# STUDY OF COCONUT OIL AS OIL BASED FLUID IN DRILLING OPERATION

Final Year Project II

By

**MARUT DAMKAEW**

Dissertation submitted in partial fulfilment of

the requirements for the

BACHELOR OF ENGINEERING (Hons)

(PETROLEUM ENGINEERING)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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# CERTIFICATION OF APPROVAL

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Approved by,

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Raja Rajeswary Suppiah
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
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# ABSTRACT

Drilling fluid is a critical component in the drilling process, where it provides the gel to efficiently lift cuttings, maintain stable wellbore and produce sufficient hydrostatic pressure that could prevent the influx of formation fluids into the wellbore.

Even-though Oil-based drilling fluids are widely used in drilling operation because it enable to provide good wellbore stability, good lubrication that leads to faster Rate of penetration, temperature stability and low formation damage but it have been proven that the disposal of oil-contaminated drill cutting causes environmental hazard especially Diesel as base oil.

Vegetable oil in this project – Coconut oil is renewable, highly biodegradable could be suitable candidate of a highly biodegradable oil-based mud to achieve the sustainable development. Thus, six mud samples were formulated with six different composition of based fluids which are Saraline, 100%, 80%, 70%, 60%, 50% Coconut oil based mud samples. This paper presents the laboratory study such as viscosity, yield point, gel strength, filtration and electric stability had been undertaken to determine whether the Coconut oil were an acceptable alternative to diesel in order to overcome environmental problem.

ACKNOWLEDGEMENTS

This Final Year Project: “Study of coconut oil as oil based fluid in drilling operation” involves many parties in order to complete it successfully. It is a golden opportunity to learn and practice engineering project with real oil & gas industry equipments.

Deepest gratitude shall be given to all Drilling fluid lab technician staffs who work together throughout this project. The strong support and willingness to share knowledge and expertise have given very wonderful experiences. Special appreciation shall go to the project’s supervisor (Ms.Raja Rajeswary A/P Suppiah) who becomes the most important people to teach and provide guidance during this work.

Not to be forgotten, all the people who helped in gaining wonderful experience along this final year project especially friends and co-workers either they work directly or indirectly in completing the job assignment. All the help and sharing of information is highly appreciated in which has enabled well performance of the project.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of study

The sustainable development of petroleum operation requires appropriate and optimize management strategies. Most of the company's projects aim to just improve the production performances & technologies to achieve maximum profit with optimum cost. Thus, environmental concern project need to be conducted, developed and implemented along the development for the sustainable tomorrow.

Drilling fluid is a circulating fluid used in rotary drilling to perform the various functions required in drilling operations. In designing a drilling fluid, the factors considered include; the well design, anticipated formation pressures and rock mechanics, formation chemistry, temperature, environmental regulations logistics and economics. The rheology of the fluid determines its effectiveness in a drilling hole.

Oil-based drilling fluids offer definite advantages over water-based mud in many drilling situation which make them especially desirable for certain types of formation, this caused  the use of oil based mud (OBM) has increased significantly in drilling operation recent years. Oil-based muds generally provide better performance in very hot or very cold environment, excellent shale inhibition, borehole stability, lubricity, thermal stability, corrosion inhibition, tolerance of contamination and ease of maintenance. Moreover, Oil-based muds cause fewer problems when drilling shale formations and allow drilling of salt zones with minimal dissolving of salt.

However, there are several significant issues that make it a bad choice for environmentally sensitive areas which are greater costs and potential pollution problems. Drilling mud has varying degree of toxicity. It is difficult and expensive to dispose in an environmentally friendly manner.

Although, Diesel oil had played the main role as the base oil since the introduction of OBM as drilling fluid, in early 1980's studies on diesel oil have shown that diesel oil is not suitable to be used as base oil due to high toxicity and aromatic contents exposure to the people and environment (Yassin, Kamis & Abdullah, 1991).

Due to increase in environmental legislation against the disposition of oil based mud and an increase in environmental awareness over the effects of diesel oil have led to strict regulations concerning the use of invert-emulsion fluids. Regulations governing offshore applications are particularly stringent, even the newer and less polluting mineral and synthetic oils in vogue now maybe adjudged unsuitable because of their non-biodegradability. Indeed, today, in many parts of the world, like the USA, United Kingdom, Holland, Norway, Nigeria and Australia, the use of diesel and mineral oil-based drilling fluids in offshore operations is severely restricted or banned because of their toxicity, persistency and bioaccumulation. A typical well may generate between 1000 and 1500 tonnes of cutting. With average oil retention of 15%, around 150-225 tonnes of oil from the drilling fluid is discharged into the sea for each well that is drilled, thereby causing a large area around the drilling site being affected. Cuttings produced during drilling must be cleaned using a costly procedure before being discarded into the ocean. The oil mud itself must be transported to land for disposal after use. The use of oil based mud in certain environmentally sensitive areas is prohibited altogether. Therefore vegetable oil based drilling fluids and synthetic based muds were introduced as environmental friendly alternatives which pose no health hazard to oilfield workers and the host community (Hinds, Smith & Morton).

Coconut oil is the vegetable oil that has been chosen as a candidate oil-based this project. Due to its both physical and chemical properties, assuming that coconut oil can replace diesel oil in OBM. However, Saraline as the mineral oil in synthetic based mud will be tested as the benchmark in this project. Throughout this project, the properties of Coconut oil based mud will be measured and characterized to ensure its usage as a substitute to mineral base oil or diesel.

### 1.2 Problem Statement

By using Diesel as base oil which contain high aromatic content and aquatic toxicity, it has been proven that it is harmful to the environment-particularly marine environment in offshore application (Yassin, Kamis & Abdullah, 1991) and in many geographical location (Amanullah, 2005). The cutting generated using diesel oil-based mud need special treatment before discharging them in order to prevent contaminated water with free oil. The transportation of cutting to onshore location increases the total drilling cost significantly (Veil, 1998).

Hence, the introduction of vegetable oils such as coconut oil with low aromatic and free-toxicity as an alternative base fluid can be potentially use and replace diesel for drilling fluid to overcome the environmental problem .

## 1.3 Objectives

The objectives of this study are:

- To conduct experiments on coconut oil as an alternative base oil
- To compare and evaluate the experimental result from Coconut oil and Saraline Oil based drilling fluid.
- To justify and summarize whether coconut oil can be an alternative base fluid for oil based mud or not.

## 1.4 Scope of Study

This project will involve the understanding of oil based mud & synthetic based mud, its properties and application. At the end of the study, the experimental result will be evaluated in order to identify and determine that coconut oil as an alternative base oil to replace diesel or mineral oil. Besides that, the performance of coconut oil in oil based mud formulation will also be analyzed.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Oil-based mud

The solids in an oil base fluid are oil wet, all additives are oil dispersible and the filtrate of the mud is oil. The water, if present, is emulsified in the oil phase. There are two basic classifications of oil-based fluids; invert emulsions and all-oil mud. The amount of water present will describe the type of oil base fluid. The oil used in these types of oil base fluids can range from crude oil. Refined oils such as diesel or mineral oils, or the non-petroleum organic fluid that is currently available. The latter type fluids - variously called inert fluids, pseudo oils, non-aqueous fluids and synthetic fluids – are now considered more environmentally acceptable than diesel or mineral oils. Invert emulsions are oil muds that are formulated to contain moderate to high concentrations of water (Amoco production company drilling fluid manual, 1994). Oil-based drilling mud and synthetic-based drilling mud have many inherent advantages over water-based drilling fluids including temperature stability, tolerance to contamination and corrosion protection (Dye et.al, 2006) and according to the Norwegian Oil Industry Association Working Group (1996).

Oil mud offers many advantages over water-based mud. The high initial cost of the oil-based mud can be a factor in not selecting this type of mud system. However, if the overall drilling costs are considered, the costs accompanying the use of an oil mud are usually less than that for a water mud.

## 2.2 Coconut Oil

**Figure 1: Coconut Sun Dried**

Refined Coconut Oil is the most used form of coconut oil worldwide which is usually rather tasteless and odorless, if not the purest or the best. It is also known by the name of RBD Coconut Oil, which stands for Refined, Bleached & Deodorized Coconut Oil. RBD oil is usually made from copra (dried coconut kernel).

The dried copra is placed in a hydraulic press with added heat and the oil is extracted. This yields up practically all the oil present, amounting to more than 60% of the dry weight of the coconut because this "crude" coconut oil is not suitable for consumption because it contains contaminants and must be refined with further heating and filtering.

It has covalent chemical bonds which consists of pairs of electrons shared by two atoms, and binds the atoms in a fixed orientation. Relatively high energies are required to break them (50 - 200 kcal/mol). Whether two atoms can form a covalent bond depends upon their electro-negativity (Coconut oil, wiki.answers.com). These are the Physical Properties of coconut oil;

- **Colour:** Colourless at or above 30$^{o}$ C. White when solid.
- **Odour:** Typical smell of Coconut (if not refined, bleached & deodorized).
- **Melting Point:** Melts at 25$^{o}$ C (76$^{o}$ Fahrenheit). Solid below this temperature.
- **Smoking Point:** 177$^{o}$C (350$^{o}$ Fahrenheit).
- **Solubility in Water:** Forms a white homogenous mixture when beaten well in little water. Otherwise insoluble in water at room temperature.
- **Density:** 924.27 Kg/Meter$^3$

Chemical Properties: Coconut Oil is predominantly composed of saturated fatty acids (about 94%), with a good percentage (above 62%) of Medium Chain Fatty Acids among them.

Coconut oil has become alternative for vegetable-oil based muds with its properties which are able to comply with the standard requirement of Oil-based mud properties. From the tables below show; Coconut oil has highest cloud and pour point (13.1 'C and 12.7 'C) among all the oil studied due to it contains short chain (6-8) carbon atom fatty acids (Akhtar, Adnan, et al., 2008). It has high flush point or smoke point of 350 °F (177 °C).Viscosity also influences the pour and cloud points of the oils. As the viscosity of coconut oil is 44.16 mPas.s or 44.16 cP and its Specific gravity (SG) is 0.9138 (Diesel oil has SG of 0.84 in 60'F (API, 1998)), they have shown the possibility of coconut oil as the new alternative.

Table-1: Rheological parameters of different oils.

| | Olive Oil | | | Coconut Oil | | | Almond Oil | | | Castor Oil | | | Sesame Oil | | | Cottonseed Oil | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sr. # | Viscosity (mPas.s) | Shear Stress (D/cm$^2$) | Shear Rate (1/s) | Viscosity (mPas.s) | Shear Stress (D/cm$^2$) | Shear Rate(1/s) | Viscosity (mPas.s) | Shear Stress (D/cm$^2$) | Shear Rate (1/s) | Viscosity (mPas.s) | Shear Stress (D/cm$^2$) | Shear Rate (1/s) | Viscosity (mPas.s) | Shear Stress (D/cm$^2$) | Shear Rate(1/s) | Viscosity (mPas.s) | Shear Stress (D/cm$^2$) | Shear Rate(1/s) |
| 1. | 65.41 | 45.79 | 70.00 | 47.19 | 33.03 | 70.00 | 66.10 | 29.74 | 45.00 | 712.28 | 7.12 | 7.12 | 54.66 | 32.80 | 60.00 | 58.57 | 35.14 | 60.00 |
| 2. | 63.24 | 47.43 | 75.00 | 45.08 | 33.81 | 75.00 | 66.06 | 33.03 | 50.00 | 700.53 | 14.01 | 14.01 | 54.43 | 35.38 | 65.00 | 58.40 | 37.96 | 65.00 |
| 3. | 61.83 | 49.47 | 80.00 | 44.52 | 35.61 | 80.00 | 65.75 | 36.16 | 55.00 | 675.75 | 20.27 | 20.27 | 54.34 | 38.04 | 70.00 | 58.37 | 40.86 | 70.00 |
| 4. | 61.14 | 51.97 | 85.00 | 44.29 | 37.65 | 85.00 | 65.75 | 39.45 | 60.00 | 684.88 | 27.40 | 27.40 | 54.37 | 40.78 | 75.00 | 58.23 | 43.68 | 75.00 |
| 5. | 60.62 | 54.56 | 90.00 | 44.09 | 39.68 | 90.00 | 65.75 | 42.74 | 65.00 | 684.10 | 34.20 | 34.20 | 54.40 | 43.52 | 80.00 | 58.31 | 46.65 | 80.00 |
| 6. | 60.31 | 57.30 | 95.00 | 44.08 | 41.88 | 95.00 | 65.52 | 45.87 | 70.00 | 682.27 | 40.94 | 40.94 | 54.33 | 46.18 | 85.00 | 58.20 | 49.47 | 85.00 |
| 7. | 60.03 | 60.03 | 100.00 | 43.99 | 43.99 | 100.00 | 65.54 | 49.15 | 75.00 | 682.08 | 47.75 | 47.75 | 54.36 | 48.92 | 90.00 | 58.18 | 52.36 | 90.00 |
| 8. | 60.01 | 63.01 | 105.00 | 44.06 | 46.26 | 105.00 | 65.45 | 52.36 | 80.00 | 680.97 | 54.48 | 54.48 | 54.30 | 51.58 | 95.00 | 58.09 | 55.18 | 95.00 |
| 9. | 59.91 | 65.91 | 110.00 | 44.05 | 48.45 | 110.00 | 65.47 | 55.65 | 85.00 | 680.10 | 61.21 | 61.21 | 54.24 | 54.24 | 100.00 | 58.08 | 58.08 | 100.00 |
| 10. | 59.90 | 68.88 | 115.00 | 44.10 | 50.72 | 115.00 | 65.40 | 58.86 | 90.00 | 679.40 | 67.94 | 67.94 | 54.27 | 56.98 | 105.00 | 58.00 | 60.90 | 105.00 |

