

THE EFFECT OF MIXING TIME ON THE RHEOLOGICAL PROPERTIES OF GINGER, COCOYAM AND XANTHAN GUM

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Abstract

The rheological properties of drilling fluid change owing to mixing time and these affect drilling in deep wells. Drilling fluid which are: oil based drilling mud (OBM), Water based drilling mud (WBM), Synthetic base drilling mud (SBM), Gas based drilling mud (GBM) and Nano based drilling mud, are determined by the fluid behaviour when it is subjected to shear stress. In this experiment, additives such as Ginger, Cocoyam and Xanthan Gum were subjected to a time constraint of five, ten and fifteen minutes. Results obtained showed that as mixing time increased for Ginger the plastic viscosity which was 40cP at five minutes mixing time decreased, Gel strength was relatively high and yield point was 120 lb/100ft² at ten minutes mixing time. For Cocoyam the Gel strength increased, Plastic viscosity was averagely high at 42_{Cp} and relatively stable and the yield point increased in less amounts but was more at five minutes mixing time at 41_{lb/100ft²} For Xanthan Gum the Gel strength and yield point increased, yield point was 142_{lb/100ft²} at fifteen minutes mixing time and the plastic viscosity was 46_{Cp} at ten minutes and decreased at fifteen minutes. Based on the foregoing, Ginger possesses the best thixotropic qualities, is much more suitable for cleaning beneath the bit and It will suspend cuttings much easier than Cocoyam and Xanthan Gum. Although cocoyam has a higher rate of gelation than ginger and xanthan gum which makes it suitable for short quiescent period of time and for hole cleaning purposes.

Keyword: Mixing time, Rheological properties, Water based mud, Cocoyam and Xanthan gum

1.0 INTRODUCTION

The successful drilling of a well is largely dependent on the rheological properties of the drilling mud used. The drilling mud being a chief constituent of the afore mentioned circulating system, is a flowing fluid applied in rotary drilling for achieving single or multiple tasks during the procedure, and it typically consists of water/oil, clay, weighing compounds and few other chemical additives [1]. The cost and effectiveness of a drilling process is affected to a large extent by the drilling fluid used in the process. Hence the importance of a drilling fluid cannot be over emphasized, drilling fluids are commonly known for their gelly nature in which they can go through a reversible transformation from high to low viscosity status when being subjected to shear stress force[2]. Usually, the industrial capability of wells is impaired by multifaceted interfaces between rock and fluid, which decrease permeability to oil and gas. For that reason, drilling mud should be cautiously formulated to diminish these undesirable effects [3].

They function to preserve hole reliability, convey the rock cuttings, managing the pressure of the mud system along with lubricating and cooling the drill bit [4] At the current time drilling mud are categorized by their external phase or basic material into five major groups, which are oil based drilling mud (OBM), Synthetic base drilling mud (SBM), Water based drilling mud (WBM), Gas based drilling mud (GBM) and Nano based drilling mud [5].

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To match the requirements of different depth intervals, the properties for drilling fluids are modified using various additives such as viscosifier, viscosity reducers, weighting materials, fluid-loss reducers, emulsifiers, Lost circulation materials, flocculants, corrosion control chemicals, defoamers and pH control additives. The addition of organic additives to drilling suspensions is of great industrial interest because of their capacity to modify their colloidal and rheological properties. The following additives were used to study the extent to which these locally derived drilling fluid additives would behave when subjected to the effect of mixing time; Ginger (*zingiber officinale* Rescoe), Cocoyams (*Colocasia esculenta*, Xanthan gum; an extracellular microbial hetero-polysaccharide produced by the aerobic fermentation of *xanthomonas campestris* [6]. It has a cellulose backbone substituted on every second residue, by a side chain consisting of two mannose units separated by a glucuronic residue. The gum is soluble either in hot or cold water, has a high viscosity at low concentrations [7]. Over the years we have imported materials to produce mud or in some cases imported already designed and produced drilling mud, this has been a major challenge especially to the indigenous companies involved in oil and gas because they have to import these materials at high costs and this has not allowed them to compete favorably and effectively. In this case, industry in this sector adjust the properties of the drilling fluid with the aid of the right types of additives which are also imported to suit the formation requirements of the area to be drilled. Research into this area is thus necessary. Nigeria is replete with natural resources in various forms, thus research to find how our own raw materials can be used or the availability of local substitutes which can be developed and examined within our country for educational and technological advancement of Nigeria.

