World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.924

THE EFFECT OF PARTICLE SIZE ON MODIFIED LOCAL STARCHES AS FLUID LOSS CONTROL ADDITIVES IN A WATER-BASED DRILLING MUD

Sarah A. Akintola[1], Oritogun I. Keziah[1] and Julius U. Akpabio[2]*

[1]Department of Petroleum Engineering, University of Ibadan, Ibadan Oyo State Nigeria.
[2]Department of Chemical and Petroleum Engineering, University of Uyo, Uyo, Nigeria.

Article Received on 14/07/2022 **Article Revised on 04/08/2022** **Article Accepted on 24/08/2022**

***Corresponding Author**
Julius U. Akpabio
Department of Chemical and Petroleum Engineering, University of Uyo, Uyo, Nigeria.

ABSTRACT

There are lots of researches on the use of local materials as substitutes for imported drilling fluid additives. This study is aimed at determining how effective modified micronized local starches (Rice, Yam, and Corn) can be used to reduce the filtration properties of a water-based mud. Starch extracted from these starchy foods using the wet milling method were chemically modified and an analytical sieve was used to obtain two different particle sizes (63 micro-meter and 75 micro-meter) for each of the starch samples. The 63 micro-meter and 75 micro-meter size modified rice, yam and corn starches were labelled A, C and E, and B, D and F, respectively. The concentrations of the modified starches were varied by 0.5g (0.5g, 1.0g and 1.5g) in the treatment of a water-based mud. Same concentration of low viscous Carboxymethyl Cellulose (CMC) (sample G) and extra high viscous CMC (sample H) served as control. The effects of particle size and varying temperatures (30^{o}C, 50^{o}C, and 70^{o}C) on the filtration properties of a water based drilling mud treated with the various modified micronized starches with a Low-temperature/low-pressure American Petroleum Institute (API) Filter Press were investigated using the API Recommended Practice 13B-1 procedure. From the result, it was observed that there was no significant difference in temperature of fluid, particle size, and the type of additive used. Also, it was observed that the addition of the modified starch to the water-based mud caused a reduction in the fluid loss and a thin filter cake was formed. These starches were found suitable for use as drilling fluid additives.

KEYWORDS: Rice, Yam, & Corn starch, fluid loss, Drilling mud Additives, Particle sizes.

1. INTRODUCTION

Drilling operation in the oil and gas industry is a demanding task because most drilling problems can be indirectly or directly attributed to drilling fluids, so formulation of drilling fluid must be carried out carefully. Drilling fluid is a mixture of water, oil, clay and various chemicals which are used during drilling operations. The use of water as base fluid had resulted from its cost and environmental affinity.[1] Drilling mud must be formulated in a way to meet all the criteria necessary to achieve a successful cost-effective drilling project. The functionality of a drilling fluid is attributed to the properties of the drilling fluid density, rheological properties (apparent and plastic yield point, gel strength (10s and 10min), and filtration properties.[2] As a result, the filtration property of a drilling mud is one of the most measured properties after rheological properties and density. Filtration property is one of the important properties of a drilling fluid used in rotary drilling operations in the oil and gas industry because a major problem associated with a high fluid loss is formation damage due to filtrate invasion therefore a minimal fluid loss is desired. The ideal filter cake must be thin, and impermeable, will reduce the fluid loss and decrease the formation damage. In addition, thin filter cake will help avoid the common drilling problem such as differential sticking and this will reduce the total drilling cost.

The daily treatments in a drilling fluid system can be observed from the measurement obtained from the mud filtration properties and the acceptable standard API test condition range of less than 15 cc/30 min is tried to be achieved by the use of fluid loss additives. Different types of chemicals are used while formulating drilling fluid in order to get the appropriate density, mud rheology, fluid loss control property etc.[3] The use of starch in developing polymeric additives in oil and gas in¬dustry had come a long way. This is as a result of its unique structure despite its short-coming in its native state, numerous modified starch derivatives have been carried out for possible use in the oilfield. The use of pregelatinized starches as drilling mud additives was first mentioned by[4] References[5,4], investigated the use of five different cassava starches as viscosifiers and fluid loss control additives in water based mud and compared with Barazan, an imported sample, they concluded that with proper quality control efforts of the local samples, they could be used as a substitute for imported grade for exploration and exploitation of oil and gas in Nigeria.

In 2015 Reference[6] carried out a comparative analysis of properties obtained from the prepared potato starch mud and those of Polyanionic cellulose (PAC). The results they got showed that combination of PAC and potato were all in line with the standard mud specifications. They[6] studied the effect of temperature and time–dependent behaviour of a water-based mud treated with maize (*zea mays)* and cassava (*manihot esculanta*) starches, they observed that both native maize (*zea mays)* and cassava (*manihot esculanta*) were good materials that could be used as drilling fluid additives, although they tend to degenerate as temperature increases with aging time.[7] investigated the impact of some reagents used in the synthesis of Carboxymethyl starch as additives in drilling mud and concluded that the use of isopropanol as solvent gave the best filtration loss properties, Reference[8] used corn starch and banana starch to test the effectiveness of different Starches as drilling fluid additives in Non Damaging Drilling Fluid (NDDF). This study has showed that Banana Starch and Corn Starch work excellently as the fluid loss control agent as NDDF.[9]

