CONCEPTUAL 3D DESIGN OF BATCH DISTILLATION COLUMN BY USING AVEVA PDMS

BY

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for award of the Degree of Chemical Engineering.

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STUDENT DECLARATION

I hereby declare that the work in this thesis is my own except for the quotations and summaries which have been duty acknowledge. The thesis has not been accepted for any degree and is not currently submitted for award of other degree.

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ABSTRACT

The main objective of this project is to design a 3D view of distillation column for biodiesel process using AVEVA PDMS. The design constraints specify that the biodiesel distillation column must be sized to fit into a standard truck-trailer. 3D design is a significant to solve the 2D design problem. The first step of this project is drawing process flow diagram (PFD) for biodiesel process. After that the simulation and sizing begin. Simulation is based on PFD and is done using ASPEN Plus. After that the resident time for distillation column can be obtained. Then the Process and Instrumentation Diagram (P&ID) will be drawn. All the control systems are included in the P&ID before 3D design. This is important to ensure the safety of equipment. After completion of P&ID, simulation process and the size of the reactor in the form of 3D can be done. All parameter involved before will be used in 3D design. 3D design is done by using AVEVA PDMS. As a result, by using AVEVA PDMS software the design will be more accurate. This software prove that the 3D design give more benefit compare to the 2D design. The end result is better product, size can be optimized and no faults in design for example equipment layout and pipe clashing. For recommendation the design structure must be including in the plant for example rack to support the equipment, the size of the trailer can also be changed and more safety precaution has to be taken in design.

ABSTRAK

Objektif utama projek ini adalah untuk mereka bentuk model 3D untuk proses biodiesel menggunakan AVEVA PDMS. Had reka bentuk untuk biodiesel kolum penyulingan mestilah dapat dimuatkan ke dalam sebuah lori treler standard. Reka bentuk 3D adalah penting untuk menyelesaikan masalah reka bentuk 2D. Langkah pertama projek ini melukis gambarajah aliran proses (PFD) untuk biodiesel process. Selepas itu, simulasi dan pengiraan untuk saiz bermula. Simulasi berdasarkan PFD dan dilakukan dengan menggunakan Aspen Plus. Kemudian Proses dan Instrumentasi Rajah (P&ID) akan dilukis. Semua sistem kawalan dimasukkan dalam P&ID sebelum reka bentuk 3D. Ini adalah penting untuk memastikan keselamatan peralatan. Selepas selesai P&ID, proses simulasi dan saiz reaktor dalam bentuk 3D boleh dilakukan. Semua parameter yang terlibat sebelum ini akan digunakan dalam reka bentuk 3D. Reka bentuk 3D dilakukan dengan menggunakan AVEVA PDMS. Hasilnya, dengan menggunakan AVEVA PDMS perisian reka bentuk akan menjadi lebih tepat. Perisian ini membuktikan bahawa reka bentuk 3D memberi manfaat yang lebih berbanding dengan reka bentuk 2D. Hasilnya adalah produk yang lebih baik, saiz boleh dioptimumkan dan tiada kesilapan dalam reka bentuk bagi susun atur peralatan seperti ‘pipe clash’. Untuk cadangan struktur reka bentuk mesti termasuk dalam design seperti rak untuk menyokong peralatan, saiz treler juga boleh berubah dan keselamatan langkah berjaga-jaga perlu diambil dalam reka bentuk.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of The Proposed Study

The main objective of this proposal is 3D design of batch distillation column for biodiesel process using AVEVA PDMS. Diesel fuel is largely utilized in the transport, agriculture, commercial, domestic, and industrial sectors for the generation of power or mechanical energy. Biodiesel has recently attracted huge attention in different countries all over the world because of its availability, renewability, non-toxicity, better gas emissions, and its biodegradability. Distillation column is one of the important equipment in the biodiesel plant. For a small scale plant usually batch distillation or packed column is used. For this project I use batch distillation column. The designing of the distillation column is using AVEVA PDMS with 3D design. Many benefit of 3D design will revealed when using this software.

AVEVA has been the world's leading engineering software provider to the plant, power and marine industries. AVEVA PDMS is the software that allows teams of designers to work together, each with their own specialist 3D color-shaded environment, but able to view all of the design going on around them. PDMS builds a sophisticated plant database from which all of the layout and detail drawings can be produced, together with accurate Material Take Off(MTO) information and all kinds of project reports such as Line List or Valve Schedules. The PDMS approach enables a wide range of sophisticated design checks to be carried out across all aspects of the design to check and improve quality. Drawings and reports are generated directly from the model database to ensure consistency between design information and the project deliverables. There are no limits to project size or complexity. PDMS is proven on projects ranging from the smallest refit to the largest green field projects, and is compatible with all the engineering issue, revision and change-control processes required across such projects.

1.2 Problem Statement

Numerous problem arise using 2D design during manufacturing stage. Many human errors can occur with conventional 2D design methods. The designer who uses 2D method has to hold much of the information mentally. With 2D views, projections might show a specific member in several different views while other members might be completely omitted to maintain drawing precision. These results in poor quantity estimation. With 2D method, non-technical people have to wait for a prototype design before they can clearly understand the project. To solve the problem, 3D design is introduce and it improve the design. All 2D design problems can be solved.

1.3 Research Objective

To design the 3D view of batch distillation column of biodiesel using AVEVA PDMS.

1.4 Scope of The Proposed Study

1.4.1 Create model and simulate batch distillation column.

1.4.2 Develop P&ID for the biodiesel plant.

1.4.3 Generate 3D design by using AVEVA PDMS

1.5 Expected Outcome

By using AVEVA PDMS the simulation and design of batch distillation column become more fast, easy, accurate and precise.

1.6 Significant of proposed study:

To improve the quality of product 3D design was introduce. With 3D design, designers can directly deal with customers. 3D design will facilitate the designer work and increase customer confidence on the product.

1.7 Thesis overview

In the next chapter,the part that will be highlight first is to gather the information by reviewing on the biodiesel process, 3D design, batch distillation and AVEVA PDMS software. Secondly, the methodology on how to conduct the research on 3D design of batch distillation for production of biodiesel.

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

2.1 BENEFIT 3D DESIGN COMPARE 2D DESIGN

In today's digital world, designers are demanding 3D to enhance their designs and improve communication with their customers. Many inventors and companies still use 2D drawings and are starting to realize the benefit of skipping the 2D step and starting off with a 3D design because 3D modeling can save time and money as well as improve customer relations (Sheryl S et al., 1998. Making 2D drawings is fast and easy, but the output is still a 2D drawing, which does not readily work with downstream systems like purchasing and manufacturing. In some cases 2D drawings are sufficient but 90% of the time they are not. In prototyping, for example, a 3D model has to be made because most of the prototyping machines require 3D data. In fact, the majority of the machines used to manufacture parts need 3D *computer-aided design* (CAD) files and do not read 2D CAD drawings because 2D drawings do not contain all information needed to develop a three-dimensional product.

When using 2D CAD drawings during the manufacturing stage, numerous problems arise. Viewing 3D CAD models helps identify errors early(Jeongsam Yet all). These errors can be found while simulating the matching and mating of parts. Through the use of 3D CAD, the assembly process of any given product can be simulated, visualized and analyzed before the design goes into production. 3D CAD models are essential beforehand in determining the volume of material needed to mold specific parts as well. The use of 3D CAD files also ensures that a design has sufficient room for other parts within the design.

Through the use of 3DCAD modeling, engineers are able to create better designs than meet the unique requirements of any client in a relatively short amount of time. The internet has many tools that allow multiple individuals to communicate and collaborate online. 3D models of products or parts can be analyzed and looked at and edited in real time through the use of desktop sharing and/or a whiteboard. From an esthetic point of view, the use 3DCAD is substantially more beneficial. A design in 3D is more realistic and the engineer has a better ability to make a design more attractive. Collaboration between fellow engineers, clients and suppliers comes at greater ease because 3DCAD files are 3 dimensional models of a specific part or application. It's much easier to communicate and collaborate when looking at a 3D model simply because it’s easier to point out elements and explain what changes need to be made.

In addition, 3D CAD is not only advantages for determining the volume of the entire project and of each part included within the design for the sole purpose of knowing how much material is necessary to develop a certain quantity, but all dimensions can be observed with ease. The total weight, width, height, length and volume very often can be crucial elements in a design, especially when performing a structural analysis and when meeting legal requirements. Testing specific alternatives and dimension changes is simple not feasible without a 3D system. Designers must find room for specific elements and components within the design. Since 3D model data can be transferred to analysis and validation tools and used for Computer Aided Manufacturing as well, it increases the accuracy of results and saves time by eliminating the need to re-create data.

The use of 3DCAD models is replacing the use of 2DCAD drawings. Because a 3D model provides much more detail, designers and engineers can communicate product information and visualize complex parts and assemblies more clearly.3DCAD is simply more accurate than 2D CAD drawings. The end result is better product, optimized in size, weight with better performance, no faults in the design, in less time, for less money. Its advanced nature allows designers to work on more complex models. The use of 3DCAD technology reduces human error.

2.2 BATCH DISTILLATION

Batch distillation is an unsteady state operation. To handle small quantities of material batch distillation is often preferable. Other than batch distillation packings may be used in small plant. In batch distillation the quantity charged to the batch usually fixed. The batch distillation column consist of pot as a reboiler , column as a condenser, some off a portion of the condensed vapour (distillate) as reflux, and one or more receivers. During operation the vapor passes upward through the column. At the top the vapour is condensed imto liquid. Some of the liquid returned to the column as reflux, and the major liquid withdraw as distillate. Batch distillation is often preferable in small quantities compared to continuous because of some advantage.

Advantage of batch distillation;

i. Economical for small volumes
ii. Flexible in accommodating changes in product formulation
iii. Flexible in modification of production rate
iv. Allow better product integrity: each batch of product can be clearly identified in terms of the feeds involved and conditions of processing. This is particularly important in industries such as pharmaceuticals and foodstuffs.

2.2.1 Application of Batch Distillation

Batch distillation has always been an important part of the production of seasonal or low capacity and high-purity chemicals. It is a very frequent separation processing the pharmaceutical industry and in waste water treatment units. In batch distillation, the composition of the source material, the vapors of the distilling compounds and the distillate change during the distillation. I n batch distillation, a still is charged (supplied) with a batch of feed mixture, which is then separated into its component fractions which are collected sequentially from most volatile to less volatile, with removed at the end. The still can then be recharged and the process repeated.

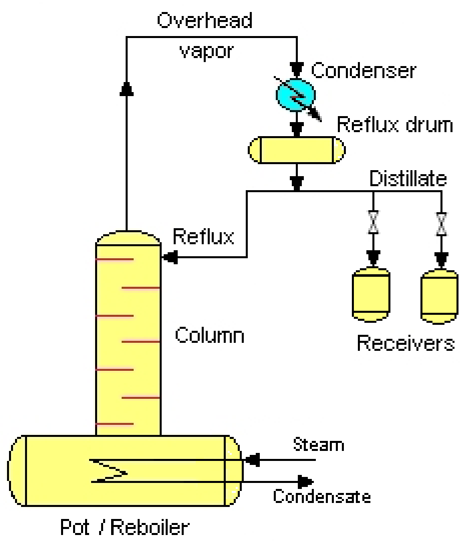


Figure 2.1: Batch Distillation

2.3 Background of biodiesel

Biodiesel is an alternative fuel for diesel engines that is produced by chemically reacting a vegetable oil or animal fat with an alcohol such as methanol. The reaction requires a catalyst, usually a strong acid or base such as sulphuric acid sodium or potassium hydroxide, and produces new chemical compounds called methyl esters. It is these esters that have come to be known as biodiesel. (A. S. Ramadhas et al., 2004).

