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Improving the Rheological Properties of Water Based Mud with the Addition of Cassava Starch

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Abstract: *This work is on the use of locally sourced cassava starch for the improvement of the rheological properties of water based mud. The efficiency of drilling operation is enhanced by the application of drilling mud with suitable additives. In this experiment, the mud samples were formulated in the absence and presence of various concentrations of cassava starch. The production method of the mud and the determination of its rheological and allied properties were carried out based on the API mud production standards. From the analyses of the experimental results, water based mud with 4% locally sourced cassava starch appears to be the optimum concentration. The cassava starch additive improves the rheological properties of the drilling mud.*
Key words: *Cassava starch, Mud, Rheological properties.*

I. Introduction

Drilling operation is enhanced by the application of drilling mud (Bourgouyne, 1991; Lyons, 1996). The three major types of drilling mud, mostly used in drilling operations, are water based drilling mud, oil based drilling mud, and synthetic based drilling mud. Drilling mud selection is a function of the behaviour of the formation to be drilled (Johannes, 2011; Joel et al, 2012). Compared to other types of drilling mud, water based mud has the advantages of higher shear thinning, high true yield strength, good bit hydraulics and reduced circulating pressure losses. It improves borehole stability (Ariffin and Amir, 2011).

The major constituent of water based mud is water; all other constituents such as bentonite and barite are regarded as additives. Bentonite is often considered as an important drilling fluid additive because it gives proper viscosity and filtration control (Mihalakis et al, 2004; Kelessidis et al, 2005; Johannes, 2011). Like most of the additives, bentonite degrades at high temperatures encountered during geothermal drilling. The problem can be solvedby the addition of various types of thinners. According to Omotioma et al (2012), fluid of cassava starch is a shear-thinning type of non-Newtonian fluid. It can be used as adhesive agent, as it has the ability to join materials by adhesion (John, 2007). Shear-thinning fluids have been called pseudo-plastic fluids, but this terminology is outdated and discouraged (Perry and Green, 2008). Several works have been carried out on the production of drilling mud and its additives (Mbagwu et al 2003; Falode et al, 2007; Apugo-Nwosuet al, 2011; Omotioma et al, 2012; Orji and Joel, 2012). On separate studies, Gumus and Udezue (2011) and Omotioma et al (2012) examined cassava starch as a potential adhesive material. From the review of the previous studies, there is need to improve the rheological properties of drilling mud using cassava starch additive.

II. Materials And Methods

2.1 Equipment and Raw Materials: The equipment used in this work include; graduated measuring cylinder, beakers, electronic weighing balance, mixer, viscometer, drilling mud balance, water bath, pH meter, and stop watch. The raw materials used in the formulation of the water based drilling fluids (in the absence and presence of various concentrations of cassava starch) are presented in Table 1 below. The cassava was got from Akpugo, Enugu State, Nigeria.

Table 1, The Raw Materials Used for the Formulation of the Drilling Mud Samples

S/N	Raw material	Function(s)	Quantity
1.	Water	Base fluid	245ml
2.	Bentonite	Viscosity and filtration control	5.0g
3.	Xanthum Gum biopolymer (XCD)	Viscosity and fluid-loss control in low solid mud	0.4g
4.	High viscosity Polyanionic Cellulose (PAC-R)	Fluid loss control and viscosifier	0.25g
5.	Modified natural polyanionic cellulose (PAC-L)	Fluid loss control and viscosifier	0.25g
6.	Potassium hydroxide (KOH)	Potassium source in inhibitive potassium mud	0.1g
7.	Sodium carbonate(Na_2CO_3)	Calcium precipitant in lower pH mud	12.0g
8.	Barite	Weighing agent	12.0g
9.	Cassava Starch	Fluid control agent	0%, 2%, 4% and 6% conc. by weight

2.2 Experimental procedure:

The cassava starch was prepared by adopting the method of the previous study (Omotioma et al, 2012). The production methods of the drilling mud and the determination of the rheological and allied properties of the mud were carried out based on the API drilling mud production standards (API, 1993; API, 2000; Ogbonna, 2010; Joel et al, 2012). The mixing method used by Joelet al (2012) was adopted. The various quantities of the raw materials (shown in Table 1 above) were measured using the graduated cylinder and electronic weighing balance. The raw materials were then poured, one after the other, with an interval of 5 minutes into the steel cup of the single spindle mixer. The application of the raw materials was carried out in a descending order as arranged in Table 1 above. The mud samples were formulated in the absence and presence of various concentrations of the cassava starch. As each material is being put into the mixer, the mixer is powered to cause the spindle to rotate and mix the contents inside the steel cup being held at a fixed position. As the materials have been completely applied into the mixer steel cup, it was allowed for 30 minutes, under stirring condition, for a total uniformity of the materials to give finely formulated water based drilling mud. Drilling mud balance was used to measure the density of the mud. Viscometer was used for the measurement of rheological properties of the formulated drilling mud. The rheological readings, API Testing,600 RPM (revolution per minutes), 300 RPM, 6 RPM and 3 RPM, were recorded.Also,10 seconds, 10 minutes and 30 minutes gel strength values wererecorded. The plastic viscosity and yield pointvalues were appropriately evaluated. The pH meter was used to measure the pH of the formulated drilling mud. This procedure is carried out in triplicate, and average value for each parameter was obtained.

