also release more carbon dioxide than gasoline, reduce the advantage with the greenhouse gas emissions.

One of the alternatives is by using Crude Palm Oil (CPO). It can be obtained from the oil palm fruit where it will be converted to biodiesel. The oil palm can be obtained easily in Malaysia but using this crude palm oil is too costly because it can be used to produce other products to meet the market demands.

According to (Hirschmann, 2020), in 2019, approximately 574.48 thousand metric tons of cooking oil was produced in Malaysia. From that values, the amount of WCO produced is estimated around 40,000 tons per year in Asia countries such as China, Malaysia, Indonesia, Thailand, Hong Kong, India, etc (Hanisah, 2013). So, another alternative where the waste cooking oil (WCO) is use instead of crude palm oil because it can save the cost for the raw material to produce biodiesel. It also can reduce the wastes generated from the WCO by converting it to biodiesel. Before using the waste cooking oil from these sources as the raw material, it needs to undergo filtering process to filter out solid or larger molecules that might contained in the oils. After filtering process has been done, then only it can be use as the main ingredient to produce the biodiesel. The characteristics or composition of the components presents in the waste cooking oil also need to be known. The composition can be found using the physiochemical properties such as acid value, saponification value, and iodine value.

There are several processes to convert WCO into biodiesel which are transesterification, esterification and supercritical. Each process has their own conditions in term of temperature and pressure. For transesterification, the process is between triglycerides contain in WCO and alcohol to produce biodiesel and glycerol. This can be shown in the figure below:

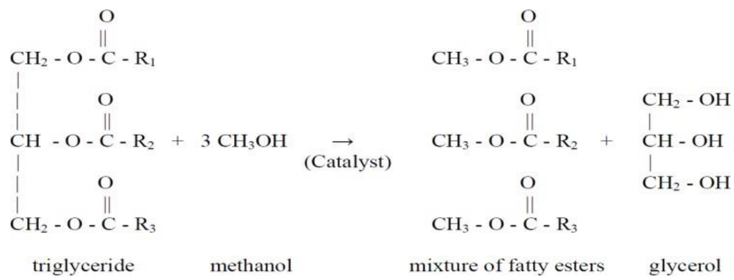

Figure 1.1.1 Transesterification Process for Biodiesel Production

For esterification, the reactants are carboxylic acid and alcohol to produce biodiesel and water. The reaction can be shown in Figure 1.1.2:

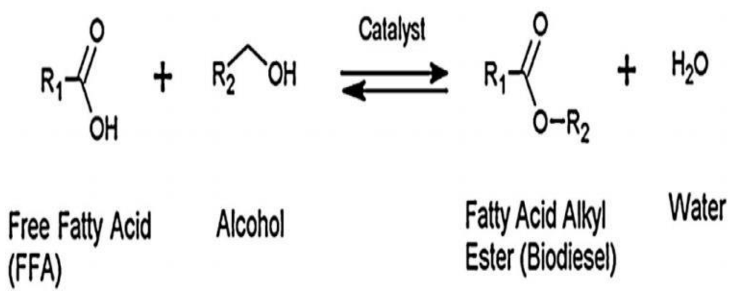

Figure 1.1.2 Esterification Process for Biodiesel Production

For supercritical process, the reaction is between WCO with alcohol to form biodiesel and glycerol at critical temperature, T_c = 274.9 °C and critical pressure, P_c = 4.6 MPa. The reaction is as follow:

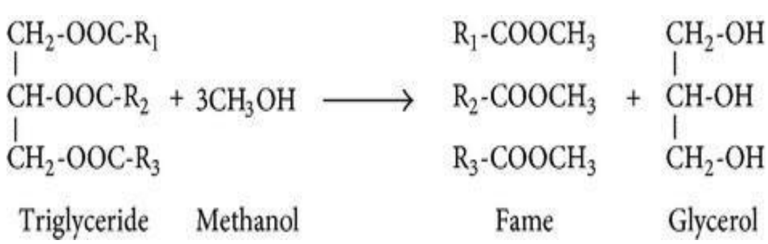

Figure 1.1.3 Supercritical Process for Biodiesel Production

The catalyst types use for the biodiesel production are also important in order to achieve higher yield of products. There are two classes of catalyst which are homogeneous and heterogeneous catalyst. Each class has their own advantages and disadvantages. Thus, it also affecting the yield of the biodiesel produced. In this research, the need to find ways to simplify the biodiesel process will also be look at. The process to convert waste cooking oil can be conducted after all the criteria has been fulfilled.

1.2 Problem Statement

The abundance of waste cooking oil generated from many sources give a negative implication to the surrounding environment because some of the WCO produced is not properly dispose. About 40,000 tonnes per year of WCO produced in Asia countries such as China, Malaysia, Indonesia, Thailand, Hong Kong, India, etc (Hanisah, 2013). If not being disposed or treated carefully, it will cause pollutions to the environment. The WCO can be disposed in various ways where it can be poured into disposable container, chill until solid, combine with other material or pour small amount into trash (Harlan, 2020). The other way is to recycle the oil and convert it into a new form of product which is biodiesel that will be useful to reduce the amount of wastes and give the WCO a new life (Alexandru, 2016). The optimization, the efficiency and the quality of the products yield from the simulation will be studied in this project. The steady-state and dynamic simulation, process design, performance modelling, and optimization capabilities of HYSYS are the reason why it is widely utilised in industry. HYSYS is a piece of software that lets you create a process model and then simulate it using sophisticated computations. ASPEN HYSYS is chosen since it can be one of the promising and able to obtained a much better result to produce biodiesel from waste cooking oil (WCO).

1.3 Objectives

The objectives for this research are:

i. To optimize the yield of biodiesel produced using the membrane reactor.

ii. To determine the simulation using ASPEN HYSYS can be achieved for the production of biodiesel.

CHAPTER 2
LITERATURE REVIEW

In previous chapter, the aim is to recycle the waste cooking oil generated in Malaysia each year. It also can be as the one of the alternatives for a renewable energy to reduce the dependency on the existing fossil fuel. This chapter will cover on the overview generation of diesel and biodiesel, sources of diesel and biodiesel, biodiesel as the source of alternative energy, waste cooking oil (WCO) as alternative source in Malaysia, energy difference between diesel and biodiesel, the existing biodiesel plant in Malaysia and simulation using ASPEN HYSYS.