Biodiesel is produced through a process known as transesterification, as shown in the equation below,

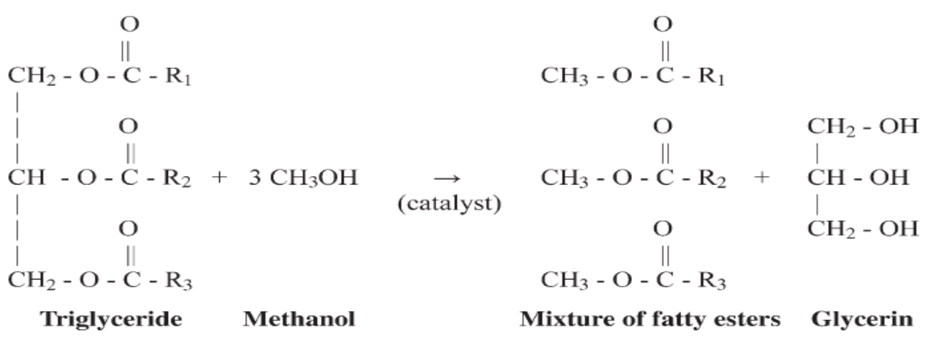


Figure 2.2: Transesterification of biodiesel

where R1, R2, and R3 are long hydrocarbon chains, sometimes called fatty acid chains.

There are only five chains that are most common in soybean oil and animal fats (others are present in small amounts).

2.3.1 Transesterification of triglycerides to biodiesel

There are four techniques transesterification methods. Amongst the four techniques, chemical conversion (transesterification) of the oil to its corresponding fatty ester is the most promising solution to the high viscosity problem. Sometimes, it is more convenient to convert the alkyl group of an ester to another alkyl group. This process is known as ester exchange or transesterification. Transesterification is the reversible reaction of a fat or oil with an alcohol (methanol or ethanol) to form fatty acid alkyl esters and glycerol. It can be alkali-, acid-, or enzyme-catalyzed; however, currently the majority of the commercialized technology resides in transesterification using alkali-catalyzed reaction (Ma F and Hanna MA., 1999). Mostly, biodiesel is derived from the vegetable oils using sodium or potassium hydroxide catalytic transesterification methanol process.

2.3.1.1 Catalytic transesterification methods

Transesterification reactions can be catalyzed by alkalis (Kotwal MS et all., 2009),and acids (Miao X et all., 2009).The catalytic transesterification of vegetable oils with methanol is an important industrial method used in biodiesel synthesis. However, these catalytic systems are less active or completely inactive for long chain alcohols. Usually, industries use sodium or potassium hydroxide or sodium or potassium methoxide as catalyst, since they are relatively cheap and quite active for this reaction (Macedo CCS et all., 2006). Enzymes-catalyzed procedures, using lipase as catalyst, do not produce side reactions, but the lipases are very expensive for industrial scale production and a three-step process was required to achieve a 95% conversion (Stavarache C et all., 2005).

2.3.1.2 Acid-catalytic transesterification methods

Biodiesel produced by transesterification reaction can be catalyzed by sulfuric, phosphoric, hydrochloric and organic sulfonic acids. Currently, the catalysts more used in biodiesel production are the organic acids, such as the derivates of toluenesulfonic acid and, more often, mineral acids such as sulfuric acid (Cardoso AL et all., 2008). Although transesterification using acid catalysts is much slower than that obtained from alkali catalysis, typically 4000 times, if high contents of water and FFAs are present in the vegetable oil, acid-catalyzed transesterification can be used.

The acid-catalyzed reaction commonly requires temperatures above 373 K and reaction times of 3–48 h have been reported, except when reactions were conducted under high temperature and pressure (Freedman B et all., 1984). These catalysts give very high yields in the transesterification process. Acid-catalyzed reactions require the use of high alcohol-to-oil molar ratios in order to obtain good product yields in practical reaction times. The mechanism of the acid-catalyzed transesterification of vegetable oils is shown in Fig. 4. It can be extended to di- and triglycerides. The protonation of carbonyl group of the ester leads to the carbocation, which after a nucleophilic attack of the alcohol produces a tetrahedral intermediate. This intermediate eliminates glycerol to form a new ester and to regenerate the catalyst (Meher LC et all., 2006).

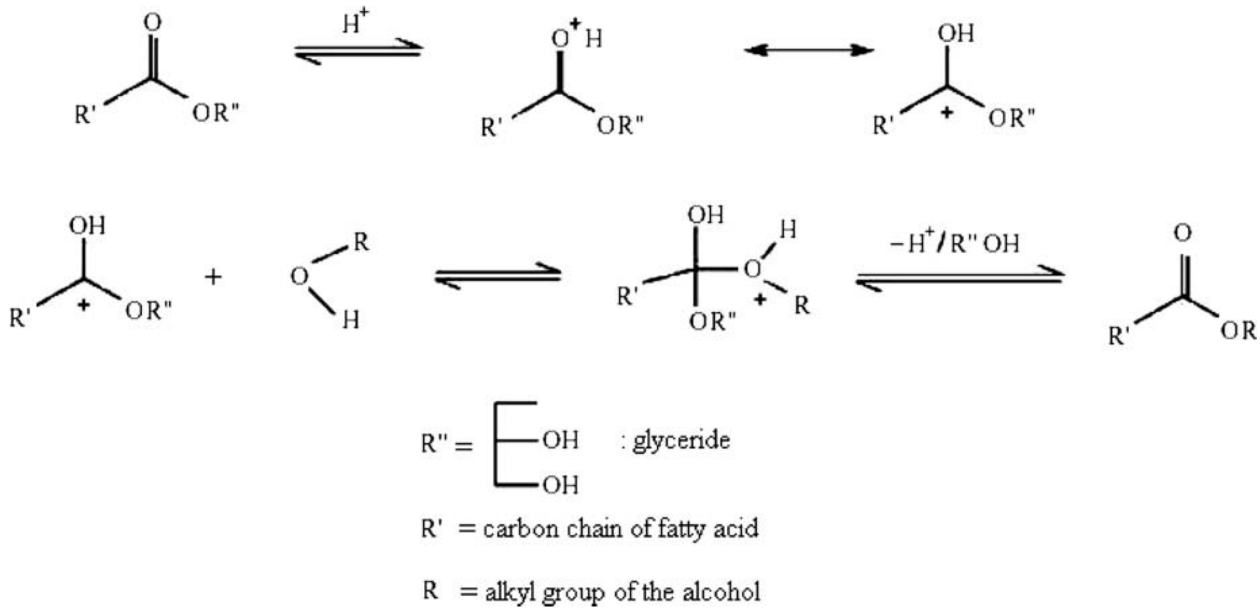


Figure 2.3: Mechanism of the acid-catalyzed transesterification(Meher LC et all., 2006).

2.3.1.3 Alkali-catalytic transesterification methods

The transesterification process is catalyzed by alkaline metal alkoxides, and hydroxides, as well as sodium or potassium carbonates. Sodium methoxide is the most widely used biodiesel catalyst with over 60% of industrial plants using this catalyst (Huber et al., 2006). Alkaline catalysts have the advantages, e.g. short reaction time and relatively low temperature can be used with only a small amount for catalyst and with little or no darkening of colour of the oil .They show high performance for obtaining vegetable oils with high quality, but a question often arises; that is, the oils contain significant amounts of FFAs which cannot be converted into biodiesels but to a lot of soap. These FFAs react with the alkaline catalyst to produce soaps that inhibit the separation of the biodiesel, glycerin, and wash water (Canakci et al., 2003).

In the alkali catalytic methanol transesterification method, the catalyst is dissolved into methanol by vigorous stirring in a small reactor. The oil is transferred into a biodiesel reactor and then the catalyst/alcohol mixture is pumped into the oil. The final mixture is stirred vigorously for 2 h at 340 K in ambient pressure. A successful transesterification reaction produces two liquid phases: ester and crude glycerol

The reaction mechanism for alkali-catalyzed transesterification was formulated as three steps. The alkali-catalyzed transesterification of vegetable oils proceeds faster than the acid-catalyzed reaction. The mechanism of the alkali-catalyzed transesterification of vegetable oils is shown in Fig. 5. The nucleophilic attack of the alkoxide at the carbonyl group of the triglyceride generates a tetrahedral intermediate (Fig. 5, Step 1), from which the alkyl ester and the corresponding anion of the diglyceride are formed (Fig. 5, Step 2). The latter deprotonates the catalyst, thus regenerating the active species (Fig. 5, Step 3), which is now able to react with a second molecule of the alcohol, starting another catalytic cycle. Diglycerides and monoglycerides are converted by the same mechanism to a mixture of alkyl esters and glycerol (Demirbas., 2005).

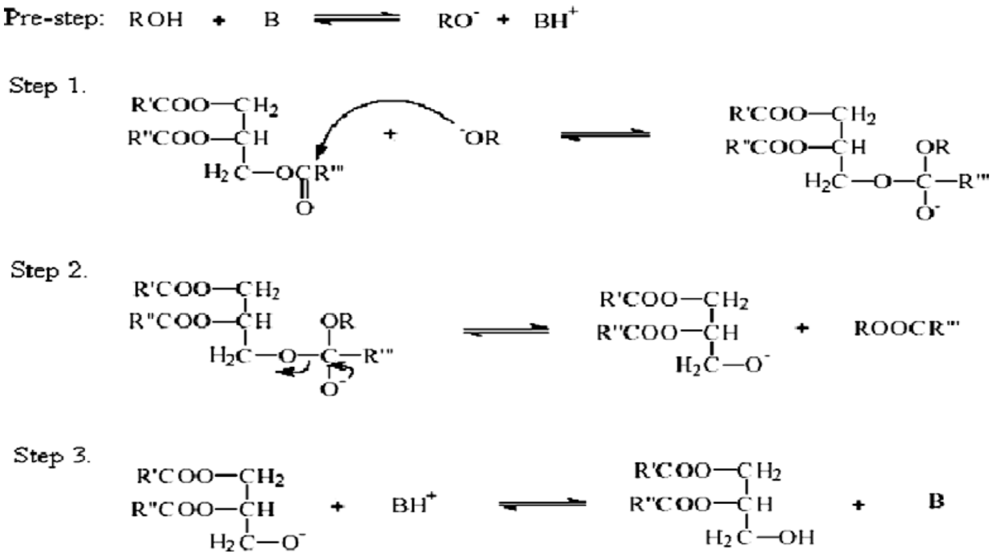


Figure 2.4: Mechanism of the alkali-catalyzed transesterification of vegetable oils (B: base) (Demirbas A., 2005).

