Developing Green Lost Circulation Material (LCM) Derived From Pineapple Peel Waste

By

Syed Mohd Ashraf Bin Sayed Zainaiabidin

Dissertation submitted in partial fulfillment of the requirement for the

Bachelor of Engineering (Hons)

(Petroleum Engineering)

APRIL 2011

Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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Approved by,

(Pn Mazlin Idress)

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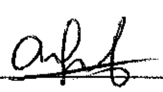
CERTIFICATION OF ORIGINALITY

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.



(SYED MOHD ASHRAF BIN SAYED ZAINAIABIDIN)

ABSTRACT

Lost circulation can be serious problem during drilling operation. It is one of the most troublesome and costly problems encountered while drilling a well. Lost circulation can be characterized by a reduction in the rate of mud returns from the well compared to the rate at which it is pumped downhole. Even with the best drilling practices circulation losses still occur. In order to reduce such losses to acceptable level lost circulation material (LCM) is used. The objectives of this study are to develop green lost circulation material from pineapple peel waste, conduct several mud testings with the green lost circulation material and compare its performance with industrial lost circulation material which is nutplug.

The equipments that been used in order to perform the testing are mixer, mud balance, viscometer, HTHP filter press, API filter press and permeability plugging apparatus (PPA). There are five mud have been mixed and tested which are base mud (B1), base mud + nut plug 1 (NP1), base mud + nut plug 2 (NP2) ,base mud + pineapple peel waste 1 (PPW1) and base mud + pineapple peel waste 2 (PPW2). Base mud (B1) and base mud + nut plug (NP1 and NP2) are mixed as a comparison for pineapple peel waste mud. For all these mud, the mud weight intentionally set to 10.5 ppg as in most cases the amount of mud weight used with lost circulation material is in the range of 8 – 11 ppg. The results of all the experiments are further discussed in this report.

ACKNOWLEDGEMENTS

Firstly, I would like to express a token of appreciation to UTP for providing laboratory equipments, facilities and funds for me to be able to conduct this project according to plan.

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I am indebted to so many people who have been helping me during my one year of completing this project, where their presences are the essence in making this project successful. They are people of my respects who involve directly or indirectly throughout this project.

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NOMENCLATURES

LCM	Loss Circulation Material
PV	Plastic Viscosity
YP	Yield Point
RPM	Revolution Per Minute
SPE	Society of Petroleum Engineers
PETRONAS	Petroliam Nasional Berhad
HPHT	High Pressure High Temperature
ppg	pound per gallon
OBM	Oil-Based Mud
SBM	Synthetic-Based Mud
WBM	Water-Based Mud
MW	Mud Weight
API	American Petroleum Institute
PPA	Permeability Plugging Apparatus

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In petroleum engineering, drilling fluid is a fluid used to drill boreholes into the earth. It is often used while drilling oil and natural gas wells and on exploration drilling rigs. Liquid drilling fluid is often called as drilling mud. A properly designed drilling fluid will enable an operator to get to the desired geological objective at the lowest overall cost. The main purposes of drilling fluids are include providing hydrostatic pressure to prevent formation fluids from entering into the well bore, keeping the drill bit cool and clean during drilling, carrying out drill cuttings, and suspending the drill cuttings while drilling is paused and when the drilling assembly is brought in and out of the hole (Scomi Oiltools Manual). The drilling fluid used for a particular job is designed to avoid formation damage and to limit corrosion.

Lost circulation material (LCM) is substances/solids that added to drilling fluids when drilling fluids are being lost to the formation downhole (Robert J. White, 1956). This substances/solids will plugged the pore throat or fracture thereby building filter cake to prevent mud loss/excessive filtrate to the formation. In this study, the author has selected the pineapple peel waste to be used as lost circulation material.

1.2 Problem Statement

Lost circulation can be one of the more serious problems that can arise during the drilling of an oil well or gas well. Circulation is said to be lost when the drilling fluid, flows into one or more geological formations instead of returning up the annulus.

1.2.1 Problem Identification

The consequences of lost circulation can be as little as the loss of a few dollars of drilling fluid or as disastrous as a blowout and loss of life, so close monitoring of tanks, pits, and flow from the well, to quickly assess and control lost circulation is taught and practiced. If the fluid in the wellbore drops due to lost circulation (or any other reason), hydrostatic pressure is reduced, thus allowing a gas or fluid, which is under a higher pressure than the reduced hydrostatic pressure, to influx into the wellbore. To prevent this problem lost circulation material need to be put in the mud. This chemical will form a bridge or plug across the area of loss that the bentonite can then cover and seal with its filter cake building ability. The lost circulation material added must be compatible with all the other additives added to the mud. In addition, the LCM is preferably non-toxic and biodegrable. The materials also should be environmental friendly and economical to use.

1.2.2 Significant of Project

The idea of the project is basically to come up with the design of green lost circulation material using fruit peel waste. Lost circulation material is essential during lost circulation as the substances can plug the pore/fracture thus preventing the mud loss. Some company put plastic and other non biodegradable substances to plug the fracture/pore space. These substances will have some chemical reactions with the formation thus pollute the environment. By creating lost circulation material using fruit peel waste it can increase the amount of green lost circulation material in the market thus can reduce the pollution.

1.3 Objectives

- Develop green lost circulation materials from pineapple peel waste
- Formulate water based mud that compatible with the green lost circulation materials
- Conduct several mud testing with the green lost circulation materials
- Compare the performance of pineapple peel lost circulation materials with industrial lost circulation material (nutplug)

1.4 Scope of Study

The scope of the project covers all research work and experiment within two semester period time. During first semester, a lot of effort is focused on research about LCM, experiment procedures, project proposal and presentation. The students need to prepare preliminary report, literature review, progress report and oral presentation. Then, during second semester, the project continues on conducting several mud testing of properties and performance of LCM. After that results from these tests will be compiled and discussed. Finally, conclusions will be made after several tests and discussions.

1.4.1 The Relevancy of Project

This project is relevant to the LCM study as the technology of using green fruit peel waste as LCM is not yet been used in the industry.. This project is also in phase with the recent technology used to prevent lost circulation. Even though the technology of using green LCM has already existed, but improvement can be made in improving the performance of LCM with the mud. Fruit peel waste is not only cheap but it can save the earth by reducing pollution.

1.4.2 Feasibility of the Project within the Scope and Time frame

The project will be conducted starting with the collection of related materials such books, journals and technical papers specifically on LCM design and LCM testing. Research will be done from time to time as to get a better understanding on the subject. This project will then focus on the preparing the fruit peel waste as LCM and lab testing. Lab testing will be done in order to prove that the project is viable. Based on the activities stated above, given five months for the researches and studies to be done as well as lab tests and for the other five months for the finalization of the project, the author feels that the project can be completed within the given time frame.

CHAPTER 2

LITERATURE REVIEW / THEORY

2.1 Lost Circulation

Lost circulation occurs when the drilling fluid, known commonly as "mud" flows into one or more geological formations instead of returning up the annulus. It can be one of the more serious problems that can arise during the drilling of an oil well or gas well (T.M. Nayberg, 1987). Lost circulation 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 happen 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 to the hole.

Even with the best drilling practices, circulation losses may occur. Circulation losses can be classified in three groups as (Ali A. Pilehvari 2002):

1. Seepage loss, when the loss rate is 1-10 bbl/hr
2. Partial loss, when the loss rate is 10-500bbl/hr
3. Complete loss, when the loss rate is over 500 bbl/hr

A wide variety of materials have been used to combat lost circulation over the years. The choice of lost circulation material to use in a given case is influenced to some degree by cost and availability in a given drilling area. Depending on the estimated width of the fractures, natural or induced, the LCMs are selected and mixed with drilling fluids in the form of a pill or run continuously with the fluid to treat the target zone.

