DEVELOPING A GREEN LOST CIRCULATION MATERIAL (LCM) DERIVED FROM SUNFLOWER SEED SHELL WASTE

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Dissertation submitted in partial fulfillment of
the requirement for the
Bachelor of Engineering (Hons)
(Petroleum Engineering)

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CERTIFICATION OF APPROVAL

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CERTIFICATION OF ORIGINALITY

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

WAN MOHD SYAFIQ WAN JUSOH

ABSTRACT

This report basically discusses the preliminary research done and basic understanding of the chosen topic, which is **developing green lost circulation materials (LCM) derived from sunflower seed shell waste**. The report concentrates around the important step for each test as the proper amount of additives were dissolved in the mud base samples and how does these result from the experimental process data correspond to the development of lost circulation material. All laboratories experimental including the development of prototype drilling fluids or base sample and the used of the sunflower seed shell additive as lost circulation material were tested using standard variations of mud tests on its rheological properties to determine its effectiveness for drilling operation. Not to forget, the main objective of this project is to study the **effectiveness of using sunflower seed shell as flaky LCM additives** to control and eliminate a wide range of lost circulation problems due to fractures, highly permeable zones or broken unconsolidated formations.

The related equipment for the test procedure involves mixer, mud balance, viscometer, HTHP and API filter press. The properties for LCM such as density, plastic viscosity, yield point, gel strength and filtration rate will be measured through the experiment in the laboratory. The LCM will be prepared in a range of particle sizes which is available in fine, medium and coarse grades, and compatible to seal the loss zone regardless of the type of drilling fluids. Its amount was variables used in the tests.

The significant of using the sunflower seed shell waste is that it has the lost circulation material characteristics to prevent the mud losses, not effect the whole drilling fluid circulation and economically inexpensive for its abundance. The sunflower seed shell shall be a most low-cost and green waste product that enables the optimum plugging to the zone of lost circulation with minimum amount of lost materials and time, considering the fact that lost circulation is one of the most serious and expensive problems in the drilling operation.

ACKNOWLEDGEMENT

Alhamdulillah, finally I have managed to successfully complete my Final Year Project. I would like to take this advantage to thank my supervisor, Pn Mazlin Idress for sharing her knowledge and guiding me all throughout the project. I would like to express my gratitude to Pn Sharifah Asmah from Scomi Oiltools for sharing her experience in drilling fluid formulations and provided the chemical for the laboratory experimental.

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INTRODUCTION

1.1 BACKGROUND OF STUDY

Lost circulation is defined as the loss of whole mud, in quantity, to exposed formations. It occurs when the drill bit encounters natural fissures, fractures or caverns, and mud flows into the newly available space. This plainly requires the presence of permeable zones with openings of sufficient size to permit the entrance and storage of lost mud. Another important factor is that a certain hydrostatic pressure must be exceeded before the formations will accept the lost mud (J. M. Bugbee, 1953). Mud flows into the formation without building a filter cake and more mud is being pump down the well than is flowing back up. Considering the loss of fluid to the formation represents a financial loss that must be dealt with, this project will concentrate on this issue and effective strategy by using low-cost lost circulation material, specifically targeted to solve the problems.

Lost circulation is both troublesome and costly. Even with the best drilling practices, circulation losses can occur and affects the overall drilling operation by increase in costs due to fighting the mud loses. Plus, time-consuming process with several possible consequences such as stuck pipe, well control incidents, the need to run additional casing strings, formation damage and poor zonal isolation. (Xiaolin Lai, 2010). Moreover, reduction in the pressure gradient may lead to wellbore instability, which could result in hole collapse and stuck pipe thus loss of litho logical information since no drilled cutting return to surface. Too often, failure to adequately address loss-related concerns can lead to excessive well costs, unnecessary high risk activities, and poor performance. Regardless, the concerns are real and potentially serious.

Commonly used lost circulation materials to combat lost circulation are fibrous, flaky or granular base and ideally, the LCM should be insoluble and inert to the mud system in which it is used. Often, granular, flake and fiber LCM are mixed together into an LCM pill and pumped into the loss zone to seal the formation. For this project, I will develop a green LCM derived from **sunflower seed shell** waste as an effective additive.

1.2 PROBLEM STATEMENT

Lost circulation is a problem as old as rotary drilling and it is the major factor in most high drilling-cost wells. As in oil and gas industry, it is recommended that when a well is planned, the possibility of lost circulation should be considered and the behavior of similar wells in the vicinity studied so that a program to properly handle lost circulation occurrences can be prepared. Once occur, the lost circulation well will cost double or triple extra money due to process of fighting the mud loses as the cost of lost mud materials must be added that of the rig time consumed and the cost of the occasionally accompanying stuck drill pipe, lost hole, blowout, or abandonment. There are also cases of missed production chargeable to lost circulation, from failure to secure production samples and decreased of productivity from the plugging of productive zones.

However, most of the commercial lost circulation materials have been tested with different levels of success and seen that it is essential to develop on the problem. Thus, it is crucial to rethink the different materials to better tackle the mud losses but at the same time reduce the drilling cost operation by using daily wastes.

In most cases, a lost circulation material or formation sealing agents have been used as effective method to restore circulation of drilling fluid as it sometimes used as a part of the mud system and suitable for preventive technique and material to combat lost circulation during drilling of an oil well.

A laboratory study will undertake on sunflower seed shell waste as a low-cost and effective lost circulation material, as well as compare the performance of industrial LCM with this new material.

1.3 OBJECTIVE AND SCOPE OF STUDY

The main objectives of this research are:

- To study and analyze the **effectiveness of using sunflower seed shell waste** as LCM additives to control the lost circulation problem.
- To determine the **optimum composition of sunflower seed shell** additive that can be used as effective lost circulation.

The scope of work for this project is involving a laboratory study on the various results and the analyses of the lost circulation material (LCM) derived from sunflower seed shell waste for the drilling fluid formulation. It consist of the literature review which involve lost circulation problems, drilling fluid properties and compositions, and the lost circulation material that was chosen and the properties of formulated drilling fluids that are going to be measured. The laboratory experiments will formulate a blend of selected drilling fluid type with the fluid loss additive and compare the properties with base fluid along with the selected industrial LCM that commonly used. Plus, the efficiency of the blend sunflower seed shell waste as an additive in mud system for the ability to control lost circulation problems will examined.

CHAPTER 2

LITERATURE REVIEW

2.1 LOST CIRCULATION DEFINITION AND CLASSIFICATION

Lost circulation, or lost returns, is defined as the loss of the drilling fluids or cement slurries into formation voids. Lost circulation problems in drilling are not confined to any one area as they may occur at any depth where the total pressure exerted against the formation exceeds the formation breakdown pressure and there is a path that allows the mud to flow into the formation.

Previous experimental work and field experience have shown that the whole mud cannot be forced into a rock formation without fracturing it. Even gravel must have a permeability of about 300 darcies before the mud can be forced into and through the natural openings between grains (Nayberg, 1987).

In general, four types of formations are responsible for lost circulation which is natural fractured formations, vugular or cavernous formations, highly permeable formations, and unconsolidated formations. These natural occurring losses can be defined as losses resulting from some aspect for formation being drilled. When the whole mud is lost to a formation, the cause in which the cracks or permeability are large enough to prevent a sealing filter cake from being laid on the wellbore.

Another type of lost circulation is mechanically induced losses, happen when the formation is fractured mechanically or resulting from some aspect directly to the drilling operation, in which these fractures may seal themselves once the pressure is relieved. If large quantities of mud are lost to these fractures, it may be washed out, causing void spaces similar to naturally occurring high porosity or high permeability zones.

Even with the best drilling practices, circulation losses can occurs in varying degrees and the severity of these losses is an indicator of the mud loss to the formation. Loss zones can be classified as:

Type of Loss Zones	Lost Severity (bbl/hr)
Seepage Loss	1-10
Partial Loss	10-500
Complete Loss	>100

Table 1: Loss Zone Classification (Nayberg, 1987)

As Seepage losses can occur in any type of loss zone and in any type of formation when the LCM's in the mud are not fine enough to complete the seal. Meanwhile Partial losses can be happen in gravels, small natural horizontal fractures and barely induced vertical fractures. Complete losses occur in long, open sections of gravel, large natural horizontal fractures, caverns, interconnected vugs, and widely opened, induced fractures.

2.2 DRILLING FLUID

In the oil and gas industry, drilling fluid is the heart of the drilling process. Generally, the drilling fluid is a fluid that is used to drill a boreholes in a daily drilling operation in which the fluid is circulated and pumped from the surface, down the drill string through the bit and back to the surface via the annulus. Drilling fluids play numerous functions and encompasses all of the composition used to aid the production and removal cuttings from the borehole. Drilling fluid is also known as mud in the industry.

