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FINAL REPORT

Developing Green Lost Circulation Material (LCM) Derived from Oil Palm Empty Fruit Bunch (EFB)

by

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Dissertation submitted in partial fulfillment of
The requirements for the
Bachelor of Engineering (Hons)
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CERTIFICATION OF APPROVAL

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Approved by,

(Puan Mazlin Binti Idrees)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JANUARY 2011

CERTIFICATION OF 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 reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(Zairul Zahha Bin Zabidi)

ABSTRACT

This report concerns on **investigation on lost circulation materials (LCM) derived from oil palm empty fruit bunch (EFB)**. This project mainly aims to study the effectiveness of using oil palm EFB as LCM additives to prevent the lost circulation problem.

The paper discusses the literature review of the lost circulation problems, the lost circulation materials and the characterization of the parameters of drilling fluid. It also confers the methodologies for LCM to resolve severe lost circulation problems and designing the mud samples, the mud densities, the rheological tests and the filtration performance volume tests. Tests have been conducted in accordance with the API 13 B and the related equipments were mixer, mud balance, viscometer and low pressure low temperature (LPLT) filter press. Properties measured through this experiment are density, plastic viscosity, yield point, 10-second and 10-minute gel strength and filtration rate.

Considering the fact that lost circulation is one of the most serious and expensive problems facing the drilling industry, lost circulation materials should be low-cost waste products, and in this case it is the oil palm EFB. Since the oil palm EFB is high in fiber, it has a very good potential to be a good fibrous LCM.

Overall, addition of 5 lb/bbl of any of the LCM additives generally improved the filtration properties; however the extent of the improvement depended on the additive material and size distribution of the additive. Nevertheless, increasing the LCM additives concentration from 5 lb/bbl and 10 lb/bbl had adversely affected and increased the amount of total filtrate volume. The optimum concentration of LCM for minimum fluid loss was found to be at 8 lb/bbl.

ACKNOWLEDGEMENT

Alhamdulillah, finally I have managed to successfully complete my Final Year Project. I would like to take this advantage to thank my supervisor, Puan Mazlin Binti Idrees for sharing her knowledge, experiences and guiding me throughout this project.

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1 INTRODUCTION

1.1 BACKGROUND STUDY

Lost circulation can simply be defined as the loss of mud to the formation. For this to occur both of the following condition must exist:

- The dynamic or static pressure exerted by the total mud column exceeds the total formation pore pressure and/or fracture gradient.
- The porosity and permeability of the formation is such that whole mud is lost to the formation thus preventing the sealing effect of the filter cake.

Lost circulation is one of the most common and potentially one of the most expensive problems encountered in a drilling operation. In the best case results are often additional operating time and increased mud and operating costs, in the worst case results are often blowouts and lost hole. Lost circulation adversely affects the overall drilling operation by:

- The lost of hydrostatic head that may result in well-control situation.
- The reduction in the pressure gradient may lead to wellbore stability, which could result in hole collapse and/or stuck pipe.
- Side tracks or complete loss of the well.
- Failure to achieve adequate annular cement coverage.
- Good quality formation evaluation may not be possible.

Due to this reason, an investigation on the lost circulation should be put in place. This will ensure that, when losses are encountered, the proper treatments are executed competently and methodically, such as using a lost circulation material (LCM) for this case. Many different type of bulk materials have been used to prevent loss of mud to the formation or to restore circulation. They may be divided into four categories:

1. Fibrous material
2. Flaky material

3. Granular material
4. Slurries whose strength increases with time after placement

These LCM are challenged at their limits of effectiveness to meet the goals of sealing the fractured, vugular, and cavernous formations. LCMs that are capable of such requirements under ideal conditions may be hampered in performance by the temperatures and chemistry encountered. And in this project, I investigated on a green LCM derived from **oil palm empty fruit bunch (EFB) fiber** for the drilling fluid formulation.

1.2 PROBLEM STATEMENT

Lost circulation is one of the most troublesome and costly problems encountered while drilling a well. It can be characterized by a reduction in the rate of mud returns from the well compared to the rate at which it is pumped down hole during a lost circulation an appreciable part or the entire volume of drilling fluid can be lost into the formation. This may happened while drilling is in progress, due to excessive hydrostatic and annular pressure drop, or during trips, when pressure surges occur due to lowering of drill pipe or casing into the hole. In general, four types of formation are responsible for lost circulation:

1. Natural or induced fractured
2. Vugular or cavernous
3. Highly permeable
4. Unconsolidated formation

A wide variety of materials have been used to combat lost circulation over the years. The choice of LCM to use in a given case is influenced to some degree by cost and availability in a given drilling area. There is a need for a LCM that is low in cost and effective in preventing drilling fluid loss and that has reduced tendency to blow around and be lost when added through the mud hopper. Oil palm EFB fiber used as medium mixed-in a special drilling fluid might solve the lost circulation problem.

1.3 SIGNIFICANCE OF THE PROJECT

The main concern of this project is to study the effectiveness of using the oil palm EFB fiber as a fluid loss additive in drilling fluid. Through this project, effective solutions which enable to reduce cost and increase the drilling performance will be achieve.

1.4 OBJECTIVES

The objectives of this research are:

- To study and understand the design of LCM.
- To investigate the effectiveness of using oil palm EFB fiber as LCM additives to prevent the lost circulation.
- To find the optimum composition of oil palm EFB fiber that can prevent for effective lost circulation.
- To analyze results and compare the oil palm EFB fiber with other LCM additives.

1.5 SCOPE OF STUDY

The scope of study for the second semester of this final year project is conducting the laboratory experiments to formulate a blend of drilling fluid with fluid loss additive and to compare the properties with the base fluid along with the industrial LCM (nut plug), and to test the efficiency of the oil palm EFB fiber for the ability to reduce the lost circulation.

2 LITERATURE REVIEW

2.1 LOST CIRCULATION DEFINITION AND CLASSIFICATION

Lost circulation is defined as the total loss of drilling fluids into the formation (Messenger 1981). For this to occur both of the following conditions must exist:

- The drilling fluid overbalances the problem formation.
- There is a path that allows the mud to flow into the formation and away from the wellbore.

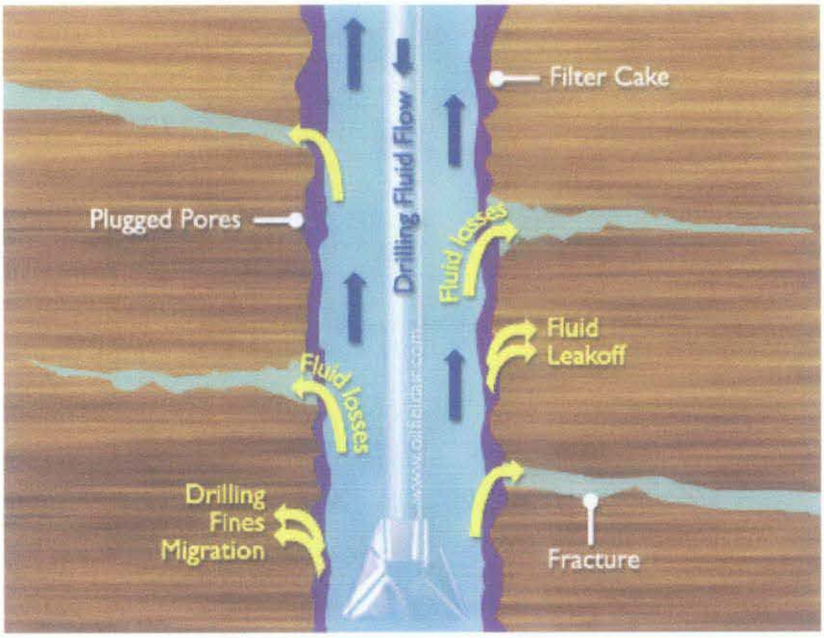

Figure 2.1 - Diagram illustrating the lost circulation

2.1.1 FORMATION TYPE OF LOSSES

Lost circulation of differing intensity can occur at any depth in various formations. In order to precisely and accurately define the situation on the rig, the type and volume of losses must be identified and classified. The type of losses can generally be classed as one of the following:

2.1.1.1 Naturally Occurring Losses

Naturally occurring losses can be defined as losses resulting from some aspect of the formation being drilled. Losses are common in various formations such as:

- Unconsolidated formations which include sand and gravel.
- Permeable formations such as poorly cemented sandstone.
- Cavernous and vugular formations which include gravel, limestone and dolomite.
- Natural fractures or fissures which can occur at all depths and in all formations. Losses increase in older, harder more consolidated formations with depth. It is common to encounter fractures near faults and areas exposed to tectonic stress. Voids and fractures can generally be recognized by a change in the drilling parameters and when this occurs losses can be expected.

Commonly, when losses occur whilst drilling these formations, they will increase proportionally with depth as more of the formation is exposed. Invariably LCM treatment of some degree, and associated lost time, is required to minimize or cure these losses.

2.1.1.2 Mechanically Induced Losses

Mechanically induced losses can be defined as losses resulting from some aspect directly related to the drilling operation. Losses are caused by over pressuring and fracturing the formation which, once fractured, will easily re-fracture with 1 over pressure. The most common causes of mechanically induced losses are:

- High hydrostatic pressure resulting from an excessive mud weight.
- High hydrostatic pressure resulting from an excessive annular cuttings load.
- High hydrostatic pressure resulting from an excessive ECD.
- High surge pressure resulting from an excessive drill string or casing running speed.

- High downhole pressure resulting from a restricted annulus.

Commonly, when losses are induced, they can be minimized or cured by altering the drilling or operational parameters without resort to loss circulation treatment.

2.1.2 SEVERITY OF LOSSES

Lost circulation occurs in varying degrees and the severity of these losses is an indicator of the mud loss to the formation. It can arbitrarily be classed as one of the following:

Table 2.1 - Classification of Loss Severity (Scomi 2010)

Type of Losses	Dynamic Losses bbl/hr	Dynamic Losses m^3/hr
Seepage losses	< 10	< 1.59
Partial losses	10 – 30	1.59 – 4.77
Severe losses	30 – 100	4.77 – 15.9
Total losses	> 100	> 15.9

2.1.2.1 Seepage Losses

Seepage losses are arbitrarily defined to as dynamic losses of up to 10 bbl per hour when circulating at the minimum pump rate used for drilling. Static losses are generally not associated with this classification. Commonly, initial seepage losses will be minimal and will increase with drilling as more of the specific formation is exposed. Losses of this severity are commonly encountered in porous sands and fractured formations.

The type of loss, naturally occurring or mechanically induced, can usually be resolved by suspending drilling, circulating the hole clean and observing the losses whilst varying the pump rate and pressure. It is not uncommon for seepage losses to self heal with time as cuttings bridge the pore throats or micro fractures.

