Potential of Banana Peels and Sugarcane Bagasse as Lost Circulation Material Additive in Drilling Mud Application

Norizzatul Akmal Ismail @ Azhar, Siti Khatijah Jamaluddin,

Faculty of Chemical Engineering, Universiti Teknologi Mara

***Abstract*—** Loss circulation occurs when drilling fluid known as mud, flows into fractures of formations and not able to recirculate in oil and gas well drilling process. This can be a serious problem in maintaining the structure of formations and pressure of the well during drilling activities. Loss of expensive mud could leads to a major financial problem in executing a drilling project. This is why loss circulation is one of the biggest problem that are need to be tackled during drilling. This leads to the focus of this paper on developing new lost circulation material in water-based mud and considering the environmental resulting issues. The objective of this paper are to conduct parametric study of banana peels and sugarcane bagasse as lost circulation material additive for drilling mud application and to investigate thermal stability of the formulated banana peels and sugarcane bagasse based lost circulation material additive for drilling mud. The performance of banana peel and sugarcane bagasse with different particle size and concentration are tested using Fann Viscometer and Low Pressure Low Temperature (LPLT). The performance of the banana peels in rheological properties and filtration properties studies are more efficient compared to the sugarcane bagasse and mud without LCM.

Keywords*— *Drilling Mud, Rheological Properties, Loss Circulation Material, Banana Peels, Sugarcane Bagasse and Filtration Test.

I. INTRODUCTION

The growth of drilling activities and exploration have increased globally nowadays into various regions that rapidly involving oil and gas industry such as Caspian Sea, Brazil and West Africa. The technology helps the rapid growth of economy and by extracting these natural resources will donate many benefits to humans. It also poses a big challenge and requires high-performance drilling fluids for these new drilling theories [1].

Figure 1 shows that drilling circulating system, a closed loop system has been used. As an analogy, drilling fluid roles like liquid that will force to heart and will circulate the system in human body. A suspension of clay particles in a liquid mixing phase is either oil based or water based that will produce emulsion defined as drilling fluid. These drilling fluid also acknowledged as drilling mud are normally used in drilling oil and natural gas wells including exploration process and production by using drilling rigs [2]. There are numerous types of drilling fluids that have been used these days depending on various factors such as geology of exploration, well stability and environment conditions. Types of drilling mud that will be used also depends on the location and characteristic of wellbore itself [3].

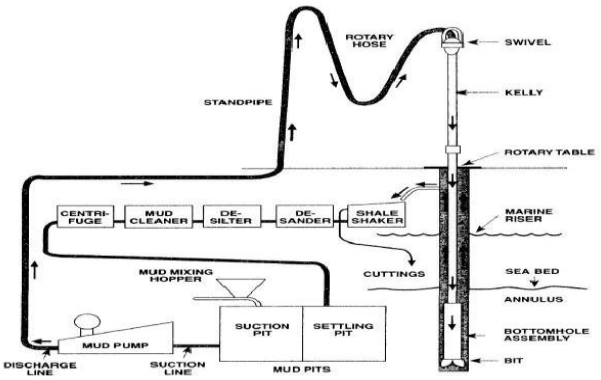

Figure 1: Closed loop system of mud circulation.

Lost circulation is one of most fundamental problems that will faced in drilling process. It increasing the cost of mud and time involved in rig operation. Lost circulation is a phenomenon in which the drilling mud flows into the formation instead of returning back to the surface or annulus. When this phenomena occur, the oil industry will suffer economically. Lost circulation also will give the consequences on the level of fluid in the well bore. Due to the loss of mud to the formation the hydrostatic pressure will become decrease. Consequently, drilling process will continue to a point where there are no fluid left inside the well bore, causing well bore damage and this phenomena is called dry drilling [3].