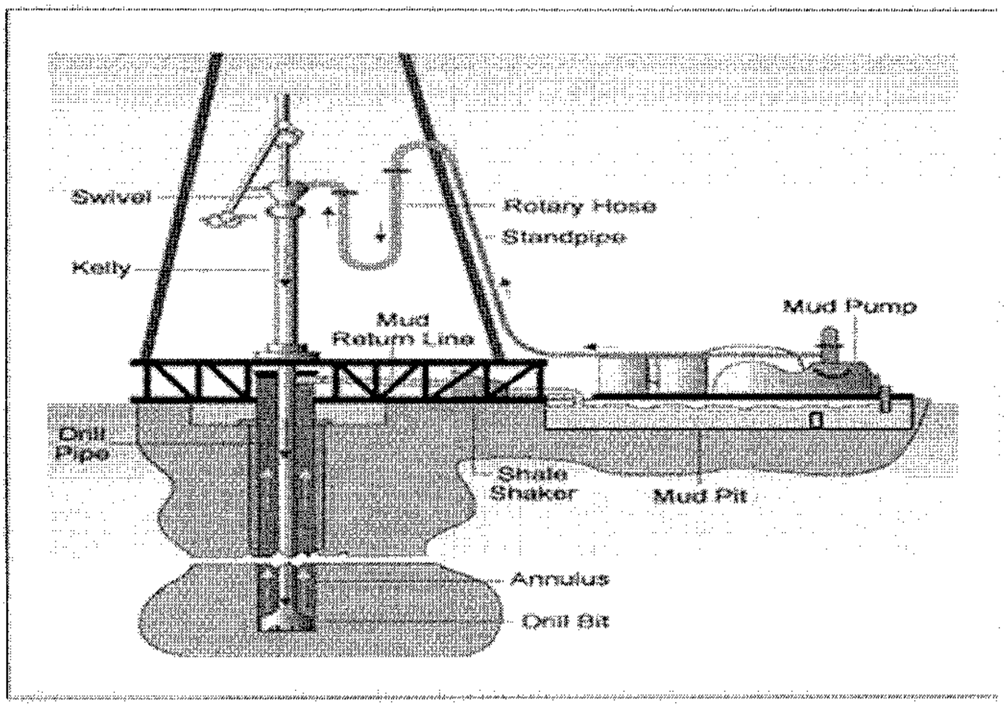

Figure 1: Drilling Fluid Circulation

There are many types of drilling fluids and they differ widely in their compositions depend upon the bore hole conditions. A properly designed mud is able to:

- ✓ Reach geological objective/target depth at lowest overall cost
- ✓ Enhance penetration rates of the drill bit
- ✓ Reduce hole problems while drilling and logging operation

✓ Minimize formation damage and prevent losses

2.2.1 Drilling Fluid Function

The drilling fluid must have the ability to stand in the very high temperature as well as high pressure and at the same time able to perform its function effectively including preserve formation in the wellbore. The primary functions of drilling fluid are:

i. Transport and Remove Cuttings

Drilling cutting or rock cutting from the drill bit activities must be removed from wellbore up to the surface through the efficient circulation of drilling fluid. Its ability to do so depends on cutting size, shape, density, and speed of fluid travelling up the well. The mud viscosity is another important property, as cuttings will settle to the bottom of the well if the viscosity is too low.

ii. Control Formation Pressure

Borehole instability is caused by the unequal mechanical stress and chemical interactions as a result from processes of drilling a well. The drilling fluid must have the ability not only to stop formation from collapse but also minimize formation damage as well as having the inhibitive property to prevent clay swelling. So, if formation pressure increases, mud density should also be increased, often with barite as weighting materials to balance pressure and keep the wellbore stable. Unbalanced formation pressures will cause an unexpected influx of pressure in the wellbore possibly leading to a blowout from pressured formation fluids.

iii. **Maintain Borehole Stability**

Wellbore stability need to be maintain each second in drilling operation especially before the casing can be run and cemented. In short, wellbore stability requires a complex balance of mechanical and chemical factors. Thus, chemical composition and mud properties must combined together to provide a stable wellbore. Weight of the mud must be within the necessary range to balance the mechanical forces.

iv. Seal Permeable Formation

When the mud column pressure is greater than the formation pressure, mud filtrate will invade the formation and a filter cake of mud solid will be deposited on the wall of the wellbore. Mud must be designed to deposit a thin, low-permeability filter cake on the formation to limit the fluid loss inside the formation.

v. Cool and Lubricate the Drill String

Heat is generated from mechanical and hydraulic forces at the bit and when the drill string rotates while drilling and rubs against casing and wellbore. The mud help cool and transfer heat away from source and lower to temperature than bottom hole. A lubricant added in the drilling fluid improves the lubricity of drilling bit and drill string while drilling process. Poor lubrication causes high torque and drag, causing the drill string and bit to damage rapidly.

2.2.2 Drilling Fluid Types

There were three types of drilling fluid commonly used in the drilling operation around the globe:

i. **Water Based Mud**

Water based mud is drilling fluid that use water as a continuous phase. A most basic water based mud system begins with water, and then clays and other chemicals to create homogenous blend water based mud. The clay is usually a combination of native clays that are suspended in the fluid while drilling, or specific types of clay that are processed. Many other chemicals are added to this mud system to achieve various effects, including viscosity control, shale stability, enhance drilling rate of penetration, cooling and lubricating of equipment.

ii. **Oil Based Mud**

In contrast, oil based mud is a mud where the base fluid is a petroleum product such as base oil. Oil based mud are used for many reasons, some being increased lubricant, enhanced shale inhibition and greater cleaning abilities with less viscosity. Oil based mud can also withstand greater heat without breaking down.

iii. **Synthetic Based Mud**

Synthetic based mud, the base fluid is synthetic oil. This is most often used on offshore rigs because it has the properties of an oil based mud, but the toxicity of the fluid fumes are much less than oil based fluid.

2.2.3 Drilling Fluid Properties

The drilling fluid properties are important to ensure the mud quality has not deteriorated and must be regularly measure at the site by its specific procedure testing.

2.2.3.1 <u>Density</u>

Mud density is widely known as mud weight in industry. This is important in maintaining well control. In most cases, mud pressure should be higher than formation pressure to prevent the walls from caving in and formation fluids entering into the wellbore. Mud density is measured using Mud Balance.

2.2.3.2 <u>Mud Viscosity</u>

Viscosity is a measure of liquid's resistance to flow and is required in addition to flow rate for hole cleaning. Viscosity of mud is measured using Viscometer and Marsh Funnel. For drilling fluids, there are 3 parameters measured which is;

i. Plastic Viscosity

Plastic viscosity is the slope of sheer stress/shear rate and is usually regarded as a guide to solids control. PV increases when the volume percent of solids increase or decrease when the size of particle decreases. It also represents the viscosity of mud. Low PV means mud capable drilling rapidly. High PV means the mud is too viscous which mean we have to dilute the mud so that the pump can pump the mud.

ii. Yield Point

Yield point is the initial resistance to flow caused by electrochemical forces between the particle or stress at which a material deforms plastically. High viscosity resulting from high yield point is caused by introduction of soluble contaminant such as salt, cement or gypsum. This parameter helps evaluate the ability of mud to lift cuttings out of annulus.

iii. Gel Strength

The gel strength indicates shear stress measured at low shear rate after a mud has set quiescently for a period of time. Excessive gel strength can cause swabbing, surging, difficulty of getting logging tools to bottom and retaining of entrapped air or gas in mud.

2.2.3.3 <u>Fluid Loss</u>

The fluid loss property of mud indicates how well the mud forms a seal against permeable formation. This is filter cake building properties of the mud or as an indication to the amount of water lost from the mud to the formation. Measurement is done by using a HTHP or API filter press depending on their mud types. This simulates the quantity of fluid loss inside the wellbore. The lower the filtrate volume the thinner the mud cakes, means that good fluid loss control in mud. The higher the filtrate volume the thicker the mud cake means we need to minimize the fluid loss.

2.3 LOST CIRCULATION MATERIAL

Lost circulation materials are mud additives designed to ensure that the fluid circulated down the hole the rotary method of well drilling return to the surface for recirculation and at the same time increase the maximum particle size present in order to plug the pores or cracks which the mud alone is unable to seal the formation. In order to perform this function, they must contain particles large enough to lodge in the largest apertures present and can be easily handled through mud pumps.

A wide variety of materials has been used over the years, probably including everything that was bulky and easily available. The particle shapes is denoted as fine, medium and coarse.

For purposes of classification these can be divided into fibrous, flake, and granular types, and mixtures of these:

- **Fibrous materials**: Generally plant fibers, animal, mineral and synthetic fibers are also found, used mainly in drilling mud to lessen the mud loss into large fractures or vugular formations. It forms a mat-like bridge over porous formations to reduce the size of the openings.

- **Flake materials**: Predominantly small flakes of the hulls. Cellophane flakes are composed of 3/8-3/4 inch graded cellulose or polyvinyl film flakes. Designed to bridge and form a mat on the formation, in which these material can plug many types of porous formations to stop the mud loss or to establish an effective seal over may permeable formation.

- **Granular materials**: Form bridges either at the formation face or within the formation matrix. The latter type of sealing is preferred, because a more permanent bridge forms within the formation and do not dislodged easily as a result of pipe movement in the wellbore.

⊙ **Blended materials**: Blends of two or more of the preceding LCM's have proved to be useful and effective in the field. It furnishes the advantage of having gradation of particles size and variation of types of materials blended in a mixture to provide effective sealing. This blend is a combination of granular, flake, and fibrous materials varying in size, shape and toughness. This blend will penetrate fractures, vugs, or extremely permeable zones and seal them off more effectively.