Various studies on the effect of reduction of the particle size of some drilling additives have been carried out A comparative study was carried out on the use of micronized ilmenite (5µm) and API barite as weighting material in the improvement of the rheological properties of drilling fluid. The sample with the micronized ilmenite (5µm) showed a significant improvement.[10] While Al-Bagoury,[11] used micronized ilmenite (5 µm) as a weighting material to improve the rheological properties of a drilling fluid and the results obtained were more favourable than those of API barite. Reference[12] examined the effect of micro sized barite in preventing barite sagging, the study showed that the micronized barite yielded insignificant improvement in preventing barite sagging. References[13,12] assessed the effect of using micronized starch in enhancing the rheological properties of water-based drilling fluid. In their experiments, different starch particle sizes (60µm, 7µm, and 1µm) were used. The result indicated that the starch micronized-based (1µm) drilling fluid was efficient in forming a thin, and impermeable filter cake. Different types of statistical tools and tests were used to analyse the experimental data and predict the measurements of filtrate with respect to various parameters such as temperature and time. Reference[14] conducted experiments for different water-clay mixtures with varying concentrations at different pressure values by using standard API filter press and High-Pressure High-Temperature filter press. An empirical correlation was developed for estimating the filtrate volume.

The developed correlation can estimate filtrate volume with an error less than 20% for a wide range of pressure values. Reference[15] derived a new model to describe the fluid loss of nanoparticle-enhanced water based drilling mud under static filtration. The newly developed model was found to fit the fluid loss profile of the water based mud containing the silica nanoparticles. The new fluid loss model compares favourably with the industry based API static model with R^2 and RMSE ranging from 0.9989–0.994 and 0.41– 0.81cm^3 respectively.[13] in his study, enhanced the rheological properties of Water-Based Drilling Fluid using micronized starch. The results obtained from the study shows that micronized starch can be generated using the wet micro grinding technique in laboratory scale. The decrease in the starch size from 60 to 1µm, increased the plastic viscosity and yield point by 250% with an optimum YP/PV ratio of 1.5; also, the micronized-based (1µm) drilling fluid has a better filter cake property.[16,17]

2. MATERIALS AND METHODOLOGY

The following materials were used in the cause of the study, Native Starch from Rice, Yam and Corn were sourced from local farmers in Kebbi, Benue, and Oyo State, respectively. The soft tissue paper, Hamilton Multimixer, spatula, Ofite Filter Press, Mechanical grinder, peeler. Table Top Electromagnetic Sieve Shakers, Bowl, Weighing balance, Spatula, Beakers, Distil water, Conical flasks, Measuring cylinder, three neck round bottom flask, Nitrogen gas, Thermometer, Heater with a magnetic stirrer and Vacuum pump were provided by the Petroleum Engineering Laboratory of the University of Ibadan, while the Bentonite, Low viscous CMC and Extra high viscous CMC obtained from Mi-Swaco were used in the preparation of the base fluid. Analytical grade Iso-propanol, Sodium hydroxide (2N), Monochloroacetic acid (40% v/w), Methanol (80%), procured from Sigma Aldrich were used. The following steps were taken: Extraction of starch from rice, yam, corn. Modification of starch into carboxymethyl starch, Particle size separation, Preparation of mud samples and Filtration tests.

2.1 Procedure for Extraction of Starch

Using the method of wet milling, three labelled bowls (1,2 and 3) were used. Then 3kg of rice and 5kg of corn were soaked in water the bowl 1 and 2, respectively, while 4kg of yam was washed, peeled, sliced before soaking inside the bowl 3 filled with water for 26 hours for ease of grinding. The soaked materials were then ground to form a paste and sieved. Then water was expelled leaving the solid part of the mixture (starch) settling at the bottom of the bowls.

NaOH solution was added to the extracted starch mixture and left for 4 hours, The NaOH solution was expelled leaving the starch sediments at the bottom of the bowl. Distilled water was added to the caked sediment in order to rinse out the NaOH and allowed to stand for 4 hours, The distilled water was expelled leaving the solid part of the mixture (starch) settling at the bottom of the bowl. The starch sediments were scooped out and were placed on a flat tray and left outside to dry from direct sun ray

2.2 Procedure for Modification of Starch

Carboxymethylation of the extracted starches was carried out using the method of Khalil *et al* (1990)[16] with sight modifications. To obtain the modified starches from rice, yam and corn, the following procedure was taken 80ml of isopropanol and 20.0 ml of distilled water were measured using a measuring cylinder and poured into a beaker. 4.0 ml of 2N sodium hydroxide was measured and poured into the isopropanol water mixture in the beaker. 10g of starch (rice, yam and corn) was measured and dispersed in the solution. The beaker containing the mixture was placed on the heater and stirred magnetically. 10.0 ml of Monochloroacetic acid (MCA 40% w/v) was measured and added to the suspension at 70^0C. The mixture was heated for 60 minutes whilst intermittently stirring and ensuring the temperature of the mixture was 70^0C using a thermometer The obtained product was filtered immediately using vacuum pump and washed with 80% methanol and left to dry.

2.3 Particle Size Determination

Particle size distribution is used to determine filtration properties and the amount of solids retained in the DF after the fluid is pumped into the system while drilling an oil and gas well. This is important. in order to effectively bridge the formation and be able to form a thin permeable filter cake. Particle size separation into 63µm and 75µm was then carried out on the modified starch samples using a Table Top Electromagnetic Sieve Shaker.

2.4 Formulation of Water Based Mud

The mud samples were prepared and labelled as shown in the Tables 1 and 2. The additives are sample A and B (Modified Rice Starch, MRS, 63µm and 75µm, respectively), sample C and D (Modified Yam Starch, MYS, 63µm and 75µm, respectively), sample E (Modified Corn Starch, MCS, 63µm and 75µm, respectively), sample G and H (Low viscous CMC and Extra high viscous CMC, respectively).