The objectives of this study are to conduct rheological study of banana peels and sugarcane bagasse as potential lost circulation material additive for drilling mud and to investigate thermal stability of the formulated banana peels and sugarcane bagasse based lost circulation material additive for drilling mud. Banana peels and sugarcane bagasse has been chosen as LCM because these material easy to get, biomass from agricultural waste and the composition has the similarity with commercialize LCM nowadays. The experiment is carried out by using three different parameters and two levels for each parameter. For the first parameter, this experiment use two different raw materials which are banana peels and sugarcane bagasse. Another parameter is concentration of both additive were set to 0.1g/ml and 0.6 g/ml. The third parameter, is particle size with three different size. The size of additives are decide by following the Abrams' Median Particle-Size Rule, 350 micron meter for fine categories and 700 micron meter for coarse categories.

To achieve the first objective, Rheological Study of mud with Loss Circulation Material was tested by using Fann Viscometer. The investigation of rheological properties are important in order

to determine the good quality of drilling fluid with additive. In order to study the thermal stability of formulated additives, samples were run at room temperature and 100psi by using the Low Pressure and Low Temperature (LPLT) Filter Press equipment.

II. METHODOLOGY

A. Preparation of Banana Peels and Sugarcane Bagasse as potential LCM

These raw materials have been collected at different locations. Sugarcane bagasse is a waste that can be obtained from sugarcane juice stall that located at Kompleks PKNS, Shah Alam and banana peels were obtained from banana stall near Giant Seksyen 7, Shah Alam. Both raw materials were cleaned by using distilled water to make sure there is no impurities left or other contaminant that will affect the result of experiment. These sample was cut into small pieces as shown in Figure 1 for easier handling and storage purpose. These sample were then dried for 2 days under sun to ensure no moisture content that may affect the efficiency of sample during experiment. Thereafter complete drying process, sample were ground into smaller size by grinder machine. Then, samples were sieved by following the desired particle sizes; 0.3mm for fine, and 0.7 mm for coarse size.

Figure 2 : Banana Peels before and after grinded and dried.

B. Mud Preparation

Mud formulation was done and the mud was modified to achieve standard mud weight as suggested by Malay Basin which is 11ppg. The Water Based Mud contain fresh water, sodium hydroxide, bentonite, xanthan gum and barite as shown in Table 1. Formulation A is a base fluid composition without loss circulation meanwhile Table 2 for formulation B of Water Based Mud with the environmental friendly additives which are banana peels and sugarcane bagasse. Amount of LCM was fixed to 6g for each sample.

Table 1: Formulation A – Base fluid composition [26]

Ingredients	Quantity
Fresh Water	350 ml
Sodium Hydroxide (NaOH)	1.0 g
Bentonite	25 g
Xanthan Gum	0.7 g
Barite	130 g

Table 2: Formulation B – Drilling Mud composition with the addition of LCM.

Ingredients	Quantity
Fresh Water	350 ml
Sodium Hydroxide (NaOH)	1.0 g
Bentonite	25 g
Xanthan Gum	0.7 g
Barite	130 g
Loss Circulation Material	6g

For the mixing procedure, each material was added into fresh water by following the procedure as show in the Table 3. Hamilton Beach Mixer has been used to mix the mud homogeneously. The mixing procedure start with pour the water in the container then sodium hydroxide was add and mixed for 3 minute with low speed. In same mixture, bentonite was adding and mixed at medium speed in 10minutes. After Xanthan gum, the barite was added to the mixture. This procedure was repeated to nine 9 with different characteristic of LCM. Figure 2 shows the mud sample without additives [4]. After completed the mixing procedure, these 9 samples was keep for one night to make sure there no segregation process occur. If this process occur, the mud formulation not suitable for drilling application.

Table 3: Mixing Procedure for Water Based Mud [4].