Even today the list of materials commercially available as lost-circulation materials is quite large in numbers:

Mud Additives

Material	Type	Name under Which Sold
Raw cotton	Fibrous	Coto Fiber, Kotten Plug
Bagasse	Fibrous	Fibertex, Mud Fiber, Milfiber
Flax shive	Fibrous	Fiber Seal
Wood fiber	Fibrous	Balsam Wool, Simpson Treewool, Stratafiber, Magco Fiber, Bell-Seal
Bark fiber	Fibrous	Silvacel, Control Fiber, Palco Seal, Cedar Seal
Textile fiber	Fibrous	Reclaim Textile Fiber
Mineral fiber	Fibrous	Control Wool, Asbestos
Leather	Fibrous	Leather Seal, Leather Floc, Leath-O
Glass fiber	Fibrous	Ultra Seal
Peat moss	Fibrous	Expanso Seal, Peat Moss
Feathers	Fibrous	Feathers
Beet pulp	Fibrous	Beet Pulp
Cellophane	Flake	Jel Flake, Cell-O-Seal, Sealflake, Milflake
Cork	Flake	Silvaflake
Mica	Flake	Micatex, Mica
Corn cobs	Flake	Fergie Seal Flakes
Cotton-seed hulls	Flake	Kotten Seal, Cotton-Seed Hulls
Vermiculite	Flake	Vermiculite
Perlite	Granular	Strataseal, Panaseal, Cal Perl, Mojave Seal, Controlite, Wellite, Circ-U-Lite
Coarse bentonite	Granular	L C Clay, Coarse Bentonite
Ground plastic	Granular	Gel Foam
Nut shells	Granular	Tuf Plug, Masterseal, Multi Seal
Nut hulls	Granular	Elseal
Ground tires	Granular	Rubber Seal, Cal Stop, Strata Cord, Cord Seal
Asphalt	Granular	Forma Seal
Wood	Granular	Super Bridge, Sawdust
Corn cobs	Granular	Fergie Seal Granular
Coke, plain and with bentonite	Granular	Coke, Tapon
Film. fiber, perlite	Mixed	Star Dust
Textile fiber and sawdust	Mixed	Kingseal
Cellulose fiber and sawdust	Mixed	Queenseal
Perlite and coarse bentonite	Mixed	Instaseal
Mineral and textile fiber and sawdust	Mixed	Fibermix
Perlite, coarse bentonite and sawdust	Mixed	Mojave Super Seal

Table 2: Material for Preventing Lost Circulation (Robert J. White, 1956)

2.3.1 Walnut Shell as the industrialized Lost Circulation Material

Walnut Shell is a granular material composed of 100% nut shells material. It is used for the treatment of lost circulation and is available in fine, medium and coarse grades. Ideally, this granular LCM is used alone or in combination with other materials and placed down hole to help retard the loss of mud into fractures or highly permeable formation. The material is not deformable, so plugging or bridging effectiveness is not adversely affected by hydrostatic pressure. Plus, each grade is carefully sized to provide maximum sealing effectiveness. Another kind of loss material, nut plug can also be used in the oil based mud system with this granular LCM.

Walnut shell can be used as a preventive LCM against seepage losses by direct addition to circulating system in concentrations of 1-3 lb/bbl (2.86-8.6 kg/m3) or as a mud additive in pill or slug form, concentration of 10-80 lb/bbl (28.5- 228 kg/m3).

PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point: N/A	**Appearance: Light brown powder**
Specific Gravity: 1.1	**Odor: Yes**
Vapor Pressure: N/A	**Form: Solid - Granular**
Percent Volatility: N/A	**pH: N/A**
Solubility: insoluble in water	**Auto ignition Temp: 283 C**

Table 3: Physical and Chemical Properties of Walnut Shell (CHEMWATCH 4660-79)

The advantages on using this loss circulation material in drilling application:

i. Walnut Shell will not ferment and is unaffected by pH or temperature
ii. Compatible in all drilling fluids type including oil mud system and water based system
iii. Particle size, shape, distribution and high compressive strength makes Walnut Shell a superior plugging material

2.3.2 Sunflower Seed Shell as Lost Circulation Material

The **sunflower seed** is the fruit of the sunflower or *Helianthus annuus*. The term "sunflower seed" is actually a misnomer when applied to the seed in its pericarp (hull). Botanically speaking, it is more properly referred to as an achene. When dehulled, the edible remainder is called the sunflower kernel.

Figure 2: Dehulled kernel (left) and whole seed with hull (right)

Sunflower seeds are more commonly eaten as a healthy snack than as part of a meal. The seeds may available as in-shell seeds or dehulled kernels. When in-shell seeds are processed, they are first dried. Afterwards, they may also be roasted or dusted with salt or flour for preservation of flavor. This snack is popular in Asia, Russia, Bulgaria, Romania, Spain, China, Iran, Canada, and the United States.

For commercial purposes, sunflower seeds are usually classified by the pattern on their husks. If the husk is solid black, the seeds are called black oil sunflower seeds. The crops may be referred to as oilseed sunflower crops. These seeds are usually pressed into sunflower oil. Striped sunflower seeds are primarily used for food.

The hulls, or shells, are mostly composed of cellulose. They compost slowly and they are sometimes burned as biomass fuel to fully utilize the waste from the sunflower seed. The major components of the sunflower seed hull are:

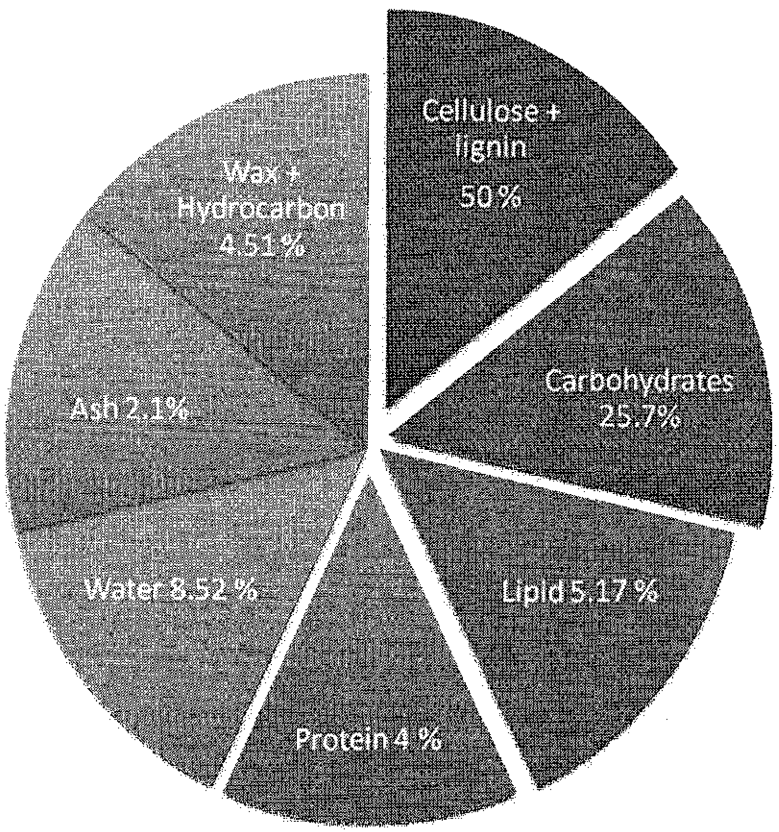

Figure 3: Major component in sunflower seed shells (Paul Cancalon, October 1971)

As the rest of the lipid fraction is oil with a composition relatively similar to that of the kernel oil. The protein fraction (4% of the total hull weight) is similar to the protein fraction of the oil cake. The carbohydrate fraction is also composed mainly of cellulose. Thus, although the sunflower shell contains some carbohydrates and lipid, it is include in a **flake-type** material because **it is predominantly small flakes of the hulls**, and the laboratory testing need to be done to ensure the hull is suitable and effective as a lost circulation material.