2.0 RESEARCH METHODOLOGY

This study was divided into three phases namely: sample collection and preparation, rheological studies and analysis and discussion of result.

Ginger was purchased in large amounts from Oba Market, Benin City. They were sliced and then dried using sunlight as a source of energy for one week and two days and weighed regularly using the electronic weighing balance until a constant weight of 805g was attained, indicating that the ginger has properly dried. The dried ginger was grinded into powder and then sieved.

Instrument: U.S.A Standard Sieve A.S.T.M.E 11 Specification, Sieve size: 0.0098 inches

Cocoyam tubers were purchased in large amounts from Oba Market, Benin City. They were sliced and then dried in sunlight for 1 week and was then measured at a weight of 1989g. It was further oven dried in the laboratory for about 6 hours at 60°C and the weight reduced to about 1765g and further reduced to a constant mass of 1649g after two other 6 hour intervals. It was then grinded into dry powder and eventually weighed 1620g due to losses of solid particles during grinding process.

2.0.1 MATERIALS AND EQUIPMENT

Weigh balance, Fann V-G Viscometer, Glass Beaker, pH Paper, Spatula, Measuring cylinder, Mud Cup, Hamilton Beach Mud mixer, Step Down Transformer, Digital Weighing Machine, Laboratory coat, Stop watch, Nose mask..

Bentonite, Xanthan Gum, Cocoyam, Ginger, Sodium Chloride, Sodium Hydroxide pellets.

2.0.2 PROCEDURE

- (i) 500ml of water was measured using a measuring cylinder and poured into a beaker.
- (ii) 5.05g of NaCl was added to the water and stirred at low speed using the Hamilton Beach Mud mixer for 3 minutes.
- (iii) 5.05g of NaOH was added to the water in order to increase the pH and stirred at low speed using the Hamilton Beach Mud mixer for 3 minutes.
- (iv) 32g of Bentonite was added and mixed at medium speed using the Hamilton Beach Mixer in order to achieve homogeneity of the mixture.
- (v) (10g of Xanthan Gum, 45g of Ginger, 45g of Cocoyam), added and mixed at high speed using the Hamilton Beach Mixer and carried for 5minutes, 10minutes and 15 minutes respectively.
- (vi) The rheological readings were then taken from the Fann V-G Viscometer at varying speeds of 100rpm, 200rpm, 300rpm and 600rpm and Gel strength (maximum deflection) at 10seconds and 10minutes were recorded and the corresponding plastic viscosities and yield points are calculated.

4.0 PRESENTATION OF RESULTS

The formula for calculating plastic viscosity: $PV = \phi_{600rpm} - \phi_{300rpm}$ (1)

The formula for calculating yield point is: $YP = \phi_{300rpm} - PV$ (2)

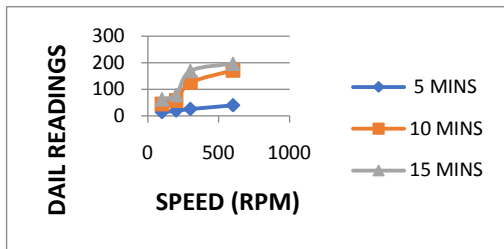


Fig 1: The effect of mixing times on the rheological properties of xanthan gum in drilling fluids

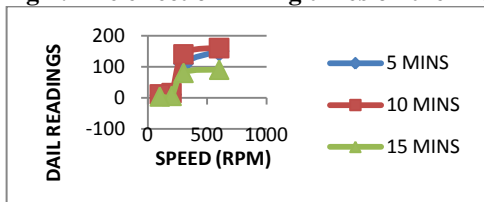


Fig 2: The effect of mixing time on the rheological properties of ginger in drilling fluids

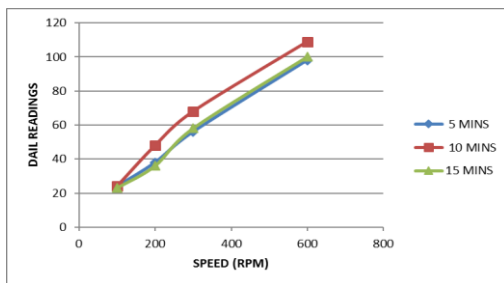


Fig 3: The effect of mixing time on the rheological properties of cocoyam in drilling fluids

