Study on Rice Husk as Lost Circulation Material

by

Mohamad Azir Syazwan Bin Sufri

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

Petroleum Engineering Programme

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Approved by,

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(Jasmi Ab. Talib)

Date:

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JANUARY 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I, Mohamad Azir Syazwan Bin Sufri (I/C No: 900516-03-5321), am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MOHAMAD AZIR SYAZWAN BIN SUFRI

Student ID : 11548

I/C No : 900516-03-5321

Date :

ABSTRACT

One of the vital factors in successful drilling operation is drilling fluid or also known as mud. Drilling fluid consist of many component. One of the main components is fluid loss control or also known as lost circulation material (LCM). Lost circulation material is a drilling fluid additive added into drilling fluid to control the drilling fluid or mud fluid loss into the formation during drilling operation. The main objective of the whole project is to find an alternative to conventional and commercial lost circulation material currently being used in drilling fluid. The scope of study mainly investigates rice husk sample taken from an area near Pasir Mas, Kelantan and evaluates its performance and behavior in drilling fluids. This project is conducted on experimental basis. Sample preparation, specific gravity evaluation, and moisture content evaluations are determined before evaluation of performance as drilling fluid additive against standard LCM product.

ACKNOWLEDEMENT

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CHAPTER 1: INTRODUCTION

1.1 Project Background

Drilling fluid or also known as mud is one of the key factors for successful drilling operation. Drilling fluid helps to facilitate safe drilling operation and satisfactory completion of the well. Drilling fluid functions are as bottom hole cleaning, removal of cuttings to the surface, controlling formation pressure, and maintain wellbore stability. These functions are controlled by the rheological and filtration properties of mud.

Drilling fluid consists of many important components. The main component of drilling fluid is fluid loss material or lost circulation material (LCM). The function of lost circulation material is to ensure that the drilling fluid circulated down in the hole returns to the surface for recirculation rather than disappearing into the formation drilled. Clay and other solid which are normal addictive of drilling fluid are also act as lost circulation material and they are adequate for sealing porous formation until the pore size or fracture size to be sealed exceed about three times the diameter of the largest particles present(Robert J White, 1956). Lost circulation material is added to drilling fluid in order to plug the pores, crack and fracture which the drilling fluid alone is unable to seal by increasing the maximum particle size present in the drilling fluid.

Conventional lost circulation material currently being used in the oil and gas industry are mica, cotton, cellophane and limestone, $CaCo_3$. In order to reduce the overall cost of lost circulation material used in local oil and gas industry, the feasibility study of rice husk from Pasir Mas had been initiated. Rice husk is waste from rice industry. Before this rice husk can be used as lost circulation then their physical must be determine first and then their performance as compared with the standard lost circulation material must be determined.

1.2 Problem Statement

Rice husk or rice hull are hard protecting covering the grain of rice. In Malaysia, rice is the staple food for its people. Thus, rice industry is one of the important industries in Malaysia. By 2010, under Malaysia's government initiative which is the Northern Corridor Economic Region (ECER), the paddy yield will increase from 4 tons per hectare in 2005 to 8 tons per hectare and the amount of the agricultural land utilized will increase from around 800,000 hectare to one million hectare. Abundant of rice husk, waste from the rice industry will be produced each year. This waste can be utilized to produce lower cost of lost circulation material. Thus, it is important to conduct a study on rice husk sample from Malaysia for potential development as drilling fluid additive.

Conventional lost circulation material currently used are mica, nut shell, plastic cotton, cellophane and limestone, $CaCo_3$ It is desired that the sample of rice husk taken from Pasir Mas, Kelantan has a potential values to be developed as commercial lost circulation material. Thus, the purpose of this project therefore was to undertake a comparative performance evaluation of rice husk sample with standard lost circulation material so it could meet API specification and could be utilized for oil well operations in Malaysia. The successfully rice husk will be used as a material in drilling mud, which is cheaper as compared to the standard product such as mica and limestone.

1.3 Objectives and Scope of Study

The main objective of the whole project is to find an alternative to standard and conventional product that currently being used as lost circulation material in drilling fluid. This is accomplished by developing a local lost circulation material production based on rice husk, waste from rice industry which is much cheaper compared to standard and conventional lost circulation material such as limestone or mica, subsequently reducing the drilling operation cost.

For my project, a rice husk sample is taken from an area near Pasir Mas, Kelantan to be evaluated as potential lost circulation material, drilling fluid additive in petroleum industry. The objectives of the project are based on the evaluation and process of the testing methods, which are:

1. To perform the laboratory testing on properties of the sample ,(specific gravity (SG) and moisture content)
2. To determine the feasibility of the sample as drilling fluid additive (lost circulation material or LCM) by comparing the performance against the standard product.

The scope of study mainly investigates the rice husk sample taken from Kelantan and evaluates its performance and behavior in drilling fluids. This experimental works can be divided into two major parts – properties of the rice husk sample (moisture content and specific gravity of the sample) and performance of rice husk as drilling fluid additive. Further research may be conducted to compare the performance between the sample and standard product of LCM. Filtration Test using API Filter Press will be conducted to evaluate the performance of the sample as lost circulation material (LCM) in drilling fluid. In order to fit within the time frame, proper research must be done beforehand. The experimental works will be focusing more on the API Filter Press for fluid loss measurement. Sets of mud formulation will also be prepared first for the evaluation of the sample behavior in the drilling fluid. Collected result and data from experiment will be analyzed and discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 Drilling Fluid

The objective of a drilling operation is to drill, evaluate and complete a well that will produce oil and/or gas efficiently. Drilling fluid is a fluid used to drill boreholes into the earth. Drilling fluids, also known as mud play vital in drilling operation and perform numerous essential functions that help make drilling operation possible. A properly designed drilling fluid will enhance penetration rates, reduce hole problems and minimize formation damage.

There are two main types of drilling fluids which are water-based mud (WBM) which can be dispersed and non-dispersed and non-aqueous fluid (NAF), usually called synthetic-based mud (SBM) or oil-based mud (OBM).

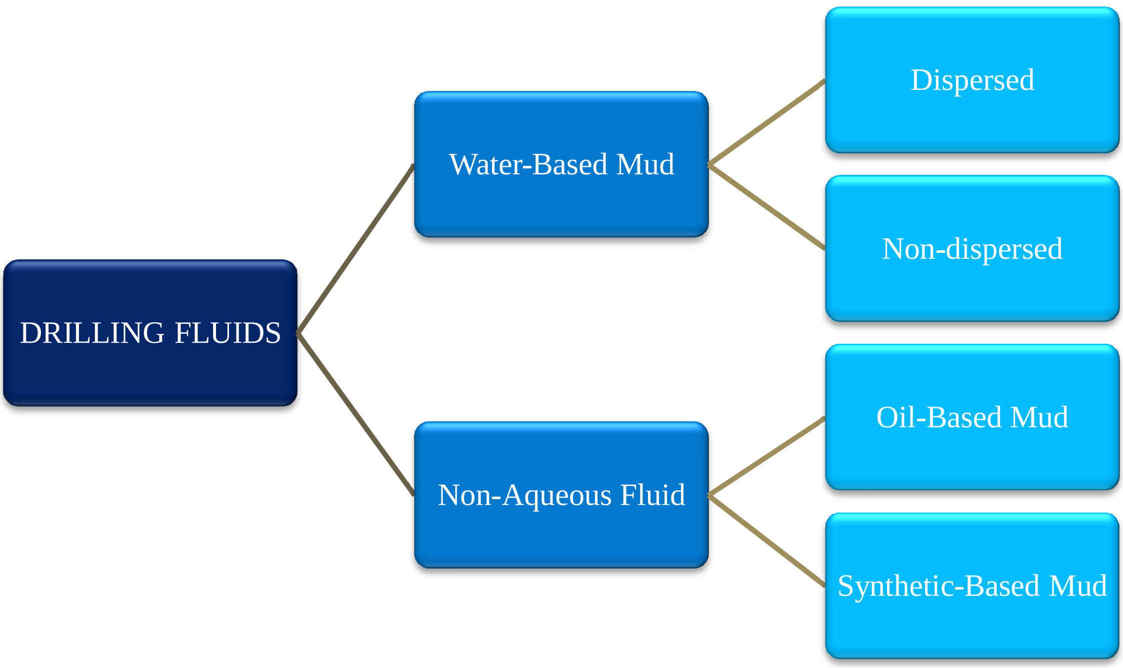

Figure 1: Classification of drilling fluids

The difference in one drilling fluid to other drilling fluid is the chemical compositions in the formulation.

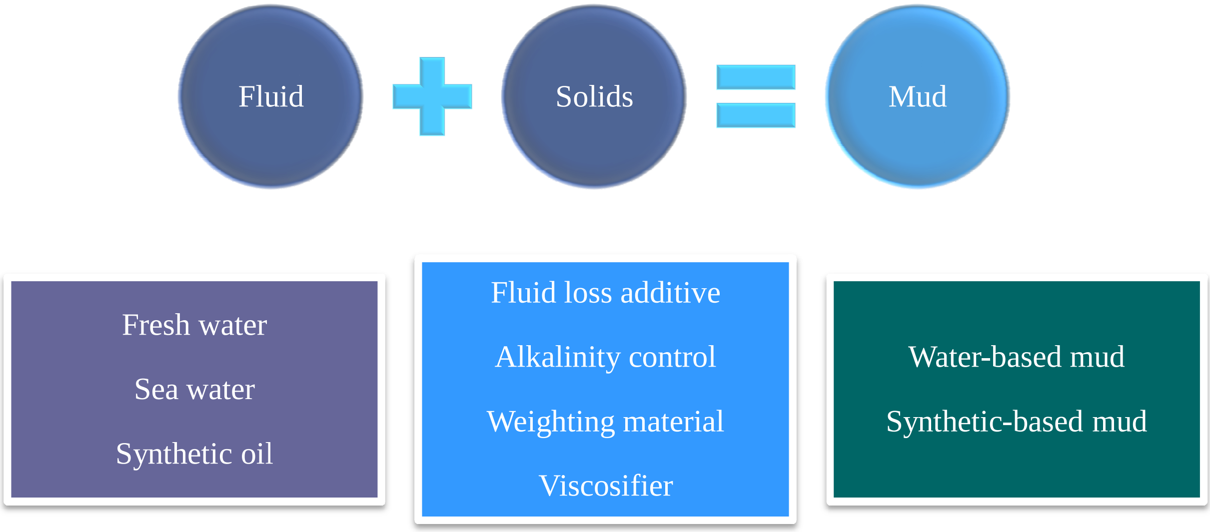

Figure 2: General composition of a drilling fluid system.