| Sr. # | Name of Oils | Average Viscosity (mPs.s) | Average Diameter (mm) | Cloud Point (°C) | Pour Point (°C) | Average Saponification Value | Average Acid Value | Average pH value | Average Specific gravity |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Olive Oil | 63.61 | 7.4 | -11.1 | -14.2 | 130.32 | 1.361 | 4.6206 | 0.9185 |
| 2 | Coconut Oil | 44.16 | 7.67 | 13.1 | 12.7 | 78.00 | 0.378 | 3.91 | 0.9138 |
| 3 | Almond Oil | 65.68 | 8.67 | -13.8 | -18.3 | 186.50 | 1.87 | 4.85 | 0.9209 |
| 4 | Castor Oil | 686.24 | 5.03 | -18.2 | -21.7 | 187.02 | 1.351 | 4.92 | 0.9598 |
| 5 | Sesame Oil | 54.37 | 8.33 | -8.7 | -11.8 | 117.48 | 0.547 | 3.80 | 0.9185 |
| 6 | Cottonseed Oil | 58.24 | 8.00 | -0.5 | -4.9 | 62.52 | 0.295 | 3.64 | 0.9186 |
| 7 | Sunflower Oil | 58.19 | 7.17 | -9.5 | -12.1 | 186.31 | 0.263 | 4.35 | 0.9175 |
| 8 | Paraffin Oil | 7.11 | 17.5 | 7.5 | 3.5 | 32.70 | 0.224 | 4.31 | 0.9999 |

**Table 2: Average values of different parameters of different Oils**

Newtonian or Non-Newtonian behavior is the most important physical property of the oils. In Newtonian liquids; the shear stress and shear rate are directly proportional to each other which will give a straight line in the profile of shear stress versus shear rate. However, the flow index value of Coconut oil is 0.9 deviating from 1 approaching the Non-Newtonian behavior as shown in table.

Table- 3 Power Law Analysis of different oils at 25±0.1 °C.

| Sr. # | Name of Oils | Consistency Index | Flow Index | Confidence of fit (%) |
|---|---|---|---|---|
| 1 | Olive Oil | 124.7 | 0.84 | 99.0 |
| 2 | Coconut Oil | 96.4 | 0.90 | 98.9 |
| 3 | Almond Oil | 70.1 | 0.98 | 99.9 |
| 4 | Castor Oil | 705.6 | 0.98 | 99.4 |
| 5 | Sesame Oil | 56.7 | 0.99 | 99.9 |
| 6 | Cottonseed Oil | 62.3 | 0.98 | 99.9 |
| 7 | Sunflower Oil | 60.0 | 0.99 | 100.0 |
| 8 | Paraffin Oil | 6.55 | 1.01 | 99.8 |

### 2.3 Saraline oil

Saraline 185V is premium-quality synthetic paraffin with a low viscosity, a low pour point and relatively high flash point using as synthetic based drilling fluid which produced from clean natural gas suitable applying in deep water exploration (Shell MDS, 2009). There are virtually no aromatics and contaminants such as sulphur and amines are contained that cause Saraline 185V readily biodegrades, non-toxic in the water column and has low sediment toxicity. It is widely used as a non-aqueous base fluid in an invert emulsion drilling mud. SARALINE 185V is produced from the reaction of a purified feedstock as opposed to highly refined/processed mineral oils, which are produced from the distillation or refining of crude oil (OGP, 2003) which manufactured by Shell MDS.

It readily biodegrades, is non-toxic in the water column and has low sediment toxicity. It has a low viscosity, a low pour point and relatively high flash point making it ideal for deepwater exploration. It is widely used as non-aqueous based fluid in an invert emulsion drilling mud in the upstream oil and gas industry. Saraline 185V and/or its variants and related products have been used at various times in Malaysia, Thailand, Vietnam, Myanmar, Indonesia, The Philippines, Bangladesh, India, Australia, New Zealand, China and the Caspian Sea since 1997.

These are the physical and chemical properties of Saraline 185V showing in the table below;

| PHYSICAL AND CHEMICAL PROPERTIES | |
|---|---|
| **Physical state:** | Liquid at ambient temperature. |
| **Colour:** | Colourless |
| **Odour:** | Odourless |
| **Initial boiling point:** | Circa 200°C |
| **Final boiling point:** | Circa 320°C |
| **Vapour pressure:** | <0.1 kPa at 40°C |
| **Density:** | Circa 780 kg/m³ at 15°C |
| **Kinematic viscosity:** | Circa 2.8 mm²/s at 40°C |
| **Vapour density (air=1):** | > 5 |
| **Pour point:** | Circa –27°C |
| **Flash point:** | > 85°C (PMCC) |
| **Flammability limit - lower:** | Circa 1%(V/V) |
| **Flammability limit - upper:** | Circa 6%(V/V) |
| **Auto-ignition temperature:** | > 220°C |
| **Explosive properties:** | In use, may form flammable/explosive vapour-air mixtures. |
| **Oxidizing properties:** | None |
| **Solubility in water:** | Insoluble |

**Table 4: Physical & Chemical Properties of Saraline 185V**

Typical Environmental Properties

| Property | Test protocol | Value | Toxicity classification |
|---|---|---|---|
| Biodegradation | | | |
| Aerobic | OECD 306 28-d | 62% | Biodegrades |
| Water Column Toxicity | | (mg/l, SPP) | |
| *Mysidopsis bahia*[1] | 96-hr $LC_{50}$ | >1,000,000 | Non-toxic |
| *T. mossambica*[2] | 96-hr $LC_{50}$ | 145,000 | Non-toxic |
| *Mugil persia*[2] | 96-hr $LC_{50}$ | 98,000 | Almost non-toxic |
| *Mugil cephalus*[2] | 96-hr $LC_{50}$ | 86,500 | Almost non-toxic |
| *Penaeus indicus*[2] | 96-hr $LC_{50}$ | 67,000 | Almost non-toxic |
| *Pagrus auratus*[2] | 96-hr $LC_{50}$ | >100,000 | Non-toxic |
| *Nitzschia closterium*[3] | 72-hr $EC_{50}$ | >83,300 | Almost Non-toxic |
| *Pagrus auratus*[4] | 72-hr $EC_{50}$ | >100,000 | Non-toxic |
| Sediment toxicity | | | |
| *Corophium volutator* | 10-d $LC_{50}$ | >50,000 mg/kg (dry) | Non-toxic |
| *Boleopthalmus boddarti* | 10-d $LC_{50}$ | 235,000 mg/l | Non-toxic |
| *Scylla serrata* | 10-d $LC_{50}$ | 128,000 mg/l | Non-toxic |
| Partition coefficient | | | |
| OECD 117 | Log $P_{ow}$ | >6.5 | Do not readily bioaccumulate if <2 or >6[5] |

**Table 5: Typical Environmental Properties of Saraline 185V**

To handling the Saraline 185V, do not eat, drink or smoke. The user only use in well-ventilated areas and take precautionary measures against static discharges as well as keep it at Ambient temperature. The storage of Saraline is to locate away from heat and other sources of ignition, do not store in unsuitable, unlabelled or incorrectly labeled container.

**2.4 Alkyl-Benzene (Toluene)**

*Toluene*, formerly known as *toluol*, is a clear, water-insoluble liquid**.** It is a mono-substituted benzene derivative, i.e., one in which a single hydrogen atom from a group of six atoms from the benzene molecule has been replaced by a univalent group, in this case $CH_3$.

It is widely used as an industrial feedstock and as a solvent. Like other solvents, toluene is sometimes also used as an inhalant drug for its intoxicating properties; however, inhaling toluene has potential to cause severe neurological harm. Toluene is an important organic solvent, but is also capable of dissolving a number of notable inorganic chemicals such as sulfur, iodine, bromine, phosphorus and other non-polar covalent substances (Toluene, en.wikipedia.org/wiki/Toluene)

Toluene reacts as a normal aromatic hydrocarbon towards electrophilic aromatic substitution. The methyl group makes it around 25 times more reactive than benzene in such reactions. It undergoes smooth sulfonation to give *p*-toluenesulfonic acid, and chlorinationby $Cl_2$ in the presence of $FeCl_3$ to give ortho and para isomers of chlorotoluene. It undergoes nitration to give ortho and paranitrotoluene isomers, but if heated it can give dinitrotoluene and ultimately the explosive trinitrotoluene (TNT).

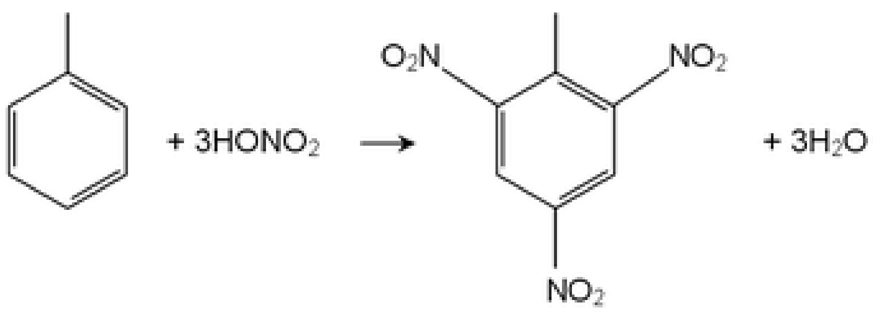



**Figure 2: Toluene Chemical Compound**

### 2.5 Base Oil Properties Requirement

Guidelines of the basic requirements had been discussed in detail by Johanscvik and Grieve who have resummarized as follow (Yassin, Kamis & Abdullah, 1991):

**a) Non-toxic and low aromatic content**

Base oil should have total aromatic hydrocarbon content of less than 5%. It should be non-acutely toxic in a standard 96 hr LC 50 toxicity test, performed using 100% water-soluble fraction of the base oil.

**b) Stable Emulsion**

The base oil must be able to form a stable emulsion.

**c) Kinematic viscosity**

It should be as low as possible. This allows the oil-based mud to be formulated at lower oil/water ratio and gives better rheology (lower plastic viscosity), especially at low mud temperature.

**d) Flash point**

It should be greater than 100'F. Higher flash point will minimize fire hazards as less hydrocarbon vapors is expected to generate above the mud.

**e) Pour point**

It should be lower than the ambient temperature to allow pump ability of mud from storage tanks.

**f) Aniline point**

It is the temperature at which an equivalent mixture of oil and aniline are no longer soluble in each other. Generally, the less saturated hydrocarbon (usually with lower heating value) will mix more radily with aniline i.e low aniline point. To minimize the deterioration of rubber component on the rig, the base oil should have an aniline point of above 65'C

**g) Non-fluorescent**

Fluorescence of the base oil is undesirable because it inhibits the ability of well-site geologist to detect native hydrocarbon when evaluating drilling cuttings.

