

Feasibility study of kenaf as fluid loss additive in water-based mud

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Abstract. Fluid loss is one of the problems encountered when drilling oil and gas wells. It may occur at any depth when the hydrostatic pressure exerted the formation exceeds the formation pressure at porous and permeable zones. Reducing the fluid loss is essential in drilling operation in order to maintain the mud properties. Mud added fluid loss additives will also trigger the changes in other mud properties. The objective of this research is to study the potential of kenaf as fluid loss additive as an alternative to commercial additives available in the market. Kenaf is a fibrous material which derived from plant and environmentally friendly. Laboratory studies were conducted to compare the rheological performance of mud at different concentrations and conditions. The results revealed that the commercial additive (PAC) performed better than kenaf as fluid loss additive. However, better results were achieved when both kenaf and PAC were mixed together at certain proportions. The results of API filtration test showed that the minimum fluid loss achieved was 7 ml. However, HPHT filtration test recorded a very small amount fluid loss.

1. Introduction

Drilling operation is one of the most important stages of hydrocarbon recovery process from the subsurface [1, 2]. Some of the key roles of drilling fluid used in every drilling operation are to bring rock cuttings to surface, cooling the drilling bit, provides hydrostatic pressure to counter formation pressure and to suspend rock cuttings when drilling is stopped [3]. These roles of drilling fluid are unchanged regardless of type of drilling mud used; either water-based mud (WBM), oil-based mud (OBM) or synthetic-based mud (SBM).

Fluid loss is worldwide drilling problem faced by all drilling operators. Fluid loss happens when hydrostatic pressure of the mud is higher than formation pressure inside the borehole, where this is the case for overbalanced drilling. When the formation is porous and permeable, the pressure difference will cause the fluid inside the mud to flow or filtrate into the formation instead of returning to the surface.

It is merely impossible to avoid fluid loss. However, it is acceptable if fluid loss can be minimized to a certain degree, where it varies between drilling operators. Some examples of fluid loss control measures include reducing mud weight during drilling through fluid loss zones, increasing wellbore



strength and using air drilling technique. Some techniques might be classified as preventive measure and some are remedial.

Fluid loss into formation means mud invasion has occurred. The product of mud invasion into formation is mud cake. Particles or additives in the mud will be deposited onto wellbore surface at the loss zone. Mud cake is an important mud filtrate product which will help to stop further invasion which causes more fluid loss. The characteristics of materials that are added the mud will determine the two important characteristics of mud cake, which are permeability and thickness. Mud cake need to be less permeable to prevent fluid transfer and thin to avoid other problems due to formation of mud cake such as pipe sticking.

To date, poly-anionic cellulose (PAC) is the most widely used additive in drilling mud to control fluid loss [4]. Since PAC need to be imported and having high price tag, more studies are needed to substitute PAC as fluid loss additive [2, 5].

Due to the high production cost and environmental effect of chemical additives, there is a huge effort by researches to move towards environmental friendly additives. The use of biodegradable materials will also reduce its disposable cost because it can be safely disposed to the environment without the need to be treated. In addition, drilling mud additives are often not available in local industry market.

They need to be imported which leads to higher overall cost of drilling operation. Thus, the need to use local materials is seen as an important aspect to be considered when formulating additive for drilling mud [2]. In short, the potential fluid loss additive need to be biodegradable, locally available, abundance, cheaper and more efficient or comparable to PAC in terms of controlling fluid loss amount.

Kenaf is used in many mud formulations to reduce fluid loss since it is fibrous and biodegradable. There are also patents published that use kenaf as one of fibre sources as fluid loss additive [6, 7]. Furthermore, the most preferred fibrous additive by a researcher came from kenaf [8]. Kenaf is also commonly used as reinforcing agent to avoid fluid loss [9]. Kenaf is also found to be an effective additive to reduce fluid loss in both WBM and OBM [10].

In addition, kenaf is mentioned as one of the specialty products that is used to control spurt losses during drilling at Gulf of Mexico [11]. In the US, there is an additive product called DrillWall™ which is composed mainly from kenaf plant's core. Production company claims that this additive can mix with all types of drilling fluid, non-toxic, can form mud cake faster and can be used in less amount (about 7-10 lbs/bbl) for the same fluid loss results compared to other additive [12].