2.5 Data analysis

The data obtained were analysed using both descriptive statistical method and inferential statistical method. This is to test if there is any significant difference between various variables with respect to the filtrate volume.

3. RESULTS AND DISCUSSION

3.1 The Fluid loss of the Mud Samples at Varying Temperature (30, 50 and 70 °C)

Figures 1 - 8 show plots of Fluid loss (cm^3) against Square root of Time (mins) for all the mud samples using different concentrations of the additives and temperatures. From Figures 1 and 2 it was observed that the trend lines of almost all the mud samples tend to align, meaning an insignificance but that of sample D shows a visible difference in filtrate volume.

Also, from Figure 3, it is observed that at 2 minutes, sample F and the control additives trend lines were very close, this implies that sample F performed better than the rest with respect to the 2 control additives. In Figure 4, at 20 minutes the trendline of sample A diverges from the rest showing a visible difference in filtrate volume before converging at 26 minutes in Figure 5 Sample F performed better than the rest from 2 minutes to 8 minutes, In Figure 6, at 4 minutes the trendline of sample C diverges from the rest indicating a significant difference in filtrate volume, but converges and aligns with the others at 10 minutes. In Figure 7, an insignificant difference in filtrate volume between sample C and sample G occurs between 4 minutes and 8 minutes. In Figure 8, The difference in filtrate volume between the sample B and F and the control additive is significant, with the Sample B and sample F performing better than the other samples.

FIGURES AND TABLES

Table 1: Drilling Mud Composition with Varying Concentrations of 63µm Modified Starches with the control samples.

	A_1	A_2	A_3	C_1	C_2	C_3	E_1	E_2	E_3	G_1	G_2	G_3	H_1	H_2	H_3
Water (ml)	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Bentonite(g)	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
MRS (g)	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MYS (g)	0.0	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCS(g)	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
CMC-lv (g)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0
CMC-hv (g)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.5

Table 2: Drilling Mud Composition with Varying Concentrations of 75µm Modified Starches.

	B_1	B_2	B_3	D_1	D_2	D_3	F_1	F_2	F_3	G_1	G_2	G_3	H_1	H_2	H_3
Water (ml)	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Bentonite(g)	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
MRS (g)	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MYS (g)	0.0	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCS(g)	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
CMC-lv (g)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0
CMC-hv (g)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.5

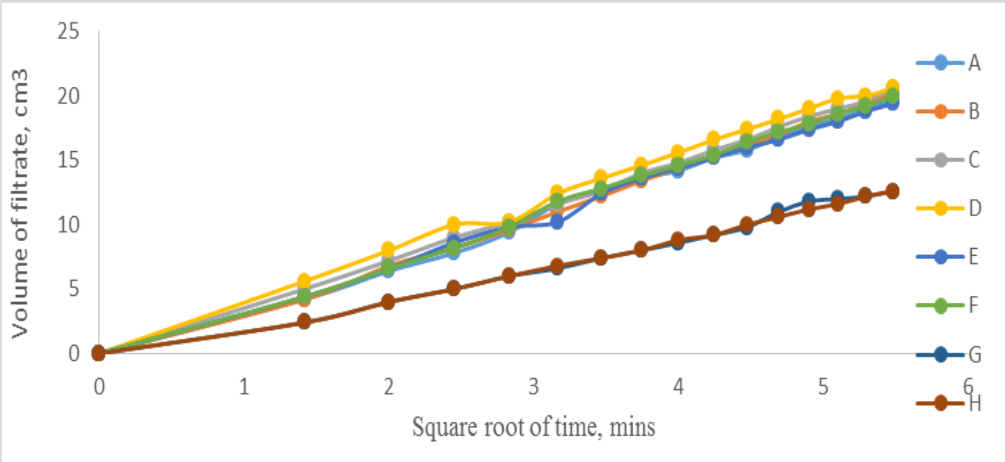

Fig.1: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 0.5g at 30^{o}C.

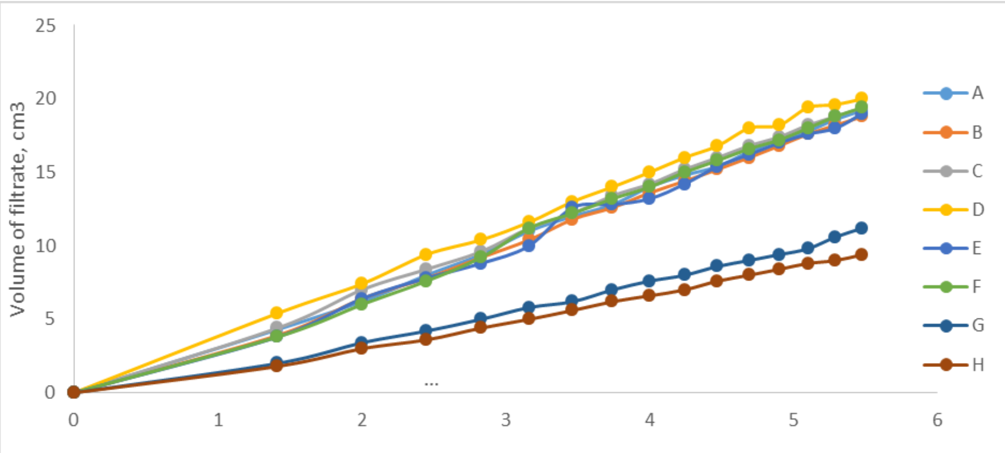

Fig 2: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 1.0g at 30^{o}C.