2.1.2.2 Partial Losses

Partial losses are arbitrarily defined as dynamic losses of 10 – 30 bbl per hour when circulating at the minimum pump rate used for drilling. Static losses are sometimes associated with this classification. Losses of this severity are commonly encountered in unconsolidated formations, vugular carbonates and fractured formations.

The type of loss, naturally occurring or mechanically induced, can usually be resolved by suspending drilling, circulating the hole clean and observing the losses whilst varying the pump rate and pressure.

2.1.2.3 Severe Losses

Severe losses are arbitrarily defined as dynamic losses of more than 30 - 100 bbl per hour when circulating at the minimum pump rate used for drilling. Static losses are generally associated with this classification. Commonly, severe losses are instantaneous as fluid is lost to a void, the initial volume lost can range from tens to hundreds of barrels after which the losses may moderate or cease. Losses of this severity are commonly encountered in vugular carbonates and fractured formations. The type of loss can be assumed to be naturally occurring.

2.1.2.4 Total Losses

Total losses are arbitrarily defined as a total absence of returns when circulating at the minimum pump rate used for drilling. Static losses are also very high which necessitates new mud volume with which to maintain a full annulus. Commonly, it is often difficult, if not impossible, to mix new mud volume at the rate required to maintain a full annulus with high static losses, such a situation may result in a well control situation as the mud column and resultant hydrostatic pressure is diminished.

2.2 DRILLING FLUID

Drilling fluid is one of the most important elements of any drilling operations. The mud has a number of functions which must all be optimized to ensure safety and minimum hole problem. Failure of the mud to meet its design functions can prove extremely costly in terms of materials and time, and can also jeopardize the successful completion of the well and may even result in major problems such as stuck pipe, kicks or blowouts.

Drilling fluids are a fluid that is used in a drilling operation in which that fluid is circulated or pumped from the surface, down the drill string, through the bit, and back to the surface via the annulus. There are basically two types of drilling mud: water-based and oil-based, depending on whether the continuous phase is water or oil. Then there are a multitude of additives which are added to either change the mud density or change its chemical properties.

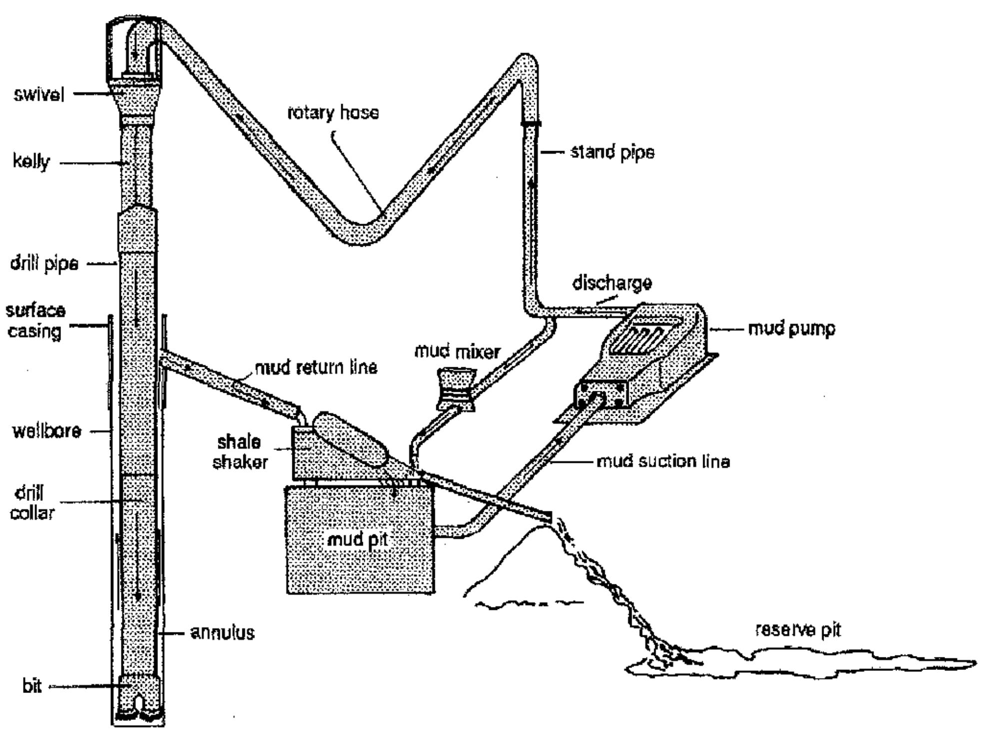

Figure 2.2 - Diagram illustrating the drilling –fluid (drilling mud) system and the flow of the fluids through the system

2.2.1 DRILLING FLUID FUNCTIONS

The drilling mud must perform the following basic functions:

i. Remove cuttings from wellbore

All cuttings from drill bit must be transported to the surface because if it is not, the drilling efficiency will decrease. Hence, mud must be designed such that it can carry cuttings to surface while circulating and to suspend the cuttings while not circulating.

ii. Cool and lubricate the bit

The rock cutting process will generate a great deal of heat at the bit so technically it will overheat and quickly wear out, unless the bit is being cooled down. The circulation of the mud will cool the bit down and help lubricate the cutting process.

iii. Protect the wall of the wellbore

The mud has to seal off the permeable formation in order to avoid any damages, hence it will form a thin impermeable mud cake (or filter cake) at the borehole wall. The cake should not be too thick, otherwise, it may cause stuck pipe.

iv. Prevent formation fluids from entering the wellbore

The mud is designed to create an overbalanced drilling condition. Hydrostatic pressure is exerted by the mud column should be slightly higher than the formation pressure because if it is not, an influx of formation fluids into the wellbore will occur. However, if the hydrostatic pressure is too high, it will fracture the formation and causes lost of circulation. The mud can sometimes seep through the filter cake and into the formation (filtrate). The lost mud and the filtrate can cause solid depositional and clay hydration in the pore space and will reduce permeability.

v. **Maintain wellbore stability**

Borehole stability problems can occur in troublesome formation and the most common problem is shale instability due to pressure differential between borehole and shale pore pressure; and the hydration of the clay within the shale by mud filtrate containing water. Pressure differential can be overcome by controlling the mud weight and the hydration of the clays can be overcome by using non-based mud or inhibited mud.

2.2.2 MUD PHYSICAL PROPERTIES

These properties are important to ensure that the mud quality has not deteriorated and must be regularly measured at the site by the field tests. If one has encountered that the mud quality has been deteriorated; it must be treated in order to function properly. (Steve Devereux)

2.2.2.1 Density

Primary control of downhole pressures is obtained with mud of such density as to exert a greater hydrostatic pressure on the formation than exists within formation pores. The lower safe limit of mud density is calculated by the density to balance the formation of the pore pressure, plus a small additional amount as a safety margin.

2.2.2.2 Fluid Loss

The fluid loss property of mud indicates how well the mud forms a seal against permeable formations. High fluid loss mud will build up a thicker, stickier wall cake that is likely to lead to problems such as differential sticking. Ideally the mud should build up a thing, tough and impermeable cake fairly quickly.

2.2.2.3 Sand Content

Sand is normally the most abrasive solid present in the mud and a high sand content will increase wear on pumps, valves and other equipments. However, all solids in the mud will contribute to mud abrasiveness. Sand content should be kept as low as possible by using the solids-control equipment properly.

2.2.3 MUD RHEOLOGY

Rheological properties measured with a rotational viscometer are commonly used to indicate solids buildups flocculation or deflocculation of solids, lifting and suspension capabilities, and to calculate hydraulics of a drilling fluid (Drilling Fluid Manual). At a given temperature and pressure, fluids a characterized by their behavior under transient conditions, as manifested by their response time to change conditions of flow. The behavior in laminar flow is characterized by their experimental flow curve.

The flow and suspension properties of drilling fluids are usually described with Bingham Plastic (BP) and power-law rheological models.

2.2.3.1 Newtonian Fluids

The shear stress of Newtonian fluids is directly proportional to the shear rate; if one variable is doubled, the other one is doubled also (Rheological Manual, 1982). The rheological equation is

$$\mu = \tau / \gamma$$

Where μ = viscosity

τ = shear stress

γ = shear rate

The equation is called Newton's Law of viscosity. All gases at ambient temperature and pressure and most simple fluid (like water) exhibits Newton behavior (Fluid Facts, 1998). The following plot is obtained in Cartesian coordinates.

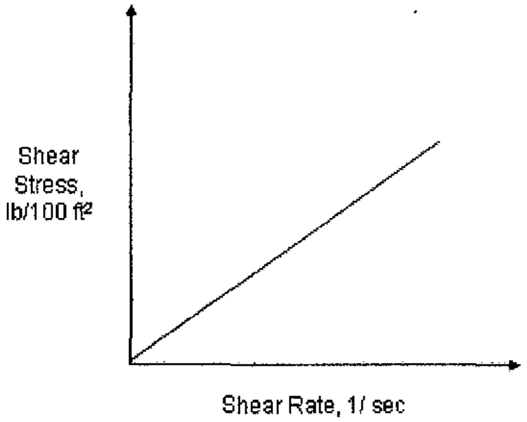

Figure 2.3 - Newtonian fluids behavior

Referring to the Figure 2.3 above, a straight line passing through the origin; the fluid begins to move as soon as a nonzero force is applied.

2.2.3.2 Non-Newtonian Fluids

Non-Newtonian fluids are fluid which has no direct proportionality between shear stress and shear rate. As shown by Figure 2.4 below.

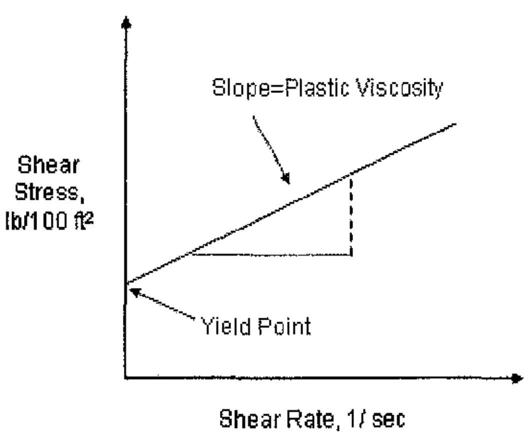

Figure 2.4 - Non-Newtonian fluids behavior

The flow behavior of non-Newtonian fluid is much more complex than Newtonian fluid. For this fluid, the viscosity varies with the shear rate. Most drilling fluids are non-Newtonian and vary considerably in their flow behavior (Fluid Facts, 1998). To be meaningful, a viscosity measurement made on a non-Newtonian must always specify the shear rate. Drilling fluid are shear thinning when they have less viscosity at higher shear rates than at a lower shear rate.

2.2.3.3 Bingham Fluids

In Bingham plastic fluids, the shear stress varies linearly with shear rate, but, unlike Newtonian fluids, a minimum force must be applied to impact motion to them. This force is known as the yield point. Such fluids are characterized by two constants (1) yield point, which corresponds to the smallest force required to set the fluid in motion (2) plastic viscosity which is the ratio between the increment in the shear stress and the corresponding increment in the shear rate, which is the curve of the slope in Figure 2.3. (Drilling Mud and Slurry Rheology Manual, 1982).

