Evaluation of Formation Damage and Fluid Loss Control Potential of Formulated Water Based Mud with Corn Cob Particles

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Abstract— **The formation damage and fluid loss control potential of water based mud formulated with corn cob particles treated with sodium hydroxide as a partial replacement for polyanionic cellulose (PAC) has been studied. Core samples were obtained from a well in Nembe Creek in the Niger Delta at a depth of 5400 feet and stored in a humidity-oven. The core samples were invaded with the formulated mud using a liquid permeameter to force the mud through the core sample at certain pressure. Physio-chemical properties such as moisture content, ash content, volatile matter, hemicellulose and cellulose were analysed and results obtained showed that cellulose content increased in the cob when treated with sodium hydroxide solution. Porosity of core samples was between 16.65-22% and permeability was up to 5,890mD. Fluid loss volume over time was highest at 12.61mls in mud sample with only corn cob particles as the fluid loss additive and was within6.5-10.49mls in samples with different percentage combination of corn cob and PAC particles. Rheological properties such as apparent viscosity, plastic viscosity, yield point and gel strength decreased as the percentage concentration of corn cob increased in the mud samples. These properties decreased gradually as temperature increased from 80^{O}F to 200^{O}F. Mud samples with 25%-75% and 50%-50% corn cob to PAC particles showed good rheological properties close to those of the standard mud. pH was slightly higher at 10.2 in mud sample with 100% of corn cob particles as fluid loss additive but lower at between 7.5-7.8 in samples where corn cobs were combined with PAC. Differences in initial and final permeability of the core samples were used to calculate the percentage damage on the core. The mud sample containing 100% corn cob as fluid loss additive caused more damage of 42.3% at 50 psi and 62% at 100 psi respectively but percentagedamage reduced in samples containing different combinations of PAC and corn cob particles.**

Keywords— ***Corn cob, fluid loss, rheological properties, formation damage, percentage combination***

I. INTRODUCTION

Drilling operations expose the producing formation to the drilling fluid and any solids and chemicals contained in that fluid. Some invasion of fluid filtrate and / or fine solids into the formation is inevitable. Damage to the formation can occur either near the wellbore face or deep into the rock during several processes such as drilling, coring, well completion, production, work over by physically plugging of pores by mud solids, rock wettability alteration, insoluble material precipitation in pore spaces, migration of fines into pore throats, introduction of an immobile phase and formation of an emulsion and blockage. On average, the cost of drilling fluid is 15%-18% of total well cost [1]. However, a small marginal spend on drilling fluid can be offset by a superior fluid performance achieved which translates to cost savings and lowers total well cost.

A drilling department can be adjudged to be successful when the well is drilled and cemented at a reduced cost without major problems. However, upon handing over to the production department, any fluids or solids invasion will affect production adversely and the same well could be seen as a “failure”.

A good number of wells are completed without casing and perforations and in these completions, near –wellbore damage is not by passed by perforations. Hence formation damage has to be minimized because avoiding it is not possible. The type of drilling fluid used is one of the most important factor that determine the success of a well drilling operation, the ability to minimize formation damage or seal permeable formation by reducing fluid passage into the formation. The drilling operations are however faced with lots of challenges and among them is the drilling fluid loss. Fluid loss which results in formation damage can be minimized using a wide range of additives in the drilling mud [2,3,4,5,6,7, 8]. The use of local materials is also advantageous in terms of cost [9, 10, 11]. Huge amount of money spent yearly by the industry to combat fluid loss and its after effect which in some cases leads to abandonment of expensive wells. Estimates put cost of fluid losses in the industry around $800 million yearly, and fluid loss products cost around $200 million [12]. To combat this several cellulose based additives have been proposed but are expensive therefore the need to test other raw materials that can serve the same purpose become necessary. This work will evaluate the potential of formulated water based mud with corn cob particles to control fluid loss and formation damage.