## 2.6 Rheological Study

Rheology is the study of the flow of matter relationship between the flow rate and the pressure (Schlumberger Oilfield Glossary) required maintaining the flow rate (either in pipe or annulus): mainly liquids but also soft solids or solids under conditions in which they flow rather than deform elastically. It applies to substances which have a complex structure, including muds, sludges, suspensions, polymers, many foods, bodily fluids, and other biological materials. Certain rheological measurements made on fluids, such as viscosity, gel strength and etc. The information we gathered from this experiment can help in the design of circulating systems required to accomplish certain desired objective in drilling operations, circulating pressures, surge and swab pressures and hole cleaning ability. . In this project, the rheological study comprises of plastic viscosity, yield point, electric stability and gel strength. Each study is so significant to choose a better base fluid.

- **Viscosity**

Viscosity is defined as the resistance of a fluid to flow and it is measured as the ratio of the shearing stress to the rate of shearing strain which This property of fluids is significant in hole cleaning to control the settling rate of drill cuttings generated by the drill bit through moving fluid and bring them up to the surface. Viscosity measured in the unit of poise which is equivalent to dyne-sec/cm2. One poise represents a high viscosity, therefore the generally unit that represents the fluids is centipoises. Centipoises is equivalent to 1/100 poise or 1 millipascal-second. There are two types of fluid characterization which are;

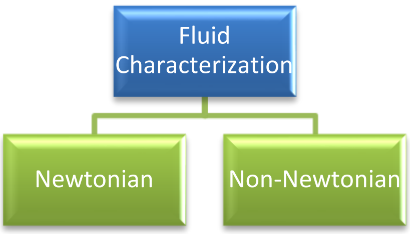



**Figure 3: Fluid Characterization**

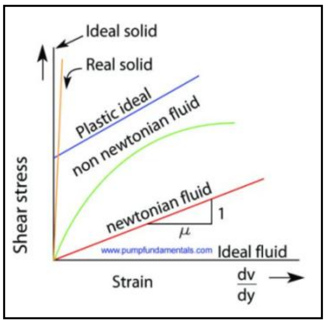



**Figure 4: Fluid Characterization Graph**

- *Newtonian* (true fluids) is a fluid where the ratio of sheer stress to shear rate or viscosity is constant. Example of a Newtonian fluid is water, light oils and etc.
- *Non-Newtonian* (plastic fluids) is a fluid whose flow properties are not described by a single constant value of viscosity. In a Newtonian fluid, the relation between the shear

stress and the strain rate is linear. Example of a Non-Newtonian fluid is the drilling mud, colloids and etc.

There are two main apparatus that the author has utilized in the laboratory which are marsh funnel and direct indicating viscometer. Marsh funnel is a simple device for routine measurement of drilling fluids viscosity. The viscosity measured through this apparatus is known as funnel viscosity. The Marsh funnel is dimensioned so that the outflow time of one quart freshwater (946 cm3) at a temperature of 70° ± 5°F (21° ± 3°C) is 26 ± 0.5 seconds. Thus, fluid which records a time more than 26 ± 0.5 seconds using the marsh funnel is more viscous compared to freshwater and vice versa.

*Test Equipments*

The FANN® Model 35 viscometer are direct reading instruments which are available in six speed and 12 speed designs for use on either 50 Hz or 60 Hz electrical power. The standard power source is 115 volts but all of the models may be fitted with a transformer which makes operation with 220/230 volts possible. These are true Coquette coaxial cylinder rotational viscometer since the test fluid is contained in the annular space (shear gap) between an outer cylinder and the bob. Viscosity measurements are made when the outer cylinder, rotating at a known velocity, causes a viscous drag to be exerted by the fluid. This drag creates a torque on the bob, which is transmitted to a precision spring where its deflection is measured and then compared with the test conditions and the instrument's constants. This system permits the true simulation of many of the significant flow process conditions encountered in industrial processing.

**Figure 5: Variable Speed Viscometer**

- **Plastic Viscosity**

Plastic viscosity relates to the resistance to flow due to interparticle friction. The friction which occurs (1) between the solids in the mud, (2) between the solids and the liquid that surrounds them, and (3) with the searing of the liquid itself is affected by the amount of solids in the mud, the size and shape of those solids and the viscosity of the continuous liquid phase.

A low Plastic Viscosity indicates that the mud is capable of drilling rapidly in the other hands, High Plastic Viscosity is caused by a viscous base fluid and by excess colloidal solids.

However, the difference between the Plastic Viscosity and Apparent Viscosity of a drilling fluid is Plastic Viscosity is the viscosity of a mud when extrapolated to infinite shear rate while The Apparent Viscosity is the viscosity of a fluid measured at a given shear rate at a fixed temperature

**Plastic Viscosity, PV = [600 rpm Reading] – [300 rpm Reading]**

Unit: **centipoise,cp**

- **Yield Point**

A parameter of the Bingham plastic model, YP is the yield stress extrapolated to a shear rate of zero. (Plastic viscosity, PV, is the other parameter of the Bingham-plastic model.) A 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- and 600-rpm viscometer dial readings by subtracting PV from the 300-rpm dial reading.

YP estimates the portion of the total viscosity that comes from attractive forces between particles suspended in the mud using to evaluate the ability of a mud to lift cuttings out of the annulus. A high YP implies a non-Newtonian fluid, one that carries cuttings better than a fluid of similar density but lower YP. YP is lowered by adding deflocculated to a clay-based mud and increased by adding freshly dispersed clay or a flocculent, such as lime.

**Yield Point, YP = [300 rpm Reading] – [Plastic Viscosity, PV]**

Unit: **lb/100 ft$^2$**

## ➢ Gel Strength

Gel strength is a measure of the ability of a colloidal dispersion to develop and retain a gel form, based on its resistance to shear. The gel, or shear, strength of a drilling mud determines its ability to hold solids in suspension. Sometimes bentonite and other colloidal clays are added to drilling fluid to increase its gel strength. Gel strength is determined when the shear stress measured at low shear rate after a mud has set quiescently for a period of time (10 seconds and 10 minutes in the standard API procedure, although measurements after 30 minutes or 16 hours may also be made). The Gel Strength is a function of the inter-particle forces. An initial 10-seconds gel and a 10-minutes gel strength measurement give an indication of the amount of gellation that will occur after circulation ceased and the mud remains in static conditions. The more the mud gels during shutdown periods, the more pump pressure is needed to initiate the circulation again.

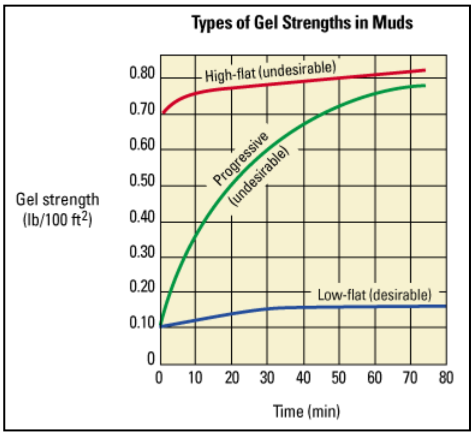



**Figure 6: Types of Gel Strengths in Mud**

## ➢ Electric Stability

Electric Stability is a test for oil-base and synthetic-base muds that indicates the emulsion and oil-wetting qualities of the sample. ES is tested by applying a voltage ES probe into a cup of 120°F [48.9°C] mud then the ES meter automatically applies an increasing voltage (from 0 to 2000 volts) across an electrode gap in the probe. Maximum voltage that the mud will sustain across the gap before conducting current is displayed as the ES voltage. This threshold voltage is referred to as the Electric Stability of the mud and is defined as the voltage. Specification value: > 600volts

## ➢ Filtration

Fluid loss is defined as the loss of a mud filtrate (Liquid phase) into a permeable formation. It is controlled by the filter cake formed of the solid constituents in the drilling fluid. The test consist of volume measurement of the forced liquid through the mud cake into the drilled formation in 30 minutes time under given pressure and temperature using standard size cell.

- *Test Equipment*

The low pressure test is made using standard cell under the API condition of 100 ± 5 psi for 30 minutes at room temperature. Filter press used for filtration tests consists of four independent filter cells mounted on common frame.

Each cell has its own valve such that any or all of the cells could be operational at the same time. Toggle valve on the top of each cell could be operated independently for the supply of air for each individual cell.

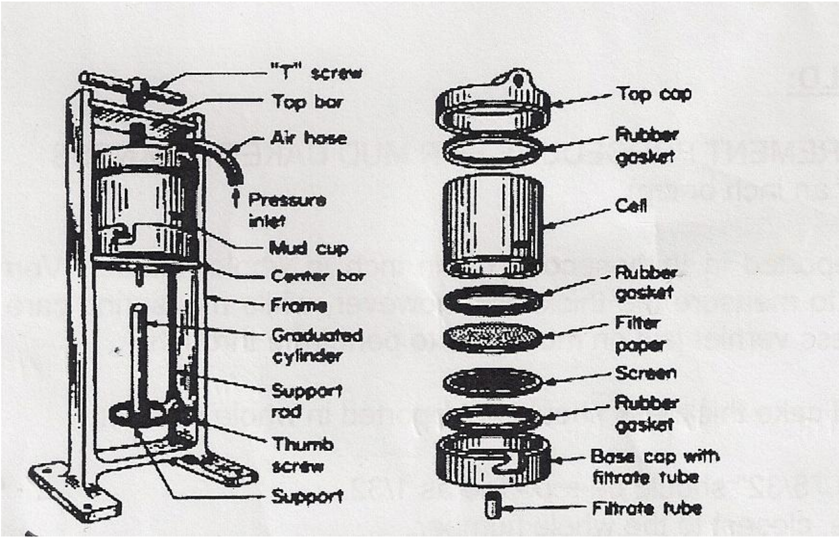



**Figure 7: Standard API Filter Press**

- *Mud cake*

Mud cake formation in drilling is very important. It is defined as the residue deposited on the borehole wall as mud loses filtrate into porous, permeable formation. One important characteristic of mud cake is its low permeability which retard further fluid loss to the formation. As this can be related to the thickness of the mud cake which may leads to many problems such as: tight hole condition, stuck pipe, formation damage and etc.

Thus, it is very important for the mud engineers to control the thickness of the mud cake and at the same time, the fluid loss into the formation. This can be achieved by adding fluid-loss additives into the mud recipe such as: Bentonite, Starch, Lignites and etc.

# CHAPTER 3

# METHODOLOGY

The study will be divided into 2 phases for FYP I and FYP II as follows:

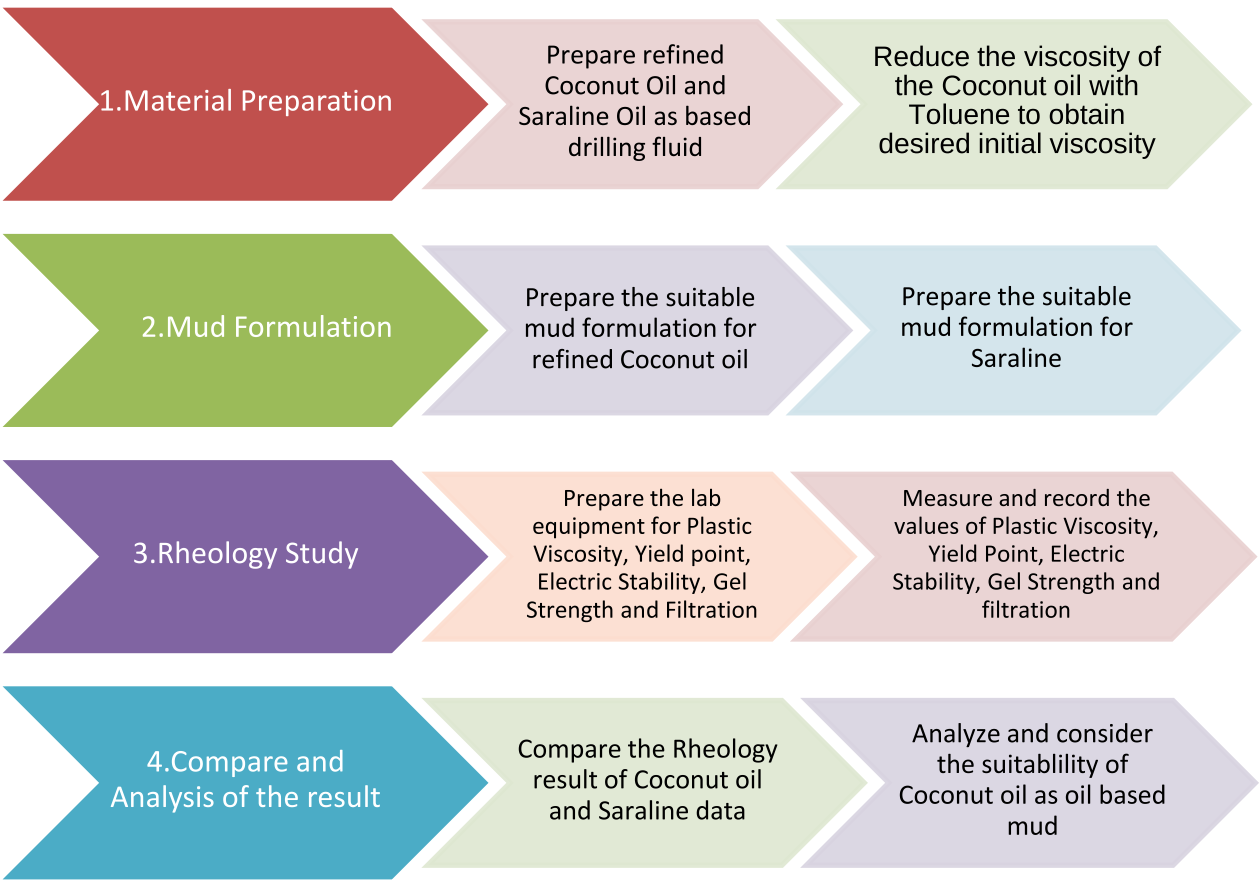
**3.1 FYP I :** Finding, Literature review obtaining efficient information & methodology to design the converting process experiment of water based drill cutting into environmental friendly organic material.