Currently, Bingham Plastic Model is the most widely used mathematical rheology model in the oil fields. Raw data are generated from 600 rpm and 300 rpm readings, which are measured by viscometer.

- Plastic viscosity (PV) = 600 rpm reading – 300 rpm reading
- Yield point (YP) = 300 rpm reading – PV

a) Plastic Viscosity (PV)

Plastic viscosity is the part of flow resistance in a mud caused primarily by the friction between the suspended particles and by the viscosity of the continuous liquid phase (Principle of Drilling Fluid Control). This parameter is a function of the concentration solids, the size and shape of the solid particles and the viscosity of the liquid phase. It increases with increasing solid content or, for constant solid content, with increasing number of solid particles (fine particles), that is, with increasing specific particle surface. A change in the plastic viscosity of a drilling fluid will cause small changes in yield point, but yield point may be altered with little or no change in plastic viscosity. Plastic viscosity and yield point are absolute flow properties and reflect the colloidal and surface active behavior of solids present in drilling fluid.

b) Yield Point (YP)

The yield point results from the cohesive forces between the particles, due to electric charges on their surfaces, on other words, it is the initial resistance to flow caused by electrochemical forces between the particles (Aminuddin, 2006). The forces exist between the solid particles are the results of positive and negative electrical charges located on or near the surface of each particle. The magnitude of these forces depend on the type of the solid and their surface charges, the amount if the solid present and the ion concentration in the liquid phase.

a) Gel Strength

The initial 10 seconds and 10 minutes gel strength are an indication of the attractive forces operative in static condition. It can be measured by using the viscometer. If the differences between these two gel strengths are large, the gel is known as progressive; if the differences are small, it is known as flat. It measures of static attractive forces, while the yield point is a measure of dynamic forces.

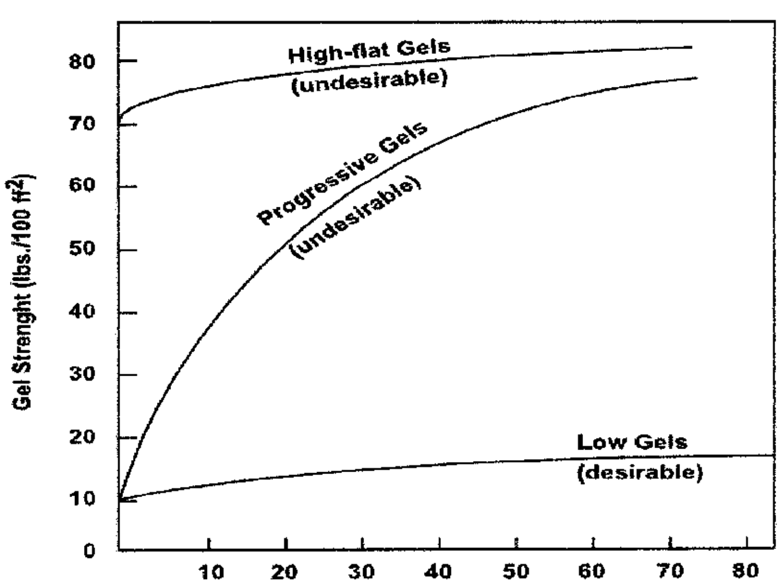

Figure 2.5 - Types of gel strengths diagram

2.3 LOST CIRCULATION MATERIAL (LCM)

According to Schlumberger Oilfield Glossary, LCM is the collective term for substances added to drilling fluids when drilling fluids are being lost to the formations downhole. Commonly used lost-circulation materials are fibrous, flaky or granular. Laymen have likened lost-circulation materials to the "fix-a-flat" materials for repair of automobile tires.

The commercially available LCM products vary from a wide variety of materials. Particle shapes are granular, flake or fibrous at sizes denoted as fine (typically 20 – 60 mesh), medium (16 – 60 mesh) and coarse (16 – 30 mesh).

- *Fibrous LCM* – Shredded sugar cane stalks (bagasse), cotton fibers, hoghair, wood fibers, sawdust, and paper pulp.
- *Flaky materials* – Shredded cellophane, mica flakes, plastic laminate and wood chips.
- *Granular materials* – Ground nutshells, calcium carbonate, sized salt, hard rubber, asphalt, gilsonite and plastic.
- *Slurries* – Hydraulic cement, diesel oil-bentonite-mud mixes, and high-filter-loss mud.

2.3.1 INDUSTRILIZED FIBROUS LOST CIRCULATION MATERIALS (LCM)

Fibrous LCM is a type of lost circulation material that is long, slender and flexible and occurs in various sizes and lengths. Fiber LCM is added to mud and placed downhole to help retard mud loss into fractures or highly permeable zones. Ideally, fiber LCM should be insoluble and inert to the mud system in which it is used. Examples are cedar fiber and cottonseed hulls.

2.3.1.1 Cedar Fiber

Cedar Fiber as shown in Figure 2.6 is a specially processed blend of fibers of controlled length, giving proper size distribution for regaining circulation. It is non-fermenting and the amount that is usually used varies from 1% to 35% by volume.

Figure 2.6 - Cedar fiber

2.3.1.2 Cottonseed Hulls

Cottonseed hulls are fibrous, biodegradable material that is an excellent bridging agent when large particle-size material is needed. They can be used in any water-base mud system. Photograph of cottonseed hulls are shown in Figure 2.7.

Figure 2.7 - Cottonseed hulls

Cottonseed hulls are used in concentrations of up to 20 lb/bbl (57 kg/m^3) as slug treatments or as an additive to the entire system. In areas of known lost circulation zones, it is advisable to pre-treat the system before drilling onto zone of loss. Cottonseed hulls can be mixed through the mud hopper or added directly to the pits and gunned into the mud. The most important aspect of combating lost circulation is using the correct particle size. Consequently, it is recommended that a combination of materials be added to ensure a good particle-size distribution.

If left in the mud for an extended period of time, cottonseed hulls can be susceptible to bacterial degradation, resulting in the release of H_2S and CO_2 into the mud. Bactericide may be necessary to prevent fermentation.

2.4 OIL PALM EMPTY FRUIT BUNCH (EFB)

Oil palm production is a major agricultural industry in Malaysia. It contributes about US$ 7.3 billion in export earnings each year, mostly from the export of palm oil. Oil palm belongs to the species *Elaeis guineensis* under the family *Palmacea*, and originated in the tropical forests of West Africa. Major industrial cultivation is in Southeast Asian countries such as Malaysia and Indonesia. Large-scale cultivation has come up in Latin America.

Figure 2.8 - Oil palm tree

Currently, there are more than three million hectares of oil palm plantations. In total, about 90 million MT of renewable biomass (trunks, fronds, shells, palm press fiber and the empty fruit bunches) are produced each year (Kamarudin, Mohamad, Arifin and Johari, 1997).

The oil palm empty fruit bunches (EFB) represent about 9% of this total. They are the residue left after the fruit bunches are pressed to extract oil at oil mills. The oil mills are located near or in the plantation itself. Oil palm EFB is a suitable raw material for recycling because it is produced in large quantities in localized areas.

Figure 2.9 - Oil palm empty fruit bunch (EFB)

Oil palm EFB fiber is one of the fibrous materials left in the palm-oil mill. Figure 2.9 shows the photographs of fruit bunch fiber. Oil palm EFB is obtained after the removal of oil seeds from fruit bunch for oil extraction. Oil palm EFB fiber is extracted by retting process of the empty fruit bunch. Average yield of Oil palm EFB fiber is about 400 g per bunch. The fibers must be cleaned of oily and dirty materials. The only current uses of this highly cellulosic material are as boiler fuel and in the preparation of potassium fertilizers. When left on the plantation floor, these waste materials create great environmental problems. Therefore, economic utilization of these fibers will be beneficial. This requires extensive study of the chemical and physical characteristics of this fiber.

Figure 2.10 - Oil palm empty fruit bunch (EFB) long fiber (left) and pulverized fiber (right)

2.4.1 EMPTY FRUIT BUNCH (EFB) PROCESSING

Oil palm EFB is now a valuable resource that has been converted into fiber for the use as:

i. Fuel for the energy or power generation
ii. Organic fertilizer or soil conditioners
iii. Filler in moulded particle boards / MDF
iv. Fiber in bales for exports
v. Mulching mats
vi. Pulp and paper
vii. Biodegradable fiber wares
viii. Light weight fiber reinforced concrete
ix. Processed animal feeds

Through continual and collaborative research and development (R&D) activities using the oil palm EFB processing system installed in many mills, the technology has improved the performance and capability of the oil palm EFB processing machine. All the machines that have been invented are able to process oil palm EFB into fiber to suit specific uses. The fibers can be baled for export or can be used directly as fuel or steam and power generation or as organic material for composting to produce fertilizer or soil conditioner (Chew Kian Sang and Tan Kim Hai, 1997).

Processing oil palm EFB into fiber involves the basic primary process of reducing the size of the bunch followed by removing the oil and water from the resultant smaller lumps. The fiber lumps are further processed through secondary processes of washing, further size reduction, drying, pressing and many others into fibers for specific end uses. These are basic processing of oil palm EFB:

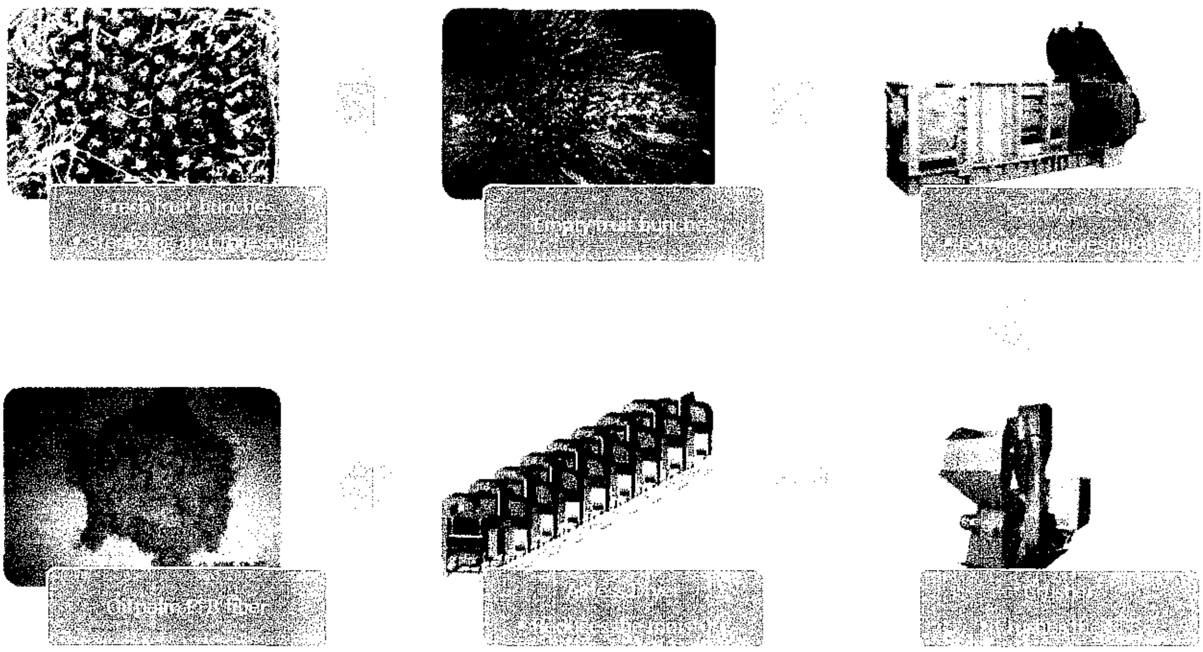

Figure 2.11 - Oil palm EFB fiber process

2.4.1.1 Bunch Reception

Fresh fruit arrives from the field as bunches or loose fruit. The fresh fruit is normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked. Large installations use weighbridges to weigh materials in trucks.

