

A Study on the Individual Impact of Cassava Starch and Hydroxyl Propyl-Modified Starch on Mud Density

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Abstract — In this research, the individual impact of cassava starch and hydroxyl propyl-modified starch on mud density of some formulated water-based drilling mud from local sourced clay have been investigated. The research aimed at investigating the independent impact of hydroxyl propyl-modified-starch and cassava starch on the mud density of formulated water-based drilling mud from local clay. This was achieved using the underpinned objectives: to separately formulate polymer water base drilling mud using hydroxyl propyl-modified-starch and cassava starch with local clay; and to examine the individual effect of the modified-starch and cassava starch on the mud density. The research adopted the comparison techniques as its methodology. The data collected from the techniques were subjected to analyses using Microsoft Excel 2012 tools. The results show that hydroxyl propyl-modified-starch and local starch can be used as weighting materials during the formulation of water-based drilling mud. Besides, hydroxyl propyl-modified-starch and local starch additives now also belong to the category of weighting materials additives. The study has demonstrated that starch generally can increase the weight of drilling mud, and soon cassava farmers will double efforts to cope with the demand of cassava starch for the production of modified-starch, to be used as weighting agent in drilling mud formulation.

Keywords – Clay, Drilling Mud, Mud Density, Cassava-Starch, hydroxyl propyl-modified-starch.

I. INTRODUCTION

In recent times, the exploration and production of crude oil is increasingly becoming a major area of concern in the global-scale due to the high rate of energy demand. Furthermore, the quantities of reservoir fluids appraised to be commercially recoverable can only be exploited by drilling production wells into the hydrocarbon pay zones some thousand feet beneath the earth, and allowing pressure gradient to force up fluids into these wells first by naturally available pressure then followed by artificial means or methods. However, this pressure gradient is kept in-place, while drilling with the use of drilling mud of controlled mud density, to drill a safe, useable and economic well. Consequently, weighting materials are used mainly to increase the mud density for total formation pressures control, to avoid kicks

that might graduate to blowout. According to Schlumberger [1], weighting materials are described as high-specific gravity and finely divided solid material used to increase density of a drilling fluid. Similarly, GEO Drilling Fluids, Inc. [2] stated that barite, calcium carbonate and hematite are weighting materials which are termed the most used, acid soluble and extremely high density mud, respectfully.

In addition, Azar and Samuel [3] categorised drilling mud-additives into seven categories, which show that barite, iron oxide, calcium carbonate, dissolved salts, and galena are weighting material-additives. Consequently, pre-gelatinization through chemical modifications of starch is used for the formulation of drilling mud in the exploration and production sector of the petroleum industry [4]. A polymer like guar gum and hydroxyl propyl are used for preparing drilling mud programme to meet basic functional requirements such as removal of drill cuttings, well stability and subsurface pressure control. To achieve these requirements the mud rheological properties and fluid loss control properties must carefully be understood and controlled. Otherwise, it will cause stuck pipe and loss of circulation, an influx or a kick that may graduate to a blowout, formation damage just to mention but few [5]. Widely used drilling mud are not environmental friendly, this have been evidenced due to the accidental and intentional release of drilling mud wastes which constitute the potential threat to environmental sustainability and human health. The functions of drilling mud must exhibit a better and successful drilling operation. Hence, polymer drilling mud with proper quality control could be used as a substitute for imported grade drilling mud for exploration and exploitation of oil and gas in Nigeria, and this studies may open new market for cassava starch and serve as economic benefit to Nigerian farmers and thus expected to provide low cost of drilling mud for Engineers [6].

Therefore, research has been focused on a number of studies: Ochoa *et al.* [7] concluded that modified cassava starches, such as activated cassava starch (AS) and carboxymethylated cassava starch (CMS0.24) are able to inhibit carbon steel corrosion. This depends on the type of modification, AS acts as mixed inhibitors and CMS0.24 acts as anodic inhibitors, whose protective properties increase with concentration. Similarly, Barrios *et al.* [8] stated that the best modifying agent was sodium monochloroacetic acid

(SMCA) as compared to monochloroacetic acid (MCAA).

Hence, this study is aimed at formulating polymer water based drilling mud from modified and cassava starches, and local clay. The mud density of the individual formulated drilling mud was compared to a widely used water based drilling mud prepared with hydroxyl propyl-modified-starch.