CHAPTER 3

METHODOLOGY

3.1 PROJECT FLOW CHART

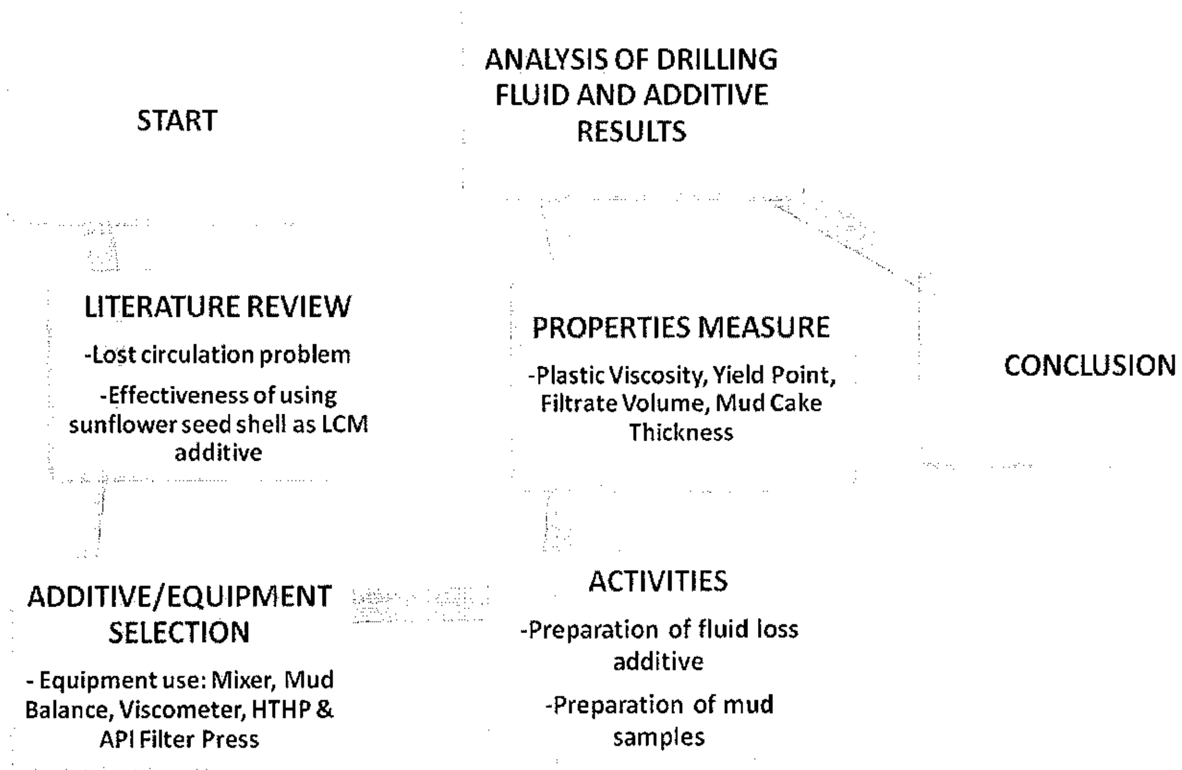

Figure 4: Project Flow Chart

3.2 PROJECT GANTT CHART

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Briefing & update on students progress														
Project work commences														
Submission of **Progress Report**								✓						
PRE-EDX combined with seminar/ Poster Exhibition/ Submission of Final Report (CD Softcopy & Softbound)														
EDX														
Final Oral Presentation													✓	
Delivery of Final Report to External Examiner / Marking by External Examiner														
Submission of hardbound copies														

Figure 5: Project Gantt Chart

3.3 PROJECT MILESTONES

No	Activities	Date
1	**Briefing & update on students progress**	**WEEK 3**
2	**Project work commences**	**WEEK 1 -8**
3.	**Submission of Progress Report**	**WEEK 8**
4.	PRE-EDX combined with seminar/ Poster Exhibition/ Submission of Final Report (CD Softcopy & Softbound)	**WEEK 11**
5.	EDX	**WEEK 12**
6.	Final Oral Presentation	**WEEK 13**
7.	Delivery of Final Report to External Examiner / Marking by External Examiner	**WEEK 14**
8.	Submission of hardbound copies	**WEEK 16**

Figure 6: Project Milestones

3.4 PREPARATION OF ADDITIVES

The sunflower seed shell waste will be collected directly from the sunflower kernels supplier in which they are using only the kernels products as edible snacks in the market. This way will minimize the cost and time, because the seeds or hulls are already dried and ready to be use as additive in drilling fluids. So, it just needs to be cut into smaller pieces of flaky things to easily blend and grind for further use in the properties testing.

Then, the additive will be grind into the smaller particles by using the Mortar Grinder which is available in the lab. A Sieve Shaker also will be used in order to obtain the desired sizes that are **1.18** mm, **600** microns and **150** microns. The selected sizes were being chosen is based on:

Particle Size (microns)	Particle Classification
>200	Coarse
200-250	Intermediate
250-74	Medium
74-44	Fine
44-2	Ultra Fine
2-0	Colloidal

Table 4: Particle Sizes (American Petroleum Institute, Dallas)

3.5 DESIGNING DRILLING FLUIDS FORMULATION

The experimental testing involved a base mud formulation designed for water base mud system to analyze the LCM applicability and effectiveness:

Mud Products	*Concentration (1 bbl)*
Water	318.73 ml
Soda Ash	0.5 lb
Caustic Soda	0.25 lb
Bentonite	12 lb
LCM (Nut Plug/ Sunflower Seed/ Corn Cobs)	5 & 10 lb
Duovis	0.3 lb
API Barite	109.19 lb (weight up to 10.5 ppg)

Table 5: Mud Formulation for Water Based Mud System

*All chemicals name is based and provided by SCOMI Oiltools except Duovis (MI Swaco).

** The laboratory testing will also involve the existing industrial LCM, **Nut Plug** and **Corn Cobs** as comparison to the sunflower seed shells test results.

3.6 DRILLING FLUID TESTS

i. Mud Density Test:

Mud density or mud weight is measures with a mud balance

- Mud balance base must be set on a flat level surface.
- Fill the mud cup with the mud.
- Replace cap and rotate until it is firmly seated, ensuring some of mud is expelled through the hole on top, to free trapped gas.
- Place the beam on base support and balance it by using the rider along the scale.
- Take the mud weight reading.

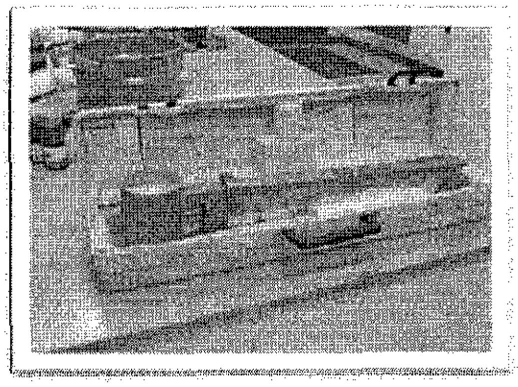

Figure 7: Mud Balance

ii. Rheology Test:

In mud rheology testing, Fann VG Rheometer or Viscometer will be used. Frequently monitor the mud rheology is essential to make sure the mud is always within specification.

- Place the mud in rheometer thermo cup and adjust the cup until the mud surface level is equal height to the scribed line on the rotor surface.
- Turn on the rheometer, first taking dial measurement at the top most speed (600 rpm), then gradually switch to lower gear and obtain all 6 reading (600 rpm, 300 rpm, 200 rpm, 100 rpm, 6 rpm, 3 rpm).
- Determining PV and YP :

  Plastic Viscosity - indicates the most of solid (sand or silt) in mud.

  PV: 600 rpm-300 rpm

  Yield Point - indicates the carrying capacity of cuttings.

  YP: 300 rpm - PV

  YP/PV Ratio: Yield Point / Plastic Viscosity

- Measure the Gel Strength value of the mud using VG Rheometer:

  -Stir sample in 600 rpm speed for 15 seconds. Slowly shift the moving gear to the lowest speed.

  -Wait for 10 seconds then turn on the 3 rpm speed and record the maximum deflection of the dial. This is 10 seconds gel reading.

  -Repeat step 1 and 2, but this time wait 10 minutes before turning on the 3 rpm speed. The maximum deflection of this reading will give 10 minutes gel reading.

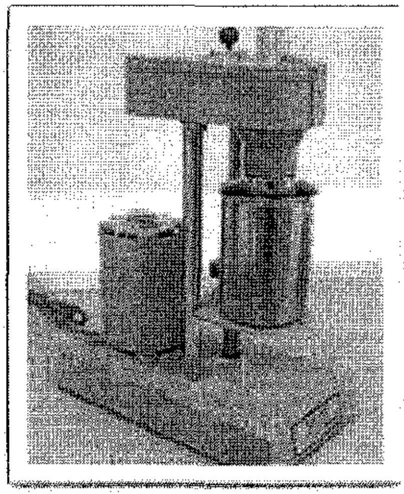

Figure 8: VG Rheometer or Viscometer

iii. API Filtrate Test using Filter Press:

The API filtrate is a test designated to measure the volume of filtrate lost in 30 minutes under a 100 psi differential pressure.

- The mud is poured into the filter press cell the filter cell then is placed in the frame. The relief valve is closed and a container will be placed under drain tube.
- Pressure should be adjusted at 100 psi which is supplied by compressed nitrogen.
- The dry cylinder is placed under the drain tube and continues collecting filtrate to the end of 30 minutes. The graduated cylinder then removed and the volume of filtrate collected is recorded.

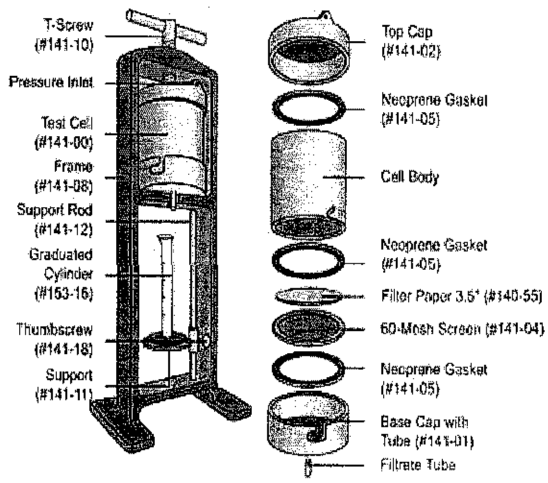

Figure 9: API Filter Press

iv. Permeability Plugging Tester (PPT) Test:

The Permeability Plugging Tester is a modification of the standard 500ml HTHP Filter press. This instrument is useful for making **filtration tests on plugging materials without the interference of particles settling on the filter medium during the heat up process**. It also useful in predicting how a drilling fluid can form a low permeable filter cake to seal off depleted, under pressured intervals and helps prevent differential sticking in the loss formation.

- Mix and prepare the Calcium Chloride brine (CaCl2) as a base fluid for the pill.
- Mix the fluid system with pill formulation (water based mud) with Hamilton Beach Mixer at 120 F.
- Perform fluid loss and spurt loss test at 1200psi/260 F on the selected gauge screen.
- Check mud weight and rheological properties.
- Run PPT Filtrate analysis on the pill.

