IOP Conf. Series: Materials Science and Engineering **358** (2018) 012022 doi:10.1088/1757-899X/358/1/012022

Oil Palm Empty Fruit Bunch (OPEFB) Fiber as Lost Circulation Material (LCM) in Water Based Mud (WBM)

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Abstract. Lost Circulation Material (LCM) is an additive used to prevent lost of mud to the formation as a results from natural or induced fractured during drilling operation. Losses of mud could give great impact to the oil industry as it increases mud cost and rig time. The objective of this research was to investigate the effect of size and concentration of Oil Palm Empty Fruit Bunch (OPEFB) as LCM in water based mud (WBM). Several important properties of WBM rheology after adding the OPEFB namely plastic viscosity, apparent viscosity, yield point and gel strength were characterized. The sizes of OPEFB added into the WBM were 150μm, 250μm, 500μm and 1000μm while the concentration of OPEFB used were 5g, 10g, 15g and 20g in 350 mL of WBM. Results indicated that the plastic viscosity and apparent viscosity increased with increasing of the OPEFB concentrations. On the other hand, the plastic viscosity and apparent viscosity decreased with increasing sizes of OPEFB. Yield point increased as the concentration and size of OPEFB increases. This study indicated that OPEFB was effective to be used as LCM for size of 150μm and concentration of 15g whereby it produced least amount of filtrate volume as well as good control in mud rheology.

1. Introduction

Lost circulation is the most troublesome problem in drilling process. It can occur when the drilling fluid losses into the formation instead of returning to the annulus [1][2][3]. It also can occur when the size of pore opening are larger than size of the solid particles in drilling fluid [4]. Lost circulation still can occur even with the best drilling practices. However, lost circulation can be reduced by adding lost circulation material (LCM) in drilling fluid that help to accelerate the formation of filter cake and therefore control the overflow of drilling fluid into the formation pores [5]. The LCM will form of a filter cake, which bridges the formation face to stabilize the wellbore [6]. There are 4 types of LCM which are fiber, flake, granular and blend of fiber, flakes and granular [1]. This research will focus on fiber types of LCM which is OPEFB. There are a few researchers have done the research using fiber types of LCM such as lemongrass and saw dust [6,10]. The smaller particle size of lemongrass forms lower filtrate volume of drilling fluid and thin filter cake when compared to drilling fluid with larger particles [8,9]. The smaller size of sawdust give least mud cake thickness but the bigger size of sawdust gives lowest filtration volume [10].

OPEFB is a by-product of the palm oil industry and is the residual bunch after removal of the fruits [11][13-15]. It is the easiest and cheapest lignocellulose resources that can be found in oil palm biomass [16][17]. Approximately fifteen million tons of OPEFB biomass waste is generated annually throughout Malaysia by palm oil mills. The waste is being discarded in open areas or burnt in incinerators which create environmental pollution problems in nearby localities by generating large quantity of solid waste and pollutant gases [11][12]. In a way to save environment, this research will evaluate the feasibility of using OPEFB as LCM additive in water based mud and the effects of its size and concentration will also be investigated.

2. Methodology

2.1. Preparation of Oil Palm Empty Fruit Bunch (OPEFB) Fiber as LCM
The fresh OPEFB sample was pre-treated by drying in the oven at 40˚C for 5 days to achieve equilibrium moisture content of below than 5 wt%. High moisture content of fresh OPEFB (±29 wt%) will affect the rheology of mud system [20]. Prior to addition in water based mud, the dried OPEFB sample was grounded using cutting mill and sieved to obtain the size range of 150μm, 250μm, 500μm and 1000μm.

2.2. Preparation of Water Based Mud as drilling fluid.
The formulation of water based mud (WBM) is shown in Table 1 [18][19]. There were four variation of OPEFB amount added in the mud formulation i.e. 5g,10g, 15g, 20 g which are based on the common range of LCM in the mud formulation. 5-10g of LCM are typically added for slight losses while 10-20g of LCM are added for major losses in drilling operation [3]. The same formulation as in Table 1 was used for different sizes of the dried OPEFB LCM i.e. 150μm, 250μm, 500μm and 1000μm. Sufficient mixing time must be allowed to ensure complete hydration and shear of the specified additives in mud during circulation. Insufficient mixing time will result Barite to settle and reduce the mud rheology. Higher amount of Barite requires longer time to homogenously mix the mud.

Table 1. Formulation for Water Based Mud.