One of the easiest ways to hydrate polymer is mixing. In some formation, the need for proper hydration of drilling mud is an advantage especially when viscosity needs to be increased. But for shaly formation, dehydration of the mud becomes useful so as to prevent the shale from taking in much water and the slough. From Figure 1,2 and 3 alongside Appendix 1,2 and 3 various mixing times for different drilling additives were analyzed to determine the best mixing time for proper hydration of the mud. Figure 1 showed that 15 minutes mixing time is the best for xanthan gum solution, Figure 2 indicated that 10 minutes mixing time should be adopted and same time should be adopted for cocoyam. Analyzing the above scenario showed that for ginger and cocoyam, excessive mixing of their solution will result in loss of viscosity.

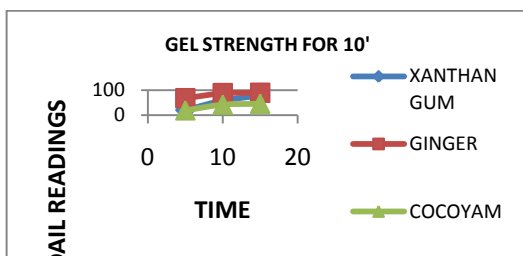


Fig 4: Gel strength for 10 Seconds

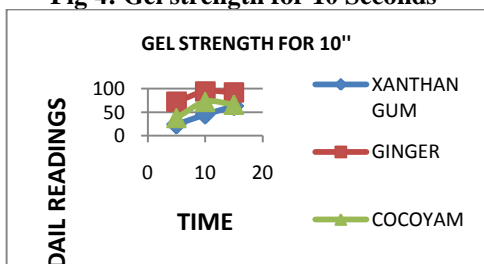


Fig 5: Gel strength for 10 Minutes

It can be seen that Ginger possesses the best thixotropic qualities to the drilling process. It will suspend cuttings much easier than Cocoyam and Xanthan Gum. This therefore makes it the most suitable in terms of static properties. Gel represents the shear stress necessary to break the gel structure and is measured after set times of ten seconds and ten minutes. These set times are arbitrary and the difference in the two measurements is an indication of the rate of gelation; from Figure 4 and 5, it is obvious that cocoyam has a higher rate of gelation than ginger and xanthan gum which makes it suitable for short quiescent period of time.

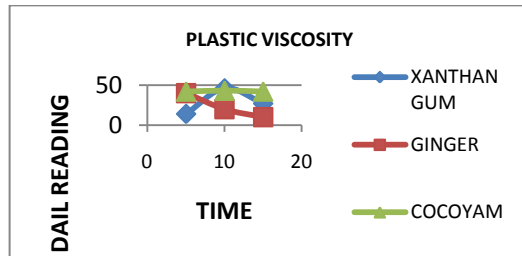


Fig 6: Comparison of Plastic Viscosities for Xanthan Gum, Ginger and Cocoyam

Figure 6 show that the plastic viscosity of xanthan gum increases from five minutes to ten minutes and decreases at fifteen minutes for this reason xanthan gum can perform different functions of cleaning the hole at ten minutes and cleaning beneath the bit at five and fifteen minutes.

The plastic viscosity of ginger decreases as mixing time increases which is more suitable for cleaning beneath the bit. Ginger has a higher penetration rate than Xanthan gum because a decrease in plastic viscosity signals a corresponding decrease in the viscosity at the bit, resulting in higher penetration rate.

The plastic viscosities of cocoyam is stable at averagely high values of 42cP. this make it suitable for hole cleaning purposes.