The quality standard achieved is initially dependent on the quality of bunches arriving at the mill. The mill cannot improve upon this quality but can prevent or minimize further deterioration.

The field factors that affect the composition and final quality of palm oil are genetic, age of the tree, agronomic, environmental, harvesting technique, handling and transport. Many of these factors are beyond the control of a small-scale processor. Perhaps some control may be exercised over harvesting technique as well as post-harvest transport and handling.

2.4.1.2 Threshing (Removal of Fruit from the Bunches)

The fresh fruit bunch consists of fruit embedded in spikelets growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelets from the bunch stem with an axe or machete and then separating the fruit from the spikelets by hand. Children and the elderly in the village earn income as casual labourers performing this activity at the factory site.

In a mechanized system a rotating drum quipped with rotary beater bars detach the fruit from the bunch, leaving the spikelets on the stem. Most small-scale processors do not have the capacity to generate steam sterilization. Therefore, the threshed fruits are cooked in water. Whole bunches which include spikelets absorb a lot of water in the cooking process. High- pressure steam is more effective in heating bunches without losing much water. Therefore, most small scale operations thresh bunches before the fruits are cooked, while high-pressure sterilization system thresh bunches after heating to loosen the fruits. Small-scale operators use the bunch waste (empty bunches) as cooking fuel. In larger mills the bunch waste is incinerated and the ash, a rich source of potassium, is returned to the plantation as fertilizer.

2.4.1.3 Sterilization of Bunches

Sterilization means the use of high-temperature wet-heat treatment of loose fruit. Cooking normally uses hot water; sterilization uses pressurized steam. The cooking action serves several purposes:

i. Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation.
ii. For large-scale installations, where bunches are cooked whole, the wet heat weakens the fruit stem and makes it easy to remove the fruit from bunches on shaking or tumbling in the threshing machine.
iii. Heat helps to solidify proteins in which the oil-bearing cells are microscopically dispersed. The protein solidification (coagulation) allows the oil-bearing cells to come together and flow more easily on application of pressure.

iv. Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process. The high heat is enough to partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily.

v. The moisture introduced by the steam acts chemically to break down gums and resins. The gums and resins cause the oil to foam during frying. Some of the gums and resins are soluble in water. Others can be made soluble in water, when broken down by wet steam (hydrolysis), so that they can be removed during oil clarification. Starches present in the fruit are hydrolysed and removed in this way.

vi. When high-pressure steam is used for sterilization, the heat causes the moisture in the nuts to expand. When the pressure is reduced the contraction of the nut leads to the detachment of the kernel from the shell wall, thus loosening the kernels within their shells. The detachment of the kernel from the shell wall greatly facilitates later nut cracking operations. From the foregoing, it is obvious that sterilization (cooking) is one of the most important operations in oil processing, ensuring the success of several other phases.

vii. However, during sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier to heat transfer, but oil oxidation increases considerably at high temperatures; hence oxidation risks are high during sterilization. Over-sterilization can also lead to poor bleach ability of the resultant oil. Sterilization is also the chief factor responsible for the discolouration of palm kernels, leading to poor bleach ability of the extracted oil and reduction of the protein value of the press cake.

2.4.1.4 Screw Press, Crusher and Airless Dryer

Screw press extrudes the residual oil from the oil palm EFB with nominal capacity of 8000 to 9000 kg/hr. Then, the crusher crushes the oil palm EFB into small particle for ease of drying. The crusher can operate with capacity of 100 to 250 kg/hr. Last but not least, the airless dryer reduces the moisture in the crushed empty fruit bunch to make it long lasting and easy to store.

2.4.2 OIL PALM EMPTY FRUIT BUNCH (EFB) CHEMICAL COMPONENTS AND SOLUBILITY

Table 2.2 shows the various chemical components present in the oil palm EFB fiber. The oil palm EFB fiber contains a higher percentage of cellulose. Lignin content is comparatively low. The total cellulose content of the fiber was found to be 65%. The fiber was found to be a very low ash content. All these factors contribute to better performance of the fiber as an LCM. Table 2.2 also compares the results with those of some other important natural fibers. Compared with coir fibers, oil palm EFB fiber is highly cellulosic. Coir has higher percentage of lignin than oil palm EFB fiber. However, the cellulose content of oil palm EFB fiber is slightly less than that of banana and sisal fibers, and much less than that of pineapple leaf fiber. The lignin contents of banana, sisal and pineapple leaf fibers are less than that of oil palm EFB.

Table 2.2 - Chemical Composition of Oil Palm Fibers and Some Important Fibers

Fiber	Lignin (%)	Cellulose (%)	Ash Content (%)
Oil palm EFB fiber	19	65	2
Oil palm mesocarp fiber	11	60	3
Coir	40-45	32-43	-
Banana	5	63-64	-
Sisal	10-14	66-72	-
Pineapple leaf fiber	12.7	81.5	-

Solubility of the fibers in different solvents is given in Table 2.3. Caustic soda solubility is higher when compared with other solvent solubility. The OPEFB fiber contains 10% water-soluble matter.

Table 2.3 - Solubility of Oil Palm Fibers in Different Solvents

Chemical Constituent	Oil Palm Empty Fruit Bunch Fiber (%)
Alcohol-benzene solubility	12
Ether solubility	12
1% caustic soda solubility	20

Cold-water solubility	8
Hot-water solubility	10

2.4.3 OIL PALM EMPTY FRUIT BUNCH (EFB) AS LCM

Oil palm EFB fiber is a natural fiber extracted from oil palm EFB. During the manufacturing process of oil palm EFB fiber, oil palm EFB is shredded, separated, refined and dried. The manufacturing process does not involve any chemical reaction or exposure. In the past few years, empty fruit bunches are mainly incinerated to produce bunch ash to be used back to the field as fertilizer. The conventional method of burning these residues normally creates an environmental problem as it generates severe air pollution that is prohibited by the Environment Protection Act. As a result, these residues that came from empty fruit bunch become more expensive to dispose.

For the purpose of commercialization, the standard recommends one grade oil palm EFB. In quantifying proportion of fiber length, the standard has established the following numerical values:

Table 2.4 - Standard Percentage of Fiber Length

Fiber Length (mm)	Proportion (Oven Dry Weight Basis) (%)
>100	30
>50 – 100	35
<50	35

The oil palm EFB has the highest fiber yield and is the only material commercially utilized for fiber extraction. The oil palm EFB fibers found to be strong and stable and could be processed easily into various dimensional grades to suit specific applications. The oil palm EFB fibers are also clean, biodegradable and compatible than many other fibers from other wood species.

In this study, the oil palm EFB fiber has been chosen to be the raw material of producing fiber LCM. Oil palm EFB fiber has all the characteristics and compositions to become a fiber LCM because the material is long, slender, and flexible and occurs in various sizes and lengths. The fiber LCM will be added to mud and placed downhole to help retard mud loss into fractures or highly permeable zones. Ideally, fiber LCM should be insoluble and inert to the mud system in which it is used.

2.5 COST COMPARISON BETWEEN NUT PLUG, CORN COB AND OIL PALM EFB

Lost circulation is the most expensive problems encountered in a drilling operation. It causes additional operating time and increased in mud and operating costs. By finding the lost circulation material that is low in cost, it can certainly decrease the operating costs.

From Figure 2.12, we can see that nut plug has the highest price in the market which is USD 200/metric ton. It is followed by corn cob and oil palm EFB with USD 85/metric ton and USD 28/metric ton respectively. Oil palm EFB has the lowest price and the difference with nut plug and corn cob is significant. Oil palm EFB is cheap in this region because oil palm is a major agricultural industry in Malaysia and it is made from oil palm fruit waste.

