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Natural fibre in improving rheology of drilling fluid: A review

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Abstract

Drilling phase is one of important phase in development plan to avoid unintended loss such as loss circulation. Loss circulation can cause drilling downtime, affected the formation condition and most probably the cost of drilling program. To overcome these problems, one of the alternatives is by adding fluid loss additive (LCM). Somehow, the conventional additive such Polyanionic-Cellulose (PAC) are mostly the first choice as LCM to curb the loss circulation problem, but other problem arises such as environmental pollution due to unfriendly additive. Hence, many research has study the alternative way to replace conventional additive. Hence this paper objective is to analyse on the natural fibre as the potential additive to reduce the loss circulation problem and suggest any improvement that can be done to the studies. From the analysis, the natural fibre has huge impact on the drilling fluid rheology and other properties. Most of the natural fibre can surpass the value of rheology properties in plastic viscosity, yield point and gel strength with certain value or size of material that indicate as concentration. Also, natural fibre modification on drilling fluid gives a big impact in fluid loss control.

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1.0 Introduction

Referring to the standard petroleum development operation, drilling program is one of the main crucial parts in oil and gas industry especially at the early phase of well development. Fluid loss control is one of the important elements in water-based mud which can affect drilling performance (Guo et al., 2014). Drilling phase consumed millions of dollars for development project in oil and gas industry for every year. The project would need to stop the drilling process if anything happened such as drill bit stuck due to no circulation of drilling fluid to bring the cutting up to the surface. This problem can also lead to blowout of well where the well need to be plug and abandon which can cause millions dollar of the process (Ganesh et al., 2019). For example, happened in Gulf of Mexico Region where the drilling crew run cementing operations and unfortunately, the cement was not circulating to the surface for 5 minutes and suddenly the well vented fluid from the intermediate casing to the top surface casing (Shelf, 2000). Basically, the main cause of loss circulation is the formation condition. If the formation is porous, it can trigger the drilling fluid to flow into the formation instead circulate to the surface. In this case, the researcher has come out one theory to counter this loss issue which is by using fluid loss additive in drilling fluid such as chemical additive, polyanionic-cellulose (PAC) or carboxymethyl cellulose (CMC). Somehow, other issues are pop up from the mixture of drilling fluid with the chemical additive such as environmental pollution toward sea water when discharge drilling waste if not meet certain criteria, high cost for drilling program and the availability of the fluid loss agents. The impact of sea water pollution can harm Marine life and coastal societies whose economies are based on fishing and tourism. Therefore, finding of suitable materials or substances that can replace the chemical additives but with the same function as fluid loss additive. Nowadays, Natural fibre has been study by many researchers as an alternative additive to replace conventional LCM. As example kenaf, oil palm trunk (OPT) and corncobs been studies to look at the improvement of rheological properties and fluid loss control. This study will review types of natural fibre that have been study as fluid loss agents.

Kenaf plant is known as *Hibiscus Cannabinus* L. where it was believed that came from sub-Saharan Africa where proved by its tameness in Sudan region during 4000 B.C. Kenaf fibre is low cost as raw material and as other possibility in textile, particleboard, fibreboard and fuel industries (Ayadi et al., 2017). Kenaf stem contains two types of fibres, which are bast fibre and core fibre as looking at outer and inner skin of kenaf stem respectively (Hui, 2019). The kenaf consists by weight of the stalk of the kenaf of 35-40% bast fibre and 60-65% core fibre (Sameni et al., 2003).

Palm trees are readily available in most Asian countries and in Malaysia, the oil palm plantation area is approximately 3.87 million hectares and there would be millions of tons of bio-waste produced annually. Palm tree has many parts that is very useable such as oil palm trunk (OPT). 40% of OPT was used by oil palm-based plywood manufacturers, while the other 60% of OPT was discarded as waste or residual. Holocellulose and lignin are the key components of oil palm biomass (OPB) material, which are roughly 70-80% and 17-25%, respectively (Sauki et al., 2020). Oil palm trunk fibre is ideal for reinforcing in construction industry (Abdullah et al., 2013).