Ingredients	Time (minutes)	Speed
Fresh Water	-	-
Sodium Hydroxide (NaOH)	3	Low
Bentonite	10	Medium
Xanthan Gum	10	Medium
Barite	12	High

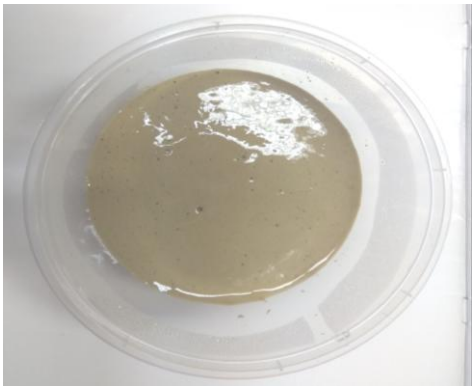

Figure 3: Water Based Mud without LCM.

C. Rheological Properties and Filtration Test Procedure.

In order to measure the plastic viscosity, gel strength, and yield point of drilling mud, Fann Viscometer was used in this test. Plastic viscosity play a function to minimize high shear rate viscosity. By reducing the plastic viscosity, a driller will reduces the viscosity at the bit will giving rise the rate of penetration. Plastic Viscosity can be measured by setting the speed at 600rpm and 300rpm and the formula as shown in equation 1. Meanwhile gel strength is important in order to classify the goo mud formulation[[5]. Gel strength is a method to measure shear stress that is required to initiate flow of fluid that has been inactive for a period of time. Gel strength also define as potential of the mud to suspend cuttings when circulation stops. In drilling operations, high viscosity and gel strength should not be mixed because it will tend to form solid particles such as cutting, barite into mud system. By addition more fluids, it will helps to reduce the solid particles. Excessive gel strength are not desirable in drilling process because it will lead to flocculation occurred, large surged pressure may encountered while running the pipe that possible to create the formation [6] . Thus the value of gel strength can be achieved when speed set up to 600rpm and the lowest 3rpm. This step was repeated by using different type of sample with different parameter. Plastic Viscosity (PV) and Yield Point (YP) were calculated based on Equation 1 and 2 respectively [7].

- PV = PV at 600rpm – PV at 300rpm (eq.1)
- YP = PV at 300rpm – PV (eq.2)

For Filtration Test, Low Pressure Low Temperature (LPLT) Filter Press was used since these samples were tested at room temperature and pressure of 100psi. Nitrogen gas was used to press the mud in the container. The filtration test will determine the amount of filtrate loss and mud cake thickness can be determined. From this result, the good quality of mud could be decide. Mud Weight and pH also was determine in order to study the properties of mud [8].

D. Thermal Stability Test

Fann Viscometer was set to three different temperature which are 25ºC, 50 ºC, and 100 ºC. Then, the best sample from previous test was tested again and the reading of plastic viscosity, gel strength and yield point was recorded and compared [9].

E. Design of Experiment.

Table 4: Design of experiment layout.

Experimental Number	Process Parameter Level		
	Raw Material	Concentration (g/mL)	Particle Size of Additive (μm)
1	-	-	-
2	SB	0.1	300
3	SB	0.6	300
4	SB	0.1	700
5	SB	0.6	700
6	BP	0.1	300
7	BP	0.6	300
8	BP	0.1	700
9	BP	0.6	700