2.1.1 Function of Drilling Fluid

The objective of a drilling operation is to drill, evaluate and complete a well that will produce oil and/or gas efficiently. Drilling fluids perform numerous essential functions that help make this possible.

These are the primary and secondary function of the drilling fluid:

Primary Function:

A. **Control formation pressure -**A drilling fluid controls the subsurface pressure by its hydrostatic pressure. Hydrostatic pressure is the force exerted by a fluid column and depends on the mud density and true vertical depth (TVD). Hydrostatic pressure used to balance the formation pressure inside the well.

B. **Transport cuttings -** As drilled cuttings are generated by the bit, they must be removed from the wellbore. To do so, drilling fluid is circulated down the drill string and through the bit, transporting the cuttings up the annulus to the surface. Then cuttings were removed from the drilling fluid using solid control equipments.

C. **Maintain stable wellbore -** Borehole instability is a natural result of the unequal mechanical stresses and physic-chemical interactions and pressures created when surfaces are exposed in the process of drilling a well. The drilling fluid must overcome both the tendency for the hole to collapse from mechanical failure and/or from chemical interaction of the formation with the drilling fluid.

Secondary Functions:

A. **Cool and lubricate the bit and drill string -** During drilling operations, heat and friction is generated at the bit and between the drill strings and wellbore. Considerable torque during rotation, and drag during trips also created due to contact between the drill strings and wellbore. As the drilling fluid passes through the bit and exits the jets/nozzles, the excess heat is removed and carried up the borehole. Circulating drilling fluid transports heat away from these frictional sites, reducing the chance of pre-mature bit failure and pipe damage.

B. **Support weight of tubular -** Drilling fluid's density provide buoyancy supports part of the weight of the drill string or casing. Any increase in mud density results in an increase in buoyancy.

C. **Provide medium for wireline logging** - Water-based and oil-based fluids have differing physical characteristics which influence log suite selection. Log response may be enhanced through selection of specific fluids that compatible with the logging program.

D. **Transmit hydraulic horsepower to bit** - Hydraulic energy provides power to mud motor for bit rotation and for MWD (measurement while drilling) and LWD (logging while drilling) tools. Hydraulic programs base on bit nozzles sizing for available mud pump horsepower to optimize jet impact at bottom well.

E. **Assist in formation evaluation -** The gathering and interpretation of sub-surface geological data from drilled cuttings, cores and electrical logs is used to determine the commercial value of the zones penetrated. Invasion of these zones by the fluid or its filtrate, whether it is oil or water, may mask or interfere with the interpretation of the data retrieved and/or prevent full commercial recovery of hydrocarbon**.**

2.1.2 Rheology of Drilling Fluid

Rheology can be defined as the science of the deformation and/or flow of matter. Rheology is the study of the flow of matter. Rheology is an extremely important property of drilling mud, drill-in fluids, work over and completion fluids, cements and specialty fluids and pills. In the drilling situation the application of rheological concepts for drilling fluids are primarily directed towards:

1. Suspension.
2. Hydraulic calculations.
3. Hole cleaning and hole erosion.
4. Filtrate migration.
5. Solids control.

The rheology properties of drilling fluid can be determined by using a Fann 35 6 speed viscometer. The six readings (600, 300, 200, 100, 6, and 3 rpm) will be taken at 120°F, according to API standard. The heating cup will be used to control the temperature of the drilling fluid. But sometimes, in certain condition and requirement, the rheology properties will be taken at 40°F, 70°F and 150°F especially when dealing with deep water mud system. Bingham plastic viscosity and yield point can be obtained by using the readings at 300 rpm and 600 rpm. The gelling characteristics of the fluid can be determined from taking a 10-second and a 10-minute gel reading.

2.1.2.1 Plastic Viscosity

Plastic viscosity (PV) means an absolute flow property indicating the flow resistance of certain types of fluids and is a parameter of the Bingham plastic model. PV is the slope of the shear stress/shear rate line above the yield point. PV represents the viscosity of a mud when extrapolated to infinite shear rate on the basis of it mathematics of the Bingham model. It is due to the physical size and presence of any solid or emulsified droplets in the fluid. The unit of the PV is centipoises, cP. PV is calculated using this formula;

Plastic viscosity, PV (cP) = 600 rpm reading – 300 rpm reading

A low PV indicates that the mud is capable of drilling rapidly because of the low viscosity of mud exiting at the bit. High PV is caused by a viscous base fluid and by excess colloidal solids. High PV means that the mud has high solid content. Dilution of the mud can reduce and lower PV value.

2.1.2.2 Yield Point

Yield point (YP) is another parameter of the Bingham plastic model. YP is the resistance to initial flow, or represents the stress required to start fluid movement. This resistance is due to electrical charges located on or near the surfaces of the particles. YP is used to evaluate the ability of a mud to lift cuttings out of the annulus. A high YP implies a non-Newtonian fluid, one that carries cuttings better than a fluid of similar density but lower YP. YP is lowered by adding deflocculant to a clay-based mud and increased by adding freshly dispersed clay or a flocculant, such as hydrated lime.

Using Fann 35 viscometer, YP, in $lb/100ft^2$, can be determined using the following formula:

Yield point, YP ($lb/100ft^2$) = 300 rpm reading – Plastic viscosity

2.1.2.3 Gel Strength

Gel strength is a measure of the ability of a colloidal dispersion to develop and retain a gel form based on its resistance to shear. The gel or shear strength of a drilling mud determines its ability to hold solids in suspension. The gel strength is used to simulate when we stop the drilling for a while, how mud the torque that we need to move back the drill pipe to start the drilling in the oil field. The higher the gel strength means the higher the pump rate needed to start circulating the mud in the hole. Low gel strength can cause the barite sagging when the mud circulation stopped. Using Fann 35 viscometer, we usually take a 10-second and a 10-minute gel reading.

2.1.2.4 API Filtration

Filtration control is one of the primary characteristics of a drilling fluid and it primarily objective is to prevent fluid loss into the permeable formations. Filtration control also fulfils a variety of functions from the prevention of differential sticking to minimization of formation damage. The filtration test is performed to study the fluid loss characteristic in a mud. API filter press usually used to study the fluid loss for water based mud. It is carried out at room temperature and with differential pressure of 100 psi. Even though this condition does not reflect the down hole 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. In the standard API procedure, time taken for running this test is 30 minute.

The calculations for this test are as follow:

Spurt loss= 7.5 minutes reading

Total fluid loss = 30 minutes reading

API fluid loss = (Total fluid loss – Spurt loss) × 2

2.2 Rice Husk and Rice Industry in Malaysia

Rice husk, also called rice hull are the hard protecting covering the grain of rice. Rice husk is the outmost layer of the paddy grain. Rice husk is separated and produced in the first step in the milling process, when it is removed from rice grain in husking stage of rice mill. The characteristic of the rice husk it is contain of high silica content has low bulk density of only 70-110 kg/m^3, 145 kg/m^3 when vibrated or 180kg/m^3 in form of brickets or pellets. Rice husk is very abrasive and wears conveying element very quickly because of its high silica contents. It is difficult to ignite and it does not burn easily with open flame. It also highly resistant to moisture penetration and fungal decomposition and therefore makes a good insulation material.

Rice industry is a strategically an important industry in Malaysia since rice is a dietary staple food for Malaysians. Rice cultivation in Malaysia was closely associated with the rural population and traditional farmers. But by 2010, under Malaysia's government initiative which is the Northern Corridor Economic Region (NCER), the paddy yield will increase from 4 tons per hectare in 2005 to 8 tons per hectare and the amount of agricultural land utilized will increase from around 800,000 hectare to one million hectares. The average profit per hectare of cultivated land will amount to RM 10,000 per hectare per annum. Since there are increases in rice cultivation and utilized agricultural land, abundant of waste from the rice industry such as rice husk will be produced each year. Rice husk normally were burned after it is separated from the grain of rice. It is desired these waste from rice industry can be commercialized as lost circulation material and can reduced overall drilling operation cost.

2.3 Lost Circulation

Lost circulation problem is one of the most troublesome, time consuming and cost inflating problem in drilling operation. The definition of lost circulation is the loss of drilling fluids into the formation voids. Lost circulation can and still occurs even with practices of best drilling practice. Lost circulation can take place while drilling is in progress or during 'trip', when pressure surges occur because of the lowering of drill pipe or casing into the hole (Nayberg, 1987).

After lost circulation occurs, the level of the drilling fluid in the annulus may drop and then stabilize at a particular level depending upon the formation pressure (Nayberg, T.M.; Petty, B.R, 1986). The degree of loss circulation may vary from gradual lowering of the mud level in the pits to complete loss of returns. Lost circulation of drilling fluids resulted in increasing of drilling time, loss of expensive mud, plugging of the productive formation and loss of well control.

