DEVELOPMENTS OF 2 INCHES LOOP PIPELINES FOR PARAFFIN DEPOSITION TESTING FACILITY USING PLANT DESIGN MANAGEMENT SYSTEM (PDMS)

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A thesis submitted to the Faculty of Chemical and Natural Resources Engineering in partial fulfillment of the requirement for the Degree of Bachelor of Engineering in Chemical Engineering (Gas Technology)

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SUPERVISOR'S DECLARATION

"I hereby declare that I have checked this project and in my opinion this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Chemical Engineering with Gas Technology."

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STUDENT'S DECLARATION

"I hereby declare that this thesis entitled "*Developments of 2 Inches Loop Pipelines for Paraffin Deposition Testing Facility Using Plant Design Management System (PDMS)*" is my own research except if it cited in the references. The study has not been accepted for any degree and is not submitted for award of other degree."

Signature : ………………………………………

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Dedicated to my beloved family

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Thank you.

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ABSTRACT

The main frontier of exploring the deepwater ocean bed is due to the risk of paraffin deposition to the pipe. Going further offshore, the risk is increases because of the increasing of the length of pipelines and decreasing of the temperature. Paraffin will start to deposit along the pipeline once there is temperature gradient between oil and pipeline. According to forecaster, the world will increasingly rely on offshore and deepwater exploration. Therefore, it can be seen that the percentage of deepwater oil production is increases year by year as the development of complementary technology is achieved. The main objectives of this study is to develop a multiphase testing loop for paraffin deposition testing by using Plant Design Management System (PDMS). The paraffin deposition testing loop consisting oil system, natural gas system, inclinable test section unit and glycol system. Therefore, it is hope that this research will be beneficial to the industry, society and environment.

PEMBANGUNAN 2 INCI LITAR PAIP BAGI UJIAN PEMENDAPAN PARAFFIN MENGUNAKAN 'PLANT DESIGN MANAGEMENT SYSTEM' (PDMS)

ABSTRAK

Sempadan utama bagi penjelajahan laut dalam adalah disebabkan risiko pemendapan parafin pada paip. Semakin jauh ke dalam laut,risiko akan lebih meningkat disebabkan oleh penigkatan panjang paip dan penurunan suhu. Parafin akan mula termendap pada paip apabila terdapat kecerunan suhu antara minyak dan paip. Menurut ramalan,kadar kebergantungan dunia pada explorasi laut dalam akan semakin meningkat. Oleh itu,peratusan produksi minyak laut dalam dapat dilihat semakin meningkat dari tahun ke tahun apabila pembangunan teknologi diperolehi. Objektif utama kajian ini adalah untuk membangunkan litar paip multi fasa bagi menguji pemendapan parafin dengan mengunakan "Plant Design Management System (PDMS)". Litar ujian pemendapan parafin mengandungi sistem minyak, sistem gas asli, seksyen ujian dan sistem glykol. Oleh itu, diharap kajian ini dapat memberi keuntungan pada industri, masyarakat dan alam sekitar.

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LIST OF ABBREVATIONS

CFD	=	Computational Fluid Dynamics
BPD	=	Barrel Per Day
Gal	=	Gallon
PDMS	=	Plant Design Management System
F	=	Fahrenheit

CHAPTER 1

INTRODUCTION

1.1 Research Background

Recently, the deep sea area exploration and production are increasing significantly because oil and gas reservoirs near the shoreline have depleted. Crude oil from the oil wells are basically contains complex mixtures which may consist of paraffin or waxes, aromatics compound, naphthenes, asphaltenes and resins. Among all these components, heavy hydrocarbon such as paraffins and asphaltenes are always responsible for production and transportation problems in pipeline system. Paraffin is a major factor for the oil and gas industry for not producing in deepwater fields especially in multiphase flow systems. For deep water exploration, the platform is estimated 160 miles away from the gas processing plant. Therefore, as the oil wells are further offshore, the risk of paraffin deposition is increases due to the longer pipeline on the cold ocean floor. This is because when the water depth increases, the temperature decreases. Once there is a temperature gradient between oil and pipe line, it is either the solid paraffin will deposit to the wall or it will be transported along the pipeline.

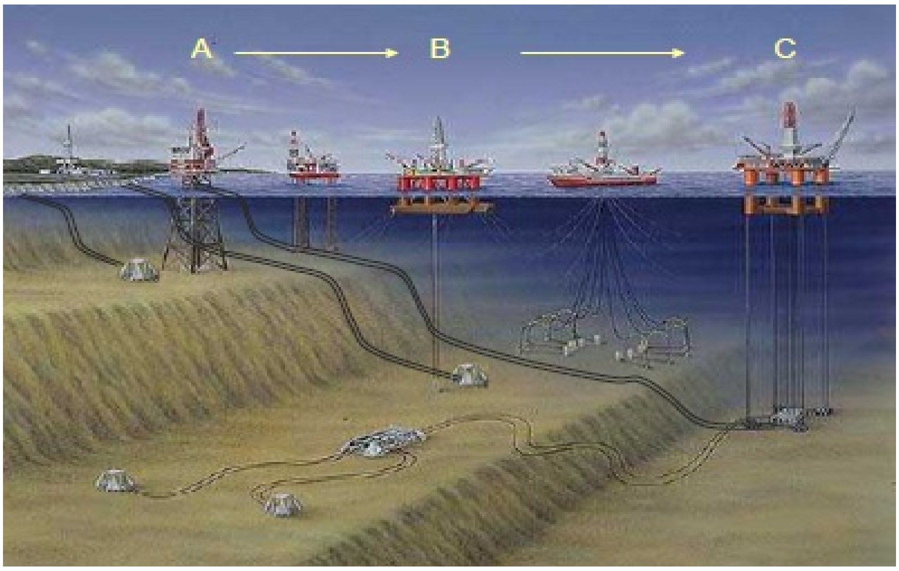

Figure 1.1 Oil productions in deep sea (Lee, 2008).

Clearly, this phenomena is unfavorable to the industry as it will increase the cost for remediation due to pipeline blockage and management. The remediation cost of pipeline blockage due to paraffin deposition is $200, 000 when the water depth is 100m, but it increases to $1,000,000 when the remediation occurs in water depths near 400m (Sarica et. al., 2003). Until today, there is several ways of treating this problem which is pipelines insulation and by injection of wax inhibitor. But, these methods consumed large amount of cost.

So, this study will be concerning on development of 2 inches pipeline for paraffin deposition testing by using Plant Design Management System (PDMS).

1.2 Problem Statement

Several extensive experimental tests have been conducted on this topic. Therefore, this study is going to develop the loop for multiphase paraffin deposition near the flowlines and wellbores by using PDMS. PDMS is a software that majorly used for design and construction work. In this challenging oil and gas world, lowering the percentage of paraffin deposition inside pipelines would be a great advantage as it will help preventing the catastrophic event and lowering the remediation cost. As mention before, there are several methods of reducing the risk of paraffin deposition which is by insulation and by using inhibitor. Pigging method can clean up the pipelines but, before it can be done, it is important to estimate the thickness and hardness of the deposits. As the pig might get stuck inside the pipelines if the deposits is too thick and hard. This situation will cause major problem and the transportation have to be stop. Therefore, getting to the bottom of this study will increase the knowledge about the development of multiphase pipe loops for paraffin deposition testing that is poorly understood before.

1.3 Objectives

The main research objectives for this study are:

1) To study the pipe specification and fittings that suitable for paraffin deposition testing.
2) To obtain the skills of handling and designing in 3 dimension by using PDMS

1.4 Scope of Study

The scope of this study is inside the property of the piping system and design. The selection of each equipments and piping components is vital in order to produce the same exact condition like in the seabed. This study will mainly focus in the equipment and piping design of multiphase flow loop. Due to the facts that wax deposition is the main frontier for deepwater exploration in the oil and gas industry. The significance of the proposed study is to bring the deepwater exploration into a new level which is needed to be more in line with the modern world. If the paraffin deposition problem can be treated, the deepwater fields will be explored widely throughout the world while minimizing remediation cost at the same time. The people in the petroleum industry will have the most benefits, in terms of money and productivity. This study will try to resolve the research questions and trying to find out what is the benefits of the implementing this method in the oil and gas industry. There will also be advantages and disadvantages and the outcomes in this study will be further reviewed.

1.5 Thesis Organization

In general, this thesis consists of 5 chapters. In Chapter 1, the introduction about the research background in brief. Meanwhile in Chapter 2, literature review from various sources is discussed to gain a deep understanding upon the subject matter. Chapter 3 contains the methodology and steps to design the pipe loop using software which consists of more information about the study's requirement. Later in Chapter 4, the results and discussion will be presented in detail which indicates how the objectives of this study are achieved. Lastly, Chapter 5 will be consisting of conclusion based on the results and few recommendations for future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Composition of Crude Oil

Crude oil or generally known as petroleum is the unrefined oil that is formed over millions of years under the ground. It is found in range of color from clear to black or in liquid or gas phase. Generally, it is made up of hydrocarbon compound. The main hydrocarbon compounds that can be found in the petroleum are complex mixture of saturates (paraffin/waxes), aromatics, naphthenes, asphaltenes and resins. Among these components, high molecular weight paraffin and asphaltenes are typically responsible for production and transportation problems in subsea pipelines system (Lee, 2008).

The carbon content normally is in the range 83-87%, and the hydrogen content varies between 10 and 14%. In addition, varying small amounts of nitrogen, oxygen, sulfur and metals (Ni and V) are found in crude oils. Wax or paraffin is a sub class of the saturates, consisting primarily of straight-chain alkanes,mainly ranging from C_{20} to C_{30}. Wax precipitates as a particulate solid at low temperature (Narve, 2002).

2.2 Wax Deposition Problem in Flow Conditions

Paraffin deposition in multiphase flow conditions has not been systematically investigated, and therefore remains poorly understood. In multiphase systems, the additional gas phase adds to the complexity of understanding wax deposition phenomena. There have been very few published studies reported on the effect of multiphase flow on the phenomena of paraffin deposition (Lee, 2008). Wax consists mainly of heavy paraffins and some naphthenes. At reservoir temperatures (70-150^{o}C) and pressures (50-100MPa), wax molecules are dissolved in the crude oil. However, as the crude oil flows through a subsea pipelines resting on the ocean floor at a temperature of 4^{o}C, the temperature of oil eventually decreases below its cloud point temperature (or wax appearance temperature,WAT) because of the heat losses to the surrounding. From this point, the solubility of wax decreases drastically and wax molecules start to precipitate out of the crude oil (Outlaw et. al., 2011).

Wax deposition along the inner walls of the pipeline increases the pressure drop, decreases the flow rate, and causes operational problems like pipeline blockage which can lead to production loss. To prevent blockage of pipelines, wax deposits should be removed periodically (Hussein et. al., 2008).

2.3 Techniques to Remove Wax Deposition

As mentioned earlier, there are many options for removing deposit in the pipeline which includes pigging, thermal techniques, chemical solvents & dissolvers and wax inhibitors. Each option is described in brief as below.

- **Pigging**- A cleaning pig are launched into a pipe which scrape the waxes at the pipewall and distribute it within the crude oil in front of the pig.
- **Thermal Techniques**- Technique that controlling the temperature of the oil either by maintained it or increased above WAT.
- **Chemical Solvents & Dissolvers –** The blending between the solvents and gas oil will produces excellent wax dispersion and dissolution properties.
- **Wax inhibitors**- Injection of chemical additives in the pipeline. There are four categories of inhibitor which is crystal modifiers, pour point depressants, dispersants and surfactants.