3.1 Experimental Result And Analysis

3.1.1 Experimental Result

The mud weight and pH of the formulated mud without the cassava starch are presented in Table 2 below.

Table 2, Mud Weight and pH of the Formulated Mud without the Cassava Starch Additive

Mud property	Value
Mud weight (1b/gal)	8.1
pH	9.1

The gel strength result of the mud in the absence and presence of different concentration of cassava starch is presented in Table 3 below.

Table 3, Gel Strength Result of the Mud in the Absence and Presence ofDifferent Concentrations of the Cassava Starch

Gel strength	Mud + 0% Cassava Starch	Mud + 2% Cassava Starch	Mud + 4% Cassava Starch	Mud + 6% Cassava Starch
10 seconds Gel strength (1b/100ft^2)	1	2	4	7
10 minutes Gel strength (1b/100ft^2)	2	3	6	9
30 minutes Gel strength (1b/100ft^2)	2	5	7	9

The Dial-readingresult of the mud in the absence and presence of different concentration of cassava starch is presented in Table 4 below.

Table 4, Dial Readings of the Formulated Drilling Mud at Room Temperature

RPM	Mud + 0% Cassava Starch	Mud + 2% Cassava Starch	Mud + 4% Cassava Starch	Mud + 6% Cassava Starch
600	21	30	34	36
300	13	20	23	24
6	2	3	7	10
2	1	2	5	8

RPM (Revolution per minute)

The Plastic viscosity, yield point and apparent viscosity of the mud werecalculated using Equations (1), (2) and (3) respectively.

$$\text{Plastic Viscosity (PV), cP} = \text{600 RPM reading} - \text{300 RPM reading} \qquad [1]$$

$$\text{Yield Point (YP), lb/100 ft2} = \text{300 RPM reading} - \text{Plastic Viscosity} \qquad [2]$$

$$\text{Apparent Viscosity (AV), cP} = \text{600 RPM reading} / 2 \qquad [3]$$

The effect of concentration on the rheological properties of the mud at room temperature (30 ^{0}C) is shown in Figure 1 below.

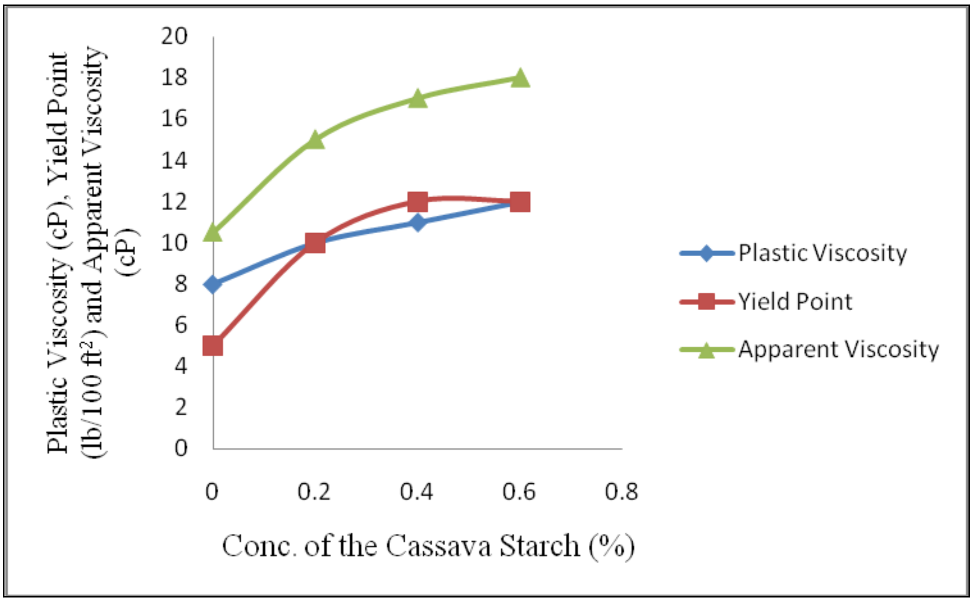

Figure 1, Effect of Concentration on the Rheological Properties of the Mud

The effect of temperature on the rheological properties of the drilling mud, with 4% cassava starch, is presented in Table 5 below.