SB: Sugarcane Bagasse
BP: Banana Peels

III.RESULT AND DISCUSSION

A. *Effects of environmental friendly additives on Rheological Properties of water based mud.*

Rheological Properties Study. Rheological properties on water based mud analyzed including the pH, mud weight, plastic viscosity (PV), yield point (YP), and gel strength (GS). All the result obtained from Fann Viscometer shows in table 5 below. Based on table 5, it is obvious that by having banana peels and sugarcane bagasse as additive in water based mud, the rheological properties are changes slowly and some changes rapidly. Banana peels and sugarcane additives enhance the value of plastic viscosity, yield point and gel strength of water based mud compared to sample number 1 which is the water based mud sample without an additives. Value of plastic viscosity, gel strength and yield point of drilling mud increased after addition of banana peels and sugarcane bagasse due to good interaction of mud and additives. Banana peels and sugarcane bagasse are biodegradable material that can contribute carbohydrate nature that contain cellulose, lignin and starch. The good interaction produce when these composition have been absorbed on clay particles of water based mud and become more homogenized when well mixed [10]. At the same time, the gel strength also increase slowly and this condition will helps during drilling process stop because the drilling mud will become concrete and the cutting will fall down and easy to handle to move out from mud circulation [11]. For yield point and plastic viscosity value, a positive result which is still in range as recommend by American Petroleum Institute also have been obtained which indicates banana peels and sugarcane bagasse can be viscosifier and shear strength improving agent with the great potential of drilling mud to lift cuttings during stop the process of drilling. However, the ideal result can be obtained in sample 6 (Banana peels as additive with fine particle size and high concentration of LCM) because this sample show the most ideal reading of Fann Viscometer. The value of plastic viscosity and gel strength are in normal range and this situation will not affect the wellbore situation as mention previously [12].

Table 5: Rheological Properties of drilling mud.

	Mud Weight (ppg)	pH	PV (Cp)	YP (Kg/m2)	GS (Kg/m2) 10s
1	11	11	10	9	18
2	8.9	12	25	35	19
3	9.1	12.1	17	41	24
4	9.7	12.6	21	60	19
5	9.9	12	35	100	41
6	9.1	11.8	19	22	24
7	9.6	11.5	27	62	36
8	9.3	11.8	18	25	11
9	9.2	11.8	22	54	34

pH and Mud Weight. By adding banana peels, pH and mud weight of water based mud were changed. These water based mud with addition of additives become more alkaline. For the mud weight, this value decrease as the loss circulation material was added into the drilling mud. The blank sample can achieve to 11ppg which is the standard mud weight that use in drilling industry. These standard range is 9.8 until 11 ppg are suggested to use with water based mud. The lowest of mud weight value is 8.9 ppg and the highest with LCM is 9.9ppg. For sugarcane bagasse, value of alkaline are more higher compare to banana peels as additive. According to previous study, banana peels and sugarcane bagasse as fluid lost agent will reduce the density of water based mud [13].

Filtration Properties Study. Same concept with the effect of LCM on rheological properties of drilling mud, these two LCM also give positive result in second experiment by using Filtration Equipment which is Low Pressure and Low Temperature (LPLT) Filter press. The objective of this test, to observe the performance of water based mud without LCM and with LCM in fluid lost controlling and formation of mud cake. Then, performances of sugarcane bagasse was compared with the banana peels.For this experiment, the pressure was fixed to 1000psi by using nitrogen gas to press the drilling mud in the aging cell and temperature was set to standard room temperature (27℃) and the duration was fixed to 30 minutes for each sample [14]. Table 6 below shows the filtration data which includes filtrate volume and filter cake thickness.

Table 6: Low Pressure Low Temperature Filter Press Result.

	Filtrate Volume,(mL)	Mudcake Thickness (1/32 inch)
1	18.5	2
2	11.5	1
3	10.5	1.5
4	13.5	4
5	11	2.2
6	10.5	1.5
7	7.0	0.5
8	12.5	1.2
9	11	2.5

1. Effect of Different Type of Raw Materials as Loss Circulation Materials.

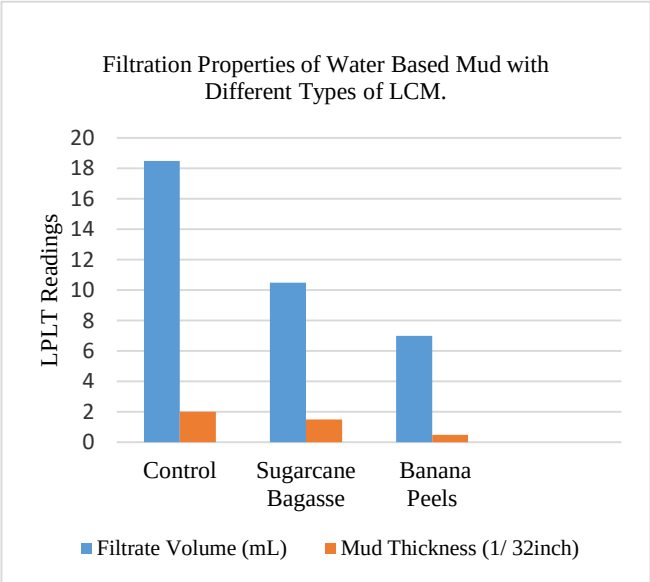

Figure 4: Filtration Properties of Water Based Mud with Different Concentration of LCM.

