OPEN HOLE GRAVEL PACKING WITH JATROPHA ESTER BASED FLUIDS

By

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DISSERTATION

Submitted to Petroleum Engineering Programme in Partial Fulfillment of the Requirements for the Degree Bachelor of Engineering (Hons)

(Petroleum Engineering)

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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August 2011

CERTIFICATION ON ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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ABSTRACT

For the past years, mud engineers had been running the gravel packing completion with two types of drilling fluid which are oil based drilling fluid while on the top part of the well and then switching to water based reservoir drilling fluid (RDF) when they reach the target zone. Even though it is a well-known fact that oil based drilling fluid has many advantage, the engineers do not want to take the risk of doing something that is irregular. However, the usage of oil based RDF for gravel packing completion is increasing nowadays due to the increasing number of successful gravel packing completion project over the years. This brings an opportunity to look at the potential of a RDF which is based on Ester-based fluid produced from the Jatropha oil. Since Jatropha oil has untapped potential for being a RDF, I decided to see if it is applicable for gravel packing completion. There will be many parameters to look at but this project will be focused on one of the important aspect in gravel packing completion which is the formation of filter cake. The filter cake that will be produced when the fluid meets the surface of a porous medium needs to be cleaned before the completion is considered complete. This is because the filter cake will disturb the porosity of the gravel packing and will cause drop in productivity. The main purpose of this project will be to produce the filter cake by running the Jatropha Ester-based fluid through a dynamic filter press machine. After that, a cleanup fluid (acid or surfactant) will be used to clean it and see if it is possible to destroy the filter cake. This parameter is very important because if the filter cake that is produced by the Jatropha Ester-based fluid is too thick and cannot be cleaned, then its potential for gravel packing application would be lessen.

ACKNOWLEDGEMENT

Without any doubt, I would firstly like to convey my highest gratitude to my Final Year Project (FYP) supervisor, Dr. Sonny Irawan for giving me the idea for this topic and giving continuous support and guidance throughout my FYP period.

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NOMENCLATURES

A	filtration area, m^2
K	permeability, m^2 or darcy, 1 $m^2 = 1.013\times10^{12}$ darcy
L	cake thickness, m
p	total pressure, Pa
Δp_c	pressure drop across cake, Pa
Δp_m	pressure drop across filter media, Pa
q	filtrate rate, $m^3/m^2/s$
Rm	resistance of filter media, 1/m
t	time, s
V	volume of filtrate, m^3
V	volume of filtrate per unit area, m
α_{av}	average specific cake resistance, $1/m^2$
ε_{av}	volume fraction of cake solids, -

Chapter 1

Introduction

1.1 Background study

The numbers of wells that are requiring sand control using gravel packing are increasing nowadays particularly in deep water wells and subsea environments where efficiency is the most important key. The top section of these wells is usually drilled by using oil based mud due to high rate of penetration. However, it is a common practice to switch to water-based fluids when the reservoir drilling starts. The reason why most operators switch to water based-mud when they reach the reservoir is because:

- Wide industry experience in gravel packing wells drilled with water-based reservoir drilling fluids (RDF) vs. concerns as to the integrity of oil-based RDF filter cakes.
- High levels of confidence in effective cleanup of water-based RDF filter cakes, providing at minimum a contingency option vs. concern as to effective cleanup of oil-based RDF filter cakes.

Drilling using oil-based RDF have higher rate of penetration, excellent shale-inhibition characteristics unmatched by any commercially available water-based fluid, gauge hole, lubrication while drilling, low maintenance cost, and many more [1]. Due to the two reasons stated above, the industry does not prefer to use oil-based RDF.

However, there are a few number of successful case histories on gravel packing wells with oil-based RDF even though they are limited [1]. This shows that using oil-based RDF is definitely possible and there are possible rooms for improvements.

There are recent researches [2] that proves the possible usage of Jatropha Ester-Based Fluids as a reservoir drilling fluid and this gives an opportunity to further research on its possibility of being used as a reservoir drilling fluid while conducting open hole gravel packing completion. Since oil-based mud is proven to be a good RDF, therefore doing research to use Ester-Based Fluids extracted from Jatropha plant for gravel packing would be an effort worthwhile.

There are a few problems that need to be looked into while conducting this study. However, this project will be focusing on one of the most important aspect which is the formation of filter cake itself and also the cleanup fluid that will remove it. The problem statement will be further discussed in the following section.

1.2 Problem Statement

Problem identification

There are two problems that usually cause operators to choose water-based RDF compared to oil-based RDF [1]:

- Wide industry experience in gravel packing wells drilled with water-based reservoir drilling fluids (RDF) vs. **concerns as to the integrity of oil-based RDF filter cakes**.
- High levels of confidence in effective cleanup of water-based RDF filter cakes, providing at minimum a contingency option vs. **concern as to effective cleanup of oil-based RDF filter cakes.**

From these two problems (in bold), it is clear that the filter cakes are important to seal off the wellbore from the formation in the stages of circulating the gravel pack into place. On the other hand, the filter cakes would have to be removed once the gravel packing is done because the filter cake would prevent permeability and reduce the well's efficiency.

The problem that needs to be solved is that will the Jatropha Ester-based fluid produce the appropriate filter cake that has the same integrity compared to conventional oil-based RDF and water-based RDF and could be stable enough to withstand the gravel packing process. Apart from that, there must be a cleanup fluid or breaker that will be able to remove the filter cake produced in order for the gravel pack to work efficiently.

Significant of the project

As the problem states, this project will be focusing on identifying the filter cake produced by Jatropha Ester-based fluids and also determines the cleanup fluid that will be used to remove the filter cake.Since Jatropha plant is an easy plant to grow, it would bring huge benefits if we could extract its possibilities of becoming a mass source for drilling fluids. It also shows possibilities of improving the Jatropha plantation industry and also hopefully brings the costs down for producing drilling fluids for open hole gravel packing. Due to that, two objectives for project are set and will be stated in the next part of this report.

1.3 Objectives

1. Produce the Jatropha Ester-Based Drilling fluid with low plastic viscosity/yield point by extracting ester form Jatropha oil using Transesterification process and mixing it with mud building materials.
2. To determine the filter cake build up when using Jatropha Ester-Based Fluids as a reservoir drilling fluid for open hole gravel packing.
3. To determine the cleanup fluid that will clean up the filter cake produced while using Jatropha Ester-Based Fluids as a reservoir drilling fluid for open hole gravel packing.

1.4 Scope of study

The scope of work for this project will mainly be separated into three big parts. One part of the project is to extract methyl ester from the Jatropha oil using transesterification process and then mix it with mud building materials to produce Jatropha Ester-based fluids. The next part of the project is to form the filter cake from the Jatropha Ester-base fluid and another part is dedicated to find the cleanup fluid to break the filter cake. Both parts will be spread out throughout two semesters.

1.5 The Relevancy of the project

Jatropha plantations are easy to take care and they can easily survive in any condition. This means that it is a possible industry that could be widely developed especially if it could be related to the oil and gas industry. There are researches about using its oil for biodiesel and also other researches relating to its usage as drilling fluid. Since ester-based fluid could be derived from the Jatropha oil, it would make a good oil-based RDF. Being more focused, this project will specifically research on its filter cake formation so that it could be used for gravel packing application. Relating the Jatropha plant to the RDF in gravel packing gives benefits for both sides economically and it's an effort worthwhile.

1.6 Feasibility of the project

As a whole, this project is very simple and can be completed within the time constrain given provided that all goes well. This project's purpose is actually to match the characteristics of the oil-based fluid taken from the Jatropha plant with the conventional oil-based fluid. There are two main objectives of this project and both the objectives can be met within the two semester period provided the procedures and schedules set are closely followed.

Chapter 2

Theory and Literature review

2.1 Gravel Packing

Gravel Packing involves placing accurately sized gravel around a screen or slotted liner in a well to form a down hole filter that prevents formation sand from entering the well yet allows the flow of formation fluids [11]. There are three objectives of doing a gravel packing completion which are sand-free production, high productivity, and completion longevity.

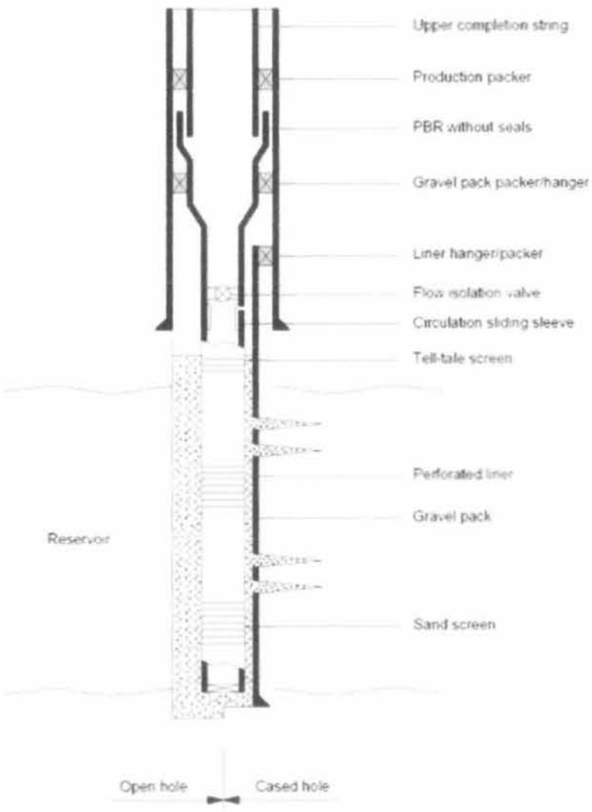

Figure 1: Typical well completion with gravel pack

The gravel pack could also be placed around a screen section and thus filling up the annulus volume between this screen section and the well bore wall or the perforated liner if the well is cased. The upper restriction of the gravel packed annulus will be the gravel pack packer/hanger.

A completion with a gravel pack involves a number of equipment components. The main purpose of the sand screen section in a gravel pack completion is to prevent the gravel pack particles to enter into the well bore. It is the gravel pack itself that is the primary sand barrier and intended to prevent the formation sand to enter into the well. The gravel pack completion will be the lower completion of the well.

2.2 Jatropha Ester-Based Fluids

Jatropha curcas is a tree that could be found in arid, semiarid or even wasteland. This is due to its drought resistant characteristic and its low fertility and moisture demand. The seed from the Jatropha curcas plant is rich in oil and ester could be derived from it. The ester derived is reported to have physical and chemical properties as an alternative to diesel oils. A related work proves that the application of Jatropha curcas mud in drilling operation would not cause formation damage and its performance was better compared to diesel oil based mud.