Table 5, Effect of Temperature on the RheologicalProperties of the DrillingMud

Parameter	30 ^{0}C	50 ^{0}C	70 ^{0}C	90 ^{0}C
600 RPM	34.0	32.0	29.0	27.0
300 RPM	23.0	22.0	20.0	18.0
Plastic Viscosity (cP)	11.0	10.0	9.0	9.0
Apparent Viscosity (cP)	17.0	16.0	14.5	13.5

RPM (Revolution per minute)

The effect of temperature on the yield point of the drilling mud, with 4% cassava starch, is presented in Figure 2 below.

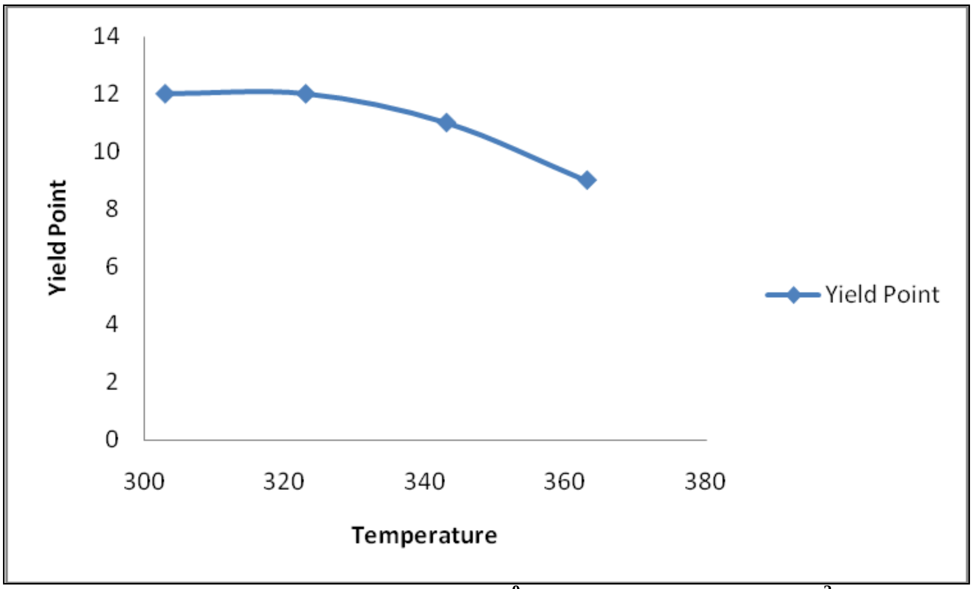

Figure 2, Effect of Temperature (^{0}K) on Yield Point (lb/100ft^2)

3.1.2 Discussion of Result

The mud weight and pH of the formulated mud in the absence of cassava starch are 8.1 (lb/gal) and 9.1 respectively (Table 2). From the pH value, the formulated mud is in alkaline state (API, 1993). The effect of concentration of the locally sourced cassava starch on the gel strength of the mud is shown in Table 3. The gel strength measures the capability of the formulated drilling fluid to hold particles in suspension after flow ceases (Lyons, 1996; Johannes, 2011). In the absence of cassava starch, Table 3 shows value of 1 at 10 seconds gel strength and equality value of 2 at 10 minutes and 30 minutes gel strengths. For all the period of gel strength determination, increase in concentration of cassava starch increases the gel strength of the mud. Similar trend was noticed in the dial-reading results of the drilling mud (Table 4).

The graphical representation of the plastic viscosity, yield point and apparent viscosity, as determined by substituting the dial-reading data into Equations (1), (2) and (3), is presented in Figure 1. The graph shows that the cassava starch additive affects the rheological properties of the drilling mud. From the chart, the same level of yield point is observed for the mud samples with 4% and 6% cassava starch. It suggests that the mud sample with 4% cassava starch is a potential optimum concentration of the cassava starch additive. With the addition of cassava starch additive, there is improvement in the rheological properties of the drilling mud.The effect of temperature on the rheological properties of the drilling mud is presented in Table 5. Increase in temperature decreases the plastic and apparent viscosities of the drilling mud. A similar trend was noticed on the effect of temperature on the yield point of the drilling mud (Figure 2).

III. Conclusion

From the analyses of the experimental results, the following conclusions can be drawn:

- Cassava starch improves the rheological properties of water based mud.
- Mud sample with 4% cassava starch is a potential optimum concentration of the cassava starch additive.
- The locally sourced cassava starch is a suitable additive for the production of water based mud.

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