2.1 Diesel and Biodiesel

Diesel fuel, commonly known as diesel oil, is a flammable liquid that is used as a fuel for diesel engines. It is often made from crude oil fractions that are less volatile than those used in gasoline or heavier than gasoline (Britannica, 2018). Biodiesel on the other hand is defined as a type of diesel fuel made from long-chain fatty acid esters obtained from plants or animals (Deborah O'Connell, 2007). Diesel is made by fractionally distilling crude oil between 200 and 350 ºC (392 and 662 ºF) at atmospheric pressure, yielding a combination of carbon chains with between 9 and 25 carbon atoms per molecule (Interstate Technology & Regulatory Council, 2014). Transesterification of vegetable oil or animal fat feedstock is a typical way to make biodiesel (Maria del Remedio Hernández, 2010). There are several differences between the diesel and biodiesel such as biodiesel has low energy as compared to diesel and this will result in more biodiesel is required to emit the same energy as diesel, and in terms of food security because biodiesel crops can be grown on valuable crop fields because it is a plant-based fuel and food shortage or a spike in the cost of food could result from bad planning (Smart alternative fuels, 2019). If spilled or discharged into the environment, biodiesel in its pure, unblended form causes considerably less damage than petroleum fuel. It is less flammable than petroleum diesel, making it safer. Biodiesel has a flashpoint of more than 130°C, compared to 52°C for petroleum diesel (Alternative Fuels Data Center, 2013). Therefore, it is safer for handling and storage biodiesel as compared to the conventional diesel.

2.2 Sources of Diesel and Biodiesel

Diesel fuel is made from a variety of sources, the most common of which is petroleum. Biomass, animal fat, biogas, natural gas, and coal liquefaction are some of the other sources. Rapeseed oil, sunflower oil, and palm oil are common feedstocks for biodiesel manufacturing. Algae has also been suggested as a source of biodiesel. Fat pockets in algae help to keep them afloat. Biodiesel can be made from this fat if it is collected and treated properly (Biomass-based diesel fuels, 2020). Diesel fuel has a wide range of performance, efficiency, and safety characteristics as a transportation fuel. Diesel fuel has a higher energy density than other liquid fuels, resulting in more useable energy per unit of volume (Biomass-based diesel fuels, 2020). Biodiesel is a clean-burning, renewable alternative to petroleum diesel that is manufactured in the United States. Biodiesel as a vehicle fuel enhances energy security, air quality, and the environment, as well as providing safety benefits (Biodiesel Benefits and Considerations, 2017). The region that consume the largest amount of diesel are developed countries (439348 million liters), high income countries (426361 million liters), developing countries (294294 million liters) and middle income countries (253317 million liters) (Moinuddin Sarker, 2013).

2.3 Biodiesel as the Source of Alternative Energy

Biodiesel is a liquid biofuel produces from the chemical processes from vegetables oil or animal fats that can be used in the existing diesel engine with small or no modification. It can be mix with diesel oil or pure biodiesel. The raw material can be from many sources such as rapeseed (European Union countries), soybean (Argentina and USA), oil palm (Asian and Central American countries), and sunflower and even also animal fats. Advantages of using biodiesel instead of diesel are it is renewable fuel, low toxicity, degrade more rapidly than diesel, and lower emission of contaminants (Romano, 2011). When tested on commercial diesel engines, biodiesel made from waste cooking oil provides greater engine performance and lower pollutants (Dalai, 2006). Biodiesel has grown in popularity in recent years as people have become more aware of the depletion of fossil fuel resources and environmental challenges (Daming Huang, 2012). The biodiesel can be obtained from 3 main processes which are transesterification, hydro-esterification, and supercritical. The summary of the three processes are shown in table below:

Table 1 Summary of the 3 Processes for Biodiesel Production

	Transesterification	Hydro-esterification	Supercritical
Purity of Biodiesel from feedstock	Biodiesel:95% Glycerin:85%	FAME:99.1wt%	FAME:97.83% Glycerol:10%
Catalyst	NaOH	-	-
Operating temperature	60 ºC	250 ºC	280 ºC
Operating pressure	4 bars	40 bars	200 bars
Green chemistry and sustainability	Reduce the harm to health and the environment	Eco-friendly	Reduce our dependency for fossil fuel or petroleum-based product
Environmental impact	No greenhouse gases being released to the environment	No wastewater was released into the environment	does not produce too much waste only wastewater
Energy consumption	Moderate	Considerably high	High temperature and pressure
Operation flexibility	Moderate operation	Any acid fatty material able to be used regardless of FFAs and water contents	Not require too many steps to get the product
Safety	Low temperature and pressure to prevent explosion incident	Subcritical condition such as 250 °C and 40 bars	Quite risky
Waste management	Reducing waste treatment load	water produced from esterification can be separated easily and reutilized	Little waste produced

2.4 Waste Cooking Oil as Alternative Source in Malaysia

The waste cooking oil is the end product from frying foods using cooking oil that are produces from the plants and animal fats. In Malaysia, 50,000 tonnes of unused cooking oil derived from vegetable oils or animal fats are discarded into the environment each year without being properly treated (Mimi Suriani Mat Daud, 2020). The discharged of waste cooking oil will lead to the clogging of sewer pipes and drains causing flooding or sewer overflows (Ashley, 2000). By coating the surface of water and preventing oxygen from dissolving, the discharge of waste cooking oil into the water system would disrupt the oxygenation process and kill aquatic life (Kabir, 2014). It can help to reduce pollution to the environment or environmental problem caused by the abundance of waste cooking oil by converting WCO into a new form of product which is biodiesel. The WCO is insoluble in water but soluble in organic solvent. Examples of organic solvent are benzene, toluene chloroethane and ethyl acetate. The origin of cooking oil come from plant-based fat such as palm oil, olive oil, sunflower oil, and coconut oil (Aliasa, 2018). There are many compounds present in WCO such as free fatty acids (FFA), solids particles and moisture. FFAs content usually increases as the WCO is used because oils and fats are subjected to diverse settings such as storage, processing, heating, or frying, the level of FFA varies with time, temperature, and moisture content. FFAs are more prone to oxidation and rancidity than neutral oils because they are less stable (S. A. Mahesar, 2014). The acid value of the WCO was 5.78 mg KOH / g oil, which has a higher value than the virgin palm oil 0.328 mg KOH / g oil. The maximum amount allowable FFA in waste cooking oil to be able to be use as the raw material for the biodiesel production is 1.5 mg KOH / g oil (Iván Dario Casallas, 2018). The WCO must undergo pre-treatment process in order to prevent the equipment from brake down like carbon deposits, plugging of the fuel lines, gelling of lubricating oils, fouled piston heads and ring sticking (Iván Dario Casallasa, 2018). All the factors that affecting the composition of WCO need to be determined first before it can be use as the feedstock for the biodiesel production. The use of WCO as a sustainable feedstock for biofuels production, maximising the value of biowaste through energy recovery while also resolving the disposal problem (Brandon Han Hoe Goh, 2020).