2.3 Filter Cake

The residue deposited on a permeable medium when a slurry, such as a drilling fluid, is forced against the medium under a pressure. Filtrate is the liquid that passes through the medium, leaving the cake on the medium. Drilling muds are tested to determine filtration rate and filter-cake properties. Cake properties such as cake thickness, toughness, slickness and permeability are important because the cake that forms on permeable zones in the wellbore can cause stuck pipe and other drilling problems. Reduced oil and gas production can result from reservoirdamage when a poor filter cake allows deep filtrate invasion. A certain degree of cake buildup is desirable to isolate formations from drilling fluids. In open hole completions in high-angle or horizontal holes, the formation of an external filter cake is preferable to a cake that forms partly inside the formation. The latter has a higher potential for formation damage.

As for application in gravel packing, to gravel pack a well it was necessary to seal off the wellbore from the formation to such an extent that substantial circulation could be maintained during gravel packing. This implied the need of a filter cake in place that needed to be removed in a separate treatment after the gravel packing operation to achieve an efficient completion [6].

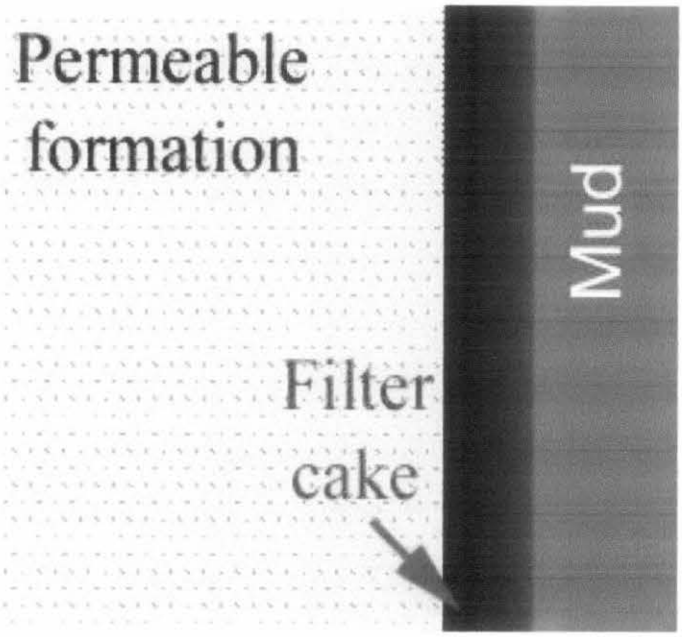

Figure 2: Filter cake

Filter cakes form most of the time during drilling operations. It is a phenomenon that takes place due to the behavior of the fluid when it is in contact with a permeable surface. There are a few ways of forming filter cakes and here are the theory behind the formation and testing of filter cakes.

The fundamental basis of the test method is cake formation followed by flow through already formed cake in one filtration test [3]. A typical volume of filtrate against time curve obtained from the test method on RHA filter aid is shown in Figure 2. It can be seen that there are three regions during the one test run: "cake formation region" before 300 seconds, "transition region" from 300 seconds to 430 seconds, and a "flow through already formed cake region" when time is greater than 430 seconds. Volume of filtrate against time data during the flow through Darcy's law can be used to calculate cake permeability. Filter media resistance is included in the permeability calculation in the test method.

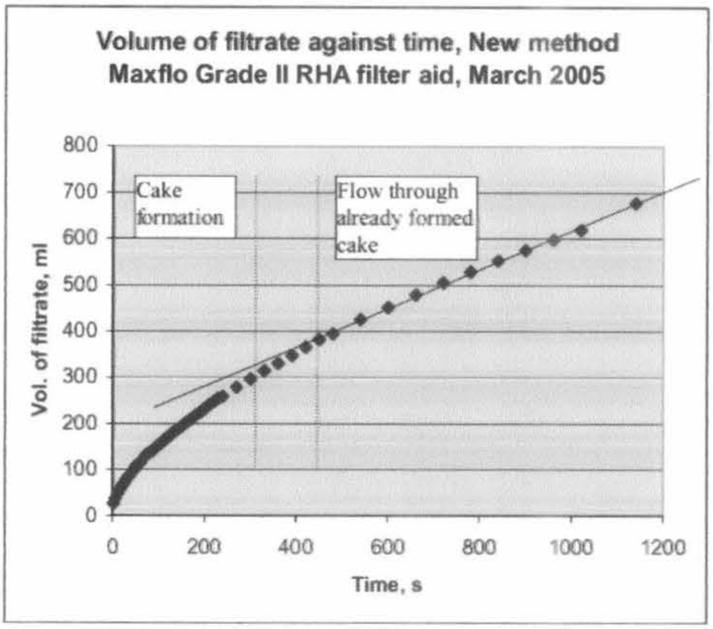

Figure 3: A typical volume of filtrate against time curve [3]

2.4 Cleanup fluid

The term cleanup fluid means the fluid which acts as a breaker [12]. What a breaker does is it reduces the viscosity of the fluid by breaking long-chain molecules that have sufficient viscosity to carry the gravel down to the open hole. In this case, we need this cleanup fluid (which contains a breaker) so that we could break down the filter cake that forms at the wall of the open hole once the gravel packing is in place [4]. The rate of cake removal depends strongly on the conditions under which the cake is formed, and it can be controlled to a large extent by varying the type of cleanup fluid.

2.5 Dynamic Filter Press

Equipment used to measure filtration under dynamic conditions [13]. Two commercial dynamic-filtration testers are available, one of which uses a thick-walled cylinder with rock-like characteristics as the filter medium to simulate radial flow into a wellbore. The other tester uses flat porous disks, such as paper or fused ceramic plates, as filter media. In a dynamic test, filter cake is continually eroded and deposited. Data from this test include a steady-state filtration rate measured during the test, and cake thickness, cake quality and return permeability of the filter medium measured at the conclusion of a test. There is no API standardized test equipment or procedure.

In the permeability test method, it is important to use a sufficient amount of slurry and an appropriate solid concentration to provide adequate amount of liquid above the cake surface after the cake is formed under a constant pressure and gravity. The test system comprises of 3 inch ID (0.00456 m2) filter cell with detachable bottom and top, a pressure regulator, and a digital balance as shown in Figure 3.

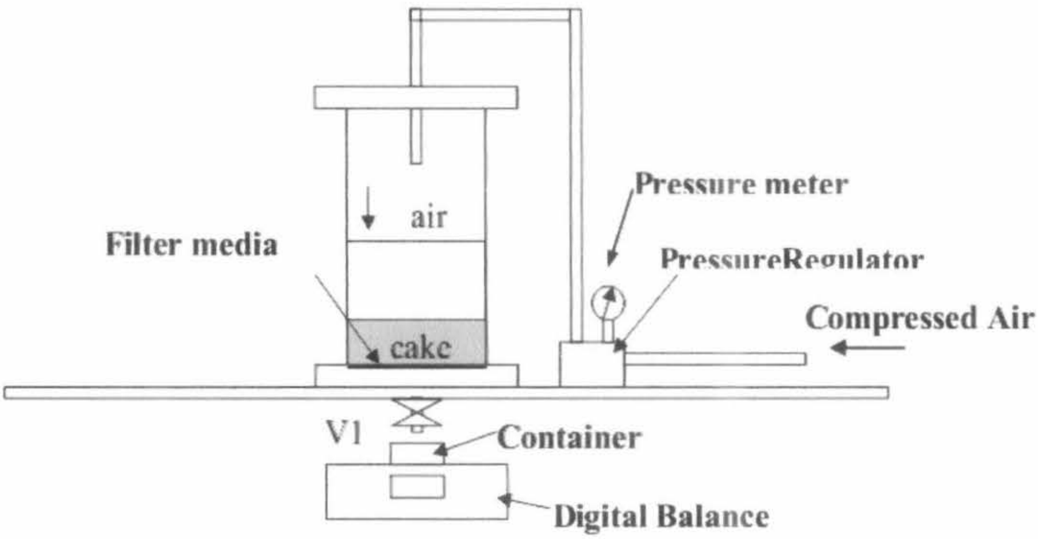

Figure 4: Pressure filtration test system[3]

Filter medium resistance can be determined by a separate test of clean water flowing through filter paper only. Filter media resistance determined by this separate test is included in the permeability calculation.

2.6 Permeability Determination

Permeability calculation is based on Darcy's Law for liquid flow through an already formed cake and a filter media [3]. A simplified model is shown in Figure 4.

Permeability calculation is based on Darcy's Law for liquid flow through an already formed cake and a filter media. A simplified model is shown in Figure 3.

Total resistance R = Resistance of cake R_c+ Resistance of filter media R_m (10)

Total pressure p = pressure drop across cake Δp_c + pressure drop across filter media Δp_m (11)

Flow rate q = rate of flow through cake = rate of flow through filter media (12)

Flow rate q=rate of flow through filter media $= K_m \dfrac{\Delta P_m}{\mu L_m}$ (13)

Flow rate q=rate of flow through filter cake $= K_c \dfrac{\Delta P_c}{\mu L_c}$ (14)

In Equations (12), (13), (14) flow rate in m3/m2/s can be obtained by the slope of the straight line region of the filtrate volume against time curve in Figure 1, divided by total filtration area. Media resistance Km can be determined by a separate clean water flow through filter media only test. Cake thickness Lc and media thickness Lm can be measured. With known Km, Lm and q, pressure drop across filter media Δpm can be calculated based on Equation (13). Pressure drop across cake Δpc can be obtained from Equation (11) with known total pressure p and pressure drop across filter media Δpm. With known q, Δpc, μ and Lc, permeability of cake can be then determined from Equation (14).

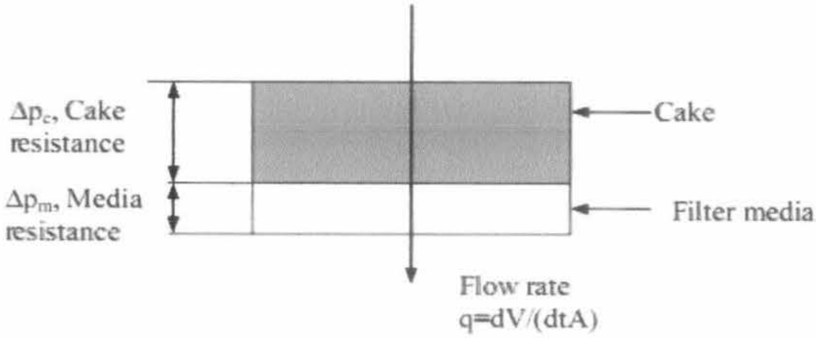

Figure 5: Flow through cake and filter media model [3]

2.7 Surfactant

In general, Surfactant is a shortened form of "surface-active agent". It is a chemical that stabilizes mixtures of oil and water by reducing the surface tension at the interface between the oil and water molecules. Because water and oil do not dissolve in each other a surfactant has to be added to the mixture to keep it from separating into layers. Surfactants in cosmetics provide one or more of six functions:

- Detergents - for cleansing
- Wetting agents - in perms
- Foaming agents - for shampoos
- Emulsifiers - in creams and lotions
- Conditioning agents - in skin and hair-care products
- Solubilizers - for perfumes and flavors

Surfactants are usually organic compounds that are amphiphilic, meaning they contain both groups present in the molecule, one being hydrophobic in nature (their tails) and hydrophilic groups in nature [10]. Hydrophilic (their heads) means water-liking and hydrophobic means water-hating/oil-liking. Therefore, a surfactant molecule contains both a water insoluble (and oil soluble component) and a water soluble component. Surfactant molecules will migrate to the water surface, where the insoluble hydrophobic group may extend out of the bulk water phase, either into the air or, if water is mixed with oil, into the oil phase, while the water soluble head group remains in the water phase. This alignment and aggregation of surfactant molecules at the surface acts to alter the surface properties of water at the water/air or water/oil interface [10].