II. MATERIALS AND METHODS

A. *Equipment and Instruments*

The following equipment were used: Wiley mill, 270 mesh (53µm) screen, knife, thermometer, drying oven, stop clock, Hamilton beach mixer, mud balance, Fann viscometer, API filter press, weighing balance, pH indicator, scale rule, transparent glass water containing vessel, Ruska liquid permeameter model 1013-801,Whatman filter paper, heating mantle, cornical flask, beakers, dessicators, crucible, muffle furnace.

B. *Reagents/Chemicals and other Materials*

Freshly harvested corn cob was obtained. The reagents and chemicals that were used for this work are as follows: sodium hydroxide, deionised water, dilute acetic acid solution (for removing remaining alkali), bentonite, barite, xanthan gum, polyanionic cellulose, ethanol, H_2SO_4.

C. *Experimental Procedure*

Alkaline Treatment of Raw Material

Corn Cobs were degrained and manually chopped and used for extraction. Corn cob chips were treated with sodium hydroxide of 2 mol/ litre since it is the cheapest, readily available and most effective alkaline solution to break down lignin and was heated at $165^{O}C$ temperature for 1 hour at solid to liquor ratio of 400g: 2mol/litre. Decomposition of heavier volatiles such as lignin occurs from temperature range of $160^{O}C$ up to $900^{O}C$ [13]. Lignin removal increases the water retention ability of fibers. Cellulose and hemicellulose starts degrading around $315^{O}C$ and $220^{O}C$ respectively. When treatment was complete, samples were washed with deionised water to remove residual chemicals and neutralized in dilute acetic acid, oven dried at $50^{O}C$ and then grinded repeatedly to very fine form. 270 mesh screen (53μm) was used to obtain the fine powdered form.

Physiochemical Properties Test

Physiochemical properties such as moisture content, ash content, hemicellulose, volatile matter and cellulose were determined by their respective ASTM standard procedures

Mud Formulation

Bentonite was prehydrated in water for 24hrs and the other additives were added accordingly and water volume was made up to 350mls. Corn cob was combined in percentages of 25, 50 and 75 with polyanionic cellulose (PAC) to make up the total 5g of the filtration control additive and mud was formulated in the order as presented in table 1.

Table 1: Formulation of one barrel of Water Based Mud [14]

S/N	ADDITIVES	FUNCTIONS	CONTENT PER BARREL
1	Water	Base fluid	323ml
2	Bentonite	Primary viscosifier	10g
3	Potassium chloride	Inhibition control	30g
4	Xanthan gum	Viscosi fier	1g
5	PHPA or PAG	Clay stabilization	5g
6	Polyanionic cellulose	Filtration control	5g

Petrophysical Properties Test

Effective porosity was determined from bulk volume and pore volume measurement. Initial permeability of the core sample was obtained by injecting water into the core sample at 50 psi and the prepared conventional and corn cob fluid samples were placed into a container and pressurized with nitrogen gas. The fluid was pumped to the face of the core in the coreholder at a constant pressure of 50psi and 100psi respectively to invade the core samples with the aim of causing damage. Upon completion of the damage process, the final permeability was obtained at 50 psi.

Flow rate Q was obtained from equation (1).

$$Q = \frac{v}{t} \qquad (1)$$

Where v = volume of fluid (cm^3) and t = time (sec)

Permeability (mD) was obtained from equation (2)

$$K = \frac{\mu Q L}{A \Delta P} \qquad (2)$$

Where μ = viscosity (cp), Q = flow rate (cm^3/s), L = length (cm), A = area (cm^2) and Δp = pressure difference (atm).