2.1.1 Types of Formations causing Loss Circulation

In general, four types of formations are responsible for lost circulation. The formations are (George C. Howard 1951):

1. Natural or intrinsic fracture
2. Induced or created fracture
3. Vugular or cavernous formation
4. Unconsolidated or highly permeable formation

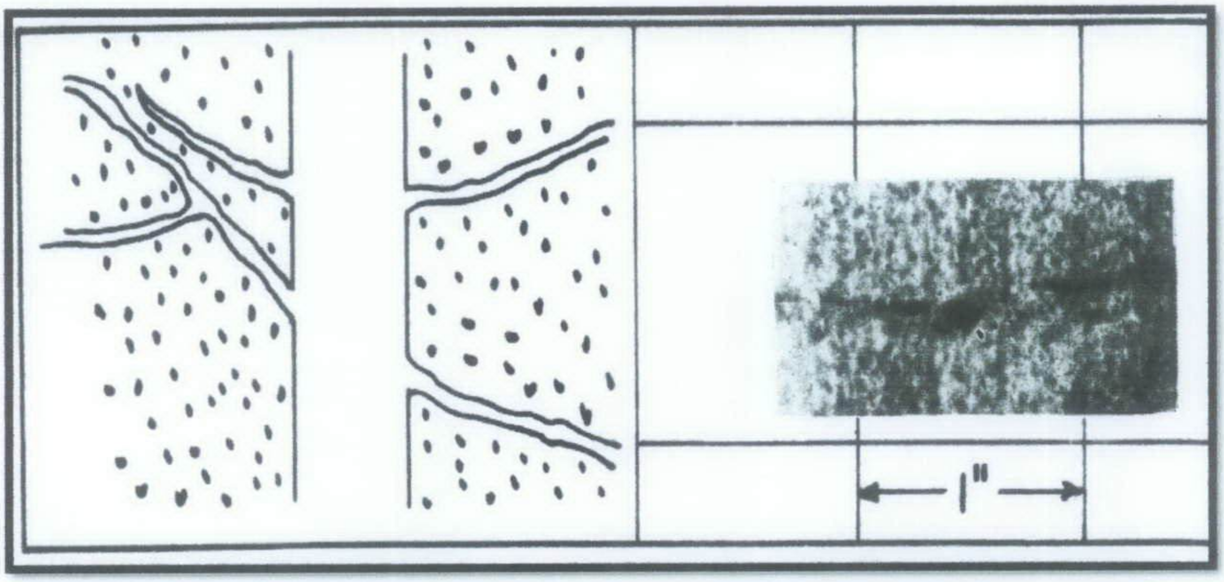

Figure 1: Natural Fracture (George C. Howard,1951)

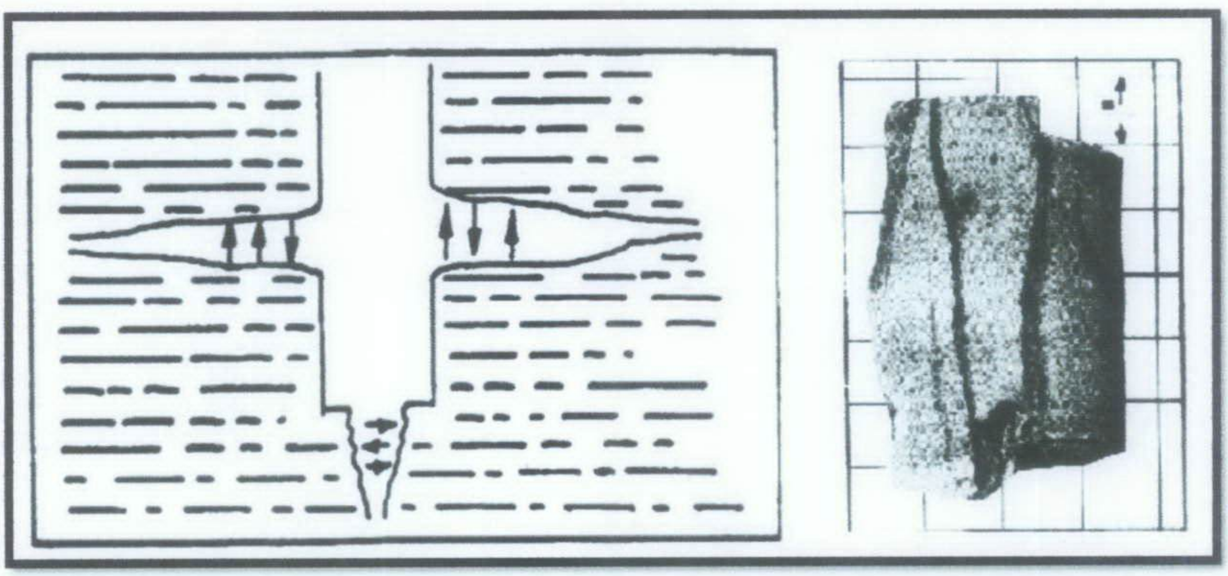

Figure 2: Induced Fracture (George C. Howard,1951)

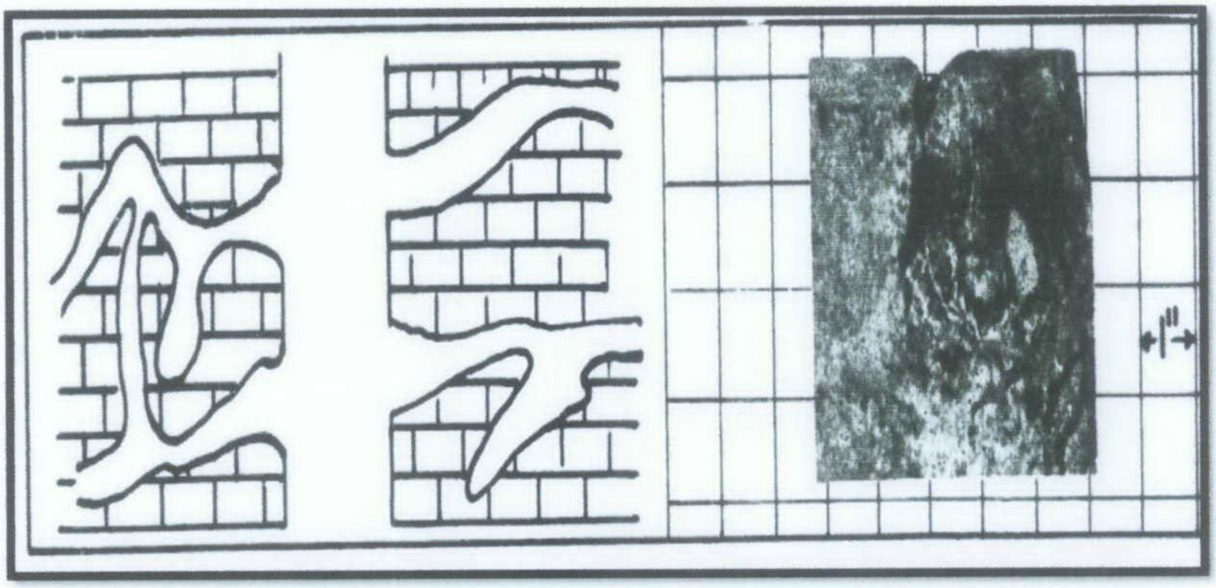

Figure 3: Cavernous or channel formation (George C. Howard,1951)

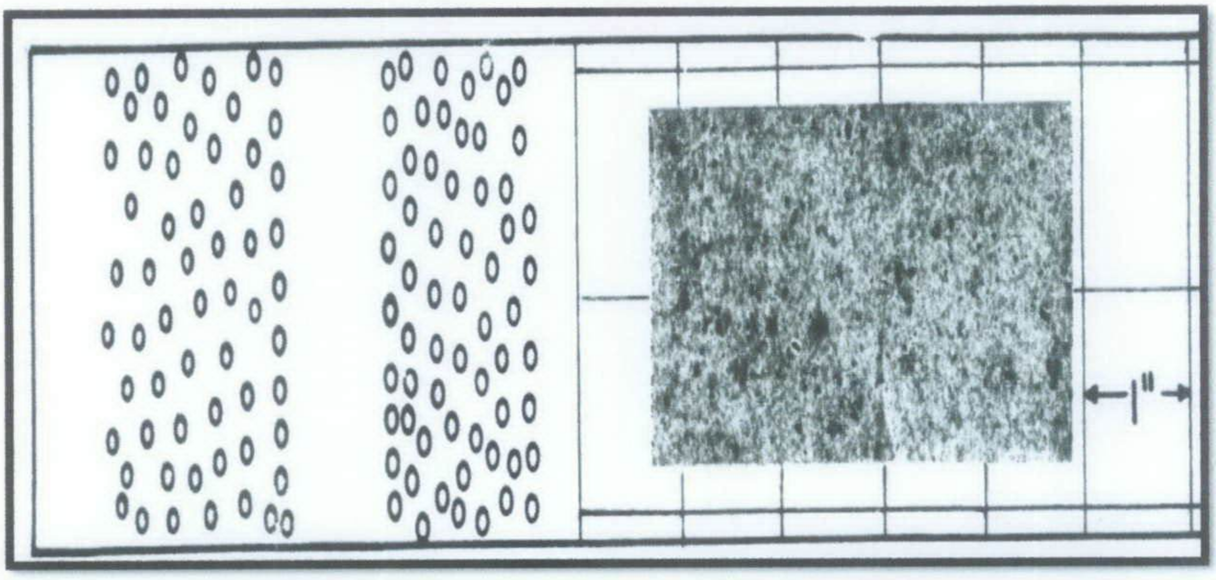

Figure 4: Unconsolidated formation (George C. Howard,1951)

Natural fractures may occur in any type of rock. Mud loss is evidenced by gradual lowering of mud in mud pits. If drilling is continuous and more fractures are exposed, complete loss of returns may be experienced. Induced fractures also may occur in any type of rock, but would be expected in formations with characteristically weak planes such as shale. Loss is usually sudden an accompanied by complete loss of returns. Conditions are conducive to the forming of induced fractures when mud weight exceeds 10.5 lb/gal. When loss of circulation occurs and adjacent wells have not experienced lost circulation, induced fractures should be suspected. Cavernous formation normally confined to limestone. Loss of return may be sudden and complete. Bit may drop from a few inches to several feet just preceding loss and drilling may be rough before loss. At unconsolidated formations there will be a gradual lowering of mud level in mud pits. Loss may become complete if drilling is continued.