Source: http://www.halliburton.com/public/pe/contents/Brochures/Web/H04347.pdf

Among these options, pigging technique is the most appropriate technique to remove wax inside the long pipeline from the pipe that lay on the sea floor to the pipe on the flow lines.

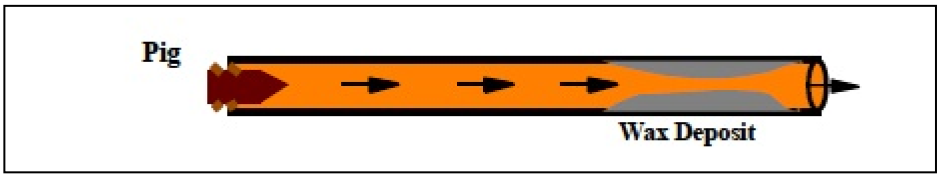

Figure 2.1 Pigging method for wax removal (Nguyen, 2004; Lee, 2008).

This is the reasons why it is very important to model the multiphase pipe loops so that the paraffin deposition and aging phenomena can be tested. As a result, appropriates chemical treatments and pigging schedules can be optimized to minimize or alleviate paraffin deposition in wellbores or flowlines (Micheal and Sarica, 2003).

2.4 Physics of Wax Deposition Phenomena

Wax precipitation during crude oil flow causes wax deposition and flow restriction. Wax deposition during the flow of waxy crude oil through subsea pipelines occurs as a result of the precipitation of wax molecules adjacent to the cold pipe wall. Thus, wax deposition can only occur when the inner pipe wall temperature is below the cloud point temperature. The precipitated wax molecules near the pipe wall start to form an incipient gel at the cold surface. The incipient gel formed at the pipe wall is a 3-D network structure of wax crystals and contains a significant amount of oil trapped in it. The incipient as a result of heat losses to the surrounding is shown as in Figure 2.2 below.

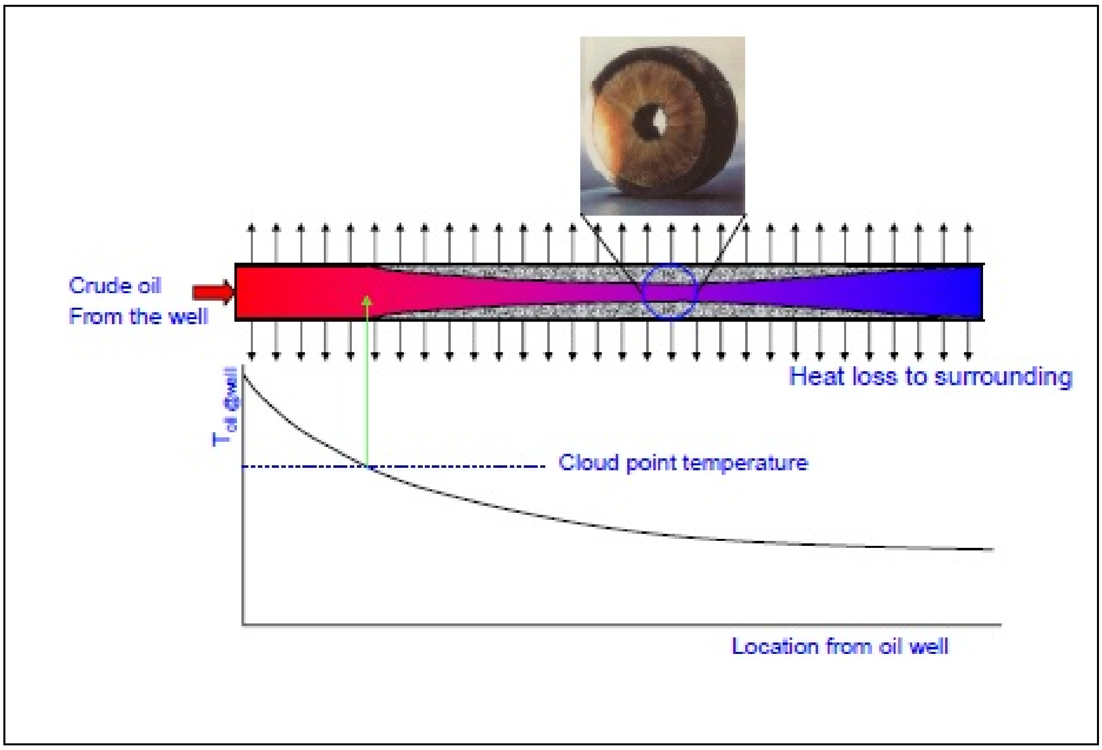

Figure 2.2 Occurrence of wax (Lee, 2008).

2.4.1 Radial Mass Transport

The radial wax transport wax concentration gradient is established by precipitation of wax molecules out of the oil. This lowered wax concentration near the oil-deposits interface results in a mass flux of the wax molecules towards the surface of the incipient gel layer. This mass flux causes the wax deposits to become thicker as time progresses. (Lee, 2008)

There is many type of radial mass transportation mechanism have suggested to cause the growth of a wax depositions which is radial convective flux (Singh et. al., 2000), molecular diffusion (Bern et. al., 1980; Burger et. al., 1981; Majeed et. al., 1990; Brown et. al., 1993; Svendsen, 1993; Ribeiro et. al., 1981; Creek et. al., 1999; Lee, 2008) and precipitated wax particle transportation. However, it is confirmed that the contribution of precipitated wax particles on the wax deposition is not significant for flow conditions encountered in oil pipelines on the ocean floor (Matzain et. al., 2008).

2.5 Development of Multiphase Flow Loop

Figure 2.3 below shows the testing facility. It comprises of oil system, gas system, glycol system, separator and test section. The flow loop is in a U-shaped. The test section is 75-ft long that is divided into three main parts: a 25-ft long thermal developing section to allow creation of the oil thermal profile, a 25-ft long test section that is divided into five segments to supervise the phenomena of paraffin deposition and also a 5-ft long spool piece to allow sample collection. Crude oil flows in the inner of 2-inch pipe while glycol circulates countercurrent in a 4-inch annulus. Those pumping, heating, and cooling system are for flow and temperature control purposes (Micheal and Sarica, 2003).

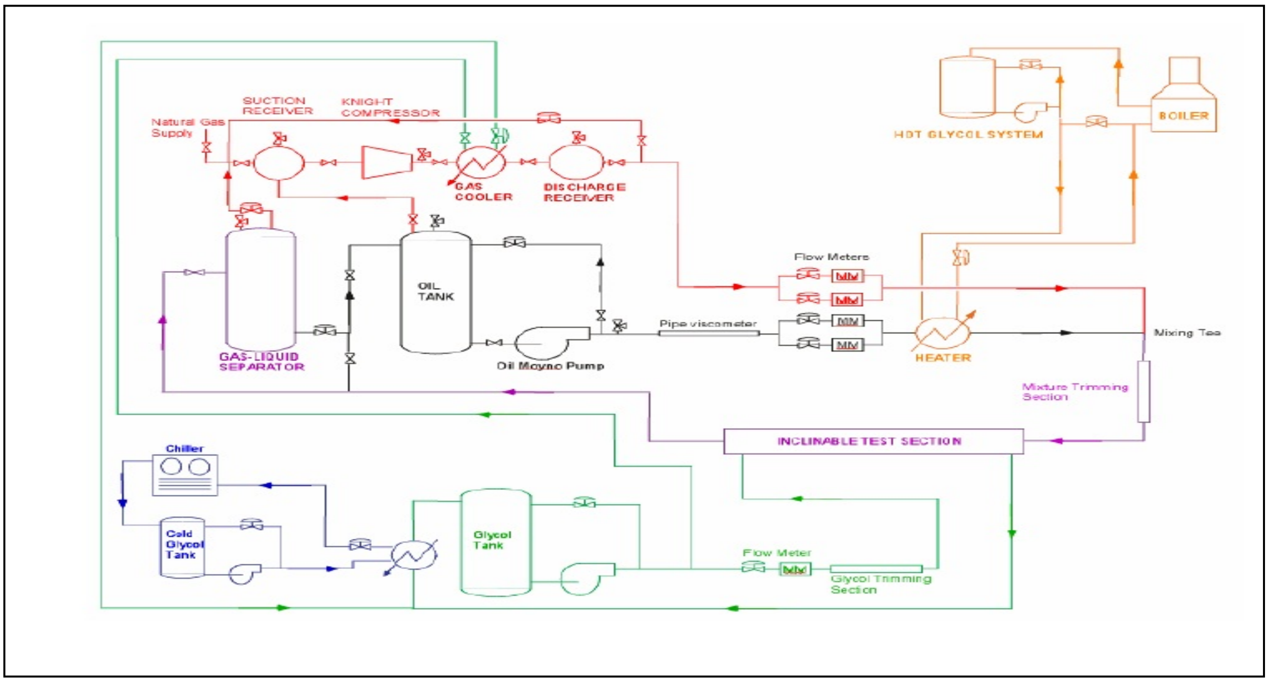

Figure 2.3 Multiphase flow loop process flow diagram (PFD) (Sarica et. al., 2004)

2.5.1 Uses of Piping

Piping is used for various purposes including for industrial (process), marine, transportation, civil engineering and for commercial purposes. In oil and gas industry, basically involves process piping, service piping and transportation piping. Process piping is used to transport fluids from storage tanks to processing units. Meanwhile, service piping or utility piping is used to pass steam, air, fuel gases, fuel oil and water for processing. Transportation piping is normally involves large pipes that is used to pass over hundred miles from offshore that is not used in this study (Sherwood, 1973).

2.6 Overview of Software

Matzain et. al (2008) said Fordyke (1995) and Apte et. al (1999) suggested that the approach for estimating paraffin deposition in multiphase flow could be similar to that for single-phase flow. They described the possible effects of different flow patterns on wax deposition and speculated on the nature of the wax deposits that could occur during each flow pattern.

A computer program following on the international standards will be used for designing paraffin deposition 2 inch multiphase flow pipelines system using PDMS. The program allows the designer to design in three dimensions that makes the equipment and piping look realistic.

2.6.1 Piping Specification in PDMS

PDMS has a set of piping specification from which designer can choose. All the components (valve, reducer, elbow & etc) in the program must be defined in the catalogue and be placed in a specification before they can be selected for joining purposes. There are 3 specifications that have always been used in the industry such as:

A1A = ANSI CLASS 150 CARBON STEEL

A3B = ANSI CLASS 300 CARBON STEEL

F1C = ANSI CLASS 150 STAINLESS STEEL

2.7 Malaysian Standard

The Malaysian Standard are developed by committees that comprise balanced representation of producers, users, consumers and other that might be relevant in this subject matter. The main function of this standard is to foster and promote standardization and accreditation. Standardization and accreditation benefits the consumers and producers and helps facilitating domestic and international user. Over past 16 years there are more than 6300 Malaysian Standard and one of it is MS930. MS930 is Malaysia Standard Code of Practice for the installation of fuel gas piping system and appliances that is derived from international standard so that it meets with the country conditions. MS930 consists of thirteen sections (MS930, 2010).