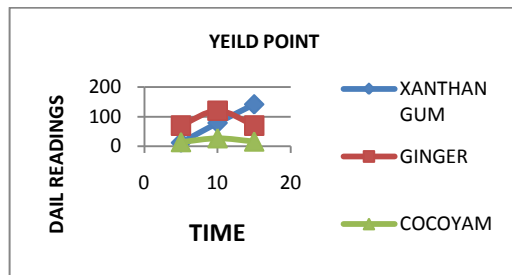


Fig 7: Comparison of Yield Point for Xanthan Gum, Ginger and Cocoyam

Result from Figure 7 indicates that the yield point of xanthan gum increases with increase in time which increases the hole cleaning capacity of the fluid and the circulating pressure drop in the annulus. Although high yield point values are primarily associated with hole cleaning capability and pressure control characteristics, it is detrimental to the problems of lost circulation, swabbing and good cutting carrying capacity hence Ginger is more suitable than xanthan gum because it increases at ten minutes mixing time to $120_{lb/100ft}^2$ and decreases again at fifteen minutes mixing time to $70_{lb/100ft}^2$.

CONCLUSION

Xanthan Gum is extensively used due to its extraordinary rheological properties which remain stable when exposed to the effect of mixing time and its compatibility with most drilling fluids. But Xanthan Gum is not cost effective. The rheological properties of ginger and cocoyam are stable when subjected to the effect of mixing time and ginger and cocoyam are cost effective additives.

Ginger and Cocoyam readily adsorb water from their mechanism of interaction with the medium and have favorable fluid loss properties. The gel strength of Ginger and that of Cocoyam is averagely high which means that suspension of particles would be very stable. Their plastic viscosity tends to be very high at average mixing time of 10 minutes but this is a manageable problem.

The research is necessary to replace foreign additives with local additives due to the major challenge of importing foreign additives at high costs and the need for increase in production operation.

APPENDIX 1: EFFECT OF MIXING TIME ON THE RHEOLOGY PROPERTIES OF XANTHAN GUM IN DRILLING FLUIDS

SPEED (RPM)	DIAL READING AT 5MINS	DIAL READING AT 10 MINS	DIAL READING AT 15MINS
600	40	171	196
300	26	125	169
200	20	58	79
100	14	45	63
GEL			
10'	20	58	78
10''	24	45	63
PV	14	46	27
YP	12	79	142

APPENDIX 2: EFFECT OF MIXING TIME ON THE RHEOLOGY PROPERTIES OF GINGER IN DRILLING FLUIDS.

SPEED (RPM)	DIAL READING AT 5MINS	DIAL READING AT 10 MINS	DIAL READING AT 15MINS
600	150	160	90
300	110	140	80
200	10	15	6
100	8	11	4
GEL			
10'	68	88	90
10''	72	94	92
PV	40	20	10
YP	70	120	70

APPENDIX 3: EFFECT OF MIXING TIME ON THE RHEOLOGY PROPERTIES OF COCOYAM IN DRILLING FLUIDS

SPEED (RPM)	DIAL READING AT 5MINS	DIAL READING AT 10 MINS	DIAL READING AT 15MINS
600	98	109	100
300	56	68	58
200	38	48	36
100	24	24	23
GEL			
10'	19	42	46
10''	38	72	66
PV	42	41	42
YP	41	27	16

REFERENCES

- [1] American Institute of Petroleum (1998). Petroleum Review, Vol. 52: *Institute of Petroleum*.
- [2] Dolz.M., Jiménez, J., Hernández, M.J., Delegido, J and Casanovas. A. (2007): Flow and thixotropic of non-contaminating oil drilling fluids formulated with bentonite and sodium carboxymethyl cellulose". Journal of Petroleum Science and Engineering, 57(3–4), 294-302.
- [3] Hamida, T., Kuru, E and Pickard, M. (2010): Filtration loss characteristics of aqueous waxy hull-less barley (WHB) solutions. Journal of Petroleum Science and Engineering, 72(1–2): 33-41.
- [4] Van Dyke, K., Baker, R., (1998). Drilling fluids, mud pumps and conditioning equipment. 1st ed. Austin, Tex.: Petroleum Extension Service.

- [5] Baba Hamed, S and Belhadri, M. (2009): Rheological properties of biopolymers drilling fluids. *Journal of Petroleum Science and Engineering*. 65(1-2), 245-255.
- [6] Bresolin, T. M. B., Milas, M., Rinaudo, M. and Ganter, J. L. M. S. (1998) *International Journal of Biological Macromolecules*, **23**(4), 263-275.
- [7] Garcia-Ochoa, F., Santos, V.E., Casas, E., (2000): Xanthan gum: production, recovery and properties *Biotechnology Advances*, pp549-579.