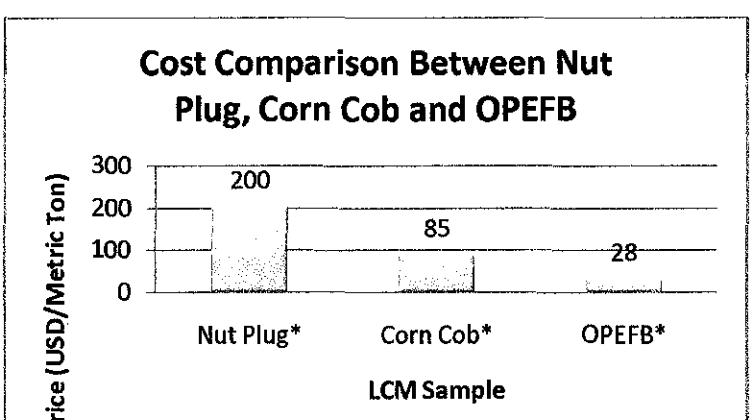

Figure 2.12 - Cost comparison between nut plug, corn cob and OPEFB

**The nut plug and corn cob prices were based from alibaba.com and oil palm EFB was based from Ir. Dr. Shahir Liew.*

3 RESEARCH METHODOLOGY

3.1 PROCEDURE IDENTIFICATION

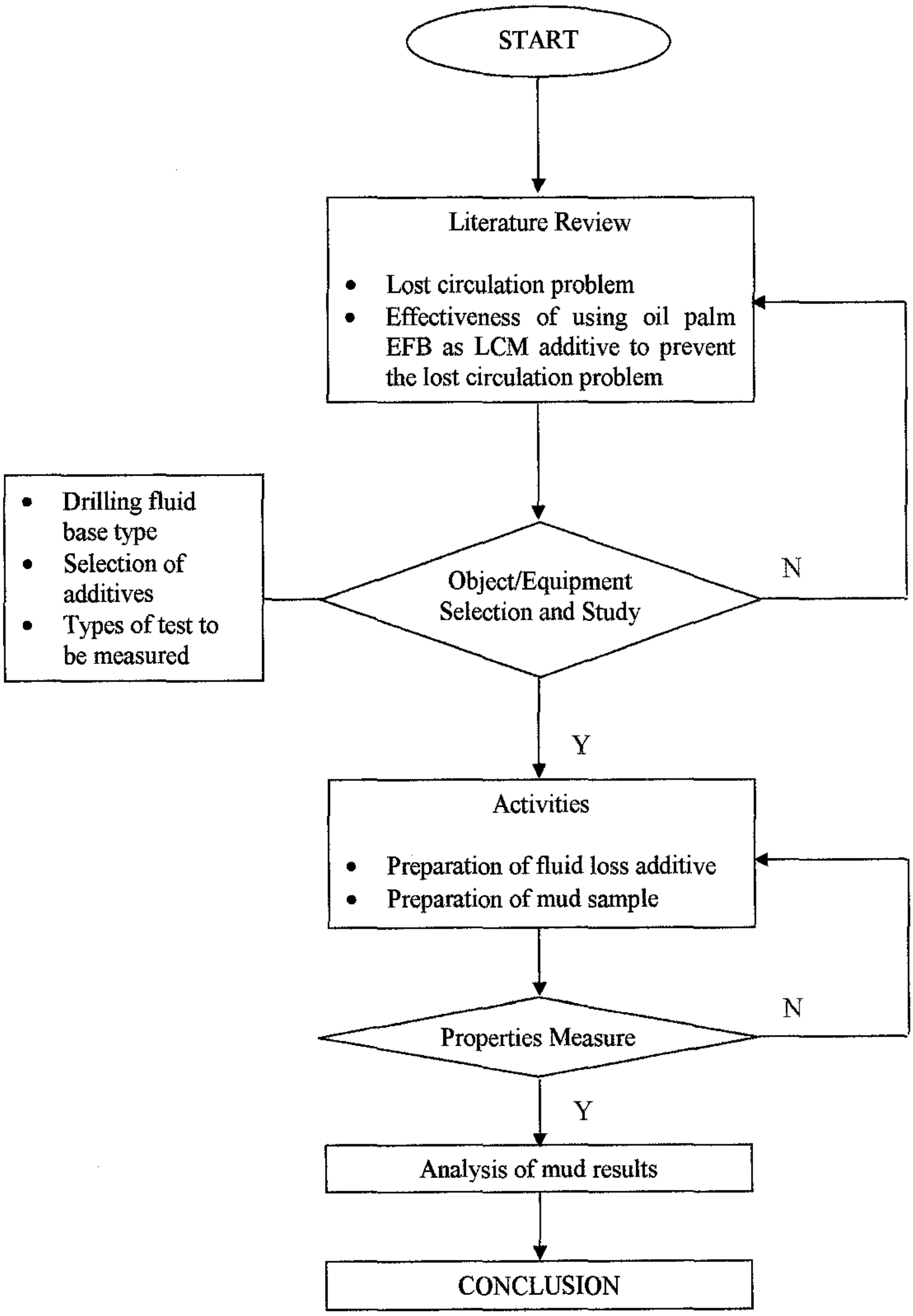

Figure 3.1 - Process Flow Chart

3.2 PROJECT ACTIVITIES

For the second stage of this project, I need to start with the experiments to proof that the oil palm EFB can be a good lost circulation material. Before starting the experiments, I have to make sure all the materials and equipments are available and in good condition. To make sure that the materials are sufficient for the experiments, I went to Scomi Warehouse in Kemaman Supply Base (KSB) during the semester break to get the basic materials to make a drilling fluid.

Figure 3.2 - A visit to Scomi Warehouse, KSB

After I finished all the preparation, the most important part which is the experiment can be done. Among the tests that I did inside the drilling fluid laboratory were mud density test, rheology test and filtrate volume performance test. Each of the test need to be done carefully as it is important to get the best data to analyze the result.

Lastly, I analyzed the result data from the experiment and compare my result with other LCM. In this project, I am investigating the effectiveness of oil palm EFB as a natural LCM.

3.3 GANTT CHART AND KEY MILESTONES

No	Details	Week													
		01	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**
1	Project work commences	■	■	■	■	■	■	■	■						
2	Submission of Progress Report								◎						
3	Project work commences									■	■	■			
4	Pre-EDX combined with seminar											◎			
5	Poster Exhibition											◎			
6	Submission of Final report											◎			
7	Final Oral Presentation														◎
8	Submission of hardbound copies														◎

◎ Key milestone ■ Process

Figure 3.3 - Gantt chart for FYP 2

3.4 PREPARATION OF ADDITIVES

The oil palm EFB fiber will be extracted by retting process of the empty fruit bunch. Retting process will be done by soaking the empty fruit bunch in water or expose to moisture to facilitate the removal of the fiber from the woody tissue by partial rotting. Average yield of oil palm EFB fiber is about 400 g per bunch. The fibers must be cleaned of oily and dirty materials.

Since the retting process will consume a lot of time, I got the oil palm EFB fiber straight from the oil palm factory with the help from Ir. Dr. Shahir Liew. Ir. Dr. Shahir Liew is the current Head of Department for Universiti Teknologi PETRONAS Civil Engineering Department and the owner of Sabutek (M) Sdn. Bhd. His factory produces oil palm EFB fiber for variety of usage.

Figure 3.4 - Meeting with Ir. Dr. Shahir Liew

Figure 3.5 - Field trip to Sabutek (M) Sdn. Bhd. at Teluk Intan, Perak

3.5 BASE SAMPLE

The base sample is set for the purpose of comparison before the usage of additives into the mud formulation. It consists of water, soda ash as total hardness reducer, bentonite as viscosifier, flowzan or xanthan gum dispersible, barite as weighting agent and caustic soda as a pH modifier. The experiments were conducted in accordance with the standard stipulated in API RP 13B-1: Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids.

3.6 NUT PLUG AND CORN COB SAMPLE

Nut plug and corn cob are well known LCM in the oil and gas industry. They are the best candidates to be used as benchmark to compare with the oil palm EFB. The nut plug and corn cob samples were prepared in order to measure the change in properties such as plastic viscosity (PV), yield point (YP), gel strength and filtration loss as compared to the base case.

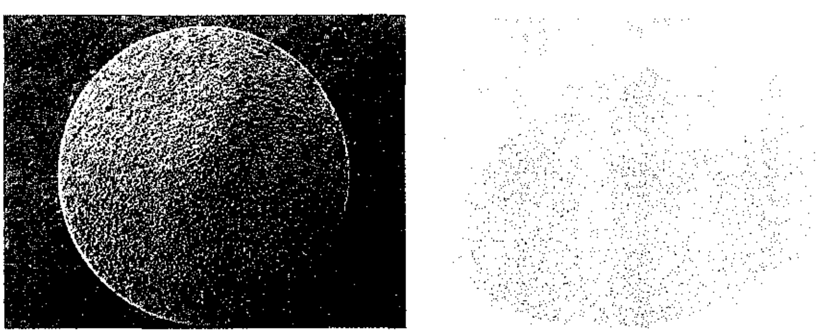

Figure 3.6 - Nut plug (left) and corn cob (right)

3.7 DESIGNING DRILLING FLUIDS

i. 0.5 ± 0.01 g of soda ash was added into 318.73 ± 5 cm^3 deionized water while stirring.
ii. After 2 ± 0.5 minutes, a suspension of 75 μm bentonite powder will be prepared by adding 12 ± 0.01 g of bentonite into the mixture while stirring.
iii. After stirring for 7 ± 0.5 minutes, 0.3 ± 0.01 g of viscosifier or commercially known as flowzan was added into the mixture.

iv. From time to time, the container is will be removed from the mixer and its side is scraped with the spatula to dislodge any bentonite adhering to the container walls. All bentonite clinging to the spatula are being assured to incorporate into the suspension.

v. After stirring for 12 ± 0.5 minutes, 109.19 ± 0.01 g of barite was added into the mixture.

vi. After 30 minutes, the additives were added into the mixture carefully.

vii. Lastly, 0.25 ± 0.5 g of caustic soda was added into the mixture.

viii. The container is then will be replaced and continued to stir. The container may need to be removed from the mixer and the sides scraped to dislodge any bentonite clinging to container walls after another 5 minutes therefore total stirring time is equal to 40 ± 1 minute.

Figure 3.7 - Flowchart of the mud mixing process

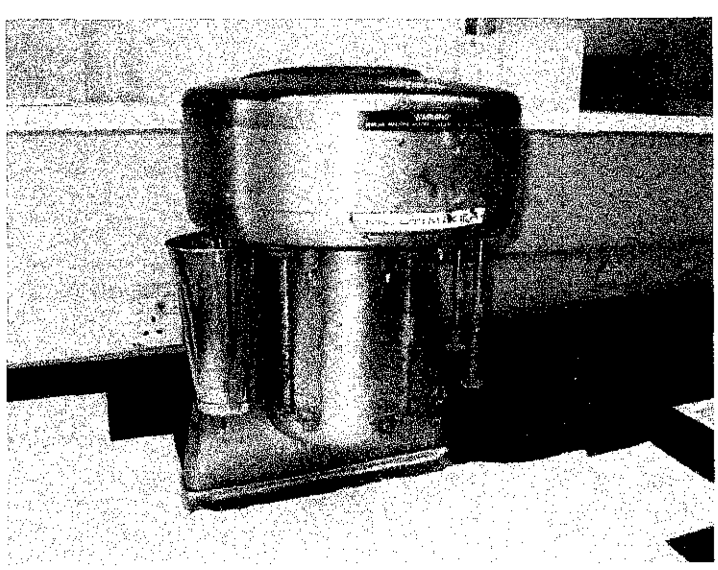

Figure 3.8 - FANN multi mixer

3.8 DRILLING FLUID TESTS

3.8.1 DETERMINING MUD WEIGHT USING THE MUD BALANCE

i. Instrument base must be set on a flat level surface.

ii. Measure and record the mud temperature.

iii. Fill the mud cup with the mud to be tested.

iv. Replace cap and rotate until it is firmly sealed, ensuring some of the mud is expelled through the hole on top, to free any trapped gas.

v. Place the beam on the base support and balance it by using the rider along the graduated scale. Balance is achieved when the bubble is directly under the centre line.

vi. Take the mud weight reading.

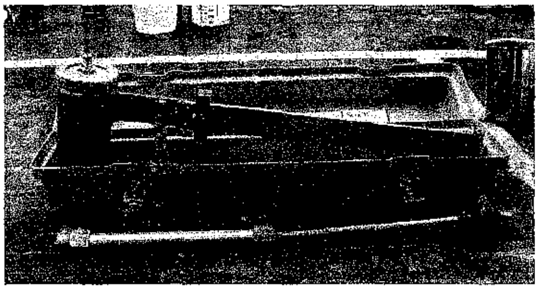

Figure 3.9 - Mud balance

3.8.2 RHEOLOGY TEST

In mud rheology testing, rheometer is used. It is important to frequently monitor the mud rheology as to make sure that the mud is always within the specification as stated in the mud program:

i. Place the sample in the rheometer thermo cup and adjust the cup until the mud surface level is equal height to the scribed line on the rotor surface.

ii. Turn on the rheometer, first taking dial measurements at the top most speed (600rpm), then gradually switch to lower gear and to obtain all readings (600,300,200,100,6,3rpms).

iii. **Determining PV** – indicate the amount of solids (sands, silts) in mud. High PV means that the mud is not clean and there is a problem with the solids control equipment.