In general, alkali-catalyzed transesterification processes are carried out at low temperatures and pressures (333–338 K and 1.4–4.2 bar) with low catalyst concentrations (0.5–2 wt.%) .

2.3.1.4 Enzyme-catalyzed transesterification methods

Although chemical transesterification using an alkaline catalysis process gives high conversion levels of triglycerides to their corresponding fatty acid alkyl esters in short reaction times, it suffers from several drawbacks: it is energy intensive, the recovery of glycerol is difficult, the acid or alkaline catalyst has to be removed from the product, alkaline wastewater requires treatment, and FFAs and water interfere with the reaction. Enzymatic catalysts like lipases are able to effectively catalyze the transesterification of triglycerides in either aqueous or non-aqueous systems (Meher et al., 2006). In particular, it should be noted that the byproduct, glycerol, can be easily recovered with simple separation processes. Nevertheless, enzymatic catalysts are often more expensive than chemical catalysts, so recycling and reusing them is often a must for commercial viability. Enzyme-catalyzed reactions have the advantage of reacting at room temperature without producing spent catalysts. However, enzyme-catalyzed system requires a much longer reaction time than the other two systems. Alcoholysis of triacylgycerols with a lipase is considered to be one of the most effective reactions for production of biodiesel. Lipases catalyze the hydrolysis of triacylgycerols into fatty acids and glycerol, as well as the reactions that involve synthesis (Karam et al).

The two main categories in which lipase-catalyzed reactions may occur are as follows (Shah et al., 2003):

(i)Hydrolysis

$RCOOR' + H2O \leftrightarrow RCOOH + R'OH.$

Synthesis: Reactions under this category can be further divided:

Esterification

$RCOOH + R'OH \leftrightarrow RCOOR' + H2O$

Transesterification: Under certain circumstances, lipases catalyze a number of transesterification reactions. These reactions can be illustrated by Equation below;

Alcoholysis

$RCOOR' + R''OH \leftrightarrow RCOOR'' + R'OH.$

Acidolysis

$RCOOR' + R''COOH \leftrightarrow R''COOR' + RCOOH$

The enzyme reactions are highly specific and chemically clean. The excess alcohol is reported to be inhibitory to some enzymes and hence a typical strategy is to feed the alcohol into the reactor in three steps of 1:1 mol ratio each. Generally, these reactions are very slow, with a three step sequence requiring from 4 to 40 h, or more. The reaction conditions are modest, from 303 to 313 K

2.3.2 Non-catalytic transesterification methods

There are two basic routes to produce biodiesel by non-catalyzed transesterification, namely, (i) BIOX co-solvent process and (ii) the supercritical alcohol process.

2.3.2.1 BIOX co-solvent process

Co-solvent options are designed to overcome slow reaction time caused by the extremely low solubility of the alcohol in the triglyceride phase. One approach that is nearing commercialization is the BIOX process. This process uses either tetrahydrofuran (THF) or methyl tert-butyl ether (MTBE) as a co-solvent to generate a one-phase system. The result is a fast reaction, on the order of 5–0 min, and no catalyst residues in either the ester or the glycerol phase. The THF co-solvent is chosen, in part, because it has a boiling point very close to that of methanol. This system requires a rather low operating temperature, 303 K (Balat M. and Balat H., 2010).

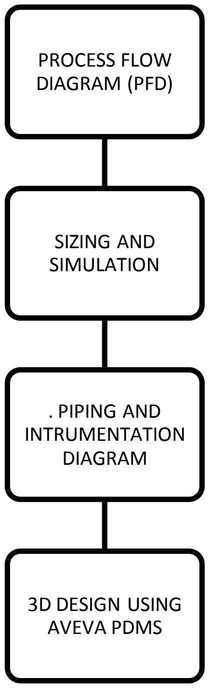
2.3.2.2 Supercritical alcohol transesterification

The transesterification of triglycerides by supercritical methanol, ethanol, propanol and butanol has proved to be the most promising process. Saka and Kusdiana proposed that biodiesel fuels may be prepared from vegetable oil via non-catalytic transesterification with supercritical methanol. Saka and Kusdiana have proposed that the reactions of rapeseed oil were complete within 240 s at 623 K, 19 MPa, and molar ratio of methanol to oil at 42. To achieve more moderate reaction conditions, further effort through the two-step preparation was made Kusdiana and Saka. In this method, oils/fats are, first, treated in subcritical water for hydrolysis reaction to produce fatty acids. After hydrolysis, the reaction mixture is separated into oil phase and water phase by decantation. The oil phase (upper portion) is mainly fatty acids, while the water phase (lower portion) contains glycerol in water. The separated oil phase is then mixed with methanol and treated at supercritical condition to produce methyl esters thorough esterification. After removing unreacted methanol and water produced in reaction, FAME can be obtained as biodiesel. Methyl esterification of fatty acids is a major reaction to produce FAME in the two-step supercritical methanol method, whereas transesterification of triglycerides is a major one in the conventional alkali- and acid-catalyzed methods. This esterification reaction is, therefore, an important step for high quality biodiesel fuel production (Minami E, Saka S., 2006).

CHAPTER 3

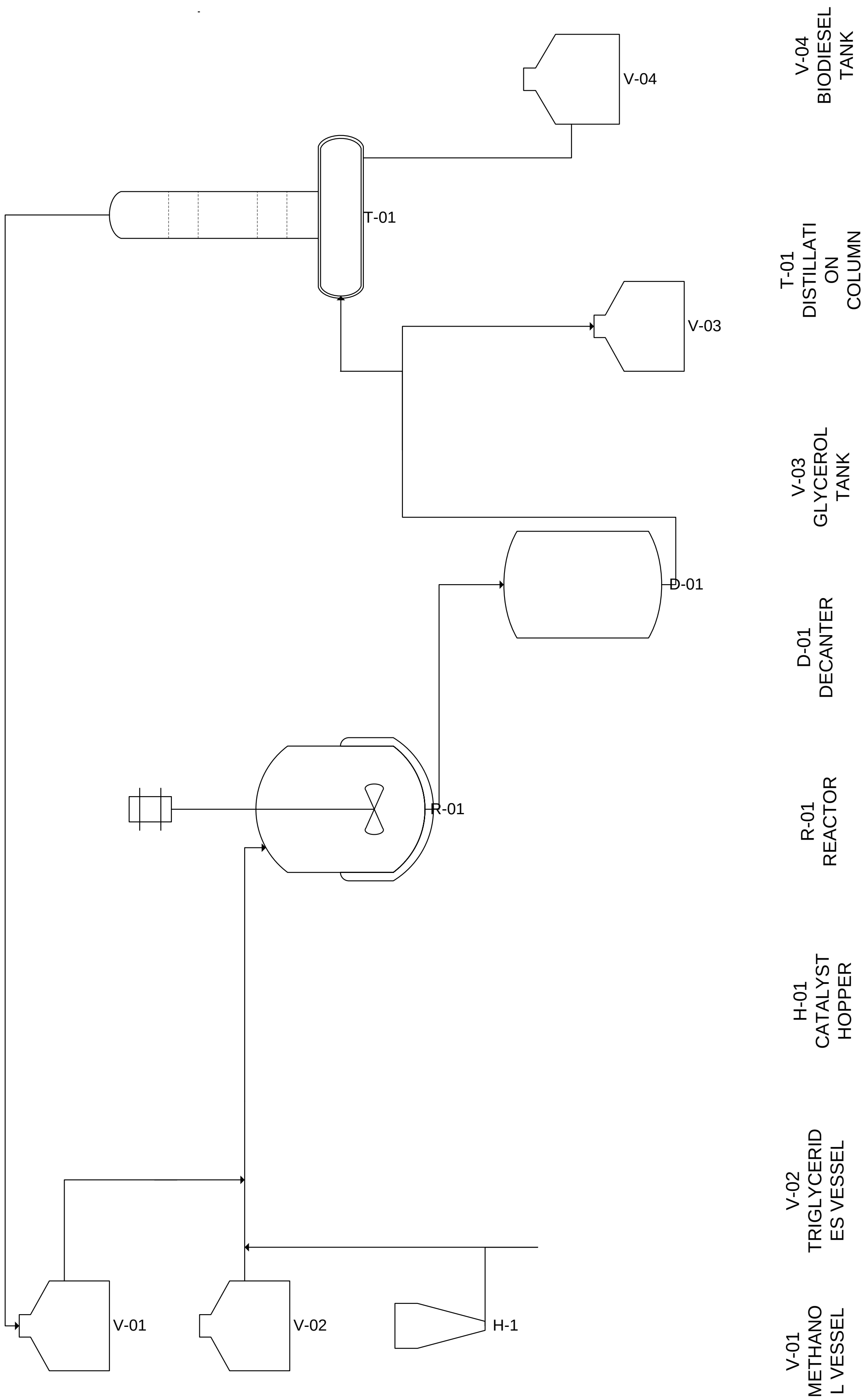
METHODOLOGY

In this research the several methods is used to complete the 3D design of distillation column. The research is started by drawing the process flow diagram. The next step is sizing and simulation for the distillation column. Then follow by the drawing of piping and instrumentation diagram by including safety and control system. Lastly, 3D design using AVEVA PDMS.



3.1 PROCESS FLOW DIAGRAM (PFD)

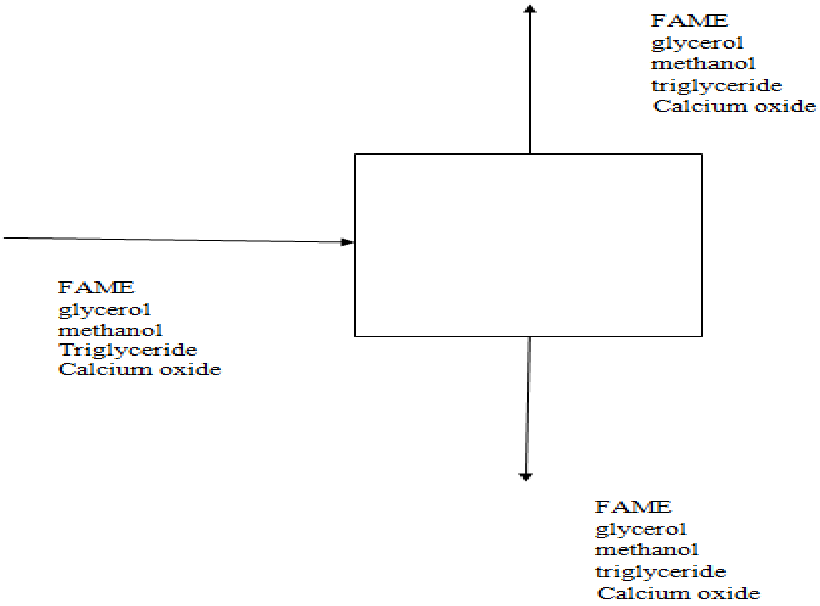
Methanol is stored in the V-01 and V-02 is for virgin palm oil. Catalyst Hopper H-01 is for Calcium Oxide, CaO in powder form. After that methanol, palm oil and CaO are feed into reactor, R-01 at temperature 25^{o}C and pressure 1 atm. The transesterification process occur and produce biodiesel (fatty acid methyl ester, FAME), glycerol and the unreacted methanol. The reactor conversion is about 98%. After that the product from reactor channel into decanter to separate glycerol from FAME and methanol by using density. The glycerol will go to the bottom, glycerol and FAME will goes top. Glycerol was drained into V-03. FAME and methanol going through the process of separation in distillation column, D-01. The top product is methanol and bottom product is biodiesel. The methanol will be recycled into V-01. Biodiesel as a product will be collected at Biodiesel Tank V-04.