Component	Quantity	Mixing time (mixing speed)
Water	318.00 mL	3 min (low)
Na_2CO_3 or aka soda ash	0.5 g	3 min (low)
NaOH or aka caustic soda	0.25 g	3 min (low)
Starch	1 g	3 min (low)
Bentonite	12 g	5 min (low)
Barite	109.20 g	7 min (medium)
LCM (OPEFB)	5g,10g, 15g, 20 g	5 min (medium)

2.3. Determination of Water Based Mud Rheology.
The viscometer was used to calculate the plastic viscosity (PV), apparent viscosity (AV), yield point (YP) and gel strength of the water based mud sample and mud density of the WBM sample was determined by using mud balance. The equations to calculate the plastic viscosity and yield point are shown in equations (1), (2) and (3) respectively [7][20][21][22]. The rheology reading at 600 rpm and 300 rpm were taken to simulate the real mud circulation rate during drilling operation. This experiment was repeated for three times and the average readings were presented in the results.

$$\text{Plastic Viscosity (PV)} = \text{Reading at 600 rpm} - \text{Reading at 300 rpm} \quad (1)$$

$$\text{Apparent Viscosity (AV)} = \frac{\text{Reading at 600 rpm}}{2} \quad (2)$$

$$\text{Yield Point (YP)} = \text{reading at 300 rpm} - \text{PV} \quad (3)$$

2.4. Determination of filtrate volume and mud cake thickness.
Low Pressure Low Temperature (LPLT) filter press was used to measure the filtrate volume under static conditions. The cell was filled with the samples up to approximately 3/4 inches height. The LPLT filtration was conducted at room temperature and at 100 psi for 30 minutes [6][7]. The readings were repeated for three times and the average readings were presented in the results.

3. Results and Discussion

3.1. Influence of OPEFB on rheological properties of water based mud.

OPEFB was added into WBM at different concentrations (5, 10, 15 and 20 g) and the experimental results were shown in Figure 1. According to previous literatures, AV reflects the flowability of drilling fluids and is related to rate of penetration, and PV is part of resistance to flow caused by the friction between the suspended particles and influenced by the viscosity of the base liquid [23]. As observed in Figure 1, AV and PV values increased when the concentration of OPEFB was increasing. This is due to the increment of solid content in drilling mud that increased the frictional force between the suspended particles. In contrast, AV and PV values decreased with the increasing size of OPEFB. It is expected that the reduction of OPEFB size could increase the surface area which increase the frictional drag and viscosity of mud as shown in 150μm-sized OPEFB. The findings are consistent with N.A. Ghazali [20] whereby both concentration and size of the solid particles will affect the mechanical friction and viscosity of mud.

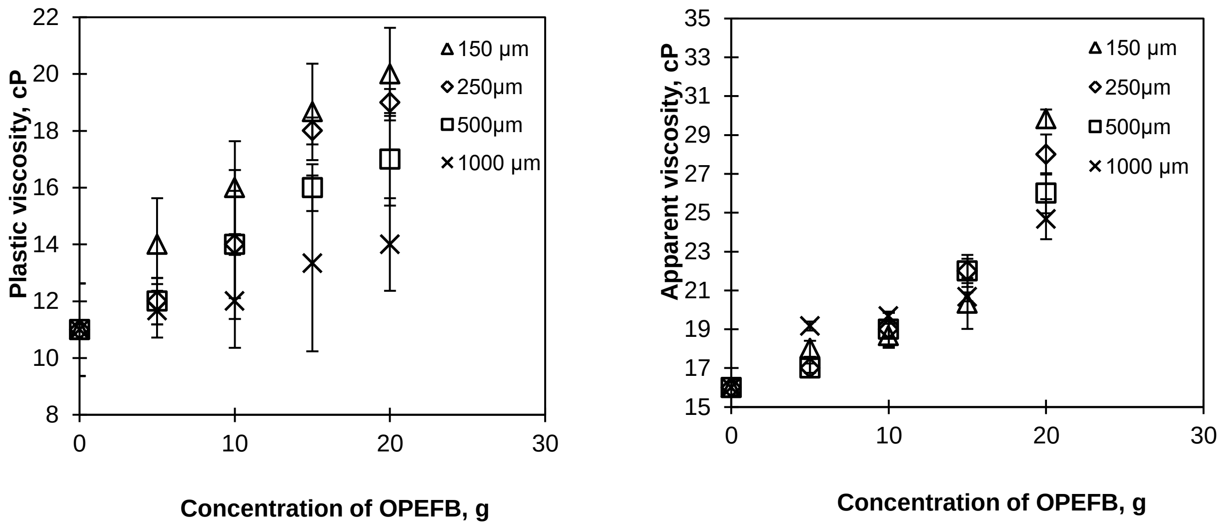

Figure 1. Plastic Viscosity (PV) and Apparent Viscosity (AV) Analysis of WBM at different concentration and size of OPEFB