2.3.1 Type of Lost Circulation Zones and Formations

Lost circulation usually caused by the nature fractures in the rock drilled, induced fracturing when pressure in the drilling fluid exceeds fracturing stress of the earth and highly permeable formation. Fractured, vugular, cavernous or highly porous formations generally have high permeability and large opening that can accept considerable volumes of drilling fluids (Nayberg, 1987). Clay and other solid which are normal addictive of drilling fluid are also act as lost circulation material and they are adequate for sealing porous formation until the pore size or fracture size to be sealed exceed about three times the diameter of the largest particles present (Robert J White, 1956).If the fracture and void are too large, they cannot be plugged by the solid present in the drilling fluids (Nayberg, 1987).

There are four types of loss circulation zone and rate. Loss zone can be classified as;

1. **Seepage loss –** when the severities of loss are less than 25 bbl/hr for WBM and less than 10 bbl/hr for SBM.
2. **Partial loss –** when the severities of loss are between 25-100 bbl/hr for WBM and 10-30 bbl/hr for SBM.
3. **Severe loss –** when the severities of loss are greater than 100 bbl/hr for WBM and > 30 bbl/hr for SBM.
4. **Complete loss –** when no return of drilling fluid to surface or the severities of loss are greater than 500 bbl/hr.

Seepage losses usually occur in any type of loss zone and any type of formation when the LCM in the mud is not fine enough to complete the seal. Partial losses occur in gravel bed, small natural horizontal fracture and barely opened induced vertical fraction. Complete losses occur to long open section of gravel, large natural horizontal fracture, caverns, interconnected vugs and to widely opened induced fractures. (Nayberg, 1987). Lost circulation problems in drilling operation are not confined to any one area. It may occur at any depth where the hydrostatic pressure exerted to the formation exceeds the formation fracture pressure. When the whole mud is lost to the formation, the cause is the cracks or permeability large enough to prevent a sealing mud cake from being laid on the wellbore. If the formation is fractured mechanically, these fractures may seal themselves once the pressure is relieved. If large quantities of mud are lost into these fractures, they may be washed out, causing the void space similar to naturally fracturing high porosity, high permeability zones.

In general, four types of formation are responsible for lost circulation problem in drilling operation:

1. Unconsolidated and high permeability formation.
2. Induced fractured formation.
3. Naturally fractured formation.
4. Cavernous formation.

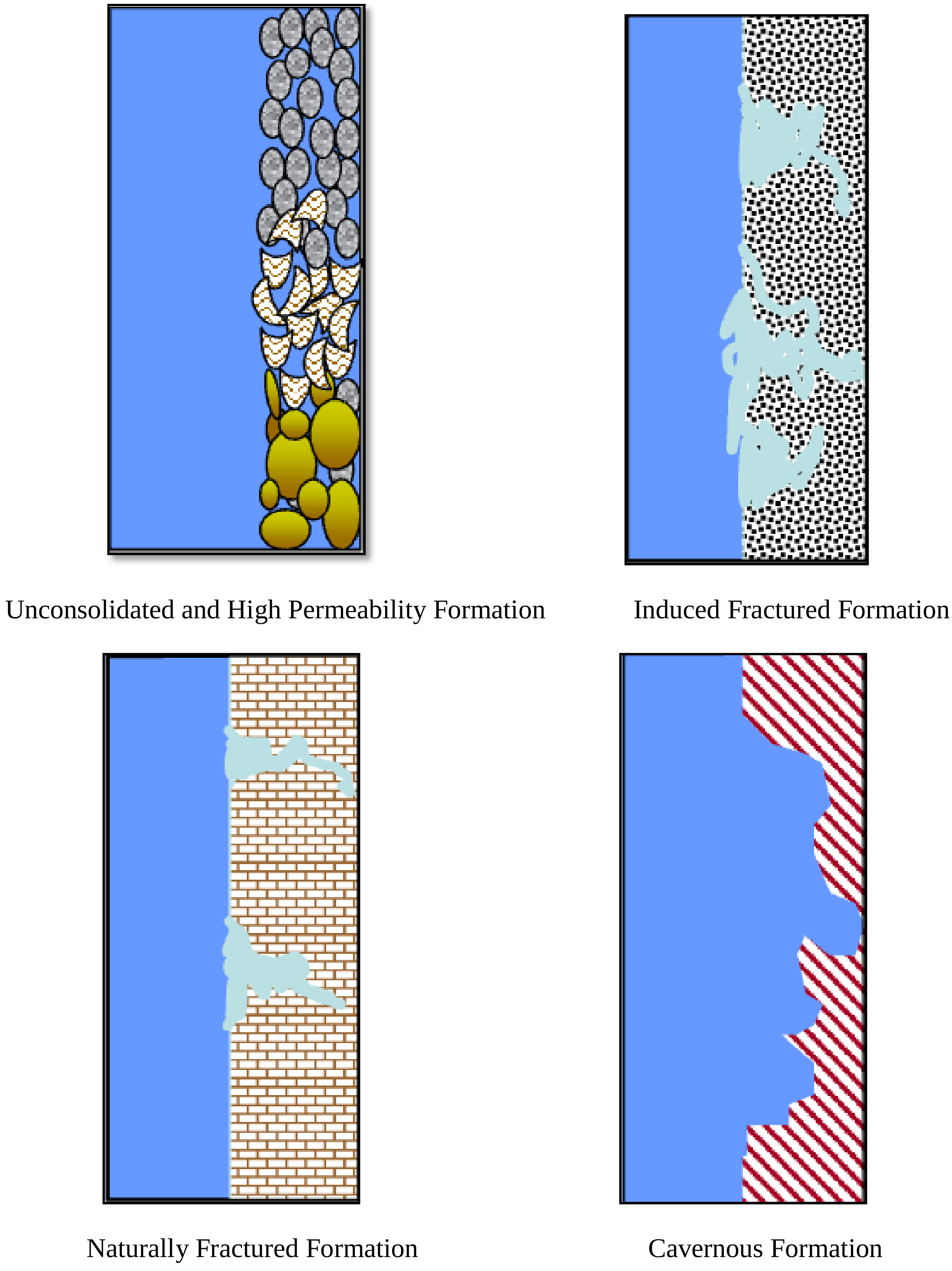

Figure 3: Type of formation

2.3.2 Types of Lost Circulation Material

Conventional lost circulation materials (LCM) consist of wide variety of materials and assortments. These LCM can be classified into four general types;

- Fibrous
- Flake
- Granular
- Blend (mixtures of the other types)

2.3.2.1 Fibrous Lost Circulation Material

Fibrous types LCM's are generally plant fibers, though representatives of animal fibers and mineral fibers are also found as well as synthetic fibers (Nayberg, 1987). Examples of conventional fibrous LCM's include raw cotton, nylon fibers, glass fibers, cedar wood fibers, mineral fibers, feather, bagasse, flax shive, bark fiber, textile fiber, peat moss and beet pulp. These type of LCM mainly used in drilling fluid to lessen the mud loss into large fractures or vugular formation. These types of LCM's form a mat-like bridge over porous formation when added into the drilling fluids and thus reduce the opening size of the formation, permitting the colloidal particles in the drilling fluid to rapidly deposit a filter cake thus completely sealing the formation.

The maximum particle size and the gradation of sizes present are more important in their performance than material of which they composed (Robert J White, 1956). The physical and chemical nature of the material however has some limitation as to the size gradation obtainable, resistance to disintegration and degradation when circulated in the mud system (Nayberg, 1987). The maximum size of the 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 resistant to disintegration than peat moss and beet pulp. The more effective of the fibrous materials will seal off sand and gravels up to beds as coarse as 1-in rock (Robert J White, 1956). Their effectiveness on cracks and fractures appears to be limited to apertures less than about 0.125 inch in width for the coarser material, down to about 0.02 inch for finer material (Robert J White, 1956).

2.3.2.2 Flake Lost Circulation Material

The most common flake-type LCM’s available are cellophane, mica, cork, corn cobs, cottonseed hulls, and vermiculite. Cotton seed hulls are included in this group even though contain some fiber and granules because they are predominantly small flake of the hulls. The flake-type LCM’s are designed to bridge and form a mat on the formation face. These materials can plug and bridge many types of porous formation to stop the mud loss or establish an effective seal over many permeable formations (Nayberg, T.M.; Petty, B.R, 1986). Commercial mica and cellophane and cellophane materials are available in coarse and fine grade. The coarse grades are effective on quite coarse gravel and on fractures up to about 0.1 inch. The finer grades are effective on medium gravel and on fractures up to about 0.06 inch.

2.3.2.3 Granular Lost Circulation Material

The most commonly used granular-type LCM’s are perlite, nut shell and ground rubber tires. Besides these, ground walnut shell, gilsonite, crushed coal, coarse bentonite, ground plastic, asphalt, wood, coke, and ground thermoset rubber are also granular-type LCMs. The granular LCM’s form two types of bridges; at the formation face and within the formation. Bridging or sealing within the formation is preferred because the LCM.s does not become dislodged easily as a result of pipe movement in the wellbore if the permanent bridge forms within the formation. They are not subjected to as much erosion as a result of fluid movement. Proper particle size distribution effect the effectiveness of granular type LCM’s. A blend of large, medium and small particles or blend of relatively large and small particles is most commonly used. The larger particles is believed to be transported into the formation where bridging occurs. The smaller-size particles plug the smaller openings until an impermeable bridge is formed (Nayberg, T.M.; Petty, B.R, 1986). Granular type LCM’s are effective on gravels up to 1 inch in size though perlite normally will not seal above about 3/8 to ½ inch gravel. On fractures, perlite is effective up to 0.1 inch. Nut shell, of the normal grade are effective up to 0.125 inch and the coarse and ground tires are effective up to 0.25 inch or about twice the size of the cracks which can be sealed with fibers or flake (Robert J White, 1956). The granular LCM’s usually works better in high solid ratio system such as cement slurries than in lower solid drilling mud systems (Nayberg, 1987).

