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Improving The Rheological Properties of Drilling Mud Using Local Based Materials

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ABSTRACT : *Locally sourced materials have been used in the past to produce drilling fluids but the major problem encountered is that the gel strength of the drilling fluids produced using local substitutes is too low and the fluid loss is too high and as a result, this is not suitable for drilling processes. The design and production of drilling fluids in Nigeria's oil and gas sector over the years has been faced with the challenges of either importing the materials to produce and or in other cases importing already prepared drilling mud. This study formulates an alternative water base mud, made up of a mixture of Guar Gum and Ginger as locally made additives to serves as viscosifiers to increase drilling mud rheological parameters and its gel strength; whichcompete favorably with imported standard viscosifiers. The study result shows that the gel strength was largely improved and its rheological parameters when compared to that of the API specifics. The combination of Guar Gum and Ginger acts as a good viscosifier, hence it can be used as additives. Ginger acts as a good viscosifier primarily and acts as a densifier secondarily in the formulation of drilling fluids.*

KEYWORDS : *Rheology, Drilling mud, Viscosifiers, Densifiers, Thixotropic, Psuedoplastic*

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I. INTRODUCTION

Drilling fluids, which represent till one fifth (15 to 18%) of the total cost of well petroleum drilling, must generally comply with three important requirement; they should be easy to use, not too expensive and environmentally friendly. The complex drilling fluids play a several functions simultaneously. They are intended to clean the well, hold the cuttings in suspension, prevent caving, ensure the tightness of the well wall, flood diesel oil or water and form and form an impermeable cake near the wellbore area. Moreover, they also have to cool and lubricate the tool, transfer the hydraulic power and carry information about the nature of the drilled formation by raising the cuttings from the bottom to the surface. Drilling fluids are commonly known for their gel or thixotropic characteristics, in which they can go through a reversible transformation from high to low viscosity status when being subjected to shear stress force (Dolz et al., 2007). These transformations ruin the microstructure of the bit will be gradually recovered when the fluid is in resting condition (Azar and Samuel, 2007). Choosing a mud system begins with the selection of a mud family, according to the nature of the rock formation, and should take into account environmental and economic constraints. The choice of the mud formulation will be the second step, where one has to decide on the range of desired properties, leading to use minimum amounts of additives. At the current time , drilling mud are categorized by their external phase or basic material into three major groups which are the Water Based Mud (WBM), the Oil Based Mud (OBM) and the Oil, Mist, Foam and Gas.

Rheology is the study of the flow of matter, primarily in a liquid state, but also as 'soft solids' or solids under conditions in which they respond with plastic flow rather than deforming elastically in response to an applied force. Viscosity is a general term used to define the internal friction generated by a fluid when a force is applied to cause it to flow. This internal friction is a result of the attraction between the molecules of a liquid and is related to a shear stress. The greater is the resistance to the shear stress, the greater is the viscosity. In fact, standard viscosity measurements do not define flow behavior within shear rate ranges imposed at the bit, annulus, and pits. The viscosity in the annulus affects hole cleaning efficiency and the viscosity in the pits influences the effectiveness of solids separation techniques. Thixotropic fluids show a time-dependent response to shear. When subjected to a constant shear rate, they will decrease in viscosity over time. Often this is seen as a large initial viscosity loss, followed by gradual further loss. Once shear is removed, thixotropic fluids recover their viscosity, but over a period of time, not instantaneously. These fluids are considered psuedoplastic.

Researches have been examining the possibilities of producing drilling fluids using strictly locally derived materials, this is partly successful as it is discovered that Nigeria have the necessary materials to produce Locally based drilling fluids and local materials have been used in the past to produce drilling fluids. However, the major problem encountered is that the gel strength of the drilling fluids produced using local substitutes is too low and the fluid loss is too high and as a result, this is not suitable for drilling processes.

Guar Gum and Ginger is one of the locally based materials used which is readily available in Nigeria and highly soluble in water is used to see if they can increase the rheology and gel strength of the drilling mud when used as additives. Thus this study focused on improving the Rheology i.e. viscosity, gel strength and flow index of drilling mud by formulating drilling mud using locally derived materials i.e. a mixture of Guar Gum and Ginger as a viscosifier.