2.8 Summary

There are previous studies that successfully developed the testing loop in real, but none of it has design it using PDMS. Therefore, this study is going to apply the same process flow diagram, modify it following required standards and presents it into three dimensional visual. It can be said that the process of designing is much more cost and time effective as the program is already equipped with equipment and pipe that follows international standards.

CHAPTER 3

METHODOLOGY

3.1 Research Tool

This research will be carried using Aveva PDMS 12.0.SP4 with piping and equipment feature for 3-D multiphase flow loop design and development.

3.1.1 Aveva PDMS 12.0.SP4

Aveva Plant Design Management System (PDMS) 12.0.SP4 is the simulator that has been chosen for this study. PDMS was chosen because of its ability to design equipments, piping system, ducting, electrical and instrumentation and architectural structure design. It provides a fully interactive, easy-to-use 3D environment and supported by Microsoft Office-style user interface, clash checking and configurable integrity checking rules identify errors and inconsistencies across the design, conventional issue, revision, and change control processes can all be applied without introducing a large overhead or delays in projects which can have many hundred users, and state-of-the-art 3D editing features with graphical handles and numeric feedback make design and modification quick and easy.

Approximately, around 80% companies related to petroleum and gas industry are using this software. Some of the advantages of PDMS that can be considered vital to this study are because of the availability of industrial world standard for piping, structural steel, ducting, hangers, supports and cable trays. It also produce high level dimension consistency and higher quality design because of its ability to perform multiple design check across the entire design and eliminates error and enable ‘right-first-time’ engineering.

3.2 Research Activities

Several steps of research activities were followed beginning with the collection of plant layout, piping and equipment specification from various sources of journals, books and standard. Then, base on the draft and equipment specification, equipments were assembled and coordinated at appropriate location by referring to human engineering factors. All of the equipment and pipe components are positioned to the north for synchronization purpose. Next, the equipments are then joined together by piping components to form complete flow loop.

3.2.1 Data Collection

A detail understanding regarding the flow loop layout and all of the specifications must be cleared at this stage. The key to design using Aveva PDMS 12.0.SP4 must be well-known prior to collection of data from various sources to be applied in the PDMS. Mostly, the equipments and pipe specifications are ought to be identified in order to join it together. The most difficult part after assembling the equipments is to design the test section and locating electrical components i.e. meter at the test section.

3.3 Process Flow Diagram (PFD)

Process flow diagram is one of the important elements required to designer to position equipments. A lot of important information can be get in this diagram such as flow direction and how the equipment are interconnected to one another. But PFD does not show any utility equipment. The utility equipments can be getting from P&ID.

3.4 Equipment Elevations

Generally, all equipment must be elevated at its minimum height. The elevation is needed for the process engineering and human engineering such as process, operational and for maintenance requirements. As for horizontal drums, shell and tube heat exchangers, and furnaces it must be supported with concrete piers. While vertical vessels like towers and base plate equipment like pump should be supported with concrete foundations.

3.5 Piping System

3.5.1 Pipe Supports

Pipe support is a steel member that is attached with pipe in order to hold the pipeline firm enough during expansion and contraction forces coming from operation. It may come in various shapes and sizes. Some typical pipe supports is describe as below:

1. **Pipe Shoes –** a standard shoe height is 4 inch. Usually used to support insulated lines on shoes fabricated from structural shape like T-section and wide flange.
2. **Spring Support –** Pipelines are supported by springs in order to accommodate thermal expansion or contraction.
3. **Trunnions and dummy leg –** Used for wide applications and are welded to the outside part of the pipe.

4. **Brackets –** Used when it is involving heavy loads. This type of supports is frequently welded to certain equipment.

3.6 Summary

This study is carried out using Aveva PDMS 12.0.SP4 equipment and piping function. PDMS is chosen as the research tools because of its dynamic feature and the availability of industrial world-standard of piping and equipment standard. As part of the methodology, data collection from various reviewed journal was applied to design the original flow loop. The flow loop is then undergoing few modifications to create three-phase condition by added water system into the loop. At this stage, the flow loop has completed. The summary of the methodology is shown in Figure 3.1 below.

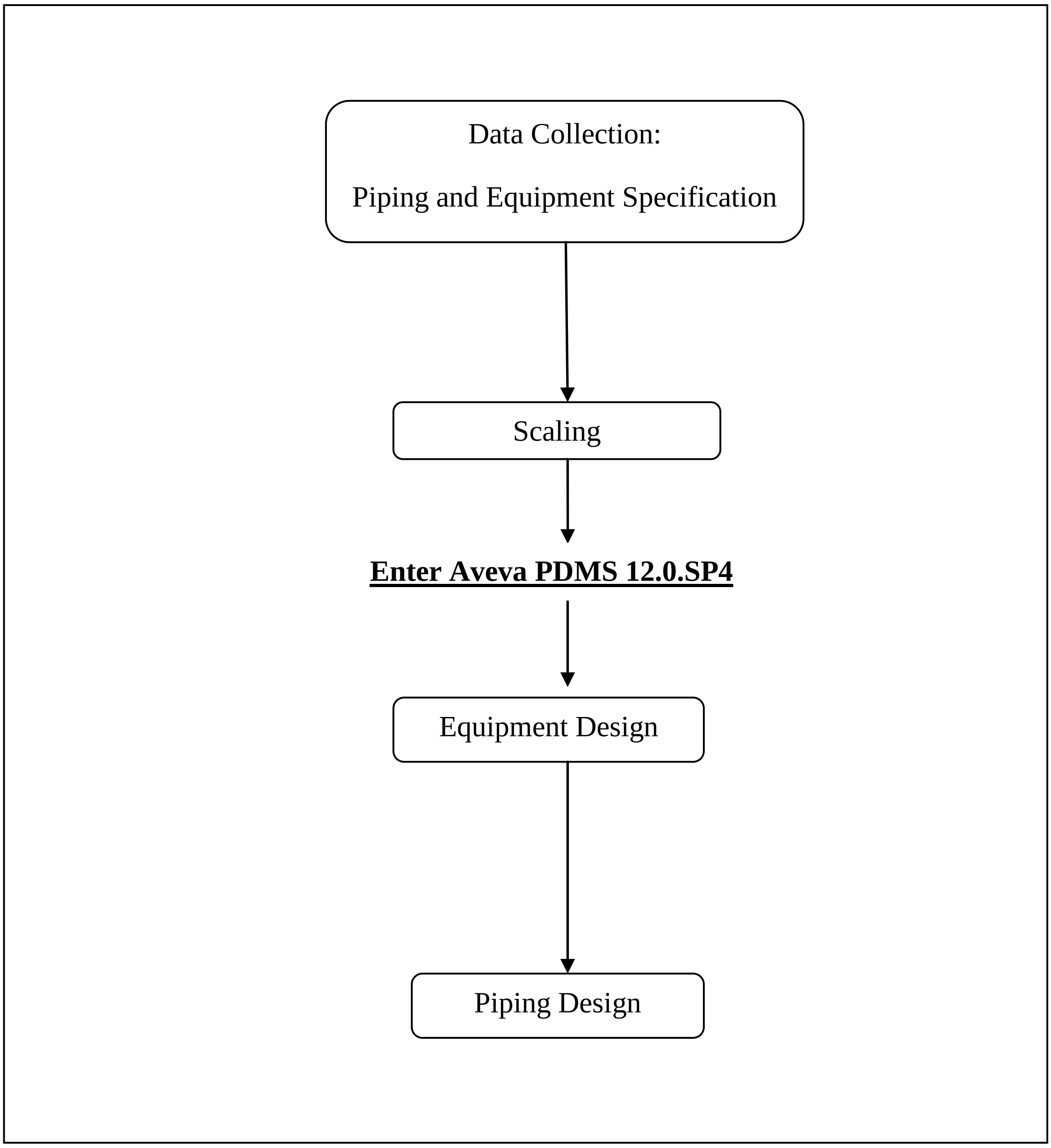

Figure 3.1 Summary of methodology

CHAPTER 4

RESULTS AND DICUSSION

4.1 Equipment Modeling

Equipment creation in PDMS enable designer to create and modify equipments that will be used in the plant. The level of detailed of the equipment model depends a lot on the project requirement. Adding greater details into the design provides realistic vision but it takes more time and cost. In this study, the level of detail is on the minimum level.

4.1.2 Equipment Hierarchy

In PDMS, all elements are owned by other elements but except for WORLD element as it is the uppermost element in the hierarchy. Elements that owned by another element is ZONE. ZONE is a member of SITE. Other element can have a few numbers of members but it can only have one owner which is the WORLD.

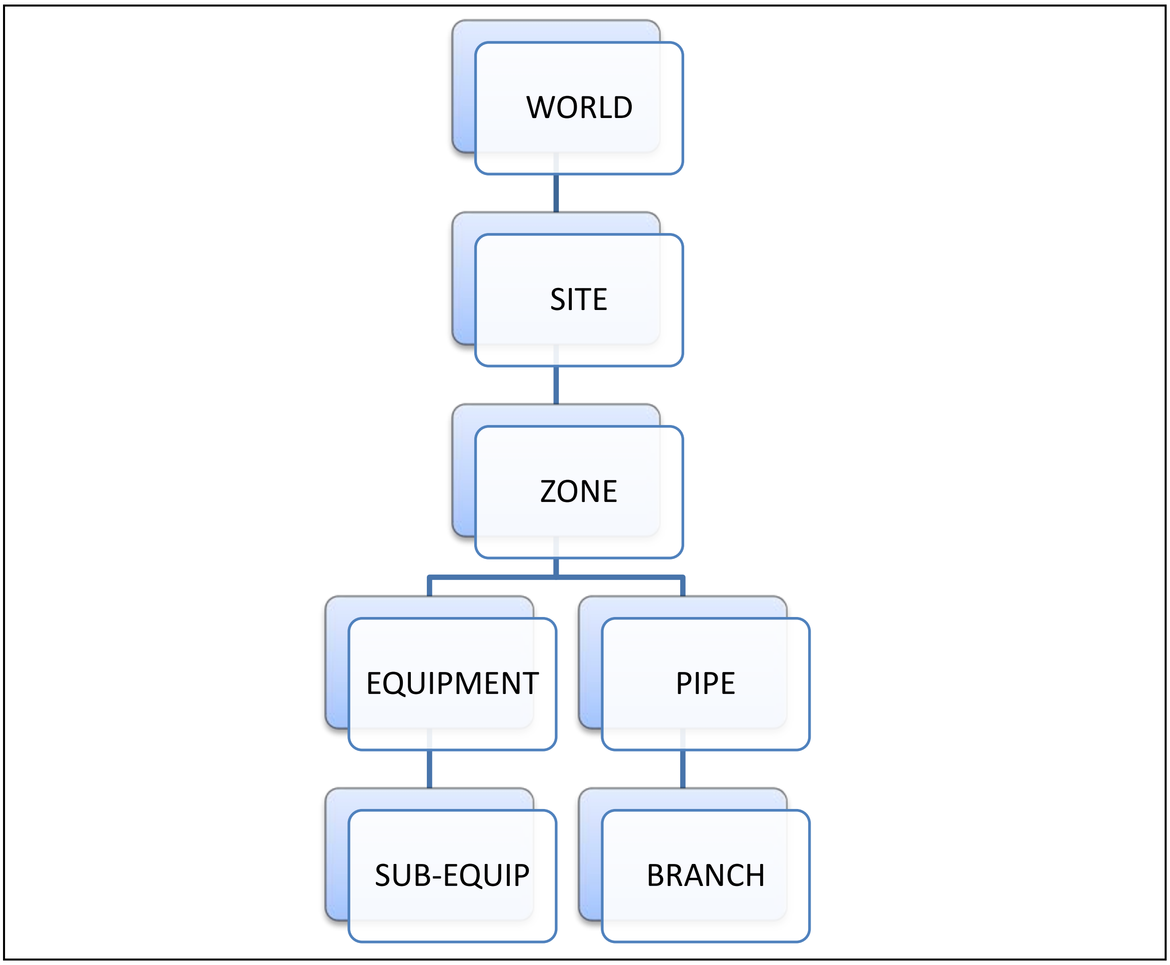

Figure 4.1 Equipment hierarchy

4.2 Multiphase Flow Loop

This loop has the capability for conducting paraffin deposition test for multiphase mixtures (water, oil and natural gas), single-phase oil and two-phase mixtures of natural gas and crude oil that flows in horizontal, near-horizontal, and vertical pipes as it have an inclinable test section. As mention before, the flow loop will be consisting of several parts includes oil system, gas system, water system, glycol system, test section and data acquisition system. The general operating condition is supposed to be similar with the conditions under water which are:

Operating Temperature: 40 – 160 F

Operating Pressure: 0 – 500 psig

Oil Flow Rate: 0 – 4,500 BPD

Gas Flow Rate: 0 – 2 MMscfd

Water Flow Rate: 0 – 1, 4175 Gal

Glycol Flow Rate: 0 – 2,00 BPD

Pipe Diameter: 2 inch

4.3 Equipment Creation

After ensuring that current element belongs to the correct member, equipment is created by clicking on the create toolbar. Equipment creation form will be automatically appeared on the window. Equipment that is needed for the project can be select in the specification element. The properties of the equipment can be set by clicking on the properties tab.

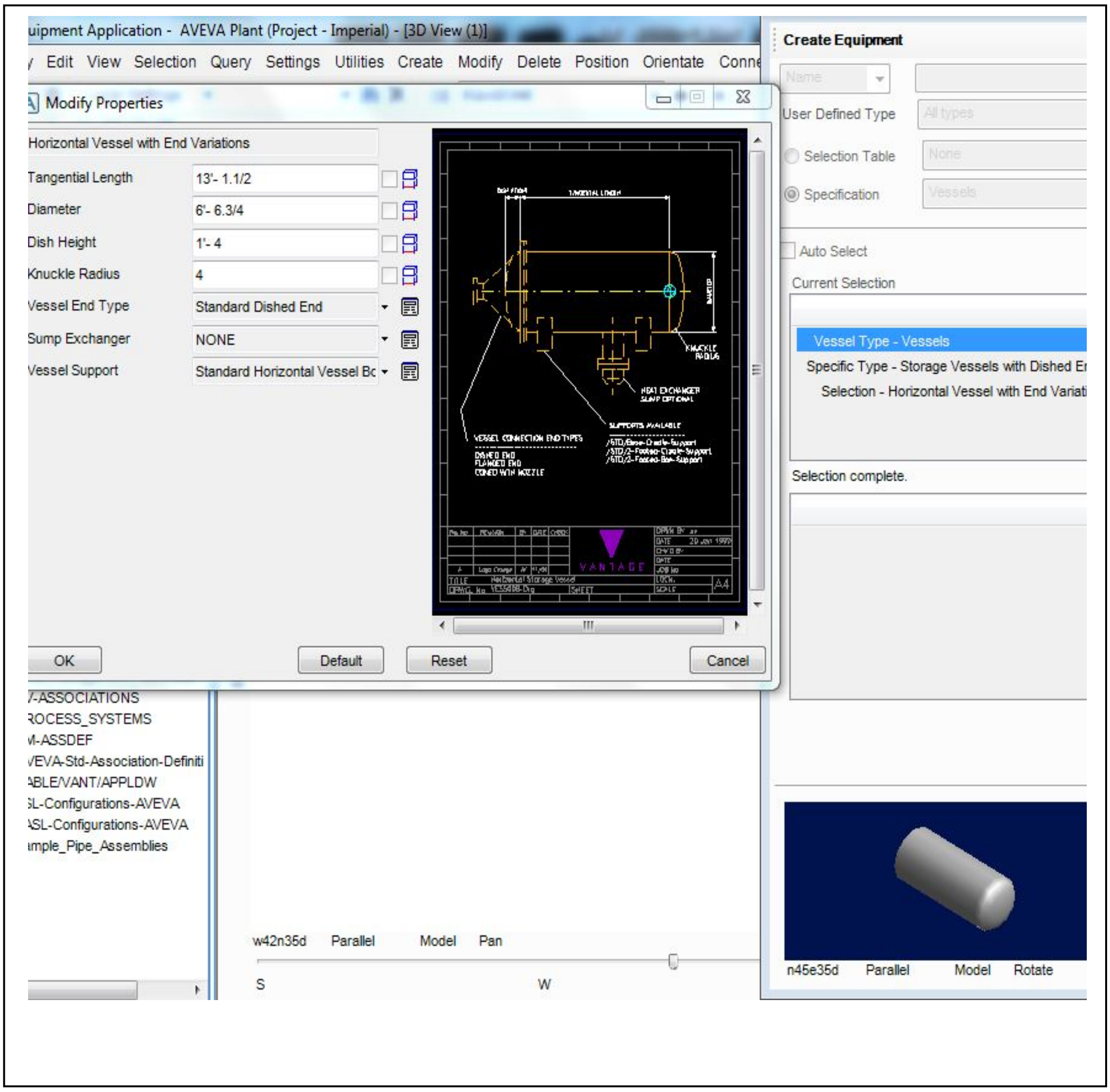

Figure 4.3.1 Equipment creation form

4.3.1 Primitives

Equipment can also be built using primitive application. This application needs the designer to decide on which primitives are going to be used for that specific equipment creation. In this study, there is several equipment that is created using primitives application such as chiller. Chiller is made up of box, four cylinders for the equipment support and also two nozzles.

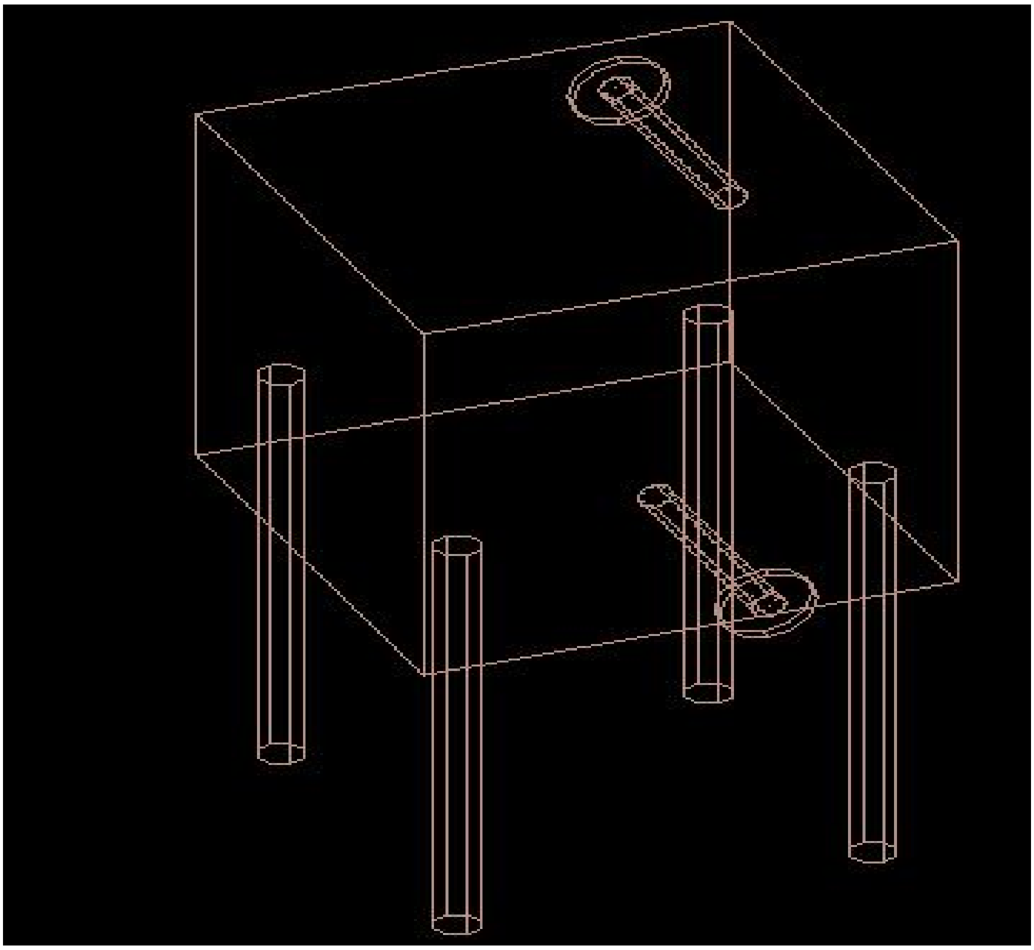

Figure 4.3.2 Creating equipment using primitive application

4.3.2 Nozzles Creation

In equipment creation, nozzle is treated as a unique element although it has a lot of similarity with primitive. Unlike primitive, nozzles have connection attributes to other elements and also store information relating to pressure and temperature. In the nozzle creation form, the nozzle can be name and its properties can be specified according to the project requirements. Other than that, generic type and nominal bore size of the nozzle can also be specified.