2.5 Energy Difference between Diesel and Biodiesel

There are several differences between the biodiesel and conventional diesel fuel. The difference between biodiesel and diesel are biodiesel can be a combination of biomass energy and traditional fossil energy while for diesel is only the traditional fossil energy. Biodiesel can be generated and can be considered as a renewable energy but diesel cannot be generated and it is non-renewable energy (Maggie, 2018). The biodiesel also has much lower carbon emissions as compared to the diesel. Lower health risk, due to reduced emissions of carcinogenic substances. It also degrades more rapidly than diesel fuel, minimizing the environmental consequences of biofuel spills (Sorichetti, 2011). Biodiesel also has much higher flash point 130 ºC while for diesel fuel, the flash point is 62.5 ºC about half than the biodiesel flash point. The disadvantage of using biodiesel is slightly higher fuel consumption due to the lower calorific value of biodiesel with a difference of 8.23 MJ/kg. Due to that, the amount of biodiesel needed to be use to achieve similar calorific value as the diesel fuel is much higher. Thus, increase the cost.

2.6 Biodiesel Plant in Malaysia and ASPEN HYSYS Software

Malaysia has 25 biodiesel plants, the bulk of which are located on Peninsula Malaysia. These have a total capacity of 2.6 million tonnes, however current output is less than 10% of the entire capacity installed (Chin, 2011). The biodiesel plant is located in Johor, Pahang, Perak, Selangor, Sabah, Negeri Sembilan, and Sarawak (MPOB, 2014). Biodiesel can be simulate using many software such as ASPEN HYSYS, ASPEN PLUS and MATLAB. The ASPEN HYSYS is the most chosen one when it come to the petroleum simulation due to it provide a wider range of data and it is the most suitable software for the production of biodiesel from waste cooking oil (WCO). It is more reliable to the oil-based products and it also being used by large company and refineries to further optimize their existing products. HYSYS is used extensively in industry due to its steady-state and dynamic simulation, process design, performance modelling, and optimization (What is ASPEN HYSYS, 2021). The parameters that will be studied in this project are temperature and pressure to be used in the ASPEN HYSYS simulation. The literature related to the ASPEN HYSYS simulation is the transesterification of waste cooking oil using ASPEN HYSYS. It is conducted to study the effect of parameters such as molar ratio of methanol to WCO, reflux ratio, and reboiler duty on biodiesel mole fraction. Increases in reboiler duty, as well as decreases in reflux ratio, total feed flow rate, and molar ratio of methanol to WCO, improve reactive distillation performance in terms of the mole fraction of m-oleate in the reboiler, according to the simulation. It can be clearly seen that ASPEN HYSYS can further improve the and determined the desired result for the simulation (Karacan, 2020).

CHAPTER 3
METHODOLOGY

3.1 Research Methodology

Figure 3.1 show the workflow for the research. The workflow needs to carefully schedule in order to execute the task efficiently:

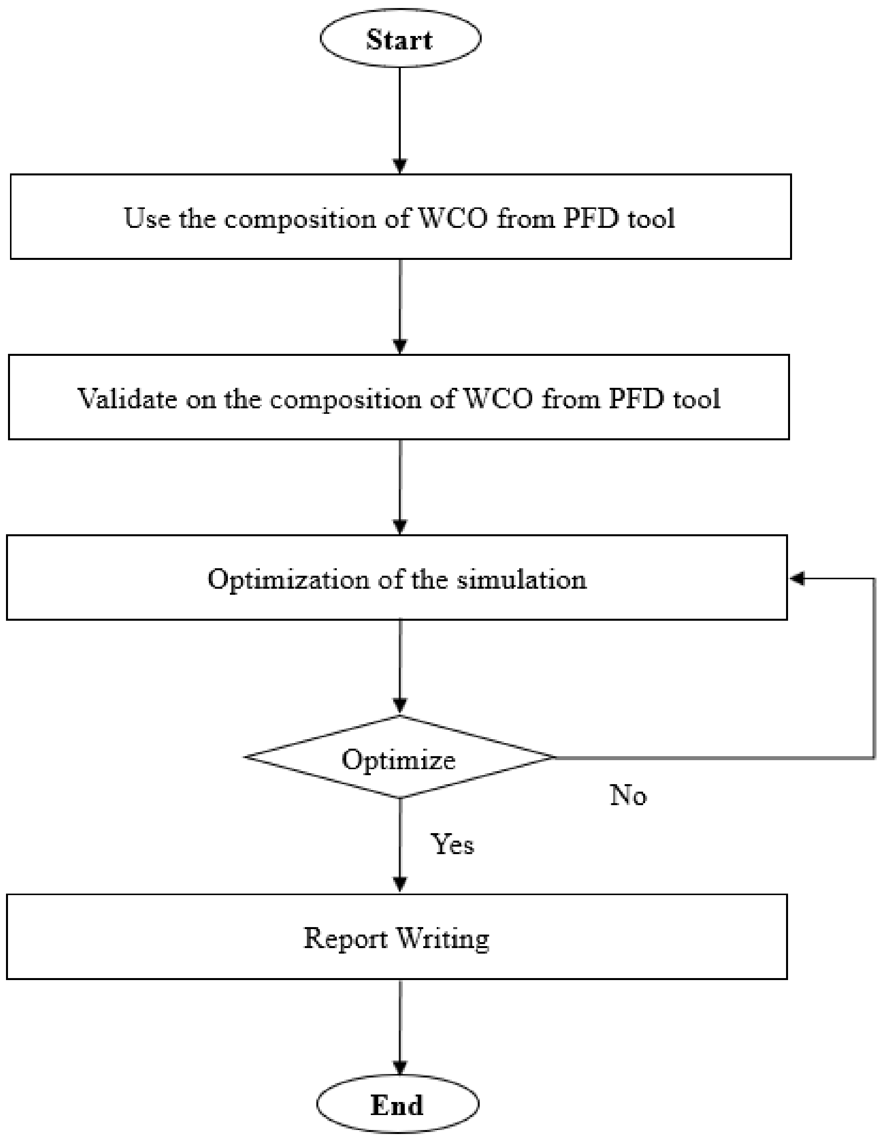

Figure 3.1 Workflow for the Project

3.2 Process Flow Diagram (PFD) and Data from Literature

Process Flow Diagram (PFD) is an important tool to show the flow of process within the project. It ensures that all the criteria to run the simulation are fulfilled and will make the process for the simulation running smoothly. Figure 3.2 show the PFD for the simulation. The parameters used for the simulation are temperature and pressure.