Millions of corncobs amount production every year as for food industry but there also defect where main problems of producing corncobs is it waste. This is because after its maturity, about 60% of maize is nutritious, while the remaining 40% has turned into waste (Lee et al., 2019). Some of agro wastes like corncobs have many uses as its potential properties in building and construction as component in concrete (Olutoge & Obakin, 2017).

2.0 Natural fibre in drilling fluid

Natural fibre is known as fibrous material that has high hydrophilic characteristics where that could cause error data collection. Hence, the preparation for natural fibre includes sourcing, cleaning, drying and grinding (Onuh et al., 2017). These four steps for preparing natural fibre as fluid loss agent is the basic method that have significantly low possibility of data error due to material preparation. Somehow, some studies skipped the cleaning part for natural fibre preparation as to observe the effectiveness of the natural fibre in controlling fluid loss such as for the untreated and treated natural fibre (Majid et al., 2019).

2.1 Rheology properties

In most of the recent studies, rheological test is one of the tests that is crucial in supporting the filtration data as to cater and compare the modification of drilling fluid on it properties changes. Roughly go through a few recent experimental study articles, the addition or modification of natural fibre in drilling fluid has big impact on its rheological properties than standard rheological properties. Table 1 shows a few recent studies on natural fibre in drilling fluid as modification material. First of all, there are a few types of natural fibre that have been categories and sources from vegetables and animal origin (Singh Dhaliwal, 2020). In the simple term, there are categories as natural cellulosic (cotton, jute, sisal, coir, flax, hemp, abaca, ramie, etc.), protein-based fibre (wool and silk), manmade cellulose fibre (viscose rayon and cellulose acetate) and from pulped wood or other resources (cotton and bamboo). These natural fibres are mostly being studied to be use in drilling program as additives and the rheological properties for each natural fibre addition have shown a better result in plastic viscosity, yield point and gel strength of the drilling mud sample.

Hussein et al. (2018) study on kenaf fibre as additives in drilling fluid of WBM. This paper makes a comparison with commercial additives, poly-anionic cellulose (PAC) as to investigate the effectiveness of kenaf fibre as fluid loss additives. The concentration that been manipulated for both material is the volume of the material which are 2 and 4 g for each material. Kenaf fibre alone as additive has low rheological properties than PAC but when the kenaf fibre mix with PAC (2 g PAC + 2 g kenaf), the rheological have better result where the result is in range of standard API (Hussein et al., 2018).

Sauki et al. (2020) tested on OPT fibres as additives to control the fluid loss of WBM. This study is using different volume (2, 4 and 6 g) of OPT fibre as to compare the concentration of the additives in the drilling fluid. The trend of plastic viscosity, yield point and gel strength is slightly increase as the concentration of OPT fibre is increasing which shows that the higher the concentration of OPT fibre, give higher rheological properties (Sauki et al., 2020).

Gunnasegaran (2011) investigated the effect of pineapple peel as lost circulation material (LCM) in WBM. The researcher compared the pineapple peel additives with nut plug as to evaluate the effectiveness

Table 1: Reported type of natural fibre used in drilling fluids and their rheology properties change.