The Nigerian Content Act, seeks to achieve the 'promotion of the development of local (Nigerian) content (both personnel and resources) in the oil industry' as one of its major goal, with this in view the need for the development of local additives as substitute for foreign additive is paramount, thereby the possibility of the use of Guar Gum and ginger in place of C.M.C or H.E.C or P.A.C due to the availability of ginger and Guar Gum Nigeria is being explored.

II. MATERIALS AND METHODS

The equipment used in experimental setup are:

1. Hamilton High Speed Mixer; used for mixing fluid and other additives.
2. Electrical Weigh Balance and measuring cylinder; used to measure different samples of different chemical materials to be used in the formulation of drilling fluids. Weigh balances are often used for dry substances and the measuring cylinders are used when liquids are to be measured.
3. Phydrion pH paper dispenser to test the acidity or alkalinity nature of the water.
4. Mud balancefor measuring the weight of the fluid in different unit.
5. Methyl Blue Kit; used to determine the cation exchange capacity of the solids present in the water based mud.
6. Beaker used for measuring volume of fresh water.
7. Spatula for collection of samples from the bulk containers for measurement.
8. Rheometer to obtain the viscosity and gel strength at various rpm and time respectively.
9. Others include marsh funnel, stop watch, mud cups

The materials used for this study were Bentonite clay, Fresh water, Guar Gum, Ginger, Poly Anionic Cellulose (PAC), Carboxyl Methyl Cellulose (CMC), Hydroxyl Ethyl Cellulose (HEC), Sodium Chloride (NaCl), Sodium Hydroxide (NaOH), the bentonite used was later found out to be illite.

All materials except for Ginger used for the study were gotten from the Petroleum Laboratory at the Petroleum Training Institute, Effurun. The Ginger was gotten from Effurun market, the experiment were also done at the PTI Lab with the following procedures.

1. 25.0g of powdered bentonite clay sample was weighed using the electronic weighing balance
2. 350mL of water was measured using a measuring cylinder.
3. The measured water and the powdered clay were poured into the Hamilton high speed mixer which was stirred thoroughly. A homogeneous mixture of water and clay was obtained.
4. After preparing the water based drilling mud, the following properties were then tested for and recorded; marsh funnel viscosity, pH, rheological properties, mud weight

This procedure was repeated for all the drilling fluid samples formulated adding the respective chemical material in addition to the spud mud and agitating till homogeneity was achieved, and then the same testing procedure followed all the tests.

III. RESULTS AND DISCUSSION

From theanalysis of the laboratory test results, it is was observed that the Bentonite clay was not up to the API standards in terms of the Rheology and Mud weight. Consequently, it needed to be improved before it can be used for drilling because, the mud had a low viscosity and mud weight value below API requirement; thus it cannot be used for drilling unless improved.

After the addition of 1g of Guar Gum to the drilling mud, it could be seen from Appendix A that the viscosity of the mud increased from 11 to 21 though HEC has the highest viscosity with 125cP followed by PAC with 82cP then CMC with 73cP.

It was also observed that the pH of the Guar Gum mixture was 10 was the same unlike for PAC which was 9, mixture of CMC and mud was 8 and that of HEC was 8.

It was also observed that n reduced after the addition of Guar Gum from 0.6517 which was the original mud system to 0.5846 which is an improvement but the PAC mixture has d least value of n with value 0.4504, the lesser the value of n the better the cleaning hole performance

From Figure 1, it is seen that before the mud was improved , it has low rheology properties but it was observed that the rheology properties of the mud system improved with increase in the mass of the ginger in the mud system, when the mass of ginger was 20g the highest viscosity reading was 48cP which is above the minimal API requirement for drilling mud, the plastic viscosity(PV) is also above the API requirement, therefore the mud system that was not able to be used for drilling has successively been improved by just the addition of 20g of ginger which can now be used for drilling.

