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Synthesis of Polymer Drilling Mud Using Blend of Guinea Corn and Millet Starches

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Abstract— *This work shows the use of blended starches from Guinea corn and Millet to formulate a water-based polymer drilling mud. The process was established through an extrusion method where the extracted starches were blended and pre-gelatinized without solvent or chemical. An already existing mud, tagged* ***CMS:HPS-Mud,*** *was used as a standard for comparing to the new mud, tagged as* ***G:M-Mud,*** *at 25°C-320°C temperature range and 0.02g/ml concentration using a filter loss method. A higher sorptivity value of 33.25 was observed at 320°C for the new starch polymer drilling mud when compared to the already existing mud whose value was 17.10. The diffusivity of both mud was also checked. This indicates the potency of the new polymer mud to have a better filter cake property. The new polymer mud also showed better filtration control behavior and lower fluid loss values than already existing mud at all temperatures. At a Temperature of 320°C, 260.00 and 739.00 of* ***G:M-Mud*** *and* ***CMS:HPS-Mud*** *were obtained respectively as the fluid loss values, indicating that the new polymer mud has a better thermal stability than the already existing mud. The new polymer mud also exhibited certain properties that are of better advantage in drilling operation such as purity, ability to absorb and retain a flowing fluid, hence reducing fluid loss more than the already existing mud at different temperatures.*

Keywords— *Blend, Guinea corn, Millet, Starch-polymer, Pre-gelatinization, Drilling mud, Sorptivity, Diffusivity.*

I. INTRODUCTION

For many reasons the petroleum industry, for many years, has spent so much money and energy into production of starch (Cyracus, 2012; Jeffrey, 2007). Starches synthesized for drilling mud in the past could be expensive, toxic to the environment with low drilling capabilities (Bernu, 2011; Longey, 2006). Hence, the much dedicated research effort to evaluate the properties and characteristics of drilling mud and to determine its performance limitations (Wami et. al, 2015; Ferguson and Klotz, 2010). There are many reasons to obtain a drilling mud with better drilling properties. When there is an excessive loss of fluid, the following effects may occur, which are; formation instability, damage, fractured formation and wastage of fluid (Amani, 2012). Fluid loss prevention is a major characteristic that determines the effectiveness of drilling fluid. For most starch and chemically synthesized drilling fluids, loss of fluid can cause an irreversible change in the drilling fluid properties, such as density or rheological faults, resulting in instability of the borehole (Amani, 2012; Mandy, 2001). Another attempt is to produce a drilling mud with good viscous property (Egun and Achandu, 2013; Okumo & Isehunwa, 2007). This determines the flow property of a mud. During drilling, less viscosity may be required at the initial depths, but at deep bottom hole, more viscous fluid may be required. Deep wells, directional wells, high penetration rates, high mud weights and high temperature gradients create conditions requiring close attention to the viscosity flow properties (Olatunde, 2011; Paulsen et al., 2001). The viscosity can be adjusted upwards and downward with polymer starch. Most starches of chemically synthesized drilling mud usually have low mud pressure, this causes the mud filtrate to move into the formation and a filter cake of mud is deposited on the walls of the wellbore (Wami et al., 2015; Mangelsdorf, 2004). For these reason, mud is designed to deposit thin, low permeability filter cake to limit the invasion (Qartar, & Giacelo, 2010; Patel et al., 2001). These few specifications placed the need to generate an environmental and ecofriendly drilling mud (Paulsen et al., 2002). Polymer starch can now be extracted from local crops such as guinea corn or millet and many other starch source. The use of starches from polymers in production of drilling mud has been described in the past (Cyracus, 2012). This paper discusses the improved properties the new polymer mud has compared to chemically modified starch. The extraction, filtration and testing process were explained in details and its advantages over a chemically modified drilling mud.

II. MATERIALS

The materials that were used in this work include; Guinea corn (Sorghum Bicolor), Millet (Panicum Miliaceum), Double distilled water Sodium Hydroxide (NaOH), Blend of Caboxymethyl starch and Hydroxypropyl starch (CMS:HPS, standard/widely-used), Bentonite Clay.

III. METHODS

Preparation of Samples

These steps were taken in preparing the samples; Starch extraction, Extrusion/Blending of starches, and Preparation of muds.