There are also a few more studies related to thermal degradation of kenaf fibres which suggest that kenaf fibre can be classified as thermally stable up to 300°C [13, 14]. At 250°F, untreated kenaf fibre only loose approximately 5% of its weight, mostly due to moisture evaporation. Furthermore, kenaf fibre also has high thermal stability. Azwa and Yousif (2013) reported that decomposition temperature of untreated kenaf fibre epoxy is 378.64°C [15]. In terms of kenaf plant itself, around 15-20 tons of dry kenaf can be produced by one hectare of kenaf in 120 days only. It also can absorb carbon dioxide (CO₂) more than any other crop plants and also able to remove heavy metals from soil [16]. These are superior advantages of kenaf fibre as fluid loss additive and also kenaf plant benefits to the environment.

The present study is a preliminary analysis of kenaf to see whether it can be used as fluid loss additive in WBM. Kenaf is fibrous and biodegradable. Plastic viscosity of the mud is related to friction between particles and mud, which affected the mud's ability to flow. Yield point and gel strength are important parameters when it comes to bringing cuttings to the surface and suspending them while drilling is ceased.

Fluid loss and mud cake thickness were focused parameters in this study which affect amount of fluid filtrate and will determine probability of occurrences of other problems such as pipe sticking and loss circulation. The effects of the addition of kenaf into WBM in terms of mud rheological properties were studied in this work and their interactions are detailed in this paper.

2. Materials and experimental procedures

2.1. Materials

Raw kenaf were sieved using multiple sieves of different sizes. These nested columns of sieves were placed on sieve shaker as shown in figure 1 and kenaf sample placed on the most top sieve. The shaker was operated for 40 minutes before sieved kenaf from sieves of sizes 45 μm , 75 μm and 106 μm were collected and labelled; ready to be used for experimental procedures. The kenaf of sizes above and below the range were discarded.



Figure 1. Nested columns of sieves arranged on a sieve shaker for sieving process.

2.2. Mud preparation

Water based drilling fluid was prepared based on the composition shown in table 1. The drilling fluid was weighed to achieve the density of 11 lb/gal (1.32 g/cc).

Table 1. Typical composition of water based drilling fluid that contains PAC and kenaf.

Components	Function	Amount
Distilled water	Base fluid	298 ml
Potassium chloride	Shale inhibitor	30 g
Caustic soda	pH control	0.2 g
Flowzan	Viscosifier	0.8 g
Barite	Weighting agent	127 g
PAC	Fluid loss additive	2 g
Kenaf	Fluid loss additive	2 g

Each component was added steadily into the distilled water in the order as shown in table 1, which was placed in a multi-mixer's cup. The mud was mixed using Hamilton beach mixer at the speed of 10,000 rpm. After a component was added into the mud, 5 minutes' interval was allowed before adding the next component to allow homogenous and thorough mixing of the component inside the mud. After all components were added, the mud was mixed for 30 minutes before moving to measuring its rheological properties. For this study, PAC was used as commercial additive.

The rheological properties of mud were measured using viscometer. Apart from plastic viscosity, other properties measured were yield point and gel strength. The fluid loss properties of the mud samples were evaluated by using API filter press and HPHT filter press. The data gathered in these experiments were volume of filtrate volume collected from the tests and thickness of mud cake after test period of 30 minutes. Electronic vernier calliper was used for measuring mud cake thickness. The filtration tests were conducted as per API RP 13B.

3. Results and discussions

3.1. Effect of each additive on rheology

Table 2 summarizes rheological properties of mud samples that contained different additives at different concentration of 2 grams and 4 grams. It also shows typical rheological properties of a mud.

Table 2. Results of rheological properties using different types of additive at 2 and 4 grams.