2.2 Drilling Fluid

In petroleum engineering, drilling fluid is a fluid used to drill boreholes into the earth. It is often used while drilling oil and natural gas wells and on exploration drilling rigs. Liquid drilling fluid is often called drilling mud. A properly designed drilling fluid will enable an operator to reach the desired geological objective at the lowest overall cost. A fluid should enhance penetration rates, reduce hole problems and minimise formation damage. Removing cuttings from the well, maintaining wellbore stability and controlling formation pressures are of primary importance on every well.

On a drilling rig, mud is pumped from the mud pits through the drill string where it sprays out of nozzles on the drill bit, cleaning and cooling the drill bit in the process. The mud then carries the crushed or cut rock (cuttings) up the annular space (annulus) between the drill string and the sides of the hole being drilled, up through the surface casing, where it emerges back at the surface. Cuttings are then filtered out with either a shale shaker, or the newer shale conveyor technology, and the mud returns to the mud pits. The mud pits are designed in such a way as to allow settling of drilled "fines", and where treatment of the fluid is done by adding chemicals and other additives to the fluid.

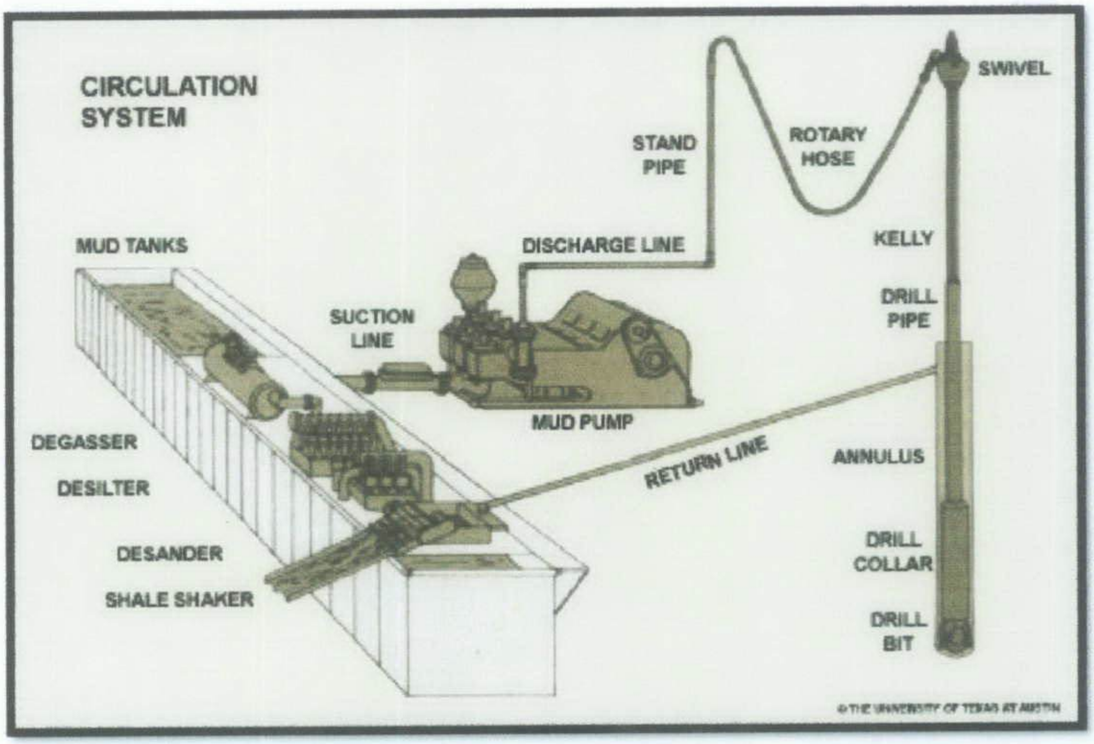

Figure 5 : Mud circulation system (Oilspillsolutions.org)

2.2.1 Types of Drilling Fluid

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.

Water Based Mud (WBM)	**Synthetic Based Mud (SBM)**
Continuous phase is water	Continuous phase is oil
Causes shale instability	Does not react with shale
Low temperature stability	High temperature stability
Low rate of penetration (ROP)	High rate of penetration (ROP)
Higher torque and drag values	Lower torque and drag values
Lower cost	Higher cost
Moderate environmental impact	Moderate to significant environmental impact

Table 1: The differences between WBM and SBM

2.2.2 Function of Drilling Fluid

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.

2.3 Lost Circulation Material

Lost circulation material can be defined as substances added to drilling fluids when drilling fluids are being lost to the formations downhole. For purposes of clarification, lost control materials can be divided into three groups according to their morphology which are fibers, flakes and granules.

Fibrous LCM's include raw cotton, cedar wood fibers, nylon fibers, bagasse, flax shive, bark fiber, textile fiber, mineral fiber, leather, glass fiber, peat moss, feathers and beat pulp. Fibrous LCM's are generally plant fibers, though representatives of animal and mineral fibers are also found, as well as synthetic fibers. The fibrous lost circulation materials are used mainly in drilling muds to lessen the mud loss into large fractures or vugular formations. When added to a drilling mud, the fibrous LCM's form a mat-like bridge over porous formations. This mat effects a reduction in the size of the openings to the formation, permitting the colloidal particles in the mud to rapidly deposit a filter cake thus completely sealing the formation that otherwise might require a cement job. The maximum size of the fibers and the gradiation of sizes are more important in their performance than the composition. The physical and chemical nature of the material however has some limitations as to the size gradiation obtainable, resistance to disintegration, and degration when circulated in the mud system. The maximum size of leather and asbestos fibers for example is considerably smaller than can be obtained with bagasse or bark fiber. Bagasse and raw cotton exhibit much greater resistance to disintegration than peat moss and beet pulp.

Flake LCM's including cellophane, mica, cork, corn cobs, cottonseed hulls, and vermiculite. Although cottonseed hulls always contain some fibers and granules, they are included in this group because they are predominantly small flakes of the hulls. Cellophane flakes are composed of 3/8 to ¾ in graded cellulose or polyvinyl film flakes. Both the cellophane and mica are commercially available in coarse and fine grades. The flaky type LCM's are designed to bridge and to form a mat on the formation face. These materials can plug and bridge many types of porous formations to stop the mud loss or establish an effective seal over many permeable formations.

Granular LCM's include ground walnut shells, gilsonite, crushed coal, perlite, coarse bentonite, ground plastic, asphalt, wood, coke, and ground thermoset rubber. The granular LCM's 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 the LCM's do not become dislodged easily as a result of pipe movement in the wellbore. They are not subjected to as much erosion as a result of fluid movement. The effectiveness of granular LCM's depends primarily on proper particle size distribution to build a bridge with decreasing permeability as it is being laid down. A blend of large, medium, and small particles or a blend of relatively large and small particles is most commonly used. It is believe that the larger particles are transport into the formation, where bridging occurs. The smaller size particles plug the smaller openings until an impermeable bridge is formed. The granular LCM's usually work better in high solids ratio system, such as cement slurries, than in lower solids drilling mud systems.

2.4 Nut Plug as the industrialized Lost Circulation Material

It is a hard fibrous product made from crushed walnut shell. It is hard, chemically inert, non toxic & biodegradable .Nut plug is in ground to granular form in specific size ranges. It is available in fine, medium and coarse particles sizes. It is utilized to control lost circulation in water & oil base drilling fluids. It may be utilized to treat the entire system in re-circulated fluids or in pill form with fibrous & flake material .It is an inert additive which is compatible in all types and densities of fluids. Treating levels depend on the severity of the losses and type of formation where the losses occur. Nut plug material may be mixed with other shaped materials to provide a wide variation for optimum control.

The advantages of using nut plug as the LCM in drilling applications are:

i. It is effective in controlling lost circulation.
ii. It has a high compressive strength and will not ferment.
iii. It is unaffected by pH or temperature.
iv. The fine grade can be circulated through a 20 Mesh Shale Shaker Screen.

The limitations of using nut plug as the LCM are:

i. Larger-sized shale-shaker screens will be needed to retain the material in the system.
ii. When using large concentrations in non-water-base fluids, increased amounts of wetting agent may be needed.