It could be observed from Figure 2 that the gel strength improved drastically after 20g of ginger was added to 1g of guar gum and bentonite which has a strength greater than that of CMC but is behind PAC and HEC in terms of gel strength.

Effect on the “n’’ and “K’’

The “n” constant indicates the degree of non-Newtonian behavior that a fluid exhibits over a defined shear rate range. As “n” decreases from one, the fluid becomes shear-thinning or pseudo plastic. This means the viscosity of the fluid will decrease with increasing shear, and immediately increase with a reduction in shear rate. Lowering the “n” constant improves hole cleaning performance by increasing the effective annular viscosity and flattening the annular velocity profile. Newtonian liquid (n=1) have more parabolic velocity profile and will have a turning effect on the cuttings and caving, tending to push them to an area of lower velocity. This results in a recycling of particles and poor hole cleaning efficiency. The shear-thinning fluid with its lower “n” constant will have a flatter velocity profile reducing the turning effect. This helps prevent particle breakage and moves the solids more directly up the hole.

It can be seen from Figure 3, that the drilling fluid formulated shows non-Newtonian property since the value of “n” was less than one. The initial dial reading without guar gum and ginger had “n” value of (0.8740). This decreases initially with subsequent addition of 1g of guar gum to (0.5846) with further addition of 4g of ginger it increased to (0.7059), with further addition of 4g it reduces to (0.6947), With further addition of 12g of ginger, the “n” value decreases to 0.4148 which is the lowest even when compared to the n of the addition of 1g of PAC (0.4504) indicating an increase in pseudo plasticity of the fluid and hole cleaning ability of the fluid. The initial increase and subsequent decrease of the value of “n” is due to fact the viscosity of ginger is dependent on concentration. “K”, the consistency index, is the shear stress or viscosity of the fluid at one sec-1 shear rate. It relates directly to the system viscosity at low shear rates. An increase in “K” raises the effective annular viscosity and, therefore the hole cleaning ability. It can also increase the bit viscosity and circulating pressure loss. From the experiment above it can be seen that there is an increase in “k” value from (0.0258 - 2.7093) with subsequent additions of 20g of ginger indicating increase in effective annular viscosity which translates to better hole cleaning capacity, increase bit viscosity and circulating pressure loss.

Figure 4 shows that at successive addition of masses of NaOH, the rheological properties of the system improved i.e. the viscosity was increased from 31 to 43 thereby it can be used to drill an alkaline formation, alkanity has a positive effect on the viscosity of the mud.

The “n” of the mud system also increased from 0.5616 to 0.3816 thereby increasing the cleaning ability of the mud system in the hole, the gel strength of the mud also increased from 11 to 19.

With all these it can be seen that the mud can be used to drill alkaline reservoirs.

From Figure 5, it can be seen that as successive addition of masses of NaCl, the rheological properties of the system reduced i.e. viscosity is reduced from 45 to 41 thereby it cannot be used to drill a salt formation, salinity has a negative effect on the viscosity of the mud

The “n” of the mud system also increased from 0.5846 to 0.6567 thereby reducing the cleaning ability of the mud system in the hole, the gel strength of the mud also reduced from 6 to 4.

With all these it can be seen that the mud can not be used to drill salt reservoirs, because a mud of higher viscosity is needed to drill a salt formation and not a mud of low viscosity.

