GREEN LOST CIRCULATION MATERIAL DERIVED FROM ORANGE PEEL WASTE

By

MOHD AZUAN BIN ABU BAKAR

DISSERTATION

Submitted to the Petroleum Engineering Programme
In Partial Fulfillment of the Requirements
For the Degree
Bachelor of Engineering (Hons)
(Petroleum Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

GREEN LOST CIRCULATION MATERIAL DERIVED FROM ORANGE PEEL WASTE

By

Mohd Azuan Bin Abu Bakar

A project dissertation is submitted to the
Petroleum Engineering Programme
UNIVERSITI TEKNOLOGI PETRONAS
In partial fulfillment of the requirements
For the degree
Bachelor of Engineering (Hons)
(Petroleum Engineering)

Approved:

Ms. Mazlin Binti Idress
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

January 2011

CERTIFICATION OF ORIGINALITY

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

MOHD AZUAN BIN ABU BAKAR

Abstract

The project is mainly about developing Green Lost Circulation Material (LCM) derived from orange peel waste. LCM is one of prominent additive in a drilling fluid. It functions to seal off fractures, micro-fractures and pore throats in order to stop severe mud loss and overall filtration losses into formation. Without LCM drilling fluid will be lost into the formation, thus increase drilling cost. Contemporary LCM made from, shredded paper, mica, wood fiber, nut hull, cellophane and etc. Some of this material can be toxic to environment and take a hundred years to be disposed. Therefore, there is a need to develop an environmental friendly lost circulation material. For this project, an orange peel waste has been chosen to be a candidate for lost circulation material. The orange peel waste is processes and blended into three sizes, which are coarse, medium and fine powder. Then, each of the size is added into the mud using five different concentration (3 lb/bbl, 5 lb/bbl, 8 lb/bbl, 10 lb/bbl and 15 lb/bbl) and tested for rheological properties, API filtration loss and density. The comparison is made based on the orange peel size and concentration. Two contemporary LCM has been chosen as a comparison with orange peel LCM which is nut plug and corn cob. The procedures for all the experiment are developed based on API 13A and API 13B specification.

Table of Contents

List of Table

List of Figure

Chapter 1

Introduction

1.1 Background of Study

During drilling operation, a drilling fluid must be circulated through the well and back to the surface. Occasionally, highly permeable or cavernous formations and fractured zones, both natural and induced by the mud pressure, are encountered and circulation is partially or completely lost. Loss of drilling fluid, owing to openings in the formation, can result in loss of hydrostatic pressure at the bottom of the hole and allow influx of formation fluids and possibly loss of well control. It is essential that circulation be regained for drilling to continue. A wide variety of materials can be added to the drilling fluid to seal off the lost circulation zones.

Lost Circulation Material (LCM) is one of the additives in drilling fluids. It functions to seal off fracture, vug or ununiformed wellbore wall to prevent lost circulation or mud lost. Lost circulation materials are flake, fiber, or granular-shaped particles. Each type is sold individually, often in two or more size grades, or two or more materials of different shapes may be sold as a blend. Materials of different shapes and sizes are often blended into the mud at the well site. Some common flake-shaped LCMs consist of shredded cellophane and paper, mica, rice hulls, cottonseed hulls, or laminated plastic. These materials lie flat across the opening to be sealed or are wedged into an opening such as a fracture. Some are sufficiently strong to withstand considerable differential pressure, whereas others are weak and the seal may be broken easily. Weaker flake materials typically are used near the surface or in combination with fibrous or granular additives.

Fibrous additives include a variety of cellulose fibers, sawdust, sugar-cane bagasse, paper, straw, leather, and many others of similar size, shape, and availability. The larger fibers function by forming a brush-heap-type mat over the opening. The seal so formed may require smaller fibrous particles to stop seepage of mud through the mat. Fibers generally have little strength and cannot withstand high differential pressures. The brush-heap seal may extend far enough into the wellbore to be dislodged by the drill string, or be rigid enough to interfere with drill string movement.

Granular LCMs generally are much stronger than the other types and include ground rubber, nylon, plastics, limestone, gilsonite, asphalt, and ground nut shells, for example, walnut and pecan. Fine, medium, and coarse-size grades are available. Granular-shaped particles enter the opening, bridge it, and form a tight seal against further mud losses. Particle size and distribution are important for this mechanism to be effective. Bridging particles must generally have a diameter one-half the opening width for a fracture or one-third the diameter of a circular opening based on Abraham rule. An effective seal requires proper gradation of particle sizes. The advantage of this mechanism is that the seal is formed outside the wellbore and is not subject to drill string action.

1.2 Problem Statement

In drilling operation, both water-based and oil-based fluids are commonly used for drilling. The loss of fluids is usually more costly for oil-based mud, because of the base fluid is more expansive but the loss of the fluid can be quite costly with water based-mud because of the chemical in the fluid. Wide varieties of chemicals are added to the mud to increase density, viscosity and gel strength. The chemical added for forming a barrier to flow on the borehole wall or in the openings connected to the wall called lost circulation material. The lost circulation material added must be compatible with all the other additives added to the mud. The problem with the conventional LCM is that some of them are toxic and non-biodegradable. Therefore, it will bring adverse effect to the environment especially in offshore activities. A wide variety of naturally occurring products have been used as lost circulation materials in the past. For example in the U.S Patent. No. 4474665 discloses the use of ground and sized cocoa bean shells, said to be universal lost circulation controller. However this product has not been widely accepted in the industry. Thus, there remain needs for a blend of materials which can function effectively to reduce fluid loss from a borehole in a wide range of circumstances. The materials also should be environmental friendly and economical to use.

1.3 Objectives

1. Develop coarse, medium and fine size green lost circulation materials derived from orange peel waste.
2. Measure the rheological properties of water-based mud after adding orange peel.
3. Measure the filtration loss before and after adding orange peel to water-based mud.

1.4 Scope of The Project

The Scope of the project is focused to determine the optimum LCM concentration and the effect of size distribution toward fluid loss reduction. In order to obtain optimum LCM concentration, several muds with different orange peel concentration need to be prepare. Then a graph fluid loss against concentration will be plotted. The concentration value with respect to the minimum fluid loss is the optimum LCM concentration. The effect of size distribution will be investigated by using three size of LCM which is fine, medium and coarse size. Then a comparison will be made based on the fluid loss result between those sizes.

1.5 The Relevancy of The Project

Over the last couple of decades, there are vast developments in drilling fluid technology. This has enable oil and gas industries to develop cheaper and environmental friendly drilling fluid additives. Lost circulation material (LCM) is one of the important additives in drilling fluid, in which it is required in a large amount. As one of the drilling fluid component, LCM contributes to the environment contamination especially to the aquatic creatures, because in certain cases, the mud is dumped into the sea. Therefore it is relevant to develop a green LCM in order to reduce contamination.

1.6 Key Milestone

Table below summarize the planned activities with expected timeline.

Table 1: Gantt chart

No	Activities	Week															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	FYP 2 briefing																
2	Lab experiment commences																
3	Submission of progress report																
4	Preparation for final report																
5	PRE-EDX combined with seminar/Poster Exhibition and Submission of final report (CD, Softcopy & softbound)																
6	EDX																
7	Final oral presentation																
8	Submission of hardbound copies																

Chapter 2
Literature Review

2.1 Introduction – Lost Circulation

Lost circulation (LC) is defined as the total loss of drilling fluids into the formation (Messenger 1981). There are two distinguishable categories of losses based on the leak-off flow paths: natural and artificial (induced) (Wang et al. 2005). Natural lost circulation occurs when drilling operations penetrate formations with large pores, vugs, leaky faults, natural fractures, etc. Induced lost circulation occurs when pressure exerted on the wellbore exceeds the maximum the wellbore can contain.

Lost circulation still presents great challenges to the petroleum industry, causing significant expenditure combating problems like mud losses and wasted rig time. In worst cases, these losses can also include costs for lost wellbores, sidetracks, bypassed reserves, and abandoned wells. Lost circulation events have garnered more attention, particularly in the recent years, because of decline in the easy-to-find reservoirs and industry operators intensifying the search for deeper reservoirs, drilling through depleted or partially depleted reservoirs, extended reach drilling and narrow mud weight window wells.

Historically, appropriate sized particulate materials, referred to as lost circulation materials (LCM) have been used to arrest or mitigate the lost circulation. 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.