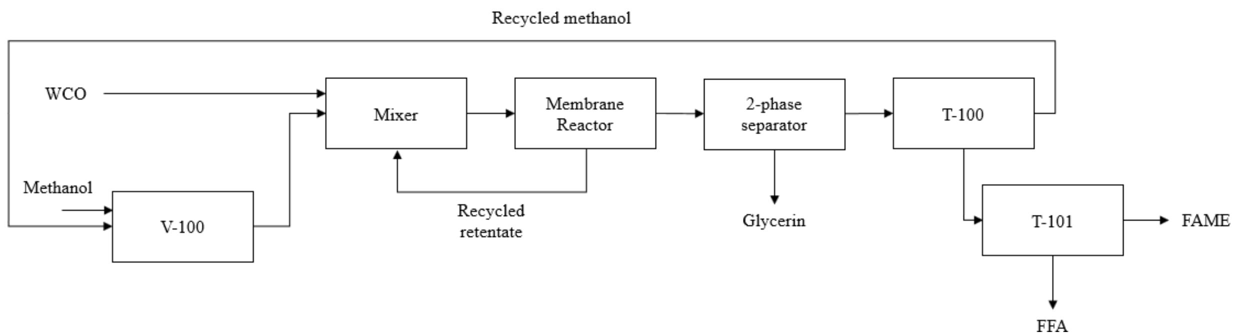

Figure 3.2 Process Flow Diagram (PFD) for Biodiesel Production from WCO

Table 2 shows the data that are obtained from main reference literature and it shows the composition of waste cooking oil (WCO).

Table 2 Composition of Waste Cooking Oil (WCO)

Components	Mass Fraction
Tripalmitin	0.074
Tristearin	0.027
Triolein	0.184
Trilinolein	0.478
Trilinolenin	0.051
Other Triglycerides	0.036
Palmitic Acid	0.013
Stearic Acid	0.005
Oleic Acid	0.032
Linoleic Acid	0.083
Linolenic Acid	0.009
Other Free Fatty Acid	0.006
H_2O	0.003

3.3 ASPEN HYSYS Environment

The interface of the aspen HYSYS need to be familiarized first so that it will be easy to conduct the simulation. The user interfaces can be seen in Figure 3.3.1 below where the important variable can be insert:

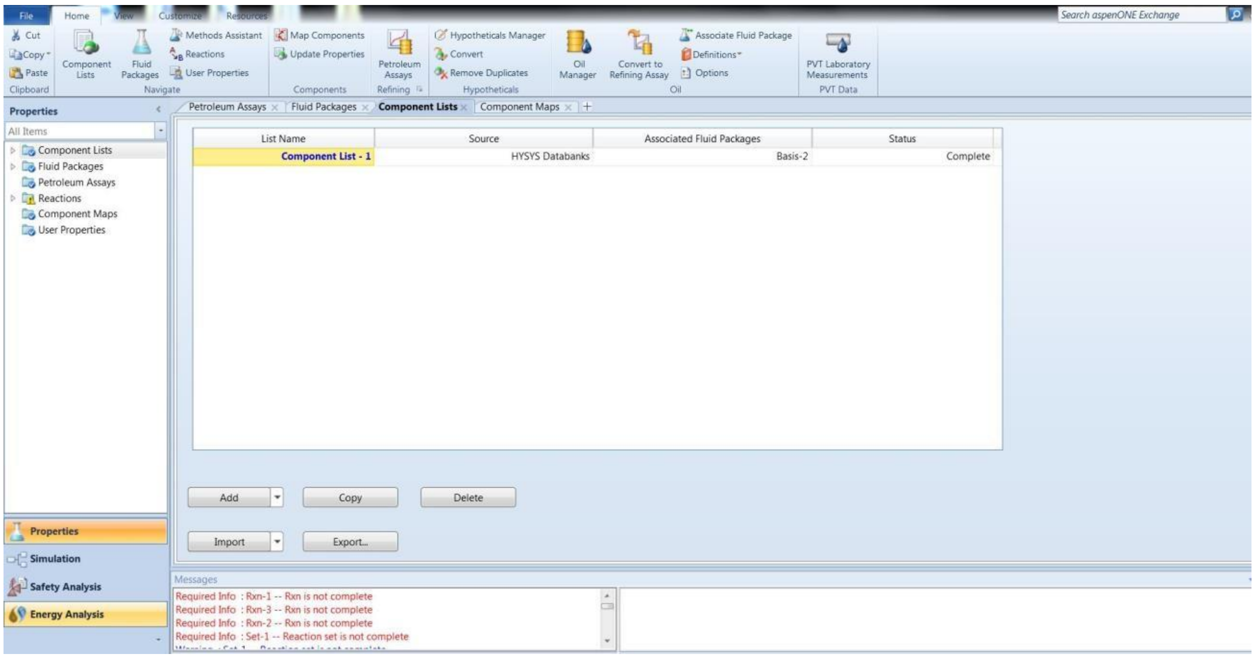

Figure 3.3.1 Interface for the Component List

The components in the raw material can be included in the simulation by double click at the component lists. The list of components will appear on this page after double click as shown in Figure 3.3.2.

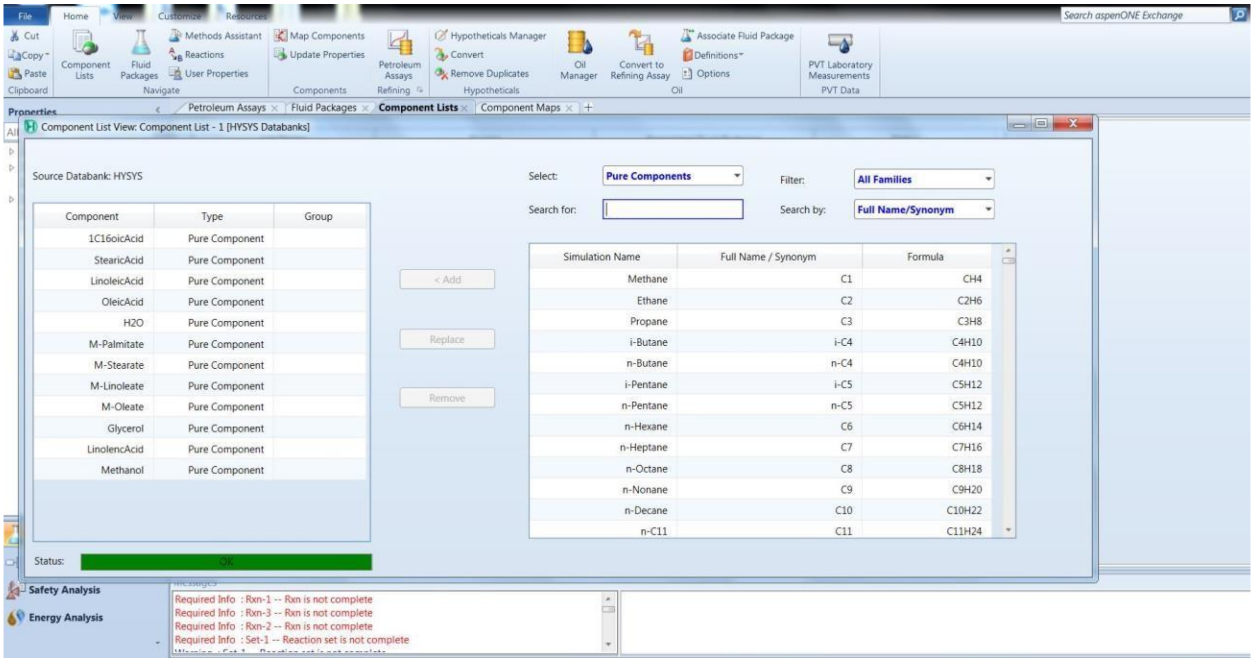

Figure 3.3.2 Interface for the List of Components in HYSYS Databanks

Next, the fluid packages interfaces to choose the suitable or desired fluid packages is shown in Figure 3.3.3:

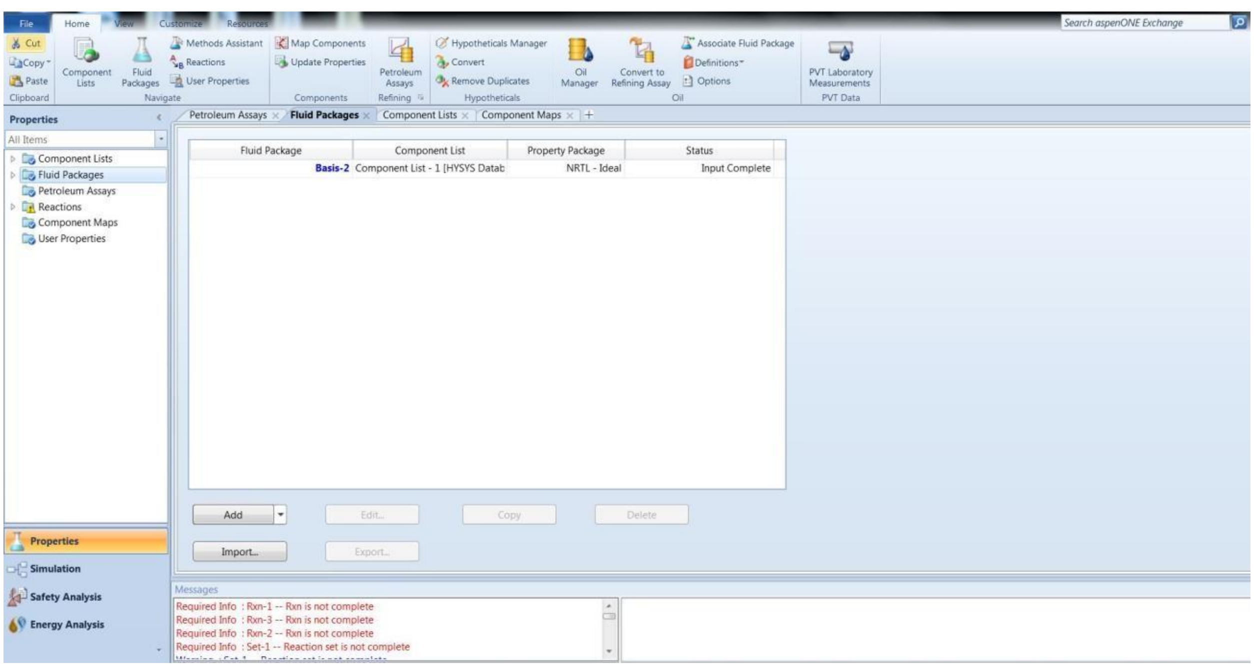

Figure 3.3.3 Fluid Packages Interface

Based on the literature review, the most suitable fluid packages for the simulation of biodiesel production is NRTL method. The fluid packages can be chosen in the fluid packages folder as shown in Figure 3.3.4 below:

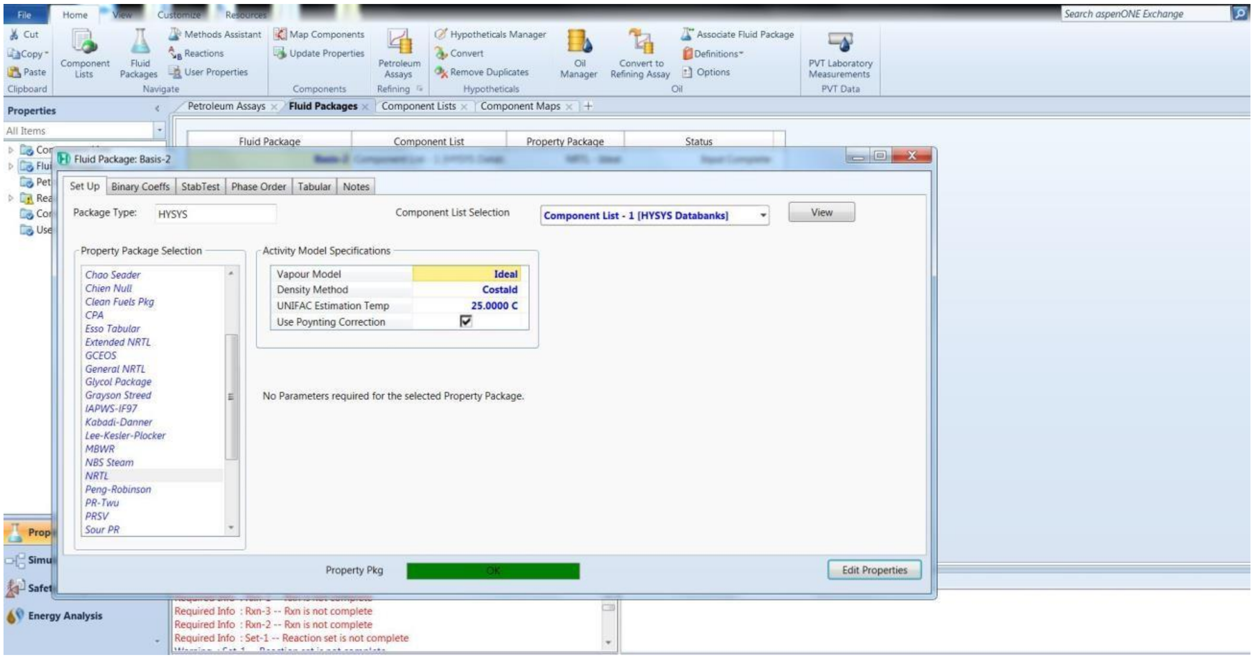

Figure 3.3.4 List of Fluid Packages Available in ASPEN HYSYS

After the fluid packages has been identified, the process flow diagram of the whole biodiesel production can be construct. The design of the flow diagram is taken from the “Aspen HYSYS Simulation for Biodiesel Production from Waste Cooking Oil using Membrane Reactor” (Abdurakhman, 2017). The Figure 3.3.5 below shows the whole process flow diagram (PFD):