Extraction of Starches

There was extraction of starches from local guinea corn and millet. The starch extraction was done by soaking the Grains of guinea corn and Millet separately in water over night. A fine paste was obtained by grinding the softened grains when removed from water. The sieving of the mash was carried out through a cloth bag into enough volume of distilled water. The extract was allowed to stay for about two hours. Thereafter, the starch was obtained by pressing out the water. Then, the starch was dried at a low temperature for twenty-four hours.

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Extrusion/Blending of Starches

Blends of novel starch products were extruded from the corn that was used to produce the starch. A starch blend prepared from the gelatinization and extrusion technique used for this work is G:M (blend of guinea corn starch and waxy corn starch). The method of preparation was done by putting the Guinea corn starch and Millet starch in water in the ratio of 85:85:45 in an extruder. The extracts are cut to tiny 2-3mm sizes. It was then exposed to a temperature of 105°C for 24hrs. The mixture was subjected to a grounder to produce lesser particles that can be used to produce the mud.

Preparation of Muds

Betonite clay was dissolved in water for 20 minutes using a mixer. After the mixing process a quantity of the new polymer starch blend (G:M) was also dissolved gradually in the entire mixture. A commonly known base, sodium hydroxide NaOH, was added to control the pH level of the mud. After the entire process, the resulting new polymer mud**(G:M-Mud)** contained 6% of bentonite and 0.02g/ml starch concentraion. While that of the chemically modified starch which was used as a standard blend **(CMS:HPS-Mud)** contained similar concentration as that of the new mud. The entire prepation process was aided with a distilled water.

IV. Experimental Method

Filter Loss Method

Filter loss is the volume of filtrate lost to the permeable material due to the process of filtration. The ability of the drilling mud to meet certain drilling requirement is determined after subjecting it to a filtration test through filter loss method. The device, standard filter press, at pressure of 200PSI carried out several tests on both samples **(G:M-Mud and CMS:HPS-Mud)** at room temperature of 25°C and higher temp of 150°C, 250C and 320C. The test was repeated for up to 3 times for both mud samples and the values obtained was recorded.

Sorptivity (S) and Diffusivity (D) of the Mud.

The Sorptivity (S) was given according to American Petroleum Institute, API, (Bertts and Jerry, 2012; Cambel et al., 2007) as

$$V=St^{½} \quad (1)$$

Where V is the filtrate volume or fluid loss or filter loss, S is the sorptivity of fluid, and was obtained as the slope of the plot, t is the filtration time in minutes.

The Diffusivity (D) was computed using equation 2 (Bertts and Jerry, 2012;).

$$\Phi(R) = \Phi o \exp^{-Dt} \quad (2)$$

Where Φo and Φ are initial and final filtration rates respectively,

D is the diffusivity of fluid, and was obtained as the slope of the plot, t is time in minutes.

TABLE 1. Experimental Data and Results for the Filtration Properties of the Muds (G:M–Mud and CMS:HPS-Mud) with 0.02g/ml Starch concentration at 25ºC, 150ºC, 250ºC, 320ºC Temperatures.

				G:M–Mud		CMS:HPS-Mud	
Temp ºC	**Time t (mins)**	**Conc (g/ml)**	**Square Root of Time, $t^{1/2}$ (mins)**	**Fluid loss, filtrate volume, V (ml)**	**Rate of filtration, (fluid loss/Time), (ml/min)**	**Fluid loss, filtrate volume, V (ml)**	**Rate of filtration, (fluid loss/Time), (ml/min)**
25ºC	50	0.02	7.07	70.00	1.40	146.00	2.92
	100	0.02	10.00	87.00	0.87	176.00	1.76
	150	0.02	12.25	98.00	0.65	197.00	1.31
	200	0.02	14.14	108.00	0.54	213.00	1.07
	250	0.02	15.81	116.00	0.46	229.00	0.92
	300	0.02	17.32	120.00	0.40	239.00	0.80
150ºC	50	0.02	7.07	128.00	2.56	221.00	4.42
	100	0.02	10.00	141.00	1.41	240.00	2.40
	150	0.02	12.25	156.00	1.04	258.00	1.72
	200	0.02	14.14	165.00	0.83	272.00	1.36
	250	0.02	15.81	175.00	0.70	285.00	1.14
	300	0.02	17.32	181.00	0.60	292.00	0.97
250ºC	50	0.02	7.07	152.00	3.04	251.00	5.02
	100	0.02	10.00	168.00	1.68	278.00	2.78
	150	0.02	12.25	179.00	1.19	306.00	2.04
	200	0.02	14.14	193.00	0.97	328.00	1.64
	250	0.02	15.81	205.00	0.82	346.00	1.38
	300	0.02	17.32	216.00	0.72	358.00	1.19
320ºC	50	0.02	7.07	177.00	3.54	398.00	7.96
	100	0.02	10.00	197.00	1.97	477.00	4.77
	150	0.02	12.25	215.00	1.43	553.00	3.69
	200	0.02	14.14	236.00	1.18	619.00	3.10
	250	0.02	15.81	244.00	0.98	678.00	2.71
	300	0.02	17.32	260.00	0.87	739.00	2.46