2.3.2.4 Blend Lost Circulation Material

Blend of two or more of the preceding LCM's have proved to be effective and useful in the field. When the size and nature of loss zone is not well-enough known to select the material best adapted for the job, blends of coarser and finer material will sometimes give quicker results. A popular blend of various LCM's furnished the advantage of having gradation of particle size and variation of the types of material blended in a sack mixture to provide effective sealing. This blend is a combination of granular, flake and fibrous material varying in size, shape and toughness. This blend will penetrate fractures, vugs or extremely permeable zones and seal them off more effectively (Nayberg, 1987).

CHAPTER 3: METHODOLOGY

3.1 Research Methodology

Student and supervisor played an important role throughout the entire project. Student who as a researcher need to do the literature review study and find his/her own way to approach the topic chosen. To ensure the student is on the right path and on the schedule, assistance and guide from supervisor are essential. Good communication between the supervisor and student played a vital factor in the success of the project. Weekly meeting, progress report and consultation session between the supervisor and student are important to establish good communication between the supervisor and the student.

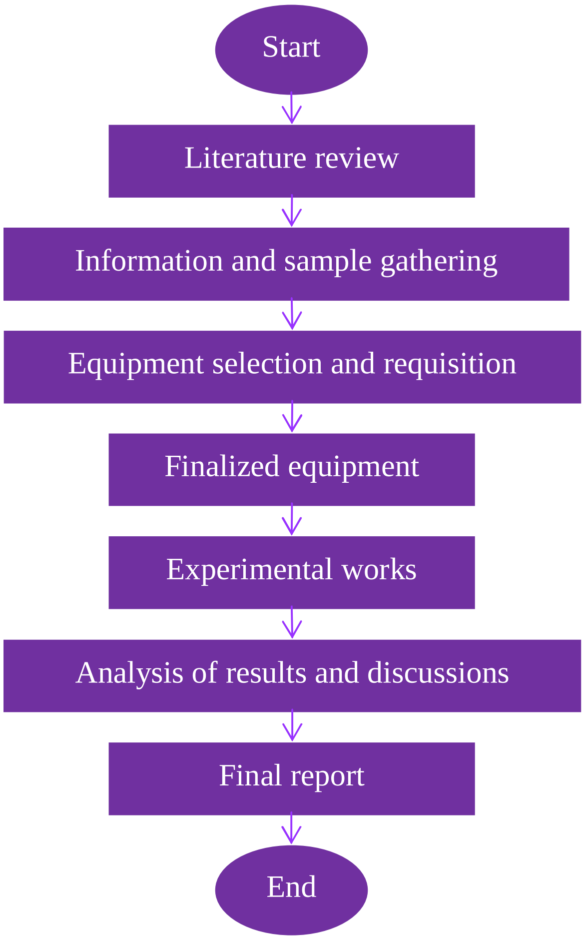

Figure 4: Research methodology.

3.2 Project Activities

The whole project is conducted on experimental and laboratory work basis. Sample from the field will be taken and prepared according to sizes by using mortar grinder and sieve shaker. Further experimental works that will be done include physical properties determination and evaluation of the sample performance as drilling fluid additive. The general flow of project activities are as shown in figure below.

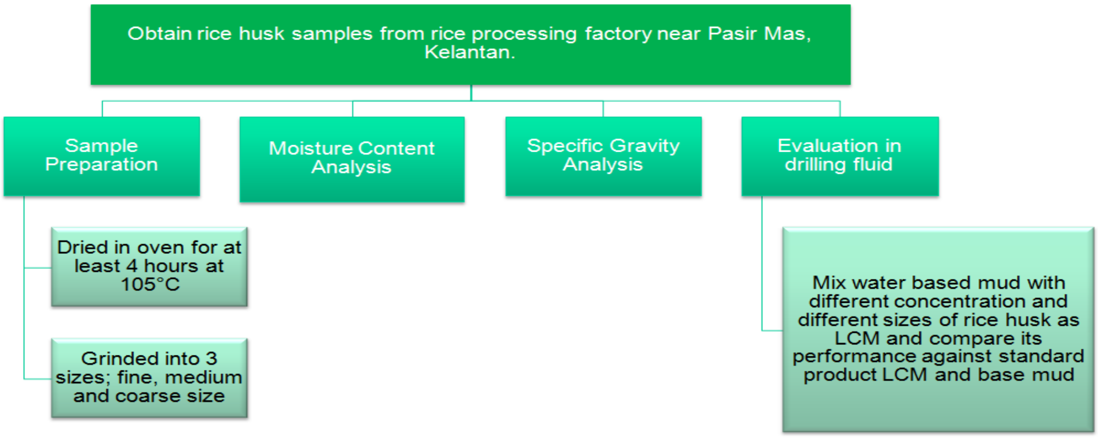

Figure 5: Project activities

3.2.1 Sample Preparation

Rice husk sample were obtained from an area near Pasir Mas, Kelantan. The sample will be dried in the oven for 4 hours at 105°C to remove the moisture content of the sample. The sample then will be crushed using mortar grinder till it become powder. Then, sample will be separated according to sizes which are fine (less 300 microns), medium (301-424 micron) and coarse (425-599 micron) by using sieve shaker.

3.2.2 Moisture Content Determination

The moisture content of the rice husk sample is determined using moisture analyzer. The principle in the moisture analyzer is the equipment measures the moisture thermo gravimetrically, based on the principles of vaporization of water during the process. The moisture balance monitors the weight loss of a sample as the material is heated. The sample weight prior to heating and after reaching a steady-state mass after drying determines the moisture content. The halogen bulb heats the sample by infrared radiation.

3.2.3 Specific Gravity Determination

Specific gravity of the rice husk samples are determined using pycnometer, special equipment used to determine specific gravity of powder. Specific gravity of the samples is needed in order to formulate the mud formulation later on.

3.2.4 Performance as Drilling Fluid Addictive

The rice husk sample will be used in 1.2 SG water based mud system and will undergo series of testing based on API(American Petroleum Institute) RP 13-B1 Recommended Practice for Field Testing Water-Based Drilling Fluids and API 13-A Specification for Drilling Fluid Materials. Then, comparison of the performance will be made between the rice husk sample and current standard product from SCOMI OILTOOLS, OPTA-CARB (limestone) in order to determine the reliability of the sample as LCM. This performance comparison is done by rheological properties and filtration test using API Filter Press according to samples concentration and size variation. The components for the mud are as below:

Table 1: Mud Component.

Product	Function
Water	Base fluid
Calcium Chloride	Water activity and density
OPTA-STAR (starch)	Filtration control
OPTA-ZAN (xantham gum)	Viscosifier
Magnesium Oxide	pH buffer
OPTA-CARB (limestone)	Lost circulation material
Rice Husk	Lost circulation material
API barite	Weighting agent

3.3 Gantt Chart

Table 2: Gantt chart for FYP 1.

Activities	Final Year Project I (FYP-1)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Gather information regarding LCM, drilling fluid and testing procedures														
In situ data collection														
Sample preparation														
Moisture content and specific gravity determination														
Data collection and interpretation														
Comparison against the standard material as drilling fluid additive														

Table 3: Gantt chart for FYP 2.

Activities	Final Year Project II (FYP-2)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Gather information regarding LCM, drilling fluid and testing procedures														
In situ data collection														
Sample preparation														
Moisture content and specific gravity determination														
Data collection and interpretation														
Comparison against the standard material as drilling fluid additive														

3.4 Key Milestones

Table 4: Key milestones for project activities.

Milestone	Final Year Project II (FYP-2)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Completion of sample preparation														
Completion of specific gravity and moisture content determination														
Data collection and interpretation for SG and moisture content.														
Completion of sample evaluation as drilling fluid material														

3.5 Lab Equipment Required

Table 5: Equipment required for each activity.

Activity	Equipment
Sample preparation	1. Mortar grinder 2. Oven 3. Sieve Shaker
Moisture content determination	4. Moisture Analyzer
Specific gravity determination	5. Pycnometer
Drilling fluid testing	6. Mixer 7. Fann 35 viscometer 8. API filter press

CHAPTER 4: Result and Discussion

4.1 Mud Specification

For this project, direct comparison between the rice husk samples with the standard product, OPTA-CARB and base mud are done according to certain specification. Direct comparison with these specifications is done to determine the performance of the LCM as drilling fluid additive bentonite. The specifications for this project are as tabulated below.

Table 6: Specification for Base, OPTA-CARB and rice husk mud

Properties	Base Mud	OPTA-CARB	Rice Husk
Plastic Viscosity, PV (cP)	14-18	14-18	14-18
Yield Point, YP (lb/100ft^2)	20-30	20-30	20-30
10 Minute Gel Strength, (lb/100ft^2)	5-15	5-15	5-15
API Fluid Loss, (cc/30min)	<10	<10	<10

4.2 Moisture Content and Specific Gravity Analysis

Rice husk are prepared into 3 different sizes which are fine (less 300 microns), medium (301-424 micron) and coarse (425-599 micron). Then, rice husk sample are tested for moisture content analysis and specific gravity, SG analysis. Below are the result for specific gravity and moisture content of the rice husk sample.