PV = 600 rpm -300 rpm

i. **Determining YP** – indicate the carrying capacity of cuttings (usually the case is that the higher the viscosity is, the higher the YP is)

YP = 300 rpm – PV

ii. **Determining Gel Value of the mud using Rheometer**:

    i. Stir the sample in 600rpm speed for 15 seconds. Just fefore the motor stops, slowly shift the moving gear to the lowest speed.
    ii. Wait for 10 seconds. After 10 seconds has finished, turn on the 3rpm speed and record the maximum deflection of the dial. This is the 10 seconds gel reading.
    iii. Repeat step one and step two, but this time, wait for 10 minutes before turning on the 3rpm speed. The maximum deflection of this reading shall give us the 10-minute gel reading.
    iv. Rewrite the gel value as (dial = 10 secs) / (dial = 10 mins)

3.8.3 DETERMINING API FILTRATE USING FILTER PRESS

The API filtrate is a test designated to determine the milliliters of filtrate lost in 30 minutes under a 100 psi pressure. Knowing the fluid loss is important since it is bad to have mud that has a high filtrate loss because this contribute to high fluid invasion and also thick mud cakes.

Figure 3.10 - FANN viscometer (left) and LPLT filter press (right)

4 RESULTS AND DISCUSSION

4.1 *COMPOSITION AND PROPERTIES OF DRILLING FLUID TESTED*

The experiments were conducted according to the standard which has stipulated in American Petroleum Institute – API 13B-1; '*Recommended Practice Standard Procedure for Testing Water-Based Drilling Fluid*'. In the experiment, the mud was mixed with additives as suggested by the API 13B-1 such as bentonite, and any changes of the properties were observed. Below are the composition of the additives used in the experiment in Table 4.1 and properties of drilling fluid tested for concentration of 5 lb/bbl and 10 lb/bbl in Table 4.2 and Table 4.3 respectively.

Table 4.1 - General composition of additives for the samples

Components	Base Sample	Nut Plug Sample	Corn Cob Sample	OPEFB Fiber Sample
Water (ml)	318.73	318.73	318.73	318.73
Soda Ash (g)	0.5	0.5	0.5	0.5
Bentonite (g)	12	12	12	12
Flowzan (g)	0.30	0.3	0.3	0.3
API Barite (g)	109.19	109.19	109.19	109.19
Caustic Soda (g)	0.25	0.25	0.25	0.25
Additives (g)		5 -10	5 -10	3-15

Table 4.2 - Properties of Drilling Fluid Tested for Concentration of 5 lb/bbl

Initial Properties	Base Sample	Nut Plug Sample	Corn Cob Sample	OPEFB (150μm)	OPEFB (600μm)	OPEFB (1.18mm)
Mud Weight (ppg)	10.5	10.5	10.5	10.5	10.5	10.5
Rheology at ...	120 F	120 F	120 F	120 F	120 F	120 F
600 rpm	45	49	39	48	33	30
300 rpm	32	36	30	34	24	22
200 rpm	26	29	26	30	19	16
100 rpm	20	23	21	23	16	12
6 rpm	9	11	15	13	13	9
3 rpm	8	10	15	10	11	9
PV, cP	13	13	9	14	9	8
YP, lb/100 ft^2	19	23	21	20	15	14
Gel 10 sec	7	10	17	11	12	14
Gel 10 min	13	18	25	16	21	24
Mud Thickness	1	2.00	2.02	2.00	2.35	2.40
API, cc/30 min	19	13.8	19.0	12.8	14.5	17.5

Table 4.3 - Properties of Drilling Fluid Tested for Concentration of 10 lb/bbl

Initial Properties	Base Sample	Nut Plug Sample	Corn Cob Sample	OPEFB (150μm)	OPEFB (600μm)	OPEFB (1.18mm)
Mud Weight (ppg)	10.5	10.5	10.5	10.5	10.5	10.5
Rheology at ...	120 F	120 F	120 F	120 F	120 F	120 F
600 rpm	45	50	41	53	36	33
300 rpm	32	35	31	38	25	23
200 rpm	26	25	25	27	21	17
100 rpm	20	20	20	20	16	14
6 rpm	9	8	13	9	11	11
3 rpm	8	7	12	7	10	10
PV, cP	13	15	10	15	11	10
YP, lb/100 ft^2	19	20	21	23	14	13
Gel 10 sec	7	10	13	8	11	12
Gel 10 min	13	12	25	10	20	20
Mud Thickness	1	2.20	2.17	2.00	2.40	2.45
API, cc/30 min	19	15	19.5	12.8	16.0	18.5

4.2 PLASTIC VISCOSITY (PV)

Plastic viscosity (PV) is proportional to rate of shear, thus largely reflects the resistance to flow due to mechanical friction of the particles. High viscosity liquids are relatively immobile when subjected to shear (a force applied to make them move), whereas low viscosity fluids flow relatively easily. Measurement of viscosity and other rheological properties were made using rotational rheometer inside the drilling fluid laboratory.

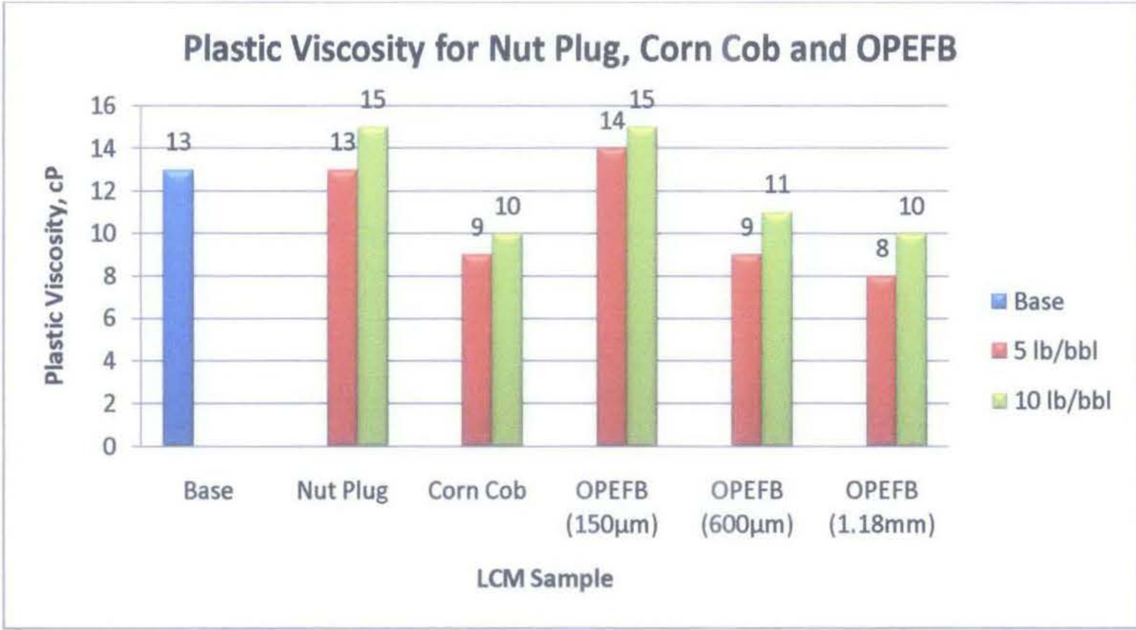

Figure 4.1 - Plastic viscosity for nut plug, corn cob and OPEFB in 5 lb/bbl and 10 lb/bbl

Figure 4.1 above illustrates the PV for base, nut plug, corn cob and oil palm EFB samples for concentration of 5 lb/bbl and 10 lb/bbl. From the figure, we can see that the viscosity for nut plug, corn cob and oil palm EFB samples increased as the concentration increased from 5 lb/bbl to 10 lb/bbl. The friction is caused by solids concentration. As for the 3 different sizes of oil palm EFB samples, the PV increased as the size of the oil palm EFB decreased from 1.18 mm to 150 µm. From *Scomi Oiltools Handbook*, the PV increases if the volume percent of solids increases or if the volume remains constant, and the size of the particle decreases. Decreasing particle size increases surface area, which increases frictional drag. Thus, the results for PV that obtained from the experiments are proven.

4.3 *YIELD POINT (YP)*

Yield point (YP) is the initial resistance to flow caused by electrochemical forces between the particles. This electrochemical force is due to changes on the surface of the particles dispersed in the fluid phase.

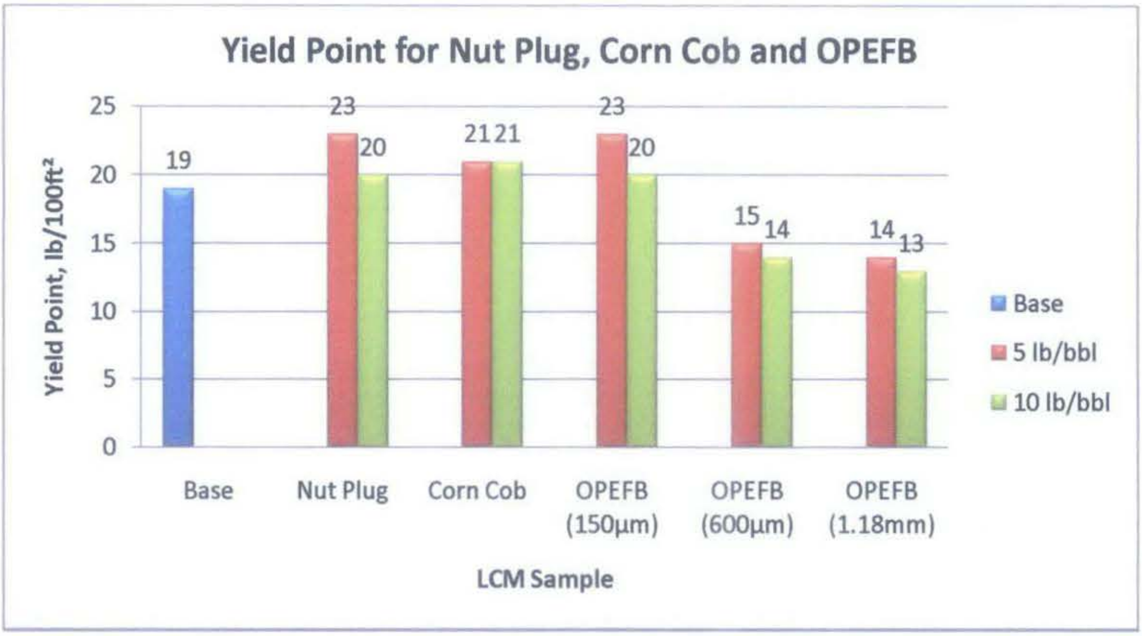

Figure 4.2 - Yield point for nut plug, corn cob and OPEFB in 5 lb/bbl and 10 lb/bbl

Figure 4.2 above illustrates the YP for base, nut plug, corn cob and oil palm EFB samples for concentration of 5 lb/bbl and 10 lb/bbl. From the figure, the YP for all sample decreased as the concentration increased from 5 lb/bbl to 10 lb/bbl except for corn cob sample as the YP maintained at 21 lb/100ft^3. It basically showed the same trend, with a reduction in the yield point as the amount was increased. As for the 3 different sizes of oil palm EFB samples, the 1.18 mm was found to have a lower value compared to 600 µm and 150 µm. This was due to the fact that there is more solid content in the fluid sample of 150 µm as compared to 1.18 mm, thus decreased the distances between inter-particles. Further increment of the amount would result in the value of yield point to decrease.