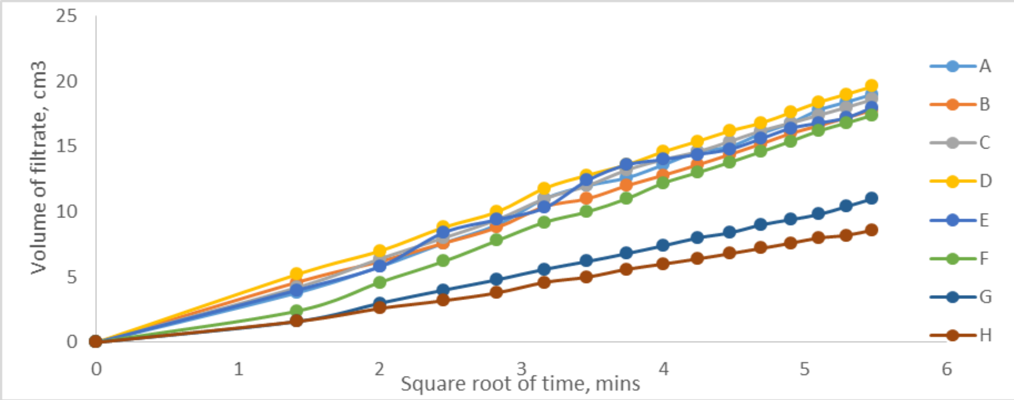

Fig 3: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 1.5g at 30°C.

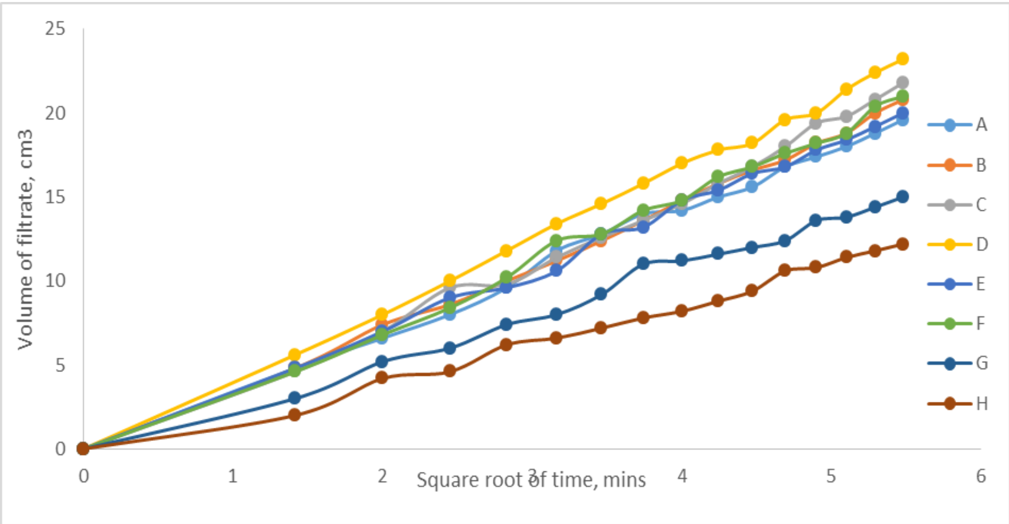

Fig 4: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 0.5g at 50°C.

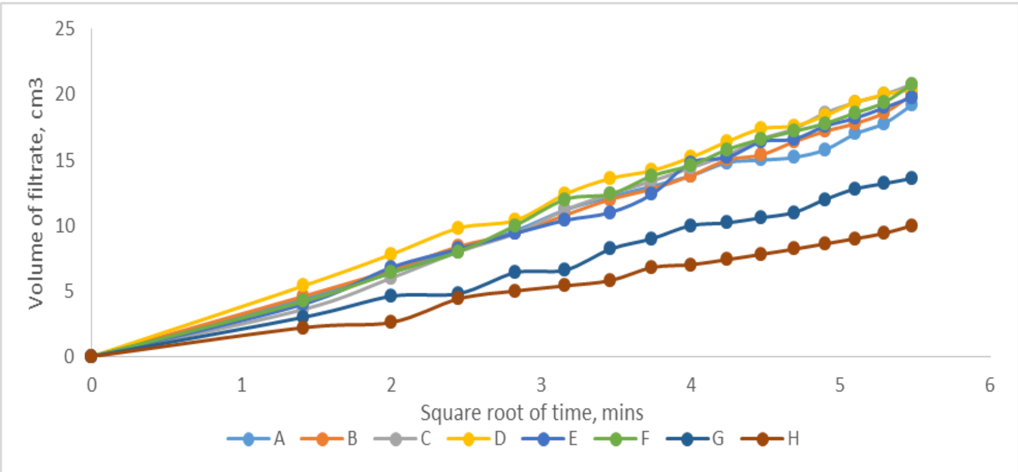

Fig 5: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 1.0g at 50°C.