Table 7: Result for Specific Gravity and Moisture Content

PROPERTIES	RESULT
Specific Gravity, SG	2.11
Moisture Content,%	3

4.3 Performance as Drilling Fluid Additive

4.3.1 Evaluation of Fine (F) and Medium (M) size Rice Husk and OPTA-CARB using 300-425 micron sand size.

Table 8: Mud Formulation and Rheological Properties Result

Product	SG	Base	1	2	3	4	5	6	7	8	9
CaCl2	2.15	46.47	46.21	45.68	45.15	46.02	45.11	44.2	46.02	45.11	44.2
Water	1	325.13	323.29	319.6	315.91	321.91	315.58	309	321.91	315.58	309
OPTA-STAR	1.6	6	6	6	6	6	6	6	6	6	6
OPTA-ZAN	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Magnesium Oxide	3.58	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rice Husk F	2.11								10	30	50
Rice Husk M	2.11					10	30	50			
Rice Husk C	2.11										
OPTA CARB	2.7		10	30	50						
Barite (Vietnam)	4.39	40.61	32.72	16.94	1.15	34.25	21.53	8.81	34.25	21.53	8.81
Initial results		Base	1	2	3	4	5	6	7	8	9
MW, lb/gal		10	10	10	10	10	10	10	10	10	10
Rheology at		120°F	120°F	120°F	120°F	120°F	120°F	120°F	120°F	120°F	120°F
600 rpm		54	57	56	61	61	90	165	67	91	142
300 rpm		40	40	41	44	46	74	124	51	71	110
200 rpm		34	33	34	37	37	63	109	42	59	95
100 rpm		25	25	26	28	27	53	84	31	46	75
6 rpm	>8	11	14	9	9	13	17	39	13	18	20
3 rpm		5	5	6	6	5	13	24	7	12	24
PV, cP	14-18	14	17	15	17	15	16	41	16	20	32
YP, lb/100ft^2	20-30	26	23	26	27	31	58	83	35	51	78
10s gel strength, lb/100ft^2		7	5	6	6	5	12	24	7	11	24
10min gel strength, lb/100ft^2	5-15	8	6	7	7	6	12	24	8	14	25
API,ml: 30 minutes (corrected)	<10	110	1	0	0	87	80	70	0	0	0
Comment		sand size 300-425 micron									

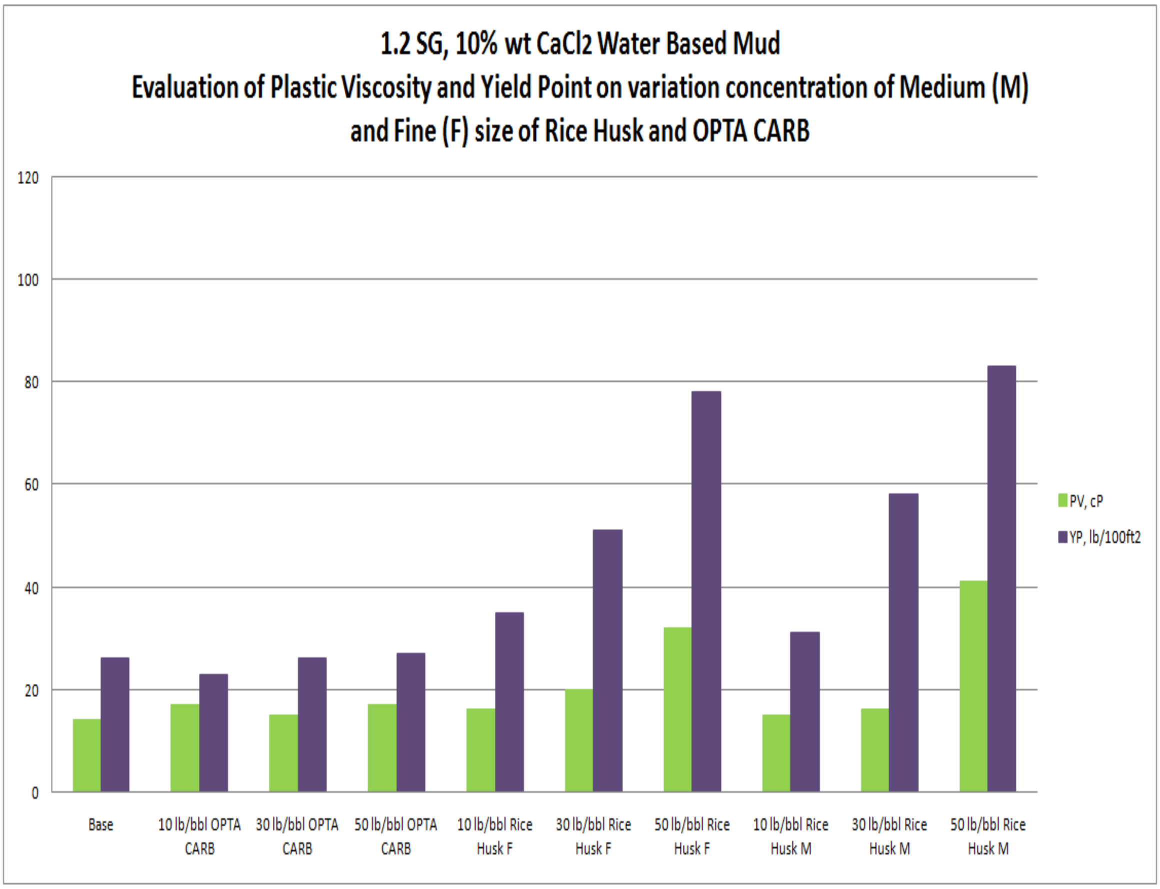

Figure 6: Evaluation of Plastic Viscosity and Yield Point on variation concentration of Medium (M) and Fine (F) size of Rice Husk and OPTA CARB

Based on the graph above, Plastic Viscosity (PV) and Yield Point of OPTA CARB (1:2 blend of OPTA CARB 100: OPTA CARB 300) mud nearly same with the base mud and does not have significant changes with the increasing of the concentration. Plastic viscosity and yield point for mud with fine (F) and medium (M) size rice husk increase with the increase of concentration. 10 lb/bbl of fine and medium size rice husk relatively gave nearly the same reading with the base mud and OPTA CARB mud, but the increasing of concentration to 30 lb/bbl and 50 lb/bbl drastically change the reading for plastic viscosity and yield point of the mud. Yield point reading for 30 lb/bbl exceed the specification required even though the plastic viscosity value are within specification while both plastic viscosity and yield point value for 50 lb/bbl exceed the specification. High plastic viscosity mud need higher pump pressure to pump the mud into the hole since the mud is more viscous.

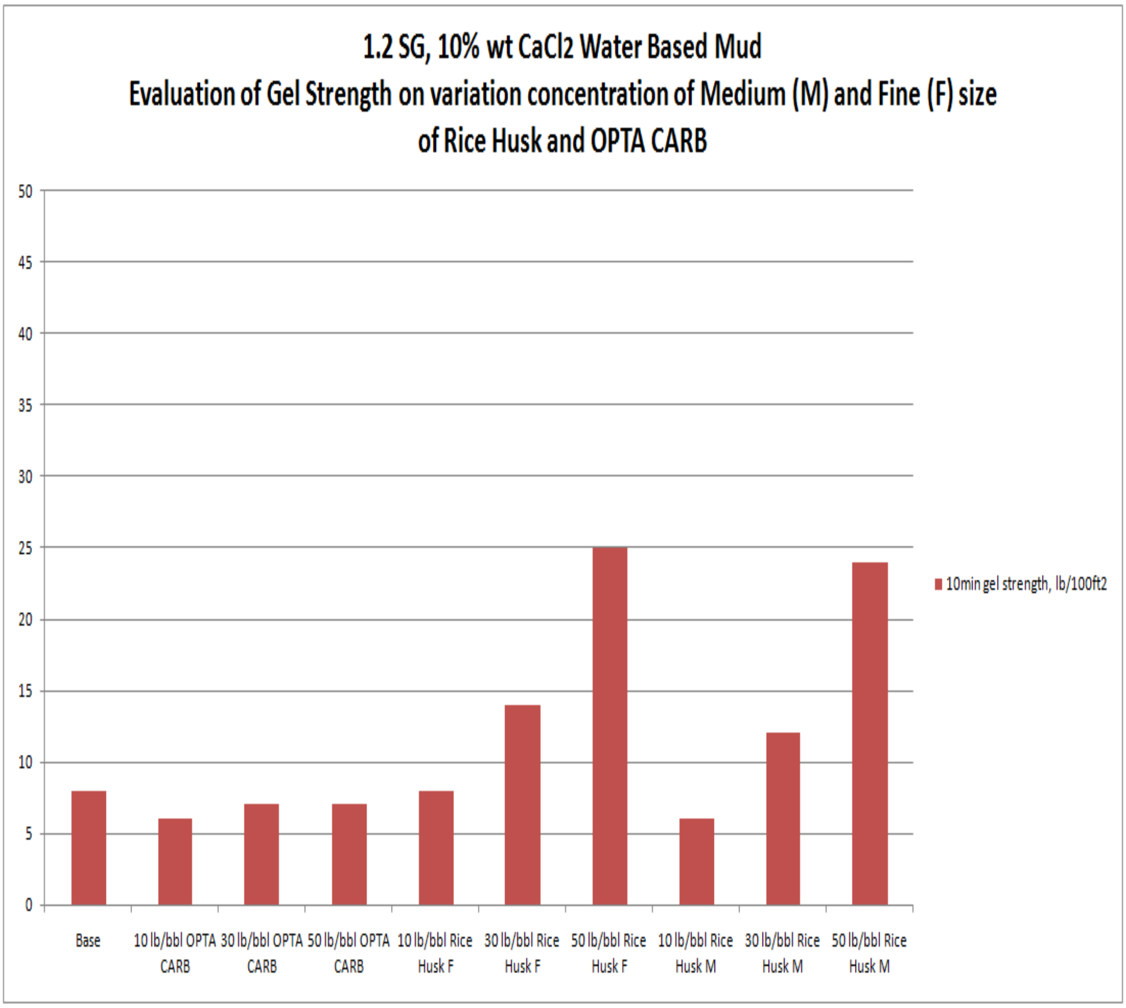

Figure 7: Evaluation of Gel Strength on variation concentration of Medium (M) and Fine (F) size of Rice Husk and OPTA CARB

Based on the result of the gel strength, all concentration of OPTA CARB mud and base mud gave the gel strength results within the specification which is between 5-15 lb/100ft^2. The increasing of the concentration of OPTA CARB in the mud does not affect the gel strength value. The gel strength results of 50 lb/bbl for both sizes are high and exceed the specification while for 10 lb/bbl and 30 lb/bbl are within the specification. High gel strength can cause the formation damage since high pump pressures are required to start back the mud circulation in the hole. Gel strength result for fine size rice husk also slightly higher than the gel strength for medium size of rice husk, maybe due to the effect of the rice husk size. This can conclude the limitation for rice husk concentration for gel strength specification is 30 lb/bbl.