Author (s)	Natural Fibre	Based fluid	Rheology properties	Result summary
Hussein et al., (2018)	Kenaf	WBM	Plastic viscosity, yield point, gel strength	• PAC additive alone have better rheology properties than kenaf. • The mixture of 2 g kenaf and 2 g PAC produce the higher rheology properties
Sauki et al., (2020)	Oil palm trunk	WBM	Plastic viscosity, yield point, gel strength	• The increasing amount of OPT in the drilling mud caused the rheology properties also increasing such as plastic viscosity from 15 to 20 cP.
Gunnasegaran, (2011)	Pineapple peel	WBM	Plastic viscosity, yield Point, gel strength	• Plastic viscosity increasing as concentration pineapple peel increase • Yield point decrease as concentration pineapple peel increase (human error or pineapple peel certain effect that reduce the attraction force between solid particles). • Gel strength decrease as pineapple peel concentration increase
Dagde & Nmegbu, (2014)	Groundnut husk	WBM	Plastic viscosity, yield point, gel strength	• 4 g Groundnut husk sample mud shows the nearest similarity in rheology properties to 2 g PAC mud sample that represent as standard mud formulated. • The deviation value for 4g Groundnut husk to 2 g PAC is only 0.02 % for 30 minutes reading.
Ganesh et al., (2019)	Coconut fibre, pine leaf fibre & bagasse fibre	WBM	Plastic viscosity, yield point, gel strength	• Actual result on rheology test is not shown on the report of the study but based on the result of filtration loss, shows that the natural fibre of coconut, pine leaf and bagasse fibre have potential in enhance the value of rheology properties as the value of fluid loss decreasing as the concentration of natural fibre increasing.
Nmegbu & Bari-Agara, (2014)	Corncobs	WBM	Plastic viscosity, yield point, gel strength	• The standard mud sample with 2 g PAC additive shows great result in rheological properties. • The increasing concentration of corncobs attribute in increasing the value of rheology properties.
Majid et al., (2019)	Durian rind	WBM	Plastic viscosity, yield point, gel strength	• The untreated durian rind has better result of rheological properties due to unremoved of pectin. • Solvent of NaOH shows the great result in extracting pectin from durian rind. • The treated durian rind has better thermal stability than untreated which can be use as LCM at high temperature environment. • The treated durian rind result in increasing of surface roughness of the material as improved the physical and mechanical properties which is interfacial shear strength where that is good used as LCM.
Azizi et al., (2013)	Agarwood	WBM	Plastic viscosity, gel strength, yield point	• The present of 6 g agarwood in the drilling mud have improved the rheological properties from 6 g bentonite as based formulation and 6 g starch addition formulation.
Idress & Hasan, (2020)	Orange peel & sunflower seed	WBM	Gel strength, plastic viscosity, yield point	• Plastic viscosity (PV) for orange peel result is 18 cP at 4% concentration of fine particle which same goes to Sunflower seed highest PV is 19 cP at same concentration and size. • Different with gel strength properties where both of material have high result at coarse size particle with 4% concentration but compare between both material, Sunflower seed is much higher gel strength than orange peel.
Salmachi et al., (2016)	Psyllium husk	WBM	Plastic viscosity, yield point, gel strength	• The increment of psyllium husk concentration in the drilling fluid, result in increment of rheological properties where at 1% weight of psyllium husk surpass the based bentonite mud.
Ismail et al., (2020)	Henna leaf & hibiscus leaf		Plastic viscosity, yield point, gel strength	• Rheological properties for both green material shows better result as it will increase as increase in green material concentration.

of the natural fibre. The concentration evaluated were 5 and 10 g for each LCM. This study shows that the increasing of concentration LCM resulted in better rheological properties, however, the nut plug LCM have better rheological properties than pineapple peel LCM such as in plastic viscosity. Besides that, for other gel strength and yield point properties, pineapple peel LCM has better result which are higher than nut plug LCM (Gunnasegaran, 2011).

Dagde & Nmegbu, (2014) study on groundnut husk as LCM in WBM that have comparison with commercial additive which is PAC. The concentration that being manipulated is the volume of Groundnut husk which is 2 and 4 g compare with 2 g PAC. The result shows that commercial additive has higher rheological properties than groundnut husk but somehow, the trend is quite same as the concentration increase, the rheological properties will also increase.

Onuh et al. (2017) were investigated two natural fibres in one article and the comparison is between both of material and combination of both materials as to evaluate the different effectiveness. The concentration for both material is 2, 4, 6, 8 and 10 g, and also for combination of both materials. From the paper, the result for rheological properties were not shown but as to evaluate from the fluid loss, the combination has lower fluid loss than other sample which make that the combination of both materials can be better LCM but as one material alone, corncobs has lower fluid loss than coconut shell. This shows that corncobs is probably much better in rheology test than coconut shell (Onuh et al., 2017).