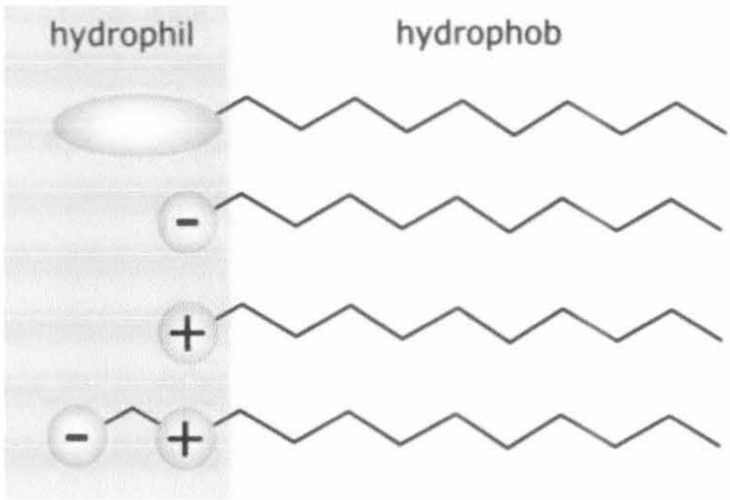

Figure 6: Surfactant classification according to the composition of their head: nonionic, anionic, cationic, and amphoteric

2.8 Fatty Acid Methyl Ester (FAME)[15]

A fatty acid methyl ester (FAME) can be created by an alkali catalyzed reaction between fats or fatty acids and methanol. The molecules in biodiesel are primarily FAMEs, usually obtained from vegetable oils by Trans esterification.

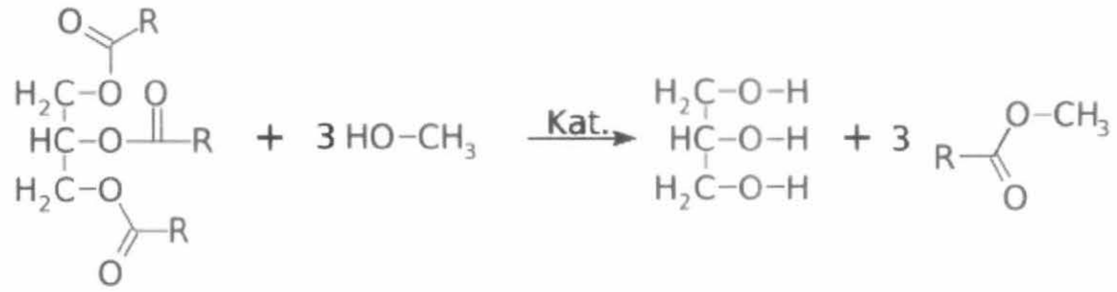

Figure 7: FAME chemical bond [15]

Since every microorganism has its specific FAME profile (microbial fingerprinting), it can be used as a tool for microbial source tracking (MST). The types and proportions of fatty acids present in cytoplasm membrane and outer membrane (gram negative) lipids of cells are major phenotypic trains.

Clinical analysis can determine the lengths, bonds, rings and branches of the FAME. To perform this analysis, a bacterial culture is taken, and the fatty acids extracted and used to form methyl esters. The volatile derivatives are then introduced into a gas chromatograph, and the patterns of the peaks help identify the organism. This is widely used in characterizing new species of bacteria, and is useful for identifying pathogenic strains.

2.9 Gas Chromatography

Gas chromatography (GC) is an analytical technique for separating compounds based primarily on their volatilities. Gas chromatography provides both qualitative and quantitative information for individual compounds present in a sample. Compounds move through a GC column as gases, either because the compounds are normally gases or they can be heated and vaporized into a gaseous state. The compounds partition between a stationary phase, which can be either solid or liquid, and a mobile phase (gas). The differential partitioning into the stationary phase allows the compounds to be separated in time and space.

2.10 Drilling Fluid Properties [16]

There are many drilling fluid properties that needs to be consider while formulating a drilling fluid. Among them are:

2.10.1 Density

Mud density is the weight per unit volume of mud and normally it is reported in Pound per Gallon (PPG). Mud density is used for providing hydrostatic pressure to control well for drilling operation.

2.10.2 Viscosity

Funnel Viscosity: It is time, in seconds for one quart of mud to flow through a Marsh funnel which has a capacity of 946 cm3. A quart of water exits the funnel in 26 seconds. This is not a true viscosity, but serves as a qualitative measure of how thick the mud sample is. The funnel viscosity is useful only for relative comparisons.

Plastic Viscosity (PV): A parameter of the Bingham plastic rheological model. PV is the slope of the shear stress-shear rate plot above the yield point. Viscometer is equipment to measure Plastic Viscosity. Plastic Viscosity is derived from the 600 rpm reading minus the 300 rpm reading and PV is in centipoises (cp). A low PV indicates that the mud is capable of drilling rapidly because of the low viscosity of mud exiting at the bit. High PV is caused by a viscous base fluid and by excess colloidal solids. To lower PV, a reduction in solids content can be achieved by dilution.

2.10.3 Yield Point

Physical meaning is the resistance to initial flow, or the stress required starting fluid movement. The Bingham plastic fluid plots as a straight line on a shear-rate (x-axis) versus shear stress (y-axis) plot, in which YP is the zero-shear-rate intercept (PV is the slope of the line). YP is calculated from 300-rpm and 600-rpm viscometer dial readings by subtracting PV from the 300-rpm dial reading and it is reported as lbf/100 ft2. YP is used to evaluate the ability of mud to lift cuttings out of the annulus. A higher YP implies that drilling fluid has ability to carry cuttings better than a fluid of similar density but lower YP.

2.10.4 Gel Strength

It is the ability of fluid to suspend fluid while mud is in static condition. Before testing gel strength, mud must be agitated for awhile in order to prevent precipitation and then let mud is in static condition for a certain limited time (10 seconds, 10 minutes or maybe 30 minutes) and then open the viscometer at 3 rpm and read the maximum reading value. In a morning report, there are 3 values of gel strength, which are Gel 10sec (lbf/100 ft2), Gel 10 mins (lbf/100 ft2) and Gel 30 mins (lbf/100 ft2).

These are the parameters that will be tested when formulating the Jatropha Ester-based drilling fluid.

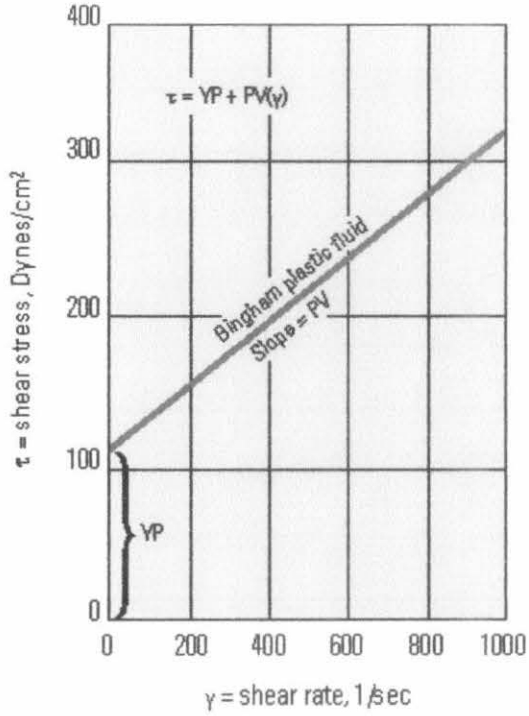

Figure 8: Bingham Plastic Model describes YP and PV [16]

Chapter 3

Methodology

3.1 Flow Cart

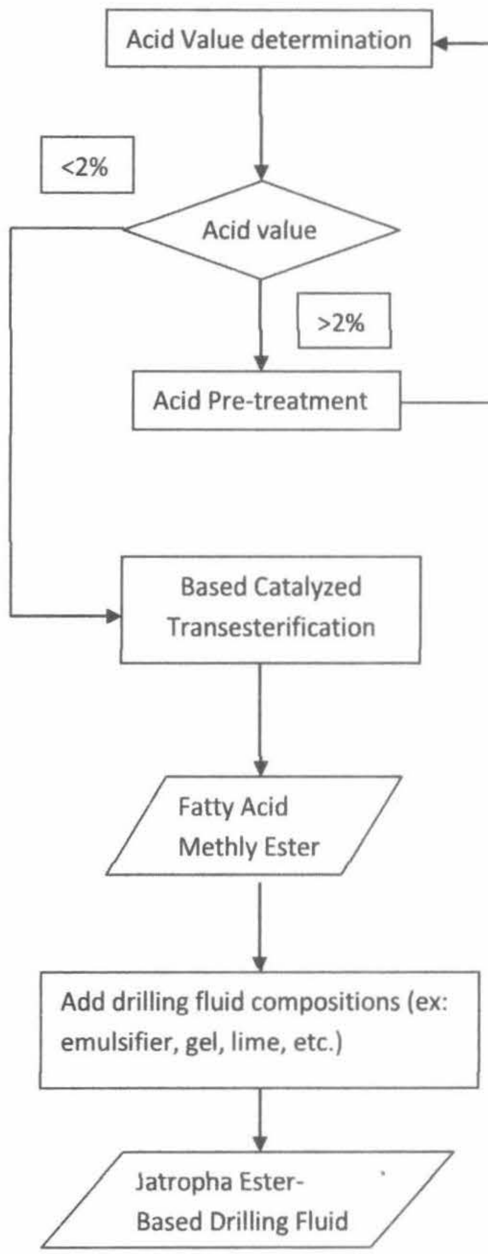

Figure 9: Methodology for producing Jatropha Ester-Based Drilling fluid

The objective is to study the filter cake that is form from the Jatropha Ester-Based fluid. That means that we would have to form the filter cake first. To do that, a test called the dynamic filtration press will be conducted.