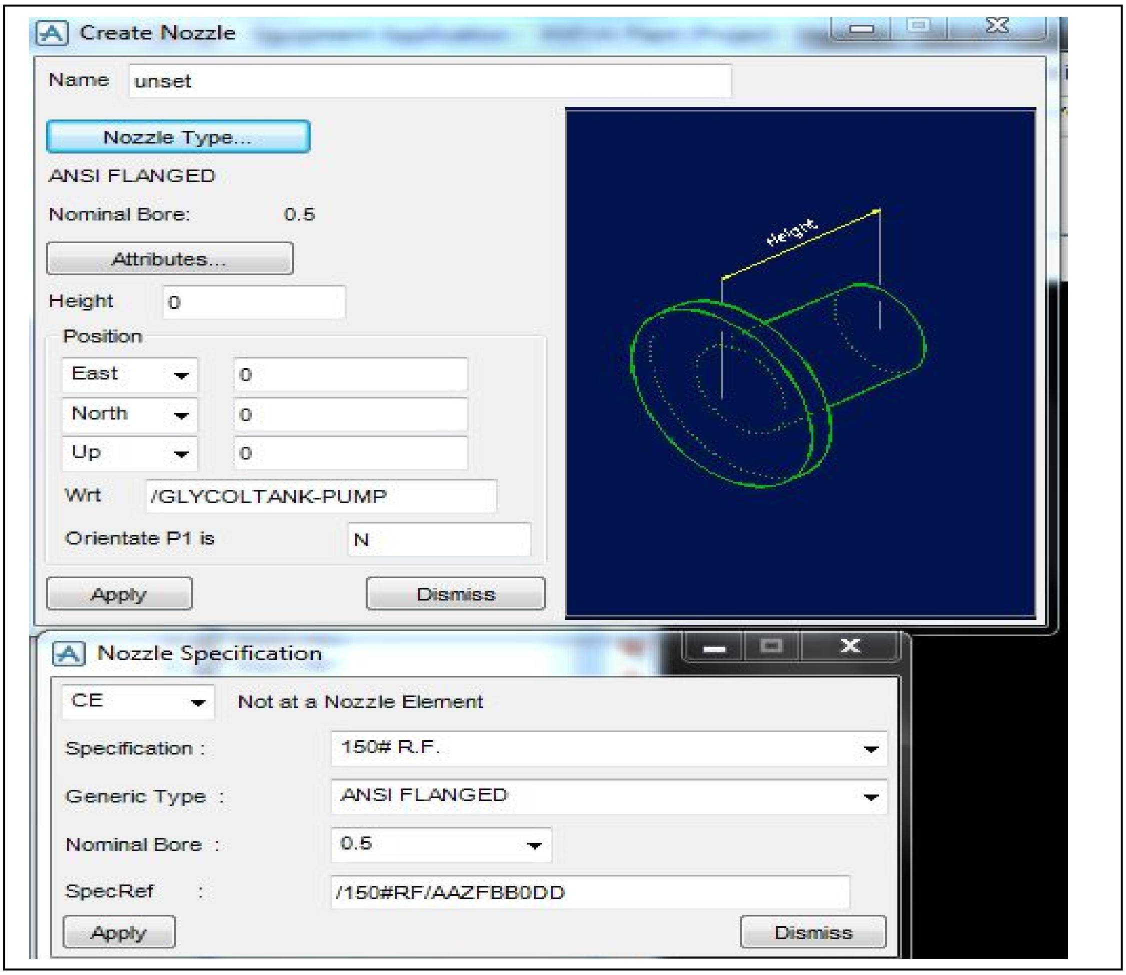

Figure 4.3.3 Nozzle creation form

4.4 Equipment Arrangements

Basically, equipments are arranged by considering site conditions together with local codes and regulations. Equipments must be compulsory group with other equipments at the same process area in order to accommodate the operation and shutdown process. To position equipment, the position control tab is used by inserting suitable coordinate.

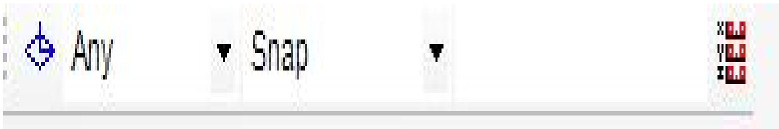

Figure 4.4.1 Positioning control of equipment

The coordinate inserted in the positioning control form to position equipments are usually dictated by other project information. Besides, equipment and primitives can also orientate by using model editor applications. Model editor enable designer to rotate or move equipment along its axis.

4.5 Multiphase Flow Facility Diagram

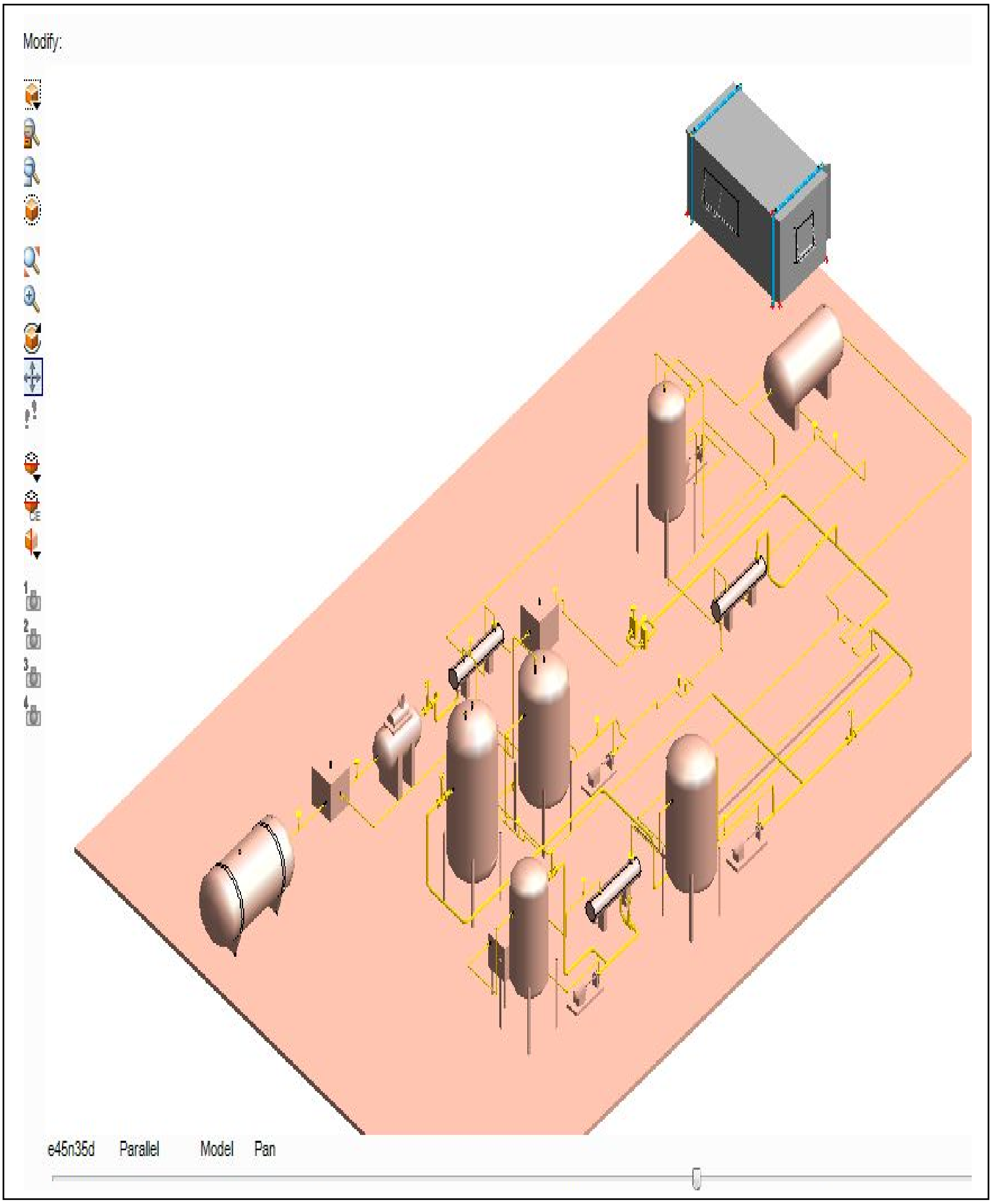

Figure 4.5.1 Isometric view of multiphase flow loop diagram using PDMS

4.6 Process Description of Developing Multiphase Flow Loop

General description of developing the multiphase flow loop for paraffin deposition is sketched in Figure 3.1. The data and properties required in which collected from various journal is now being used in the equipment design and piping design sections.

4.6.1 Oil System

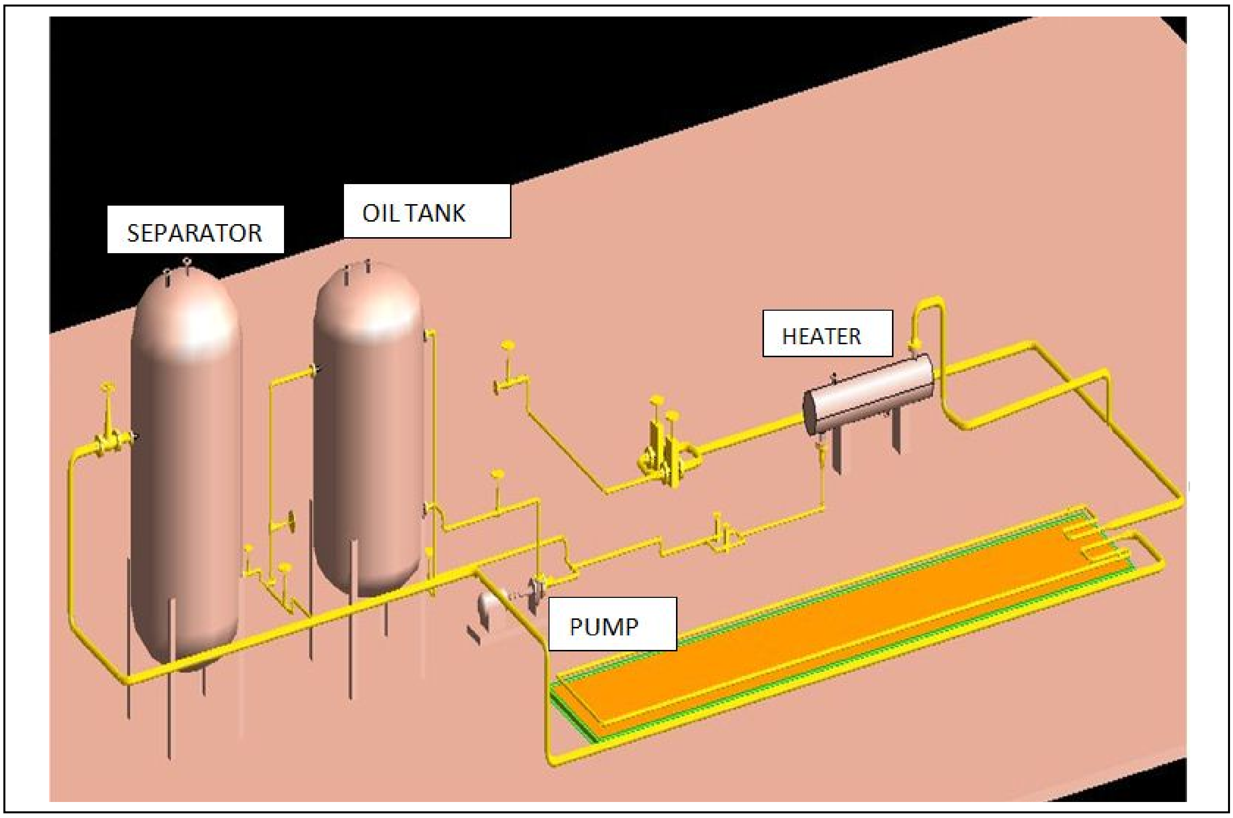

Figure 4.6.1 Oil system flow loop

Oil system in the loop consists of oil tank, oil pump, pipe viscometer, metering section, and heat exchanger. The volume of the oil tank is 25 bbl. Progressing cavity pump with a capacity of 4,500 BPD and has the capability of providing 200 psi pressure keeps the oil circulating in the loop. The flow rate of the oil is control by the pump speed. In the metering section, there are two Micro Motion mass flow meter (used for different flow range) that measured the flow rate and density.

Pipe viscometer is 15-ft long it is used to measure apparent viscosity. Oil is then flows to the shell and tube heat exchanger to change the temperature base on requirement. After achieving desired temperature, oil is mixed with gas in mixed tee. The mixture flows through trimming section. In trimming section, electric is supply to heat the pipe wall. Oil tank and flow lines in this system are insulated and electrically heat traced to avoid deposition of paraffin at outside of the test section.