3.2 SIMULATION AND SIZING

3.2.1 Material and Energy Balance

Batch Distillation Column.



SPECIES	INPUT	OUTPUT (TOP)	OUTPUT(BOTTOM)
Methanol	0.0090 kmol	0.0085 kmol	0.0004 kmol
FAME (biodiesel)	0.439 kmol	0.0219 kmol	0.4167 kmol
Glycerol	0.0110 kmol	0.0050 kmol	0.0061 kmol
Triglyceride	0.0002 kmol	1.12299E-05 kmol	0.0002 kmol
Calcium Oxide	0.0004 kmol	4.34278E-07 kmol	0.0004 kmol

3.2.2 MECHANICAL DESIGN

Sizing Distillation Column.

Refer to the appendices for the sizing calculation.

HT= Height of vessel

Ht= torispherical height

D= diameter

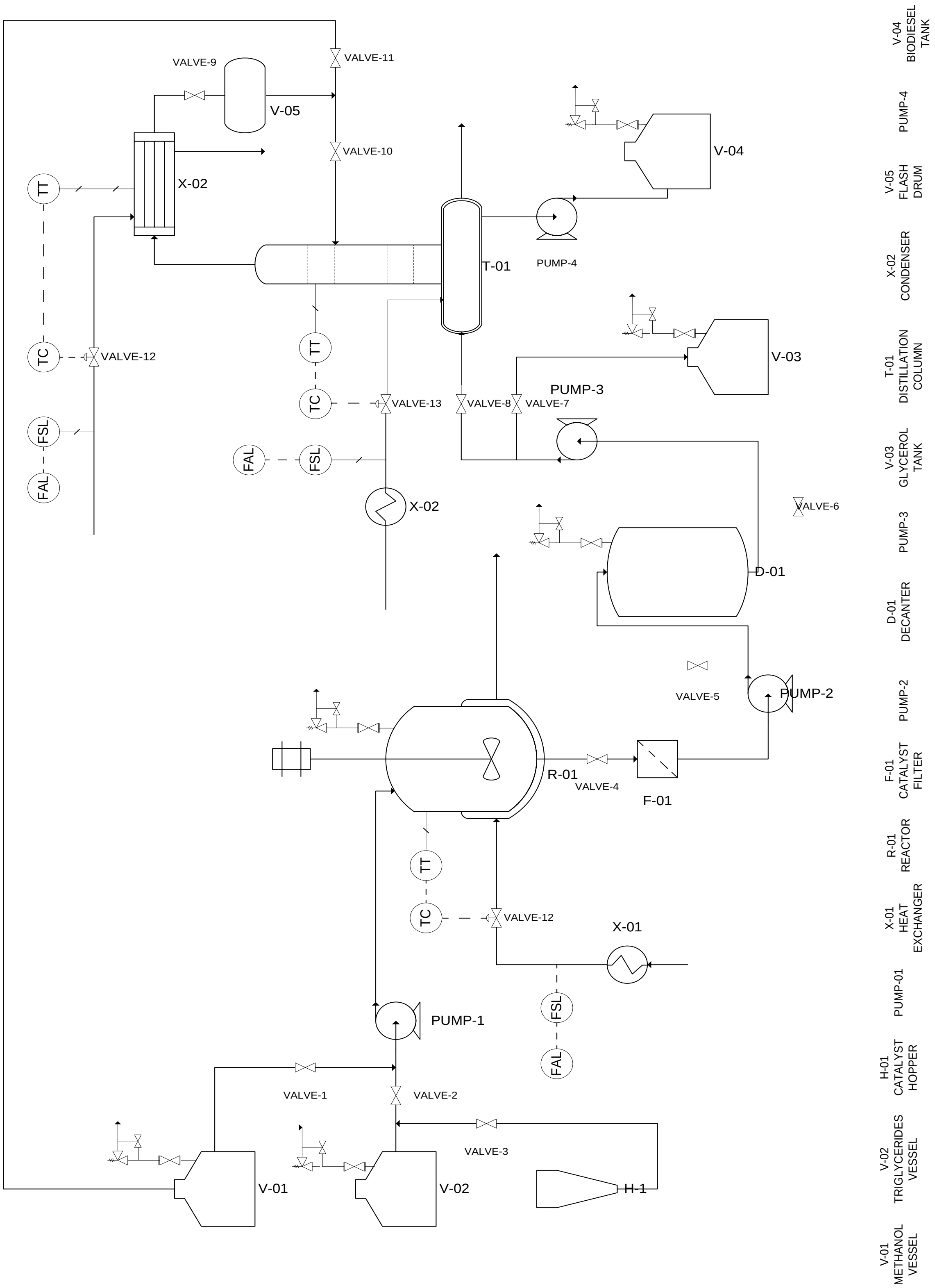
For Bottom Vessel

Specification	Value(mm)
HT	633
Ht	54
D	890

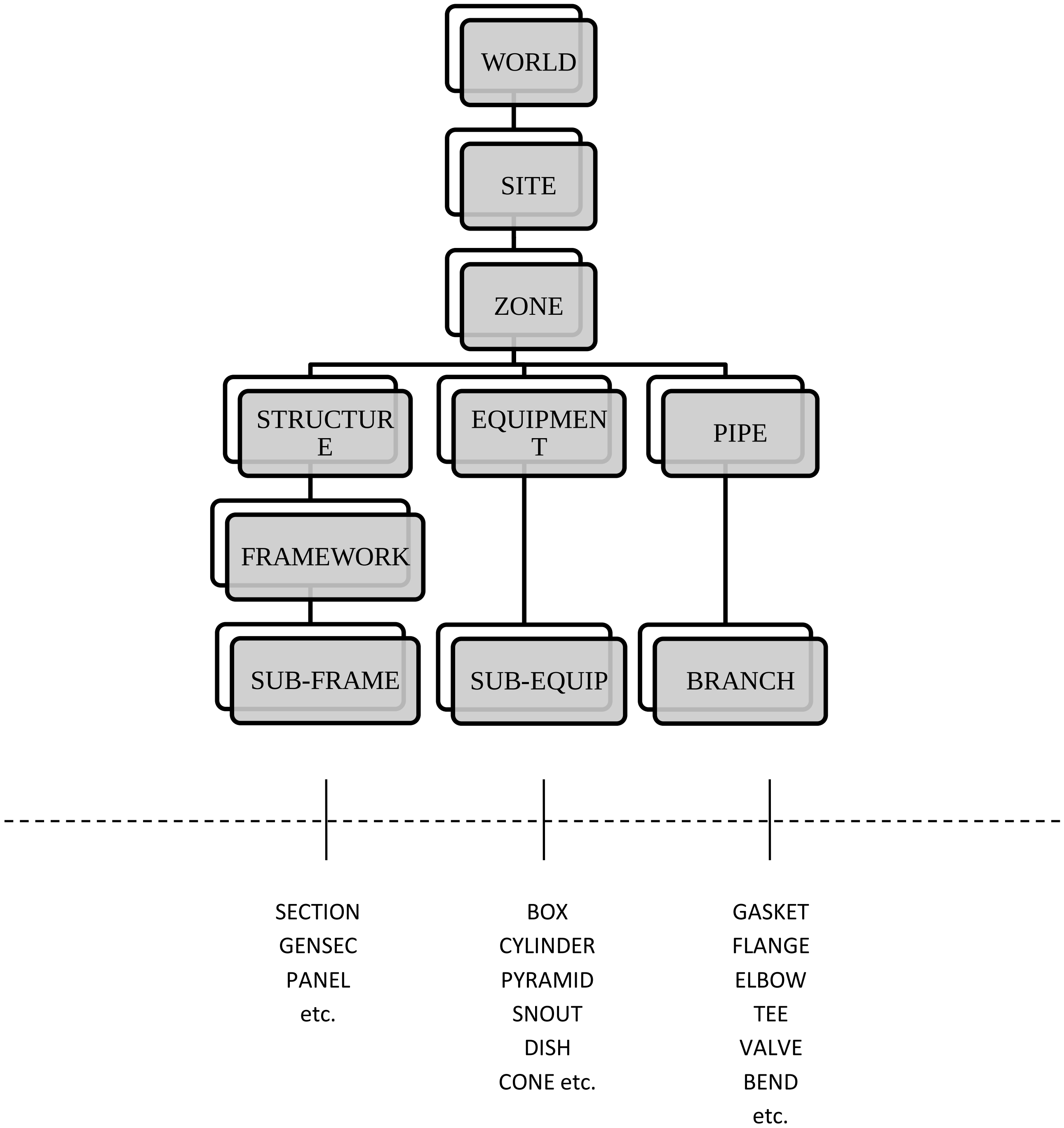
SIZING OF FAME STORAGE TANK

Specification	Value (mm)
HT	1056
Ht	28
D	467

3.3 PIPING AND INTRUMENTATION DIAGRAM(P&ID)



3.4 3D DESIGN USING AVEVA PDMS



The PDMS Design Database Hierarch

3.4.1 World (WORL)

In AVEVA PDMS to start 3D design, it is very important to create world. Each database has its own WORLD element as the first element in the hierarchy. World cannot be deleted or rename.

3.4.2 Site (SITE)

Below the WORLD the second level of the hierarchy is SITE. A SITE may be considered as a significant collection of plant, whose size is not necessary determined by physical area, but by practical considerations. It may, for example be the whole project, or one part of a large project. There can be as many SITEs within a PDMS project a required for data organization.

3.4.3 Zone (ZONE)

The next level below SITE is a ZONE. As with a SITE, a ZONE is not necessarily used to define physical area, it is more likely to store similar types of items for easy reference, such as piping system in one ZONE, related equipment in another, and so on. There can be many ZONEs owned by a site as required for data organization. For my project under ZONE I created the trailer by size of 7.2meters length 2.4m height and 2.4 meters width as a limitation for the project. So the equipment will be design and arrange in that area.

3.4.4 Equipment (EQUI)

Equipment items are built up in PDMS using element known as primitives. Each piece of equipment can comprise any number of primitive shapes positioned in space to represent the equipment item. The primitives may be owned directly by EQUI element or by Sub-Equipment element. All equipments are created under EQUI element. Equipments that are created under EQUI element are:

1) V-02-TRIGLYCERIDES VESSEL
2) H-01-CATALYST HOPPER
3) R-01-REACTOR
4) F-01-CATALYST FILTER
5) D-01-DECANTER
6) V-03-GLYCEROL TANK
7) T-01-DISTILLATION COLUMN
8) V-04-BIODIESEL TANK
9) X-02-CONDENSER
10) V-05-FLASH DRUM

Each equipment has its own Sub-Equipment element. In PDMS the equipment can be taken directly from standard equipment if the design same for equipment that we want. But we need to specify each parameter for the equipment. If the standard equipment design does not meet the design specification that we want, we have to design the equipment by using primitives. The combination of primitives will create complete equipment.