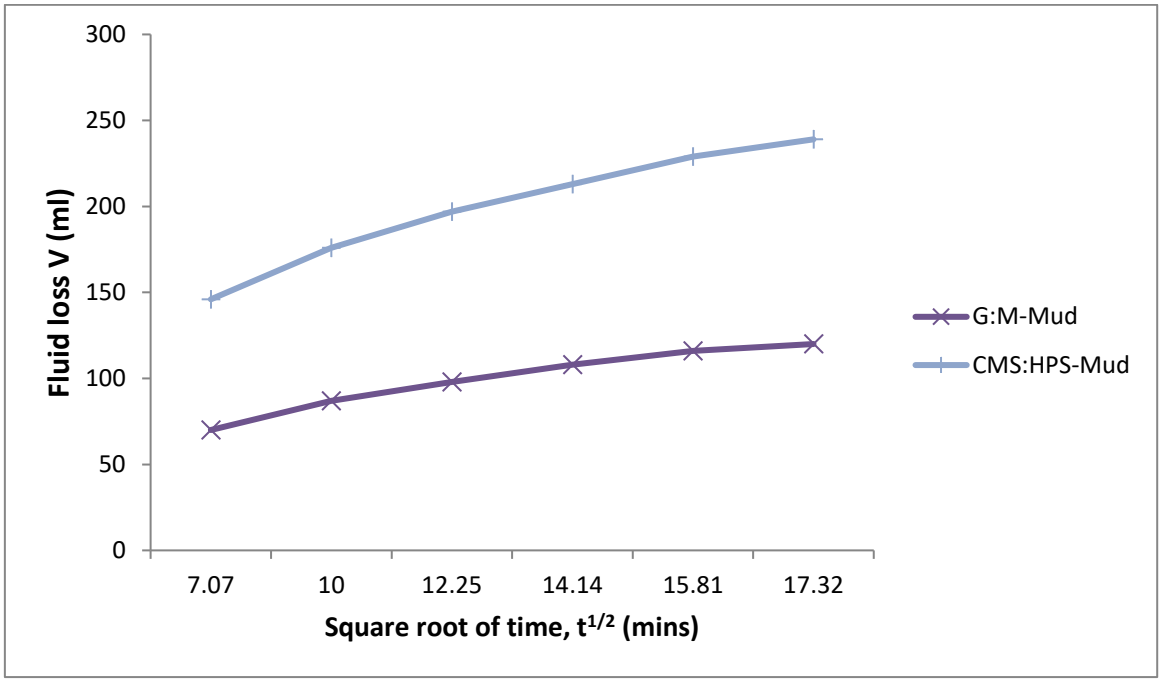

Fig. 1. Plot of Fluid Loss versus Square Root of Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 25°C.