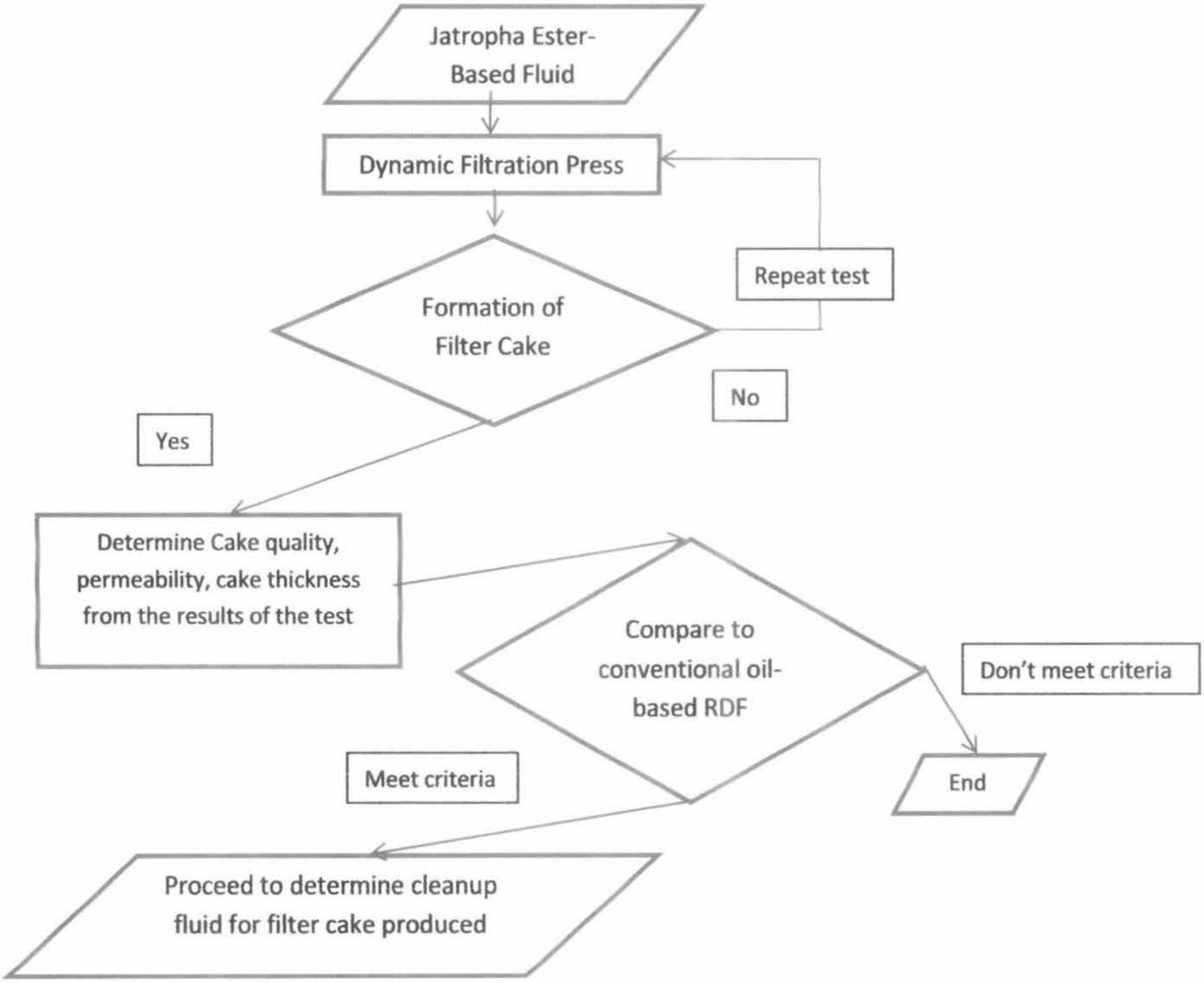

Figure 10: Methodology for forming filter cake from Jatropha Ester-Based fluid

Next up in the methodology, we would exchange the Jatropha ester-based fluid with a cleanup fluid so that we could see if the cleanup fluid could break the filter cake.

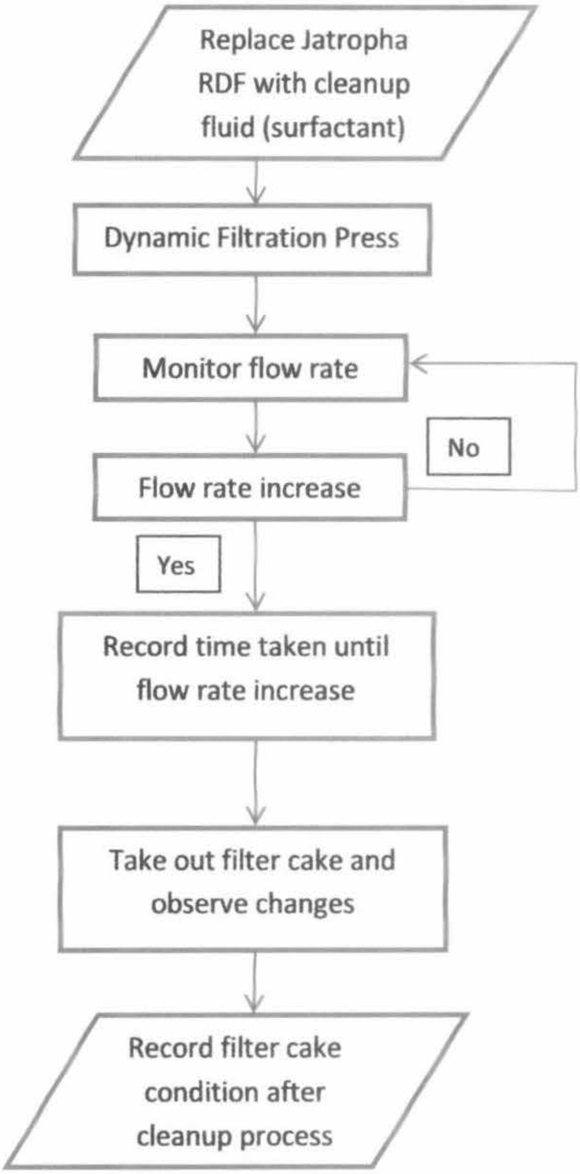

Figure 11: Methodology to determine the cleanup fluid to break the filter cake

3.2 Gant Chart for FYP

Following the scope of work and methodology, this Gant chart represents the timeline estimated to complete the project within the time constraints.

Activity	FYP 1				FYP 2			
	JAN	FEB	MAR	APRL	MAY	JUNE	JULY	AUG
Early stage documentation								
Studies on oil based RDF's filter cake. (obj. 1)								
Conduct Dynamic Filtration Press to Jatropha ester-base fluid. (obj. 1)								
Studies on the filter cake produced by Jatropha ester base fluid (filtration rate, cake quality, cake thickness, etc.) (obj. 1)								
Research literature for best cleanup fluid for filter cake produced. (obj.2)								
Run tests to find cleanup fluid that could break the filter cake. (obj. 2)								
End stage documentation								

Key Milestones	FYP 1				FYP 2			
	JAN	FEB	MAR	APRL	MAY	JUNE	JULY	AUG
Completion of Experiment to produce filter cake								
Determine filter cake properties (obj. 1)								
Completion of Experiment to find cleanup fluid (obj.2)								

Table 1: Gant chart for FYP and Key Milestones

3.3 Tools, Equipment and Materials

Stated below are the list of tools, equipment, and materials needed to conduct this project:

Materials:

Most of the materials that will be used in this project are chemical materials. There are two main parts in this project where they are needed and they are stated below:

Fatty Acid Methyl Ester extraction from Jatropha oil

1. Methanol
2. Sodium Methoxide ($NaCH_3O$)
3. Jatropha Oil

Drilling fluid formulation

1. Jatropha FAME
2. Confi Mul Primer (emulsifier)
3. Confi Mul Secondary (emulsifier)
4. Confi Gel
5. Confi Trol
6. Lime
7. Water
8. Calcium Chloride ($CaCl_2$)
9. Barite

Most of the materials will be available in the lab while those which are not will have to be purchased.

Equipment:

High Pressure High Temperature (HPHT) Static Filter Press

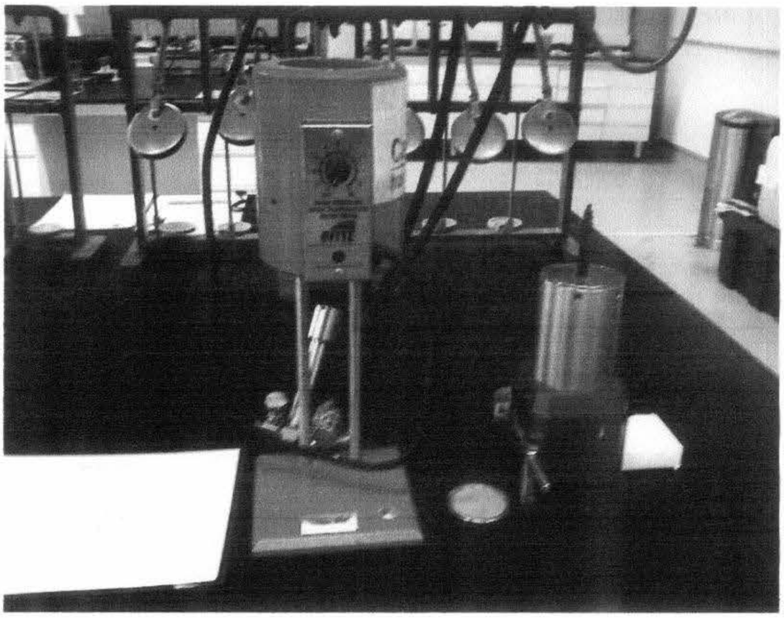

Figure 12: HPHT Static Filter Press

Operating Procedure [6]:

1. Connect the heating well power strip cords to a 3-wire outlet which will provide 3200 watts - about 28 amperes on 115 volts or about 14 amperes on 230 volts (this may require two separate power sources not related to the same fuse in the main fuse panel). Each filter press heating well is connected through a separate receptacle switch at the back of the assembly. This allows any number of the four units to be heated individually. Place a dial-type metal thermometer into the well in the heating jacket and preheat to 10°F (6°C) above the desired test temperature. A pilot light will come on when the heating jacket is at the desired temperature as selected by the thermostat control knob.

2. Stir the sample for 10 minutes with a high speed mixer. Close all needle valves, invert the cell and carefully pour the test fluid into the cell body. Do not fill the cell closer than 0.5 inch (13 millimeters) from the O-ring groove to allow for heat expansion of the fluid. Do not spill fluid on the O-ring inside the cell.

3. Check the O-ring for nicks and cuts on the inside of the female coupling on the top pressure assembly. Apply a thin coat of silicone grease to the O-ring but do not seal up the hole with grease. Place a circle of filter paper in the groove and install an O-ring on top of the paper. Place the cell cap into the cell, and twist into position so the cap locking screws will fasten to the wings of the cell cap. Evenly tighten the set screws with the Allen wrench.

4. Place the cell in the heating jacket with the outlet or filter side of the cell cap properly oriented down. All valves should be closed. Transfer the thermometer into the thermometer well within the cell.