2.5 Pineapple Peel Waste as Lost Circulation Material

Pineapple (*Ananas comosus*) is the common name for a tropical plant and its edible fruit which are coalesced berries. Pineapples are the only bromeliad fruit in widespread cultivation. It can be grown as an ornamental, especially from the leafy tops.

Figure 6 : Pineapple fruit

Pineapple peel was chosen because the fruit can be found everywhere around the world. As the food industry related to pineapple increasing we can say that the source of pineapple peel waste is also increasing. The factory may sell at very low price or even can get free to oil and gas company. Using fruit peel waste are not only cheap but it also environmental friendly. The peel are biodegradable over time thus it not affect the bottomhole formation. The morphology of pineapple peel waste will be cut to be flaky type shape. The skin of pineapple also contains some fibre thus it suitable to be lost circulation material. This type of LCM is designed to bridge and to form a mat on the formation face. It can plug and bridge many types of porous formations to stop the mud loss or to establish an effective seal over many permeable formations.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

In order to achieve the objectives of this project, literature review and studies have to be carried out to understand pineapple peel waste and lost circulation material better. This has been done prior to and during this preliminary report. Sources of reference are such as the Society of Petroleum Engineers published papers, textbook references, online references etc. The scope of review covered the theory of lost circulation material, rheology properties of drilling fluid and others mud testing.

Following this, an appropriate drilling fluid to be tested with the LCM is designed. Samples of pineapple peel waste are first prepared according to desired size. This sample will undergo series of tests with the mud which are permeability plugging test, formation damage test and several basic mud testing. From these tests, the effectiveness of using pineapple as lost circulation material will be known.

3.2 Project Work Flow

The project activities flow is shown in Figure 1.

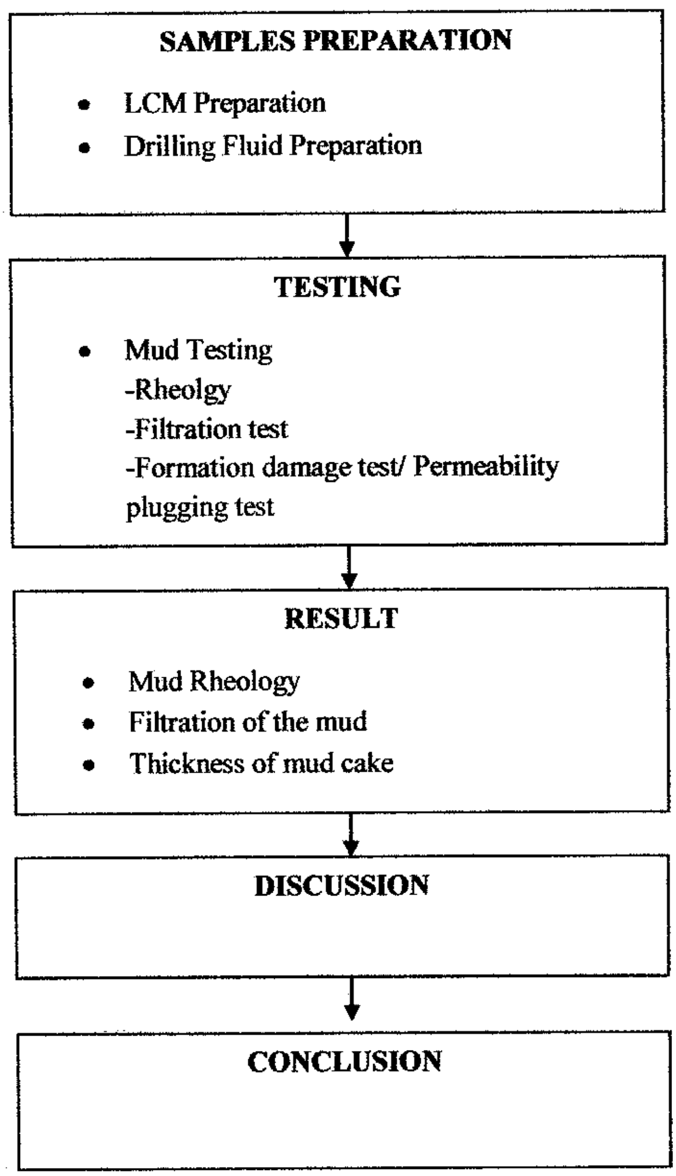

Figure 7 : Project Activities Flow Chart

3.3 Samples Preparation

The pineapple peels were obtained from local fruit market. The pineapple peels waste later will be dried under the sun for 12 hours to remove the water content and to make it easier to be grinded and blended. After that, the dried pineapple peel waste will be grinded and blended into a powder and the particle size will determined using a siever. The particle size of the pineapple peel waste that will be used for this project is 150µm.

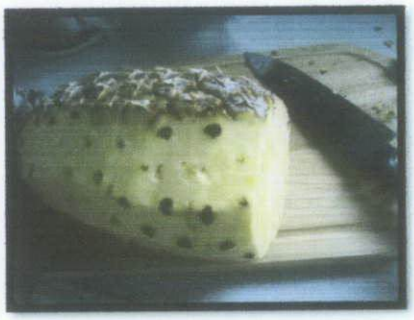

Figure 8 : Pineapple peel

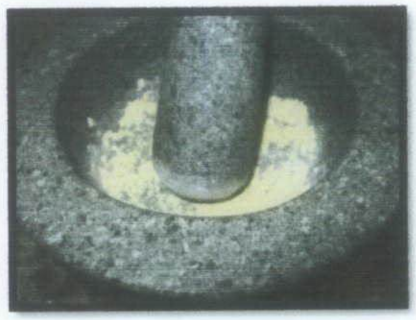

Figure 9 : Pineapple peel after been grinded

Drilling fluid is prepared by mixing fluid phase (water or oil), solids and additives.

Figure 10 : Composition of Mud

3.4 Testing

3.4.1 Mud density

Figure 11 : Mud balance (FANN)

The Mud Balance is used for mud weight determinations and is the recommended equipment in the API standard procedures for testing drilling fluids. The mud balance is accurate to within +/- 0,1 lb/gal (or 0.5 lb/ft3, 0.01 g/ml , 10 g/l). It is designed such that the mud cup, at one end of the beam, is balanced by a fixed counterweight at the other end, with a sliding weight rider free to move along the graduated scale. A level bubble is mounted on the beam to allow accurate balancing. This, most basic, of mud properties is often reported incorrectly due to the use of an inaccurately calibrated mud balance. The time to check the balance is not when a well control situation develops but on a routine daily basis. The mud test kit will contain both standard mud balances and a pressurized Halliburton mud balance. Both types are calibrated by weighing distilled water at 70 °F (21.1 °C) and obtaining a reading of 1.00 SG / 8.33 lb/gal. If this is not the case adjust the balance by adding or removing lead shot as required.

Experience has shown that, under normal drilling conditions, the standard balance gives the same reading as the pressurized balance. For ease of use, therefore, the standard balance may be routinely used to measure mud density. At the first indication of gas or air entrapment in the mud only the pressurized balance should be used. On a tourly basis the pressurized balance will be used to confirm it is reading the same as the standard balance.

3.4.2 Marsh Funnel

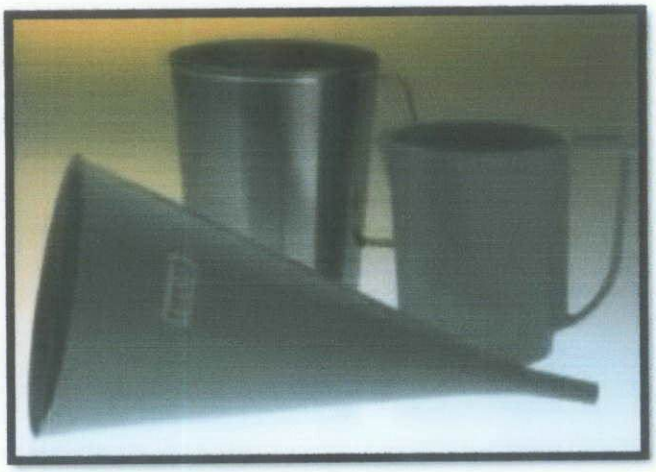

Figure 12 : Marsh funnel (FANN)

The Marsh Funnel Viscometer is used for routine viscosity measurements. The results obtained are greatly influenced by rate of gelation and density. The latter varies the hydrostatic head of the column of mud in the funnel. Because of these variations, the viscosities obtained cannot be correlated directly with those obtained using the rotational viscometers, and therefore can only be used as an indicator of mud stability, or relative changes to mud properties. The funnel viscosity is a good quick guide to whether water based mud is thickening or thinning. However further analysis of rheology and solids content will be required before embarking on any treatment program. The result is temperature dependent but not to the same degree as SBM. The funnel viscosity is, therefore, a more relevant indicator of trends in a WBM.