Next is from Ganesh et al., (2019) who study a few natural fibres as additive in drilling fluid for fluid loss test. The natural fibre that been tested in water based mud are coconut, pine leaf and bagasse fibre. This paper compares the rheology properties for each natural fibre among each other as to evaluate which natural fibre is much better with same volume of concentration (30 and 40 ppb). Somehow, this paper does not show a detail result from the rheological test but from bridging test, that can conclude the bagasse have better bridging strength which in theoretically, material that can withstand the bridging stand up till 500 psi is have the great rheology properties. In this case, bagasse fibre have better result of rheology properties followed with coconut fibre and pine leaf fibre (Ganesh et al., 2019).

Nmegbu & Bari-Agara, (2014) the second researcher who interest in study corncobs as natural fibre in water-based mud that used as LCM. As to observe the effectiveness of corncobs in drilling fluid, the study was compared with commercial additives which is PAC. The concentration of corncobs used is 2 and 3 g that was compared with 2 g of PAC. The rheology properties for corncobs sample mud is low than PAC sample mud (Nmegbu & Bari-Agara, 2014).

Majid et al. (2019) investigated on durian rind fibre as LCM in water-based mud as in this paper will compare the rheology properties with treated and untreated durian rind but with the standard based mud as benchmark of the study. The rheological result for treated and untreated durian rind have significantly differences where the untreated have much better result of rheology properties with different size of the material. The fine particle has higher value of plastic viscosity, gel strength and yield point and slightly reduce with increasing size particle which same goes with volume of the material added in mud sample. The untreated durian rind has smooth result than treated durian rind. This is because of pectin have been removed that caused the gel is absence and release the durian rind particle (Majid et al., 2019).

Azizi et al. (2013) studied on agarwood fibre as additives in water-based mud that will be compared with conventional additives, starch. The concentration of agarwood was manipulated where the size was used is 45 and 90 microns. This size was mixed together with certain percentage but with same volume used. The result shows that the sample with agarwood have high plastic viscosity and yield point than conventional additives (Azizi et al., 2013).

Idress & Hasan (2020) investigated sunflower seed and orange peel as LCM in water based mud and the result were compared between each mud sample of sunflower seed and orange peel. The concentration was manipulated is the size particle (fine, medium, coarse and fine and medium) with increasing of material volume (0.8, 1.3, 2.2, 2.7 and 4.0%). The increasing in volume of material shows the increasing of rheology properties. Different with size particle where the fine size has higher value of rheology properties and decreasing with increasing size particle. The combination of medium and fine particle shows the highest result from fine particle (Idress & Hasan, 2020).

Salmachi et al., (2016) study on psyllium husk as fluid loss additives in water based mud and was compared with based mud where the based mud is bentonite additives. The concentration of psyllium husk that being manipulated was the volume of the material (0.25, 0.5, 0.75 and 1%). The rheology properties show significantly increase as increasing in concentration of psyllium husk volume. The concentration at 0.75% shows the result that is acceptable in range but still low than bentonite based mud. Mud sample at 1% of psyllium husk has surpass the rheology value of bentonite based mud (Salmachi et al., 2016).

Ismail et al. (2020) study was quite different from other paper of fibre material where this paper was used henna leaf and hibiscus leaf as LCM in water based mud. This paper also used PAC additives as based mud sample for comparison purposes. The concentration that being manipulated was the volume of the material (10, 20, 30, and 40 g). Based on the result of rheology properties test, henna leaf has low value of plastic viscosity, yield point and gel strength than hibiscus leaf. Somehow, the PAC additives sample has higher value of plastic viscosity, yield point and gel strength than hibiscus leaf (Ismail et al., 2020).