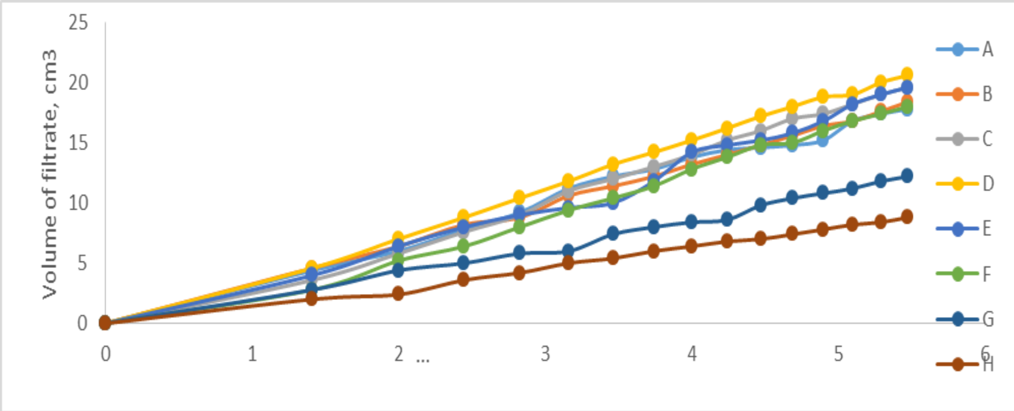

Fig 6: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 1.5g at 50^{o}C.

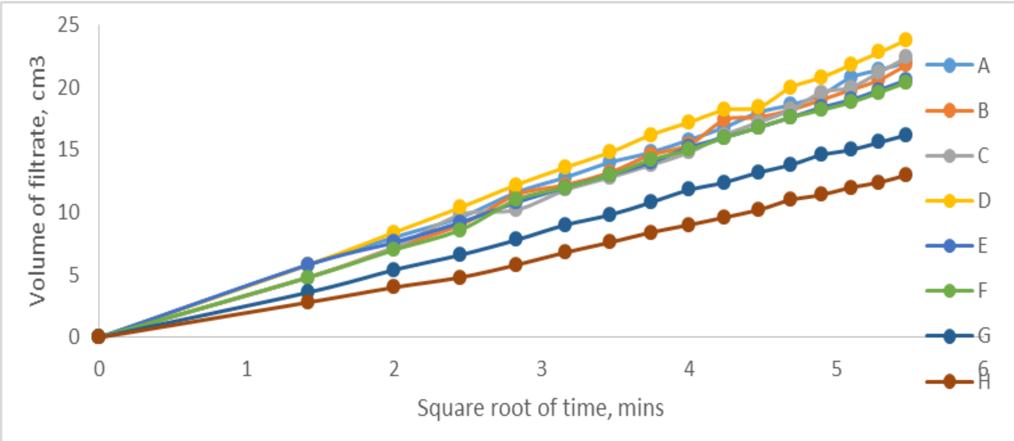

Fig 7: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 0.5g at 70^{o}C.

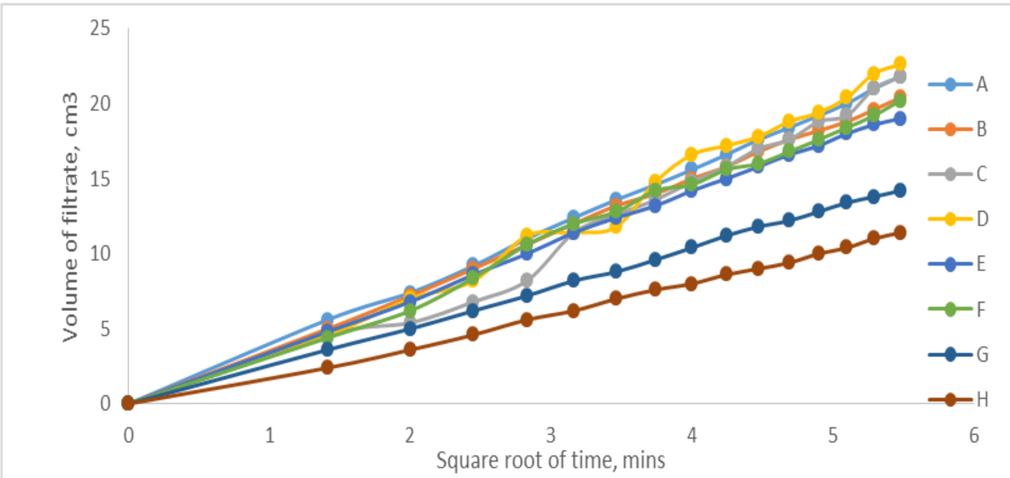

Fig 8: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 1.0g at 70^{o}C.

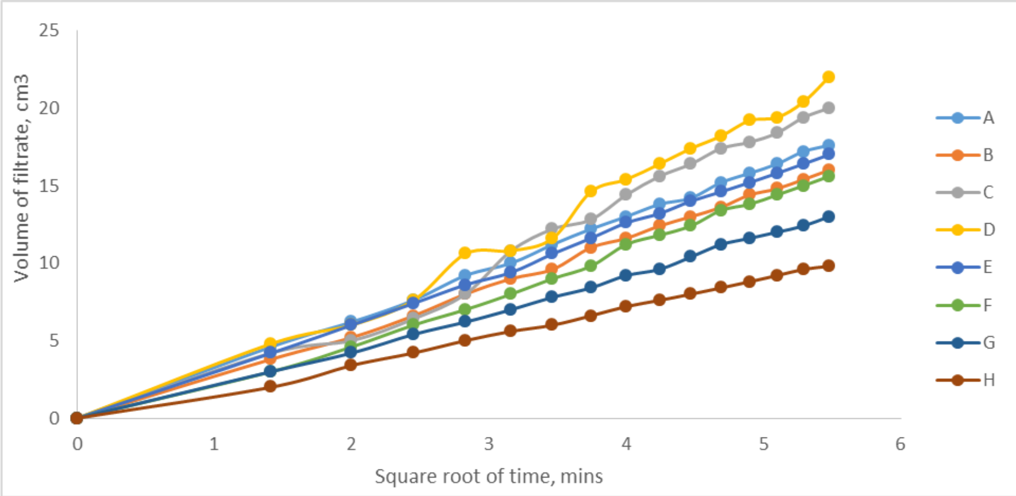

Fig. 9: Fluid loss (cm^3) against Square root of Time (mins) for all samples using a concentration of 1.5g at 70^{o}C.