3.4.3 Rheology Test

Figure 13 : Fann 35 viscometer

Rheology basically can be defined as the science of the deformation and/or flow of solids, liquids and gases under applied stress. In drilling, it is still a common practice to express the flow characteristics in terms of simple viscosity terms such as the constants used in the Bingham Plastic and Power Law models.

Most drilling fluids have critical yield stress which must be exceeded before flow is initiated. This characteristic follows the Bingham Plastic model closely. However, the Bingham model could not accurately describe the fluid rheological characteristics in all drilling situations due to its inability in describing fluid flow over a long shear rate range. In this case, the Power Law model is then thought to be more accurate in describing the flow characteristics of drilling fluids over the shear rate ranges experienced in the wellbore. The only downfall of this model is that it does not fully describe drilling fluids as it does not have a yield stress and underestimates low shear rate viscosity. Due to these reasons, a modified Power

Law (Herschel-Bulkley model) is produced from the results of the previous models (Bingham, Power Law, and Newtonian).

The diagram below shows the differences between the Bingham Plastic, the Power Law and the modified Power Law models. The modified Power Law which is located in between the two other models shows more resemblance to the flow profile of a typical drilling mud.

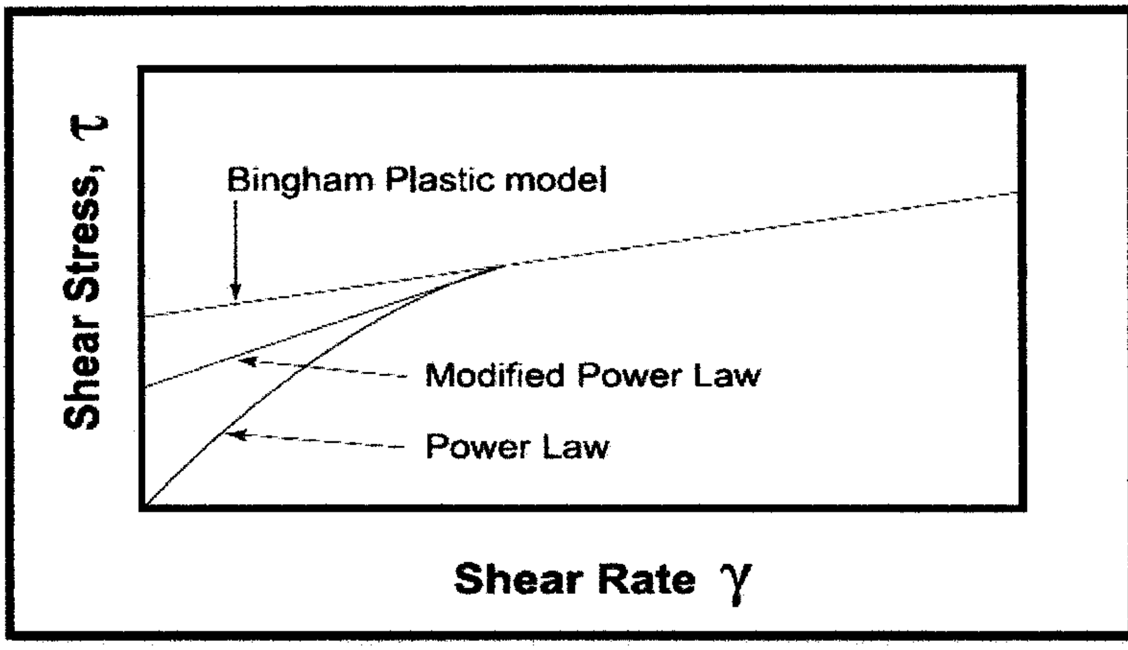

Figure 14 : Comparison between Bingham Plastic, Modified Power Law and Power

The rheology test is carried out on the viscometer Fann 35. The viscometer has 6 different speeds (600, 300, 200, 100, 6 and 3 rpm). From these 6 readings, the Plastic Viscosity (PV) and the Yield Point (YP) can be determined. PV is the resistance to flow due to mechanical friction of the properties. It is affected by the solids concentration, size and shape of the solids and the viscosity of the fluid phase in the mud. The higher the volume percent of solids, the higher the surface area and thus the higher the PV will be. YP is the initial resistance to flow caused by electrochemical forces between the particles. The charges on the surface of the particles dispersed in the fluid phase are what cause the electrochemical forces to present. YP is highly dependent on the surface properties of the mud solids, the volume concentrations of the solids, and the ionic environment of the liquid surrounding the solids.

In general, PV indicates the flow characteristics of the mud when it is moving rapidly, whereas YP indicates the flow characteristics when the mud is moving slowly or at rest. In both cases, higher values indicate a more viscous mud. The units for PV is centiPoise (cP), whereas for YP is lb/100 ft^2. The gel strengths readings are also determined from the viscometer. The gel strengths will indicate the behavior of the mud over time when it is in static condition, that is, when the mud circulation is stopped. Gel strength is run for 10 seconds and 10 minutes. The difference between the two readings will then be used to indicate whether the mud has progressive gel or not. Progressive gel is a term used when the difference between the two gel strength readings are too large, which is undesirable. Progressive gels are caused by high solids concentration which leads to flocculation. If flocculation occurs, there may be a need to increase the power of the pump to circulate the mud again after being at rest, which is cost consuming.

3.4.4 API Filtrate Test

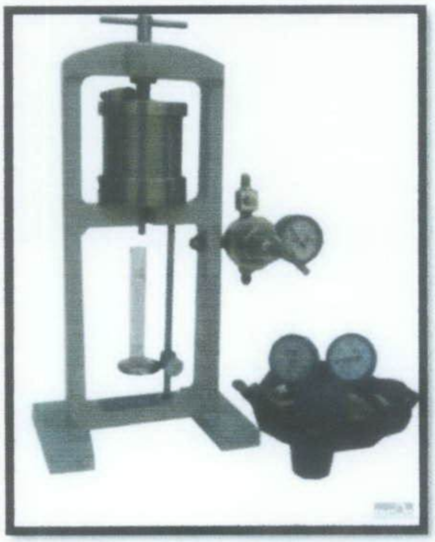

Figure 15 : API filter press

The API Filtrate Test is performed to study the fluid loss characteristic in a mud. This test is carried out at room temperature with 100 psi (690 kPa) differential pressure. Even though this condition does not reflect the downhole conditions, experience has shown that this test is a reliable way of measuring the amount of fluid loss from the mud to the wellbore formation at any given moment. The thickness of the filtrate cake is also considered in conjunction with the amount of the fluid loss collected. Lab testing experience has also shown that solids content in the mud is the most influencing factor. A low solids polymer mud may have a relatively high fluid loss but the filter cake is almost non-existent, whereas a high solids mud may have a lower fluid loss but a much thicker filter cake.

3.4.5 High Temperature High Pressure (HTHP) Filtrate Test

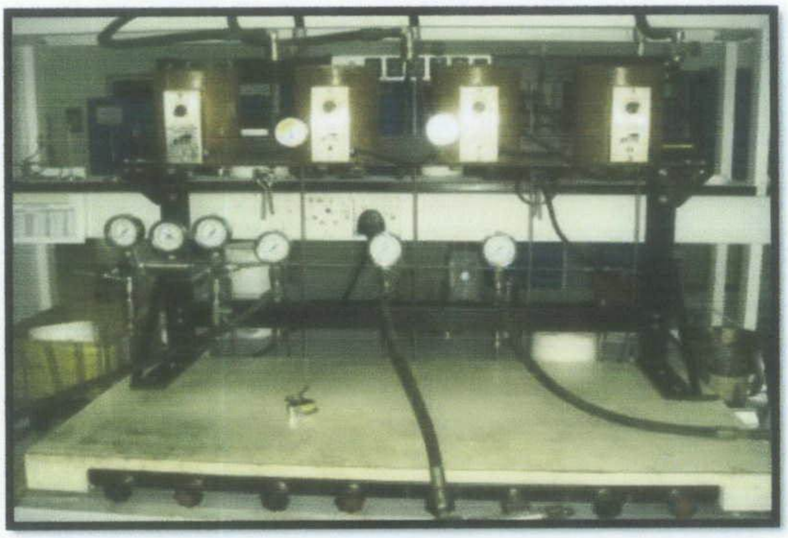

Figure 16: HTHP filtration

The HTHP Filtrate Test is basically of the same concept as the API Filtrate test, except that it is usually done at temperatures up to $350^{O}F$ and with differential pressure of 500 psi. As the standard API cell is twice the area of the HTHP cell, the amount of the filtrate collected from HTHP test must be doubled. The amount of fluid loss was taken at the value of cc/30min. Due to its high temperature and high pressure nature, care must be taken seriously while performing this test. This equipment help simulate the same condition in a HTHP wellbore. Normally, SBM/OBM is used for testing but sometimes, WBM is also tested using the equipment