5. Connect the pressuring assembly to the top male slip coupling by lifting the lock ring and sliding the pressure assembly onto the male coupling. Release the lock ring and the top pressure assembly has been installed. If operating over 200°F place the back pressure receiver on the bottom valve assembly and install as above.

6. Keeping the valves closed, adjust the top and bottom regulators to 100 pounds per square inch (690 kilopascals). Open the top valves one full turn and apply 100 psi (690 kilopascals) to the fluid sample inside the cell. This pressure will minimize boiling while the sample is heating. Maintain this pressure on the fluid until the desired temperature is stabilized, as indicated by the thermometer. The heating time of the sample should neverexceed one hour.

7. When the fluid sample reaches the desired test temperature, increase the pressure on the top pressure unit to 600 psi (4140 kilopascals). Open the bottom valve to initiate filtration and begin timing.

8. Collect the filtrate for 30 minutes maintaining the selected test temperature within ±5°F (±3°C). If back pressure rises above 100 psi (690 kPa) during the test, cautiously reduce the pressure by opening the valve on the receiver and drawing off some of the filtrate into the graduated cylinder.

9. At the end of the test, the pressure lines will need to be depressurized before they can be removed from the cell assembly. Turn the red and black knobs (that are associated with the cell you wish to depressurize) clockwise so no additional pressure is added to the pressure lines. Close the two needle valves located above the cell and the one needle valve on the bollom cell.

Open the 1/8" needle valve attached to the back pressure receiver tube and remove the remaining sample into the graduated cylinder. Remove the graduated cylinder and drain off the remaining pressure from the low pressure line. Slowly open the needle valve on the high pressure line located above the cell assembly and drain off the pressure in the high pressure line. Remove the top and bottom couplings to disconnect the pressure lines from the cell. After allowing the cell to cool (see caution below) slowly opens the valves on the cell to release trapped pressure from within the cell.

Caution: Pressure inside the sample cell will still be approximately 500 psi (3450 kPa). Keep the cell upright and cool it to room temperature before disassembling. The cell must be cool for at least one hour at room temperature or at least 10 minutes in cool water before loosening the cap locking screws and removing the cell cap.

10. Drain any remaining filtrate into the graduate cylinder. Correct the total filtrate volume collected to a standard filtration test area of 7.1 square inches (45.8 cm2) by doubling the filtrate volume collected in 30 minutes.

Record this total filtrate volume (doubled), and the temperature, pressure and time.

11. Remove thecell from the heating jacket and allow it to cool to room temperature or quick cool the cell by immersion in cool water. Maintain the cell in an upright position during this procedure and bleed off the cell pressure by opening the needle valves when the cell has cooled.

12. Invert the cell and loosed the cell cap screws with the Allen wrench. Use extreme care to save the filter paper and deposited filter cake. Discard the fluid inside the cell, and retrieve the filter cake.

13. Wash the filter cake on the paper with a gentle stream of water. Measure and report the thickness of the filter cake to the nearest 1/32 inch (0.8 millimeter).

14. Clean and dry the apparatus thoroughly after each use. Inspect and replace if necessary all O-rings.

Multi mixer

Figure 13: Multi mixer

Operating procedure:

1. Make sure machine is in good working condition and safe to use
2. Switch on the main power supply
3. Put the cup mixer at the proper place (the clip)
4. The ingredient can be added when the mixer operates
5. Clean equipment after use to avoid rust (columns)

Viscometer

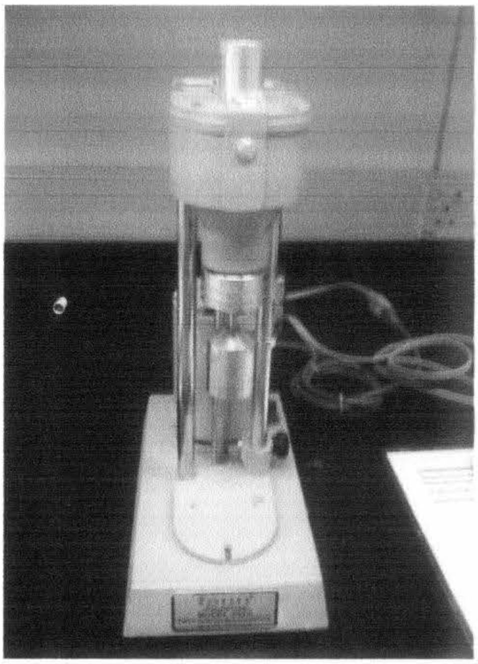

Figure 14: Viscometer

Operating procedure:

1. Switch on the power supply
2. Put the mud into the mud cup until the marking line and place the cup in the viscometer
3. Adjust the level and lock it
4. Select the selector in High position
5. When motor is running, change the gear knob to 600 rpm and take the reading at scale
6. Take the reading for 600 rpm (high position) and 300 rpm (low position)
7. Switch off equipment and clean after use.

Mud Balance

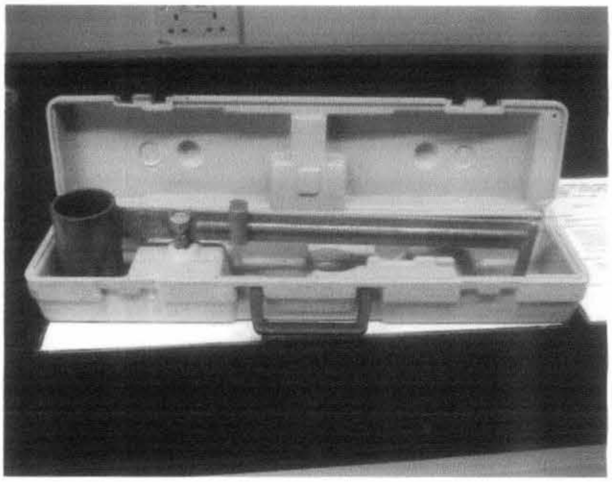

Figure 15: Mud balance

Operating Procedure:

1. Balance cup must be cleaned and dry before it is filled with drilling fluid sample
2. Place the base stand on a surface that is approximately level
3. Fill the balance cup with the sample to be tested and clean the outside of the balance cup and lid
4. Fit the knife edge of the balance arm into the fulcrum and balance the assembly by moving the rider along the arm. The mud balance is horizontal when the level bubble fluctuates on equal distance to either side of the line.
5. Take reading from the side of the rider nearest to the balance cup
6. Clean after use
7.

Chapter 4

Results and Findings

Before beginning with the experiments for determining the filter cake form by the Jatropha Ester-based fluid and its clean up fluid, I must first prepare the Jatropha Ester-based fluid itself first. To do so, there are several steps that are needed to be taken which will be included in this part of the report.

4.1 Extraction of Ester from the Jatropha Curcas oil

In order to have a Jatropha Ester-based fluid as a drilling fluid, I must first extract Ester from the Jatropha oil. To do so, I will need to have a chemical reaction between some chemicals and the Jatropha oil so that I can take out the Ester. I am going to extract **Fatty Acid Methyl Ester** (FAME) from the Jatropha oil. However, before I can do that, I need to check the **free fatty acid content** the Jatropha oil by determining the acid value of the Jatropha oil. The experiment was done as follow:

Research Methodology

Synthesis Fatty Acid Methyl Ester (FAME) from Jatropha Oil

Procedure

Procedure 1: Acid Value Determination

a) 1 drop of phenolphthalein and 0.1M NaOH is added into 50 ml ethanol.

b) The mixture is then added into 5g of sample (jatropha oil).

c) Shake the mixture.

d) 0.1M NaOH is added drop wise into the mixture until the colour of the mixture turn to pink.

e) Volume of NaOH needed to change the colour is taken.

f) Acid value is then calculated using:

$$\% \, acid \, value = \frac{volume \, of \, NaOH \, \times 28.2}{weight \, sample}$$

g) If acid value is >2%, proceed with Procedure 2.

Procedure 2: Acid Pre-treatment

a) Oil is poured into round bottom flask 3 necks and heated to 50°C.

b) Solution of H_2SO_4 (1% w/w) in methanol (60% w/w) is heated to 50°C.

c) The solution is added into the round bottom flask. The temperature is maintained at 50°C in water bath.

d) Allowed reaction for 2 hours.

e) The mixture is then poured into separation funnel and allowed to settle overnight.

f) Procedure 1 is repeated to check the new acid value.

g) If acid value is $\leq$ 2%, proceed with Procedure 3.

Procedure 3: Base Catalyzed Transesterification[22]

a) 1 mol of oil is poured into round bottom glass 3 necks and heated to 60°C in water bath.

b) Solution of $NaCH_3O$ (0.5% w/w) in 7 mol of methanol is prepared without heating.

c) The solution is added into the round bottom glass.

d) Allowed reaction for 2 hours.

e) The mixture is then poured into separation funnel and allowed to settle overnight.

f) Separate the glycerol at bottom layer from fatty acid methyl ester at top layer.

g) FAME is water washed several times to remove residual methanol, base and glycerol.

h) Methyl ester is analysed using Gas Chromatography Mass Spectroscopy (GCMS).

Methyl ester will then undergo saponification process using hydrochloric acid for conversion to fatty acids.

Result and Discussion

<u>*Experiment 1*</u>

Acid Value determination of Jatropha Oil (using Procedure 1)

Result:

i. Volume of NaOH needed to change the indicator colour to pink is 10.5ml
ii. Need to do acid treatment (Procedure 2) to reduce Free Fatty Acid in Jatropha Oil

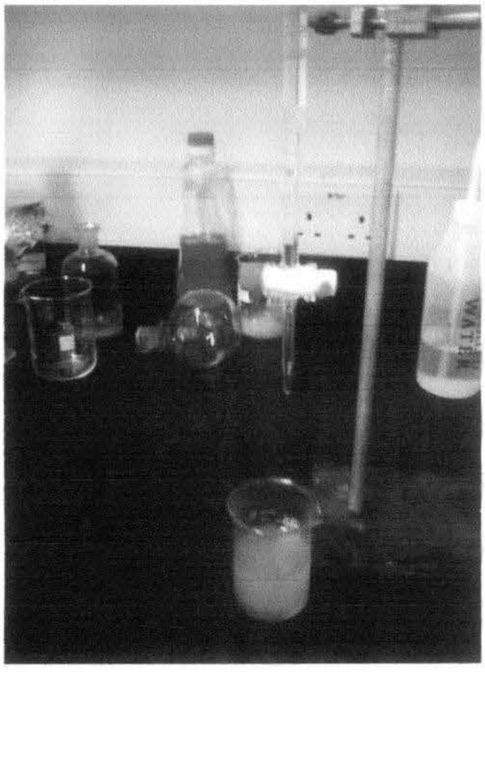

Figure 16: Volume of NaOH needed to change the indicator colour to pink is taken to measure acid value.