3.2. Statistical Test for Significance in Particle for Each Additive

From the boxes and the whiskers in the box plot for Figures 10 to 12 for the modified rice, yam and corn starches, respectively. There were not much variability in the filtrate volume for both particle sizes as they tend to have the same inter-quartile ranges, and similar spread in variability. While the bar chart in Figures. 13, 14 and 15 further suggests no much difference in the filtrate volume of both particle sizes as they shared a similar average filtrate volume.

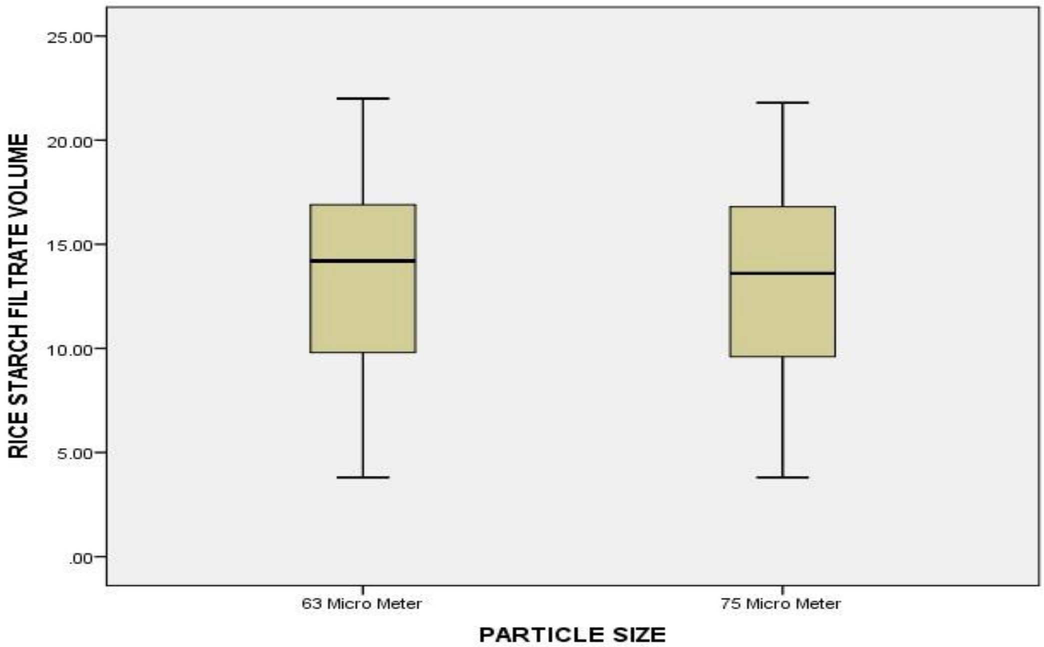

Fig. 10: Box plot of MRS filtrate volume (cm^3) against Particle size.

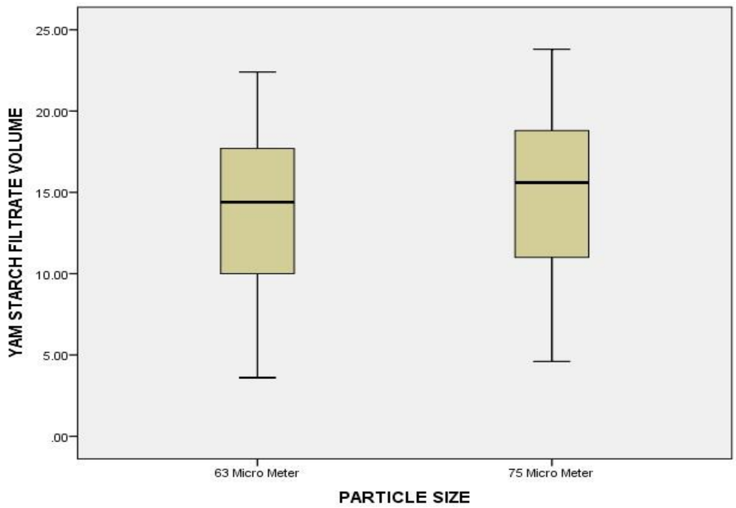

Fig. 11: Box plot of MYS filtrate volume (cm^3) against Particle size.