3.4.6 Permeability Plugging Test

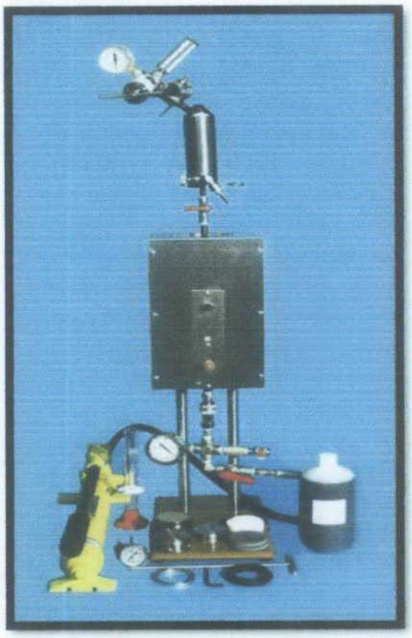

Figure 17: Permeability Plugging Apparatus

This will be conducted to determine the amount of filtrate and also the thickness of mud cake. The concept of this equipment is the same as HPHT test but the only different is this test will be conducted upside down. This means that the thickness of the mud cake will not be affected by the gravity. Instead of using filter paper this equipment use ceramic disk to stimulate more of well formation. The permeability of the ceramic disk to be used is 35md. Differential pressure of this equipment is set to be 500 psi.

3.4.7 Formation Damage Test

Formation damage test is done as a confirmation to permeability plugging test if that test succeed. This kind of test uses core plug from the formation to test it with the mud. The effect on the core plug itself will be known after conducting this test. Thickness of the mudcake and filtrate of the mud will be recorded as well.

3.5 Gantt Chart

The Gantt chart is provided together with the report in the Appendices section. Noted that the Gantt Chart is a guideline for our project timeline. It can be changed from time to time depending on certain circumstances.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Mud Formulation

For this study, there are only water based mud have been conducted due to time constraint. There are totals of five mud have been mixed which are base mud (B1), base mud + nut plug 1 (NP1), base mud + nut plug 2 (NP2) ,base mud + pineapple peel waste 1 (PPW1) and base mud + pineapple peel waste 2 (PPW2). Base mud (B1) and base mud + nut plug (NP1 and NP2) are mixed as a comparison for pineapple peel waste mud. For both LCM additives, two concentrations of 5 lb/bbl and 10 lb/bbl were mixed to give better understanding of mud properties. The result from the testing will be compared and analyzed. Below are the formulations of the mud that we tested.

	Base	Nut Plug		Pineapple Peel Waste	
Products	B1	NP1	NP2	PPW1	PPW2
Water	323.08	323.08	323.08	323.08	323.08
Soda Ash	0.50	0.50	0.50	0.50	0.50
Bentonite	12.00	12.00	12.00	12.00	12.00
Flowzan	1.00	1.00	1.00	1.00	1.00
Caustic Soda	0.25	0.25	0.25	0.25	0.25
API barite	71.33	71.33	71.33	71.33	71.33
Nut Plug		5.00	10.00		
Pineapple Peel				5.00	10.00

Table 2 : Formulation for 1 barrel of mud

4.2 Results

	Base	Nut Plug		Pineapple Peel Waste	
Rheology	1	NP1	NP2	PPW1	PPW2
Mud weight	10.5ppg	10.5ppg	10.5ppg	10.5ppg	10.5ppg
Rheology at ...	120F	120F	120F	120F	120F
600 rpm	45	49	50	48	55
300 rpm	32	36	35	37	35
200 rpm	26	29	25	30	30
100 rpm	20	23	20	24	25
6 rpm	9	11	8	11	10
3 rpm	8	10	7	9	8
PV,cP	13	13	15	11	20
YP , $lb/100ft^2$	19	23	20	26	15
Gel 10 sec	7	10	10	8	9
Gel 10 min	13	18	12	14	11
Thickness	1	2.2	2	2	2.5
API , cc/30min	13.8	13.8	15	13.7	13
PPT					
Spurt Loss	5.8	5		6.8	
Filtrate	7	6		6	
Mud cake	1	2		2.2	

Table 3 : Mud formulation result

Mud Weight

Density is the most important mud property affecting penetration rate. For any given formation pressure, the higher the density, the greater will be the differential pressure. In the experiment, the mud weight is intentionally set to be 10.5ppg. Only one mud weight is chosen in the experiment. Chemical that important in order to control the mud weight in this project is API barite.

Plastic Viscosity

Plastic viscosity is proportional to rate of shear, thus largely reflects the resistance to flow due to mechanical friction of the particles. Plastic viscosity is a function of solids concentration and shape. It will be expected to increase with decreasing particle size with the same volume of solids. Addition of more lost circulation material in the mud also can increase the plastic viscosity of the mud. This can be proven in the experiment as the amounts of LCM are increased the value of PV also increased.

Plastic Viscosity (PV) in cP = 600 reading – 300 reading

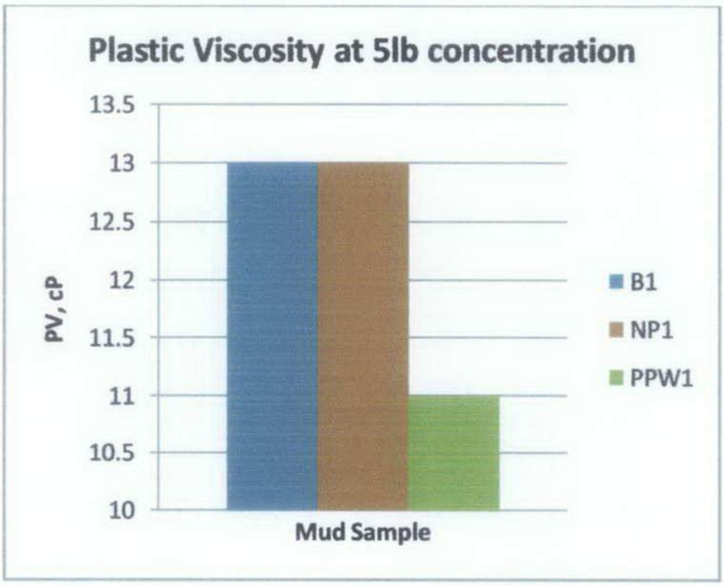

Figure 18 : Plastic Viscosity of B1, NP1 and PPW1 mud

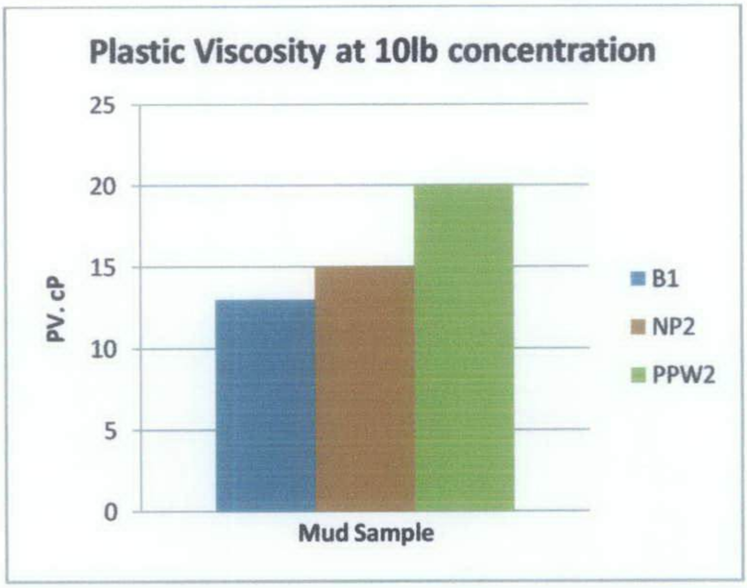

Figure 19 : Plastic Viscosity of B1, NP2 and PPW2 mud

Figure 18 and figure 19 show that the plastic viscosity of each mud according to LCM concentration. From these two graphs we can see that the value of PV increased as the amount of LCM increased by 5lb. The value of PV for nut plug mud changed from 13 cP to 15 cP while for pineapple peel waste changed from 11 cP to 20 cP. This mean that addition of more pineapple peel LCM in the mud has greater effect in plastic viscosity compared to nut plug.

Yield Point

Yield point is a function of the concentration of mud solids and their surface changes and potentials which affect inter particle forces. From the result both nut plug mud and pineapple peel waste mud decreased in yield point after concentration for each of the LCM are increased by 5lb.