Yield point is an important rheological parameter for drilling fluids and reflects the resistance to initial flow or the stress required to initiate fluid movement. Figure 2 revealed that YP goes up as the concentration and size of OPEFB increase. This is because the yield point is influenced by the concentration of solid in mud. Type and amount of solids in the mud alters the mechanical iteration and therefore influence the yield point of the mud [25]. However, the trend progresively increased at 20g concentration due to coagulation and flocculation of OPEFB particles especially for finer particles. It can be postulated that the positively charged OPEFB which is a fibrous material absorbed water around the particles and decrease the distance between the charges on the particles and increase coagulation and flocculation process.

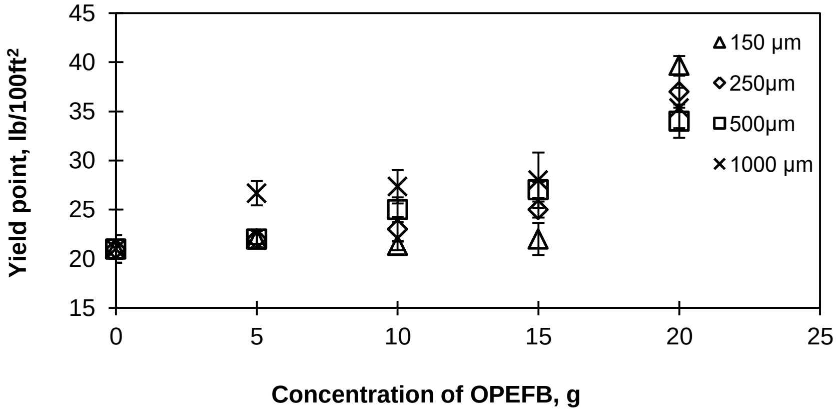

Figure 2. Yield point of WBM at different concentration and size of OPEFB

Gel strength is also an important property in drilling mud and indicates the ability of drilling fluid to suspend drill cutting. It measures the attractive forces of mud particles under static conditions for 10 seconds and 10 minutes [20]. Figure 3 shows the gel strength is increased when the concentration and size of OPEFB increased. The gel strength is increased simultaneously with the increasing of mud viscosity as the viscosity gives major relation to the value of gel strength theoretically [24]. A reasonable gel strength is vital to prevent immediate settling of solids when circulation has stopped. The findings revealed that there are no significant difference of the gel strength values for 10 sec and 10 min (overall data show less than 50% difference). This indicate no on-going build up process that might occur during re-circulation process of OPEFB-mud. However, a precaution need to be done for high concentration of OPEFB (20g) as the production of high gel strength (35-40 lb/100 ft^2) may retard separation process of cuttings and requires high pumping pressure to break the circulation.