Additive	Plastic Viscosity (cP)	Yield Point (lb/100ft ²)	(Pa)	Gel 10s (lb/100ft ²)	(Pa)	Gel 10m (lb/100ft ²)	(Pa)
Typical values	35-45	30-40	14.4-19.2	7	3.4	12	5.7
2g PAC	30	33	15.8	6	2.9	8	3.8
2g Kenaf	27	6	2.9	4	1.9	4	1.9
4g PAC	60	140	67.1	21	10.1	30	14.4
4g Kenaf	30	12	5.7	5	2.4	5	2.4

Additive	API Fluid loss (ml)	API Mud Cake (/32-inch)	HPHT Fluid Loss (ml)	HPHT Mud Cake (/32-inch)
Typical values	<5	<8	<5	<8
2g PAC	12.8	1.6	16.5	8.3
2g Kenaf	41.5	4.1	21	8.1
4g PAC	4.5	3	6	6.9
4g Kenaf	30.5	4.6	19.5	9.1

Rheological properties achieved using 2 grams of PAC were generally the best in terms of getting the values closest to typical values. This was true for plastic viscosity, yield point and gel strength. For fluid loss and mud cake thickness for both API and HPHT tests, lowest values were recorded using 4 grams of PAC. When kenaf was added, the values were still out of ranges of typical especially on fluid loss amount recorded, both using 2 and 4 grams.

PAC is hydrophilic in nature and soluble in water. PAC and water particles are attracted to each other which causes an increase of plastic viscosity, yield point and gel strength. Higher content of

PAC increased the values of these properties. In addition, when more PAC was added, thicker mud cake build-up happened which blocks water to filtrate and reduced amount of fluid loss. Kenaf is not soluble in water. Kenaf fibre also not absorbing water and does not swell as much as PAC. This explains why addition of kenaf did not improve plastic viscosity, yield point and gel strength.

As observed in table 2, acceptable values were achieved when 2 grams of PAC was added into the mud. However, fluid losses were still way higher than acceptable range. The next experimental procedures were to combine both PAC and kenaf into the same mud sample.

3.2. Effect of mixture of additives on rheology

Table 3 depicts results obtained when both PAC and kenaf were added into the mud. Amount of PAC used was constant at 2 grams for all mud sample, and kenaf amount was increased incrementally at 0.5 grams.

Table 3. Results of rheological properties when both additives were added into the same mud sample.

Additive	Plastic Viscosity (cP)	Yield Point (lb/100ft ²)	(Pa)	Gel 10s (lb/100ft ²)	(Pa)	Gel 10m (lb/100ft ²)	(Pa)
Typical values	35-45	30-40	14.4-19.2	7	3.4	12	5.7
2g PAC	30	33	15.9	6	2.9	8	3.8
2g PAC + 0.5g Kenaf	22	18	8.6	3	1.4	3	1.4
2g PAC + 1.0g Kenaf	20	26	12.5	3	1.4	3	1.4
2g PAC + 1.5g Kenaf	30	28	13.4	4	1.9	4	1.9
2g PAC + 2.0g Kenaf	37	30	14.4	4	1.9	5	2.4

Additive	API Fluid loss (ml)	API Mud Cake (/32-inch)	HPHT Fluid Loss (ml)	HPHT Mud Cake (/32-inch)
Typical values	<5	<8	<5	<8
2g PAC	12.8	1.6	16.5	8.3
2g PAC + 0.5g Kenaf	7.5	2.2	2.0	8.3
2g PAC + 1.0g Kenaf	7.5	2.3	1.0	8.3
2g PAC + 1.5g Kenaf	7.2	2.3	0.5	8.4
2g PAC + 2.0g Kenaf	7.0	2.4	0.0	8.8

Based on table 3, rheological properties achieved using 2 grams of PAC were generally the best in terms of getting the values closest to typical values. This was true for plastic viscosity, yield point and gel strength. For fluid loss and mud cake thickness for both API and HPHT tests, the data are illustrated in figures 2 and 3 respectively.

From Figure 3, higher fluid loss recorded via HPHT test compared to API test without presence of kenaf, but thickness of mud cake was considerable. Mud cake was getting slightly thicker with presence of only 0.5 gram of kenaf while fluid loss was drastically reduced. The fluid loss was reduced for about 85%, from 16 ml to 3 ml. Reduction of fluid loss continued to occur at higher kenaf concentrations but in a much slower rate. Thickest mud cake recorded at 2 grams kenaf concentration which is 8.8/32 inch which is an increase of only around 7% compared to the thickness without presence of kenaf. At HPHT condition, some amount of PAC and kenaf would get degraded and

transformed into char and gas. Cellulose char was in a smaller size than its original form. This suggests rapid decrease in fluid loss once kenaf was introduced. More of these smaller particles will get deposited, trapped and accumulated as mud cake which helps in forming denser mud cake thus reducing fluid filtrate through it. Even some portion of the cellulose undergone degradation due to high temperature, there are still some that are in their original form. This explains why mud cake thickness continued to increase with higher kenaf concentration.