As in Figure 4, banana peels still play the good performances in the filtration study compared to the sugarcane bagasse because the volume of filtrate in banana peel water based formulation shows the lowest result compared to sugarcane bagasse. These two value does not have any big different which is proven that they have great ability to perform as a good environmentally additives in the drilling mud application. Banana peels tends to gives a significant result compared to sugarcane bagasse because it contains lignin, starch and cellulose and fibrous is one of the fluid loss control agent characteristic. The ideal filter cake is thin and impermeable. The lowest mud cake thickness is obtained from the banana peels. In the drilling applications, it was suggested that to have the thin mud cake thickness so piping blockage could be avoid. [15].

2. Effect of Different Particle Size of Loss Circulation Materials.

Analysis of particle size distribution normally used in order to determine filtration loss properties, and amount of solid retains in the drilling mud after the fluid is pumped into the system. A drilling fluid should be contain particle size ranging up to the requisite maximum should be able to effectively bridge the formation and form the filter cake [16]. At the same time permeability of filter cake also depends on the particle size distribution as increasing the size of LCM will lead to decreases of permeability due to the fact that colloidal particle get packed tightly [17].Four set of samples were prepared for each type of mud with different particle size for this two loss circulation material. Figure 5 shows the decrement pattern of filtrate volume as the particle size decrease.

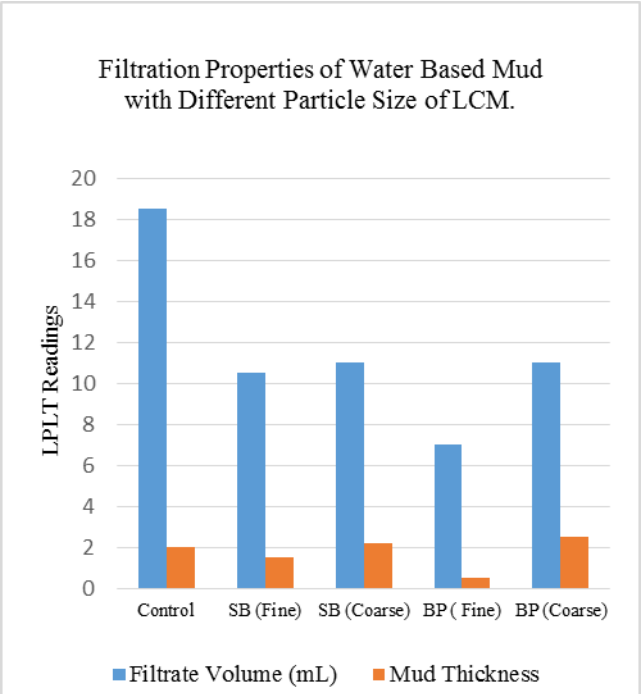

Figure 5: Filtration Properties of Water Based Mud with Different Particle Size of LCM.

The smaller the particle size of drilling mud additives forms lower filtrate volume of drilling obtained. The fine sized of LCM have more surface area so they possess more resistance to pressure and they can plug more formation. For the mud cake thickness, it will contribute to several effects on the drilling and production well. The best range of mud cake thickness is between 2 to 25mm. From Figure 5, the mud cake thickness increase as the particle size increase. Filtrate volume is directly proportional to the filter cake thickness. The lowest mud cake thickness is 0.5/32 inch comes from sample 6 (banana peels with fine particle size and high concentration of LCM) .This mud cake with a low permeability is formed on the walls of the barehole due to differential pressure. Therefore, it recommended to have low thickness of filter cake which will act as barrier between formations and drilled bore [18].