2.2 Types of Formations Causing Loss Circulation

Basically there are four types of formation that contribute to the loss circulation. The classification of those type of formation has been agrees by several of authorities (George C.Howard 1951). The formations are:

1. Natural or Intrinsic fracture (figure 1)
2. Induced or created fracture (figure 2)

3. Cavernous formation (crevices and channel)- (figure 3)
4. Unconsolidated or Highly permeable formation (loose gravel)- (figure 4)

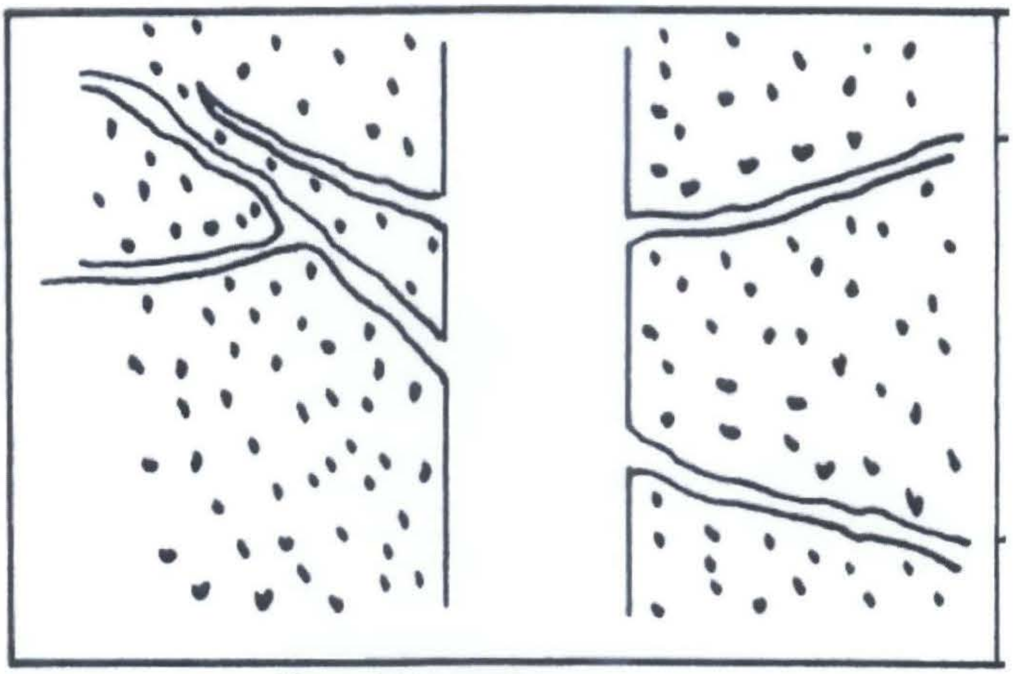


Figure 1: Natural Fracture

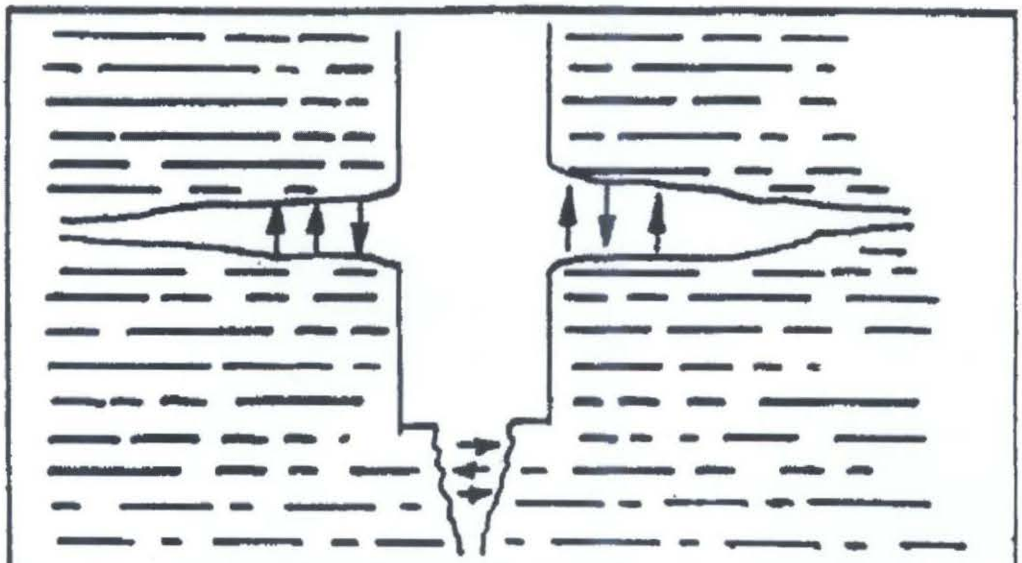


Figure 2: Induced Fracture

*Picture taken from "An Analysis and The Control of Lost Circulation Material' George C. Howard and P.P Scott

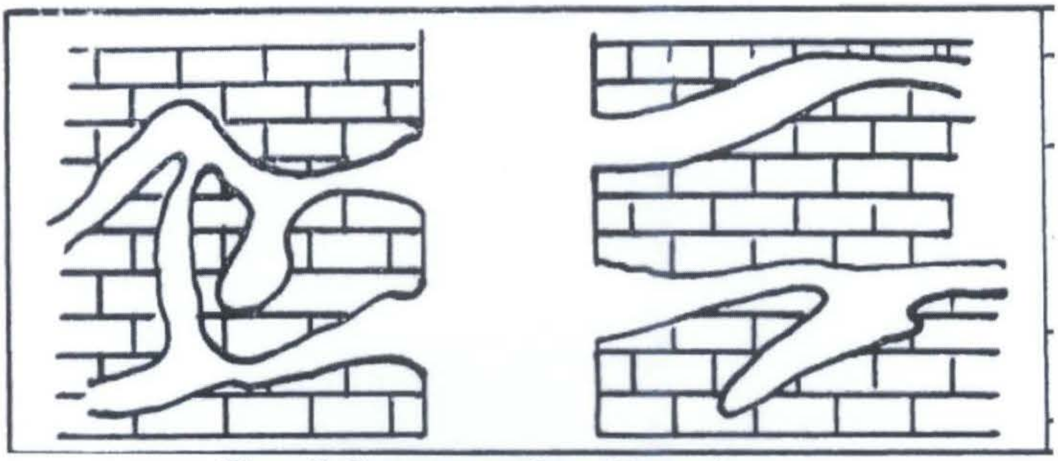


Figure 3: Cavernous or channel formation

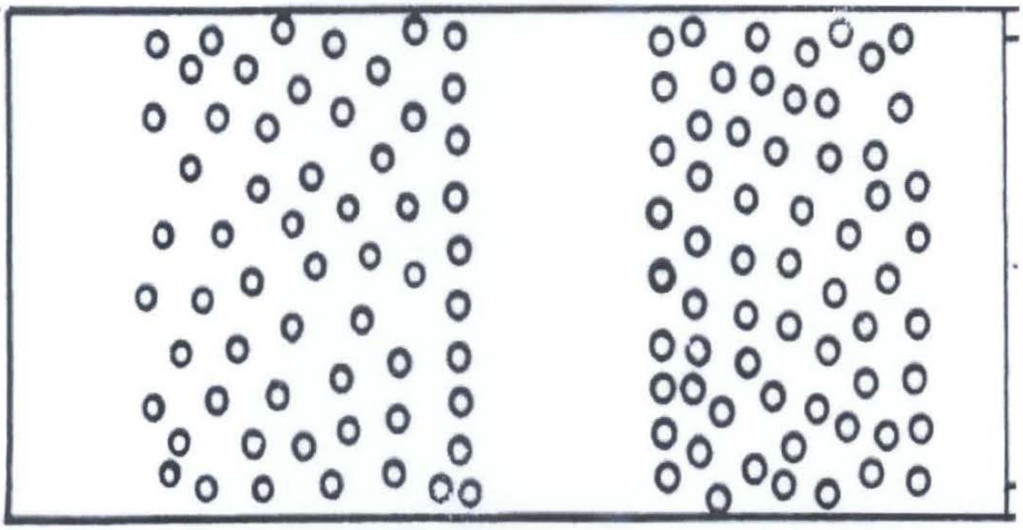


Figure 4: Unconsolidated formation

*Picture taken from "An Analysis and The Control of Lost Circulation Material' George C. Howard and P.P Scott

Induced fracture is distinguished from natural fracture primarily by the fact that the loss of the mud to induced fracture requires the imposition of pressure of sufficient magnitude to break formation, while the loss of the mud to natural fracture require only sufficient pressure to exceed that of the fluid within formation. Cavernous formation differ from fracture in that cavern are probable a result of solution phenomena. Loss of mud to cavern occur when the mud pressure exceed the formation pressure of that cavern. The loss of mud to loose gravel require that intergranular passage be of sufficient size to permit whole mud entry and as in the case of natural fracture and cavern, the mud pressure logically exceed formation pressure.

2.3 Drilling Fluids.

Drilling fluids or muds are considered an essential component of the rotary drilling process used in drilling for oil and gas on land and in offshore environments. This fluid performs a variety of functions that influence the drilling rate, and the cost, efficiency, and safety of the operation. Drilling fluid functions describe tasks which the drilling fluid is capable of performing, although some may not be essential on every well. Removing cuttings from the well and controlling formation pressures are of primary importance on every well. Though the order of importance is determined by well conditions and current operations, the most common drilling fluid functions are:

1. Remove cuttings from the well.
2. Control formation pressures.
3. Suspend and release cuttings.
4. Seal permeable formations.
5. Maintain wellbore stability.
6. Minimize reservoir damage.
7. Cool, lubricate, and support the bit and drilling assembly.

2.4 Classification of Drilling Fluids

1. Water Based Muds

The vast majority of all drilling fluids are water-based systems. The types depend on the composition of the water phase (pH, ionic content, etc), viscosity builders (clays or polymers), and rheological control agents (deflocculants or dispersants). Freshwater fluids can range from clear water having no additives to high density muds containing clays, barite, and various organic additives. Onshore wells typically use freshwater muds, as do some offshore wells where highly weighted muds are needed. Freshwater muds may be operated at pH levels ranging from 7 to 11. When drilling using clear water, small amounts of polymeric flocculants may be added to remove drill solids in a large settling pit in order to maintain a clean fluid for fast drilling. When a viscous fluid is required, clays or water-soluble polymers are added. Freshwater is ideal for formulating stable drilling fluids as many mud additives are most effective in a system of low ionic strength. Inorganic or organic additives control the rheological behavior of the clays, particularly at elevated temperatures. An organic polymer may be used for filtration control. Mud pH is generally alkaline and, in fact, many viscosity control agents require an environment of pH >9. Sodium hydroxide is by far the most widely used alkalinity control agent. Clay-based freshwater muds can be weighted to any desired density required to control formation pressures.