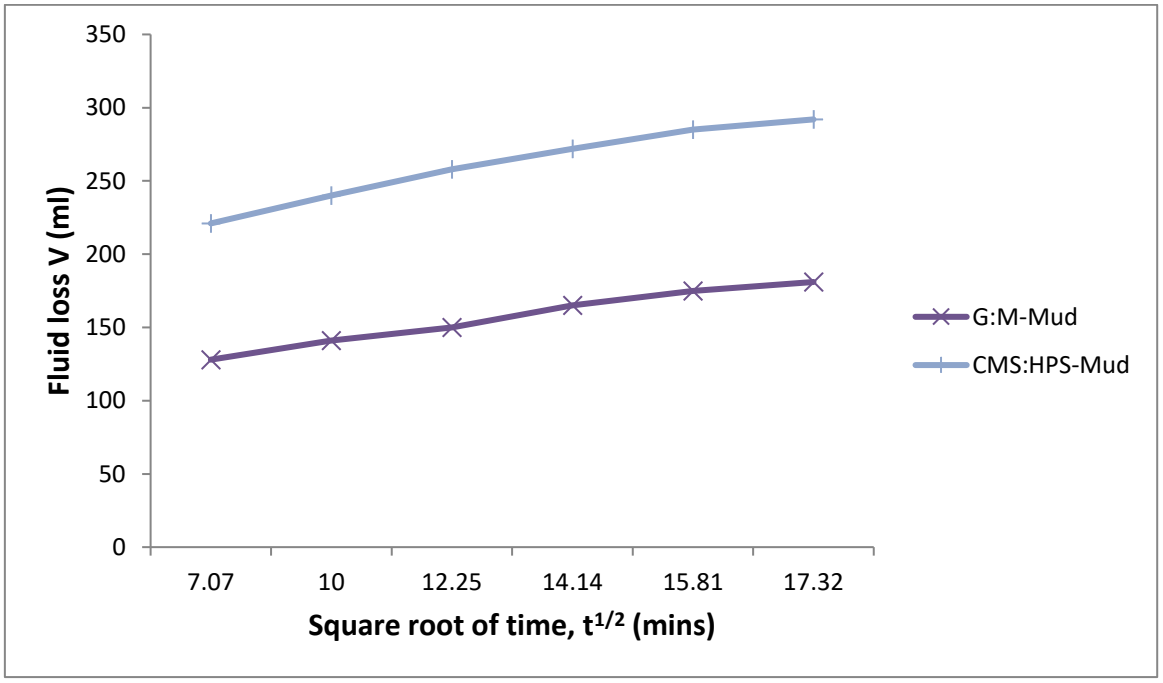

Fig. 2. Plot of Fluid Loss versus Square Root of Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 150°C.

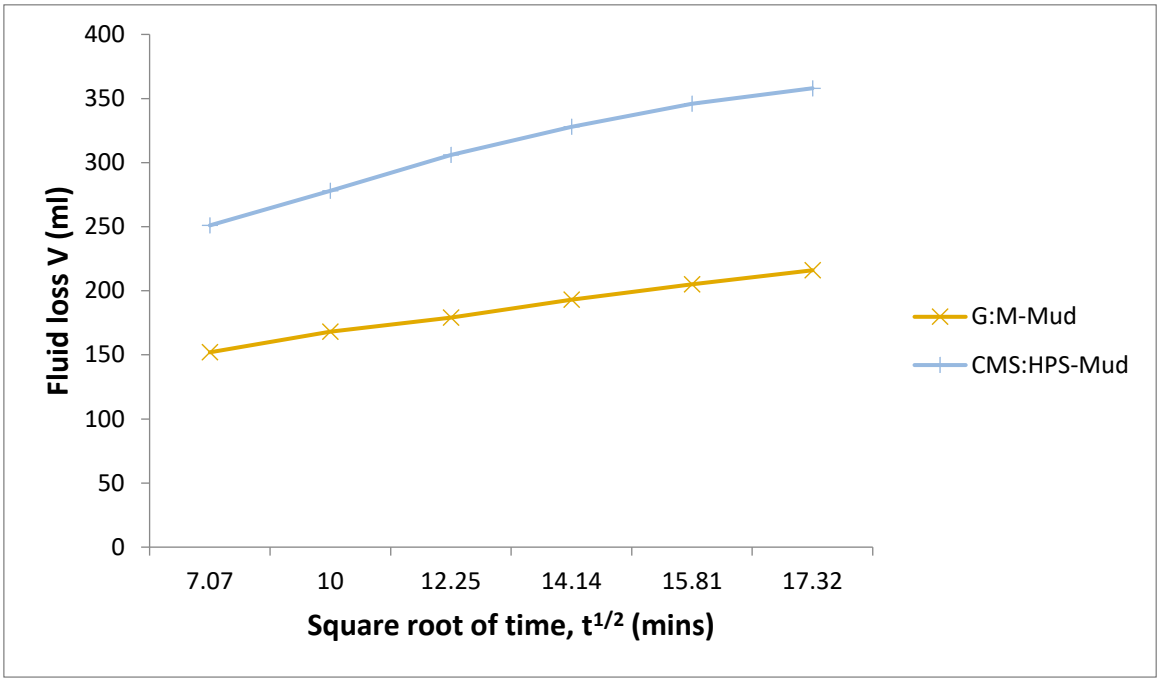

Fig. 3. Plot of Fluid Loss versus Square Root of Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 250°C.