3. Effect of Different Concentration of Loss Circulation Materials.

The experimental results reveal that the lost circulation control was influenced by the concentration of lost circulation material. According to Ismail et al (2015), the higher the concentration of drilling fluid additives, the better performances of LCM to control the mud loss. In general, by increasing the concentration of LCM, bridging will occur faster and fluid loss decline [19]. As shown in

Figure 6, the higher concentration of LCM tested (0.6mg/L) resulted in the lowest amount of fluid loss. Mud sample without LCM give 18.5 ml of mud lost. Meanwhile banana peels and sugarcane bagasse can reduce amount of fluid loss until 7.0ml which is almost 50% difference compared to sample of mud without LCM.

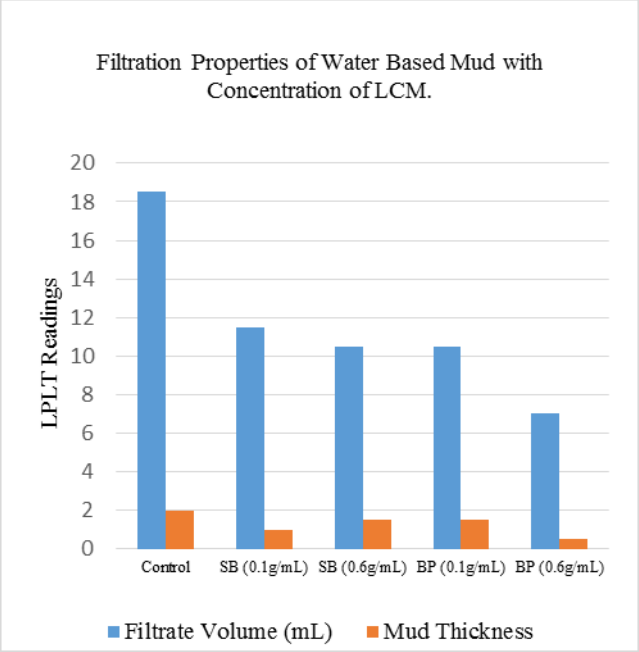

Figure 6: Filtration Properties of Water Based Mud with Different Concentration of LCM.

B. Thermal Stability Test for Loss Circulation Materials.

From filtration and rheological test and result analysis, sample 6 which is water based mud added with banana peels as additive. Banana peels with fine particle size and high concentration has been chosen as the optimum additives to prevent loss circulation materials. Therefore, this sample was used to complete objective 2 of this study, which to investigate the thermal stability of the optimum LCM. Table 7 shows the result obtain from Thermal Stability Test on Rheological Properties of Water Based Mud with LCM.

Table 7: Result of Thermal Stability Test on Rheological Properties of Water Based Mud with LCM.

	Temperature, (ºC)	Yield Point, (kg/m^2)	Gel Strength, (kg/m^2)		Plastic Viscosity, (*cp*)
			10 s	10 min	
Sample 6	25	62	36	58	27
	50	28	20	32	17
	100	25	11	29	5

According to the standard by American Petroleum Institute (API), the increase of temperature in wellbore will affect the properties of drilling mud itself [20]. As shown in Figure 7 and Table 7, as the temperature increase up to 100 ºC, the rheological properties show the decreased pattern in the Fann viscometer reading. The reading of yield point at first temperature was $62kg/m^2$ then decrease to 28 kg/m^2 and $25kg/m^2$. Same goes to gel strength and plastic viscosity value decrease as well as the temperature increases. Temperature can make affect in stability and resistant rheology of mud. Further experiment should be done in HPHT in order to study the maximum temperature this banana peel additives can performed and before run at HPHT [21].