4.6.2 Gas System

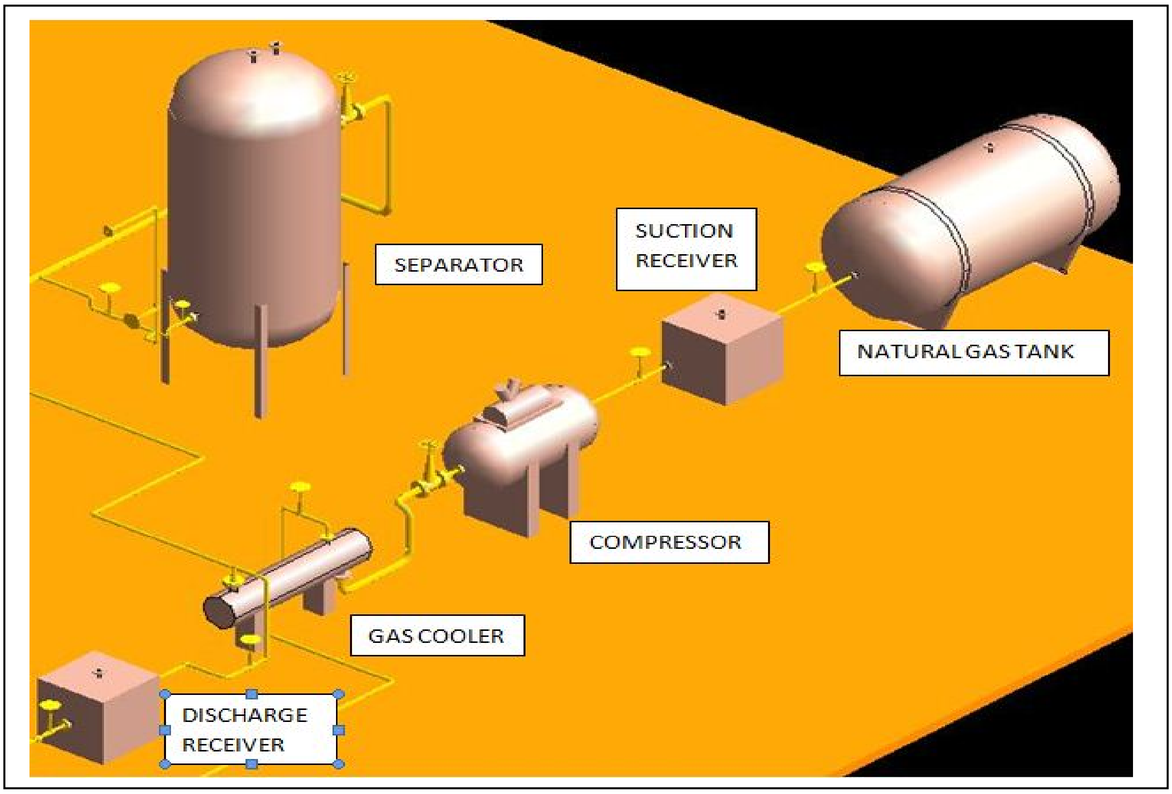

Figure 4.6.2 Gas system flow loop

Like the oil system, gas system consists of gas tank, reciprocating compressor, cooler, discharge receiver and Micro Motion mass flow meters. The gas supplied is circulating inside the pipe with a two-stage reciprocating compressor through a cooler. The gas is then discharge through discharge receiver before its flow rate and density is metered by either one of Micro Motion mass flow meter by depending on the gas flow ranges. Next, the gas will be mixed at the mixed tee before it enters the test section. From test section, the mixture will be separated and returns back to compressor suction receiver.

4.6.3 Glycol System

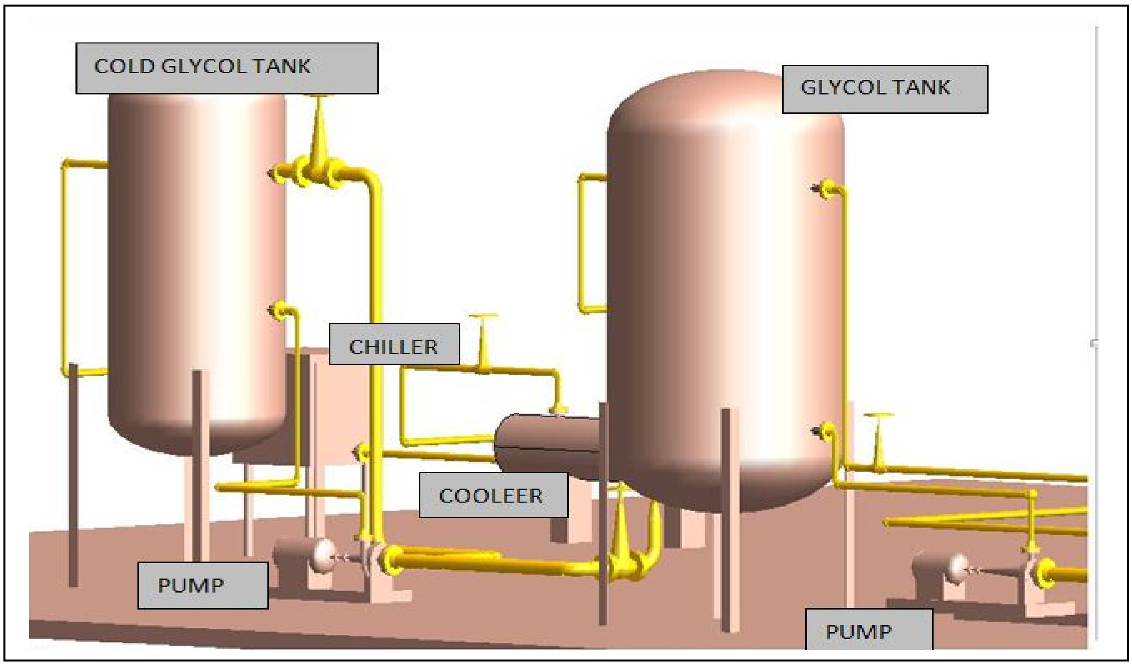

Figure 4.6.3 Cold glycol system

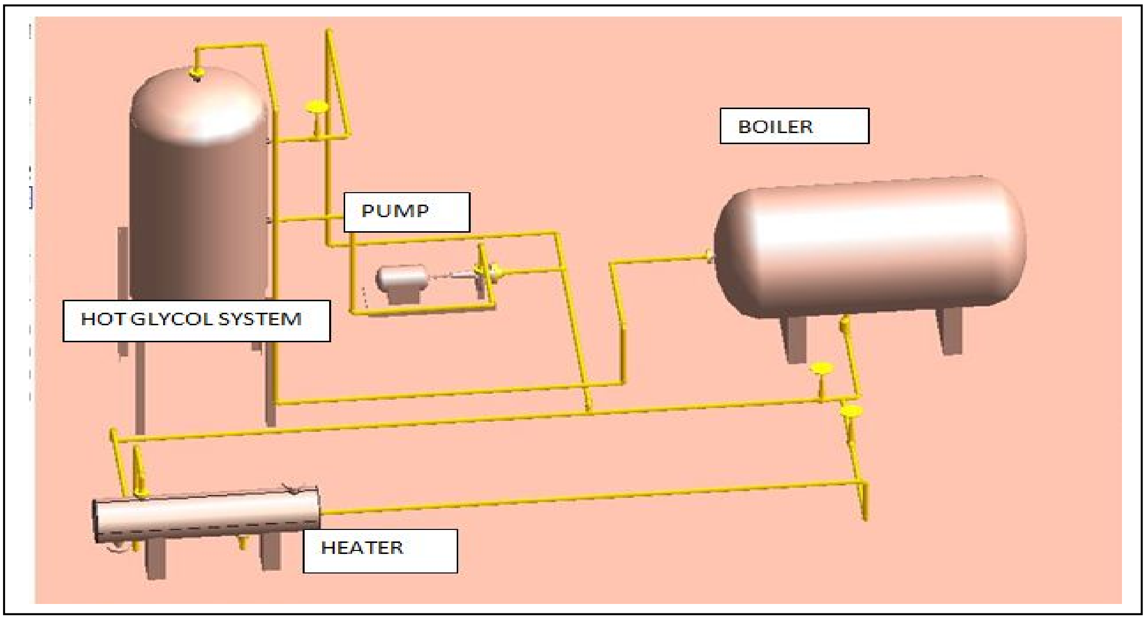

Figure 4.6.4 Hot glycol system

The main glycol is circulated countercurrent inside the annulus of the test section while the hot and cold glycol system function is to control the temperature of fluids. The system is equipped with mass flow meter, heat exchangers, boiler and a chiller. The glycol flow rate is measured by mass flow meter and its temperature is controlled by heat exchanger. As the cold glycol is always set to 40^{o}F therefore, it must passed chiller and heat exchanger back to the cold glycol tank. While hot glycol circulates through the oil heat exchanger to control the oil temperature before it back to the boiler and hot glycol tank.

4.6.4 Test Section

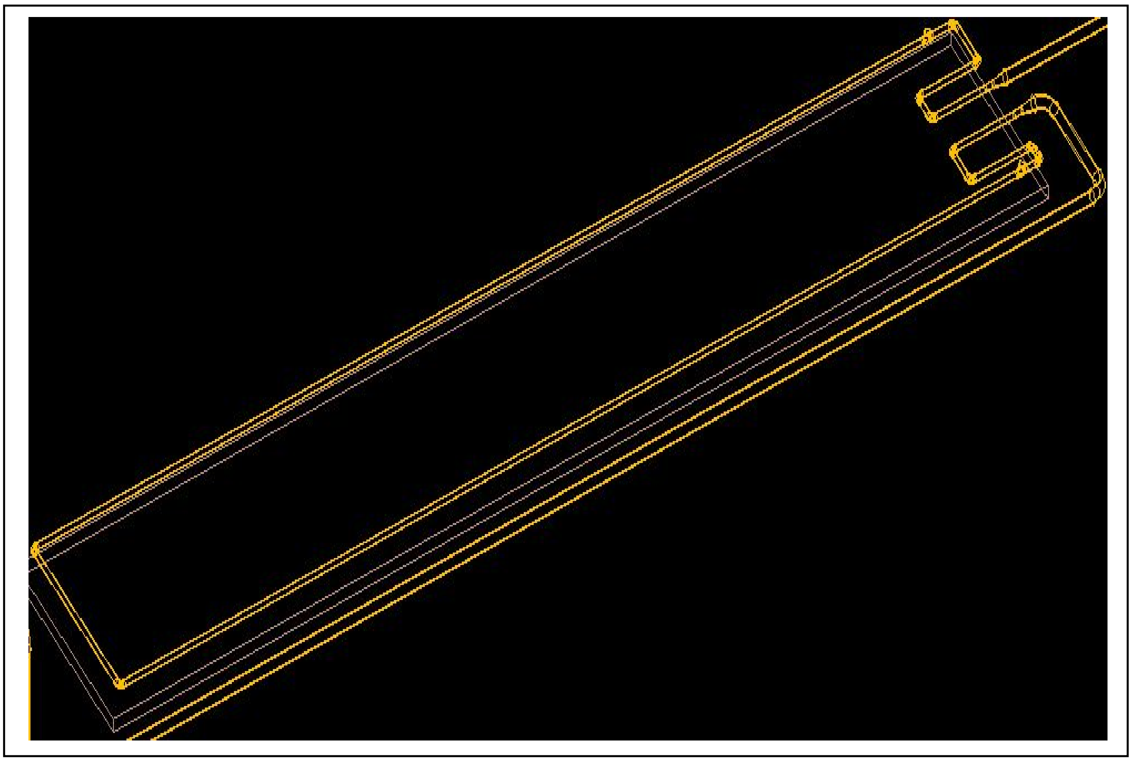

Figure 4.6.5 2 inch test section

The test section consists of inclinable stainless steel pipe with 75-ft 2 inch diameter that can be raised vertically from horizontal position. This is in order to create the horizontal condition at the flow lines and vertical condition at the well bores. There is also a 10-ft hydrodynamic section that allows development of flows before entering 25-ft thermal developing section jacketed with a 4 inch CPVC pipe in which glycol is circulated to keep the required temperature constant. Next section is a 25-ft long deposition measurement section where temperature profile and pressure drop in pipe are measure. Spool piece is a 5-ft long bend pipe that can be removed for test sampling or inspection.