2. Oil Based Muds

Oil-based drilling fluids have diesel or mineral oil as a continuous phase with both internal water and solid phases. Fluids having no or very low water content are usually called oil-base muds or all oil muds; fluids having higher water contents are called invert oil–emulsion muds, or simply inverts. Most oil muds maintain a fixed oil–water ratio depending on the desired properties. Oil muds are employed for high angle wells where good lubricity is required, for high temperature wells where water-based systems may be thermally unstable, for drilling water-sensitive shale formations, or where corrosive gases such as hydrogen sulfide and carbon dioxide may be encountered. Environmental restrictions and cost often limit use, although higher drilling rates achievable using oil muds and polycrystalline diamond compact (PDC) bits can often offset the high fluid and disposal costs.

2.5 Drilling Fluids Component.

1. Base fluids

   Base fluid used to make drilling fluid will determine whether the final mud is WBM or OBM. The examples of base fluid are:

   WBM – Make up water, sea water

OBM – base oil such as Saraline, Sarapar, Escaid.

2. Viscosifier

   Viscosifier is the additives used in order to increase the viscosity of drilling to desire value. Viscosifier can be classified into two type; Low Viscosifier chemical and High Viscosifier chemical. Low Viscosifier chemical such as PAC LV (Polyanionic Cellulose) will provide low viscosity properties to the mud whereas High Viscosifier chemical such as PAC HV or CMC (Carbomethyl Cellulose) will provide high viscosity increase to the drilling mud.

3. pH controller

   pH controller such as caustic soda used to control the pH value of the mud. The desired mud pH usually ranges from 8 – 10. We don't want the pH to be low because it will cause the mud to be acidic and corrode the casing.

4. Shale stabilization

   Shale stabilization additives prevent the shale cutting and formation shale from hydration, swelling and/or dispersed when in contact with water. The additives will coat the cutting and prevent the shale from reacting with water in the mud or formation. Example of shale stabilization additives are potassium chloride, glycol, partially hydrolyze polyacrylamide (PHPA).

5. Weighting agent

   The main function of weighting agent is to provide adequate hydrostatic pressure to the mud to counterbalance the pressure from the formation. It is important so that the formation fluid does not flow to the well and cause blown out. The suitable amount of the weighting agent also play an important factor, if we put excessive amount of weighting agent, the hydrostatic pressure of the mud will be to high relatively to the formation pressure. This will cause formation fracture and mud loss. Examples of the weighting agent are barite and hematite.

6. Bridging agent

   Bridging agent function to seal off fracture, crack or pore in the formation to prevent mud loss. Example of the bridging agent is calcium carbonate, nut plug, cellophane and etc.

2.6 Lost Circulation Materials (LCM)

Viewed in a broad sense, lost-circulation materials are mud additives designed to ensure that the fluid circulated down the hole in the rotary method of well drilling returns to the surface for recirculation rather than disappearing into the formation drilled. This is a problem that has been with the Industry from the very beginning of the rotary method of drilling. One of the first patents issued was concerned with this problem. The M T. Chapman, U. S Patent 443069 issued in 1890 covers a method of drilling porous formations by rotary means and of laying down an impermeable filter cake through sands and gravel by using gumbo, bran, rice, grain, or other adhesive material in the circulating fluid.

In this broad sense the clay and other solids which are normal constituents of drilling muds are lost-circulation materials and they are adequate for sealing porous formations until the pore size or crack to be sealed exceeds about three times the diameter of the largest particles present. At this point, lost-circulation materials, in the restricted sense with which we are concerned are substances added to drilling muds to increase the maximum particle size present in order to plug the pores or cracks which the mud alone is unable to seal In order to perform this function, they must contain particles large enough to lodge in the largest apertures present Inasmuch as the maximum size material which can be handled through mud pumps is limited, this places an upper limit on the size openings which can be sealed by this method. According to Abram rule, to effectively plug the pore or crack, the median particle size of the bridging agent should be equal or slightly 1/3 the median size of the formation. A little consideration will also show that there must be a suitable gradation of lost-circulation particle sizes to pack in such a manner that they form a base on which a mud filter cake can build.

2.7 LCM Shapes

To function properly, a drilling fluid must be circulated through the well and back to the surface. Occasionally, highly permeable or cavernous formations and fractured zones, both natural and induced by the mud pressure, are encountered and circulation is partially or completely lost. Loss of drilling fluid, owing to openings in the formation, can result in loss of hydrostatic pressure at the bottom of the hole and allow influx of formation fluids and possibly loss of well control. It is essential that circulation be regained for drilling to continue. A wide variety of materials can be added to the drilling fluid to seal off the lost circulation zones. The particle sizes of these materials are typically much larger than the particle sizes of solids normally suspended in the mud which are generally <150 mm in diameter. Some of the same materials may be used for controlling filtration rates or for stabilizing shale formations but in such cases would be much smaller in particle size than atypical lost circulation material (LCM).

Lost circulation materials are flake, fiber, or granular-shaped particles. Each type is sold individually, often in two or more size grades, or two or more materials of different shapes may be sold as a blend. Materials of different shapes and sizes are often blended into the mud at the well site. Some common flake-shaped LCMs consist of shredded cellophane and paper, mica, rice hulls, cottonseed hulls, or laminated plastic. These materials lie flat across the opening to be sealed or are wedged into an opening such as a fracture. Some are sufficiently strong to withstand considerable differential pressure, whereas others are weak and the seal may be broken easily. Weaker flake materials typically are used near the surface or in combination with fibrous or granular additives. Fibrous additives include a variety of cellulose fibers, sawdust, sugar-cane bagasse, paper, straw, leather, and many others of similar size, shape, and availability. The larger fibers function by forming a brush-heap-type mat over the opening. The seal so formed may require smaller fibrous particles to stop seepage of mud through the mat. Fibers generally have little strength and cannot withstand high differential pressures. The brush-heap seal may extend far enough into the wellbore to be dislodged by the drill string, or be rigid enough to interfere with drill string movement.

Granular LCMs generally are much stronger than the other types and include ground rubber, nylon, plastics, limestone, gilsonite, asphalt, and groundnut shells, example, walnut and pecan. Fine-, medium-, and coarse-size grades are available. Granular-shaped particles enter the opening; bridge it, and forma tight seal against further mud losses. Particle size and distribution are important for this mechanism to be effective. Bridging particles must generally have a diameter one-half the opening width for a fracture or one-third the diameter of a circular opening (pores). An effective seal requires proper gradation of particle sizes. The advantage of this mechanism is that the seal is formed outside the wellbore and is not subject to drill string action.

A wide variety of materials has been used over the years, probably including everything that was bulky and available at one time or another. Even today the list of materials commercially available as lost-circulation materials is impressive (see Table 1). For purposes of classification these can be divided into fibrous, flaky, and granular types, and mixtures of these.

2.8 Materials and Methods

Orange peels were obtained from local fruit juice industry. The analysis of chemical and physical properties of non-enzymatically orange peel has been done by Alexandre Espachs-Barroso, Robert C. Soliva-Fortuny, Olga Martin-Belloso in the paper 'A natural clouding agent from orange peels obtained using polygalacturonase and cellulose based on Association of Official Analytical Chemists (A.O.A.C.) (1990) methods. All results were expressed on a dry weight basis determined by drying samples at 105°C for 12 h. The analyses of orange peel were performed in duplicate and the average values were used. Table 2 state the result of the study.

The orange peel waste will be dried under the sun for 12 hours to remove moisture and make it easier to be blended. The dried orange peel will be blended into a powder and the particle size will be determined using sieve shaker. The sizes that will be used for this project are 150μm for fine, 600μm for medium and 1.8 mm for coarse size.

Table 2: List of materials used for preventing lost circulation

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

*taken from "Lost Circulation Material and Their Evaluation' Robert J. White.

Table 3: Characterization of orange peel

Parameter	Value
Soluble solids (°Brix)	7.1 ± 1.2
pH	3.93 ± 0.03
Total acidity (g of citric acid/100 ml)	0.29 ± 0.03
Formol index	34.0 ± 2.4
Humidity (%)	85.9 ± 1.6
Fat (%) in DM	1.55 ± 0.17
Protein (%) in DM	6.16 ± 0.23
Ashes (%) in DM	3.29 ± 0.19
Carbohydrates (%) in DM	89.0 ± 1.1
Soluble fiber (%) in DM	
Neutral sugars	3.8 ± 0.3
Uronic acids	1.04 ± 0.18
Insoluble fiber (%) in DM	
Neutral sugars	17.1 ± 1.6
Uronic acids	7.1 ± 0.9
Klason lignin	3.2 ± 0.4
Pectin (%) in DM	17 ± 4
Essentials oils (ml/kg)	1.45 ± 0.16
Color	
*a**	8.52 ± 0.22
*b**	52.3 ± 0.8
*L**	70.2 ± 0.7

Values are means ± SD.
DM, dry matter.