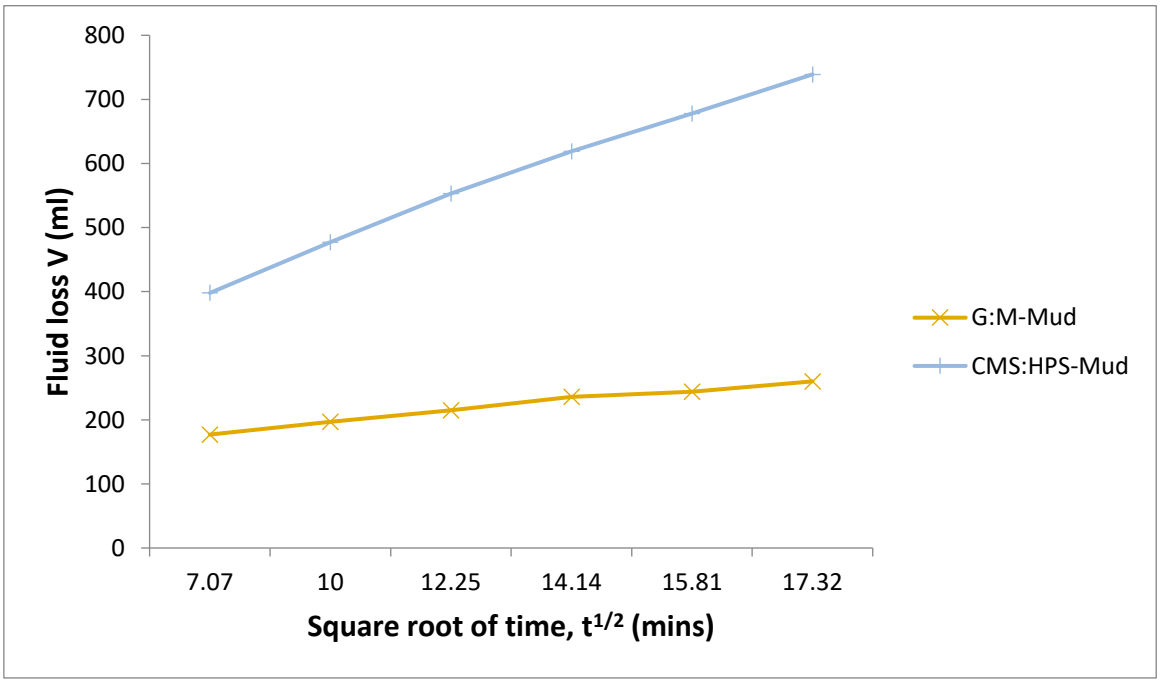

Fig. 4. Plot of Fluid Loss versus Square Root of Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 320°C.