### 3.1.1 Design and Plan the drilling fluid experiment

- Sufficient information preparation base oil alternative for drilling fluid
- Preparation for the experimental set-up, seek for the place to purchase based-oil, Additives, materials, laboratory equipments and etc.
- Having the discussion with and obtain recommendation from bioremediation specialized company and organization.

**3.2 FYP II:** To conduct and analyze the experiments which resulting the most suitable solution conveying contaminate

### 3.2.1 Methodology Process



## 3.3 Based Mud Formulation

In order to obtain the test mud, we need to conduct to mud mixing with different criteria/ formula. The composition of each test has shown in the table below.

| Product | SG | Time (Mixing) | Composition (gram) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Sample#1 | Sample#2 | Sample#3 | Sample#4 | Sample#5 | Sample#6 |
| **Saraline 185V** | 0.77 | 4 min | 183.6 | - | - | - | - | - |
| **Coconut Oil** | 0.9138 | | - | 241.18 | 192.944 | 168.826 | 144.708 | 120.59 |
| **Toluene** | | | - | - | 48.236 | 72.354 | 96.472 | 120.59 |
| **CONFI-MUL P** | 0.95 | | 8 | 8 | 8 | 8 | 8 | 8 |
| **CONFI-GEL** | 1.57 | 5 min | 7 | 7 | 7 | 7 | 7 | 7 |
| **CONFI-TROL** | 1.05 | 2 min | 8 | 8 | 8 | 8 | 8 | 8 |
| **Lime** | 2.30 | 2 min | 4 | 4 | 4 | 4 | 4 | 4 |
| **Fresh Water** | 1.00 | 15 min | 59 | 67.31 | 67.31 | 67.31 | 67.31 | 67.31 |
| **$CaCl_2$** | 3.49 | | 20.9 | 12.64 | 12.64 | 12.64 | 12.64 | 12.64 |
| **DRILL-BAR** | 4.39 | 33 min | 129.46 | 1.88 | 1.88 | 1.88 | 1.88 | 1.88 |
| **Mud Density (lb/ga)l** | | | 10.8 | 9.05 | 9.15 | 8.9 | 9.1 | 9.15 |

**Table 6: Mud Composition**

***Remarks:***

**Sample#1:** Saraline Oil

**Sample#2:** Coconut Oil 100%

**Sample#3:** Coconut Oil 80% with Toluene 20%

**Sample#4:** Coconut Oil 70% with Toluene 30%

**Sample#5:** Coconut Oil 60% with Toluene 40%

**Sample#6:** Coconut Oil 50% with Toluene 50%

## 3.4 Equipment Requirement

### Equipments

- Multi Mixer
- FANN Model 35
- HTHP Filter press
- Electric Stability Meter
- Basic Lab Equipments (ex. Beaker, Heater, Oven, Separator funnel, Thermometer)

**Materials**

- Coconut Oil
- Saraline Oil
- Methyl-Benzene
- CONFI-MUL P
- CONFI-GEL
- CONFI-TROL
- Lime
- Fresh Water
- $CaCl_2$
- DRILL-BAR

### 3.5 Addition of Methyl-benzene to Castor oil

The most common methods used to reduce oil viscosity in the Biodiesel industry is called transesterification. The problem with the transestrification refining method is that it is relatively expensive and produces a quantity of glycerin byproduct that has to be processed again before it has any value. The final fuel product has detergent qualities that can clean out existing fuel tanks and the resulting debris is prone to clog fuel filters for a while.

So, to reduce oil viscosity in a less expensive and much lesser time consuming way, addition of solvent preferably Alkyl-benzene is conducted in this project. This is because addition of Alkyl-benzene reduces the density of the oil and thus decreases the oil viscosity. The purpose of making a solvent blended biofuel is to thin the resulting blended oil to near the viscosity of diesel oil and reduce its gel-point. The resulting solution should be a uniform solution without precipitates.

Vegetable oils are an attractive renewable source for alternative diesel fuels. However, the relatively high kinematic viscosity of vegetable oils must be reduced to make them more compatible with conventional compression-ignition engines and fuel systems. Cosolvent blending is a low-cost and easy-to-adapt technology that reduces viscosity (and gel point) by diluting the vegetable oil with a low-(molecular weight solvent), which is in our case is Methyl-benzene(Toluene).

Blending methods vary; however, the most common method of making Blended Biofuels Diesel (BBD) is to blend the solvent with the source vegetable oil because blending solvents with vegetable oils has three basic functions. Blending reduces the viscosity of the source oil, reduces its gel-point, and tends to force water, and other contaminants, out of solution. This means that thinned oil will drop its contaminant load much more quickly than more viscous source oil.

## 3.6 PROJECT TIMELINE FYP I

| Activities in FYP I | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W 10 | W 11 | W 12 | W 13 | W 14 | W 15 | W 16 | W 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27/5 | 3/6 | 10/5 | 17/6 | 24/6 | 1/7 | 8/7 | 15/7 | 22/7 | 29/7 | 5/8 | 12/8 | 19/8 | 26/8 | 2/9 | 9/9 | 16/9 |
| Selection of project topic | | | | | | | | | | | | | | | Study week | Final Examination Week | Semester Break |
| Preliminary research work | | | | | | | | | | | | | | | | | |
| a) Literature review: **Study of coconut oil as oil based drilling fluid in drilling operation**. | | | | | | | | | | | | | | | | | |
| Submission of extended proposal | | | | | | | | | | | | | | | | | |
| Proposal defense | | | | | | | | | | | | | | | | | |
| Project work continues | | | | | | | | | | | | | | | | | |
| Finding, Literature review, Experiment design | | | | | | | | | | | | | | | | | |
| Submission of Interim Draft Report | | | | | | | | | | | | | | | | | |
| Submission of Interim Report | | | | | | | | | | | | | | | | | |

**Table 7: Final Year Project I (May 2012) proposed activities timeline**

### 3.7 PROJECT TIMELINE FYP II

| Activities in FYP II | W 1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 | W 15 | W 16 | W 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prepare Lab equipment and material for experiment | | ■ | ■ | | | | | | | | | | | | Study week | Final Examination Week | Semester Break |
| Rheology study of coconut oil and Saraline oil | | | | ■ | ■ | ■ | ■ | | | | | | | | | | |
| Submission of Progress report | | | | | | | | ☺ | | | | | | | | | |
| Analysis of obtained result | | | | | | | | ■ | | | | | | | | | |
| Pre-EDX and poster submission | | | | | | | | | | ☺ | | | | | | | |
| Final Report Submission | | | | | | | | | | | ■ | ■ | ■ | | | | |
| EDX | | | | | | | | | | | | ☺ | | | | | |
| Final Oral Presentation | | | | | | | | | | | | | ☺ | | | | |

**Table 8: Final Year Project II (Sep 2012) proposed activities timeline**

# CHAPTER 4

# RESULT & DISCUSSION

In this experiment, there are 6 samples which different base oil compositions have been tested: Saraline Oil, 100% Coconut oil, 80% Coconut oil, 70% Coconut oil, 60% Coconut oil and 50% Coconut oil respectively. Moreover, there are two conditions have been conducted in this experimental project which is A) lab condition B) reservoir condition.

## 4.1 Base Oil Physical Properties

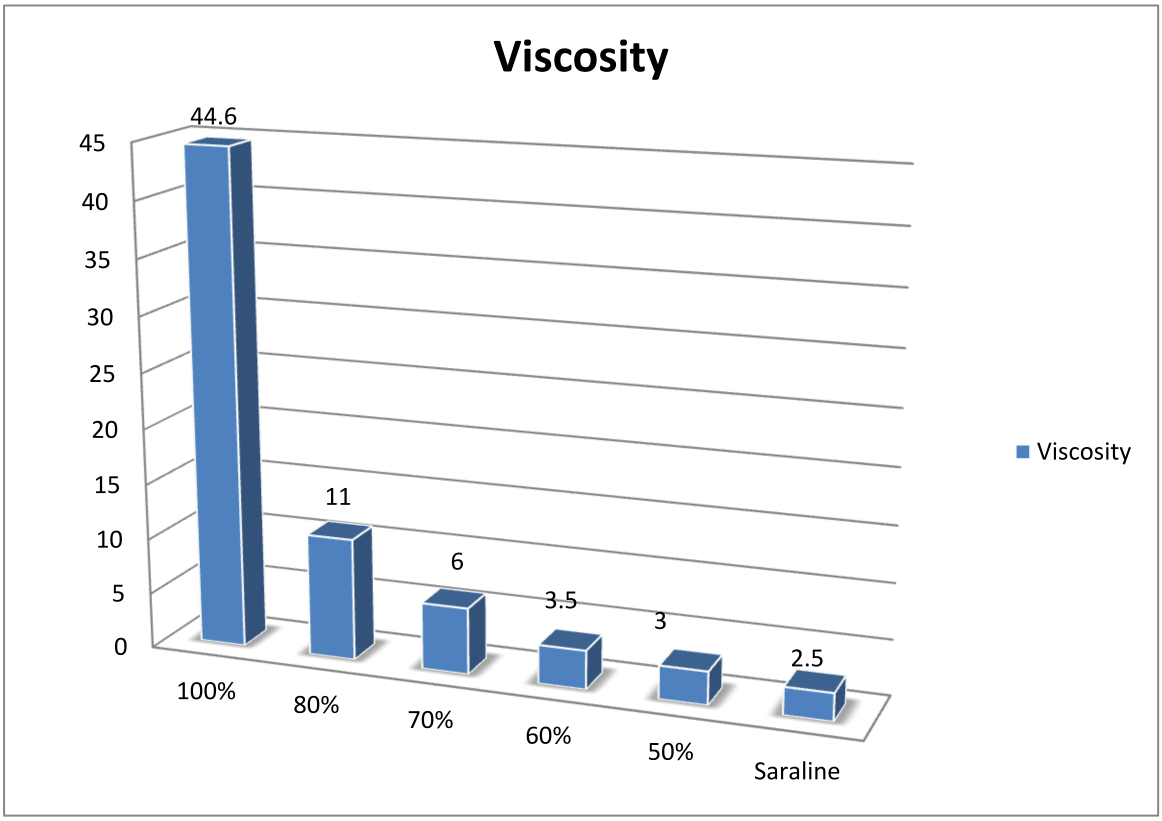
The initial testing of the base mud systems are currently being carried out. The objective is to measure the basic properties of each oil-based that will be using as the parameters to produce a suitable formulation and that the comparison tests on the mud properties by using various samples of mud. Table 9 shows the property's value of each based oil, while figure 8-9 show the comparison graph of their properties. The high pour-point of the Coconut oil is not critical in hot climates region such as South East Asia. However, it would make the oils undesirable for use in cold climates. Another undesired property is the low aniline point value where it could indicate the possibility of deterioration of rubber products on the rig. Special care should be strictly outlined to eliminate this problem. All rubber components in the drilling system should be substituted by neoprene or similar components to avoid any possible failure due to rubber degradation.

| Properties | Saraline | 100% Coconut Oil | 80% Coconut Oil | 70% Coconut Oil | 60% Coconut Oil | 50% Coconut Oil |
|---|---|---|---|---|---|---|
| 600 rpm | 5.5 | 96.5 | 23 | 13 | 8 | 7 |
| 300 rpm | 3 | 50 | 12 | 7 | 4.5 | 4 |
| Average Viscosity | 2.5 | 46.5 | 11 | 6 | 3.5 | 3 |
| Yield Point | 0.5 | 3.5 | 1 | 1 | 1 | 1 |
| Specific Gravity | 0.77 | 0.9234 | 0.9234 | 0.9 | 0.90816 | 0.9134 |

**Table 9: Based Oil Properties**

Figure 8 has summarized the data in table 9 in graphical form demonstrating that the viscosity of 100 % Coconut oil shows the maximum value of 44.6 cP which has highly significant different from 2.5 cP of Saraline. However, after the coconut oil has been dilute its density with Toluene by composition of 20%, 30%, 40% and 50% of Toluene accordingly, the results show the positive trend of decreasing viscosity of coconut oil from 44.6 cP in 100% to 11 cP(80%), 6 cP(70%), 3.5 cP(60%) and 3 cP (50%) respectively.