Chapter 3
Research Methodology and Planning Activities

3.1 Methodology

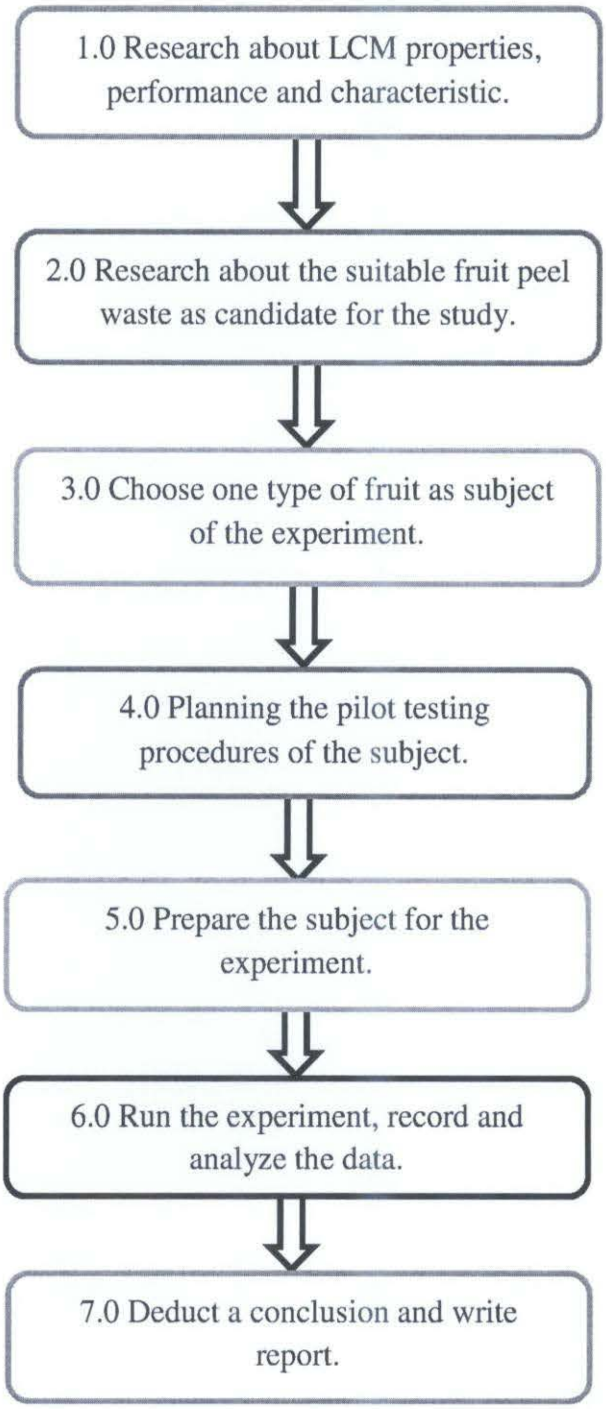


Figure 5: Methodology of the project.

3.2 Tools and Attire

Table 7 below is a list of item, quantity and its function that will be used throughout the experiment.

Table 4: Tools required

No	Tools	Quantity	Function
1	Hamilton Beach Mixer	2	To mix mud composition
2	Mud Cup	2	To contain mud
3	Thermo Cup	1	To test mud at different temperature according to API
4	Mud Balance	1	Measure the density of the mud
5	Fann 35 Viscometer (1.0 spring grade)	1	Measure viscosity of the mud at different rotation speed
6	API Filtration Loss	1	Measure fluid loss of the mud at 100 psi differential pressure
8	Filter paper	1 box	To filter solids flow through it
9	10 ml measuring cylinder	1	Measure fluid loss and filtration loss volume
10	100 ml beaker	1	Measure fluid loss volume

1. Hamilton Beach Mixer
   - Shear the mixture of solid and liquid in mud cup
   - Has 3 level of speed

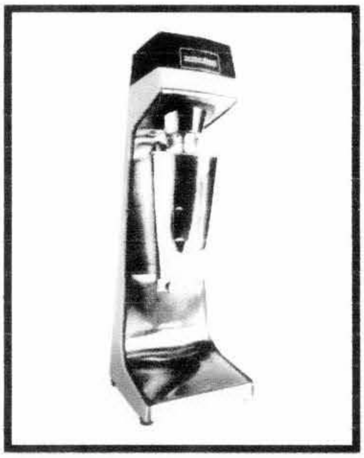


Figure 6: Hamilton Beach Mixer

2. Mud Balance
    - measure density of the mud
    - Need to be calibrated using water
    - Density water = 8.33 lb/gal

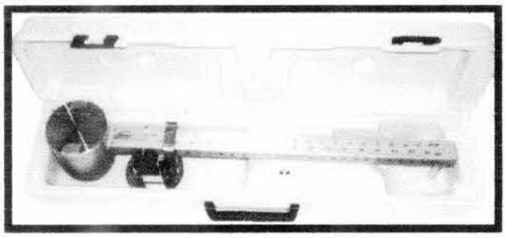


Figure 7: Mud Balance

3. Viscometer
    - Measure plastic viscosity, yield point and gel strength of the mud
    - Have 6 speed variation ; 600 rpm, 300 rpm, 200 rpm, 100 rpm, 6 rpm and 3 rpm.

Figure 8: Fann viscometer

4. API Filtration Press
    - Measure the fluid/water loss from the mud as 100 psi pressure exerted to the mud in 30 minutes and filter cake thickness.
    - The fluid loss is the volume (in millilitres) of filtrate collected in this time period and the filter cake thickness (in millimetres) is the thickness of the cake that is deposited on the filter paper in this time period.

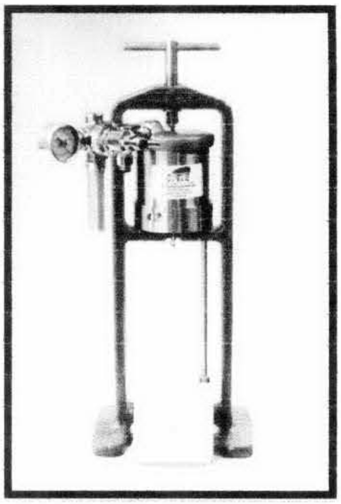


Figure 9: API Filtration loss

For safety purpose, there are several attire, that are compulsory to wear when carry out the experiment:

Table 5: list of attire

No	Items	Quantity
1	Lab coat	1
2	Safety Glass	1
3	Safety Shoes	1

Figure 10: Example of Personnel Protective Equipment (PPE).

3.3 Pilot Testing – Experiment Procedures

Test Procedures

There are three major tests involved to evaluate the performance of orange peel as LCM which are:

2 Rheological measurement

3 API Filtration loss

4 Density measurement

3.3.1 API Filtration Loss procedure.

Equipment:

1. Filtration Cell
2. OFI specially Hardened Filter paper - Filtration Area 7.07 sq.in (Alternatively Whatman No 50 paper)
3. Low Pressure CO2 supply 100 psi (690 kPa) (Soda stream cartridges)
4. Stop Clock
5. 10 and 25 ml measuring cylinders

Procedures

1. Prepare 1 barrel of mud with LCM materials and stir in container for 1 to 5 minute on the mixer. Adjust mud temperature to 77 ±2 °F (25 ±l °C).
2. Pour the mud into filter press cell. Before adding mud, be sure each part of the filter cell is dry and that all gaskets are not distorted or worn. Pour the mud to within about l/2 inch (13 mm) of the top of the cell. Complete assembly of the filter press cell. Place filter cell in frame and close relief valve. Place a container under the drain tube.
3. Set one timer for 7.5 ±0.1 minutes and the second timer for 30 ±0.1 minutes. Start both timers and adjust pressure on cell at 100 ±5 psi (690 +35 kPa). Both of these steps shall be completed in less than 15 seconds. Pressure shall be supplied by compressed air, nitrogen, or helium.

4. At 7.5 ±0.1 minutes on the first timer remove the container and any adhering liquid on the drain tube and discard. Place the dry 10 cm^3 graduated cylinder under the drain tube and continue collecting filtrate to the end of the second timer set at 30 minutes. Remove the graduated cylinder and record the volume of filtrate collected.

Calculation of Filtrate volume

Calculate the filtrate volume of the mud as:

Filtrate volume, cm3 = 2 x V_c

Where V_c is filtrate volume collected between 7.5 and 30 minutes.

3.3.2 Viscosity measurement.

Equipment:

1. Fann 35, 110 volt or 120 volt, powered by a two speed synchronous motor to obtain speeds of 3, 6, 100, 200, 300 and 600.
2. Mud cup
3. Stopwatch
4. Thermometer 32 - 220 °F (0 - 104 °C)

Procedures.

1. Prepare a 1 barrel of water based mud with LCM.
2. After stirring for 5±0.5 minutes, remove the container from mixer and scrape its sides with the spatula to dislodge any mud adhering to container walls. Be sure all mud clinging to the spatula is incorporated into the suspension.
3. After that, pour the mud into the viscometer cup provided with the direct indicating viscometer. The dial readings at 600 and 300 rpm rotor speed settings

of the viscometer shall be recorded when a constant value for each rpm is reached. Readings shall be taken at mud test temperature of 77 ±2°F (25 ±1°C).

4. Next, age the mud up to 16 hours in a sealed or covered container or aging cell. Put the mud in roller oven at 150°F and 250°F temperature. Record storage temperature and storage duration.
5. After aging for 16 hours, take out the mud from the rolling oven and cooled in the water bath. After the mud has been cooled, pour the mud into the mixer container. Stir the mud on the mixer for 5 ±0.5 minutes.
6. Pour the mud into the viscometer cup provided with the direct indicating viscometer. The dial readings at 600 and 300 rpm rotor speed settings of the viscometer shall be recorded when a constant value for each rpm is reached. Readings shall be taken at mud test temperature of 77 ±2°F (25 ±1°C).

Calculation of Plastic Viscosity (PV) and Yield Point (YP).

1. Apparent viscosity, AV = 600 rpm / 2
2. Plastic Viscosity, PV = 600 rpm – 300 rpm
3. Yield Point = 300 rpm – PV
4. Yield Point/Plastic Viscosity ratio = YP/PV

3.3.3 Density measurement

Equipment

1. Standard Mud Balance

Procedures

1. Instrument base must be set on a flat level surface.
2. Measure and record the mud temperature.

3. Fill the mud cup with the mud to be tested. Gently tap the cup to encourage any entrapped gas to break out.

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

5. Holding cap firmly (with cap hole covered with thumb) wipe the outside of the cup until it is clean and dry.

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

Calculation.