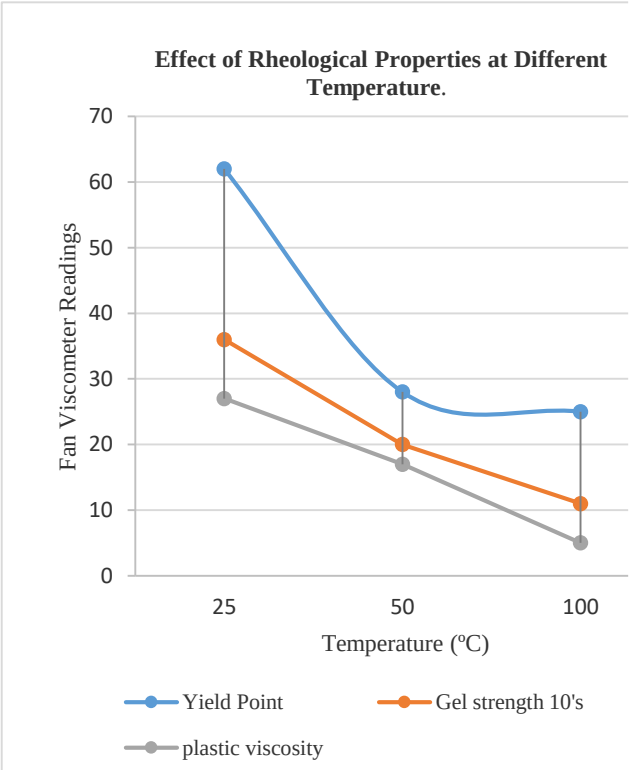

Figure 7: Effect of Rheological Properties at Different Temperature.

IV. CONCLUSION

In conclusion, the important factor that can contribute to better performances of loss circulation material are particle size distribution, concentration of additives and type of materials used. This experiment shows the performance of fine size of lost circulation control materials is better than coarse size because fine size has better filling behavior. In addition, as concentration of lost circulation agents increases significantly, it gives better results in its filtration parameters. By comparing all samples, Banana Peels have the best results compared to sugarcane bagasse as they have variety of crude fibre and the higher content of cellulose, lignin and starch. For the thermal stability study, when the temperature increase rapidly, the performance of rheological properties of banana peels are degrade. At the same time, pH and mud weight of drilling mud are affected by using different type of additives. Lastly, banana peels and sugarcane bagasse are both suitable as environmentally additives in water based mud. By focusing more on biodegradable materials it will be another alternative to enhance the safe environment and reduce the dependency on chemical additives. Apart from that's, it could help in reducing cost of processing compared to synthetic and chemical additives and banana peels and sugarcane bagasse are available in large source.

For recommendation, first, particle size of additives should be used in a smaller range like 20 micron until 100 micron. By having small ranges of particles size distribution, it's could give the different pattern of result on rheological and filtration properties. Then, researcher also can improve the mud formulation with different amount of additive that will be used in the drilling mud formulation. At the same time, the mixing procedure also need to

be modified such as do the hot and cold rolling to make sure the mud and additives mix more perfectly.

ACKNOWLDEGMENT

Thank you to my supervisor, Miss Siti Khatijah Binti Jamaludin for her valuable guidance and advice throughout this final year project and thesis. Thank you to Universiti Teknologi MARA (UiTM) for giving this chance and space to do this research. I also would like to acknowledge with much appreciation to my parents, and Drilling Gas Laboratory Technician En Redzuan Yusof and En Hafizan for guiding me to complete this research.

References

[1]. Anton Gerner (2012). *Lost circulation experimental study in Oil Based mud and analyzing experimental data.*

[2]. Apaleke AS, Al-Majed A, Enamul HM (2012).'*Drilling Fluid: State of The Art and Future Trend'.* North Africa Technical Conference and Exhibition. 20–22 February 2012. Cairo, Egypt.

[3]. Amir M. Shaikh. (2010). *Environmental Management of Drilling Mud.* Department of Applied Earth Sciences, University of Technology, Netherlands.