2.2 Fluid loss properties

Recent study on evaluating filtration loss are using HPHT or LPLT filter press with certain temperature and pressure that will be compare with based mud or each other material with different concentration of material used. The fluid loss determination is based on the volume of fluid that being collected after the pressure being applied for a few minutes to the mud samples. The acceptable fluid loss (approximate 5 mL) is determined by the thickness of the mud cake (approximate 2 mm) where some of the mud sample will have great thickness but low fluid loss. This can cause drill bit stuck during drilling due to thickness of mud cake. Hence, the acceptable is where the mud cake acceptable range or could say thinnest mud cake with low fluid loss is greatest mud sample.

Based on Hussein et al. (2018), the natural fibre is kenaf that compare with PAC as commercial additives as LCM. The result for kenaf fibre alone were high of fluid loss than PAC but when combination of kenaf fibre and PAC give a great impact on controlling fluid loss. This is because kenaf fibre still has no water absorption and does not swell as much as PAC. When mixed both material together, the filtration of fluid loss was reduced up till 0 mL as using HPHT and 7 mL for API filter press (Hussein et al., 2018).

Sauki et al. (2020) investigated on OPT with two different methods to observe the effectiveness of controlling fluid loss which is the volume of the OPT and the size of the OPT. The increasing of OPT amount causing the fluid loss reducing. This is because thickness of the mud cake increasing from 0.5 to 0.79 mm but still within the range 2 mm. On the other hand, the size particle decreasing will fill in the gap between filter cake which make the fluid loss volume reducing from 6.5 to 5.2 mL (Sauki et al., 2020).

Agwu et al., (2019) studied on saw dust and rice husk as fluid loss additives. The concentration was manipulated by the volume added in the mud sample. The result was still give a same trend where the increasing of material volume will reduce the volume of fluid loss. Rice husk has high filtration control than Saw dust of 0.02 kg amount of each material produce 13 and 16 mL of fluid loss respectively. Somehow, the increasing amount of rice husk and saw dust will cause the increase the thickness of the mud cake where at 0.02 kg, saw dust is 3.3 mm and rice husk is 3.8 mm. Based on the acceptable range, the thickness for saw dust and rice husk at 0.02 kg is within acceptable range (Agwu et al., 2019).

Gunnasegaran, (2011) used pineapple peel as LCM in water-based mud where the study was focused on the amount of the material. The result of filtration test from this paper was same trend by using API filter press where the volume of the fluid loss decreasing as the amount of pineapple peel increasing. The filtration increasing about 20.6% where the thickness of mud cake also increasing as the amount of material increasing about 13.6% (Gunnasegaran, 2011).

Dagde & Nmegbu (2014) studied on groundnut husk as fluid loss agent in order to determine the effectiveness of this material in controlling fluid loss. The result from API filter press shows that groundnut husk with 4 g volume in mud sample have similarity to commercial mud sample, PAC even after reach 20min the volume was reduced about 5% from PAC mud sample. At the end of 30min test, the fluid loss for groundnut husk is lower than PAC mud sample (Dagde & Nmegbu, 2014).

Onuh et al., (2017) evaluated the filtration test on water based mud with natural fibre additives as LCM which are coconut shell and corncobs. The equipment used is LPLT filter press. The concentration manipulated as stated in rheological test. Individually,

Table 2: Reported type of natural fibre used in drilling fluids and fluid loss property