3.4.4.1 Primitives

Primitives are the basic building blocks of PDMS. They are used by other disciplines to create catalogue components. There are many types of primitives; each with its own features which when combined with other primitives can represent complex shapes. Examples of primitives are nozzle (NOZZ), box (BOX), cylinder (CYLI), pyramid (PYRA), cone (CONE) and dish (DISH).

After all equipment been design, the nozzle is place for every equipment. Each nozzle is using ANSI standard. The nozzle is very important for piping.

3.4.5 Pipe (PIPE)

The piping in PDMS should be start by creating the PIPE element. Pipes may be considered like lines on a flow sheet. They may run between several end connection points and are usually grouped by a common specification and process.

3.4.5.1 Branch (BRAN)

Each PIPE element have BRAN element. Branch elements are section of a pipe, which have known start and finish points. In PDMS the start and finish points are called the Head and Tail. After branch has been created, Head and Tail of the pipe have been specifying. Heads and Tails may be connected to Nozzles, Tees or other Heads and Tails, depending on the configuration of the pipe, or left open end. For my project most of the pipe Head and Tail are connected to the nozzles in the equipment.

3.4.5.2 Piping Components

After that the piping component has been selected. Each branch needs flange and gasket. The elbow and tee are selected depend on the pipe location and situation. Some of the pipe has more than one branch so it is very important to place tee in that pipe.

3.4.6 Safety

Since the plant space has limit, the equipment is arranged properly. Trailer design limits the order equipment in the plant. To maximize space, equipment was stacked where possible. Process safety valve placed on the equipment upper perimeter of the trailer to release pressure if the pressure exceeds the limit.

3D DISTILLATION COLUMN

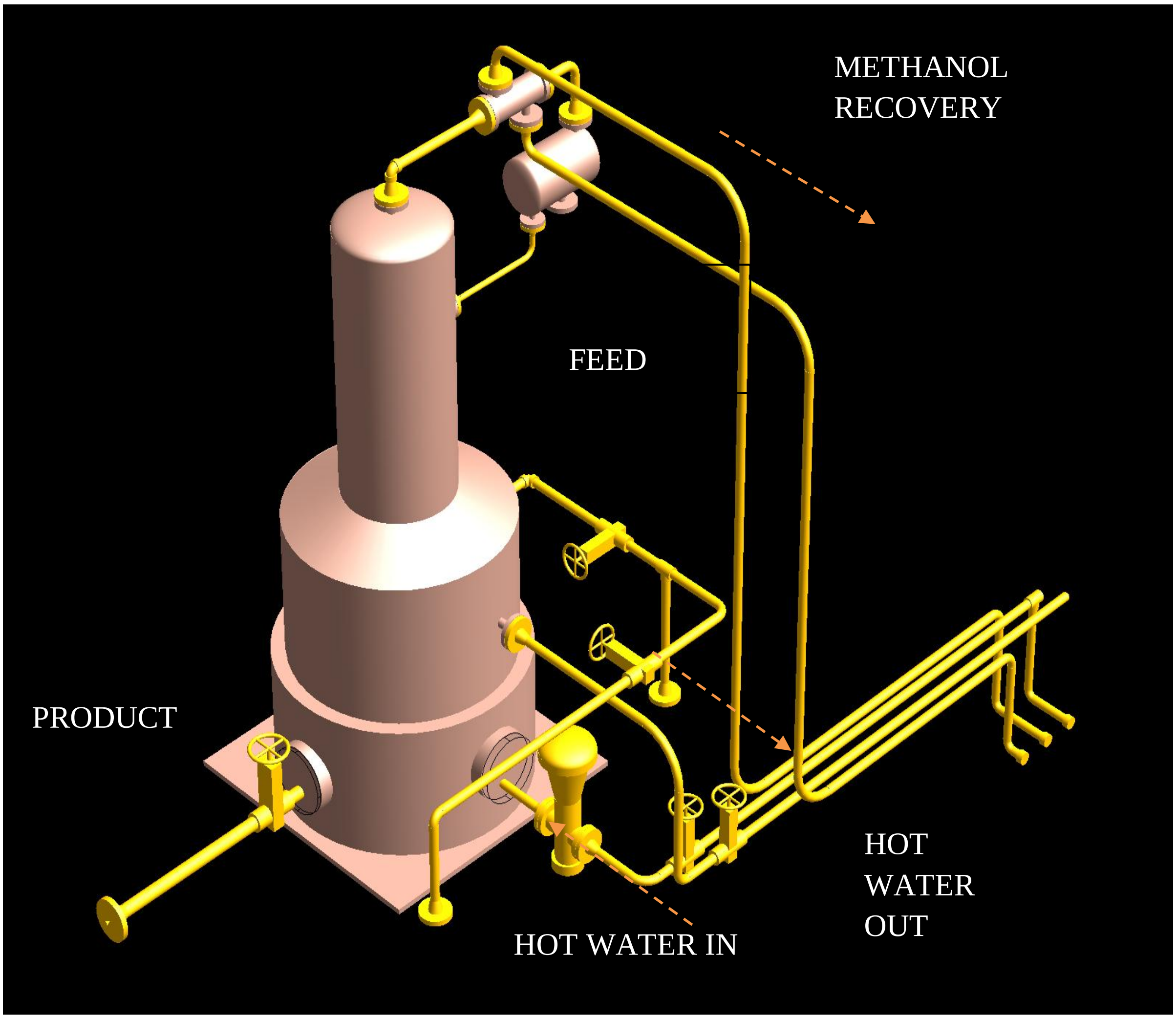


Figure 3.1: Distillation Column equipment and piping

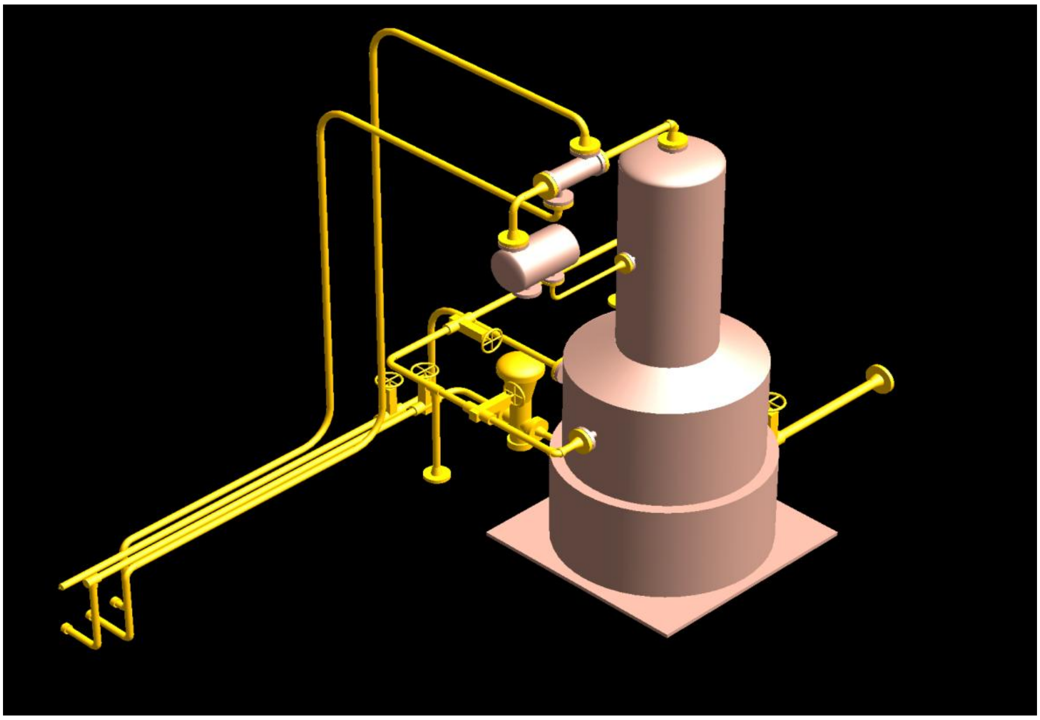


Figure 3.2: Distillation Column Isometric View 1

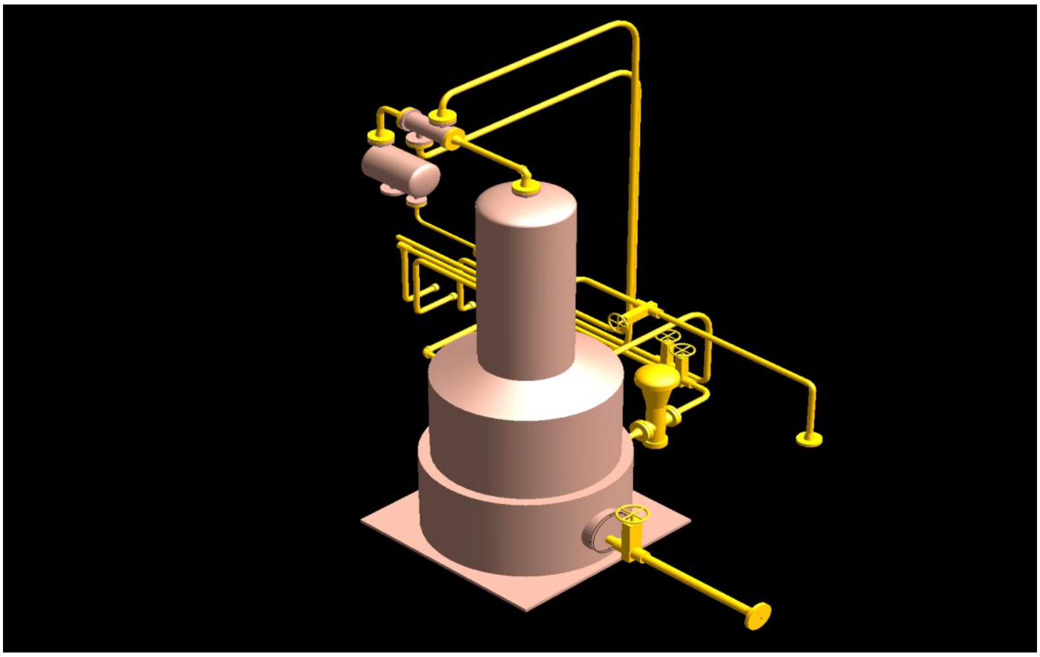


Figure 3.3: Distillation Column Isometric View 2

CHAPTER 4

RESULT

4.1 3D VIEW OF BIODIESEL PLANT USING AVEVA PDMS

4.1.1 EQUIPMENT

The figure below shows the whole plant of biodiesel in 3D view without the piping.