The density of the mud obtained from the graduated scale value when it is balance.

3.4 Project Activities

First thing must be done before going deep into the project is to investigate about LCM properties and function. The research involve sort of materials including journal, SPE paper, text book, handbook, site visit, discussion with lecturer or industries personnel and through other reasonable resources. After understanding the LCM material, another research should be done in order to find suitable fruit peel waste candidate. The fruit peel waste should satisfy some of the criteria of LCM such as:

a) Shape – fiber, flake or granular shape.
b) Size – coarse, medium or fine
c) Concentration

After, done with the research, an orange fruit peel waste will be chosen. The orange fruit peel waste will be prepared for pilot testing. Pilot testing of drilling fluids is testing performed on proportionately small-scale samples. It is an essential part of drilling fluid testing and treating. Pilot testing minimizes the risk of sending a fluid downhole that may be incompatible with the formations to be drilled or that may be ineffective under downhole conditions. Pilot testing of LCM should be planning carefully, so that the right mud formulation can be obtained and the cost of the experiment can be minimized.

The experiment of LCM involves testing properties such as rheology (plastic viscosity and yield point), fluid loss, filtration loss, density and particle size analysis. The equipment needed for the experiment are Hamilton Beach mixer, mud cup, Fann 35 Viscometer, thermocup, API filtration loss, mud balance, shale shaker.

After testing LCM, the result will be recorded and analyzed to determine its performance. The comparison can be made with contemporary LCM. Last but not least, a conclusion can be made whether the LCM made from orange peel waste has a potential to be commercialized based on its performance and cost compared to the contemporary LCM.

Chapter 4
Result and Discussion

4.1 Result

Base mud formulations are formulated using excel programme for weighted water based mud as shown in table 3. There are three LCM sizes distribution tested which are fine, medium and coarse. For each size distribution five concentrations of orange peel sample which are 3 lb/bbl ,5 lb/bbl, 8 lb/bbl, 10 lb/bbl and 15 lb/bbl are added to the base mud formulation.

Table 6: Base mud formulation

No	Items	Concentration, (lb/gal)
1	Water	318.730
2	Soda Ash	0.5
3	Viscosifier	0.3
4	Caustic Soda	0.25
5	Bentonite	12
6	API Barite	109.190

Several basic mud tests are done to test the properties of each mud including rheological test, mud weight, gel strength and API filtration loss. Table 4, 5, 6 summarizes the test result.

Table 7: Summary of the test result for base and fine size Orange Peel LCM.

Properties						
Sample size	Base	Fine	Fine	Fine	Fine	Fine
Orange peel concentration, lb/bbl	0	3	5	8	10	15
Mud weight, lb/bbl	10	10 - 11	10 - 11	10 - 11	10 - 11	10 - 11
Rheology at 120°F						
600 rpm	45	48	50	55	59	66
300 rpm	33	35	36	39	42	49
200 rpm	26	28	31	32	32	39
100 rpm	20	22	25	25	25	32
6 rpm	9	11	12	14	15	22
3 rpm	8	9	11	12	14	21
PV,cP	12	13	14	16	17	17
YP , $lb/100ft^2$	21	22	22	23	25	32
Gel 10 sec	8	9.5	11	10	10	12
Gel 10 min	13	14.5	16	15	14	21
Thickness	1	1.25	1.5	1.65	1.8	2
API , cc/30min	13.8	13.2	12.6	12.8	13	15

Table 8: Summary of the test result for medium size Orange Peel LCM.

Properties					
Sample size	Medium	Medium	Medium	Medium	Medium
Orange peel concentration, lb/bbl	3	5	8	10	15
Mud weight, lb/bbl	10 - 11	10 - 11	10 - 11	10 - 11	10 - 11
Rheology at 120°F					
600 rpm	48	51	53	54	63
300 rpm	36	38	39	40	47
200 rpm	26	27	28	28	35
100 rpm	21	22	22	23	30
6 rpm	10	11	12	12	19
3 rpm	8	8	9	10	17
PV,cP	12	13	14	14	16
YP , lb/100ft²	24	25	25	26	31
Gel 10 sec	8	8	9	11	13
Gel 10 min	15	16	17	19	26
Thickness	1.25	1.5	1.75	2	2
API , cc/30min	13.7	13.6	13.8	14	17

Table 9: Summary of the test result for coarse size Orange Peel LCM.

Properties					
Sample size	Coarse	Coarse	Coarse	Coarse	Coarse
Orange peel concentration, lb/bbl	3	5	8	10	15
Mud weight, lb/bbl	10 - 11	10 - 11	10 - 11	10 - 11	10 - 11
Rheology at 120°F					
600 rpm	48	50	53	56	63
300 rpm	35	37	40	42	49
200 rpm	5	23	26	28	35
100 rpm	18	16	18	21	28
6 rpm	8	7	9	10	17
3 rpm	6	5	6	7	14
PV,cP	11	13	13	14	15
YP , lb/100ft²	24	24	27	28	34
Gel 10 sec	5	5	6	7	14
Gel 10 min	14	16	17	18	25
Thickness	1	1	1.5	2	2.2
API , cc/30min	14.1	14.4	15.2	16	22

4.2 Discussion

Rheological Properties

Plastic viscosity

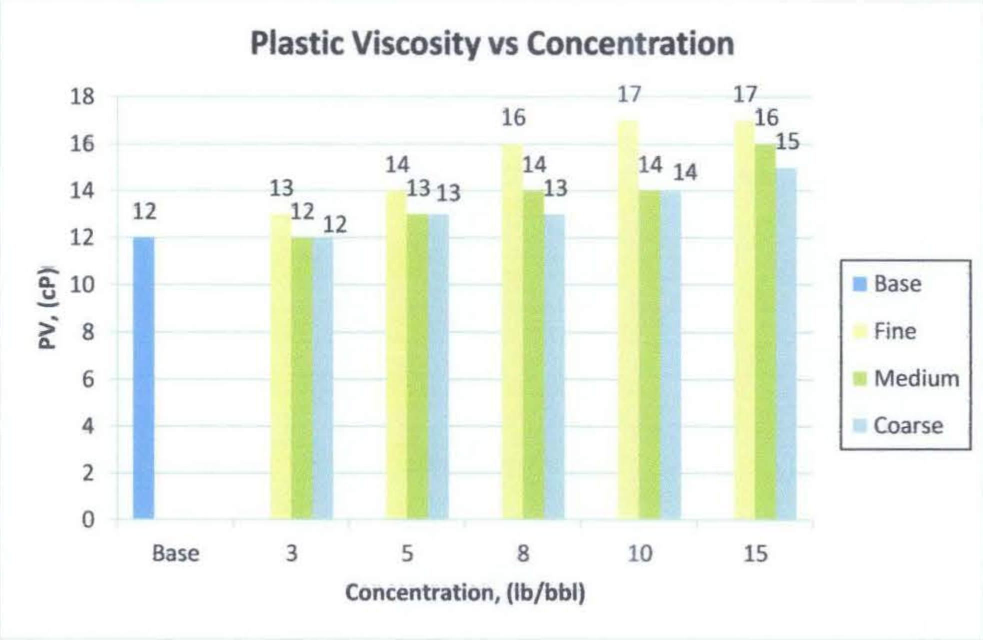


Figure 11: Plastic viscosity comparison for base mud and all orange peel samples.

The effect of adding orange peel with different concentration towards plastic viscosity is shown in figure 6. As it can be seen, the base mud has lowest plastic viscosity while addition of 10 lb/bbl or 15 lb/bbl fine orange peel will result in highest plastic viscosity. If we analyze from LCM size distribution trend, fine size orange peel tend to yield higher plastic viscosity value followed by medium and coarse size. It is because fine size orange peel has more surface area compare to medium and coarse size orange peel. Therefore, it has more surfaces exposed for friction with other fluid and additives in the mud which will result in higher plastic viscosity value. Thus, we can conclude that increasing the solid content/surface area of orange peel will increase plastic viscosity of the mud.

Yield Point

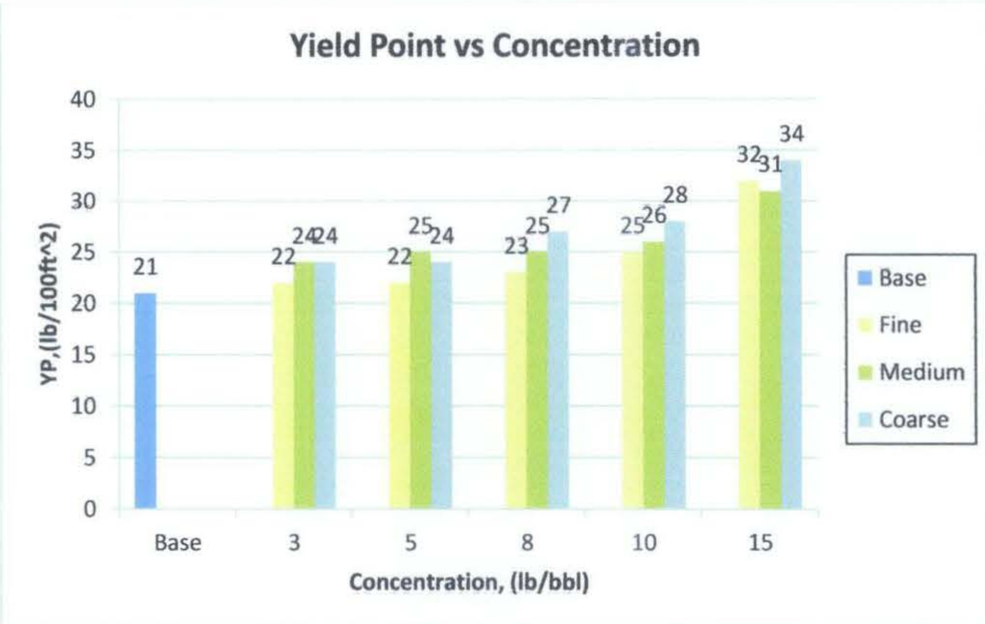


Figure 12: Yield Point comparison for base mud and all Orange Peel samples concentration.