Percentage Formation Damage

The percentage formation damage by formulated drilling fluid was determined from equation (3)

$$\text{Percentage Mud damage} = \frac{KB - KE}{KB} \times 100 \qquad (3)$$

Where KB = permeability of formation (mD)

KB = permeability of formation after damage (mD)

III. RESULTS AND DISCUSSIONS

A. *Physio-Chemical Properties of Raw Material*

The physiochemical properties of corn cob before and after treatment are presented in Table 2

Table 2: Physio-Chemical Properties of Raw Material (Corn Cob) Before and After Alkaline Treatment with Sodium Hydroxide

Property	Before (%)	Treatment	After Treatment (%)
Moisture content	6.20		1.85
Ash content	3.15		0.83
Volatile matter	11.83		12.23
Lignin	14.0		10.02
Hemicellulose	35.90		28.70
Cellulose	46.05		61.17

Differences in physiochemical properties of the corn cob showed that moisture content, ash content, lignin and hemicellulose all reduced after alkaline treatment of the corn

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cobs. Volatile matter increased slightly with the treatment. Cellulose content increased significant as a result of the degradation in lignin, hemicellulose and ash by alkaline treatment. The reduction in the lignin increases the water uptake capacity of the fiber and in agreement with the result of [15].

B. Fluid Loss in Formulated Water Based Mud Samples

Filtrate loss in the various formulated mud samples is shown in Figure 1

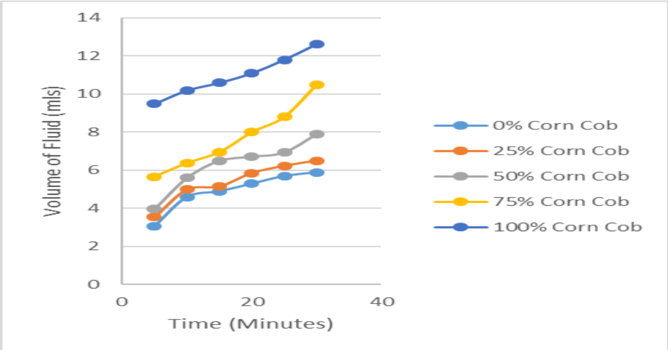

Figure 1: Fluid Loss in Formulated Water Based Mud Samples

Fluid loss value in mud sample E with 100% cob was highest at 12.61mls. At 0% Corn cob, fluid loss in Sample A was lowest at 5.9mls. It was observed in samples with 25%, 50% and 75% Corn cob respectively (i.e as the percentage of PAC decreases), that the volume of fluid loss increases. The fluid loss volume in all the samples were within the maximum limit for API filtrate volume of 23mls when High Viscosity Polyanionic Cellulose is used in water based drilling mud [16].

C. Formation Damage by different mud samples

The percentage damage resulting from the use of the different drilling mud samples at 50 and 100 psi injection pressures are shown in Figure 2

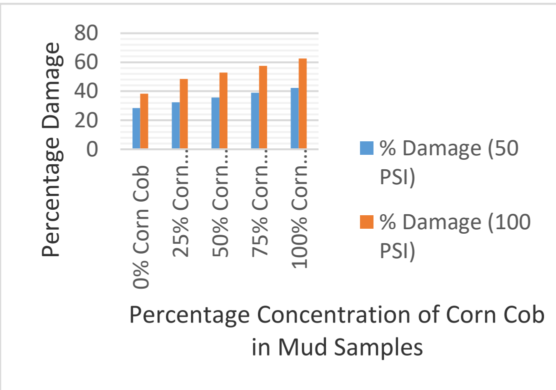

Figure 2: Percentage Damage by Formulated Water Based Drilling Mud at 50 and 100 psi.

Percentage comparison of damage done at 50 and 100 psi showed that more damage was done when the injection pressure increased from 50 to 100 psi but was highest in sample E with 100% Corn cob. This is as a result of the Corn cob particles not been able to form impermeable mud cake to withstand high pressures. Sample A which was the standard mud with 0% Corn cob showed the lowest percentage damage of 28.33% at 50psi and 38.25% at 100psi. Samples B, C and D all showed increased percentage damage as the percentage concentration of Corn cob was increased and PAC was reduced.