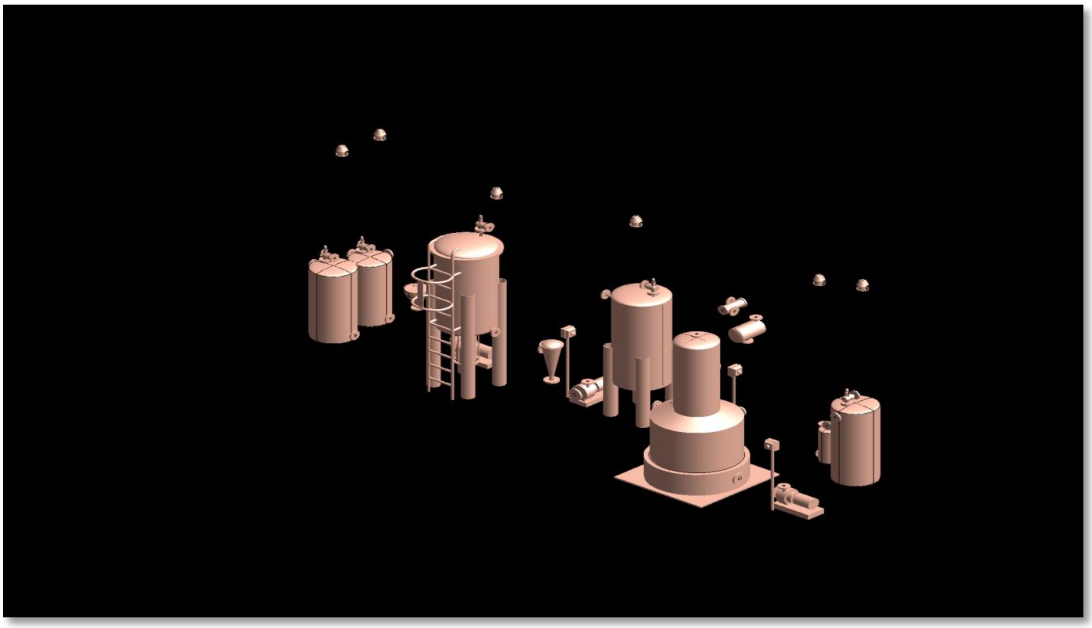


Figure 4.1: Equipment Isometric 1

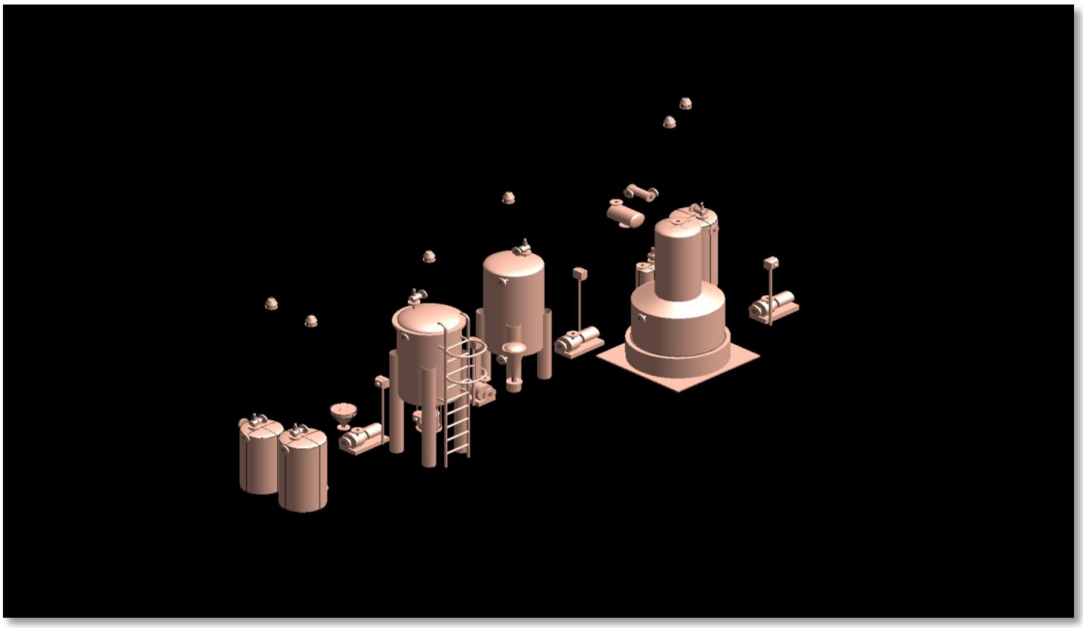


Figure 4.2: Equipment Isometric 2

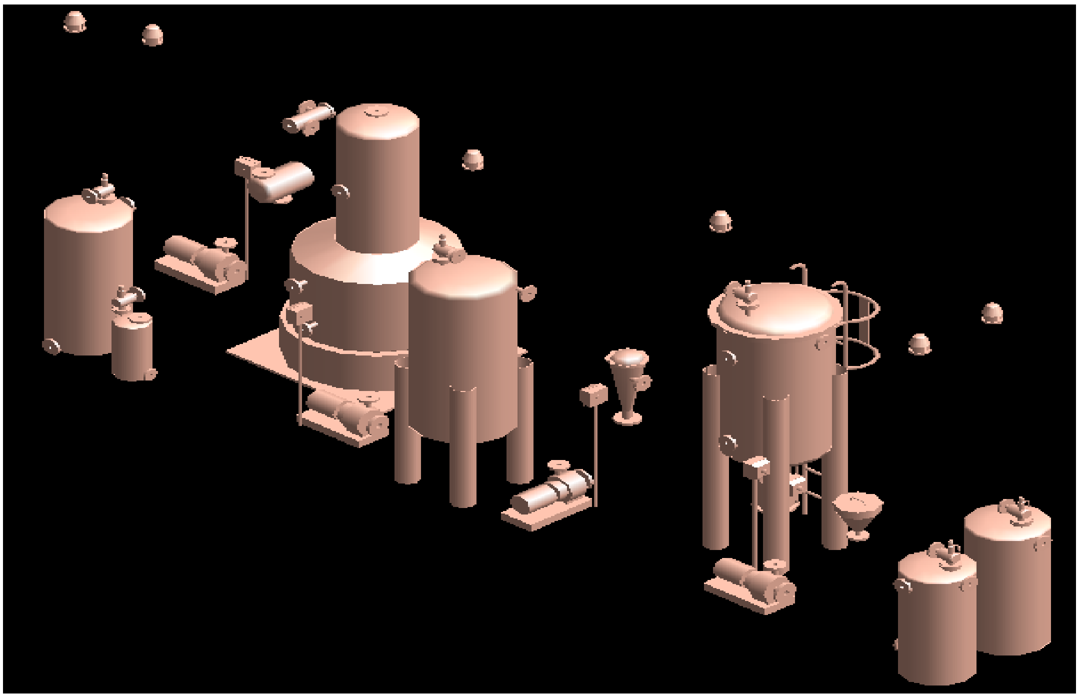


Figure 4.3: Equipment Isometric 3

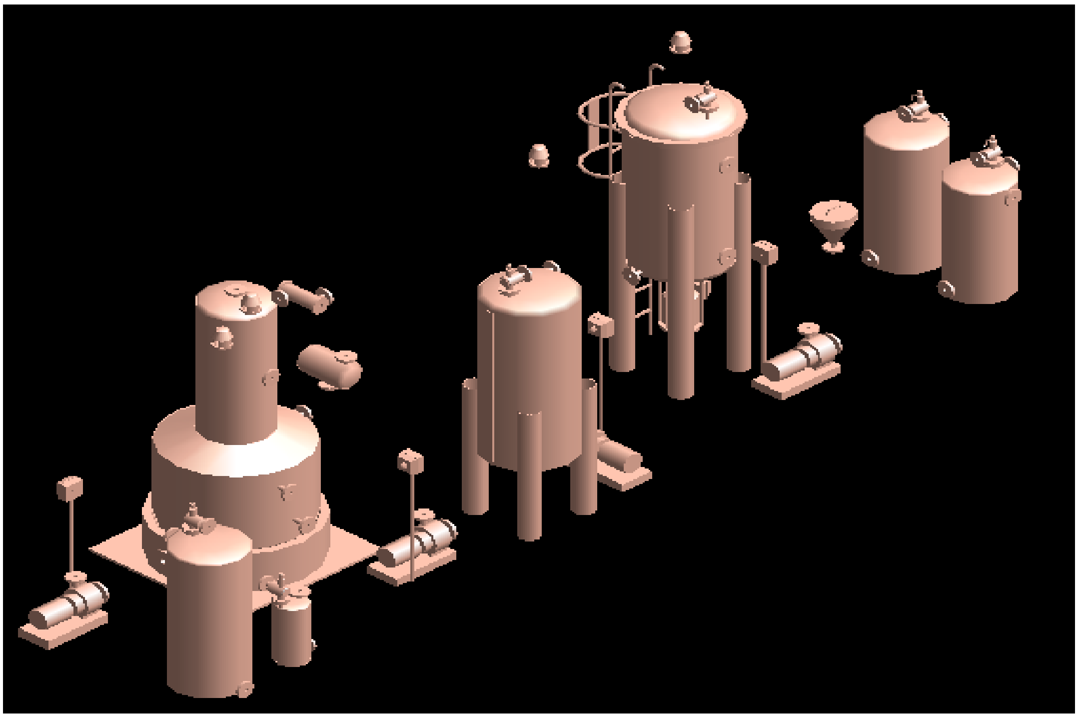


Figure 4.4: Equipment Isometric 4

4.1.2 Equipment with piping

The figure below shows the 3D after the piping process.