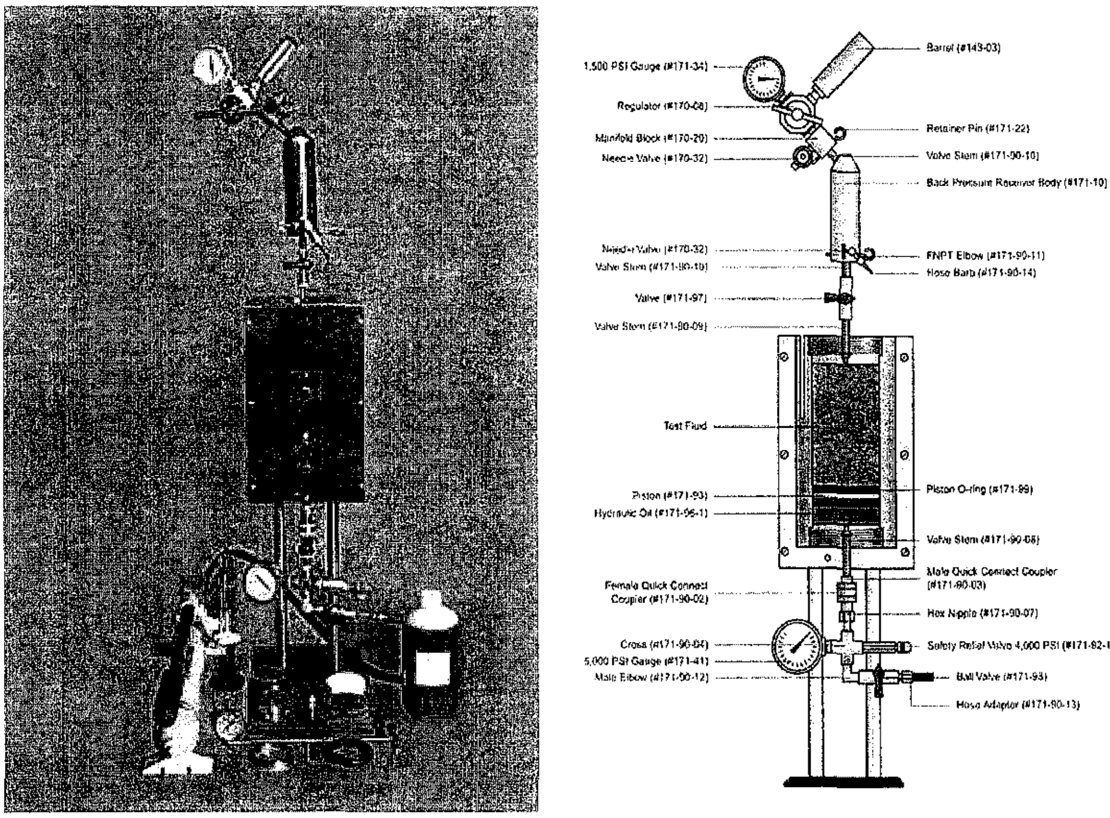

Figure 10: Permeability Plugging Tester (PPT)

CHAPTER 4
RESULTS & DISCUSSION

4.1 BASE SAMPLE

In this laboratory experiments, the base samples is used for the purpose of comparison before the usage of the additives in the mud formulations, as there is a specific **mud formulations** stated in Table 6 and Table 7 with the different sizes of LCM additives.

In order to analyze the applicability of the sunflower seed shells waste as LCM, water based mud are used, and three different particles size of sunflower seed shells which are **1.18 mm**, **600 micron** and **150 micron** will be tested.

Plus, the existing industrial lost circulation material, **Nut Plug** and **Corn Cobs** were used as comparison to the sunflower seed shells properties. This LCM will be put into the mud formulations in last session of experiment to see the properties different and changes between them.

4.2 COMPOSITION AND PROPERTIES OF DRILLING FLUID TESTED

All mud properties measurement including the original properties of mud base samples, the mud properties after the used of sunflower seed shells, Nut Plug, and Corn Cobs additives were conducted according to the standard, as the functioning of drilling mud to combat lost circulations is directly related to its density, plastic viscosity, yield point, gel strength, and filtration characteristics.

However, only several testing procedure were done because the laboratory equipments limitations, which cause only water base mud samples and water base mud with LCM additives can be done and any changes of the mud properties were observed carefully. The composition of the mud base samples and additives used in the experiment were:

Product	Mix 1 lab barrel in Hamilton Beach mixer	
	Base Sample	**Base Sample + LCM**
Water, (ml)	318.73	318.73
Soda Ash, (g)	0.5	0.5
Drill Gel, (g)	12	12
Caustic Soda, (g)	0.25	0.25
Duovis, (g)	0.3	0.3
API Barite, (g)	109.19	109.19
***Nut Plug, (g)**	-	**5 & 10**
***Sunflower Seed Shell, (g)**	-	**5, 8, 10 & 15**
*** Corn cobs, (g)**	-	**5 & 10**

Table 6: Mud formulation for the water base samples and LCM additives

The mud formulations were tested according to the amount and the **fine size** of LCM additives (**150 micron only**) were used to get the data as below.

Base Sample		**Base Sample + Nut Plug**	**Base Sample + Sunflower Seed**	**Base Sample + Corn Cobs**
Mud weight, ppg	10.5	10.5	10.5	10.5
Rheology	120F	120F	120F	120F
600 rpm	45	49	40	41
300 rpm	32	36	28	31
200 rpm	26	29	22	26
100 rpm	20	23	17	21
6 rpm	9	11	10	15
3 rpm	8	10	10	15
PV, cP	13	13	12	10
YP, lb/100ft²	19	23	16	21
Gel Strength-10 sec	7	10	9	17
Gel Strength-10 min	13	18	24	25
Cake Thickness, mm	1	2.2	1.59	2.02
API Filtrate, cc/30min	19	13.8	11	19

Table 7: Mud properties tested for base sample and **5 lb/bbl** concentration of LCM additives.

Base Sample		Base Sample + Nut Plug	Base Sample + Sunflower Seed	Base Sample + Corn Cobs
Mud weight, ppg	10.5	10.5	10.5	10.5
Rheology	120F	120F	120F	120F
600 rpm	45	50	49	39
300 rpm	32	35	34	30
200 rpm	26	25	27	25
100 rpm	20	20	19	20
6 rpm	9	8	11	13
3 rpm	8	7	11	12
PV, cP	13	15	15	9
YP , lb/100ft²	19	20	19	21
Gel Strength-10 sec	7	10	9	13
Gel Strength-10 min	13	12	26	25
Cake Thickness, mm	1	2	1.8	2.17
API Filtrate , cc/30min	19	15	9.5	19

Table 8: Mud properties tested for base sample and **10 lb/bbl** concentration of LCM additives.

Base Sample		Base Sample + Sunflower Seed Shell (150 micron)			
Amount, (g)	**0**	**5**	**8**	**10**	**15**
Mud weight, ppg	10.5	10.5	10.5	10.5	10.5
Rheology	120F	120F	120F	120F	120F
600 rpm	45	40	49	49	54
300 rpm	32	28	35	34	38
200 rpm	26	22	28	27	30
100 rpm	20	17	21	19	32
6 rpm	9	10	13	11	12
3 rpm	8	10	13	11	12
PV, cP	13	12	14	15	17
YP , lb/100ft²	19	16	21	19	20
Gel Strength-10 sec	7	9	11	9	12
Gel Strength-10 min	13	24	25	23	32
Cake Thickness, mm	1	1.59	1.65	1.8	2.3
API Filtrate , cc/30min	19	11	10	9.5	9

Table 9: Mud properties tested for fine size (150 microns) of **Sunflower Seed Shell** additives.

4.3 MUD WEIGHT

The mud weight intentionally set at **10.5 ppg** for each mud formulation as in most cases the amount of mud weight used to combat lost circulation is around 8 to 11 ppg. This high mud weight is important in maintaining the well control as mud pressure should be higher than formation pressure to prevent the walls from caving in and formation fluids entering into the wellbore.

In this experiment, API Barite is added into the mud as weighting agent, as the amount of barite increased, the mud weight of the formulation increased as well. The more a mud weight, the denser it is and the more pressure it exerts on formations exposed to the wellbore. As the first step for each test the proper amount of additives were dissolves in the mud samples. For both LCM additives, two concentrations of **5 lb/bbl** and **10 lb/bbl** were tested in addition to the plain mud sample and the mud weight for each concentration were maintain by using Mud Balance before proceed with another testing.

4.4 PLASTIC VISCOSITY & YIELD POINT

Plastic viscosity usually regarded as a guide to solids control by the relationship that exists between the Shear Stress and the Shear Rate. PV increases when the volume percent of solids or emulsified droplets increase or decrease when the size of particle decreases. PV can be affected by size distribution, shape or concentration of solids. In short, **PV should be as low as possible** and it also represents the viscosity of mud.

Yield Point is the viscosity due to the chemical attraction between the particles. The magnitude of these forces will depend on the type of their solid present, and the ion concentration in the liquid phase. It is a measure of flocculation and gives some indication of the hole cleaning ability of the mud, especially when the mud is in motion. High viscosity resulting from high yield point is caused by introduction of soluble contaminant (ions) such as salt, cement or gypsum. **YP helps evaluate the ability of mud to lift cuttings out of annulus**.