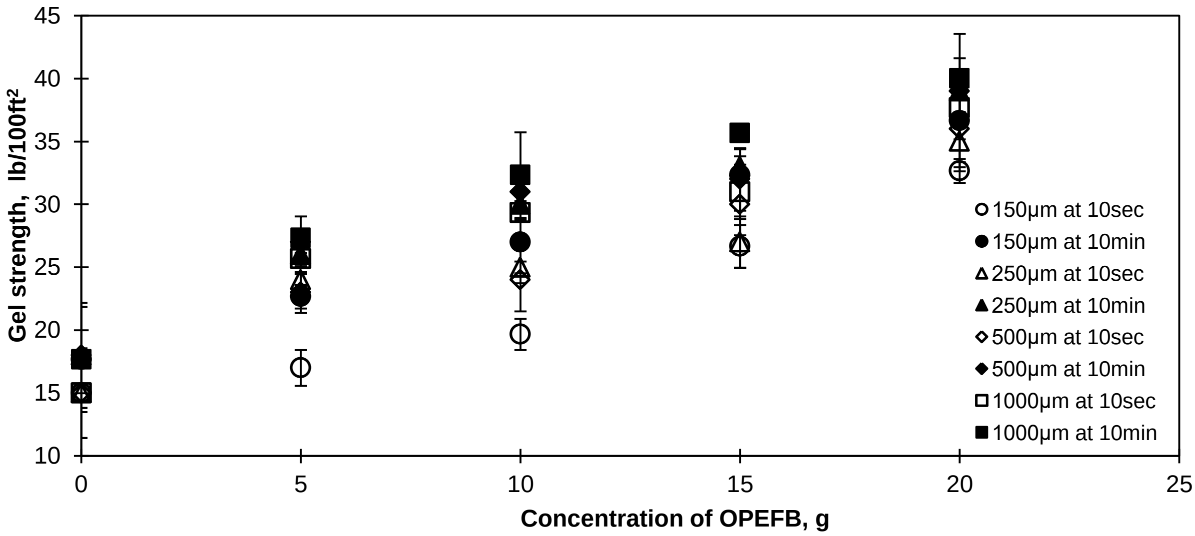

Figure 3. Gel strength of WBM at different concentration and size of OPEFB

3.2 Influence of OPEFB on filtration loss of water based mud.

The filtration loss and mud cake thickness of OPEFB-WBM are shown in Figure 4. The filtration loss is decreases when the concentration of OPEFB increased while the filter cake thickness is increased when the concentration of OPEFB increases. It shows that the OPEFB particles have filled the pore spaces and formed a thicker mud cake and prevent the fluid loss from passing through the filter paper. A good drilling mud is typically produced filter cake with a thickness of less than 3 mm. However, higher particle size of OPEFB is adversely influence the filter cake forming process, causing increased in mud cake thickness. It is advisable not to use 20g of OPEFB as it will increase the mud cake thickness more than 3mm from the based mud. This may lead to potential pipe sticking in later drilling operation. The 15g concentration of 150 µm and 250 µm sizes of OPEFB can reduce the filtrate volume up to 32% and increase the mud thickness about 3 mm from the based mud which can be considered as a fair limit.

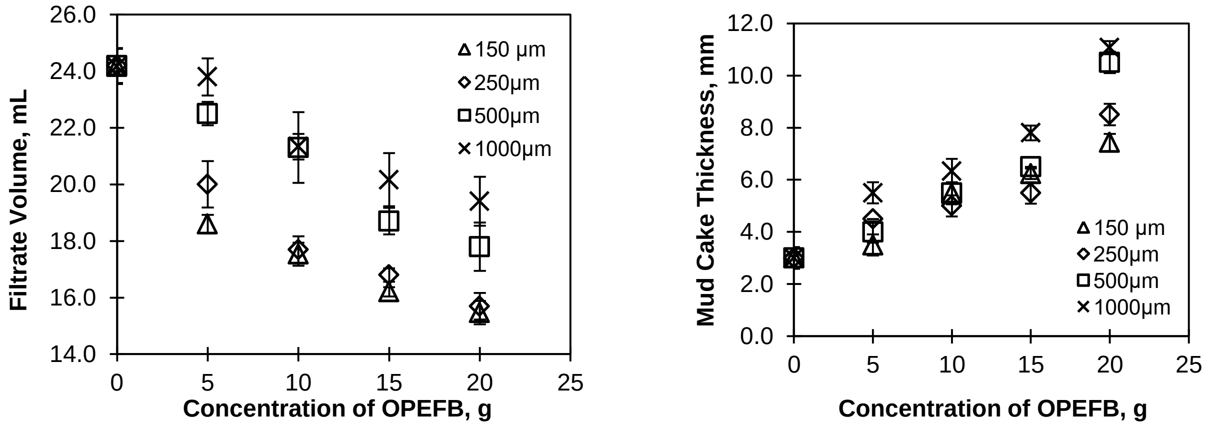

Figure 4. Filtrate analysis of WBM at different concentration and size of OPEFB

4. Conclusion

It can be generally concluded that the addition of OPEFB into the mud could improve the rheology and filtration properties of water based mud. However, proper selection of its size and concentration is vital to fit the condition of drilling operation. OPEFB is suitable to be used as LCM in WBM as it can reduce the filtrate volume and plug the the pore spaces of the formation by having thicker mud cake.

Acknowledgment

The authors would like to thank Universiti Teknologi MARA for the financial support through the ARAS Grant: 600-RMI/DANA 5/3/ARAS (37/2015), LESTARI Grant: 600-IRMI/DANA 5/3/LESTARI (0028/2016), FRGS Grant: 600-RMI/FRGS 5/3 (98/2015) and 600-RMI/RAGS 5/3 (60/2012)

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