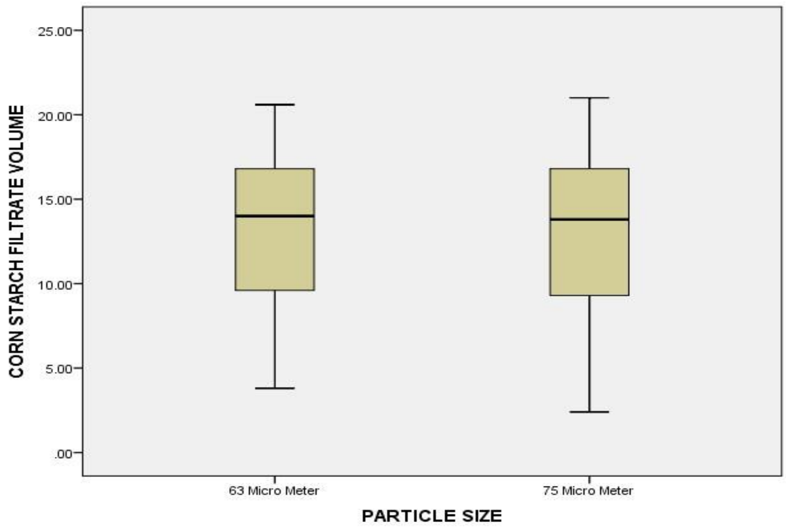

Fig. 12: Box plot of MCS filtrate volume (cm^3) against Particle size.

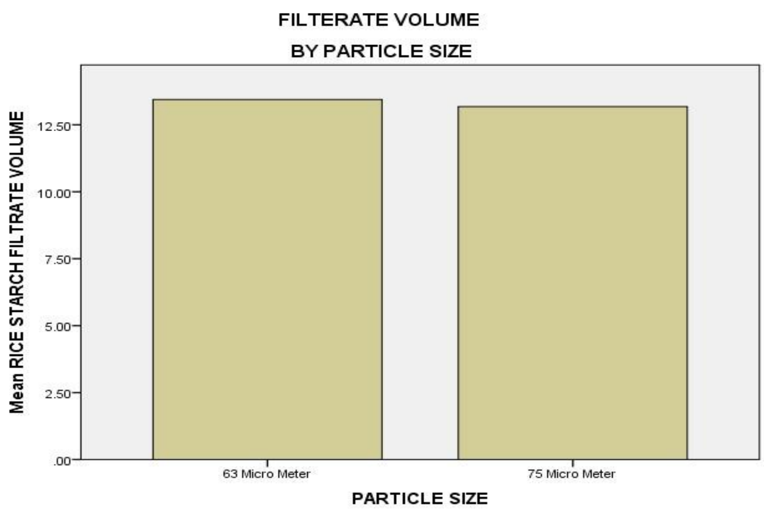

Fig. 13: Bar chart of MRS filtrate volume (cm^3) against particle size.

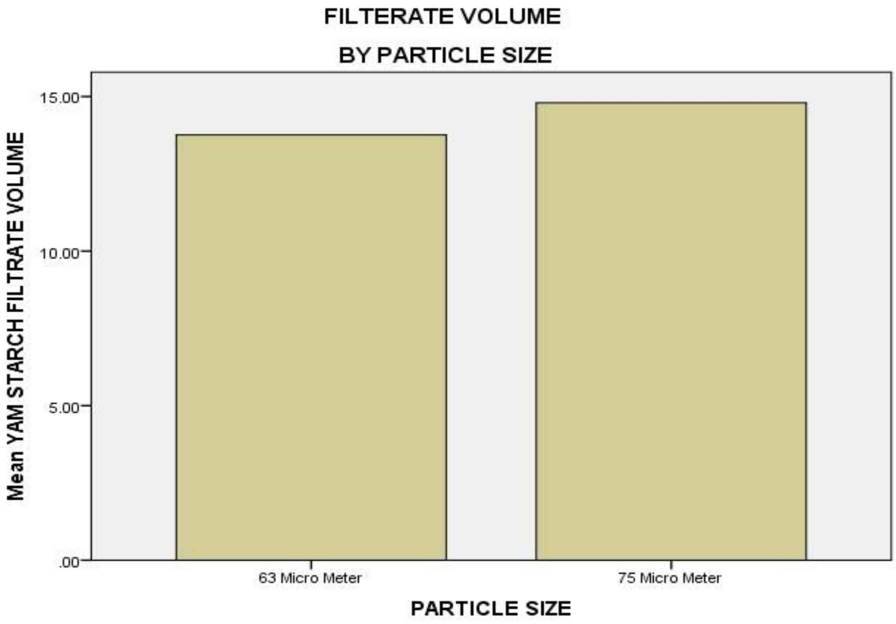

Fig. 14: Bar chart of the MYS Filtrate volume (cm^3) against particle size.

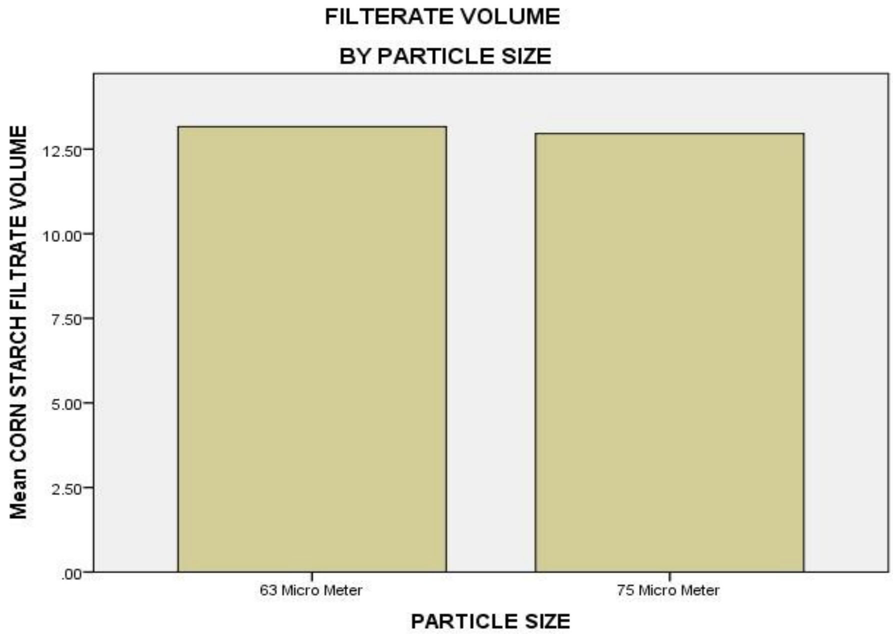

Fig. 15: Bar chart of MCS filtrate volume (cm^3) against Particle size.