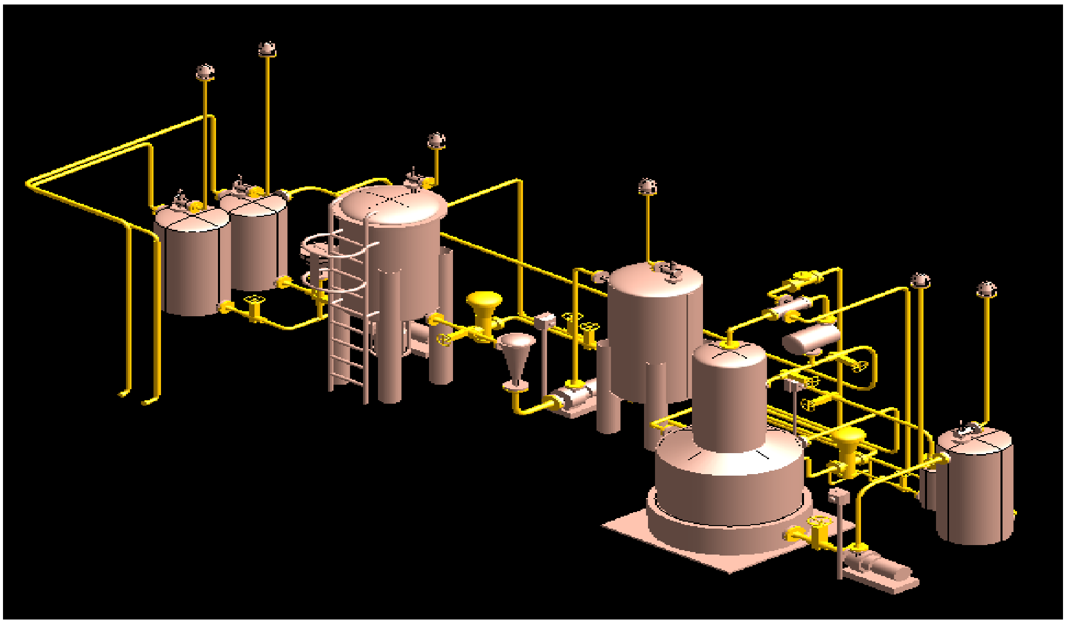


Figure 4.5: Equipment with piping Isometric 1

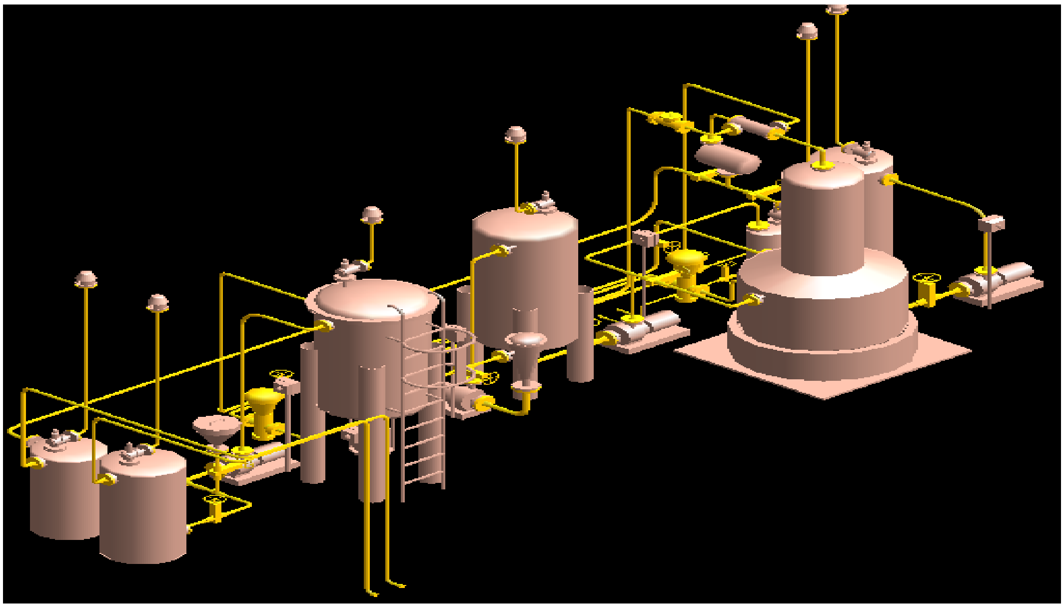


Figure 4.6: Equipment with piping Isometric 2

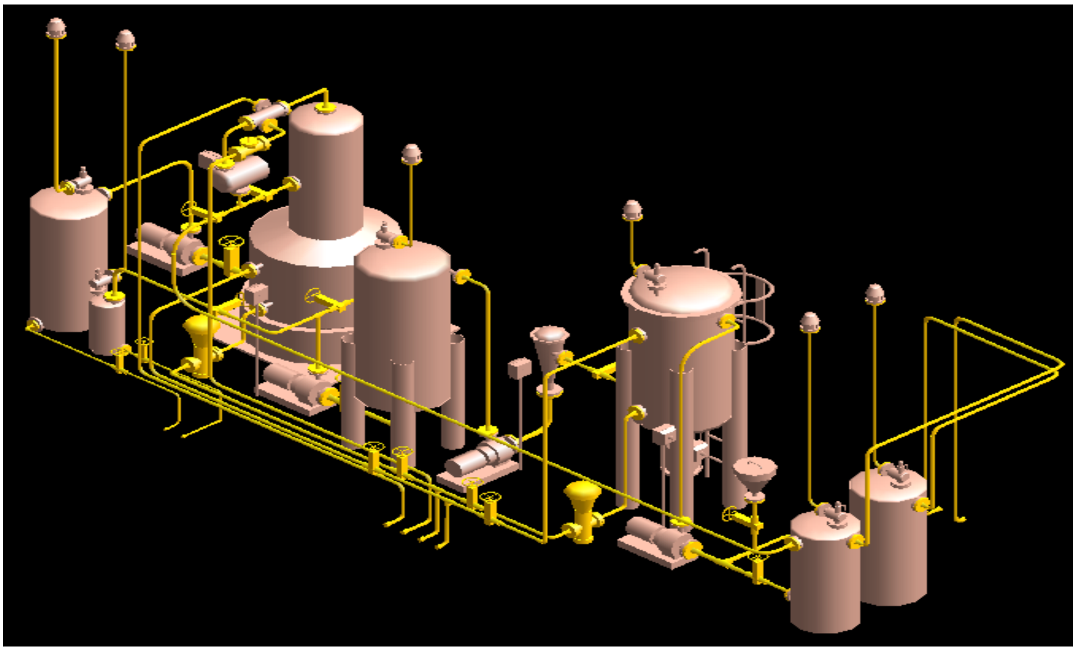


Figure 4.7: Equipment with piping Isometric 3

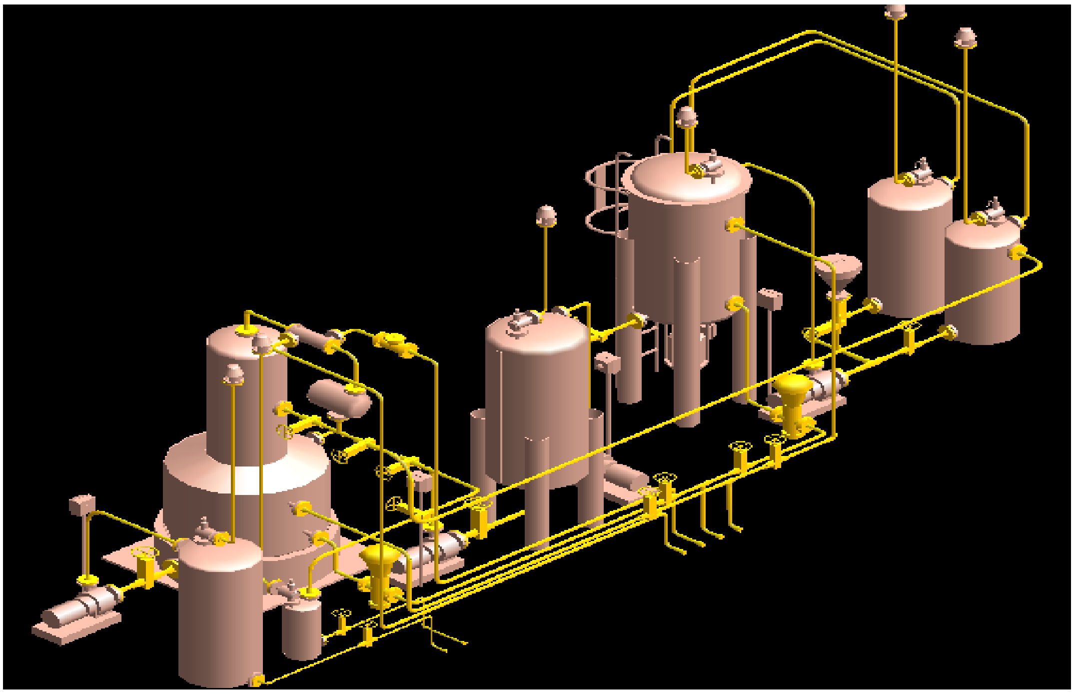
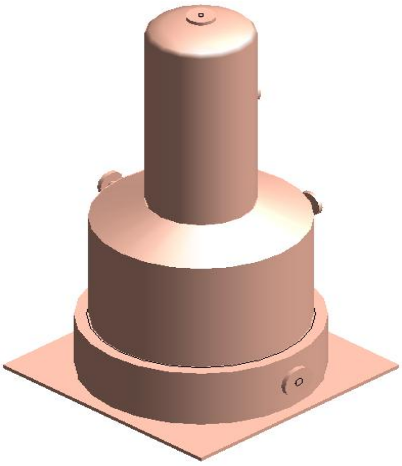
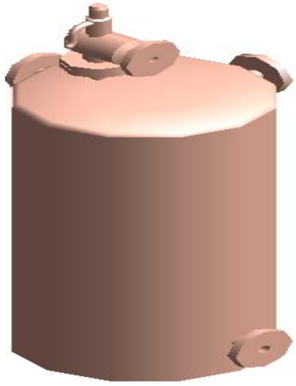
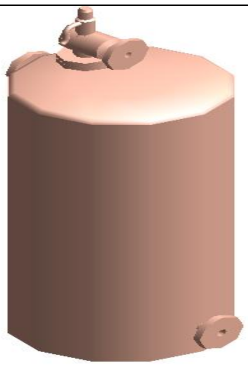
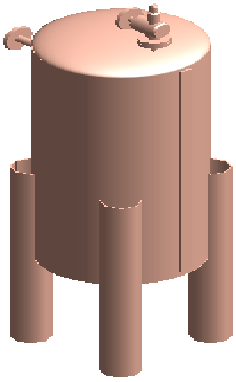
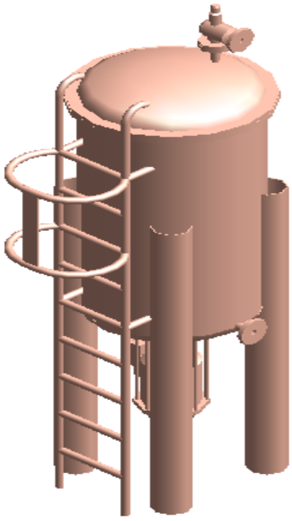
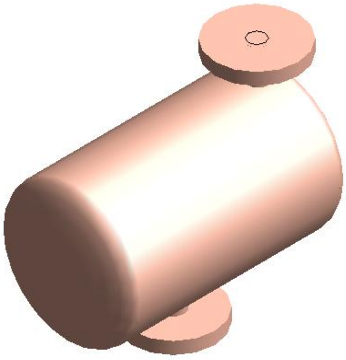
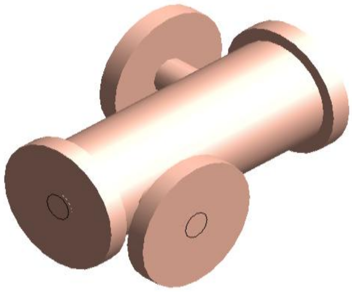
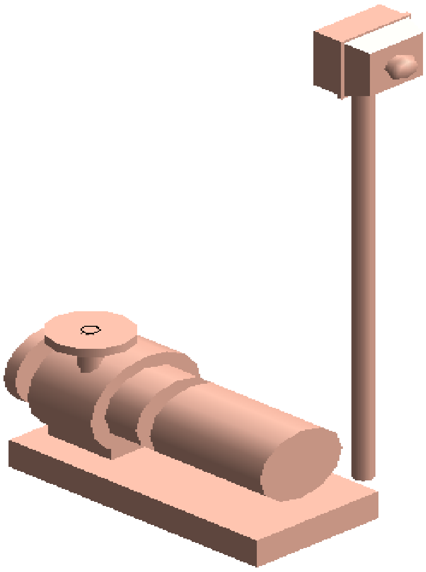


Figure 4.8: Equipment with piping Isometric 4

4.1.3 Equipment in research

EQUIPMENT	NAME
	T-01 – batch distillation column
	V-01- methanol storage tank
	H-01 – Calcium Oxide catalyst Hopper

	V-02 – triglyceride storage tank
	D-01 - Decanter
	R-01 – Biodiesel reactor
	F-01 – filter tank

	V-05 – Flash Drum
	X-02 – Condenser
	Centrifugal pump -Equipped with switch button

	Process Safety Valve

4.2 DISCUSSION

4.2 .1 Plant Layout

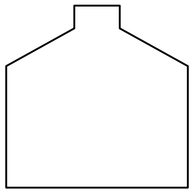
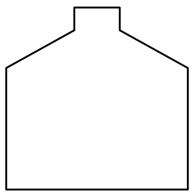
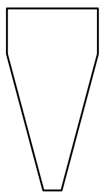
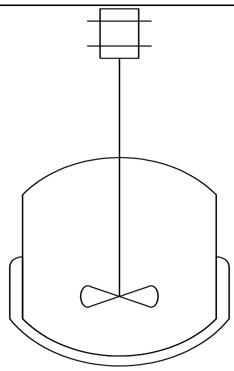
The plant for biodiesel production is contained in a trailer. The trailer dimensions are 7.2 meter long 2.4 meter high and 2.4 meters wide.