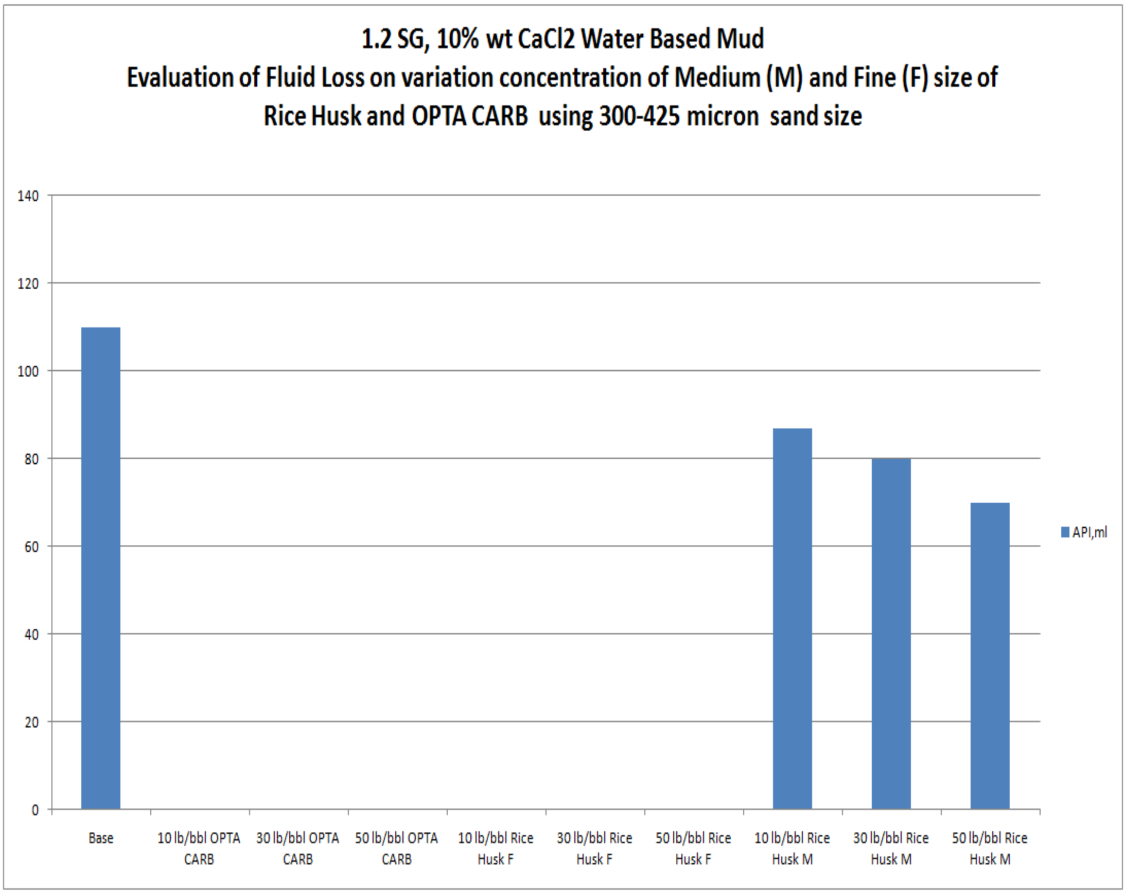

Figure 8: Evaluation of Fluid Loss on variation concentration of Medium (M) and Fine (F) size of Rice Husk and OPTA CARB using 300-425 micron sand size

Based on the graph above, base mud, mud with no lost circulation material (LCM) has the highest fluid loss which is 110 ml is 300-425 microns sand size. All concentrations of OPTA CARB have no fluid loss. 10 lb/bbl medium size rice husk gave 87 ml fluid loss, 30 lb/bbl medium size rice husk gave 80 ml fluid loss and 50 lb/bbl medium size rice husk gave 70 ml fluid loss. Declining trend of fluid loss occurred with the increasing of the medium size rice husk's concentration. For all concentration of fine size rice husk, no fluid loss collected. Only mud with OPTA CARB and fine size rice husk meet the specification required for fluid loss which is less than 10 ml. OPTA CARB and fine size rice husk completely sealed the sand therefore no fluid loss occurred while medium size rice husk cannot seal the sand effectively due to the unsuitable size of the rice husk.

4.3.2 Evaluation of Fine (F) and Coarse (C) size Rice Husk and OPTA-CARB using 426-600 micron sand size.

Table 9: Mud Formulation and Rheological Properties Result

Product	SG	Base	1	2	3	4	5	6	7	8	9
CaCl2	2.15	46.47	46.21	45.68	45.15	46.02	45.11	44.2	46.02	45.11	44.2
Water	1	325.13	323.29	319.6	315.91	321.91	315.58	309	321.91	315.58	309
OPTA-STAR	1.6	6	6	6	6	6	6	6	6	6	6
OPTA-ZAN	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Magnesium Oxide	3.58	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rice Husk F	2.11								10	30	50
Rice Husk M	2.11										
Rice Husk C	2.11					10	30	50			
OPTA CARB	2.7		10	30	50						
Barite (Vietnam)	4.39	40.61	32.72	16.94	1.15	34.25	21.53	8.81	34.25	21.53	8.81
Initial results		Base	1	2	3	4	5	6	7	8	9
MW, lb/gal		10	10	10	10	10	10	10	10	10	10
Rheology at		120^{0}F	120^{0}F	120^{0}F	120^{0}F	120^{0}F	120^{0}F	120^{0}F	120^{0}F	120^{0}F	120^{0}F
600 rpm		54	57	63	63	62	92	174	67	91	142
300 rpm		40	41	45	44	46	72	143	51	71	110
200 rpm		34	34	37	37	38	63	115	42	59	95
100 rpm		25	25	28	27	29	52	90	31	46	75
6 rpm	>8	11	12	9	13	9	33	48	13	18	20
3 rpm		5	6	6	6	5	23	36	7	12	24
PV, cP	14-18	14	16	18	19	16	20	31	16	20	32
YP, lb/100ft^2	20-30	26	25	27	25	30	52	112	35	51	78
10s gel strength, lb/100ft^2		7	6	7	7	6	24	72	7	11	24
10min gel strength, lb/100ft^2	5-15	8	6	8	7	7	25	46	8	14	25
API,ml: 30 minutes (corrected)	<10	130	37	30	25	118	100	90	6	1	0.5
Comment		sand size 426-600 micron									

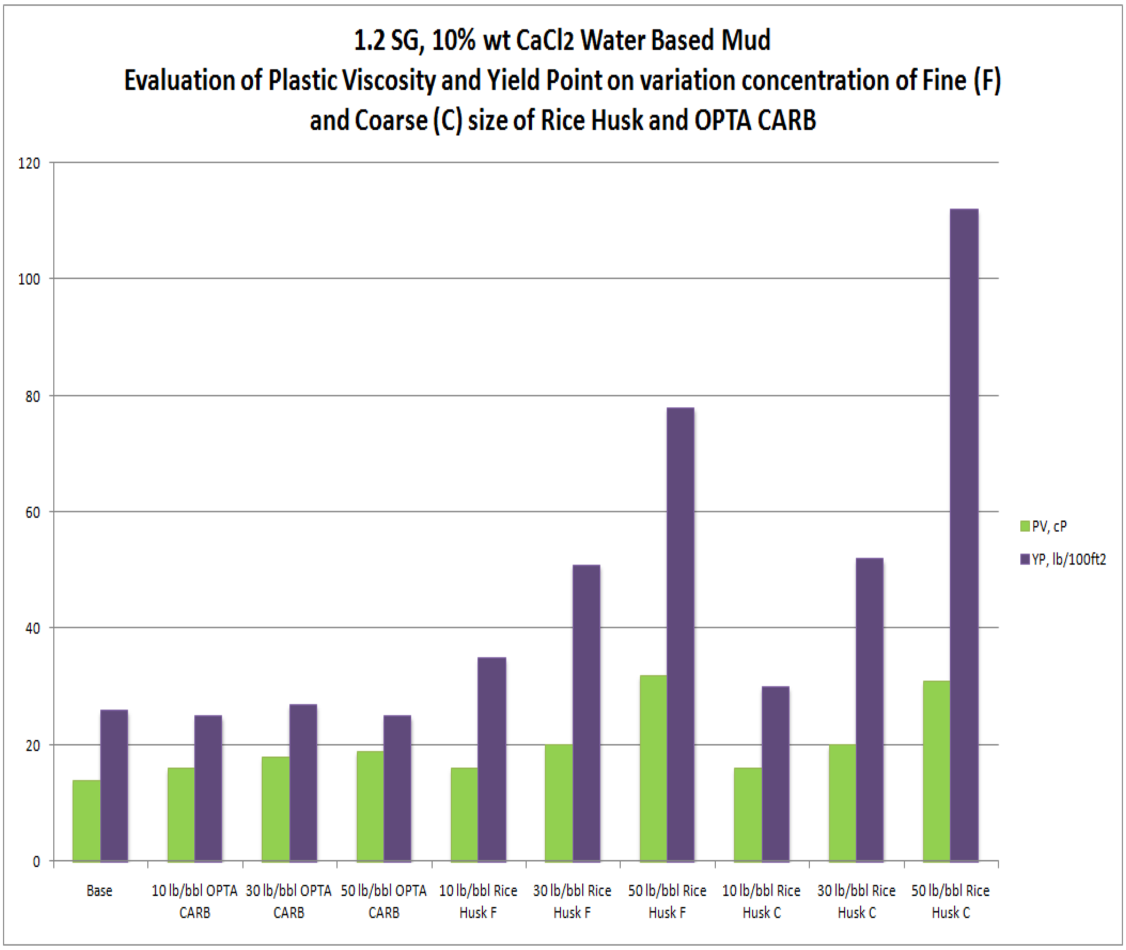

Figure 9: Evaluation of Plastic Viscosity and Yield Point on variation concentration of Fine (F) and Coarse (C) size of Rice Husk and OPTA CARB