Experiment 2

Acid treatment (procedure reliability test purpose, using Procedure 2)

Oil weight: 35.00g

Methanol weight: 21.00g

H_2SO_4 weight: 0.35g

Result:

i. During mixing, milky colour is appeared.
ii. After mixture is settled, 2 distinguish layer is appeared, top layer is taken to be treated Jatropha oil.
iii. Run Procedure 2 to test on new acid value.
iv. NaOH needed to change the colour of the indicator is 2 ml (before treated, NaOH needed is 10.5ml)

Discussion:

i. Method is proven suitable for acid treatment.

Experiment 3

Acid Treatment (for whole Jatropha Oil available)

Oil weight: 215.05g

Methanol weight: 129.03g

H_2SO_4 weight: 3.85g

Result:

i. During mixing, milky colour appeared.

ii. The mixture is allowed to settle for 2 days.

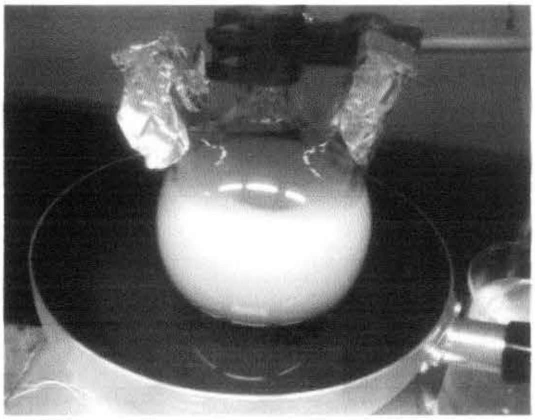

Figure 17: Milky colour appeared when mixing

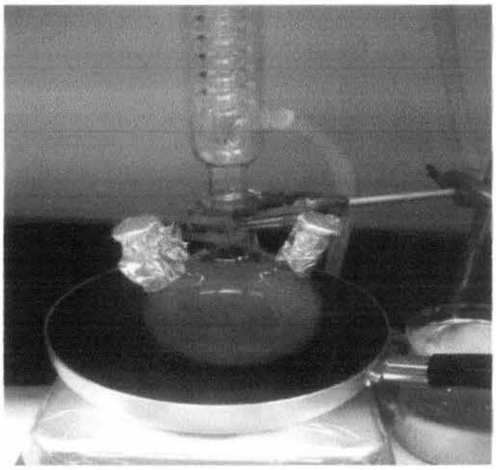

Figure 18: After 2 hours reaction

Figure 19: Mixture is allowed to settle for 2 days

Experiment 4

Synthesis Fatty acid methyl ester from Jatropha Oil (using Procedure 3)

Jatropha Oil weight: 160.22g

Methanol weight: 42.82g

$NaCH_3O$ weight: 0.81g

Result:

i. 2 distinguish layer is observed. Top layer is methyl ester and bottom layer is glycerol.

ii. Several water wash is needed to increase purity and remove residual methanol and catalyst.

iii. Percentage of methyl ester recovered = 94%

iv. Need to do sample analysis but queue to use GCMS is long (approximate 2 weeks).

Discussion:

i. Need to ask around to get the fastest way for analyzing collected methyl ester.

ii. Procedure 2 is proven as a reliable method in converting oil into fatty acid methyl ester due to recovery rate achieved is 94%.

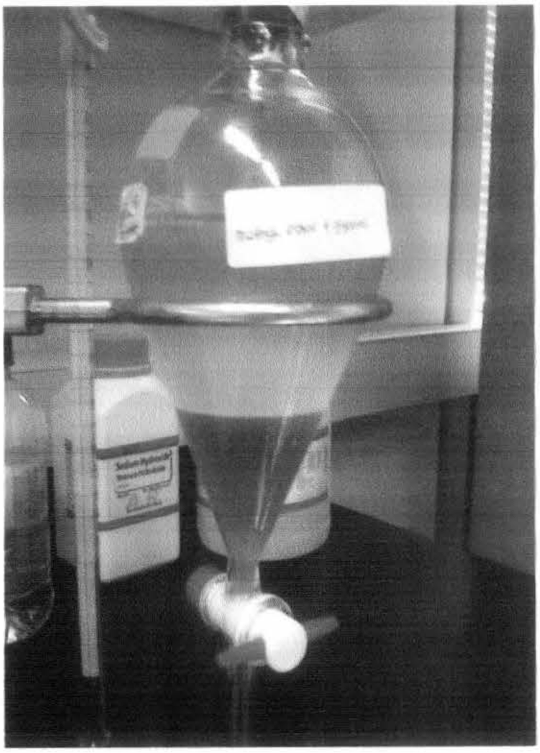

Figure 20: 2 distinguish layer of methyl ester and glycerol appeared.

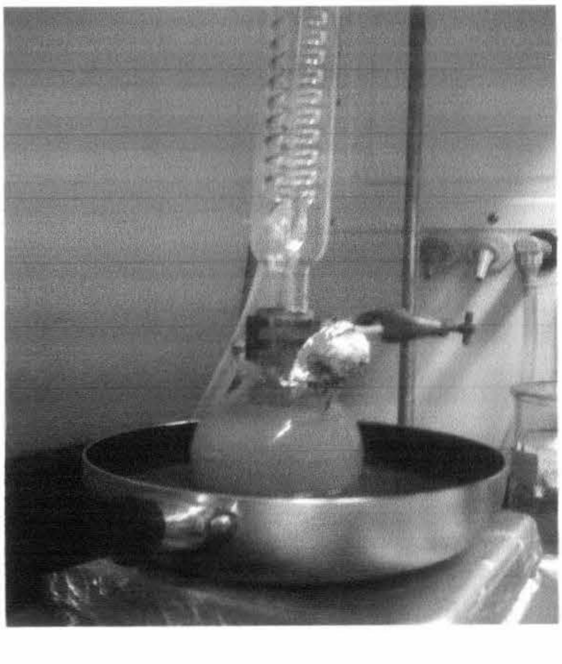

Figure 21: Using water bath technique and condenser

4.2 Making of Jatropha Ester-Based Drilling fluid

After extracting the ester from the Jatropha oil, I must turn it into drilling mud in order for it to be tested to meet the desired objectives. A mud formulation was needed to ensure the right mix of the drilling mud. In this process, a side objective was set which is to get a drilling fluid with low yield point. This is because for the past experiments, the Jatropha Ester-based fluid produced a drilling mud which has high yield point value which will cause problems when used in the field. Even though this is a trial and error basis to have the perfect mud composition, there must be a base composition that is needed to be followed. This mud composition could be done by using an Excel spreadsheet provided by SCOMI.

The base mud composition is as follow:

Jatropha Based 10ppg, 80:20 OWR 23% $CaCl_2$ (95%)

	Specific Gravity	Concentration (g)	Time (min)
Jatropha	0.878	213.49	
Confi Mul P	0.95	2.00	2
Confi Mul S	0.95	6.00	2
Confi Gel	1.60	2.00	5
Confi Trol	1.30	6.00	5
Lime	2.30	8.00	5
*Water	1.00	60.79	15
*$CaCl_2$	3.92	19.42	
Barite	4.39	102.48	Until 1 hour

Table 2: Mud composition

*Mix first

Experiment 1: Preparation of the drilling fluid

Procedure:

1. Prepare the material needed for the composition based on their concerntration (listed in table 2) in grams.
2. Place the materials in to the multimixer according to the time sequence (in table 2).

Results and Discussion:

1. After one hour of mixing, the mud could be observed as having a dark grey colour .
2. Drilling fluid is not viscous and seems to flow easily.

Figure 22: Preparation of materials to make the mud

Figure 23:After one hour of mixing, mud is dark grey in colour.

Experiment 2: Density Determination

Procedure:

1. Pour mud into the mud balance until it fills up the cup.
2. Close the cup and clear access mud that flows out.
3. Determine the density.

Results and Discussion:

1. The density recorded is 9.6ppg which is equivalent to the target density in the mud formulation which is 10ppg.

Experiment 3: Determination of Plastic Viscosity (PV) and Yeild Point (YP)

Procedure:

1. Pour mud into mud cup and place in viscometer
2. Run viscometer (as shown in operating procedure)
3. Record reading at 300 rpm and 600 rpm
4. PV and YP can be determined using the following equation

PV= (reading at 600 rpm) – (reading at 300 rpm)

YP= (reading at 300 rpm) – PV

Results and Discussion:

Reading at 600 rpm	Reading at 300 rpm
4 cp	3 cp

Table 3: Readings of viscometer

1. Based on the data recorded, we have PV = 1cp and YP = 2cp
2. As to where this progress is, there needs to be more justifications to whether this data is valid or not.

3. The standard PV and YP of conventional needs to be considered eventhough the target of getting a very low PV and YP is met. There might be some errors in the formulation or calculations.

4.3 Filter Cake Production

Experiment 1 : Static Filter Press

Procedure :

1. Pour the drilling fluid in to the press chamber and place the filter paper before closing the chamber with its top cover.
2. Make sure both top and bottom valves are closed.
3. The temperature was set to 170ºF and left until the meter shows the desired temperature.
4. Once the temperature reaches 170ºF, the pressure regulator is set to 600 psi (the maximum that the regulator could go) and release the preassure valve that connects with the static filter press machine.
5. Slowly open the top valve and allow pressure into the chamber.
6. Then open the lower valve to release the liquid into the cup.
7. Leave for 30 minutes.
8. Open chamber then slowly take out the filter paper and the filter cake.

Figure 24: Filter paper place in the static filter press

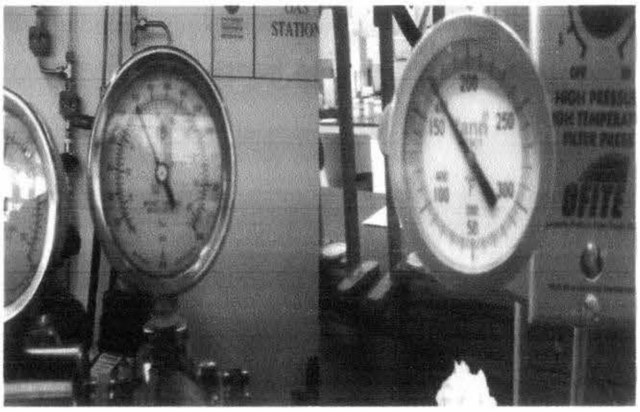

Figure 25: Pressure and Temperature

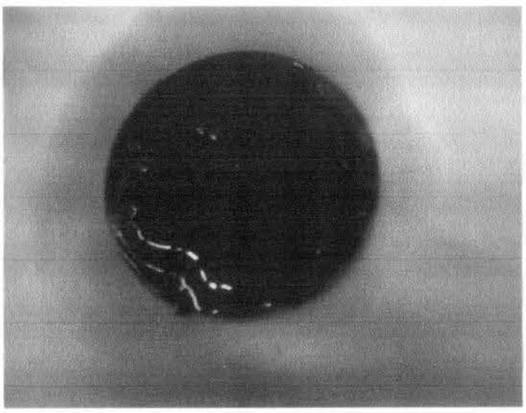

Figure 26: Filter Cake produced

Experiment 2 : Filter Cake thickness determination

After producing the filter cake, I have to determine the thickness of the cake. The best way to do this is by using a digital vernier caliper.