Author (s)	Natural Fibre	Bases Fluid	Result Summary
Hussein et al., (2018)	Kenaf	WBM	• Fluid loss for kenaf concentration is higher than PAC at 2 g for API LPLT filter press and 4 g for HPHT filter press. • The mixture of 2 g PAC and 2 g kenaf has lowest fluid loss.
Sauki et al., (2020)	Oil palm trunk	WBM	• OPT fibre with size of 75 – 150 μm reduced fluid loss from 6.5 mL to 5 mL. • The increasing concentration of OPT also effect in reduction of fluid loss.
Agwu et al., (2019)	Rice husk & saw dust	WBM	• Rice husk and saw dust has lower mud loss than PAC after 0.01 and 0.015 kg of concentration respectively. • Rice husk has smooth texture mud than saw dust which good for preventing differential pipe sticking. • Spurt volume decreasing as the concentration for both increasing and at 0.02 kg for both cellulosic materials, the spurt volume is at same value. • Mud cake thickness for both materials not met API standard.
Gunnasegaran, (2011)	Pineapple peel	WBM	• Amount of filtrate decrease as LCM concentration increase (due to viscosity increase) • Mud cake thickness decrease as the concentration of LCM increase.
Dagde & Nmegbu, (2014)	Ground nut husk	WBM	• The volume of fluid loss for ground nut husk formulation is slightly higher than based mud formulated at 5 minutes measurement but rapidly decrease as the time of measurement increase where lower than based mud formulated.
Onuh et al., (2017)	Coconut shell & corncobs	WBM	• By individually, the corncobs has lower fluid loss than Coconut shell. • If combine both materials, the fluid loss shows the lowest fluid loss.
Ganesh et al., (2019)	Coconut fibre, pine leaf fibre & bagasse fibre	WBM	• Bagasse fibre shows low fluid loss and higher bridging capacity at lower concentration. • Coconut shell have capability to seal the wells with lesser pore size without problems. • Pine leaf fibre could not fully success seal the well because of its characteristics of fragility. • Bagasse fibre have less density can give better sealing capability.
Nmegbu & Bari-Agara, (2014)	Corncobs	WBM	• Corncobs additives have low fluid loss test than PAC which is preferred as fluid loss agents.
Majid et al., (2019)	Durian rind	WBM	• Fluid loss for untreated durian rind has smooth result where the fluid loss decreases with the concentration increase for each material size. • Unlike treated durian rind where the result was disrupted by pectin-less in the materials. • The best size for fluid loss is intermediate size with 20 ppb concentration.
Azizi et al., (2013)	Agarwood	WBM	• By adding agarwood in drilling mud, the fluid loss can be reducing but still high than starch material. • As for sizing comparison between agarwood in drilling fluid, the fluid loss for 50% 45 micron and 50% of 90 micron has the lowest than other size composition but still high than starch material.
Idress & Hasan, (2020)	Orange peel & sunflower seed	WBM	• Fluid loss for combination of fine and medium particle for both materials, give a better result than one size composition of LCM. • Sunflower seed result of fluid loss for combination particle size is the lowest than orange peel.
Salmachi et al., (2016)	Psyllium husk	WBM	• Psyllium husk concentration at 0.75% and 1% in drilling fluid has low fluid loss than based bentonite mud.
Ismail et al., (2020)	Henna leaf & hibiscus leaf	WBM	• Fluid loss of henna leaf and hibiscus leaf at concentration 1.0 and 2.0 g is still high than PAC-LV additives in drilling fluid but the thickness of mud cake is lower than PAC-LV for both concentrations.

corncobs have better fluid loss control than coconut shell but the combination of both materials have much lower fluid loss (Onuh et al., 2017) . Comparing to Ganesh et al. (2019), who studied coconut fibre, pine leaf fibre and bagasse fibre as LCM, the test was quite different where the filtration loss was determined by using bridging machine. Bridging machine was used to determine the capability of the mud to sustain at certain pressure and at the same time can collect data about the fluid loss of the mud. The pressure started at 50 psi and increase 50 psi for 30 minutes until the pressure become 500 psi. Coconut fibre shows the capability in sealing the wells with small pore size. Somehow, the ranking of highest capability in sealing the wells start from bagasse follow with coconut and lastly pine leaf fibre. Hence, the fluid loss for bagasse is lower than coconut and pine leaf fibre (Ganesh et al., 2019). Coconut fibre still shows better result in controlling fluid loss and further info in sealing the wells with low pore size well condition.