**Figure 8: Viscosity of each based oil**




As discussed earlier, the viscosity of the vegetable oils is very high. (about 44.6 cP). The application of these oils might cause a high PV in the mud system especially at low-temperature drilling. The problem may be solved by the following methods (Yassin, Kamis, & Abdullah, 1991)

- Dilution by mixing with thin mineral oil (not so much recommend as the introducing of mineral oil will increase the toxicity level of the mud system)
- Find other low-viscosity Coconut oil
- Emulsification a portion of oil in water
- Thinning with appropriate thinner

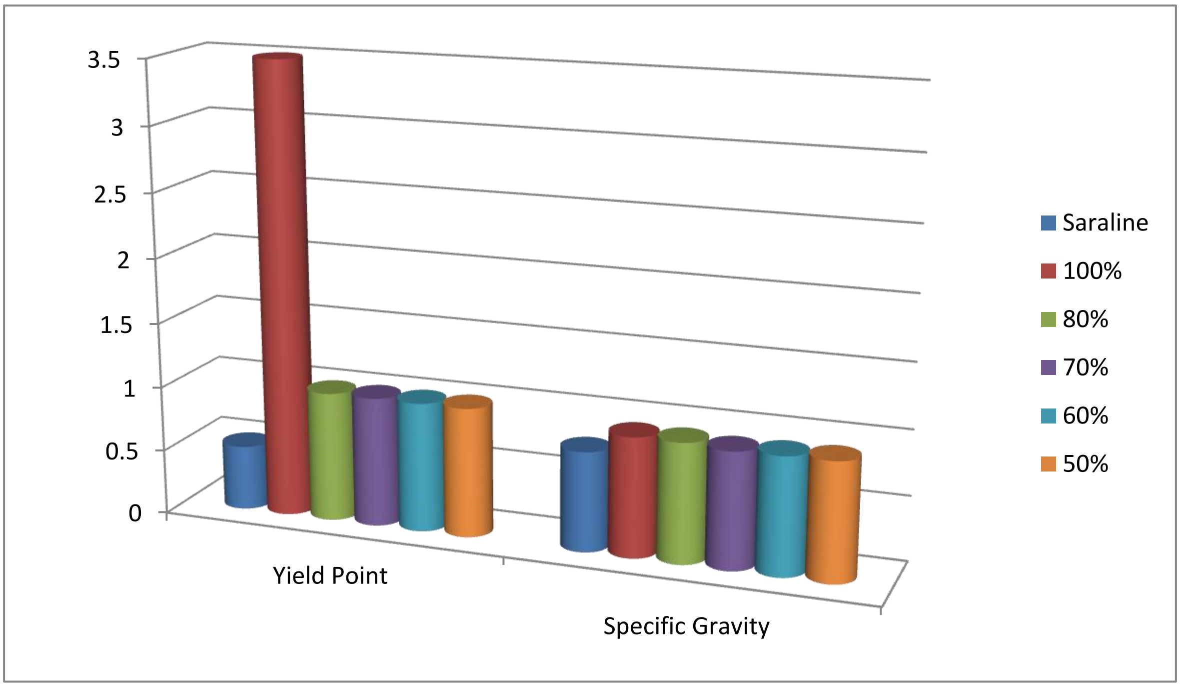



**Figure 9: Yield Point and Specific Gravity of each based oil**

Besides, Yield point and Specific gravity of base oils have shown in this figure. Yield point of 100% coconut oil again shows the maximum of the value, while Saraline obtain the minimum value. The rest of diluted coconuts give the same value of Yield point with 1 lb/100 $ft^2$.

Specific gravity of Saraline shows the minimum value obtained of 0.77, although the coconut oils show that even they have been diluted but the specific gravity still constant with approximately of 0.9

### 4.2 Lab Condition

The mud formulation process begin to create the each sample according to the formula that been conducted by the mud calculator software. The results of lab condition are presented in Table 10 & 11.

| Properties | Saraline | | 100 % Coconut Oil | | 80 % Coconut Oil | | 70 % Coconut Oil | | 60 % Coconut Oil | | 50% Coconut Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Trial 1* | *Trial 2* | *Trial 1* | *Trial 2* | *Trial 1* | *Trial 2* | *Trial 1* | *Trial 2* | *Trial 1* | *Trial 2* | *Trial 1* | *Trial 2* |
| **600 rpm** | 30 | 31.5 | 153 | 177 | 126 | 128 | 130 | 131 | 75 | 77 | 60 | 62 |
| **300 rpm** | 17.5 | 17.5 | 99 | 110 | 76.5 | 77.5 | 81.5 | 81.5 | 48 | 49 | 38.5 | 40.5 |
| **Viscosity** | 12 | 14 | 54 | 67 | 49.5 | 50.5 | 48.5 | 50 | 27 | 28 | 21.5 | 21.5 |
| **Avg. Viscosity** | 13 | | 60.5 | | 50 | | 49.25 | | 27.5 | | 21.5 | |
| **Yield Point** | 5 | 3.5 | 46 | 43 | 27 | 27 | 33 | 31.5 | 21 | 21 | 17 | 19 |
| **Avg. YP** | 4.25 | | 44.5 | | 27 | | 32.25 | | 21 | | 18 | |
| **Gel St. (10 s)** | 5 | 5 | 20 | 20 | 20 | 20 | 25 | 25 | 18 | 20 | 20 | 22 |
| **Gel St. (10 min)** | 7 | 7 | 24 | 24 | 25 | 25 | 35 | 35 | 24 | 24 | 23 | 23 |
| **Electric Stability** | 345 | 345 | 314 | 315 | 1159 | 1159 | 876 | 876 | 570 | 570 | 478 | 478 |
| **Mud Weight** | 10.8 | 10.8 | 9.05 | 9.05 | 9.15 | 9.15 | 8.9 | 8.9 | 9.1 | 9.1 | 9.0 | 9.0 |

**Table 10: Mud properties result – Lab Condition**

| Time Period | Saraline | | 100 % Coconut Oil | | 80 % Coconut Oil | | 70 % Coconut Oil | | 60 % Coconut Oil | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss |
| **5 min** | 250 | 2 | 253 | 3 | 250 | 2.5 | 260 | 2.5 | 248 | 3 |
| **10 min** | 250 | 3 | 253 | 4 | 245 | 3.7 | 250 | 3 | 252 | 3.6 |
| **15 min** | 250 | 3.8 | 249 | 4.8 | 240 | 4.5 | 250 | 3.5 | 250 | 4 |
| **20 min** | 250 | 4 | 245 | 5.5 | 240 | 5.3 | 250 | 3.8 | 247 | 4.3 |
| **25 min** | 250 | 4.5 | 245 | 6.25 | 240 | 5.5 | 245 | 4 | 245 | 4.4 |
| **30 min** | 250 | 5 | 245 | 7 | 250 | 5.9 | 250 | 4.4 | 250 | 4.5 |
| **Mud Thickness** | 0.4 cm/ 0.15in | | 0.7 cm / 0.25 in | | 0.45 cm/ 0.18 in | | 0.55 cm/ 0.23 in | | 0.6 cm/ 0.25 in | |

**Table 11: Filtration Fluid Loss – Lab Condition**

The lab condition is conducted under the room temperature and pressure which can demonstrate the normal condition of the sample that been mixed. More graphs are presented in Figure 10 – 14 showing the properties comparison. From the graphs show the coconut oil mud has much higher viscosity, yield point, gel strength and electric stability. However, the more dilute of Coconut oil, the less different on the properties of Viscosity and Yield point. Besides, it has no significant change in Gel Strength. Higher filtration volume and thicker filter mud cakes are also been observed.

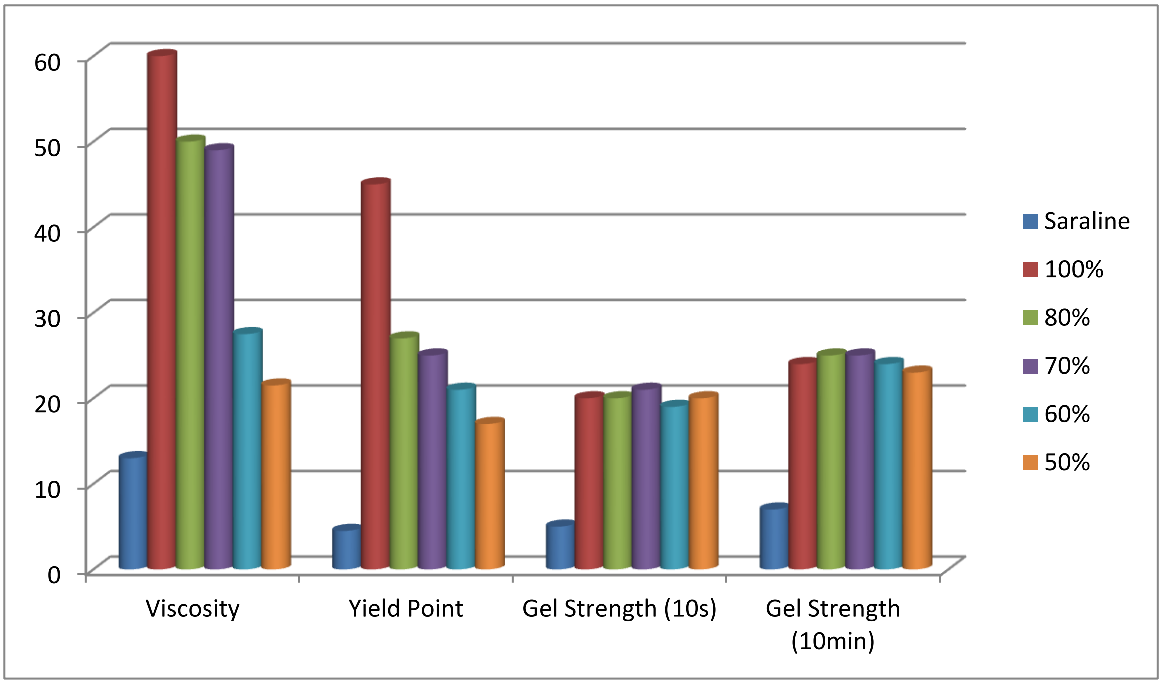



**Figure 10: Rheological Properties of each based oil – Lab Condition**

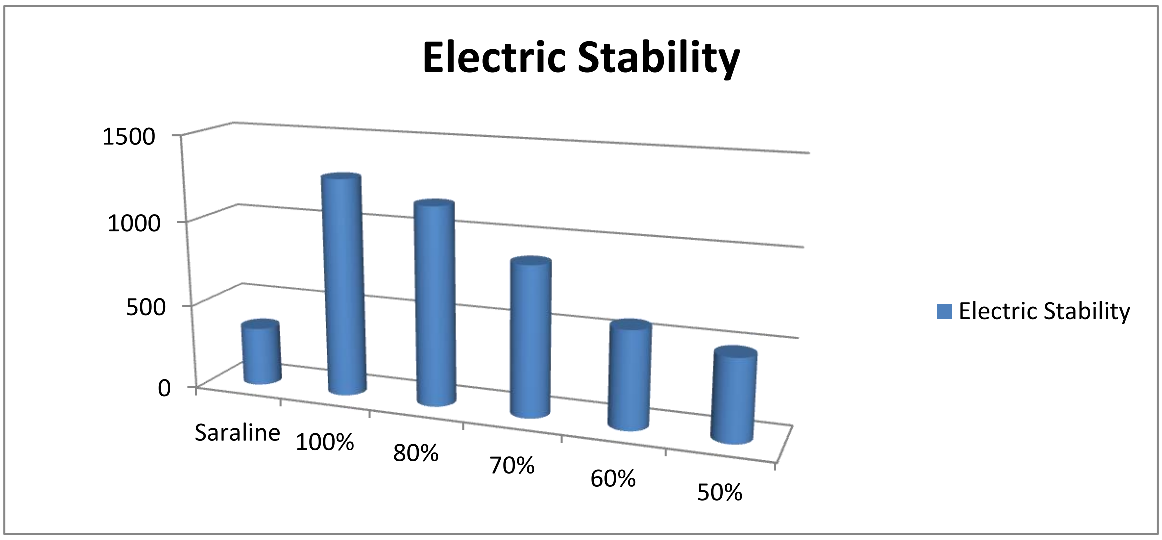



**Figure 11: Electric Stability of each base oil**

Electric stability in figure 11 demonstrate the trend that 100% Coconut oil give the highest value of electric stability due to the properties of high dense oil. However, the electric stability is decreasing according to the increasing of Toluene in coconut oil composition.