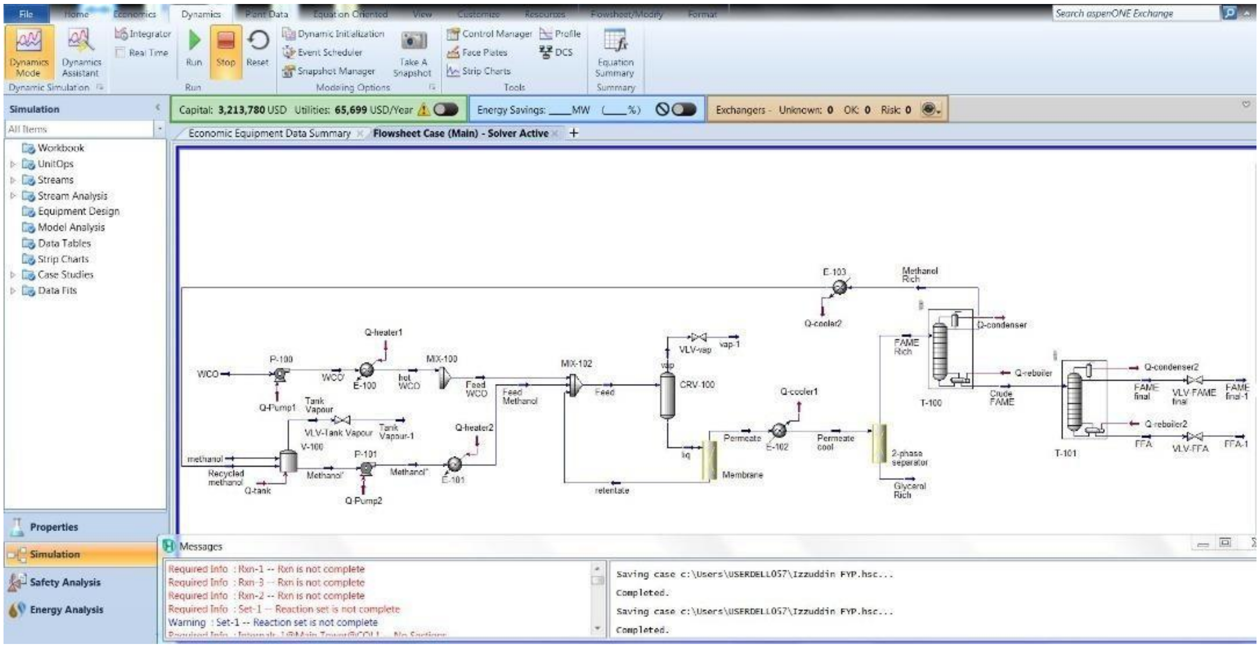

Figure 3.3.5 Process Flow Diagram (PFD) for the Simulation

The condition for the raw material uses in the simulation is shown in Figure 3.3.6, Figure 3.3.7 and Figure 3.3.8 where the main raw materials are waste cooking oil (WCO), methanol and recycled methanol:

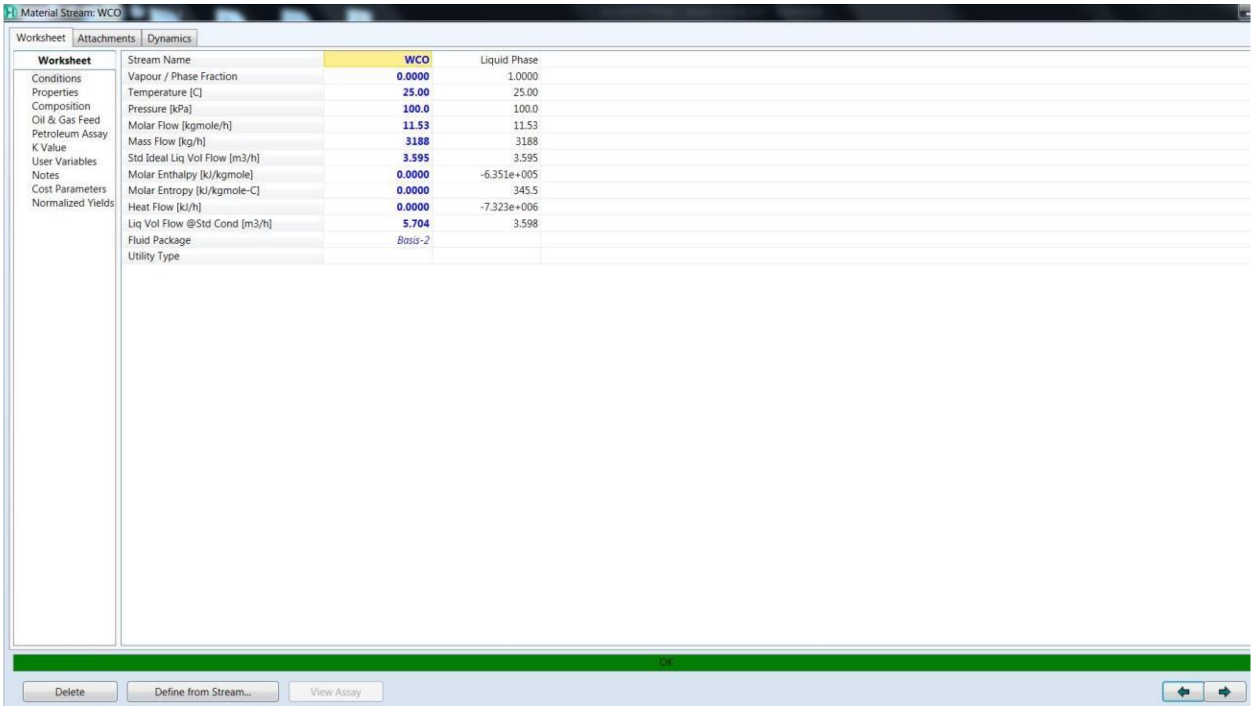

Figure 3.3.6 Waste Cooking Oil (WCO) Properties at the Feed Stream

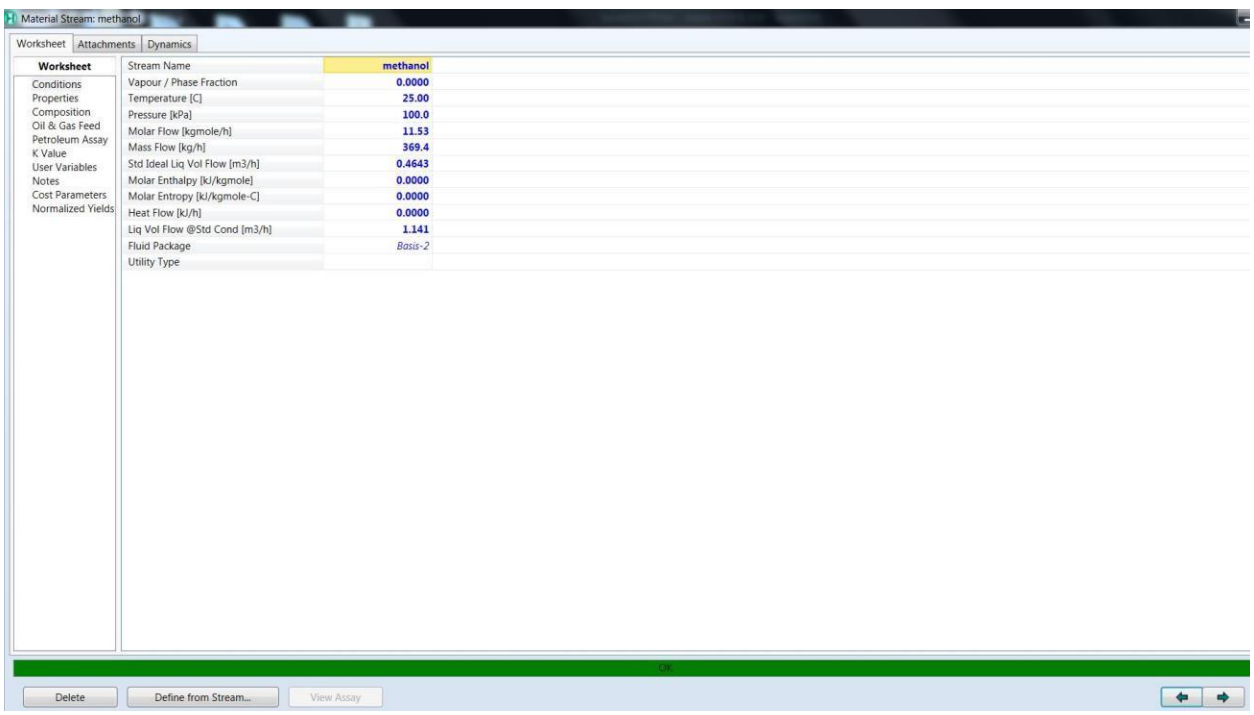

Figure 3.3.7 Methanol Properties at the Feed Stream

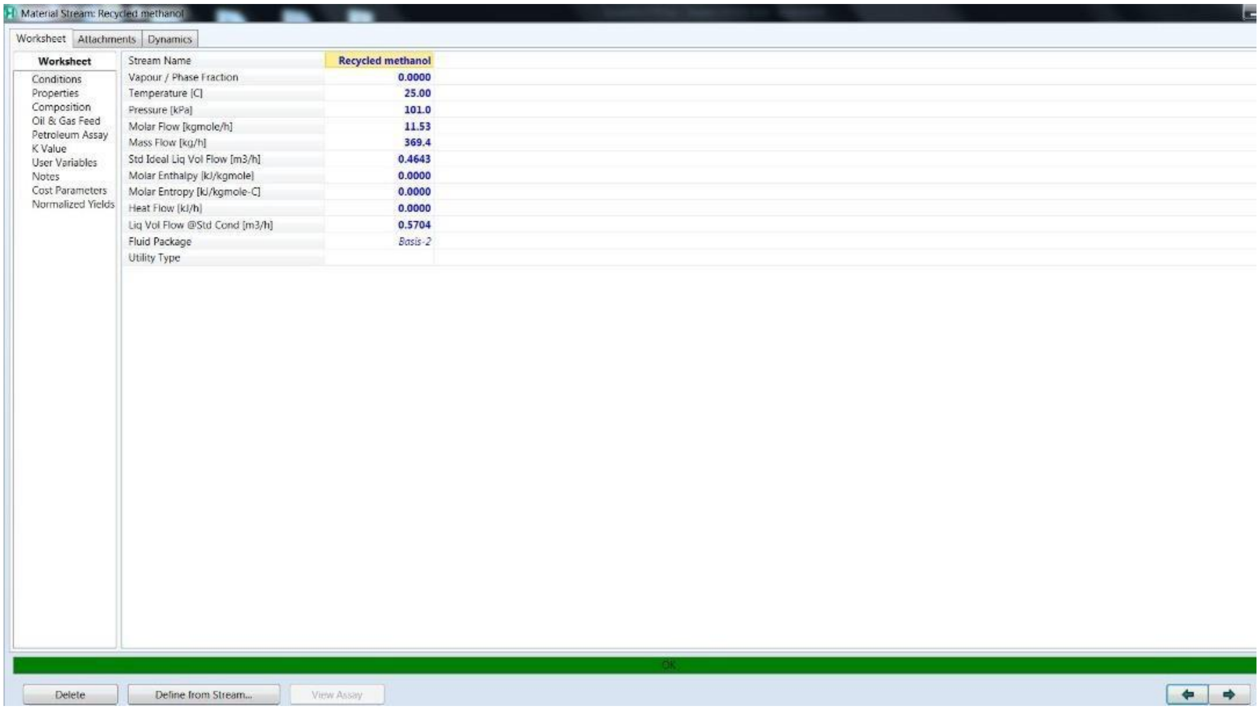

Figure 3.3.8 Recycled Methanol Properties at the Feed Stream

The reaction involved in this simulation is transesterification reaction that occur within the membrane reactor. Components involved in the reaction are primarily waste cooking oil (WCO) and methanol to produce biodiesel (FAME) and glycerin. The condition for reaction to occurs is at temperature of 383.1 K and pressure of 11.51 bar (Abdurakhman, 2017).

After all the required data has been inserted in the ASPEN simulation, the simulation can be conducted and run if there is no major issue or error occur during the interval to obtain the result and it can be used for the next chapter which is the result and discussion.

CHAPTER 4
RESULT AND DISCUSSION

4.1 Result

This chapter display the result obtained from the simulation that are described in Chapter 3. All the result will be discussed with detailed in order to meet the objective for the whole research project. The discussion for the result is also being discuss in this chapter.

The simulation has been conducted using ASPEN HYSYS and the result cannot be obtained and achieved according to desired plan since too many errors occur during the simulation. These errors have caused the whole simulation not able to be run and perform well.

4.2 Discussion

From the flowsheet summary on the mass balance part, the total flow of inlet stream is not equal with the total flow of outlet stream with relative imbalance percentage around 10.73%. This might result from the miscalculation of each individual components for every equipment in the process flow diagram (PFD). Figure 4.2.1 shows the mass balance part for the plant.

The dynamic mode use for the simulation adjust all the equipment that have a minor error and it will enable the equipment to be use for the simulation. It also alters the data that have been inserted manually according to the existing data in the HYSYS databanks and this might be also the reason to have the imbalance mass flow in at the raw material and mass flow out at the product site.