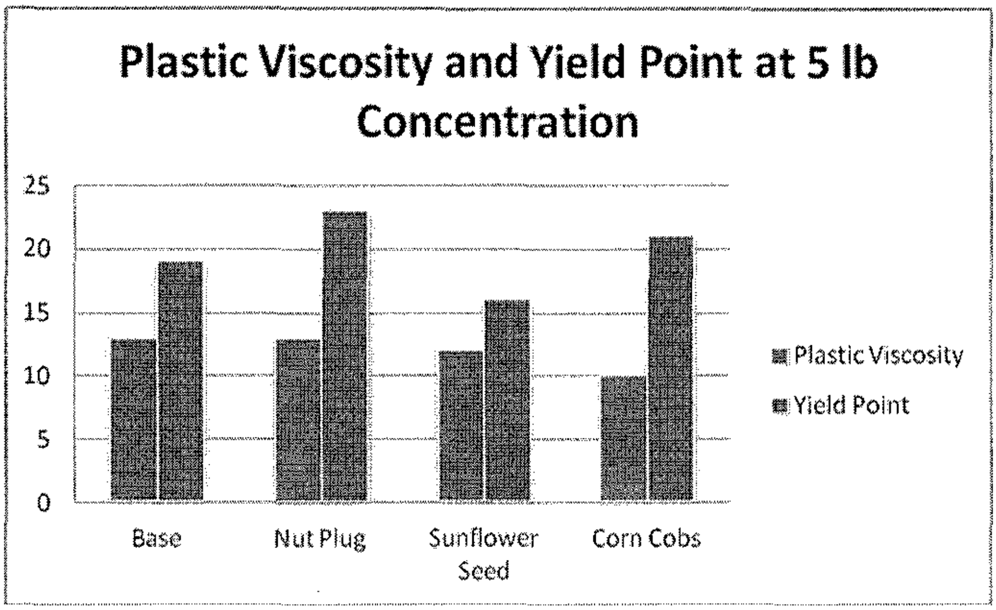

Figure 11: Plastic Viscosity and Yield Point of Base Sample and LCM additives at **5 lb/bbl** concentration.

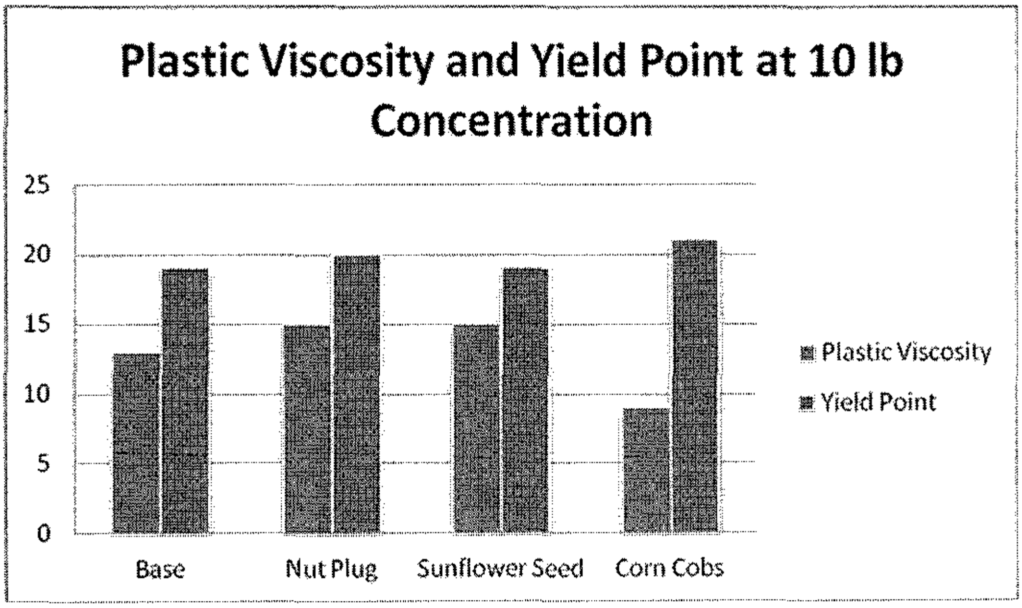

Figure 12: Plastic Viscosity and Yield Point of Base Sample and LCM additives at **10 lb/bbl** concentration.

Figure 11 and Figure 12 above illustrate that the plastic viscosity for base sample with Sunflower Seed Shell additive are almost the same and in a range between the viscosity of Nut Plug and Corn Cobs, and it increased as the amount of additive increased, which is shown in Figure 12. Meanwhile the Yield Point is increased as the amount of additives was continually added except for Nut Plug which is slightly decreased. The Sunflower Seed Shell additive shows the lowest Yield Point compare to the others at 10 lb/bbl concentration and show same characteristic as Nut Plug.

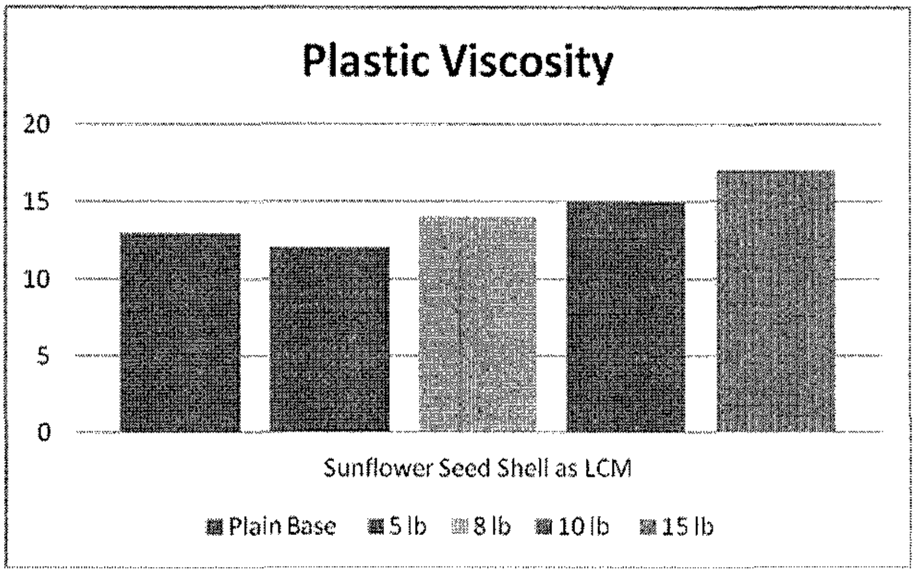

Figure 13 (a): Plastic Viscosity of Base Sample and Base Sample with Sunflower Seed Shell additives.

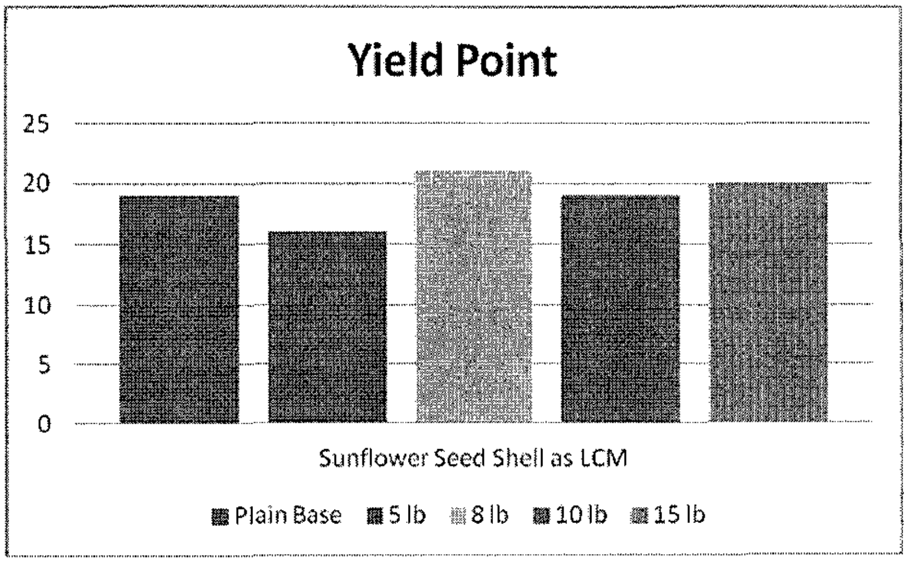

Figure 13 (b): Yield Point of Base Sample and Base Sample with Sunflower Seed Shell additives.

Figure 13 (a) shows for each of the additional Sunflower Seed Shell additives, the trend is almost to a linear straight graph as it is increased as the amount of additive increased. But, it is expected that the further increment of additives will caused the plastic viscosity to decrease which it will reach its optimum values.

From Figure 13 (b), the value of yield point increases as the amount of additives increased, but then prior to yield point it will return to its original shape when the applied stress is removed and become permanent and non-reversible. They began to be permanent is slightly around 8 lb. The **yield strength** or elastic limit is around **20 lb/100 ft^2** and the ultimate strength is around **21 lb/100 ft^2.**

4.5 GEL STRENGTH

The gel strength indicates attraction force between solids **under static condition** and closely related to Yield Point. It is actually refer to the increase of viscosity at zero shear rates. **Excessive gel strength can cause poor efficiency** of solids control equipment, swabbing, surging, difficulty of getting logging tools to bottom and retaining of entrapped air or gas in mud. Meanwhile, Barite will sag or settlement if insufficient gel strength occur. Desirable gel strength is in which it increase only slightly after 10 minutes, even if the 10 second gel is high.