The yield point is sensitive to the electrochemical environment, indicating the need for chemical treatment. The yield point might be reduced by the addition of substances which neutralize electric charges such as thinning agent and by addition of chemicals to precipitate the contaminants.

4.4 GEL STRENGTH

Gel strength, 10-second and 10-minute, measured on the viscometer; indicate strength of attractive forces (gelation) in a drilling liquid under static conditions. Excessive gelation is caused by high solids concentration leading to flocculation.

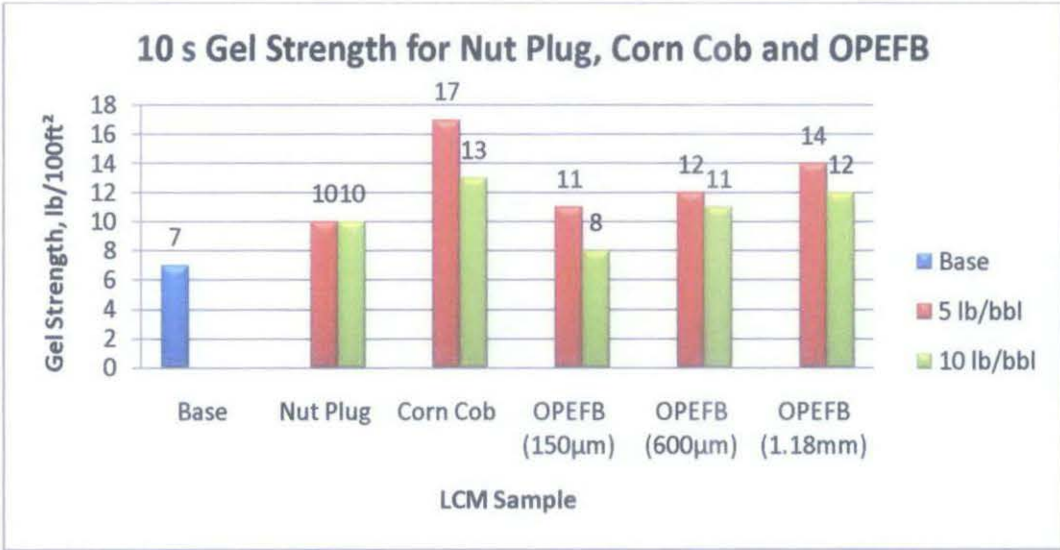

Figure 4.3 - 10-second gel strength for nut plug, corn cob and OPEFB in 5 lb/bbl and 10 lb/bbl

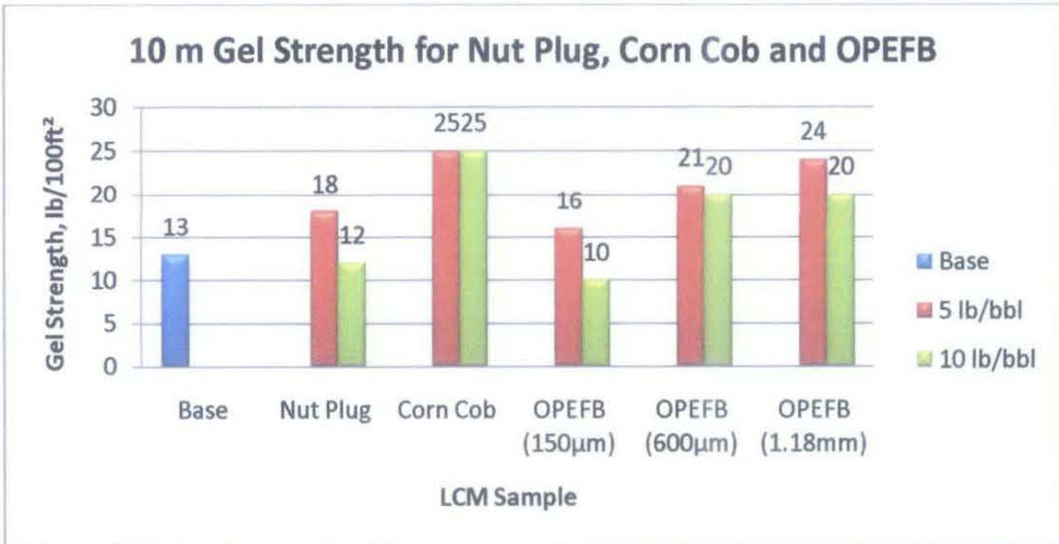

Figure 4.4 - 10-minute gel strength for nut plug, corn cob and OPEFB in 5 lb/bbl and 10 lb/bbl

Figure 4.3 and Figure 4.4 above illustrate the 10-second and 10-minute gel strength for base, nut plug, corn cob and oil palm EFB samples in 5 lb/bbl and 10 lb/bbl.

From both of the figures above, we can see that the gel strength decreased as the concentration is increased from 5 lb/bbl to 10 lb/bbl except for nut plug in 10-second gel strength and corn cob in 10-minute gel which had the same gel strength for both concentrations.

As for the 3 different sizes of oil palm EFB samples, the particle size of 1.18 mm showed a higher value as compared to 600 μm and 150 μm. The trends of the graph for gel strength are almost identical with the yield point graph. This could be probably due to the attractive forces in the mud system.

Gel strengths and yield point are both a measure of the attractive forces in a mud system. A decrease in one usually results in a decrease in the other; therefore, similar chemical treatments are used to modify them both. The 10-second gel reading more closely approximates the true yield stress in most drilling fluid systems.

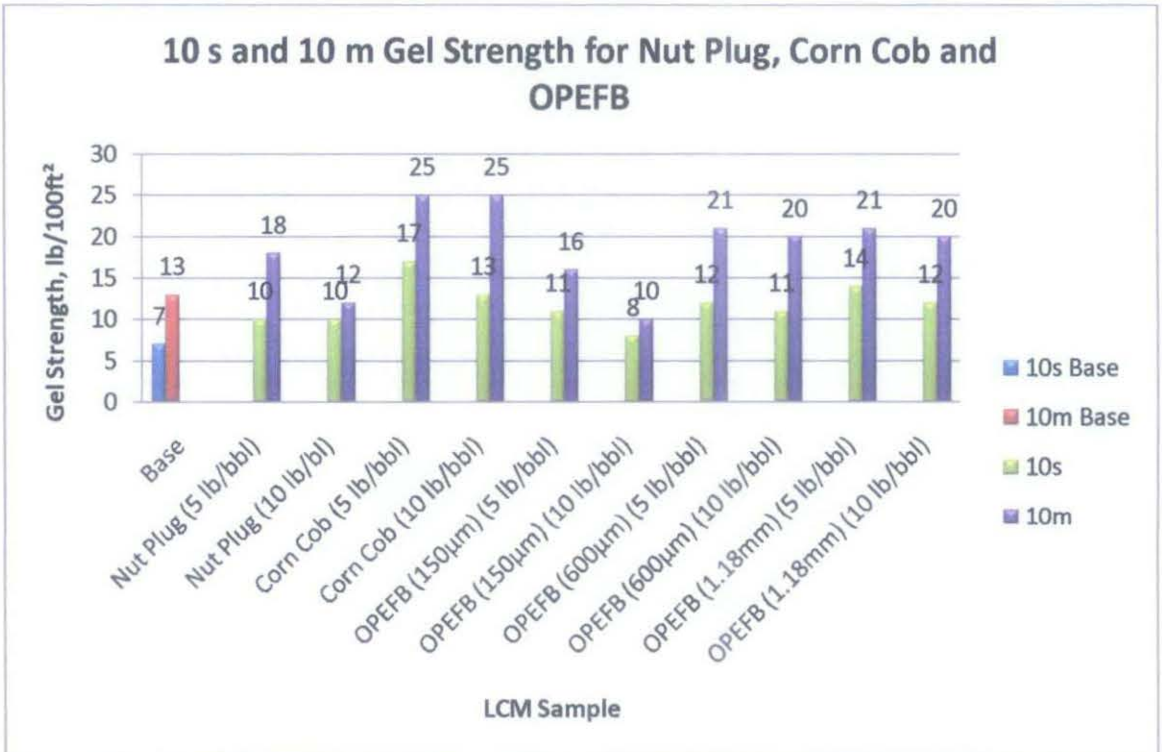

Figure 4.5 - 10-second and 10-minute gel strength for nut plug, corn cob and OPEFB in 5 lb/bbl and 10 lb/bbl

Figure 4.5 is the 10-second and 10-minute gel strength for nut plug, corn cob and OPEFB in 5 lb/bbl and 10 lb/bbl. From the figure, the values between 10-second and 10-minute gel strength are acceptable. The most significant difference between 10-

second and 10-minute gel strength is for corn cob at concentration of 10 lb/bbl. It is important to compare between the 10-second and 10-minute gel strength because if there is a wide range between the initial and 10-minute gel readings, they are called "progressive gels" which is not a desirable situation.

The magnitude of gelation with time is a key factor for the performance of the drilling fluid. Gelation should not be allowed to become much higher that is necessary to perform the function of suspension of cuttings and weight material. For suspension "low-flat gels" are desired.

4.5 FILTRATES

Filtrates are the liquid part of the mud. When the mud is forced against a permeable zone, the solids in the mud will form a plaster or "wall cake" against the formation face. Some of the liquid fraction will filter through this cake and into the formation. This liquid fraction (water plus dissolved salts) is the filtrate.

4.5.1 EFFECT OF LCM MATERIAL TYPE AND CONCENTRATION

The effect of LCM material type and concentration on total filtrate with water based mud is shown in Figure 4.6. As it can be seen, the 150 μm oil palm EFB fiber performed better than other samples. The next best performer is the nut plug sample.

As for the effect of LCM concentration, addition of 5 lb/bbl of the additives have improved filtration properties of the mud compared to the plain base mud for all additives. As the figure show, increasing the additives concentration from 5 lb/bbl to 10 lb/bbl has adversely affected the filtration properties, and in the case of corn cob in concentration of 10 lb/bbl sample, the filtrate amounts have exceeded that of base sample.