The result for Plastic Viscosity (PV) and Yield Point (YP) shows that mud with OPTA CARB (1:2 blend of OPTA CARB 300: OPTA CARB 400) show same trend with the base mud without any lost circulation material. However, plastic viscosity and yield point reading for rice husk mud increasing with the increasing of rice husk concentration for both sizes. For fine and coarse size rice husk, only 10 lb/bbl that meet the specification. For both plastic viscosity and yield point, the reading for coarse size rice husk is greater than fine size rice husk. The Yield Point reading for coarse size rice husk increase drastically from 52 lb/100ft^2 for 30 lb/bbl to 112 lb/100ft^2 for 50 lb/bbl. Once again, the limitation for rice husk concentration for fine and coarse size rice husk is 10 lb/bbl since the rheology properties change significantly with any changes in concentration greater than 10 lb/bbl.

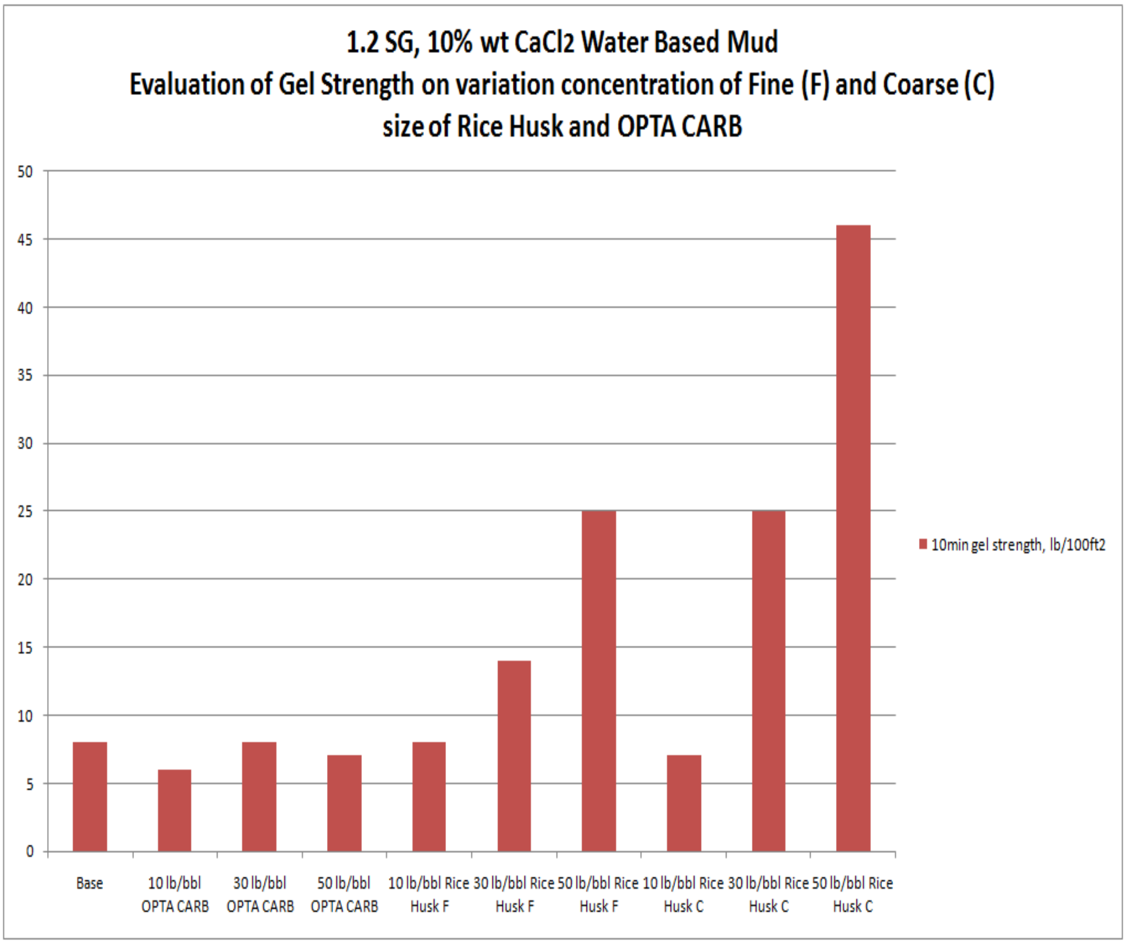

Figure 10: Evaluation of Gel Strength on variation concentration of Fine (F) and Coarse (C) size of Rice Husk and OPTA CARB

Gel strength result show that base mud and all concentration for OPTA CARB mud are within the specification required. For fine size rice husk, 10 lb/bbl and 30 lb/bbl also gave the reading within the specification. For coarse size rice husk, only 10 lb/bbl rice husk concentration that meet the specification which is between 5-15 lb/100ft^2. 50 lb/bbl of coarse size rice husk gave the highest value for gel strength reading which 46 lb/100ft^2. The value for gel strength for 50 lb/bbl fine size rice husk is same with the 30 lb/bbl coarse size rice husk.

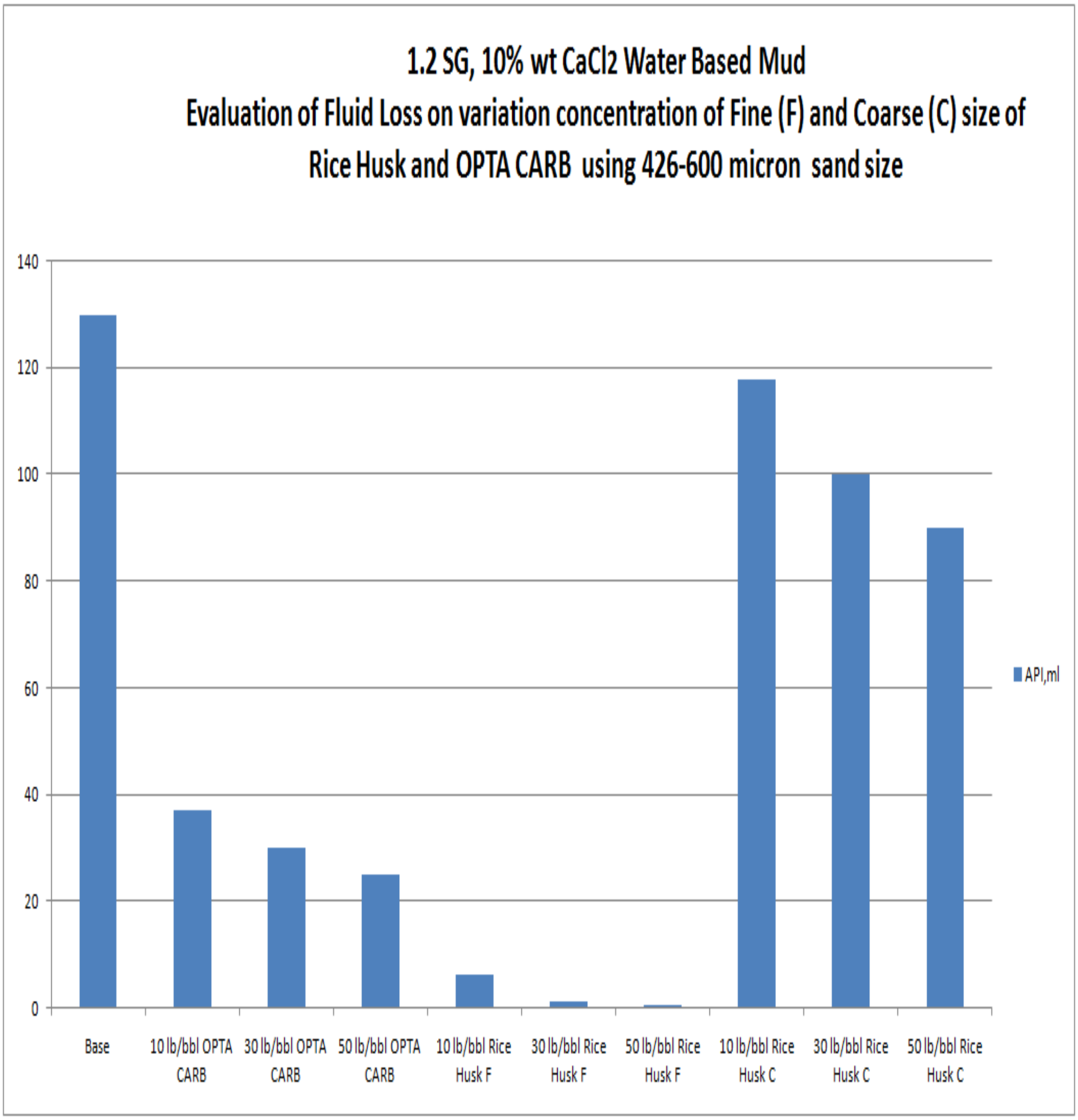

Figure 11: Evaluation of Fluid Loss on variation concentration of Fine (F) and Coarse (C) size of Rice Husk and OPTA CARB using 426-600 micron sand size