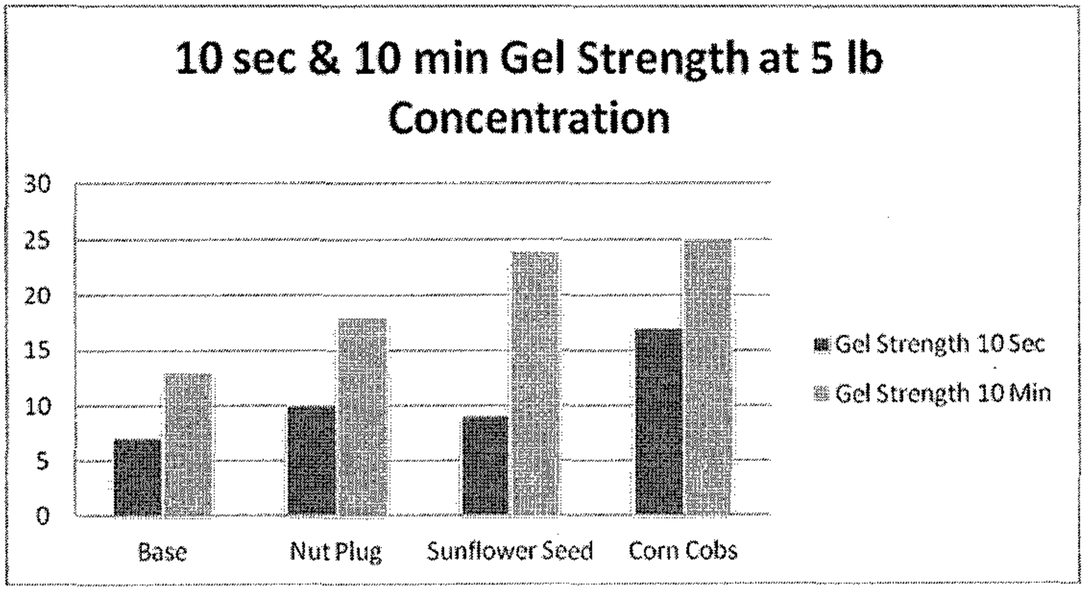

Figure 14: 10 sec & 10 min Gel Strength of Base Sample and LCM additives at **5 lb/bbl** concentration.

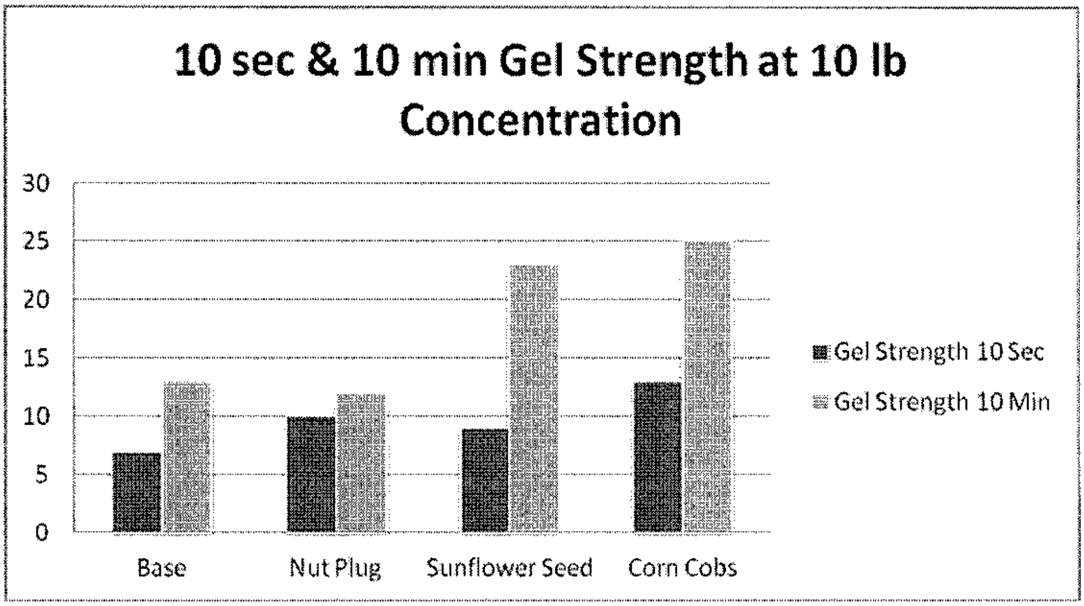

Figure 15: 10 sec & 10 min Gel Strength of Base Sample and LCM additives at **10 lb/bbl** concentration.

As both the Figure 14 and Figure 15 shown, they illustrate that the values of gel strength for all LCM additives obtained tend to decrease as the amount of concentration is increased. The base sample with Nut Plug, Sunflower Seed Shell, or Corn Cobs tends to decrease because in general, high or excessive gel strength is not desirable.

4.6 FILTRATES & MUD CAKE THICKNESS

Filtrate is an indication the amount of water lost from the mud to the formation, where by measurement is done by using a filter press. This simulates the quantity of fluid loss inside the wellbore. The solids in the mud forms as a filter cake which prevents excessive fluid loss, which the filter cake should be thin, flexible with low permeability, and have correct solids distribution. Thick filter cake reduce the effective hole diameter, and increase the chance of differential sticking.

The **lower the filtrate volume the thinner the mud cakes, means that good fluid loss control** in mud. The higher the filtrate volume the thicker the mud cake means we need to minimize the fluid loss.

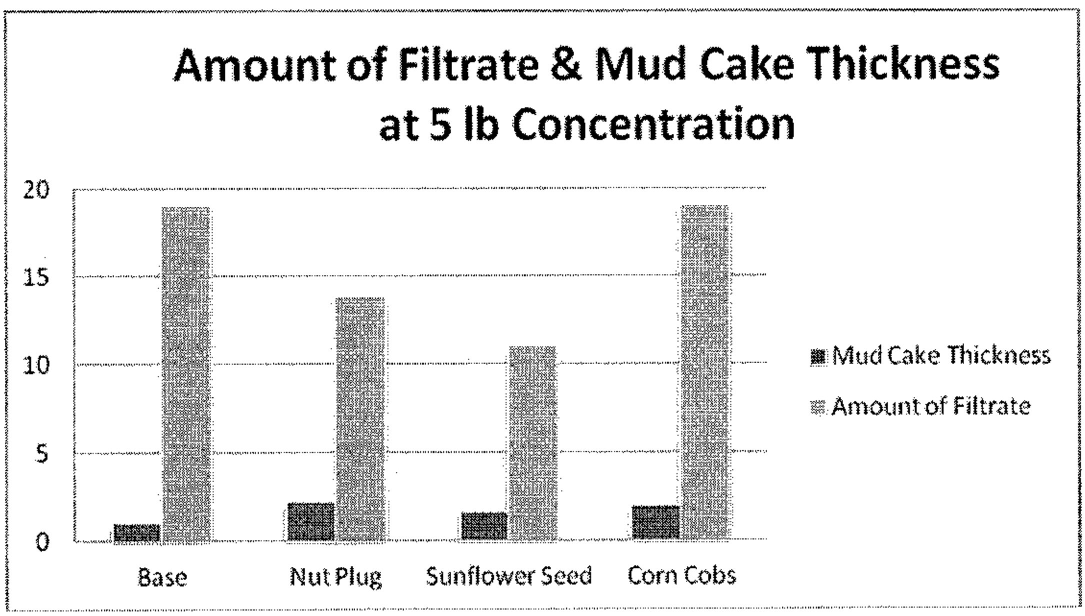

Figure 16: Amount of Filtrate & Mud Cake Thickness of Base Sample and LCM additives at **5 lb/bbl** concentration.

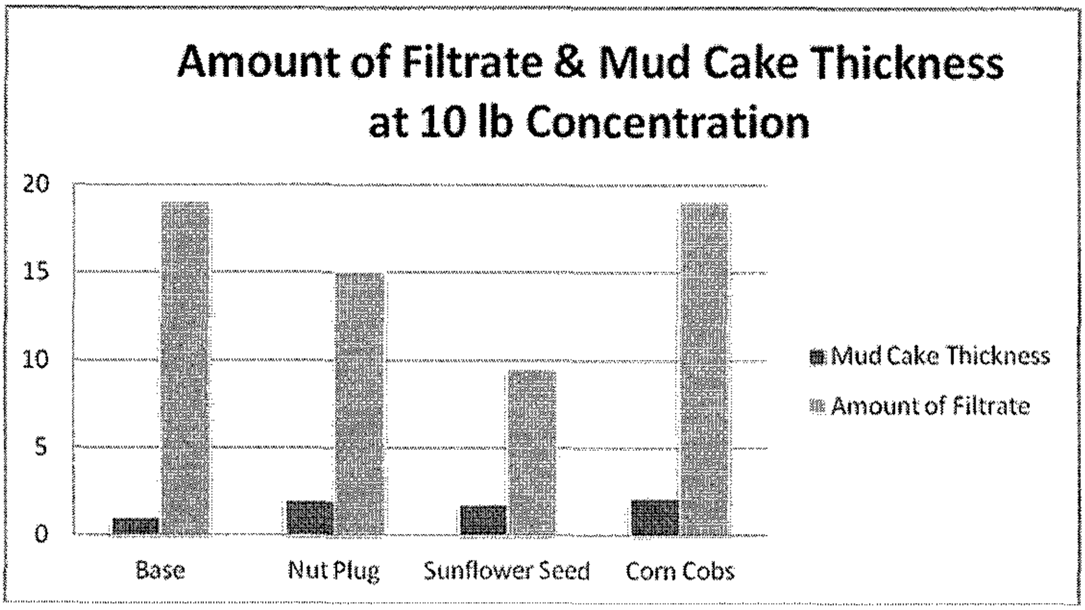

Figure 17: Amount of Filtrate & Mud Cake Thickness of Base Sample and LCM additives at **10 lb/bbl** concentration.