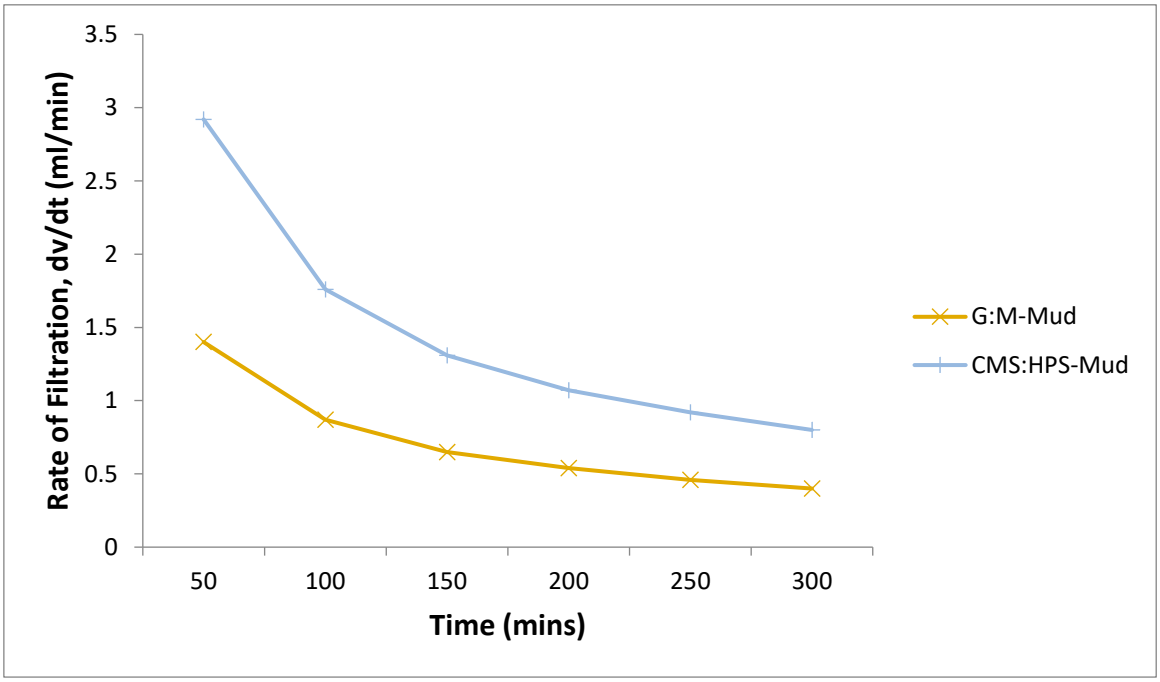

Fig. 5. Plot of Rate of Filtration versus Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at Room Temperature, 25°C.

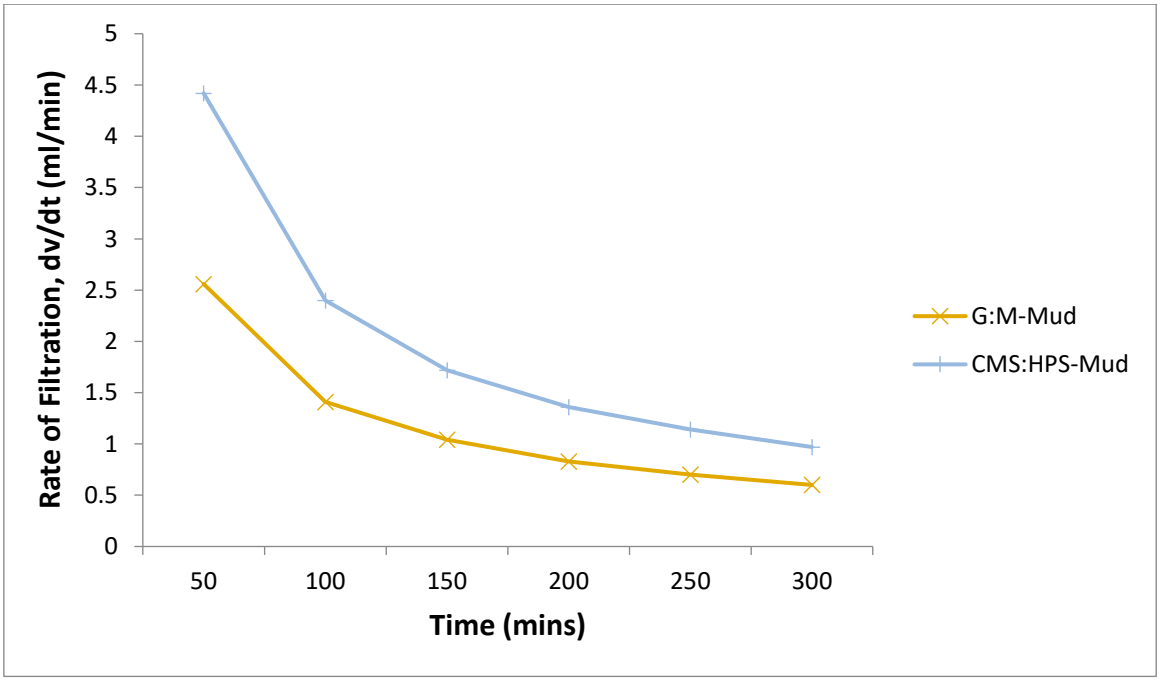

Fig. 6. Plot of Rate of filtration versus Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 150ºC.