The flow loop is control by data acquisition system. This means, less people are required for supervision as all important variables and control features can be controlled inside the control room. Control logics are in place for oil and glycol flow rates and inlet temperatures together with safety measurement.

4.7 Pipework Modeling

In PDMS there is a separate design hierarchy for pipe routing. The hierarchy is different from equipment modeling. In principle, each pipe element may own a number of branches. While branches may have its own piping components such as valves, reducers, flanges and tees. The hierarchy is shown in Figure 4.6.1 below:

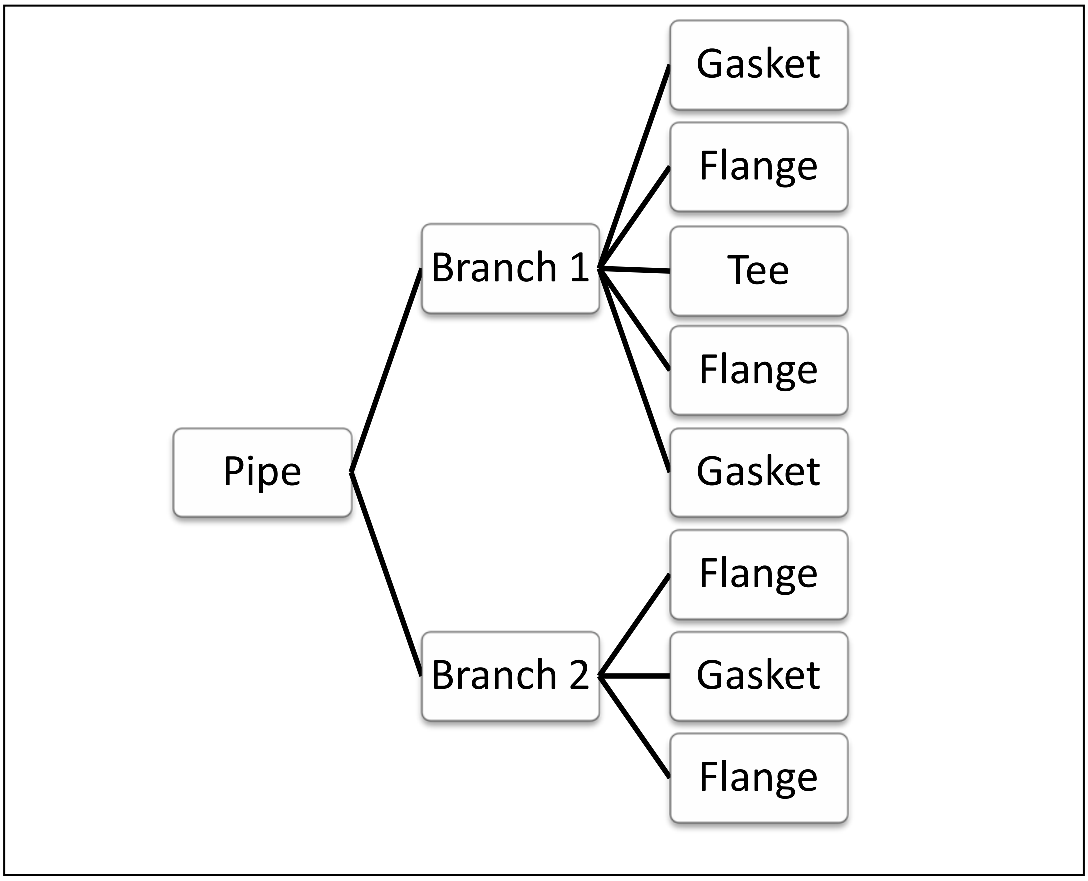

Figure 4.7.1 Pipework design hierarchy

There is a difference between pipe and branch. Pipe is considered to have any number of ends while branch can only have a maximum two ends. Even so branch only has two ends but, it can have its own components like a tee which connects it to other branches.

4.7.1 Pipe Creations

The first step of creating pipe using PDMS is to know the functions of pipework toolbar. Pipework toolbar enable designer to manipulate pipes, branches and branch components. The functions that can be used in the toolbar is resets the default pipe specification, pipe creation form, pipe modifications, pipe creation components, reselecting piping components, deleting range of piping components, align components and orientate components.

Once the pipe creation form is displayed on the monitor, user has to insert in the data required like the bore size, insulation, tracing, temperature and pressure. The bore indicated in the form is the nominal bore for that own pipe and it has not effect upon the pipe route. It is also necessary to ensure the correct zone that the pipe belongs to by navigating to the design explorer.

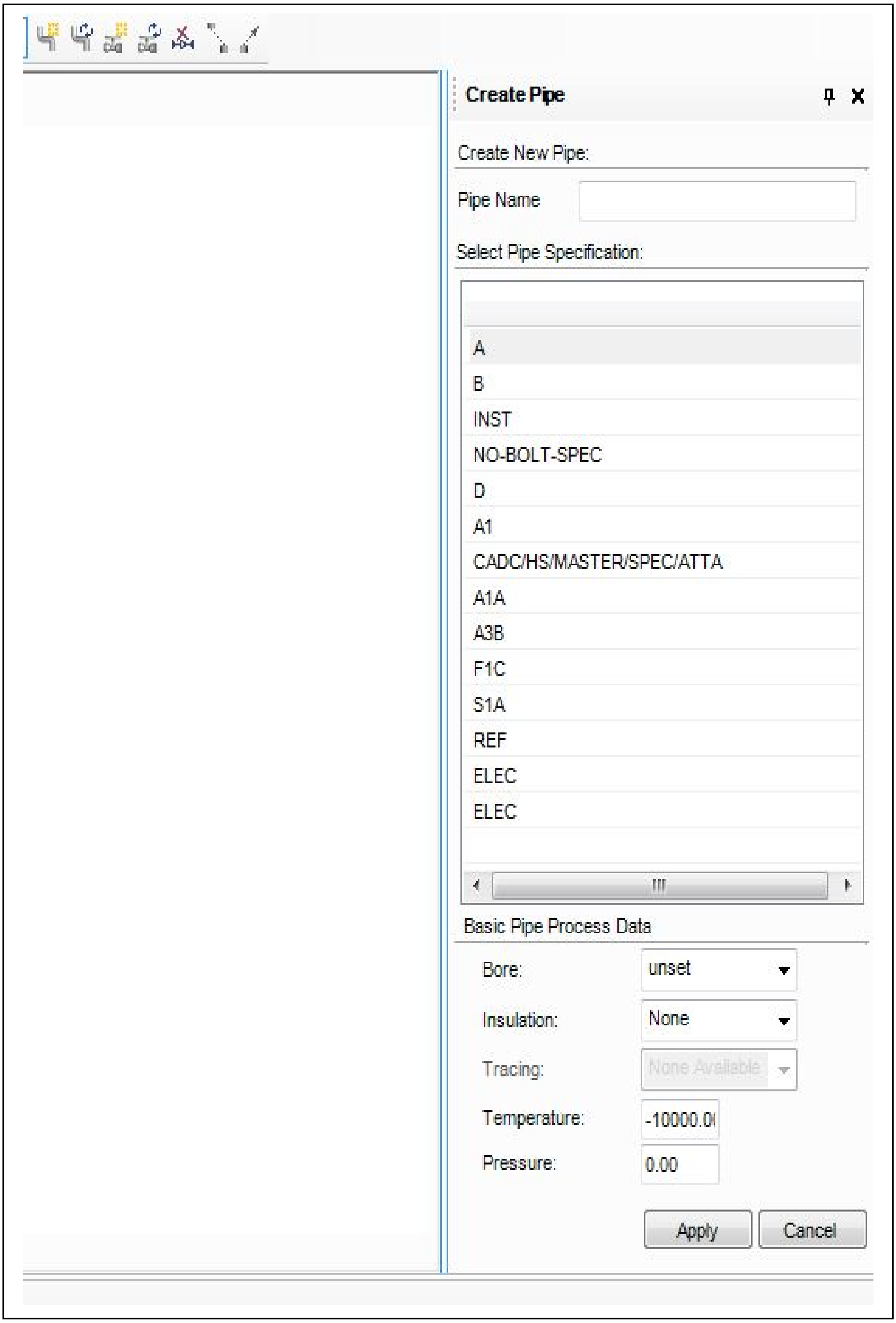

Figure 4.7.2 Pipe creation form and pipe toolbar

4.7.2 Pipe Branch Heads and Tails

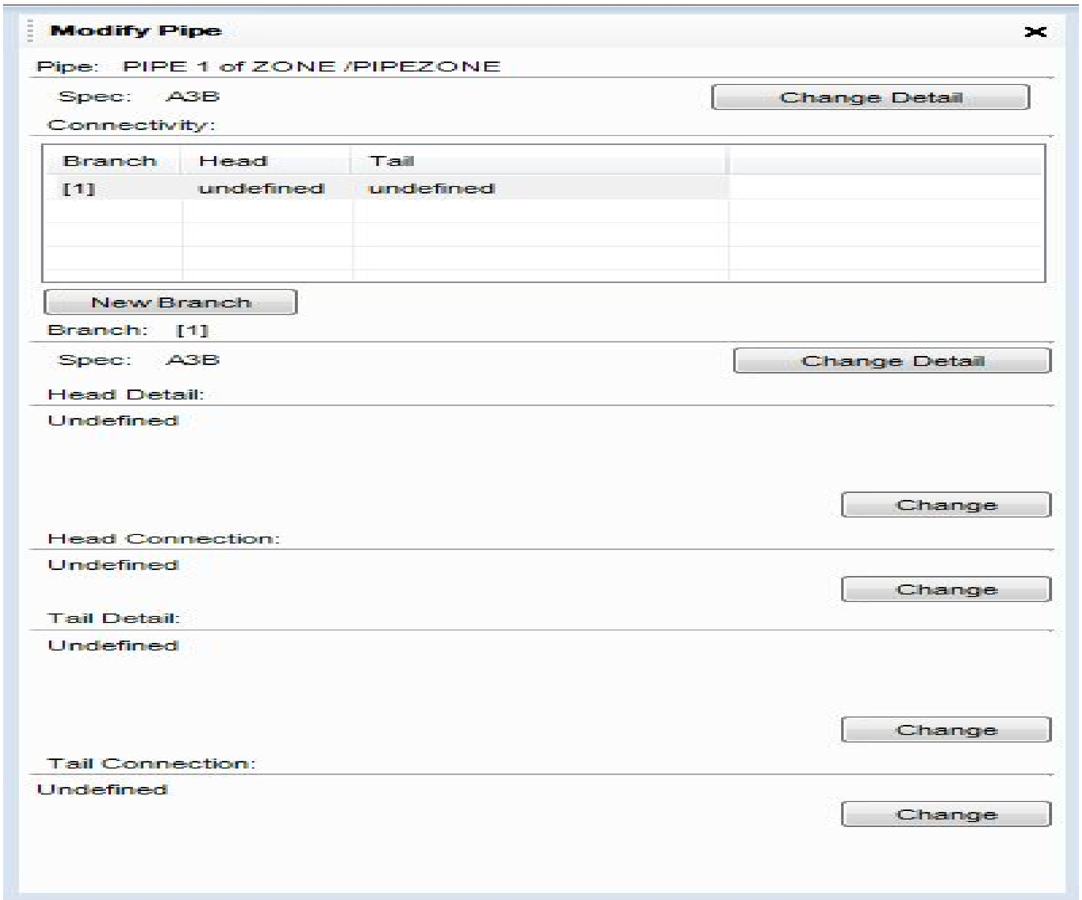

Figure 4.7.3 Pipe modification form

Upon clicking the apply button on the pipe creation form, the pipe modification form will appeared automatically. Here, the head and tail of the pipe must be specified to which it belong. It can either be specified by locating the coordinate or just by picking the location using computer cursor. When the head and tail have been defined, a single dotted line connecting between those two points will be appeared.