4. CONCLUSION

The filtration loss properties of different samples of drilling fluid formulated with modified starch of different types (Rice, Yam, Cassava), different particle sizes (63µm and 75µm) and different concentrations as a fluid loss additive, were studied at 30°C, 50°C and 70°C in comparison with two controls low viscous CMC and extra high viscous CMC. From the analysis of the results obtained it was observed that as the concentration of the

Carboxymethyl starch added increases, less fluid was lost from the drilling fluid, and there was no significant difference of the filtrate volume in respect to the two different particle sizes used. Also increasing the temperature of the mud samples slightly increased the filtrate volume of the drilling fluid.

From the results it can be seen that decreasing the starch size results in better filter cake thickness this can aid in preventing drilling related borehole problems.

REFERENCES

1. Al-Marhoun, M.A, and Rahman, S.S. (1998): Optimizing the Properties of water-based Polymer Drilling Fluids for Penetrating Formations with Electrolyte Influx. Erdol Erdgas, 318-323.
2. Aston, M.S. and Elliot, G.P. (1994). Water-based glycol drilling muds: shale inhibition mechanisms. Paper presented at the European Petroleum Conference, London, United Kingdom.
3. Amanullah, M, Marsden, J.R, Shaw, H.F. An experimental study of the swelling behavior of mud rocks in the presence of drilling mud systems. Can J of Pet Technol, 1997; 36: 45–50.
4. Zhang, L.-M.; Tan, Y.-B.; Li, Z.-M: Application of a new family of amphoteric cellulose-based graft copolymers as drilling-mud additives. Colloid Polymer. Sci., 1999; 277: 1001–1004.
5. Ademiluyi, T., Joel, O. F. and Kazeem, A. A., Investigation Of Local Polymer (Cassava Starches) As A Substitute For Imported Sample In Viscosity And Fluid Loss Control Of Water Based Drilling Mud. Journal of Engineering and Applied Sciences, 2011; 6(12).
6. Akintola, A. S. and Isehunwa, S. O. Temperature and Time–Dependent Behaviour of a Water Base Mud Treated with Maize (*Zea mays)* and Cassava (*Manihot esculanta*) Starches". *Journal of Scientific Research and Reports*, 2015; 5(7): 591-597.
7. Minaev, K M, Martynova, D O Zakharov, A S Sagitov, R R Ber, A A and Ulyanova O S (2016): Synthesis of Carboxymethyl Starch for increasing drilling mud quality in drilling oil and gas wells: IOP Conf. Series: Earth and Environmental Science 43 012071.
8. Talukdar, P., Kalita, S., Pandey, A., Dutta, U. Singh, R. Effectiveness of different Starches as Drilling Fluid Additives in Non Damaging Drilling Fluid: International Journal of Applied Engineering Research ISSN 0973-4562, 2018; 13(16): 12469-12474.

9. Steele, C.; and Al Bagoury, M. Micronised ilmenite - A new, intermediate weight material for drilling fluids. Paper AADE-12-FTCE-12 presented at the AADE Fluids Technical Conference and Exhibition held at the Hilton Houston North Hotel, Houston, TX, 2012; 10–11.
10. Al-Bagoury, M. Micronized ilmenite—a non-damaging and non- sagging new weight material for drilling fluids. Paper SPE-169182 presented at the SPE Bergen, Bergen, Norway, 2014.
11. Mohamed, A.K.; Elkatatny, S.A.; Mahmoud, M.A.; Shawabkeh, R.A.; Al-Majed, A.A.: The evaluation of micronized barite as a weighting material for completing HPHT wells. Paper SPE- 183768-MS presented at the SPE middle east oil & gas show and conference. Manama, Kingdom of Bahrain, 2017.
12. Elkatatny, S. M. Enhancing the Rheological Properties of Water-Based Drilling Fluid Using Micronized Starch: *Arabian Journal for Science and Engineering*, 2019; 44: 5433–5442.
13. Elkatatny, S.M.; Nasr-El-Din, H.; and Al-Bagoury, M.: Properties of ilmenite water-based drilling fluids for HPHT applications. Paper SPE 16983 presented at the 6th international petroleum technology conference, Beijing, China, 2013.
14. Ozbayoglu, E., Gunes, C., Apak, E. C., Kok, M. V. and Iscan, A. G. (2007): Empirical Correlations for Estimating Filtrate Volume of Water Based Drilling Fluids. Petroleum Science and Technology Publication details, including instructions for authors and subscription information: http://www.tandfonline.com/loi/lpet20
15. Afolabi, R. O., Orodu, O. D. and Seteyeobot, I.: Predictive modelling of the impact of silica nanoparticles on fluid loss of water based drilling mud, Applied Clay Science, 2018; 151: 37-45.
16. Khalil, M.I., Hasheem, A. and Hebesish, A. Carboxymethylation of maize starch. Starch, 1990; 42: 60-63.
17. American Institute of Petroleum. Petroleum Review, Institute of Petroleum, 1998; 52.