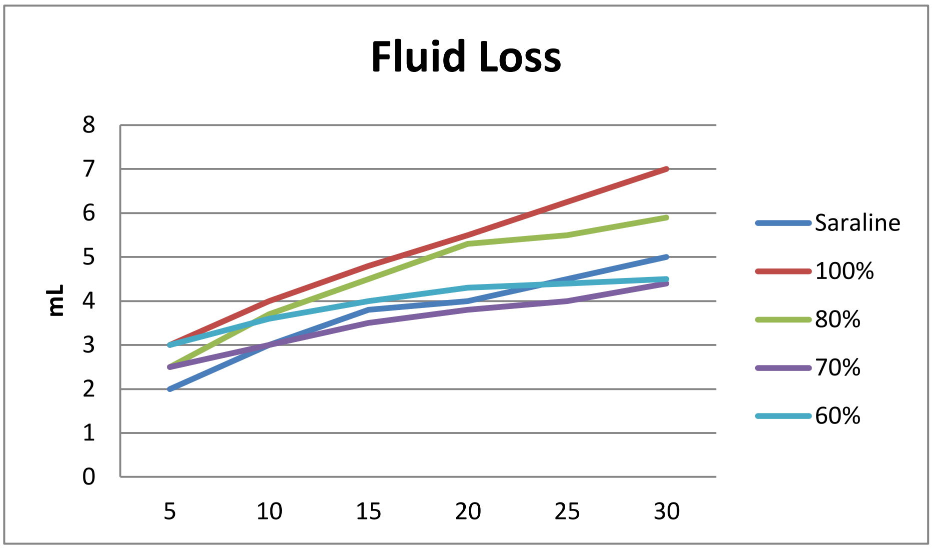



**Figure 12: Filtration Fluid loss of each based oil**

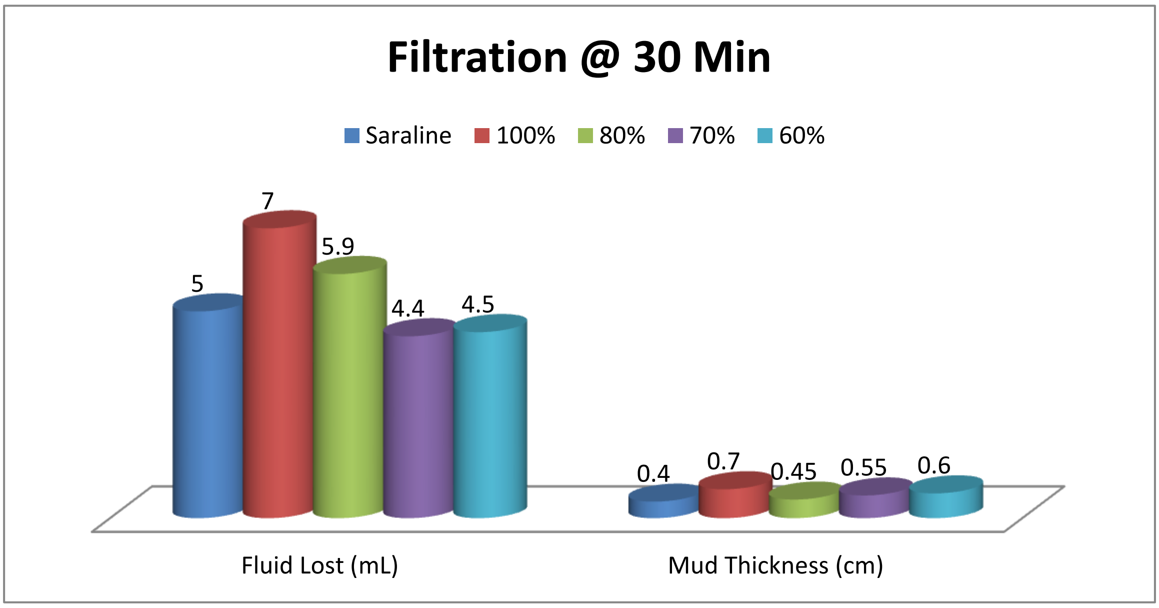



**Figure 13: Filtration & Mud Thickness at 30 min of each based oil**

The graph of amount fluid loss from 0 min to 30 mins have constructed in figure 12 which the trend of graphical lines give the positive potential to be good drilling fluid. The ideal graph of the fluid loss is that in the early minutes of conducting HTHP test, there will be steep increasing line due to high fluid loss, and then later on the loss of fluid will be decreasing until constant.

Moreover, figure 13 illustrates that 100% coconut obtains the most fluid loss (7 mL) at the end of the test with 30 mins, while the rest has decreasing the amount of fluid loss accordingly to the composition of sample. Saraline as base oil obtain 5 mL of fluid loss at 30 mins.

Furthermore, mud thickness of Saraline is 0.4 cms, while the coconut oil based are 0.7 cms. for 100%, 0.45 cms. for 80%, 0.55 cms for 70% and 0.6 cms for 60% Coconut oil. The figures of mud thickness are shown in figure 14 below.

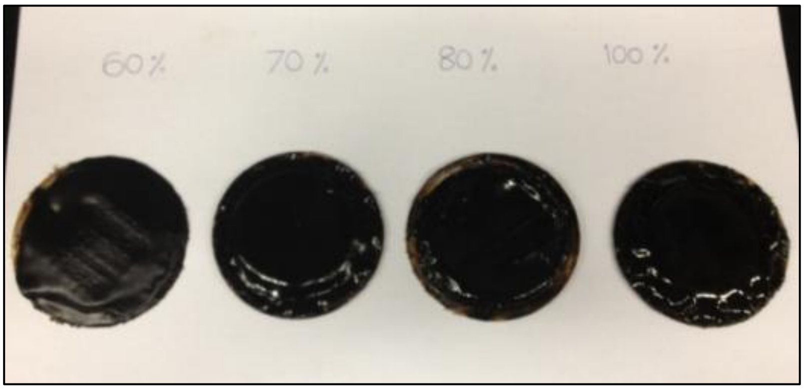



**Figure 14: Mud Thickness**

### 4.3 Reservoir Condition (After Hot Rolling)

On the other hand, the justification of the mud rheological properties had also been undertaken by putting in hot rolling to simulate down-hole condition with 120'C (250'F) and 100 psi. Table 12 shows the rheological result after hot rolling which has slightly changed from the result of before hot rolling.

**Table 12: Mud Properties result – Reservoir Condition**

| Properties | Saraline | 70 % Coconut Oil | 60 % Coconut Oil | 50 % Coconut Oil |
|---|---|---|---|---|
| **600 rpm** | 30 | 91 | 85 | 62 |
| **300 rpm** | 17 | 50 | 48 | 40 |
| **Avg. Viscosity** | 13 | 41 | 37 | 22 |
| **Yield Point** | 4 | 9 | 11 | 18 |
| **Gel St. (10 s)** | 5 | 7 | 8 | 8 |
| **Gel St. (10 min)** | 8 | 9 | 9 | 9 |
| **Electric Stability** | 354 | 1536 | 1434 | 674 |
| **Mud Weight** | 11.625 | 10.022 | 10.022 | 10.022 |

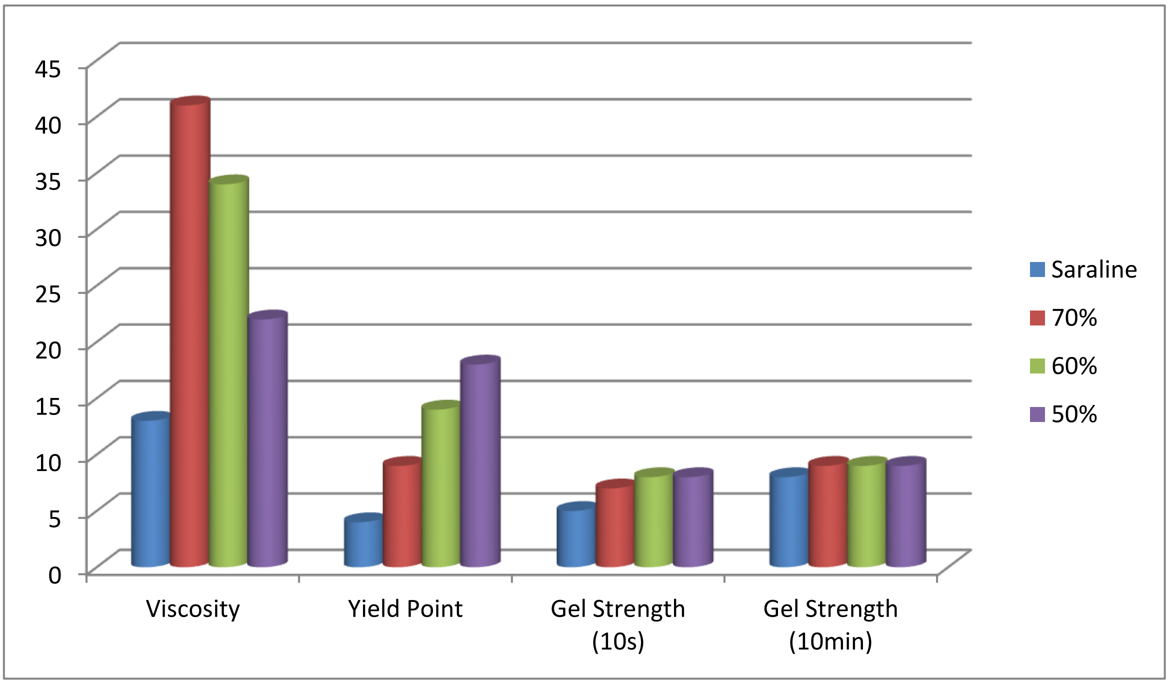



**Figure 15: Rheological Properties of each based oil – after Hot Rolling**

The comparison in Figure 15 show that there is still higher viscosity in Coconut oil which the maximum value is 70% coconut oil with 41 cP but the viscosity is decreasing due to the dilution that 37 cP in 60% and 22 cP in 50% while Saraline shows 13 cP, yet yield point result shows in opposite way where the more dilute coconut oil, the wider range of difference. Although, the gel strength value obtained appear to be just slightly difference. Moreover, the appearance of high fluid loss is still observed.