Figure 7 shows the comparison of yield point (YP) for each type of the mud. The base mud has the lowest yield point. After adding 3 lb/bbl, 5 lb/bbl, 8 lb/bbl, 10 lb/bbl and 15 lb/bbl orange peel samples, the yield point increase gradually. Yield point can be described as the minimum stress/pressure needed to initiate fluid flow. The mud with higher YP will has the ability to carry cuttings more that mud with lower YP but it requires higher pump pressure to initiate flow. From the figure 7, fine size orange peel tend to has the lower YP value than coarse size orange peel in almost all concentrations.

Mud Cake Thickness

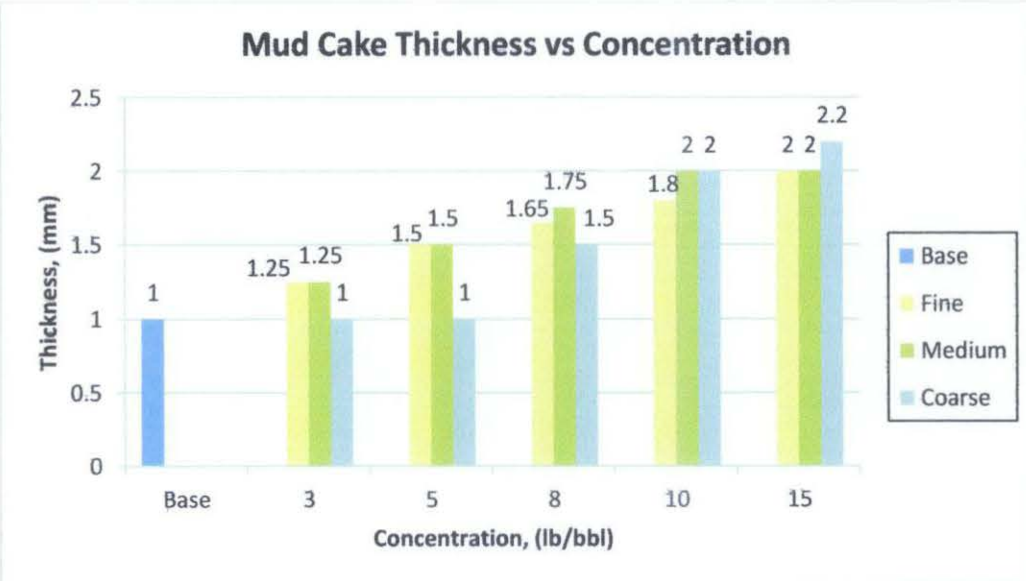


Figure 13: Mud Cake thickness comparison for base and all Orange Peel samples concentration.

After running API filter loss experiment, mud thickness can be measured. Mud thickness is prominent in real drilling operation because thicker mud cake formation will result in various problems such as stuck pipe or logging equipment. From figure 8, it is clear that as the Orange Peel LCM concentration increase, the mud cake thickness also increase. From 3 lb/bbl to 10 lb/bbl, medium size Orange Peel LCM has the highest mud thickness while in 15lb/bbl, coarse size Orange Peel LCM has highest mud thickness.

Filtration loss

I. API filtration loss

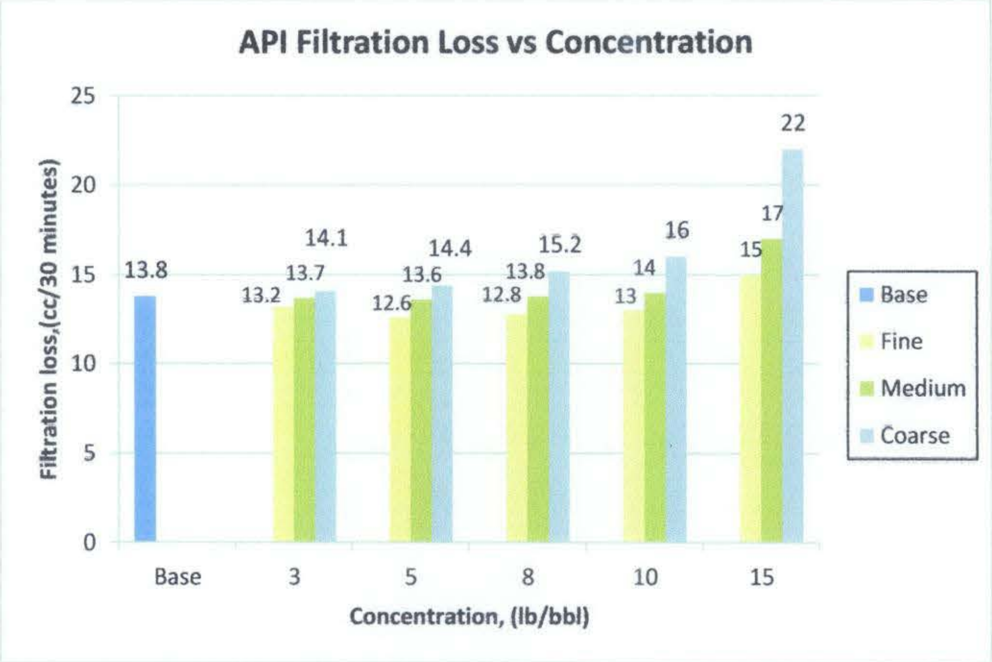


Figure 14: API Filtration loss comparison for base and fine orange peel sample

From figure 8 the minimum fluid loss, 12.6 cc/30minutes is obtained in addition of 5 lb/bbl fine size Orange Peel LCM. The highest fluid loss is 22 cc/30 minutes in addition of 15 lb/bbl coarse size Orange Peel LCM. Basically, the addition of fine size Orange Peel LCM will improve filtration properties of the mud up to 10 lb/bbl. However, the addition of coarse size Orange Peel LCM has adverse effect to the filtration properties. Therefore, between three sizes Orange Peel LCM, fine size has the best performance as filtration loss material. The optimum concentration for fine size orange Peel LCM is 5 lb/bbl because it yield the lowest fluid loss in the mud system as can be seen in figure 10.

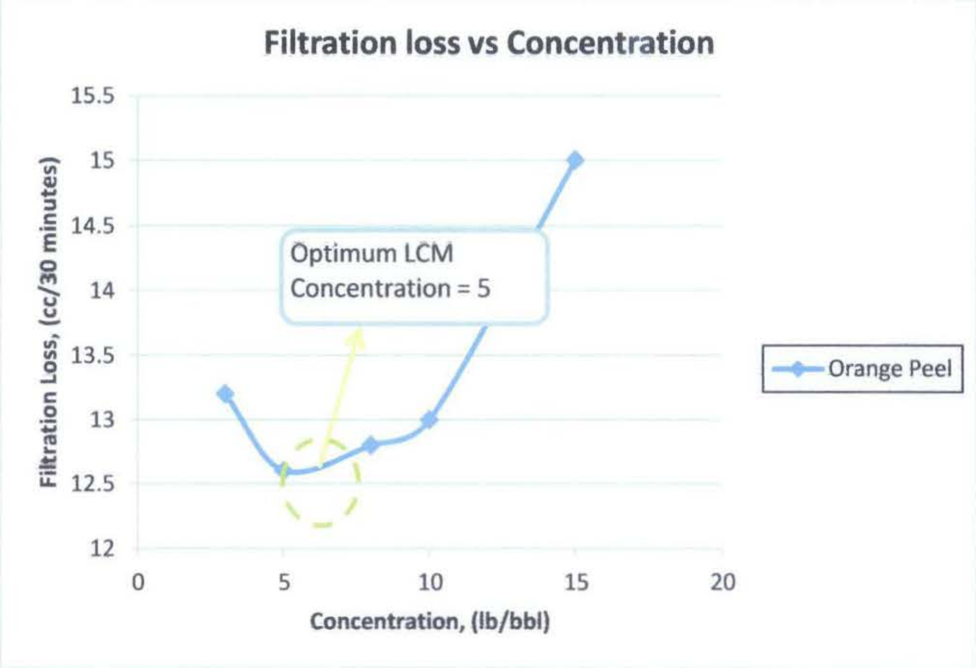


Figure 15: Optimum Concentration for Orange Peel LCM.

Comparison between Orange Peel LCM ,Nut plug and Corn cob.