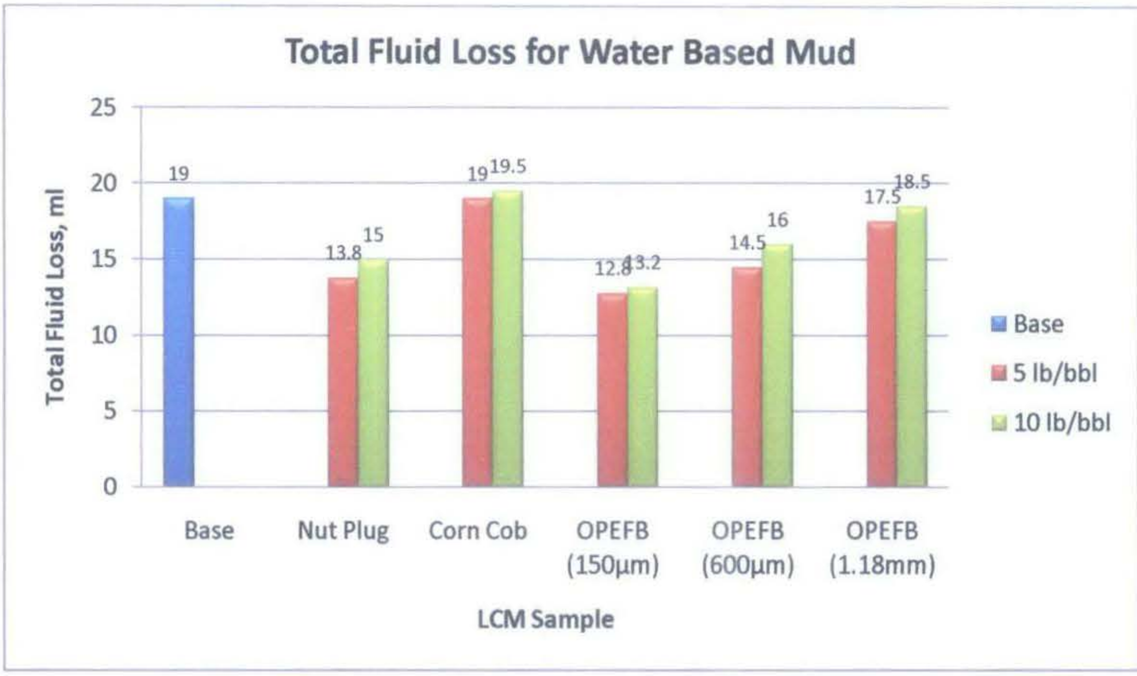

Figure 4.6 - Total fluid loss for water based mud

In order to determine the optimum concentration for the additives, additional concentrations of 3 lb/bbl, 8 lb/bbl and 15 lb/bbl experiments were conducted with 3 different sizes of oil palm EFB fiber. Results are reflected in Figure 4.7. As it can be seen, total filtrate passes through a minimum in the range of 8 lb/bbl. Other researchers have also reported that there is an optimum concentration for maximum effect of LCM additives.

4.5.2 EFFECT OF LCM SIZE

The effect of LCM size distribution was studied for oil palm EFB fiber since that is the only additives that were available in various sizes. Figure 4.8 shows the result of oil palm EFB fiber size distribution in the water-based mud. As it can be seen, 150 µm oil palm EFB fiber performs the best followed by 600 µm and 1.18 mm. Other researchers have also reported that fine size distributions have performed better than the coarse sizes.

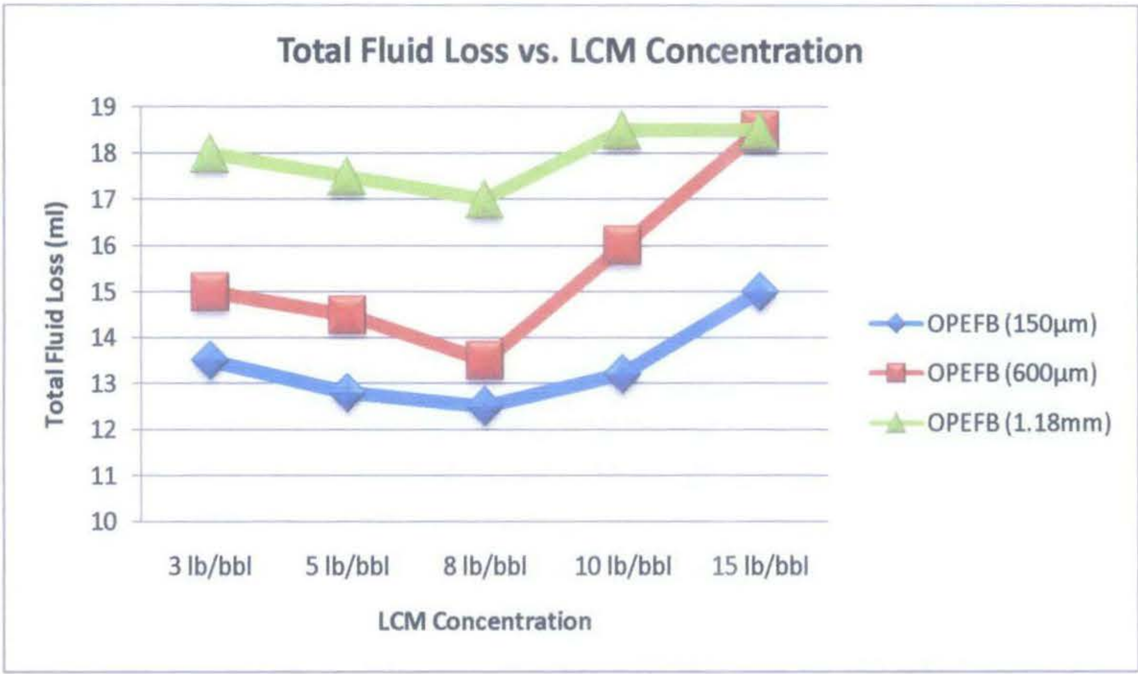

Figure 4.7 - Total Fluid Loss vs. LCM Concentration

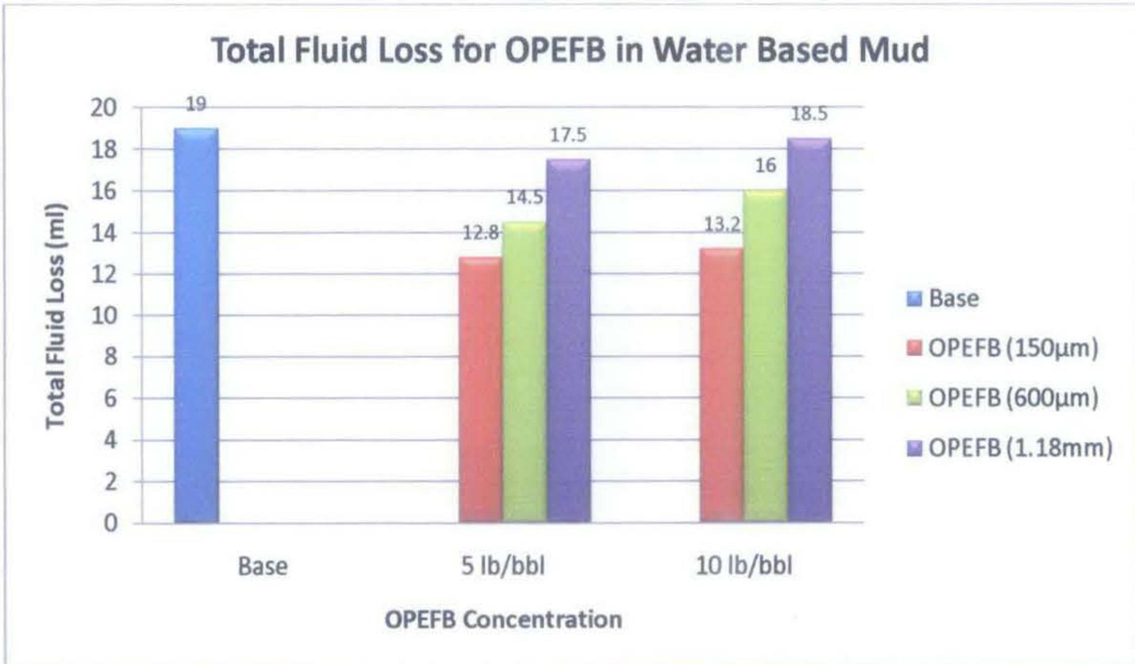

Figure 4.8 - Effect of LCM Concentration and Size Distribution on Total Fluid Loss for OPEFB in Water Based Mud

5 CONCLUSIONS

The functioning of a drilling mud is directly related to its density, viscosity, gel strength and filtration characteristics. In order to for the performance of drilling to be controlled, it must be carefully made up and treated during drilling. Proper treatment of mud can affect any one of its properties, but, because the properties are often related, treatment will often affect several, if not all, of the properties.

Oil palm EFB fiber was chosen to be the additive tested in this project because of the fact that oil palm EFB fiber is cheap and easy to get since oil palm is a major agricultural industry in Malaysia. Oil palm EFB fiber is also one of the fibrous material left in the oil palm mill which is suitable to be used as LCM. Apart of its effectiveness in cost and availability, considering that it is a waste also means that it is an environmentally friendly additive, hence it is sensible to choose the oil palm EFB fiber to be tested for a better drilling fluid formulation.

Overall, addition of 5 lb/bbl of any of the LCM additives generally improved the filtration properties; however the extent of the improvement depended on the additive material and size distribution of the additive. Nevertheless, increasing the LCM additives concentration from 5 lb/bbl and 10 lb/bbl had adversely affected and increased the amount of total filtrate volume. The optimum concentration of LCM for minimum fluid loss was found to be at 8 lb/bbl.

Lastly, the results from the experiments show that oil palm EFB fiber is better than nut plug and corn cob which have been used regularly in the oil and gas industry as LCM. Plus, the cost for oil palm EFB is only USD 28/metric ton which is cheaper than nut plug and corn cob. Here, we can conclude that the oil palm EFB fiber is effective as an LCM and low in cost.

6 RECOMMENDATIONS

For future work, more works are needed to investigate the best formulation of the additives. The particle size of the additives should be varied from 1 to 300 μm. The amount use should be tested from the minimum, so that proper graph will be obtained.

More test should be conducted to get an accurate result such as High Temperature High Pressure (HTHP) test, dynamic filtration test, formation damage test, x-ray fluorescence test, and solid-liquid content test. These tests should be able to justify, identify and investigate further the properties of the fluid.

Lastly, the chemical analysis of the fluid should also be tested and this category includes other drilling mud properties such as pH, alkalinity, calcium content, salt content and others that affect the performance of the drilling mud, either as chemical additives or as a contaminants.

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