Yield Point (YP) in lb/100ft2 = 300 reading – PV

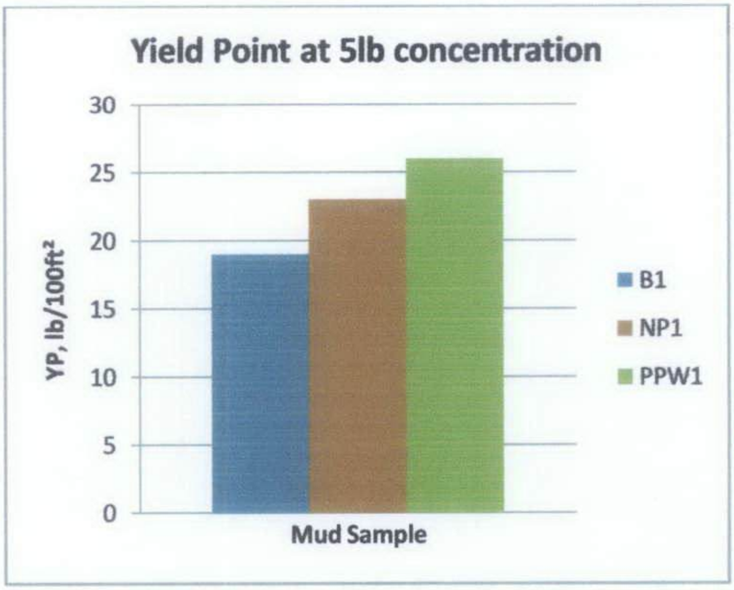

Figure 20 : Yield Point of B1, NP1 and PPW1 mud

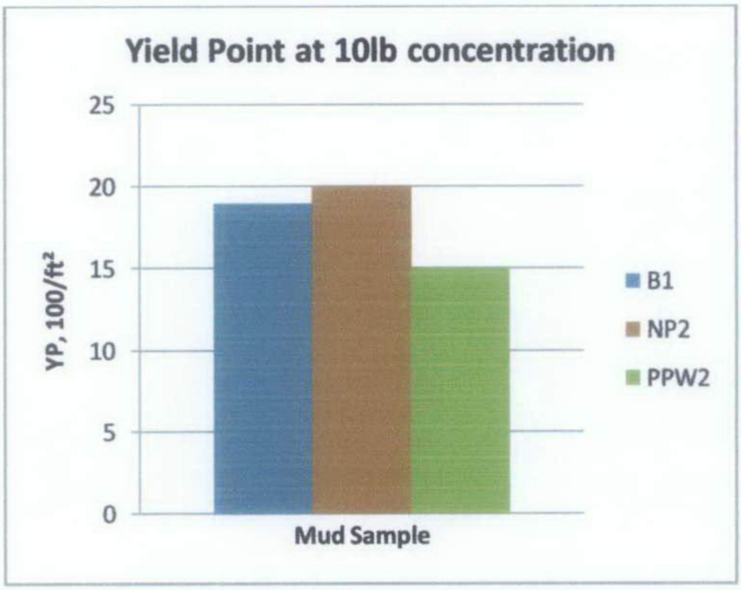

Figure 21 : Yield Point of B1, NP2 and PPW2 mud

From the figures above we can see the yield point of mud for 5 lb and 10 lb concentrations. The value of yield point for both mud decreased as the concentration of LCM increased. The value of yield point for pineapple peel waste mud has greater downturn compared to nut plug mud. Supposedly the value of yield point will increase as the amount of solid increased. This maybe happening due to human error while conducting the experiment or due to the fact that pineapple peel LCM has certain effect that reduce the attraction force between solid particles.

Filtration

When the mud is given pressure the solid from the mud will form a layer of solid called "mud 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. The rate of loss through a cake is dependent upon particle size distribution in the mud and the incorporation of droplets of water and/or oil in the openings between the solids. The openings are controlled by the filtration control agents. The basic filtration control agent of many water base muds is bentonite. From the result the amount of water filtered is decreasing as the amount of additives is increasing. This proves the fact that as the amount of additives is increasing, the viscosity increased too, causing the water to be less filtered.

Mud Cake Thickness

The experiment that conducted to determine the mud cake are API filter press test and PPA test but result from PPA test are more précised. It has been suggested that PPA provides better representation of downhole static filtration condition as it used ceramic disk instead filter paper. Basically, PPA is a HTHP (high temperature high pressure) fluid loss cell that has been modified to better simulate well bore conditions. Pressure is applied from the bottom of the cell by using pump and filtrate is collected out on the top, thus avoiding faulty readings due to settling of particles. There are only three muds have been conducted for this test which are base mud (B1), base mud + nut plug (NP1) and base mud + pineapple peel waste (PPW1). Based on the result the thickness of mud cake for B1 mud is 1mm, NP1 mud is 2mm and PPW1 mud is 2.2mm. The thickness of mud cake should be not too thick as it can create problem in drilling operation such as stuck pipe and hole cleaning. The optimum mud cake that been suggested by Scomi are around 2mm to 2.5mm.