D. Permeability of Drilling Mud Invasion at 50 psi Injection Pressure

The original permeability before mud invasion and final permeability of core samples after invasion by formulated drilling mud samples is shown in Figure 3

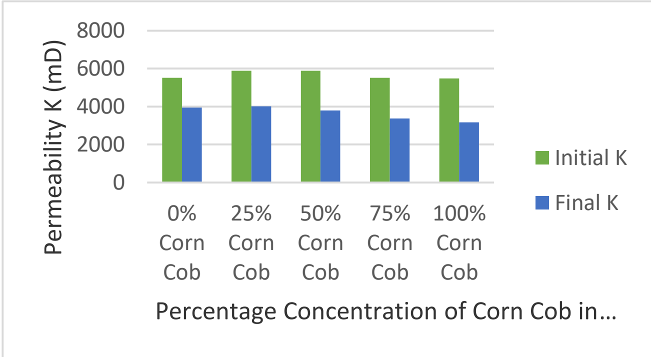

Fig 3: Differences in the Initial and Final Permeability as a Result of Mud Injection at 50 psi Pressure.

Permeability reduction was observed as the percentage concentration of Corn cob in the mud gradually increased (reduction in percentage concentration of PAC in mud samples). These shows that the presence of PAC aids the rapid formation of mud cake stopping further filtrate invasion.

E. Permeability of Drilling Mud Invasion at 100 psi Injection Pressure

The original permeability before mud invasion and final permeability of core samples after invasion by formulated drilling mud samples is shown in Figure 4

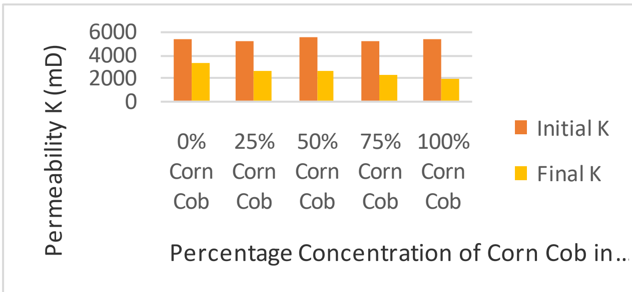

Figure 4: Comparison of the Differences in the Initial and Final Permeability after Mud Injection at 100 psi Pressure.

The gap between the initial and final permeability widened which shows that more damage was done at this pressure. The final permeability values further reduced. Mud samples with lesser percentage concentration of Corn cob showed lowest percentage damage. This is due to the presence of

PAC that enhances the water based drilling mud by formation of mud cake to plug holes stopping further filtrate invasion.

F. Plastic Viscosities of Mud Samples at Different Temperatures

The plastic viscosity in the formulated mud samples at different temperature are shown in Figure 5

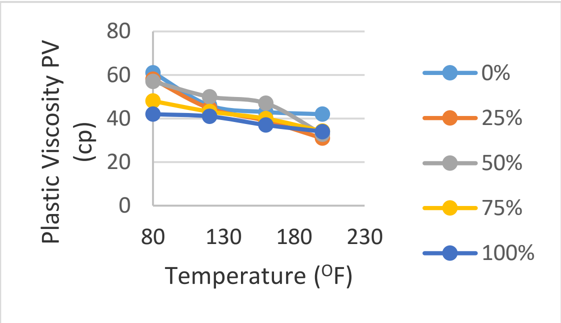

Figure 5: Plastic Viscosity of Formulated mud Samples at Different Temperatures.

Plastic viscosity was observed to decrease as the percentage concentration of Corn Cob increased and the percentage concentration of PAC decreased in the drilling mud samples. Sample A with 0% corn cob and 100% PAC had the highest plastic viscosity of 61cp and sample E with 100% Corn cob and 0% PAC had the lowest plastic viscosity value of 41cp. The low plastic viscosity value can be accounted for by the presence of high percentage concentration of Corn Cob. Increase in Temperature from 80^{O}F to 200^{O}F showed a gradual reduction in plastic viscosity in mud samples. The plastic viscosity values were all within the API limit of less than 65cp for water based mud. (America Petroleum Institute, 2010).