Table 13 shows the filtration after hot rolling which the significant in fluid loss can be observed.

| Time Period | Saraline | | 70 % Coconut Oil | | 60 % Coconut Oil | | 50 % Coconut Oil | |
|---|---|---|---|---|---|---|---|---|
| | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss | Temp (‘F) | Fluid Loss |
| **5 min** | 240 | 2.4 | 250 | 5 | 250 | 4.5 | 260 | 5.5 |
| **10 min** | 240 | 2.6 | 250 | 7 | 245 | 6 | 255 | 7 |
| **15 min** | 250 | 3 | 250 | 8.5 | 245 | 7 | 245 | 7.5 |
| **20 min** | 255 | 3.25 | 250 | 9.5 | 247 | 8 | 245 | 7.9 |
| **25 min** | 253 | 3.5 | 250 | 10.3 | 247 | 8.8 | 247 | 8 |
| **30 min** | 250 | 3.7 | 250 | 11.5 | 247 | 9.5 | 249 | 8 |
| **Mud Thickness** | 0.25 cm/ 0.1 in | | 0.4 cm/ 0.16 in | | 0.5 cm/ 0.1968 in | | 0.55 cm/ 0.2165 in | |

**Table 13: Mud Properties result – Reservoir Condition**

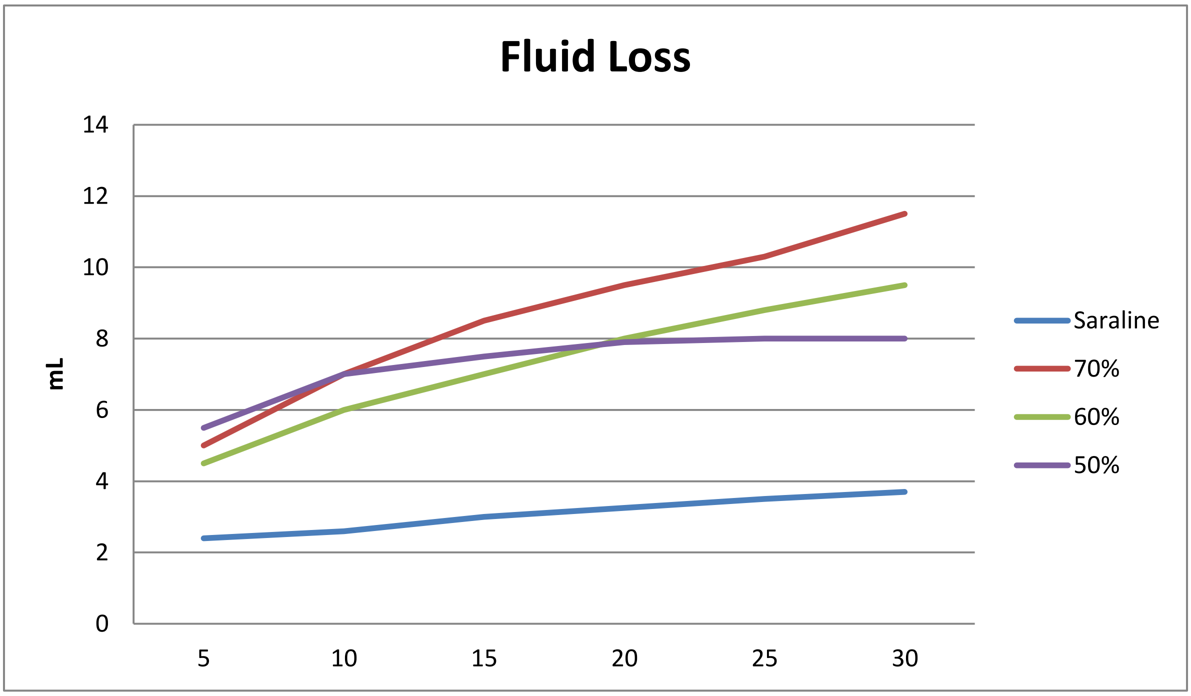



**Figure 16: Filtration Fluid loss of each based oil – after Hot Rolling**

The ideal graph of the fluid loss is that in the early minutes of conducting HTHP test, there will be steep increasing line due to high fluid loss, and then later on the loss of fluid will be decreasing until constant. Figure 16 showing the graph of amount fluid loss from 0 min to 30 mins which the trend of graphical lines also give the positive potential to be good drilling fluid similar to lab condition.

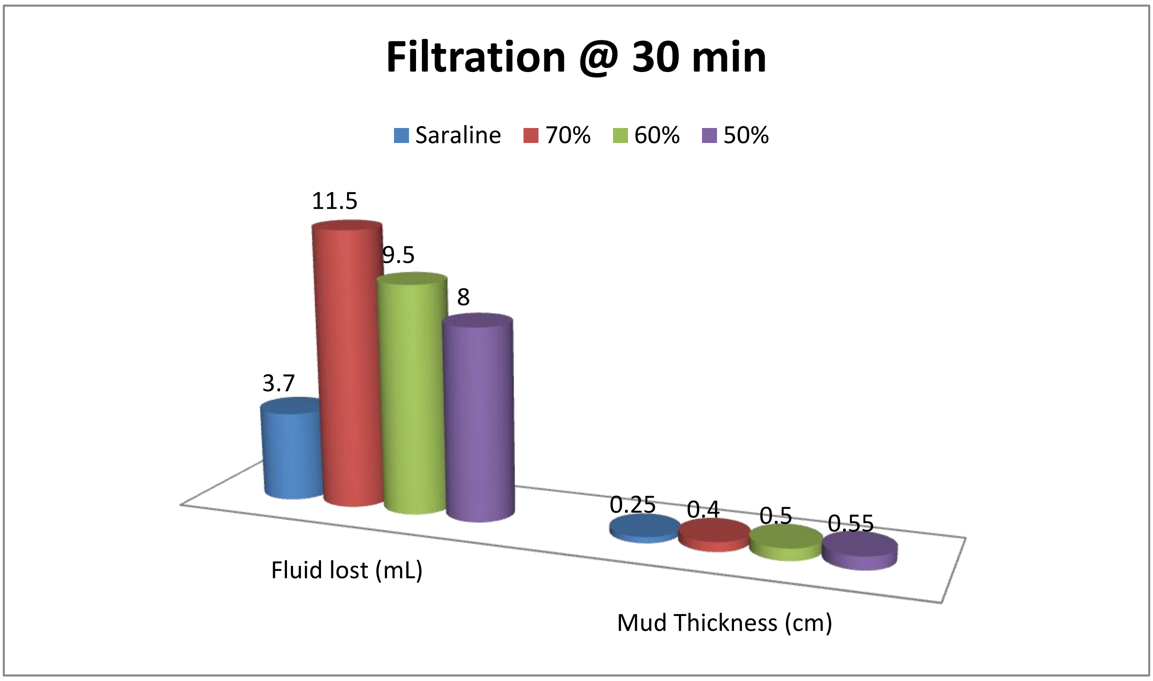



**Figure 17: Filtration & Mud Thickness at 30 min – after Hot Rolling**

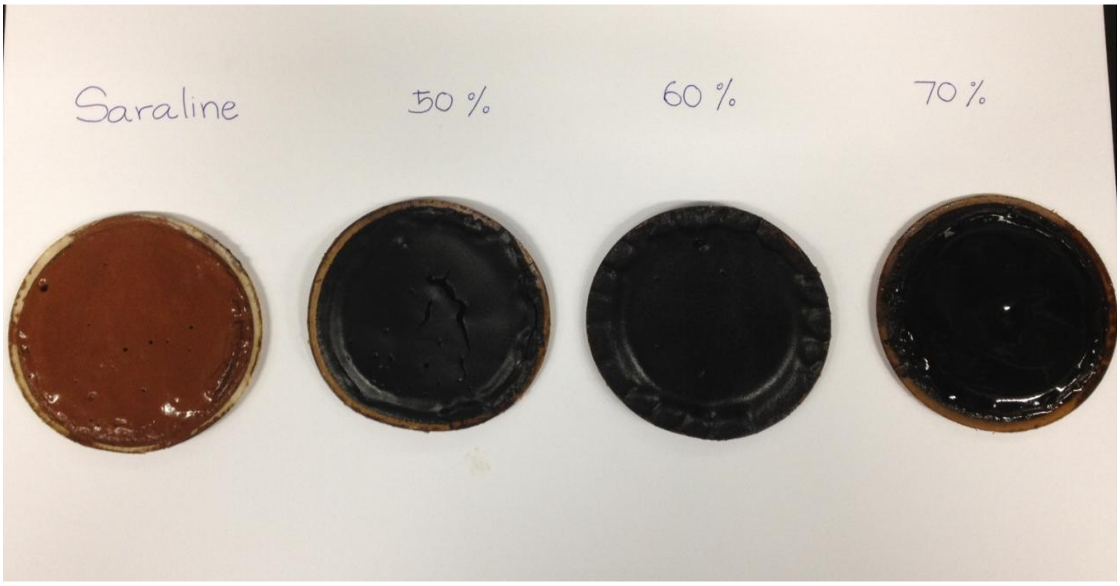



**Figure 18: Mud Thickness – after hot rolling**

Furthermore, figure 17 & 18 illustrate the filtration fluid loss at 30 mins and mud thickness which Saraline as base oil obtain 3.7 mL of fluid loss at 30 mins where 70% coconut obtains the most fluid loss (11.5 mL) at the end of the test with 30 mins, while the rest has decreasing the amount of fluid loss accordingly to the composition of sample..

Since, both conditions show high filtration volume and thicker filter mud cakes, the addition of fluid loss control agent to system was necessary in order to achieve the similar desired HPHT fluid loss value.

For Electric stability in figure 19 has also shown the similar as other graph which is 70% coconut oil has obtained the highest value of electric stability of 1536 following by 60% with 1434 and 674 in 50%. Beside, Saraline has measured to be the lowest electric stability of 354.

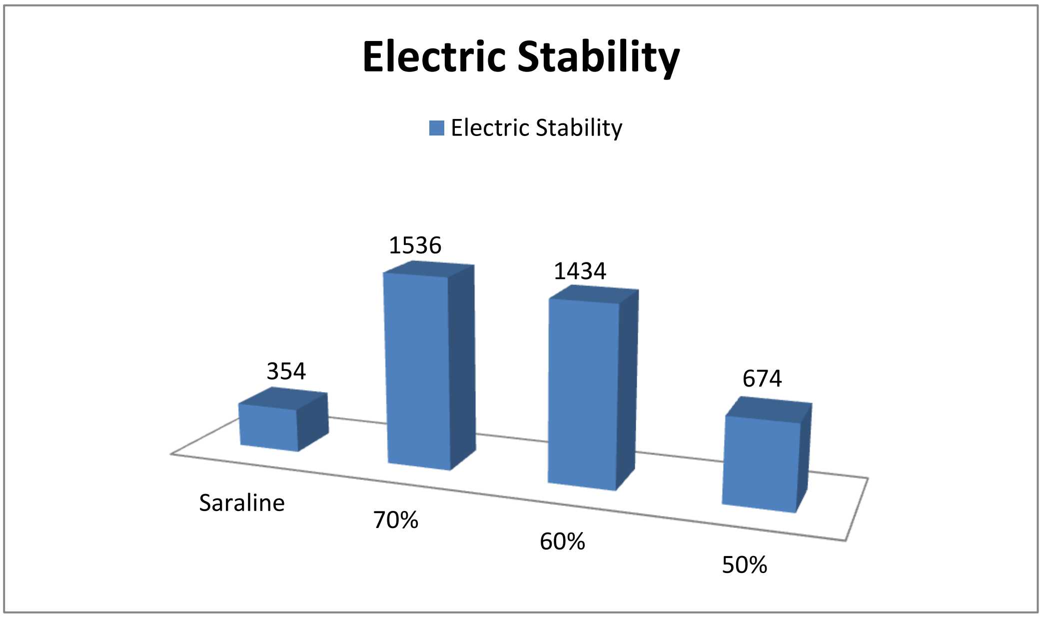



**Figure 19: Electric Stability of each based oil – after Hot Rolling**

### 4.4 Comparison of the conditions

In last section of result, the comparison of properties between lab condition and reservoir condition (figure 20-23) have been conducted to observe the change, they have no significant changed in viscosity unlike the gel strength that Saraline oil and 50% Coconut oil do not show much different but 60% & 70% show in opposite way.