Figure 22 : Mud cake of B1 mud on 35 micron ceramic disk

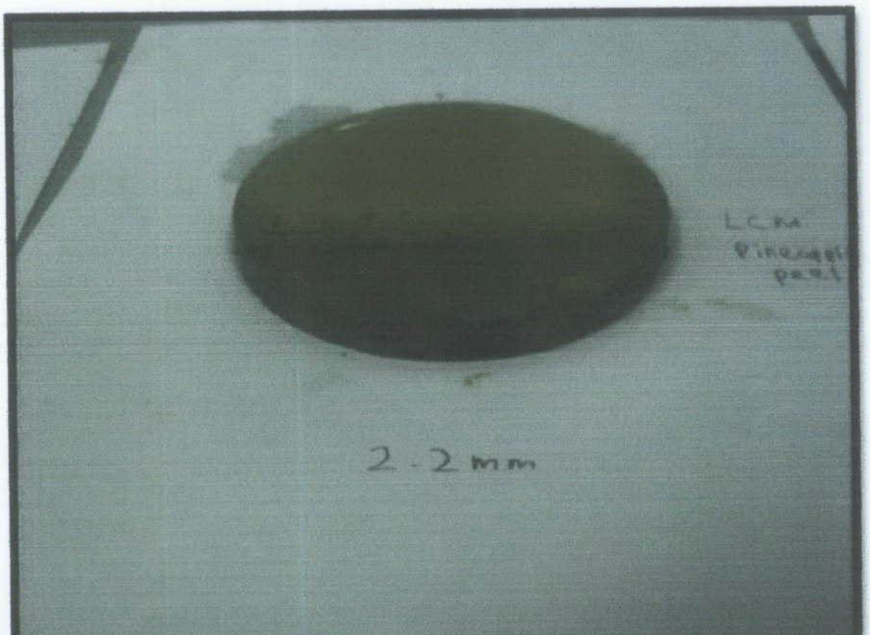

Figure 23 : Mud cake of PPW1 mud on 35 micron ceramic disk

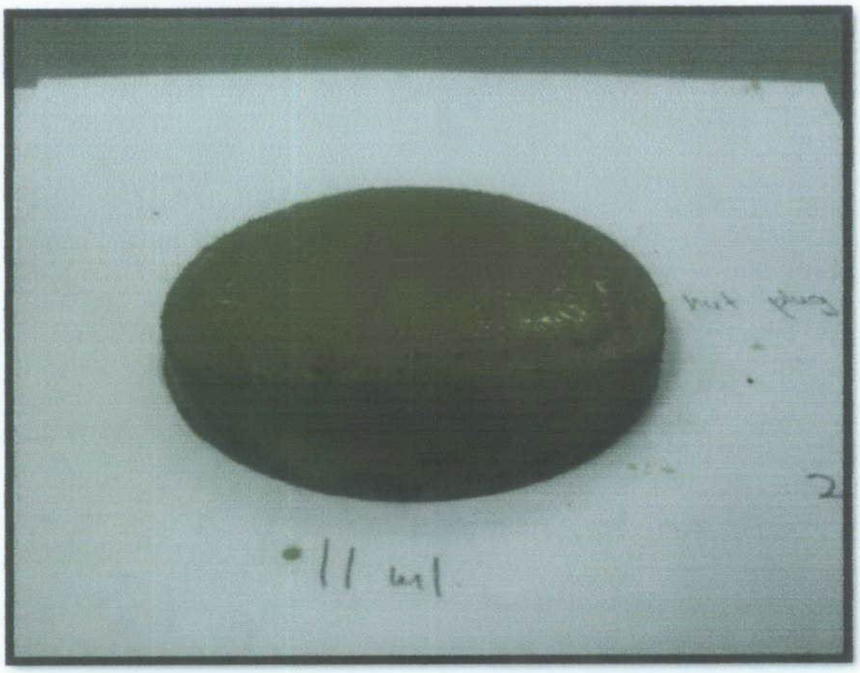

Figure 24: Mud cake of NP1 mud on 35 micron ceramic disk

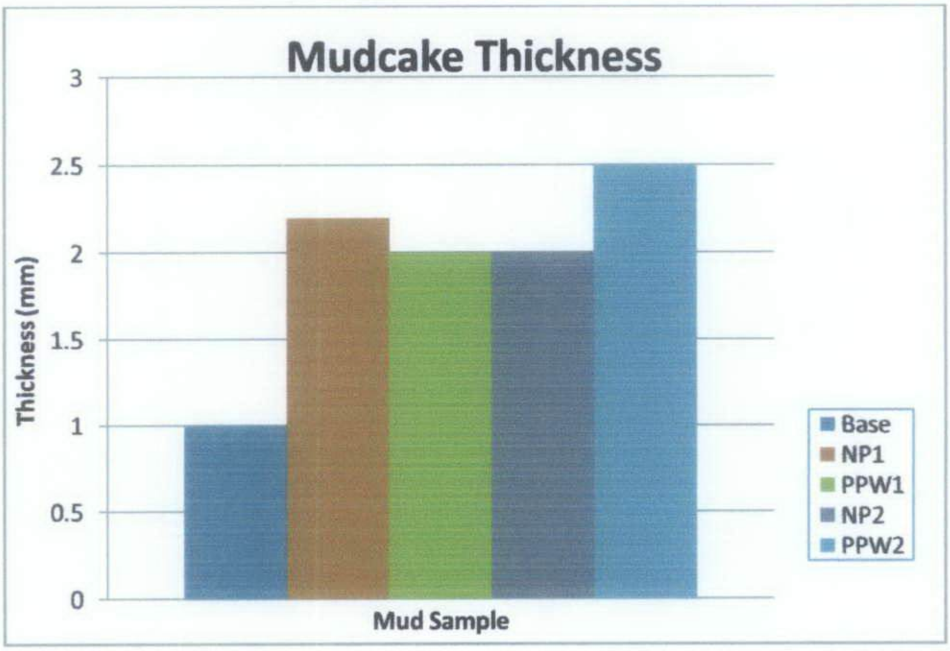

Figure 25 : Mud cake thickness using API filter press

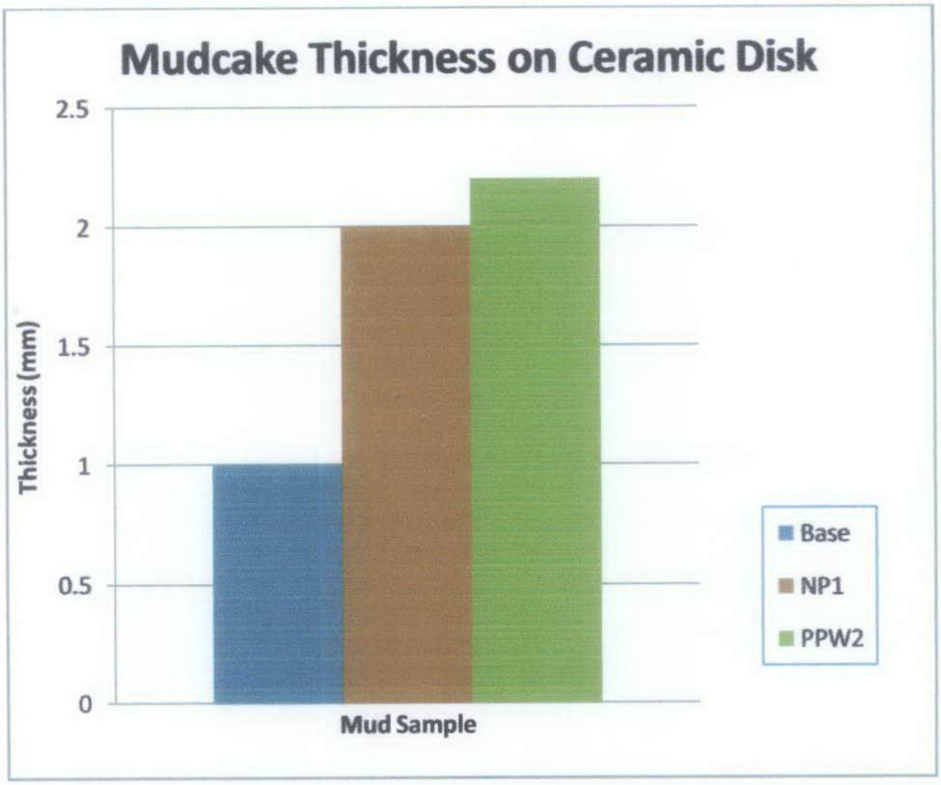

Figure 26 : Mud cake thickness using permeability plugging apparatus (PPA)

4.3 Discussion

All of the tests have been conducted at Scomi GRTC due to lack of some equipments in UTP drilling fluid lab such as mud cup, heating cup and permeability plugging apparatus (PPA). PPA is needed to build mud cake on the ceramic disk. This equipment provides better representation of downhole static filtration condition compare to API filter press and HTHP filter press.

CHAPTER 5

CONCLUSION

Lost circulation material is very important in preventing mud losses to the formation. Even with the best drilling practices lost circulation still occur. Thus it is essential to put lost circulation material to minimize mud losses to the formation. Pineapple peel was chosen to be the lost circulation material in this project because of the fact the fruit can be found everywhere around the world. Apart from its effectiveness in cost and availability, it is also environmentally friendly additive, hence it is sensible to choose these pineapple peel waste as lost circulation material.

Based on the experimental results, we can say that the pineapple peel waste can be used as lost circulation material. In comparison with the industry used lost circulation material (LCM) which is nutplug, it has not much different in term of effectiveness base on filtration test using API filter press and permeability plugging apparatus (PPA). The data from the API filtration test may not be reliable as the mud cake was formed on top of the filter paper but the data is essential in predicting the mud behavior. The results from the permeability plugging test show that the pineapple peel waste mud is slightly thicker with different of only 0.2mm in comparison with the nut plug mud while the filtrate from these two mud are the same. The thickness of mud cake from the pineapple peel waste mud is still in the range of optimum value so that I can say the experiments were quite successful. However, there are still a lot of things need to be done first before the product can be commercialized to the market as the experiments only covered the testing of the mud with medium size pineapple peel waste only. Further testing with all different particle size (fine, medium and coarse) are still needed to confirm the effectiveness of using pineapple peel waste as lost circulation material n the industry.

CHAPTER 6

RECOMMENDATIONS

More specific studies should be conducted in order to have more accurate results. For instance;

1. Other drilling fluid type which is oil-based mud should also be considered in the analysis in the future as it will show the compatibility of the lost circulation material with other type of drilling fluid.
2. The particle size of the lost circulation should be varied from fine, medium and coarse. The particle size selected in this project only covered the medium size.
3. Formation Damage Test should be conducted to measure the effectiveness of the loss circulation materials (LCM) to seal the fractures.
4. The mud should be tested with the actual reservoir pressure and temperature to have more accurate result.

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APPENDICES

Gantt Chart for FYP 1

No	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Topic selection/confirmation														
2	Preliminary Research Study														
3	Submission of Preliminary Report														
4	Literature Review on pipeline riser and pipeline stress and displace.														
5	Data Gathering														
6	Submission of Progress Report														
7	FYP 1 Seminar (Compulsary)														
8	Software Familiarization														
9	Continue Literature Review and Software Familiarization														
10	Report Preparation														
11	Submission of Interim Report														
12	Oral Presentation (study week)														

Gantt Chart for FYP 2

No	Task Name	Duration	Jan 2011 Semester (weeks)													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Sample preparation	2 weeks														
2	Further research about LCM	1 weeks														
3	Mud preparation	2 week														
4	Mud testing	3 weeks														
5	Progress report preparation	2 weeks														
6	Submission of Progress Report	1 days														
7	Preparation on final presentation and final report	1 week														
8	Final presentation	1 day														

Mixing Procedure

Water Based Mud

Products	Mixing order	Mixing time, min
Make up water	1	-
Soda ash	2	2 minutes each
Salt	3	2 minutes each
Bentonite	4	2 minutes each
Fluid loss additives	5	5 minutes each
Viscosifiers	6	5 minutes each
Weighting agent	7	2 minutes each
pH control	8	2 minutes each
Contaminants; Rev dust, OCMA Clay	9	2 minutes each

Table 4: Mixing procedure for WBM (Scomi)

*Total mixing is 45 minutes

Synthetic Based Mud

Products	Mixing order	Mixing time, min
Base oil	1	-
Emulsifier: primary, secondary	2	2 minutes each
Fluid loss additives	3	5 minutes each
Organophilic clays	4	5 minutes each
Lime	5	2 minutes each
Brine	6	10-15 minutes each
Wetting agent	7	2 minutes each
Weighting agent	8	2 minutes each
Contaminants; Rev dust, OCMA Clay	9	2 minutes each

Table 5: Mixing procedure for SBM (Scomi)

*Total mixing is 60 minutes

Lab Experiments at SCOMI