Nmegbu & Bari-Agara (2014) investigated corncobs as LCM in water-based mud that compared with PAC additives. PAC is well known as commercial additives. The result for rheology shows that corncobs have low rheological properties than PAC but fluid loss control for corncobs is much high capability than PAC where the volume loss is low than PAC. The volume of fluid loss decreasing as the concentration decreasing (Nmegbu & Bari-Agara, 2014). This proved that corncobs have capability in controlling fluid loss even the rheology properties are still high than commercial additive mud. Onuh et al., (2017) also proved that corncobs have lower fluid loss than coconut shell.

Majid et al., (2019) studied was a bit different where the natural fibre that being studied is durian rind which the comparison is based on the treated and untreated durian rind. The water-based mud formulation was the mud sample to be used to determine the filtration loss. The concentration also being manipulated as to determine the suitable volume and particle size for fluid loss agent of durian rind in water-based mud. The trend for untreated fluid loss of durian rind is smoother than treated durian rind. This is because of the pectin and pores in the durian rind. The higher volume of durian rind has higher ability to control fluid loss which different with particle size where the smallest size particle has much lower fluid loss. The untreated durian rind has lower fluid loss than treated durian.

Azizi et al. (2013) studied on waste natural fibre which is agarwood that act as LCM in water-based mud and compared the capability with starch as commercial additive of loss circulation. Based on the concentration and particle size that been said in rheology test, agarwood has better in rheology test but somehow the filtration test for starch additive is lower of fluid loss than agarwood additive. Nevertheless, the particle size combination of 45 micron 50% and 90 micron 50% has the nearest to the starch additive fluid loss. This shows that if the volume of agarwood increase could surpass the starch additive.

Referring to Idress & Hasan (2020) that worked on orange peel and sunflower seed for filtration test where the concentration being manipulated were particle size and amount of both materials. The equipment that been used to tested the filtration test is API filter press at 100 psi. The result was compared between both natural materials. The fluid loss for both materials were managed to get low as the concentration increased. Different with sizing where the size of material increase, the control efficiency is reducing where the fluid loss is higher than fine grain. Somehow, the combination of fine and medium shows the lowest fluid loss than other size.

Salmachi et al. (2016) studied on psyllium husk where the filtration test was used API filter press with 100 psi for 30 minutes. The result was compared with bentonite-based mud. The result shows that the same trend where the concentration increasing has lower fluid loss. Psyllium husk has lower fluid loss than bentonite-based mud. The high viscosity produced by psyllium husk prevents mud from flowing through the filter paper.

Study by Ismail et al. (2020) was a bit different as stated before, where the material used as LCM is not much of a fibrous material. As previously mentioned, the material used were henna leaf and hibiscus leaf. API and HPHT filter press were the equipment used at 100 and 500 psi, respectively. HPHT shows the fluid loss was a bit higher than API due to value of pressure applied. Hibiscus leaf has more strength to control the filtration loss compared to henna leaf but still higher than commercial additives of PAC of low viscosity. Somehow, the mud cake thickness is less than PAC low viscosity.

3.0 Conclusion

This review reports the use of natural fibre in drilling fluid especially in water-based mud. It presents that most of the natural fibre tested can improve the rheology properties and also the fluid loss. Some conclusions can be drawn:

- Most all-natural fibre act as LCM in drilling fluid had huge improvement in rheology properties and fluid loss control.
- Most of the natural fibre that being studied can surpass the value of rheology properties in plastic viscosity, yield point and gel strength that being used by industry as commercial additives with certain value or size.
- The filtration test was observed that natural fibre modification on drilling fluid give a big impact in fluid loss control.
- Some of the natural fibre have high fluid loss that are not suitable to be used in drilling fluid formulation.
- Suggestion on modification such as combination of particle size, combination with some of conventional additive, the amount of LCM and the condition of the LCM.
- The addition of natural fibre in drilling fluid also give impact on mud cake characteristics where it could improve the sticking coefficient.

On the other hand, some further study can be conducted to overcome natural fibre weakness such as, combine with one or more type of natural fibre and different type of particle size. Lastly, usage of natural fibre can also be evaluate using other based mud such as oil-based mud.

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