[4] Azlinda Aziz *et.al* (2013). *Agarwood Waste as A New Fluid Loss Control Agent in Water Based Drilling Fluid.* International Journal of Science and Engineering,5(2),101-105.Faculty of Chemical Enginnering,Universiti Teknologi MARA 40450 Shah Alam,Selangor,Malaysia.

[5]. Akeju *et al* (2014), *The Use of Crassostrea Virginica as Lost Circulation Material in Water-Based Drilling Mud,* International Journal of Engineering and Technology Volume 4 No. 2, 1Department of Petroleum Engineering, University of Ibadan, Ibadan, Nigeria

[6] Amir M. Shaikh. (2010). *Environmental Management of Drilling Mud.* Department of Applied Earth Sciences, University of Technology, Netherlands.

[7] Annudeep Singh Dhiman.(2012). *Rheological Properties and Corrosion Characteristic ofDrilling Mud Additives*. Department of Engineering, Dalhousie University, Halifax Nova Scotia.

[8] Anton Gerner (2012), *Lost circulation experimental study in Oil Based mud and analyzing experimental data.*

[9] Apaleke AS, Al-Majed A, Enamul HM (2012). '*Drilling Fluid: State of The Art and Future Trend'.* North Africa Technical Conference and Exhibition. 20–22 February 2012.Cairo, Egypt.

[10] Darley Smith and George M. (1988). *Drilling and Work Engineering Department*. Saudi Aramco Drilling Manual. Saudi Arabia: Saudi ARAMCO Drilling and Workover Engineering Department.

[11] Ismail *et al* (2015), *The Impact of Durian Rind in Water based Mud in Combating Lost Circulation,* Petroleum Resources Corporation Institute for Oil and Gas, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

[12] Kafashi *et al* (2016), *Effects of Sugarcane and Polyanionic Cellulose on Rheological Properties of Drilling mud*: an Experimental Approach, Institute of Petroleum Engineering, University of Tehran, Tehran, Iran. Maersk Drilling (n,d). *The Drilling Industry* retrieved form http://www.maerskdrilling.com/en/about-us/the-drilling-industry, on 5th December, 2016.

[13] Max R.Annis and Martin V.Smith.(1974). *Drilling Fluids Technology.* Exxon Company,USA.

[14] Mir Yusif Mir Babayev (2012). *A Brief History of Oil and Gas Well Drilling*, Visions of Azerbaijan, Discover the Land of Fire, retrieved from http://www.visions.az/en/news/366/4ca556e3/, on 2nd December 2016.

[15] Mortadha Alsaba and Runar Nygaard. (2014). *Review of Lost Circulation Material and Treatments with an Updated Classification*. American Association of Drilling Engineers. Missouri University of Science and Technology.

[16] Mortadha Alsaba. (2015). *Investigation of Lost Circulation Materials Impact on Fracture Gradient.* Doctoral Dissertations. Paper 2437. Geoscience and Geological and Petroleum Engineering. Missouri University.

[17] n.a. (1999). *Prevention and Control of Lost Circulation Best Practice*. Atlantic RichfieldCompany, Plano, Texas.

[18] Needa *et al* (2016), *Controlling bentonite- based drilling mud properties using sepiolite nanoparticles*, Petroleum Exploration and Development, Volume 43, Issue 4, Research Institute of Petroleum Exploration and Development, PetroChina, Elsevier.

[19] Nwaoboli Awele. (2014*). Investigation of Additives on Drilling Mud Performance As A Case Study*. Chemical Engineering Department, Aalborg University, Denmark.

[20] Pilehvari, A. A. and V. R. Nyshadham (2002). *Effect of Material Type and Size Distribution on Performance of Loss/Seepage Control Material*, Society of Petroleum Engineers.

[21] Robert H.White. (n.d).*Lost circulation Material and Their Evaluation*, Google Patents.S. Mukherjee. (2013). *The Science of Clays: Applications in Industry, Engineering and Environment*. Capital Publishing Company