Figure 16 and Figure 17 above illustrate that the amount of water filtered is decreasing as the amount of additives is increasing for the case of Sunflower Seed Shell additive but then slightly increase for the case of fine Nut Plug and same amount of filtrate with the used of Corn Cobs. The water filtrated by the Sunflower Seed Shell is the lowest compared to others.

Both figures above also shows that as the amount of additives were added gradually into the mud formulation, the mud cake's thickness will be increase gradually too, due to the increasing of its densities and slurry. This affects the amount of water filtered to decrease, causing the thickness of the mud cake increase too as well.

While Figure 18 (a) and Figure 18 (b) below shows the amount of filtrate from the base sample with Sunflower Seed Shell additives and the mud cake thickness, respectively. The amount of water filtrated is decreasing as the amount of Sunflower Seed Shell additives is increasing and as the amount of additives were added, the mud cake thickness will be increasing gradually too. From both graph, the **optimum value** or the best possible value for the mud formulation to work effectively is around 10 lb/bbl.

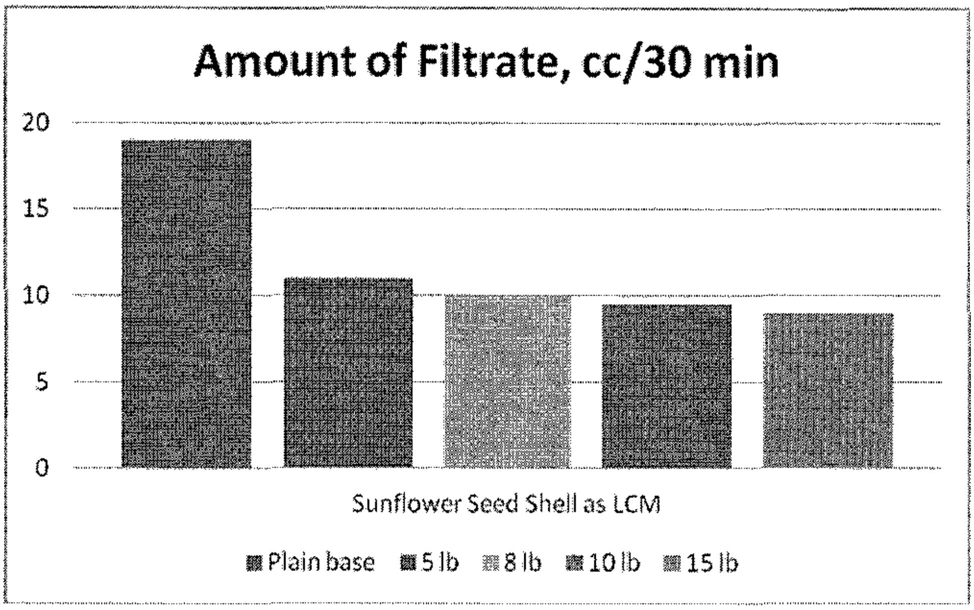

Figure 18 (a): Amount of Filtrate of Base Sample and Base Sample with Sunflower Seed Shell additives.

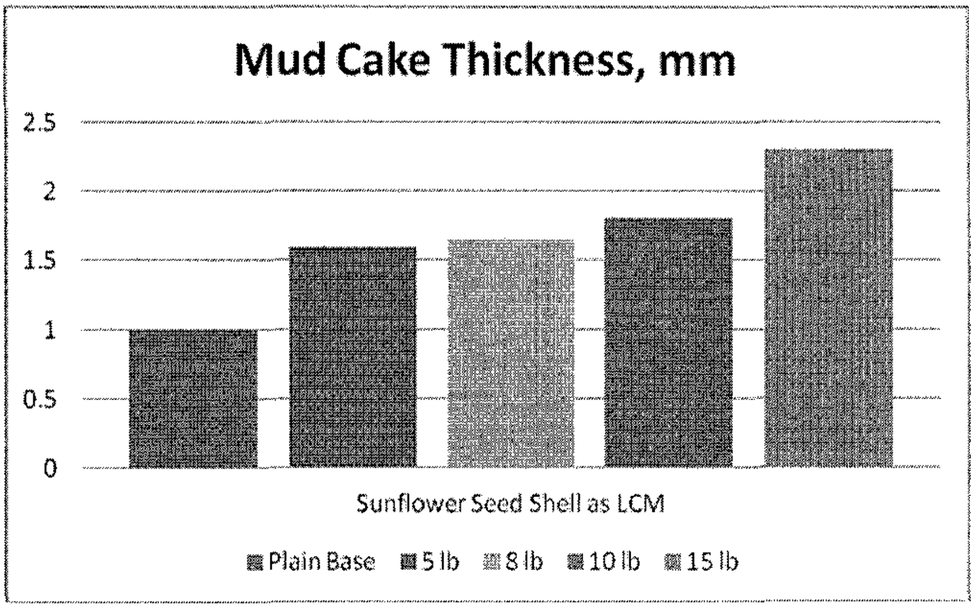

Figure 18 (b): Mud Cake Thickness of Base Sample and Base Sample with Sunflower Seed Shell additives.

CHAPTER 5

CONCLUSION

All mud properties measurement including the original properties of mud base samples, the mud properties with the used of Sunflower Seed Shells, Nut Plug, and Corn Cobs additives were conducted according to the standard, as the functioning of drilling mud to combat lost circulations is directly related to its density, plastic viscosity, yield point, gel strength, and filtration characteristics.

In this experiment, the mud weight intentionally set at 10.5 ppg for each mud formulation and API Barite is added into the mud as a weighting agent, as the amount of barite increased, the mud weight of the formulation increased as well. The important step for each test is the proper amounts of additives were dissolves in the mud samples.

Thus, the parameters for evaluation during the experiments were amount of additives added and the used of industrial LCM properties as comparison. The selected sizes of additives were 1.18 mm, 600 microns and 150 microns, but then only fine size is used for the comparison which is 150 microns. For all LCM additives, two concentrations of 5 lb/bbl and 10 lb/bbl were tested in addition to the plain mud sample. However, only for Sunflower Seed Shell additional concentrations of 3 lb/bbl, 8 lb/bbl, and 15 lb/bbl were tested in order to determine optimum additive concentration.

Overall, the results show that as the amount of Sunflower Seed Shell additives is increased, the density, plastic viscosity and yield point for all mud formulation increased as well. Meanwhile, the gel strength and the amount of filtrate show a reverse relationship with the added amount as the measurement went decreased as the amount of additives were added progressively. Hence, other additional concentrations of additives did affect and has a direct relationship with properties measured.

Also, the most important properties in order to determine the effectiveness of LCM is the filtration properties, as the Sunflower Seed Shell additive give lower amount of filtrate and thinner mud cake thickness compare to both industrial LCM for comparison, as the lower the filtrate volume and the thinner the mud cakes, means that good fluid loss control in mud. However, the additional of 5 lb/bbl and 10 lb/bbl of LCM additives which consist of Nut Plug, Corn Cobs and Sunflower Seed Shell in base mud did improve the filtration properties of each mud.

The **optimum value** or the best possible value for the mud formulation to work effectively is around 10 lb/bbl, which is 150 microns size of Sunflower Seed Shell with the concentration of 28.53 kg/m^3. Comparing it with the other additives, the optimum value obtained for corn cobs is 9.5 lb/bbl at the size of 125 microns and have the concentration of 26.9 kg/m^3.The optimum value or typical treating levels for preventive measures of Nut Plug is from 2 to 5 lb/bbl, with the size of 500 microns to 4mm with the concentration of 5.7 to 14.26 kg/m^3. For more severe losses, the amount of 5 to 25 lb/bbl will be used with the concentration of 14.26 to 71.3 kg/m^3.

Hence, this means that the Sunflower Seed Shell additive is effective enough to be used as a lost circulation material because the optimum value is in the range of both industrial LCM as for comparison. Plus, the experimental results show lower amount of filtrate and thinner mud cake thickness compare to Nut Plug and Corn Cobs as well which means Sunflower Seed Shell has good fluid loss control in mud and can be an effective lost circulation treating material.

CHAPTER 6
RECOMMENDATIONS

For further improvement, more particle size of the additive needed to be tested, in order to investigate the best size and formulation for the various treating level to combat loss circulation especially in the case of severe losses as the treating levels are really depend on the severity of the losses and type of formation where the losses occur. Thus, the particle size of the additive should be varied from a very fine to the large size of additives.

Moreover, more tests should be conducted in order to investigate and identify the ability of Sunflower Seed Shell as effective LCM, as the additives may be mixed with other shaped materials as it may provide a wide variation for optimum control of lost circulation such as sugar cane, walnut and pecan. The additive also can be added to other special slurries, such as high fluid loss squeezes, to assist in forming strong bridging plugs as well. So, further test need to be done to wider the additive application towards its function improvement.

The usage of oil as the base fluid or mud also can be tested to identify the Sunflower Seed Shell additive compatibility in all drilling fluids type including oil mud system as the Sunflower Seed Shell itself contain some lipid fraction which is oil. The LCM effectiveness in water base mud and oil base mud should be done in future together with an economic evaluation for both drilling fluid system.

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