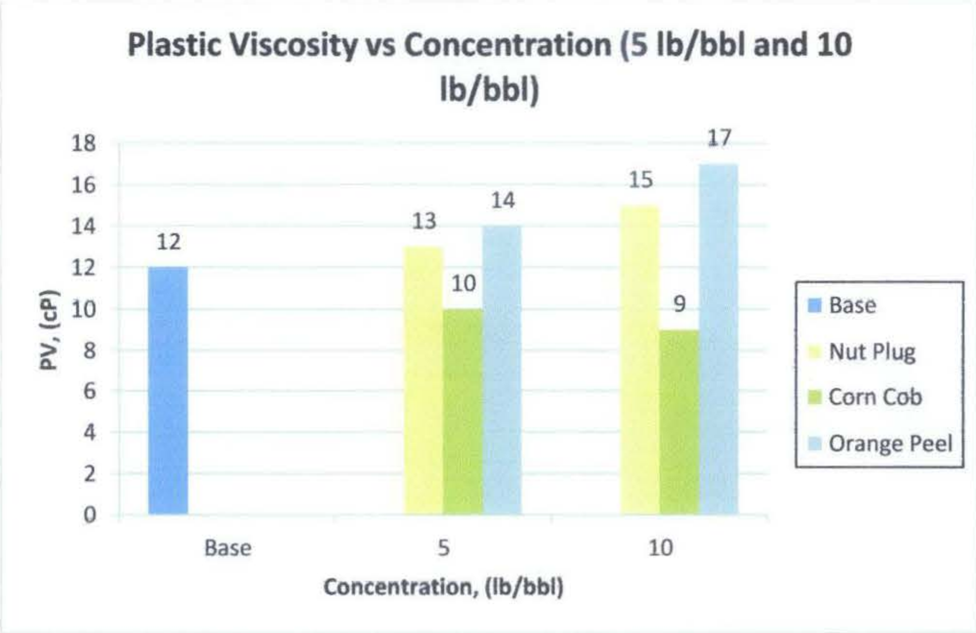


Figure 16: Plastic viscosity comparison between Orange Peel LCM, Nut plug and Corn cob.

Orange Peel LCM is compared with the contemporary LCM used in the industry to evaluate its performance. The industry samples used is nut plug and corn cob. The comparison is made based on three properties which are plastic viscosity, yield point and API filtration loss. Only two concentrations are used in this experiment, 5 lb/bbl and 10 lb/bbl. Figure 11 show a comparison in term of plastic viscosity. It can be seen that Orange Peel LCM has higher plastic viscosity in both concentration compare to the nut plug and corn cob.

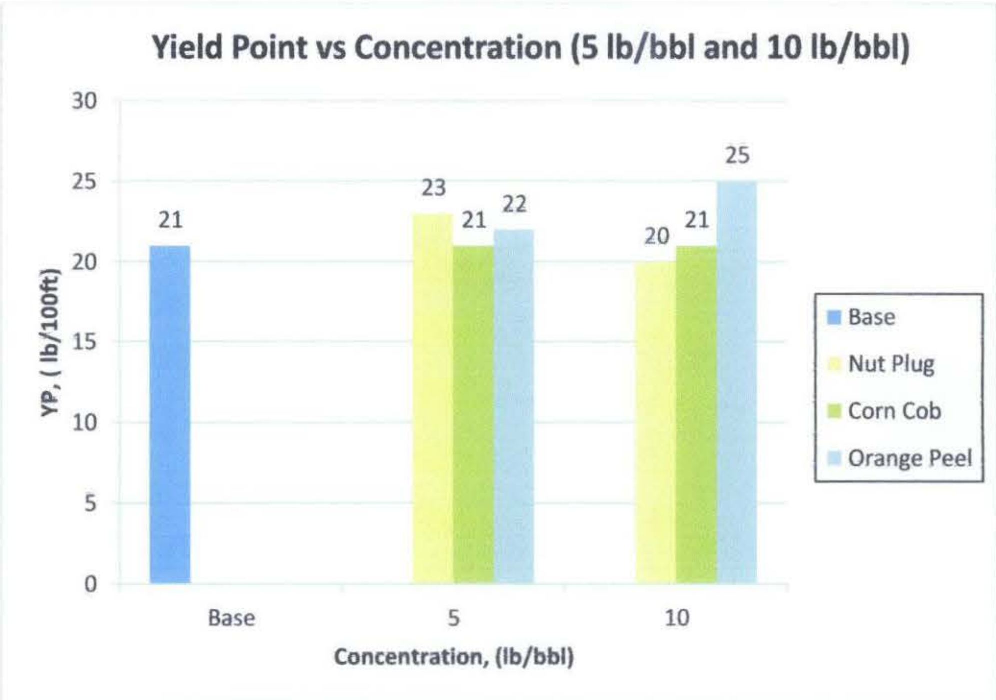


Figure 17: Yield point comparison between Orange Peel LCM, Nut plug and Corn cob.

In terms of yield point, 5 lb/bbl Orange Peel concentration has a close performance to nut plug and corn cob whereas for 10 lb/bbl it has slightly higher yield point. Therefore, in real drilling operation, the pressure required to initiate flow of the mud added with Orange Peel LCM will be almost the same with Nut plug or corn cob if 5 lb/bbl is used.

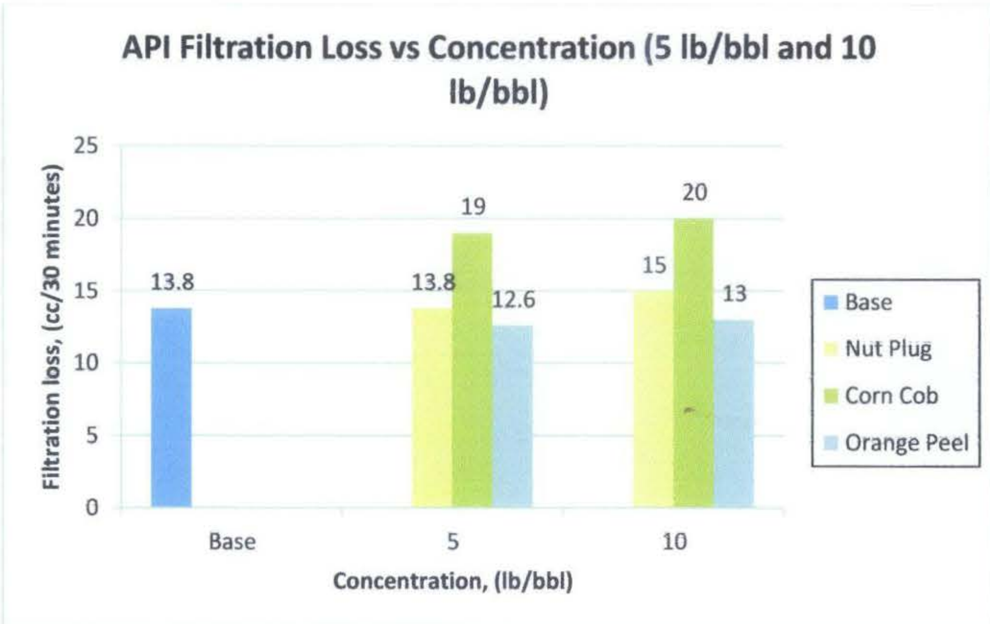


Figure 18: API Filtration loss comparison between Orange Peel LCM, Nut plug and Corn cob.

For filtration loss, Orange Peel LCM has a better filtration in both 5 lb/bbl and 10 lb/bbl concentration than nut plug and corn cob as shown in figure 13. This proves that orange peel is an effective material to reduce lost circulation. Based on the optimum concentration for each material, Orange Peel LCM has optimum concentration of 5 lb/bbl, corn cob has 9.5 lb/bbl and nut plug is 5.7 lb/bbl. Orange Peel require less quantity to achieve lowest filtration loss than corn cob and nut plug.

Chapter 5
Conclusion and Recommendation

5.1 Conclusion

Lost Circulation material is a prominent additive in drilling fluid to prevent mud loss to the formation. The effectiveness of LCM additives to the mud can be evaluate in term of mud properties which are plastic viscosity, yield point, mud cake thickness and filtration loss.

Orange peel waste has been chosen as green LCM because of environment and economic factor. There are there size orange peels used in this project which are fine, medium and coarse. After all size orange peel has been evaluated, the best size which is fine is compared with the contemporary LCM used in the industry which are nut plug and corn cob.

The parameters used in experiment are particle size and LCM concentration. Three size chosen are 150μm for fine, 600μm for medium and 1.8 mm for coarse size. Five LCM concentrations has been used in this project which are 3 lb/bbl, 5 lb/bbl, 8 lb/bbl, 10 lb/bbl and 15 lb/bbl.

Based on the result obtained from the experiment, fine size orange peel tend to produce higher plastic viscosity followed by medium and coarse size. This is because fine size orange peel has more surface area due to high smaller particle size. In term of yield point, coarse size orange peel has higher yield point in all concentration. Therefore coarse size orange peel has higher ability to remove cutting but require more pump pressure to initiate flow.

If we look on the mud cake thickness, the medium size has a tendency to produce thicker mud cake than fine or coarse size. Thus, it is not encouraged to use medium size orange peel because thicker mud cake may cause various problems such as stuck pipe or logging tools. The most important properties in order to be efficient LCM are the filtration loss. Among the three sizes, the fine size orange peel has the best filtration loss property which is 12.6 cc/30 minutes with optimum concentration of 5 lb/bbl.

Fine size has been chosen as the best size for orange peel LCM. Next, fine size orange peel will be compared to the nut plug and corn cob using only two concentrations which are 5 lb/bbl and 10 lb/bbl. In term of plastic viscosity, fine orange peel tends to produce higher plastic viscosity in both concentrations compared to nut plug and corn cob.

For yield point, 5 lb/bbl orange peel has a close yield point value to the nut plug and corn cob yield point. For 10 lb/bbl the orange peel yield point increase to 25 which is the highest compare to nut plug and corn cob.

For filtration loss properties, orange peel has the lowest filtration loss in both concentrations which is very good. Therefore, orange peel is a suitable material to overcome lost circulation problem.

5.2 Recommendations

Further research need to be done to investigate more various size and concentration effect to the mud rheological and filtration properties. In addition, it is suggested that orange peel LCM should be tested in high pressure and high temperature (HPHT) condition to have better understanding regarding its behavior. The behavior of filtration loss in HPHT can be tested in HPHT filtration loss equipment.