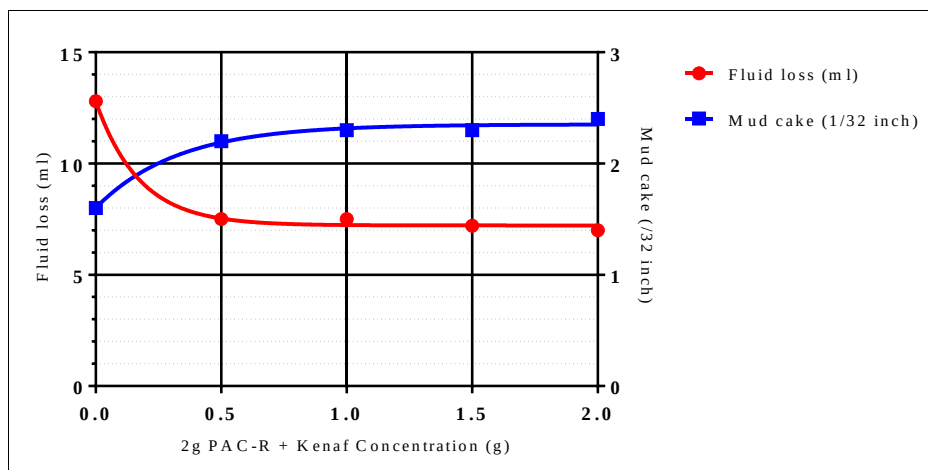


Figure 2. Fluid loss and mud cake thickness obtained using API filter press.

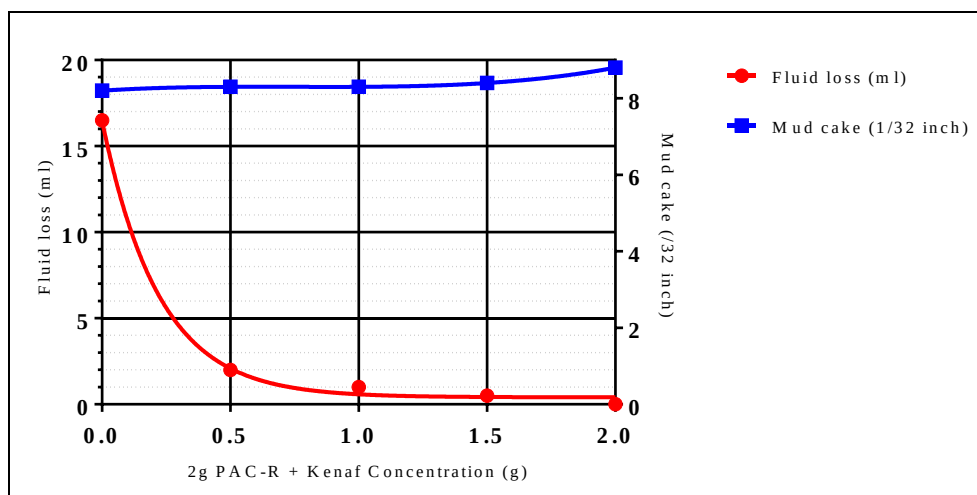


Figure 3. Fluid loss and mud cake thickness obtained using HPHT filtration test.

4. Conclusions

The experimental results show that the commercial fluid loss additives (PAC) performed better than kenaf as fluid loss additive when they were used separately. However, mixing the both the

kenaf and PAC at certain proportions produced better results. The API filtration test showed that the minimum fluid loss achieved was 7 ml. However, at HPHT filtration test, a very minimal amount fluid loss was obtained which mean that it is nearly prevents the fluid loss into the formation.

Nomenclatures

µm	–	micrometer
Pa	–	pascal
cP	–	centipoise

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