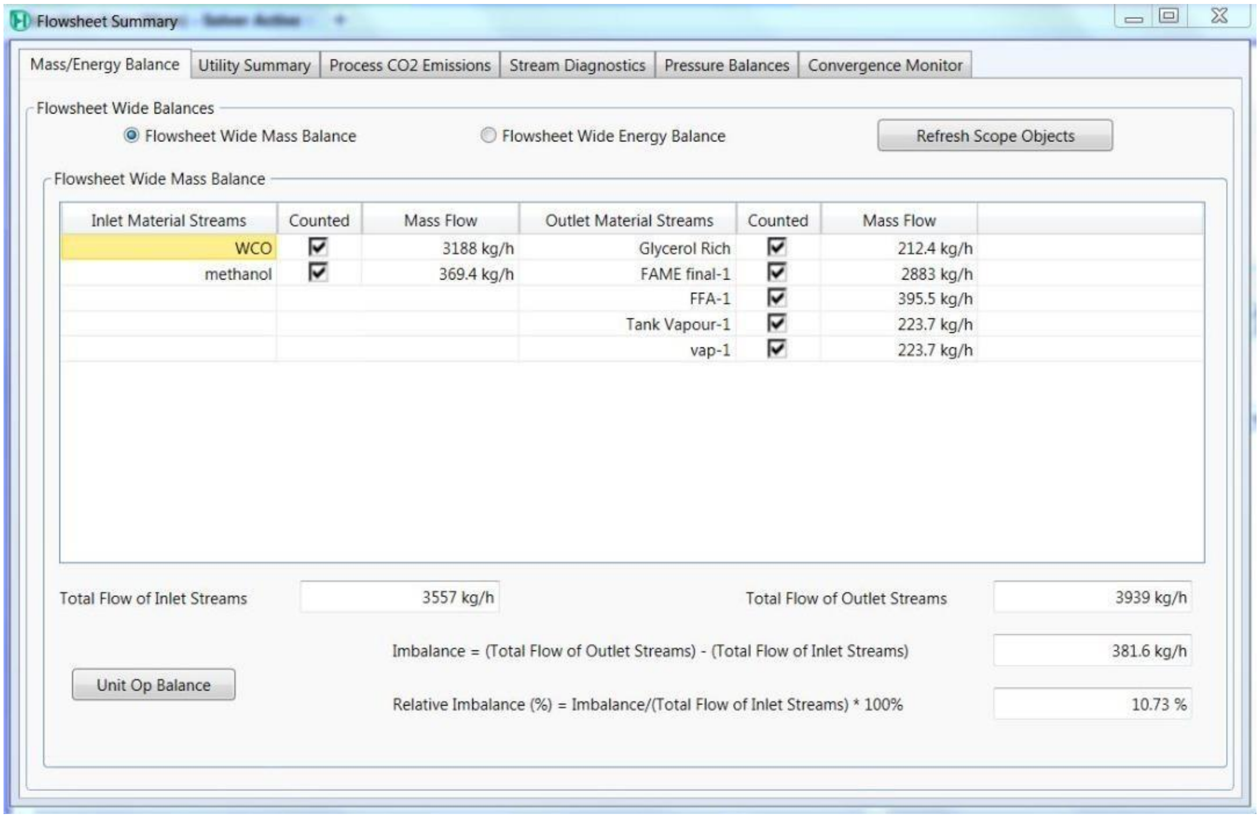

Figure 4.2.1 Mass Balance Summary for the Simulation

This is the figure for the PFD of the simulation when the data is inserted manually and from Figure 4.2.2, it can be seen that around 8 equipment which are E-100, E-101, E-103, E-104, membrane, 2-phase separator, T-100 and T-101 is yellow in color which indicate the equipment has some error in it. For all of heat exchanger in the PFD, the main error is the pressure over specified and for the membrane and 2-phase separator, the error appears after double click at the equipment, it shows that the splits over specified. Lastly, the error found in T-100 and T-101 are the distillation column is unconverged. The other 6 equipment which are P-100, P-101, V-100, MIX-100 and MIX-101 and CRV-100 is ready to be use and no error found for that particular equipment.

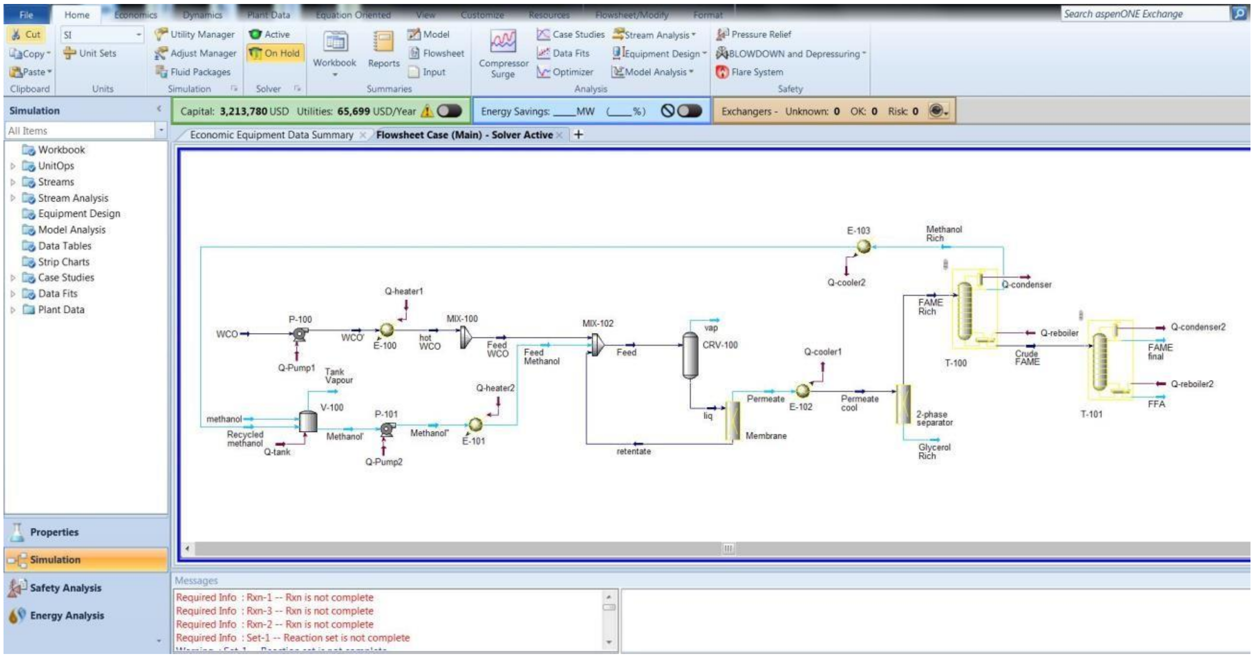

Figure 4.2.2 Process Flow Diagram (PFD) without the aid of Dynamic Mode

Figure 4.2.3 below shows the PFD after the dynamic mode has been use to aid the simulation. It manages to reduce the number of equipment that have errors from 8 to 2 equipment only. The dynamic mode automatically made some changes so that the equipment able to be use without any error. Only 2 equipment that cannot be solve by the dynamic mode because the error is too complicated and need manual intervention to solve it. After many tries to adjust the error found in the membrane and 2-phase separator, the result is still the same where the splits over specified. The error is unable to be corrected due to not enough understanding on the meaning of splits over specified.