IV. FIGURES AND TABLES

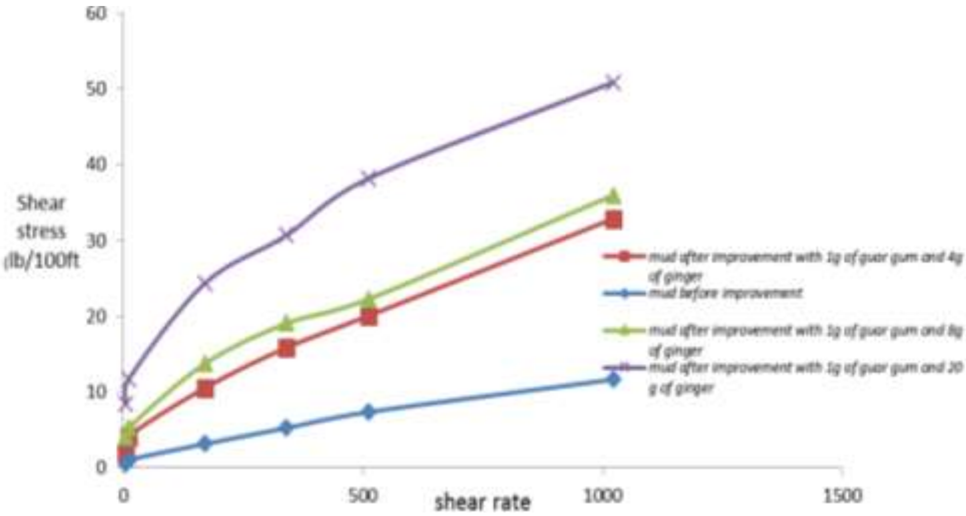
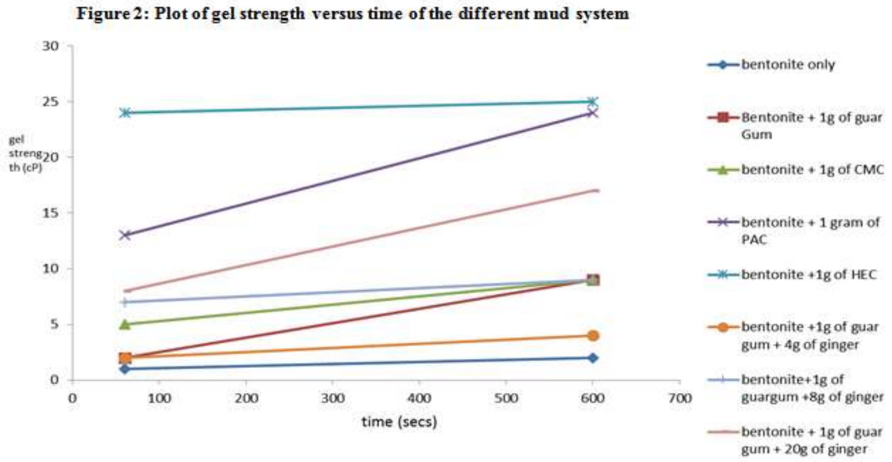