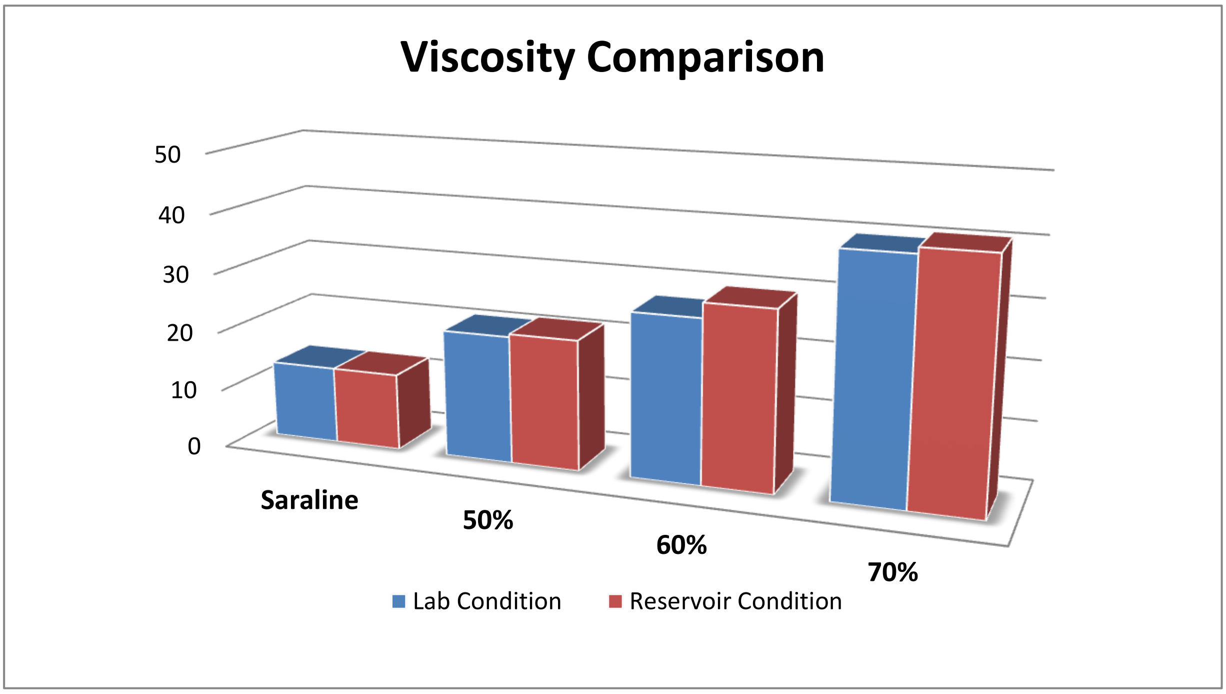



**Figure 20: Comparison of Viscosity Before/After Hot Rolling**

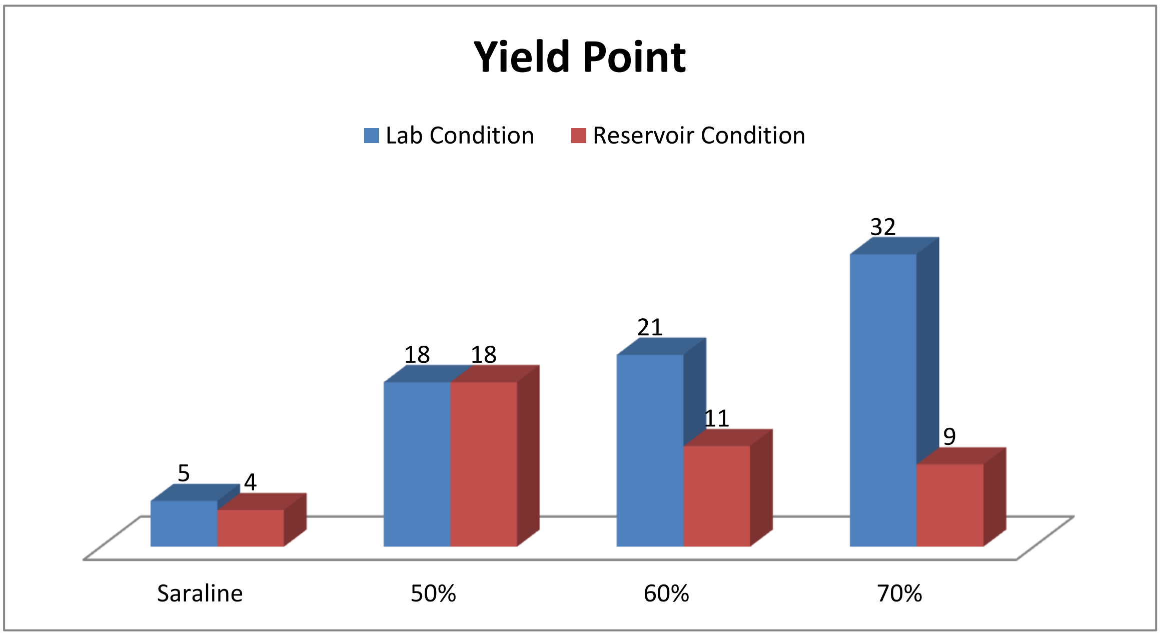



**Figure 21: Comparison of Yield Point Before/After Hot Rolling**

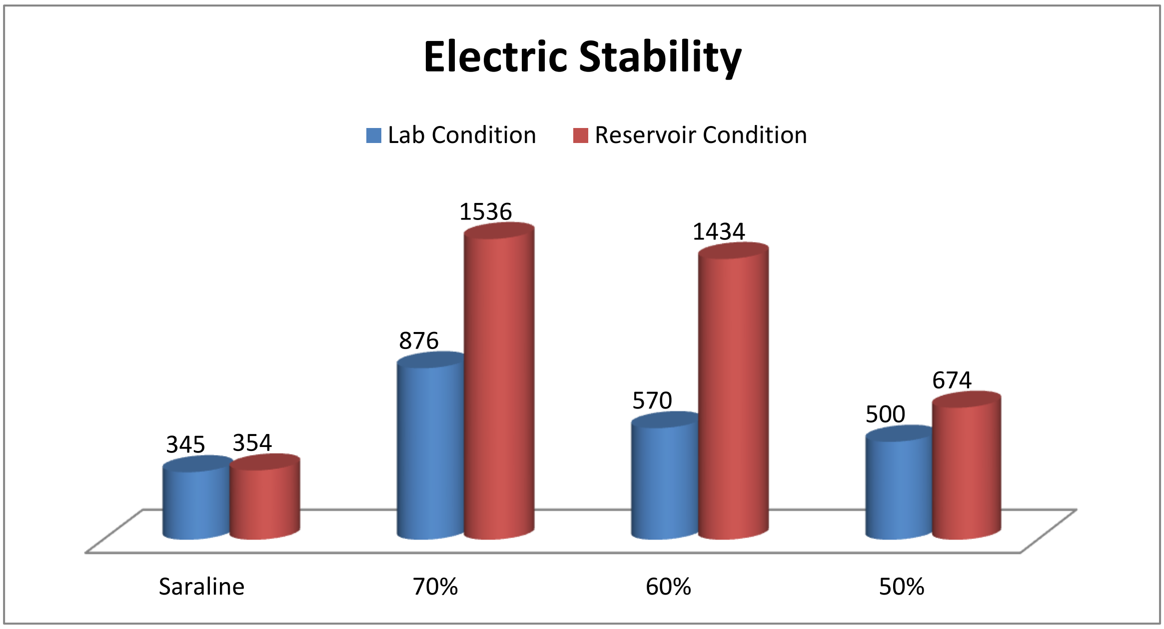



**Figure 22: Comparison of Electric Stability Before/After Hot Rolling**

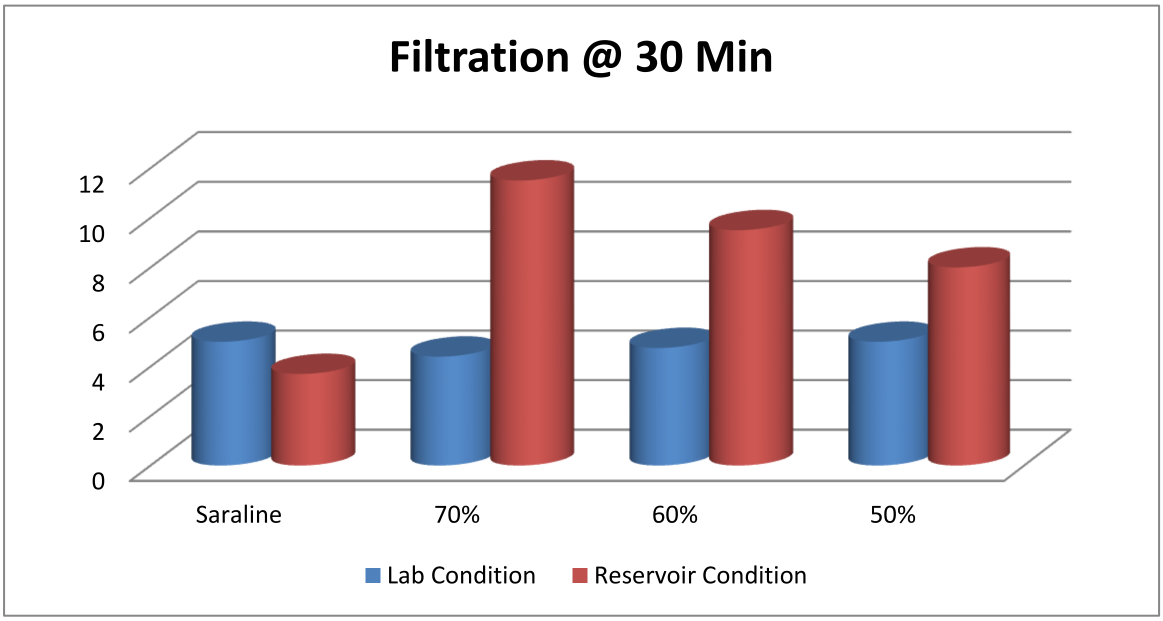



**Figure 23: Comparison of Filtration Volume Before/After Hot Rolling**

For Electric stability and filtration, Saraline oil based mud have shown just slightly different, even-though, Coconut oil based mud show clearly different which have been assumed that because of its chemical compound inside the Coconut oil itself has been affected after expose to the heat. However, further investigation still needed for this justice.

# CHAPTER 5

# CONCLUSION & RECOMMENDATION

## 5.1 Conclusion

From both lab condition and reservoir condition rheology test result, Coconut oil were found to have acceptable base oil properties, even-though it does not acquire much of an ideal base fluid to be use in drilling operation. It shows some promise for use as oil-base drilling fluid, the promising qualities are higher flash point, non-toxic and good emulsion stability. However, the vegetable oil exhibit some undesired properties that needs further investigation including high viscosity and high pour point. Therefore, further works such as reduce viscosity of coconut oil with proper agent can be treated to some extent.

In term of environmental concern, the main advantage of the vegetable oil (Coconut oil) is that they are generally regarded as non-toxic and no aromatic content and widely used in the food industries. Their flash point is higher than that of mineral oils. This value would minimize the possibility of posing extreme fire hazard continuously and will reduce the hazard of oil vapor in the mud processing areas thus provide a safer working condition to the rig workers. Anyway, the Coconut oil's environmental impact needs to be investigated in more detail.

From overall result, to use Coconut oil as alternative oil base show the positive possibility, although proper consideration of specific additive addition or appropriate mud formulation is needed to be carefully investigated and implemented.

### 5.2 Recommendation

Since this project is the first implementation of the usage of Coconut oil as base oil in drilling fluid operation, there are still on trial and error procedure. Further recommendations need to be in place in order to achieve the maximum positive outcome.

As been stated earlier, the viscosity of Coconut oil oils is very high with 44.6 cP which might cause a high PV in the mud system especially at low-temperature drilling. Therefore, a carefully studies on the decreasing of viscosity need to be implemented with appropriate procedure such as

- Dilution by mixing with thin mineral oil
- Find other low-viscosity Coconut oil
- Emulsification a portion of oil in water
- Thinning with appropriate thinner

Moreover, the detail studies on Coconut oil chemical compound would lead a proper choosing additive to drilling fluid composition because the chemical bond inside coconut oil plays main role on chemical mixing agent and the reaction between the chemical used.

Besides the theory parts, there might be error during the experiment for Coconut oil such as improper dilution process of coconut oil by Toluene or the filtration process on HTHP. Therefore, proper experimental procedures need to be confirmed to ensure the experimental result and outcome.

Finally, the recommendation of this project is to have further investigation in more detail for both theoretical part and experimental part in order to achieve and obtain the most reliable result as well as to ensure the justification that Coconut oil can be a good candidate to replace diesel in drilling fluid operation.

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