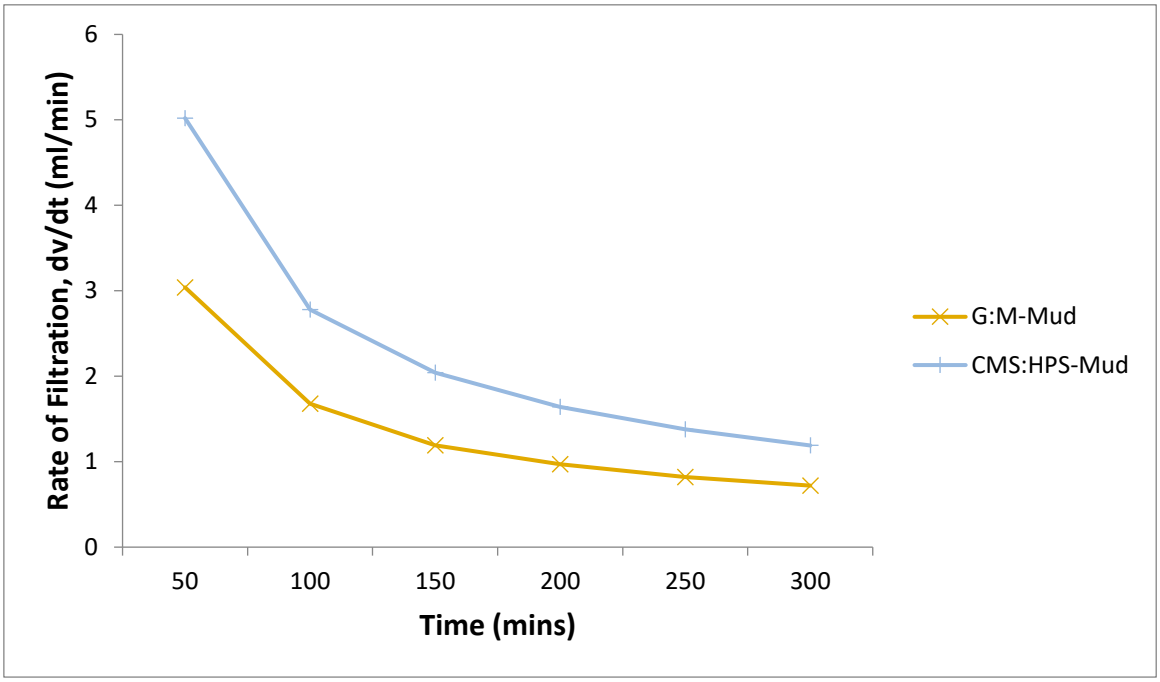

Fig. 7. Plot of Rate of filtration versus Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 250°C.