The chemical properties analysis of the orange peel such as calcium content, salt content, pH, cation exchange capacity should also be tested because these properties give significant effect to the drilling fluid performance.

The orange peel LCM can also be tested in oil based mud. Then, the result of its rheological properties and filtration loss can be compare with water based mud. Several popular mud system such as KCL/PHPA/Glycol and silicate mud system can also be used to simulate the behavior of the orange peel. Last but not least, the economic analysis and availability of the orange peel LCM is the most important factor need to analyze to ensure its success in industry.

References

1. AOAC (1984). Official methods of analysis (14th ed.). Washington, DC: Association of Official Analytical Chemists.

2. Messenger, J.U, Lost Circulation, Pennwell Publishing Company, Tulsa, Oklahoma (1981).

3. Vickers, Stephen; Cowie, Martin; Jones, Tom and Allan J. Twynam. 2006. A New Methodology that Surpasses Current Bridging Theories to Efficiently Seal a Varied Pore Throat Distribution as Found in Natural Reservoir Formations. Paper AADE-06-DF-HO-16 presented at the AADE Fluids Conference, Houston, Texas, USA, 11-12 April.

4. Arunesh Kumar, Sharath Savari, Donald L. Whitfill, and Dale E. Jamison, Halliburton, Wellbore Strengthening: The Less-Studied Properties of Lost-Circulation Materials, SPE 133484, paper presentation for SPE Annual Technical Conference and Exhibition held in Florence, Italy, 19–22 September 2010

5. Goins, W.C, JR. Weichert, J, P Burba, L. Jr, Dawson. D.D Jr and Teplitz:Oil and Gas Journal(April 12, 1951, 86.

6. Aston M S. Drilling Fluids for Wellbore Strengthening[C]. SPE/IADC 87130 presented at the 2004 IADC/SPE Drilling Conference, Dallas, Texas, March 2-4.

7. Hong (Max) Wang, Mohamed Y Soliman ,Brian F Towler. Investigation of Facttors for Strengthening a Wellbore by Propping[C]. SPE 112629, presented at 2008 IADC/SPE Drilling Conference, Orlando, Florida, U.S.A., 4 March 2008.

8. Wang H, Sweatman R, Engelman B. The Key to Successfully Applying Today's Lost-Circulation Solutions[C]. SPE 95895. Presented at 2005 SPE Annual Technical Conference and Exhibition, Dallas, Texas, U.S.A., 9-12 October 2005.

9. Bugbee J M Lost Circulation - A Major Problem in Exploration and Development of Drilling and Production Practice, 14.(1953)

10. Standard Procedure for Field Testing Water-Based Drilling Fluids, API RP 13B-1, 1st ed., American Petroleum Institute, Washington, D.C., June 1990.

11. Standard Procedure for Field Testing Oil-Based Drilling Fluids, API RP 13B-2, 2nd ed., American Petroleum Institute, Washington, D.C., Dec. 1991.

12. Specification for Drilling Fluid Materials, API Spec. 13A, 15th ed., Sect. 2, American Petroleum Institute, Washington, D.C., May 1, 1993.

13. H. van Olphen, An Introduction to Clay Colloid Chemistry, 2nd ed., John Wiley & Sons, Inc., New York, 1977.

14. G. R. Gray and H. C. H. Darley, Composition and Properties of Oil Well Drilling Fluids, 5th ed., Gulf Publishing Co., Houston, Tex., 1988, pp. 582–583.

15. W. R. Clements, M. A. Jarrett, and E. K. Morton, Society of Petroleum Engineers Annual Conference, SPE 16686, Dallas, Tex., Sept. 27–30, 1987.

16. P. I. Reid, R. C. Minton, and A. Twynam, Society of Petroleum Engineers European Petroleum Conference, SPE 24979, Cannes, France, Nov. 16–18, 1992.

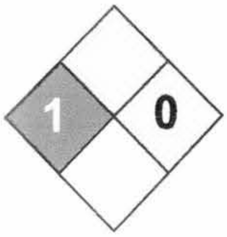
17. Science Lab.com, Material Safety Data Sheet, Orange Peel Powder MSDS.

18. Vickers, Stephen; Cowie, Martin; Jones, Tom and Allan J. Twynam. 2006. A New Methodology that Surpasses Current Bridging Theories to Efficiently Seal a Varied Pore Throat Distribution as Found in Natural Reservoir Formations. Paper AADE-06-DF-HO-16 presented at the AADE Fluids Conference, Houston, Texas, USA, 11-12 April.

19. Goud, M. C. and Givi Joseph. 2006. Drilling Fluid Additives and Engineering to Improve Formation Integrity. Paper SPE/IADC 104002 presented at the SPE/IADC Indian Drilling Technology Conference and Exhibition, Mumbai, India, 16-18 October.

APPENDICES

ScienceLab.com
Chemicals & Laboratory Equipment



Health	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Orange Peel Powder MSDS

Section 1: Chemical Product and Company Identification

'roduct Name: Orange Peel Powder

:atalog Codes: SLO1246

:AS#: Not available.

ₓTECS: Not available.

TSCA: TSCA 8(b) inventory: No products were found.

:I#: Not available.

ˢynonym:

:hemical Name: Orange Peel Powder

:hemical Formula: Not available.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

ımposition:

Name	CAS #	% by Weight
Orange Peel Powder		100

ıxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

ıtential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of ıalation.

ıtential Chronic Health Effects:
\RCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. :VELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

'e Contact:
ıeck for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 nutes. Get medical attention if irritation occurs.

:in Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

rious Skin Contact: Not available.

ıalation:
nhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical ention.

rious Inhalation: Not available.

ȝestion:
ı NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious rson. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, , belt or waistband.

rious Ingestion: Not available.

Section 5: Fire and Explosion Data

ımmability of the Product: May be combustible at high temperature.

ıto-Ignition Temperature: Not available.

ısh Points: Not available.

ımmable Limits: Not available.

oducts of Combustion: Not available.

'e Hazards in Presence of Various Substances:
ghtly flammable to flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

plosion Hazards in Presence of Various Substances:
sks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in esence of static discharge: Not available.

'e Fighting Media and Instructions:
/ALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

ıecial Remarks on Fire Hazards: Not available.

ıecial Remarks on Explosion Hazards: Organic dusts can form explosive mixtures in air.

Section 6: Accidental Release Measures

nall Spill:
ıe appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on ɘ contaminated surface and dispose of according to local and regional authority requirements.

rge Spill:
ıe a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the ntaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

ecautions:
ıep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a ne hood. Ground all equipment containing material. Do not breathe dust.

orage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 24°C (75.2°F).

Section 8: Exposure Controls/Personal Protection

ıgineering Controls:
ıe process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended posure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants low the exposure limit.

rsonal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. ɔves.

rsonal Protection in Case of a Large Spill:
lash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid ıalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this ɔduct.

posure Limits: Not available.

Section 9: Physical and Chemical Properties

ysical state and appearance: Solid. (Powdered solid.)

lor: Characteristic.

ste: Not available.

ılecular Weight: Not available.

ılor: Beige.

I (1% soln/water): Not available.

ıiling Point: Not available.

ılting Point: Not available.

itical Temperature: Not available.

ecific Gravity: Not available.

por Pressure: Not applicable.

por Density: Not available.

latility: Not available.

lor Threshold: Not available.

ıter/Oil Dist. Coeff.: Not available.

ıicity (in Water): Not available.

ıpersion Properties: Not available.

lubility: Not available.

Section 10: Stability and Reactivity Data

ıbility: The product is stable.

ıtability Temperature: Not available.

ınditions of Instability: Excess heat, incompatible materials

:ompatibility with various substances: Not available.

rrosivity: Not available.

ecial Remarks on Reactivity: No information available at this time.

ecial Remarks on Corrosivity: Not available.

lymerization: Will not occur.

Section 11: Toxicological Information

utes of Entry: Inhalation. Ingestion.

xicity to Animals:
50: Not available. LC50: Not available.

ronic Effects on Humans: Not available.

her Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

ecial Remarks on Toxicity to Animals: Not available.

ecial Remarks on Chronic Effects on Humans: Not available.

ecial Remarks on other Toxic Effects on Humans:
ute Potential Health Effects: Skin: May cause skin irritation. Eyes: Dust may cause eye irritation. Ingestion: Swallowing this iterial during normal handling is not likely to be harmful. Inhalation: This material may produce dust. May cause respiratory ct irritation. Breathing small amounts of this material during normal handling is not likely to be harmful. Breathing large iounts may be harmful. The toxicological properties of this substance have not been fully investigated.

Section 12: Ecological Information

otoxicity: Not available.

D5 and COD: Not available.

oducts of Biodegradation:
ssibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

xicity of the Products of Biodegradation: Not available.

ecial Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

iste Disposal:
iste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

T Classification: Not a DOT controlled material (United States).

ntification: Not applicable.

ecial Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

deral and State Regulations: No products were found.

her Regulations: Not available.

her Classifications:

HMIS (Canada): Not controlled under WHMIS (Canada).

CL (EEC):
is product is not classified according to the EU regulations. Not applicable.

IIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

tional Fire Protection Association (U.S.A.):

Health: 1

Flammability: 1

Reactivity: 0

Specific hazard:

otective Equipment:
oves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

ferences: Not available.

her Special Considerations: Not available.

eated: 10/10/2005 11:06 AM

st Updated: 11/06/2008 12:00 PM

e information above is believed to be accurate and represents the best information currently available to us. However, we ike no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume liability resulting from its use. Users should make their own investigations to determine the suitability of the information for eir particular purposes. In no event shall ScienceLab.com be liable for any claims, losses, or damages of any third party or for st profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com s been advised of the possibility of such damages.