Figure 1: Plot of shear stress versus shear rate of the different mud system

Figure 2: Plot of gel strength versus time of the different mud system



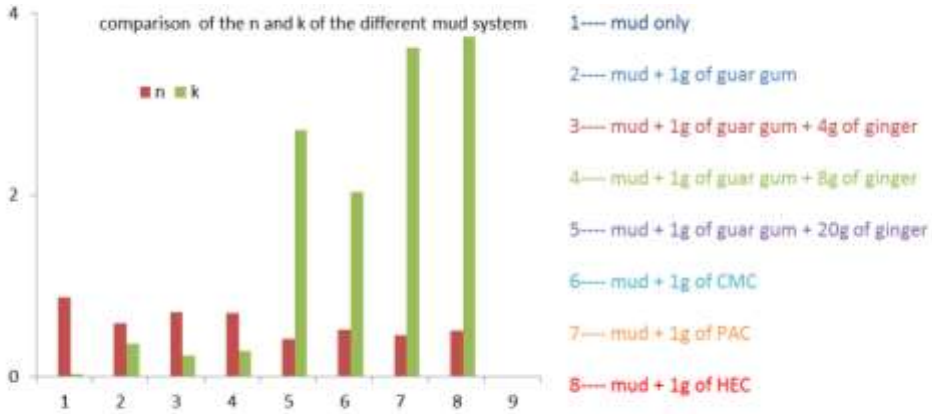


Figure 3: Comparison of the n and k of the different mud system

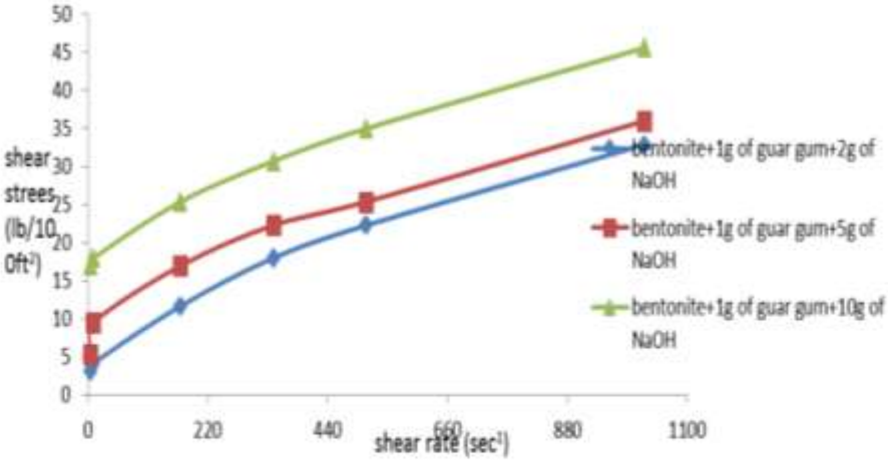


Figure 4: Plot showing the effect of varying mass of NaOH on the different mud system

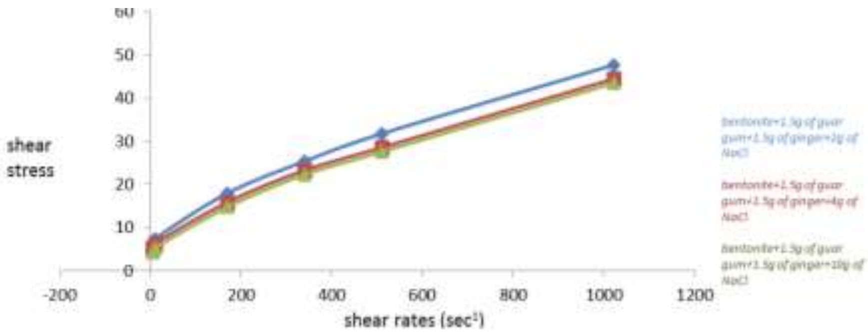


Figure 5: Plot showing the effect of varying mass of NaCl on the different mud system

V. CONCLUSION

The conclusions derived from the study, where based on the experiments carried out at room temperature.The combination of Guar Gum and Ginger acts as a good viscosifier, thereby it can be used as an additive for drilling fluid formulation. Although, Ginger acts as a good viscosifier primarily and acts as a densifier secondarily in the formulation of drilling fluids, but with the increase in salt concentration the viscosity of ginger with guar gum decreases this means that the drilling fluid cannot be used in a salt formation.

With the increase in alkalinity the viscosity of ginger with guar gum increases exponentially this means that it can be used successfully in an alkaline formation.

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APPENDIX

Appendix A: RPM, AV , PV, YP, gel strengths,n,k and mud weight of the mud system Bentonite + Different Viscosifiers on the Mud System (Bentonite + 1gram of Guar Gum, CMC, HEC, PAC)

Sample conc. of 350ml of water	**Rheometer Reading (rpm)**						**Mud Weight (ppg)**	**pH**	**AV (cP)**	**PV (cP)**	**YP (lb/100ft^2)**	**10 secs gel strength**	**10 mins gel strength**	**n**	**K**
	3	***6***	***100***	***200***	***300***	***600***									
25.0g of bentonite+ 1g of Guar GUM	2	3	8	11	14	21	8.65	10	10.5	7	7	2	9	0.5846	0.3654
25.0g of bentonite+ 1g of PAC	11	14	38	52	60	82	8.65	9	41	22	38	13	24	0.4504	3.6164
25.0g of bentonite + 1g of CMC	5	7	29	41	51	73	8.65	8	36.5	22	29	5	9	0.5171	2.0279
25.0g of bentonite + 1g of HEC	24	28	65	80	88	125	8.65	8	62.5	37	51	24	35	0.5061	3.7476

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