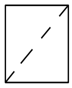
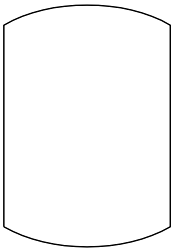
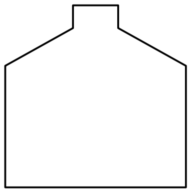
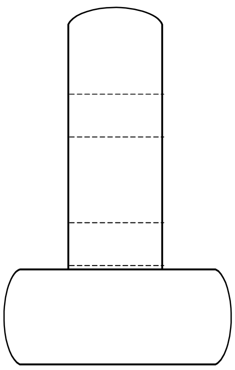
The equipments are arranged based on the biodiesel process, where it start with methanol vessel and end with biodiesel tank. The biodiesel reactor was arranged near the methanol and triglycerides vessel. The batch distillation column was arranged near to its condenser and biodiesel tank. Most of the equipment parallel to each other. Most equipment stacked on the left and right is left empty as a space for the passage of workers for maintenance. Since the area for biodiesel plant is limited the distance each equipment is not too far.

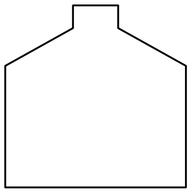
For pipes, using AVEVA PDMS piping arrangement is not a big problem because this software has a clash checking. The clash pipe will be detected. For the arrangement of pipe most of them on the right because the pipe for steam at the right.

Process safety valve placed on the equipment upper perimeter of the trailer to release pressure if the pressure exceeds the limit. The process safety valve placed upper each of the vessels.

4.2.2 P&ID Process Description

NAME/ID	Symbol	Condition	Function
V-01 METHANOL VESSEL		T= $25^{o}C$ P= 1atm	Store methanol before feed into reactor.
V-02 TRIGLYCERIDES VESSEL		T= $25^{o}C$ P= 1atm	Store palm oil before feed into reactor
H-01 CATALYST HOPPER		T= $25^{o}C$ P= 1atm	Feed Calcium Oxide as a catalyst for the reaction
R-01 REACTOR		T= $60^{o}C$ P= 1atm Conversion= 0.98 Catalyst= CaO Catalyst Oxide	Transesterification process occur to produce FAME and glycerol

F-01 CATALYST FILTER		$T= 25^{o}C$ P= 1atm	Filtering catalyst before the product enter decanter.
D-01 DECANTER		$T= 25^{o}C$ P= 1atm	Separate glycerol from FAME and methanol by using density.
V-03 GLYCEROL TANK		$T= 25^{o}C$ P= 1atm	Store glycerol that have been separated from decanter.
T-01 DISTILLATION COLUMN		$T_{FEED}= 70^{o}C$ P= 1atm	-Separate biodiesel from methanol -The ratio of the height to diameter was varied to ensure that the heights of the tanks were below 2.4 meter.

V-04 BIODIESEL TANK		T= 25^{o}C P= 1atm	Store the biodiesel
X-02 CONDENSER		T= 25^{o}C P= 1atm	To condensate methanol from vapor to liquid state.
V-05 FLASH DRUM		T= 25^{o}C P= 1atm	To store liquid of methanol before recycle it.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As for the conclusion, all objectives of the study had been achieved. By using AVEVA PDMS software the design will be more accurate. This software prove that the 3D design give more benefit compare to the 2D design. The end result is better product, size can be optimized and no faults in design. The 3D design show client more detail about project before build it in real world. Other than that 3D design also allows designers to work on more complex models because 3D CAD illustrate better than 3D CAD.

5.2 RECOMMENDATION

There are some recommendations for better design. The design structure must be including in the plant for example rack to support the equipment. For a more realistic result, pipe racks should be including in the design. In actual plant the pipe racks is very important to prevent pipe breakage or leaks that could potentially impact the health, welfare and safety of plant personnel. Pipe support structures should maintain symmetry and uniformity. Proper fastening of the pipes to the supporting structure is essential in the design of pipe racks. If the contents of pipe are hazardous, dynamic analysis is very important to prevent any danger to public safety.

By changing the type of reactor for this plant, the whole layout will change. For example we can use supercritical reactor or homogeneous reactor. By try using other type reactor comparison can be done and we can know which design more versatile and can optimize the used of materials and energy. For example in supercritical reactor did not use any catalyst. So the raw material cost can be cut.

Other than that the size of the trailer can also be changed. By increasing the size of trailer production rate of biodiesel also can be increase. The large size also gives the advantage of equipment arrangement. With greater size, the arrangement of equipment will be much easier and safer. Smaller size trailer also give some benefit. Small plant much easier to handle and it is also flexible. As a safety measure, the basin must be placed beneath each of the major equipment. The purpose of basin is to contain any spills or leaks. Methanol is a flammable liquid, for safety around methanol tanks required space for firefighting access if any incident occurs.

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APPENDICES

MECHANICAL DESIGN

Sizing Distillation column.

volume of FAME = 0.16 m3

volume of methanol = 0.116849398 m3

For Bottom Vessel:

TOTAL VL = 0.276849398 m^3

VOLUME OF CYLINDER = VL = ((3.142)*(D^2)*2L)/4

ASSUME THAT: D = 2L

THEREFORE: L =(3.142*(D^2)*(D/2))/4

D =0.88997088m

L =0.44498544m

The allowance that given for volume of vapor = 10%

Vv =0.1

VL Therefore,

Vv =0.02768494m^3

Then, storage tank volume ,Vs

Vs = VL + Vv

Vs =0.304534338m^3

Vs = (3.142*(D^2)*2L)/4

therefore, the height of storage tank,

Hs =0.578744257m 578.7442571 mm

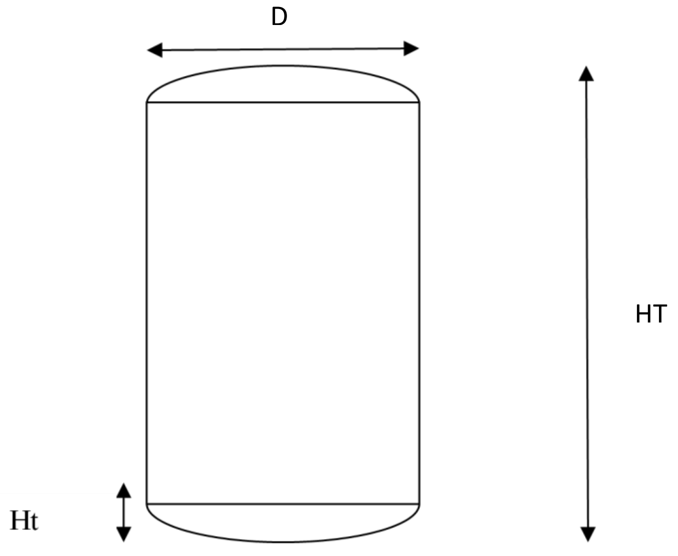
height of torispherical for the reactor, Ht;

take ,ϴ =20°

tan ϴ =0.364

Ht =0.053991567m 53.99156671 mm

total height of the storage tank , HT =0.632735824 m 632.7358239 mm



specification	Value(mm)
HT	633
Ht	54
D	890

assumption:

1) the top diameter of pot head is half of the bottom vessel diameter of the distillation column

2*D bottom = D pot head

diameter of pot head D =0.44498544m 444.9854399mm

2) The height of the pot head,

diameter of pot head,2D = L, length of pot height

L =2D

L =0.88997088m 889.9708799mm

allowance 10% =88.99708799 mm

total HT =978.9679678mm

3) trays, the tray inside the top head has 3 unit

for each unit the position is = 0.29665696m 296.65696mm assume that the tray is using berl packaging, then the height for each unit is = L = 5%D

L =0.022249272m 22.249272mm

SIZING OF FAME STORAGE TANK,

volume of FAME =0.16 m^3

V_L =0.16m3

The storage tank is design vertical. Take the height as twice the diameter, a reasonable value for a cylinder;

$V_L = \frac{\pi D2h}{4}$ …………(1)

L= 2D …………(2)

Substitute (2) into (1)

$V_L = \frac{\pi D3}{2}$

D =0.466997547 m 466.9975468 mm

L =0.933995094m 933.9950937 mm

The allowance that given for volume of vapor = 10%

Vv =0.1VL

Therefore, Vv =0.016m^3

Then, storage tank volume ,Vs

Vs = VL + Vv

Vs =0.176m^3

therefore, the height of storage tank,

Hs =1.027394603m 1027.394603mm

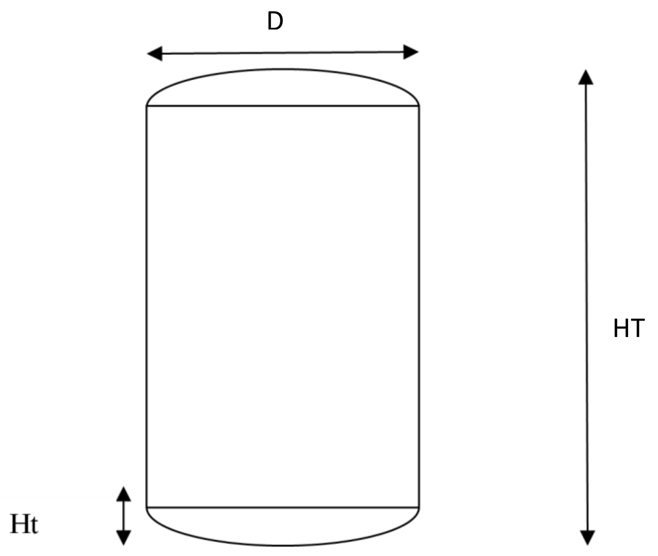
height of torispherical for the storage tank, Ht;

take ,ϴ =20^O

tan Ɵ =0.364

Ht =0.028331185m 28.33118451mm

total height of the storage tank , HT =1.055725788m 1055.725788mm



Specification	Value (mm)
HT	1056
Ht	28
D	467