Procedure:

1. Place the filter cake on a firm and level ground.
2. Measure using the vernier caliper and record reading from lcd screen.

Results :

Cake thickness is 3.73mm

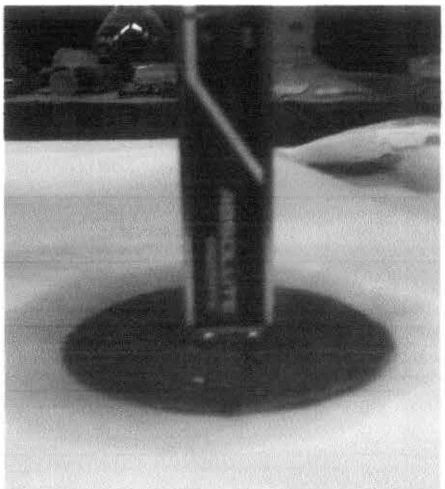

Figure 27: Measurement of cake thickness

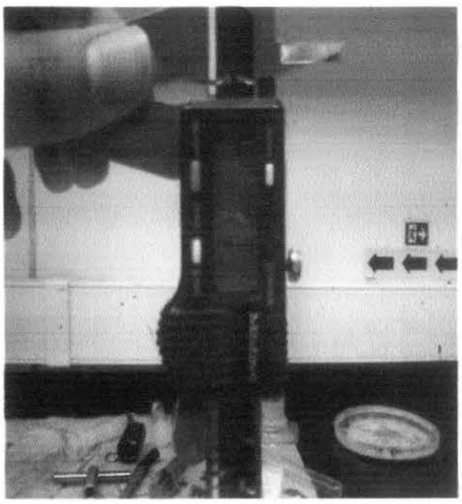

Figure 28: Digital reading of cake thickness

Chapter 5

Discussions

5.1 Discussion on methyl ester extraction from Jatropha oil

The first part of my FYP is to extract the methyl ester from the Jatropha oil. The procedures taken and the results gained had been discussed in the previous part of this report. There are a few other matters that needs to be discussed regarding the experiment conducted.

5.1.1 Discussions of result

One of the way to know whether the methly ester was properly extracted is by sending it for Gas Chromatography (GC) test. Fortunately, GC is available in UTP and could be done at building 4 at the chemistry department. After sending for GC, I got the reading of peaks which I could not understand. After comparing with the journals, I could see that there are difference between the GC readings given in the journal and the ones I received. Since I could not understand how to read the readings, I was told to refer to Mr. Mustaq who is a PhD student here in UTP. He was willing to help and he tried to explain what the readings show. In conclusion, Mr. Mustaq gave me the green light to use the methyl ester extracted for the next part of my project.

5.1.2 Error

In every experiment, there will be two type of error which are system error and human error. Based on the Gas Chromatograpy (GC), the peak we were supposed to get is not similar to what is stated in the journals due to the error that took place.

System Error

- The hotplate in the labarotary could not stay at a steady temperature causing the temparature of the reaction to be unstable. This may disturb the reaction of the chemical taking place.
- The magnetic stirir that I was using was not in perfect condition and does not stir very well with the right amount of force. Could also disturb the reaction of the chemicals.
- The volume of the glass apparatus is too small causing me to have to extract the methyl ester in several batches. There might be a high chance of inconsistancy and when mixed together, the mixture might not be in the best condition.

Human Error

- When conducting the experiment, I did not have enough experience in the chemical lab causing me to do minor mistakes such as not reading the measurements at the apparatus correctly (parallax error). The apparatus used may not be used correctly due to this lack of experience.
- I did not have all my time dedicated to conducting the experiment due to classes, other projects and tests. Sometimes I have to leave the experiment running unattended due to attending classes.

5.2 Discussions on Drilling fluid formulation

For my next part of the project is the drilling fluid formulation using theFatty Acid Methyl Ester (FAME) which I extracted from the Jatropha oil. Dr. Sonny Irawan gave me instructions to find the best formulations using the ingredients stated at the eariler parts of this report and come up with a drilling fluid which has low Plastic Viscosity (PV) and Yield Point (YP). The mud formulation I had was only used as a base formulation and I had to change the formula accordingly until I have the best drilling fluid formulation. However, I was restricted due to the limited volume of FAME from the Jatropha oil.

The target is to get a drilling fluid with low PV and YP and based on the experiments I conducted, I managed to get PV of 1cp and YP of 2 cp which is quiet low. However, there are errors that needs to be discussed.

5.2.1 Error

Human Error

Since I did not have enough FAME, the last batch of drilling fluid was not enough for the viscometer. However, I was able tomake it work but there may be some error in the data of PV and YP that was collected. Another issue is that since the viscometer has an analog meter, the reading was not stable and I do not know the correct position on my eyes to read the best reading. This also causes an error to the data collected.

5.2.2 Discussion on drilling fluid

The drilling fluid formulated has very low viscosity and does not help in Gravel Packing application. This drilling fluid does not have the abbility to carry the gravel down to the desired depth due to its low density and low viscosity. Eventhough I did not have the chance to test the gel strenght since all the fluid was used to create the filter cake, I could assume that it has low gel strenght due to its clear physical properties. If I had more of the FAME, I could have improved my formulation by adding more additives to make the gel strength increase. However, I did not have enough time to extract more FAME from the Jatropha oil. In conclusion, the Jatropha Ester-Based drilling fluid that I formulated still does not have its clear use in gravel packing but is a good drilling fluid for drilling use at low pressure and low temperature wells.

5.3 Discussions of Filter cake produced

The filter cake that was produced using a static filter press had the thickness of 3.7mm. The filter cake was not viscous and could easily be destroyed even if soaked with water. Only the fact that it was made by oil based mud made it a little bit difficult to be destroyed with water. In old gravel packing technology, this drilling fluid could not be used because at that time, thick filter cakes are needed to hold the gravel in place until it is totally packed. However today, the filter cake is not need for the placement of the gravel so this low viscosity drilling fluid could be used provided that the gel strenght of the drilling fluid is increased. There are also a few errors that is needed to be discussed.

5.3.1 Errors

Human Error

I was only able to produce the filter cake once due to limited volume of FAME. I decided to go with the standard API procedure which is to run the filter press for 30 minutes. However, there were still many liquid in the chamber when I opened it and I think that I ended the filter press process too soon. Since I did not have a second chance, I had to take whatever that I have as a result of my experiment.

System Error

The static filter press could only go up to 600 psi where else the desired pressure was to be up to 1000 psi.

5.4 Limitations

After going through two semesters of final year project, I find that there are a few limitations that prevent me from completing all three of my objectives. Most of the limitations that I experience are during the process of extracting the methyl ester from the Jatropha oil due to lack of experience and otherThe limitations are:

Equipment and material constraints

While conducting tests and experiments, there are sometimes limited material and equipments in the lab. Some of the materials and even equipments need to be bought and that takes up time. Not all equipments are situated at the lab and they need to be sourced from else where. For example:

When trying to extract the mythly ester from the Jatropha Oil, I could not even get my hands on a basic material such as methanol because I had to request from the chemical department. However, they said that I could not take the stock available because I was from a different department.

In the chemical lab, there are no glassware available and everything needs to be sourced else where. The ones that I could get my hands on are sometimes used for classes so I could only have them certain days of the week causing further delay.

Some of the glassware in the lab are not sufficient and their volume is too small for me to mass produce the methyl ester causing me problems at the later stages of the project.

Knowledge and experience constrain

Eventhough I went through a lot of journals and papers during FYP 1 which gives a lot of experiments procedures which are very detailed and easy to understand, the lack of experience gives a big impact when actually conducting the experiment. While conducting chemical experiments, I was having difficulties of getting the experiment right during the first few times causing huge delays. For example:

The extraction of metyl ester from the Jatropha oil needs a reaction between methanol and the Jatropha oil with the help of a catalyst. In order for the reaction to take place, I need to heat up the mixture. Due to lack of experience, I did not use a condenser and that causes the methanol to evaporate which leaves me with a lot of soap. In order to get the right method, I had to track down some master students which my supervisor had suggested and try to approach them for help. This causes a huge delay and makes something that should take two or three days becomes almost a whole week.

Time constraints

Time constraint is the biggest constraint of all and here are a few time constraints that I had to face during the completion of this project:

We did not have a one and a half month gap between FYP 1 and FYP 2 like what the previous students had. Due to this, we did not have sufficient time to order our equipments and materials. Usually, the time taken for the order to arrive is during that one and a half month period but for our case, it had taken up our precious FYP 2 period.

The addition of another objective to extract the methyl ester from the Jatropha oil at the end of FYP1 caused me to do more research on journals and papers eventhough FYP2 already started. This gave me a poor start on my FYP2.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

This project started up with three objectives but due to time constraints, I was only able to complete two of the three. As for the first objective, I was able to extract the FAME from the Jatropha oil and made it into a Jatropha Ester-Based drilling fluid. The objective was to formulate a drilling fluid with low plastic viscosity (PV) and yield point (YP) and despite the errors discussed in the earlier part of this report, I was able to achieve that. I dare say that the formulation that I used to create the drilling fluid is useful. However, there might need some changes in the formulation to make it applicable for gravel packing such as increase its gel strength or maybe even increase the fluid's viscosity and density without increasing its PV and YP too much.

The second objective was to produce filter cake and the filter cake produced during my experiment was not entitled to be compared with conventional filter cake produced by oil based mud. The conclusion that I can say is that due to the low viscosity and density of the drilling fluid, the filter cake that was produced was thin (at 3.7mm) and is not dense. The filter cake was not solid (probably due to the errors discussed) and could easily be washed away using normal water with a little help of soap which is some form of surfactant.

The completion of the third objective was somewhat impossible since I had run out of Jatropha FAME which means that I could not formulate more drilling fluid for the test. The filter cake that I had produced was not up to API specifications and I could not repeat the experiment. Due to time constraint, it was impossible for me to extract more FAME from the Jatropha.

6.2 Recommendations

The best recommendations that I can think of is that if in the future, another FYP student takes up the topic similar as mine, they should be given my report from the supervisor as reference so that the future FYP student do not have to repeat what had been done. As for my experience, I had to track down the methodology of the extraction of FAME from the Jatropha oil only to find weeks later that this process was already done. I could have saved a lot of valuable FYP2 time and concentrate more on the gravel packing aspect of the project. Another recommendation for future FYP students is that each student is given a mentor from master or PHD student to guide them through their project. This is because some supervisors are busy and do not have enough time to focus on each of his or her FYP students. The supervisors also do not have time to visit the students or help the students while conducting the experiments and tests. With the guide from a master or PHD student, the FYP projects can go smoothly and the outcome of projects from FYP would be more beneficial.