The next step in designing pipeline is to create and position series of fitting which define the pipe route required. It is essential to decide which piping components are needed in the process. The pipe must be arranged so that it meets with the design requirements. It not necessary to know the dimension of the fitting as PDMS will derive it automatically from the catalogue. The components type that is available in the program below is as shown in Figure 4.6.3 below. After components type has been selected, there is maybe several sub type available that needs the user to choose, such as flange connector by weld-neck, screwed or blind.

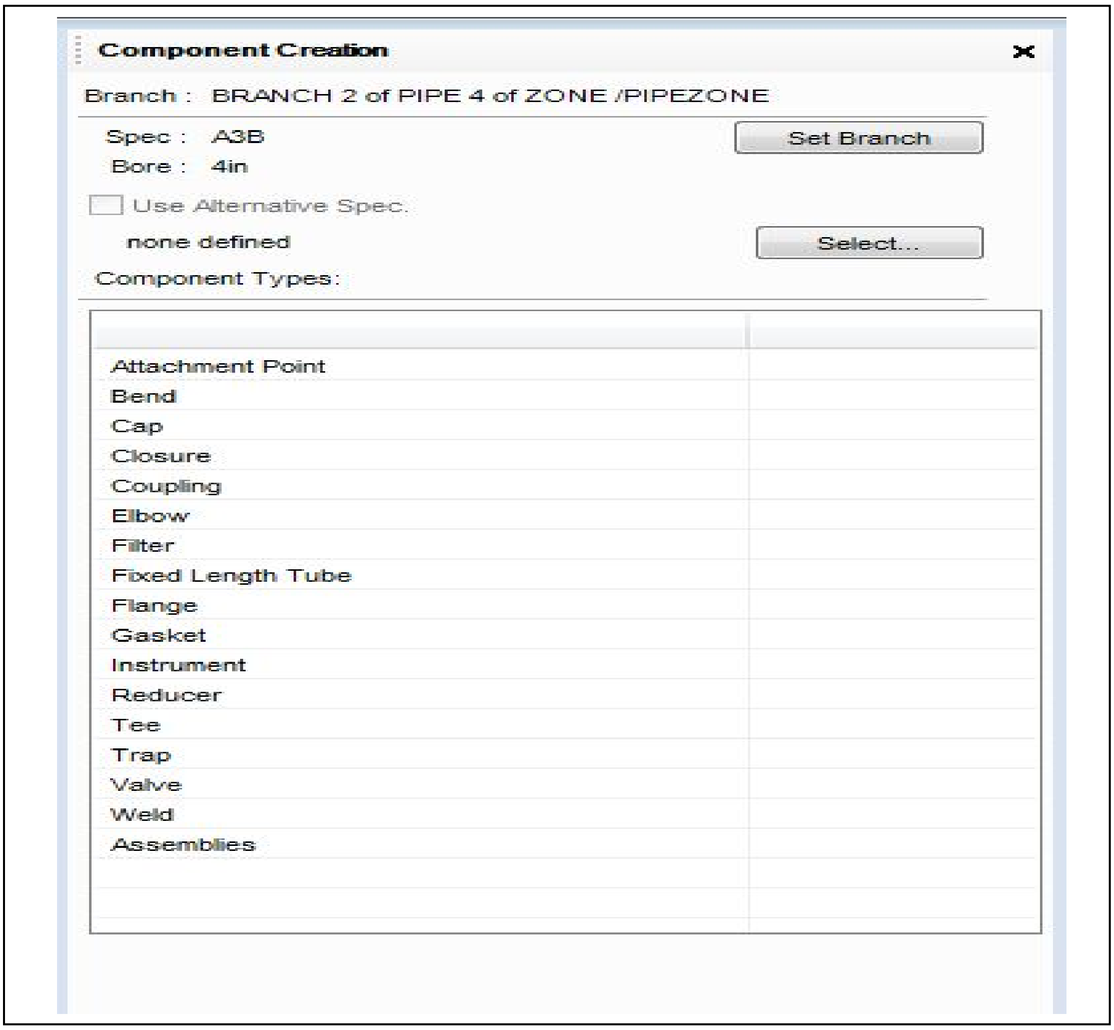

Figure 4.7.4 Component creation form

4.7.3 Pipe Head and Pipe Tail Connection

Figure 4.6.4 below shows the pipe connection between oil tank and pump. The head of the pipe is positioned at the oil tank nozzle while the tail is positioned on the pump suction nozzle. Along the head and tail, there are a few of pipe components chosen which 90 degree elbow and globe valve are.

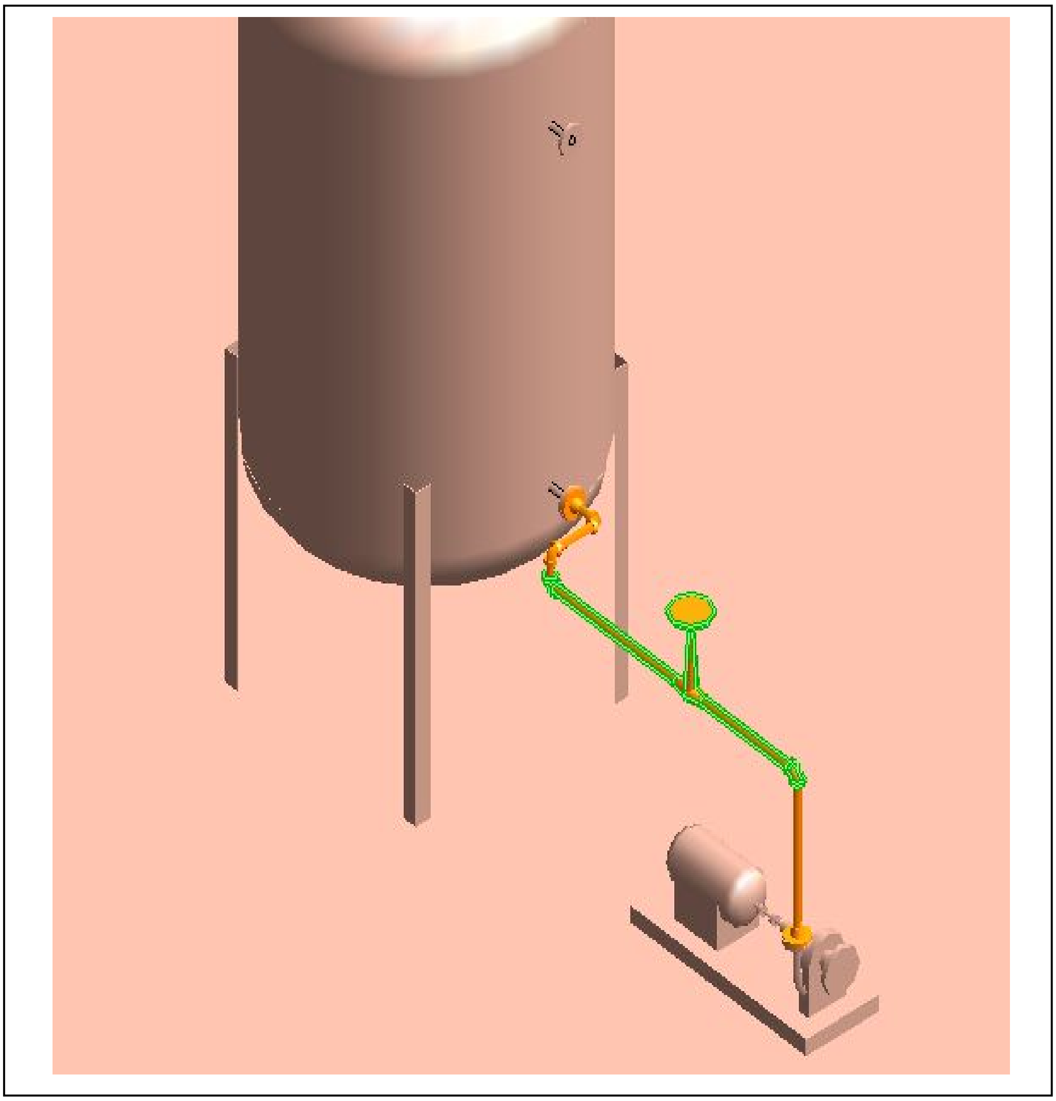

Figure 4.7.5 Head and tail pipe connection

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Summary

In this study, the problem of developing of 2 inch pipelines for paraffin deposition testing has been addressed. The available process flow diagram (PFD) is for the two-phase test. Therefore, the PFD is used for design by using the PDMS. The literature review on the paraffin deposition phenomena and the software itself has been elaborated in Chapter 2.

The methodology for this study is discussed in detailed in Chapter 3 which focusing more on the PDMS system. The design detailed is discussed in Chapter 4 where each system in the flow loop is described in deep. Practically, the result obtained in this study is as expected the same with the process flow diagram (PFD) as this study intended to focus more on the skills to work the PDMS. The pipe fittings and specification for this flow loop is determined precisely in order to create condition similar in the under water.

5.2 Conclusions

There are a few preliminary steps in order to design the paraffin deposition testing loop. The first is gathering all the information and creating process flow diagram for the process before using the data in PDMS. Along this study of designing the testing loop, few vital observations were noted based on the pipe design using PDMS and industrial pipe specification. The right selection of fitting used for the pipe will basically determined the cost of the project. This paraffin testing loop has been developed by considering the equipment selection and pipe fitting in most economical way.

5.3 Recommendations for Future Work

The problem of paraffin deposition problem inside pipeline seems can be resolved when the deposition and paraffin aging phenomena is known. Then only appropriate treatments such as pigging schedule or chemical treatment can be optimum. This study has inspired many ideas for future research. Some of can be summarized as follows:

1. Modification of flow loop by adding water system to create 3-phase condition.
2. Adding cold finger apparatus to conduct preliminary oil-water deposition test for deposition physics studies.
3. Run the testing loop by using Computational Fluid Dynamics (CFD).
4. Designing the flow loop with high level of equipments and pipe details.

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