Evaluation of fluid loss using 426-600 micron of sand size showed that the base mud with no fluid loss gave the highest value which is 130 ml. OPTA CARB mud also gave high fluid loss, above the specification for all concentration. For 10 lb/bbl of OPTA CARB, the fluid loss is 37 ml, 30 ml fluid loss for 30 lb/bbl and 25 ml of fluid loss for 50 lb/bbl OPTA CARB. This can be resulted from the improper size selection of OPTA CARB used in the mud. Improper size selection of lost circulation material greatly affects the fluid loss because lost circulation material cannot properly seal the formation. For fine size rice husk, all concentration showed low fluid loss result and meet the specification. 10 lb/bbl fine size rice husk gave 6 ml fluid loss, 30 lb/bbl fine size rice husk gave 1 ml fluid loss while 50 lb/bbl fine size rice husk gave 0.5 ml of fluid loss. 10 lb/bbl of coarse size rice husk gave 118 ml fluid loss while 30 lb/bbl of coarse size rice husk gave 100 ml fluid loss. For 50 lb/bbl coarse size rice husk, the fluid loss reading is 90 ml. From the coarse size rice husk result, we can conclude that the coarse size rice husk cannot be used in the 426-600 microns formation size. Even though there are no significant changes in fluid loss test using 426-600 micros sand size when using coarse size rice husk, the declining trend of the fluid loss can be observe with the increase of rice husk concentration.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the specific gravity and moisture content analysis, the result for rice husk specific gravity is 2.11 SG and 3% of moisture content in the rice husk sample. For the rice husk performance as the drilling fluid additive, the result show that the rice husk samples gave the reading for rheological properties; Plastic Viscosity (PV), Yield Point (YP) and gel strength within the specification in certain concentration. For this project specification, the limitation for rice husk concentration is 10 lb/bbl regardless of the rice husk size. Beyond this limit, the rheological properties of the mud change drastically with the increasing of the rice husk concentration. This can be seen in the high reading of PV, YP and gel strength value in 30 lb/bbl and 50 lb/bbl of rice husk mud, an indication that the rheological properties changed because of high concentration of rice husk. For comparison between rice husk and standard product, the standard product performance for rheological properties seem to be better than rice husk performance because OPTA CARB (limestone) concentration does not affect mud rheological properties.

For rice husk performance in fluid loss test using API Filter Press, the result depending on the selection of the rice husk size. As we can see from the result of fluid loss test, only fine size of rice husk work effectively as lost circulation material in both sand sizes. Both medium and coarse sizes rice husk seem does not working as expected even though the medium size rice husk which is 300-425 microns were tested in same 300-425 micron sand size while coarse size rice husk that were tested in 426-600 micron sand size are same size with the sand size. However, the declining trend of fluid loss can be observed with the increasing of rice husk concentration. For fine sizes rice husk performance, the results are comparable with the standard product, OPTA CARB. In fluid loss test using 300-425 micron sand size, both fine rice husk and OPTA CARB (1:2 blend of OPTA CARB 100: OPTA CARB 300) does not have any fluid loss. For test matrix using 426-600 micron sand, fine rice husk performance for fluid loss are better than OPTA CARB (1:2 blend of OPTA CARB 300: OPTA CARB 400) performance. This may be due to improper size selection of OPTA CARB but is also indicate that rice husk performance for fluid loss test is comparable or even greater than OPTA CARB if the size selection of rice husk is right. Rice husk result for fluid loss test showed that even with the incorrect size selection, the trend of fluid loss declining can be observed.

As a conclusion, the performance of rice husk is comparable with standard product within certain condition and limitation especially its concentration and size selection. It is cost effective to utilize the local rice husk as lost circulation material. Abundant of rice husk were produced each year in Malaysia and it is not fully commercialize and utilized yet. The cost of standard LCM such as mica and limestone, $CaCo_3$ were uneconomical if we could exploit the rice husk resources. Limestone and mica mining involved higher cost rather than the cost of rice husk; waste of rice industry. Overall, this study meet the major objective which is to find an alternative to conventional lost circulation material for drilling purposes, which subsequently reduces the operating cost and tested its performance against standard product.

5.2 Recommendation

The study on rice husk to commercialize as lost circulation material is a lengthy project and needs lot of experimental study to compare its performance. The main focus for this project is to determine the performance of the sample, whether it is suitable for lost circulation material or not. Since there is time constraint for this project, I only managed to test it performance in two formation size and under ambient temperature. Overall, 20 mud formulations were done for this project and the increment of the concentrations were done in extreme manner in order to see the trend of the performance. The limitations for rice husk concentration are not exactly determined since there are no variations of concentration for other chemical. Further experiment and evaluation should be done in order to prove that the rice husk will work in drilling fluid especially in high pressure and temperature by using Permeability Plugging Apparatus with different sizes of ceramic disks to simulate different formations sizes.

The most important thing that we need to remember is that certain type of lost circulation material can effectively sealed the different size fractures. Thus, it is essential to determine which size of fractures that the rice husk sample can sealed effectively. Thus, in order to increase the effectiveness of the sample, it is recommended to prepare the sample with different sizes and grade. Rice husk sample also can be blended with other type of LCM in order to increase the performance of rice husk as lost circulation material.

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APPENDICES

Rice Husk Sample

Figure 12: Rice Husk sample.

Sample Preparation and Properties Determination Equipment

Figure 13: Mortar Grinder

Figure 14: Sieve Shaker

Figure 15: Pycnometer

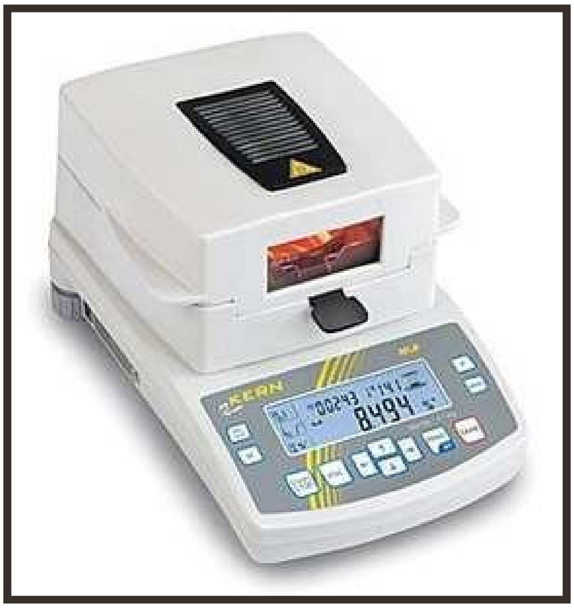

Figure 16: Moisture Analyzer.

Mud Testing Equipment

Figure 17: Hamilton Beach.

Figure 18: Fann 35 viscometer.

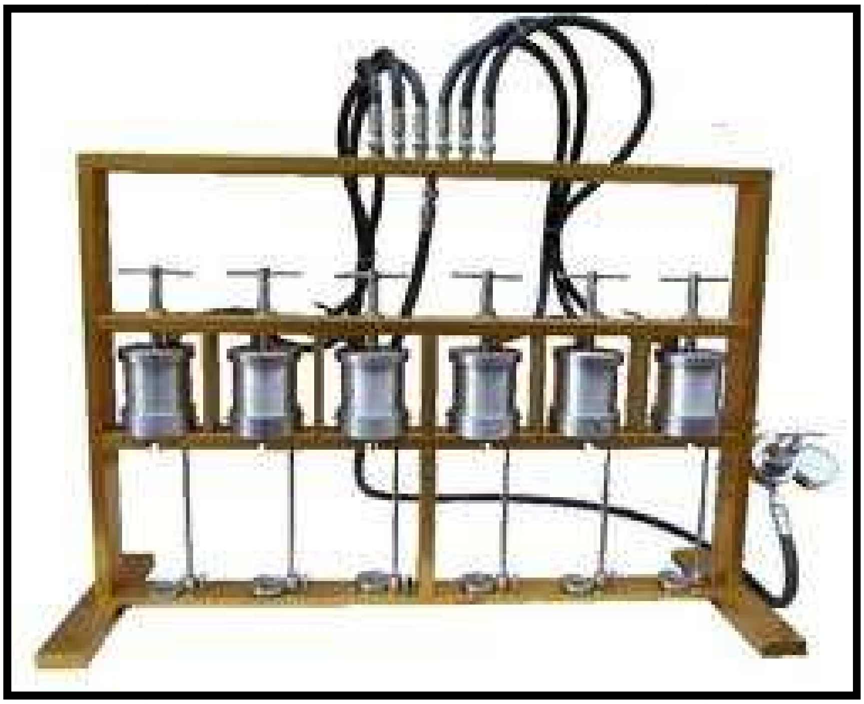

Figure 19: API Filter Press

Figure 20: During API Fluid Loss Test

Figure 21: After API Fluid Loss Test

Figure 22: Mud Cake using rice husk

Figure 23: Mud Cake using rice husk 2

Figure 24: Mud Cake using OPTA CARB

Figure 25: Mud Cake Using OPTA CARB

Mixing Procedure

Table 10: Standard Mixing Procedure

Products	Mix 1 lab bbl on Hamilton mixer		
	Order	Speed	t, min
Water	1	High	-
Calcium Chloride	2	High	2
OPTA-STAR	3	High	5
OPTA-ZAN	4	High	5
Magnesium Oxide	5	High	5
Barite	6	High	2
Additional		High	21
OPTA-CARB/ Rice Husk	7	High	5
Total			45