G. Apparent Viscosity of Mud Samples at Different Temperatures

The apparent viscosity of formulated water based drilling mud samples at different temperatures are shown in Figure 6

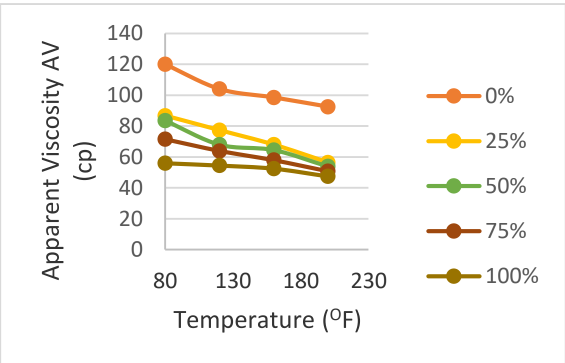

Figure 6: Apparent Viscosity of Formulated Mud Samples at Different Temperatures.

Apparent viscosity also decreased gradually from the initial values at 80^{O}F for all mud samples as temperature increased. Apart from the mud sample with 100% Corn Cob at 200^{O}F that showed AV value slightly below the limit of acceptability, all other formulated samples showed plastic viscosity values within the API limit of more than 50cp for water based mud (American Petroleum Institute, 2010).

H. Yield Point of Mud Samples at Different Temperatures

The yield point in all the formulated water based mud samples at different temperatures are shown in Figure 7

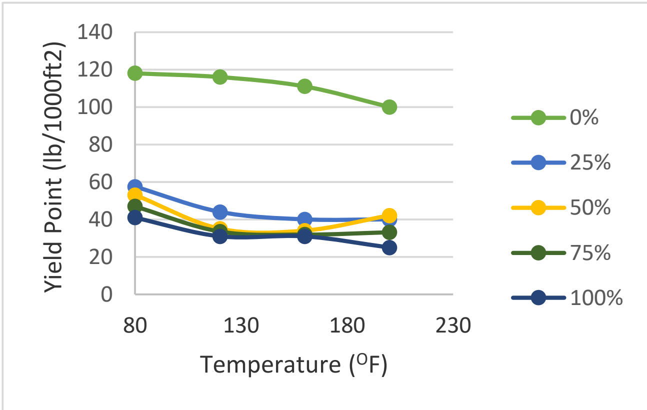

Figure 7: Yield point of Drilling Fluid Samples at Different Temperatures.

Yield point showed similar behavior as PV and AV. The values all decreased gradually from the initial values at 80^{O}F for all mud samples as temperature increased.

I. Gel Strength in Formulated Mud Samples at Different Temperatures

The 10 Minutes gel strength in the formulated samples of drilling mud at different temperatures are shown in Figure 8

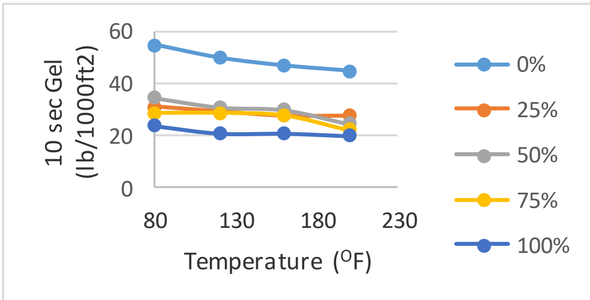

Figure 8: 10 Minutes Gel Strength of Mud Samples at Different Temperatures

10 minutes gel strength values all decreased gradually from the initial values at 80^{O}F for all mud samples as temperature increased.

IV. CONCLUSION

The following conclusions were drawn;
The increase in cellulose content of corn cob was as a result of treatment with sodium hydroxide solution. Stability of pH and mud weight was dependent on mud with combination of corn cob and PAC unlike that with 100% corn cob. Fluid loss

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property of mud formulated with combination of corn cob and PAC were lesser compared to when only local material was used. Mud rheological properties that affects formation damage such as apparent viscosity (AV), plastic viscosity (PV), yield point (YP) and gel strength all behaved in a similar way upon increase in temperature to $200^{O}F$ in mud with combination of corn cob and PAC and also that with 100% corn cob. Corn cob only as fluid loss additive caused the most damage to the formation and reduction in formation damage by the mud depends more on percentage combinations of corn cob at 25%, 50% and 75% with PAC.

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