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APPENDIX

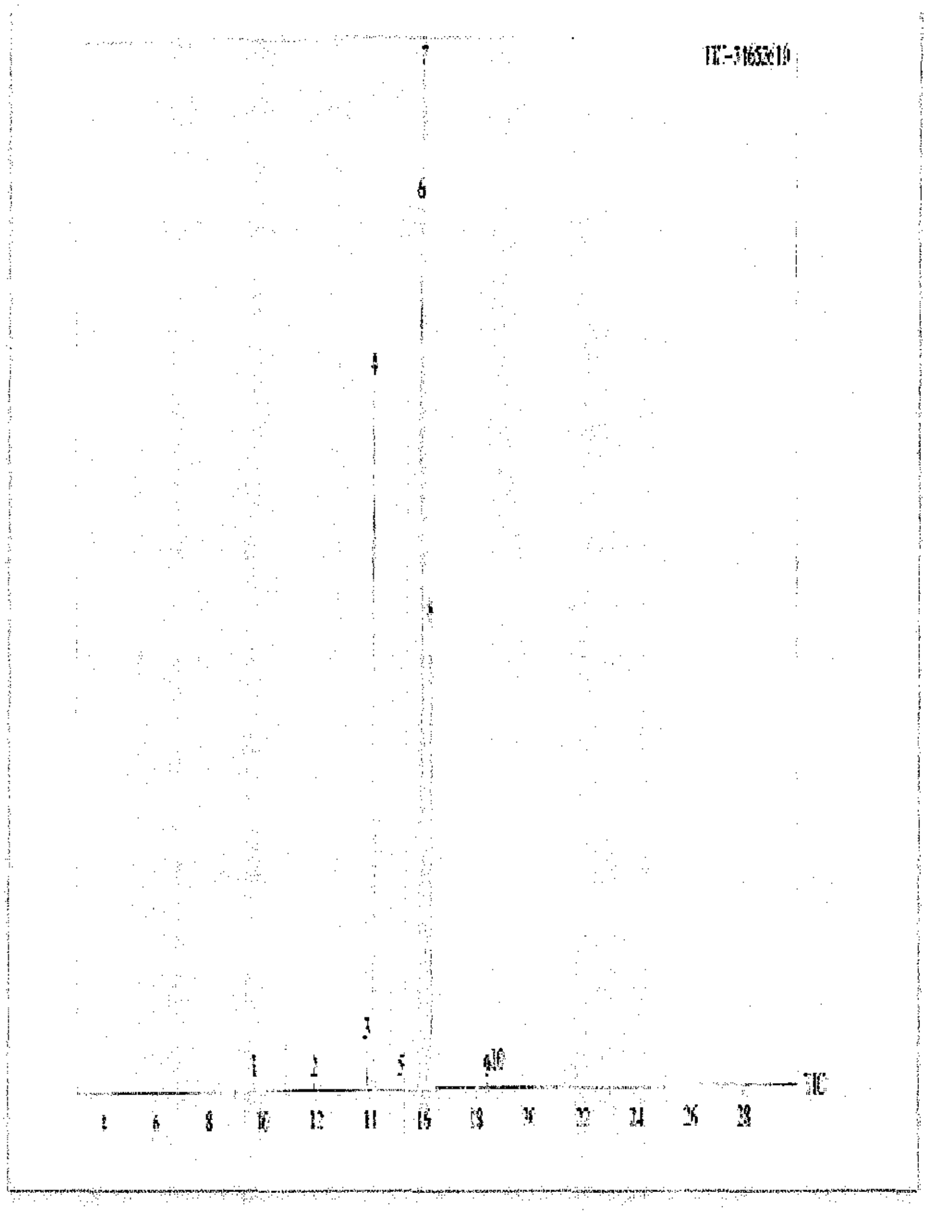

Figure 29: GCMS for Jatropha FAME

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FORM 10

UNIVERSITI TEKNOLOGI PETRONAS

FYP Part II – FINAL ORAL PRESENTATION SCORE SHEET

(To be completed by Supervisor/Examiner)

Student's Name : Mohamad Hashimi b. Mohamad Hashim (10714)

Project Title : Open Hole gravel packing with Jatropha Ester based fluid

Programme : ~~Eng~~ Petroleum Engineering.

Category	Criteria for Judging Quality	Excellent	Very, Very Good	Very Good	Good	Above Average	Just Average	Poor	Very Poor – Marginal Pass	Very Bad - Failure
		Please circle the appropriate grade for each category								
Introduction (10)	• Background of Study • Problem Statement - Problem Identification - Significant of the Project • Objective and Scope of Study • The Relevancy of the Project • Feasibility of the Project within the Scope and Time frame	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Literature Review and/or Theory (10)	• No. of references • Critical analysis of literature • Citation and cross referencing • Relevancy and recentness of the literature	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Methodology (10)	• Research Methodology • Project activities • Key milestone • Gantt Chart • Tools (eg. Equipment, hardware, etc.) required.	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Result and Discussion (20)	• Findings • Data Gathering/ Data Analysis • Experimentation/Modelling/ Prototype/Project Deliverables	A (20)	A- (17)	B+ (16)	B (15)	C+ (13)	C (11)	D+ (10)	D (9)	F (4)
Conclusions and Recommendations (10)	• Relevancy to the Objectives • Suggested Future Work for Expansion and Continuation	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Clarity of presentation (10)	• Fluency and choice of words (using language clearly and accurately) Pronunciation, articulation • Use of aids (graphs, diagrams, objects etc) • Continuity of Presentation	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Non-verbal Communication (10)	• Appearance; Facial expression; Confidence • Gesture; Eye Contact, Pauses	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Questions and Answers (20)	• Technical and factual accuracy; Grasp of subject • Creativity – use of example • Convincing Answer, Showing creativity and Innovativeness	A (20)	A- (17)	B+ (16)	B (15)	C+ (13)	C (11)	D+ (10)	D (9)	F (4)
TOTAL SCORE										
OVERALL GRADE (refer to UTP Grading Scheme below)										

Comments:

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Supervisor/Examiner's signature

Name : ____________________ Date : __________

UNIVERSITI TEKNOLOGI PETRONAS

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UTP-ACA-PROG-FYP-01.08	2.0	Xx xx

FORM 10

FYP Part II – FINAL ORAL PRESENTATION SCORE SHEET

(To be completed by Supervisor/Examiner)

Student's Name : Mohamad Hashimi b. Mohamad Hashim (10714)

Project Title : ~~Jatropha F~~ Open Hole gravel packing with Jatropha Ester Base

Programme : Petroleum Engineering.

Category	Criteria for Judging Quality	Excellent	Very, Very Good	Very Good	Good	Above Average	Just Average	Poor	Very Poor – Marginal Pass	Very Bad - Failure
		Please circle the appropriate grade for each category								
Introduction (10)	• Background of Study • Problem Statement - Problem Identification - Significant of the Project • Objective and Scope of Study • The Relevancy of the Project • Feasibility of the Project within the Scope and Time frame	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Literature Review and/or Theory (10)	• No. of references • Critical analysis of literature • Citation and cross referencing • Relevancy and recentness of the literature	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Methodology (10)	• Research Methodology • Project activities • Key milestone • Gantt Chart • Tools (eg. Equipment, hardware, etc.) required.	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Result and Discussion (20)	• Findings • Data Gathering/ Data Analysis • Experimentation/Modelling/ Prototype/Project Deliverables	A (20)	A- (17)	B+ (16)	B (15)	C+ (13)	C (11)	D+ (10)	D (9)	F (4)
Conclusions and Recommendations (10)	• Relevancy to the Objectives • Suggested Future Work for Expansion and Continuation	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Clarity of presentation (10)	• Fluency and choice of words (using language clearly and accurately) Pronunciation, articulation • Use of aids (graphs, diagrams, objects etc) • Continuity of Presentation	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Non-verbal Communication (10)	• Appearance; Facial expression; Confidence • Gesture; Eye Contact, Pauses	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Questions and Answers (20)	• Technical and factual accuracy; Grasp of subject • Creativity – use of example • Convincing Answer, Showing creativity and Innovativeness	A (20)	A- (17)	B+ (16)	B (15)	C+ (13)	C (11)	D+ (10)	D (9)	F (4)
TOTAL SCORE										
OVERALL GRADE (refer to UTP Grading Scheme below)										

Comments:

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Supervisor/Examiner's signature

Name : ____________________ Date : __________

UNIVERSITI TEKNOLOGI PETRONAS

APPENDIX 3-10

Doc. Ref. No.	Issue Version	Date
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FORM 10

FYP Part II – FINAL ORAL PRESENTATION SCORE SHEET

(To be completed by Supervisor/Examiner)

Student's Name : Mohamad Hashimi b. Mohamad Hashim (10714)

Project Title : Open Hole Gravel packing with Jatropha Ester-Based Fluids

Programme : Petroleum Engineering

Category	Criteria for Judging Quality	Excellent	Very, Very Good	Very Good	Good	Above Average	Just Average	Poor	Very Poor – Marginal Pass	Very Bad - Failure
		Please circle the appropriate grade for each category								
Introduction (10)	• Background of Study • Problem Statement - Problem Identification - Significant of the Project • Objective and Scope of Study • The Relevancy of the Project • Feasibility of the Project within the Scope and Time frame	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Literature Review and/or Theory (10)	• No. of references • Critical analysis of literature • Citation and cross referencing • Relevancy and recentness of the literature	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Methodology (10)	• Research Methodology • Project activities • Key milestone • Gantt Chart • Tools (eg. Equipment, hardware, etc.) required.	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Result and Discussion (20)	• Findings • Data Gathering/ Data Analysis • Experimentation/Modelling/ Prototype/Project Deliverables	A (20)	A- (17)	B+ (16)	B (15)	C+ (13)	C (11)	D+ (10)	D (9)	F (4)
Conclusions and Recommendations (10)	• Relevancy to the Objectives • Suggested Future Work for Expansion and Continuation	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Clarity of presentation (10)	• Fluency and choice of words (using language clearly and accurately) Pronunciation, articulation • Use of aids (graphs, diagrams, objects etc) • Continuity of Presentation	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Non-verbal Communication (10)	• Appearance; Facial expression; Confidence • Gesture; Eye Contact, Pauses	A (10)	A- (8.5)	B+ (8)	B (7.5)	C+ (6.5)	C (5.5)	D+ (5)	D (4.5)	F (2)
Questions and Answers (20)	• Technical and factual accuracy; Grasp of subject • Creativity – use of example • Convincing Answer, Showing creativity and Innovativeness	A (20)	A- (17)	B+ (16)	B (15)	C+ (13)	C (11)	D+ (10)	D (9)	F (4)
TOTAL SCORE										
OVERALL GRADE (refer to UTP Grading Scheme below)										

Comments:

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Supervisor/Examiner's signature

Name : __________________ Date : __________