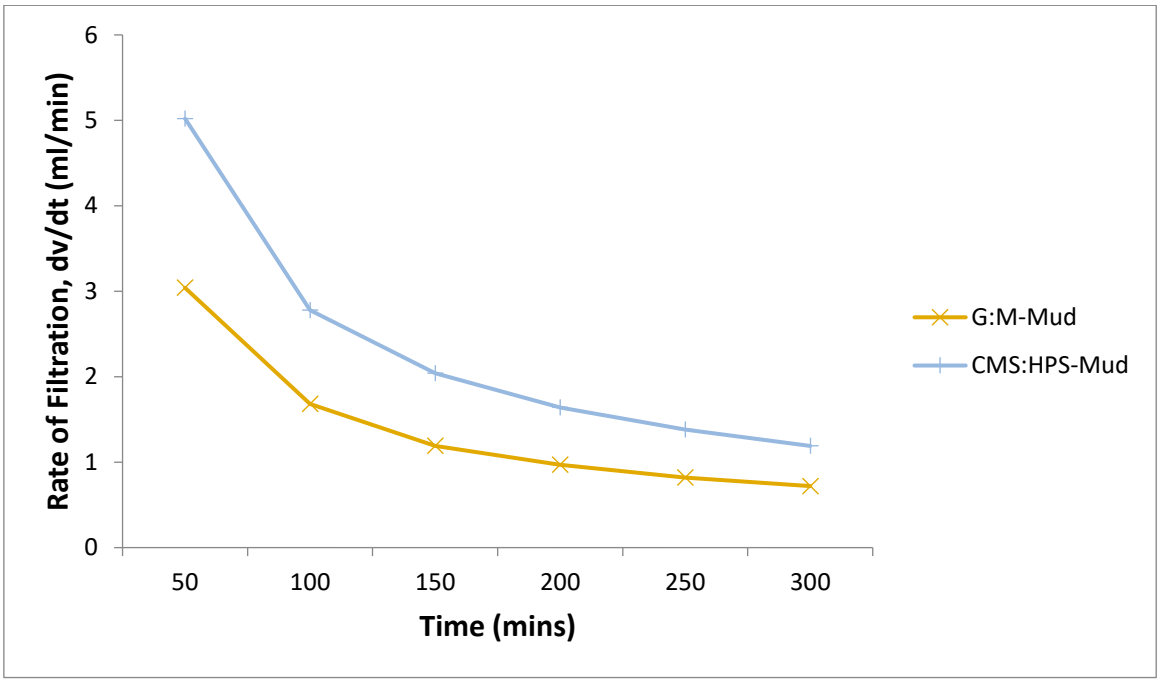

Fig. 8. Plot of Rate of filtration versus Time for the Muds (G:M-Mud and CMS:HPS-Mud) with 0.02g/ml Starch Concentration at High Temperature, 320°C.

V. Result and Discussion

The experimental data plotted in Figure 1, 2, 3 & 4 shows the curve of G:M-mud and CMS: HPS-Mud at various temperatures of 25°C, 150°C, 250°C and 320°C respectively. The mud followed the API law for standard filtration law which states that fluid loss increases with square root of time (Bertts and Jerry, 2012). And this is broadly represented in the resulting fluid loss figure of (G:M-Mud) and (CMS:HPS-Mud) whose values were obtained to be 210.00ml and 739.00ml respectively at highest testing temperature of 320°C. It was observed that flow of fluid increases with temperature, that is, as the temperature and time increases, the more excited the fluid molecules. This also resulted in an increase fluid volume, reduced molecular friction and increased flow rate (Amani, 2012). Also an increased temperature resulted in high mud quantity and less formation of filter cake (Wami et al., 2015). The graph of figure 5-8 shows the plot of rate of filtration on the vertical against time (min) on the horizontal for both (G:M-Mud) and (CMS:HPS-Mud) samples. The rate of filtration

value for (G:M-Mud) was obtained by dividing fluid loss value of the mud with time while that of (CMS:HPS-Mud) was obtained from similar calculation. The graph was plotted at different temperatures of 25ºC, 150ºC, 250ºC and 320ºC showing a decline as represented in figure 5, 6, 7 & 8 respectively for both G:M-Mud and CMS:Mud samples. The greatest decline was seen to be CMS:HPS mud at 320ºC which started from 7.96 to 2.46 compared to our new polymer which began at 3.54 to 0.87 rate of filtration against time. This shows that the new polymer mud had a moderate and better decay of rate of filtration compared to the standard existing mud.

The sorptivity was taken as the slop of the graph at temperature of 25ºC, 150ºC, 250ºC and 320ºC.

TABLE 2. Values of Sorptivity, S of the Muds at all the Temperatures under study.

Temperature	G:M-Mud	CMS:HPS-Mud
25 ºC	49.73	34.97
150ºC	42.68	27.11
250 ºC	37.82	22.10
320 ºC	33.25	17.10

The new polymer mud had better sorptivity at 320ºC. This indicate that the new polymer drilling mud can perform effectively at high depth drilling process.

TABLE 3. Values of Fluid Diffusivity, D of the Muds at all the Temperatures under study.

Temperature	G:M-Mud	CMS:HPS-Mud
25 ºC	0.058	0.107
150ºC	0.094	0.173
250 ºC	0.128	0.335
320ºC	0.305	0.707

Similarly, diffusivity of a drilling mud is a measure of a fluid to transmit into the atmosphere. The observation from table 3 showed that the already existing mud had a higher diffusivity than the new polymer mud at all temperatures.

VI. Conclusion

From all calculations and readings, it is observed the above results showed that the new polymer mud had better sorptivity than the already existing mud. The diffusivity of the already existing mud was higher than the new mud showing that it is not suitable for a drilling operation. It, then, implies that each of the new muds has greater ability than any of the already existing muds in building up effective filter cake and absorbing flowing fluid. Ability to build up filter cake, to absorb fluid, to control fluid flow, and reduce fluid loss is dependent on viscosity.

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