II THE RESEARCH'S PARADIGM

The description of the research using conceptualised models or pattern, to encapsulate the research methodology is termed paradigm. However, in this study, the positivist paradigm was adopted and applied. Figure 1 is an empiricism model that was conceptualised to present the model in a top-bottom approach [9]. Consequently, the model shows that the research emanated from the petroleum industry scholastics area water-based drilling mud with the aimed focus, to formulate polymer water-based drilling mud using hydroxyl propyl-modified starch and cassava starch with local clay. And objectively, to separately formulate polymer water base drilling mud using hydroxyl propyl-modified-starch and cassava starch with local clay; and finally, to examine the individual impact of the hydroxyl propyl-modified-starch and cassava starch on the mud density of the formulated mud,

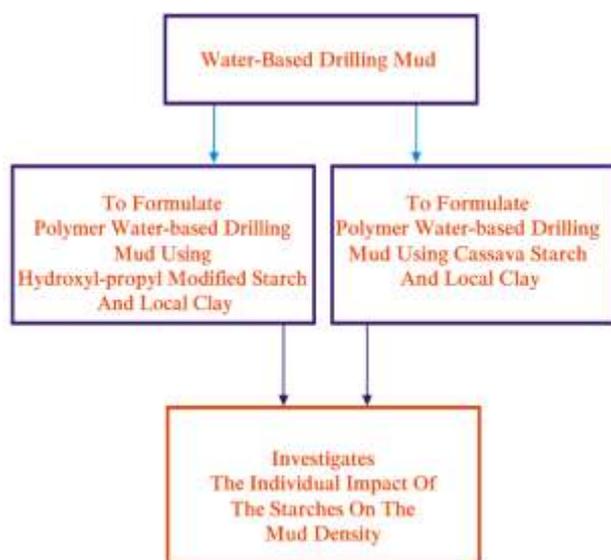


Figure 1.1: The model used for the Research

III METHODOLOGY

3.1 Materials and Methods

3.1.1 Materials

The materials used in conducting these experiments include the following: desiccant, masking tape, 500ml-beakers, weighing balance, polyethene bags, mud mixer, hand-mixer, 20-liter buckets, centrifuge,

distilled water, oven, thermometers, electrical grinder, mortar pestle, and 75um sieve.

3.1.2 Methods

3.1.2.1 Clay Samples Collection and Mud Preparation

From the Wilberforce Island, Bayelsa State, Nigeria, the locally sourced raw wet clay samples were excavated and collected at some average depths between 1.5m to 1.7m from three (3) different locations. From each of these field locations, four (4) kilograms of the wet raw clay were bagged carefully in some labelled polyethene bags. Subsequently, in the petroleum drilling engineering laboratory, Niger Delta University, each of the raw sampled clay were dried in the sun rays at an average recorded temperature of 600C for 14 days. Consequently, these dried raw clay samples were ground to powdered form with an electrical grinder. Furthermore, 10 litres of distilled water were poured into each of the five different buckets which had a capacity of 20-litre. And each of dried powdered raw sampled clays was poured into each the buckets. Each of the bucket contents was mixed rigorously with the hand mixer, to emulsify. The emulsified mixture of major constituent of clay and water (mud) in each of the buckets were allowed to stand alone and age for 24hrs to settle out silts, sands and other weighting constituents present in the mud.

The supernatants from each of the buckets were decanted into waste drains and the residues - which are the muds, were decanted and sieved with a 70µm sieve and the filtrate was allowed to settle down while continuously decanting the water. The concentrated clay was then transferred into centrifuge cups and set to rotate in the centrifuge at a revolution of 2000rpm for 40 minutes. The clay was then removed and spread on a pan then allowed to dry in an oven over a 50oC temperature for 30 minutes. The dried clay cakes were allowed to cool for 1hr and were ground to fine sizes with mortar and pestle after and were sieve with a 75um sieve. Each of these very fine-particles samples were placed in desiccants.

3.1.2.2 Starch Preparation

25kg of cassava tubers (*Manihot esculenta*) were peeled and cut into irregular smaller sizes; these reduced sizes of *M. esculenta* were soaked and washed in distilled water, and ground using an electric grinder to produce a paste. The paste was diluted with 10 liters of distilled water, and then poured into a doubled fiber bag of 75µm pores. Subsequently, the inlet of bag that contained the paste was tied firmly with rope and subjected to mechanical pressing; while the filtrate (plentiful amount of the mixture of suspended starch and distilled water) was received in a 20-liter bucket. Thereafter, the *M. esculenta* residual cake in the bag was discarded in line with environmental-

friendly manner. Furthermore, the filtrate (suspension) was allowed to settle down while the supernatant layer decanted. Further removal of water was done by centrifugation for 25 minutes and the solid starch spread on a pan and dried in the sun ray at an average recorded temperature of 60°C for 16-days. The dried starch was then ground using mortar and pestle. The ground starch was sieved with a 2000µm sieve and stored in a desiccant.

3.1.2.3 Water-Based Drilling Mud Preparation

From each of the dried fine powdered clay samples (see table 3.1) 18 sub-samples were measured out from LC1 and poured into 18 beakers of 500ml capacity

Table 3.1: Formulated Water-Based Drilling Mud and its Configuration without Additives.

A	B	C	D
Powered Clay Sample Code	Location	Prepared Powdered Clay Sub-Sample Code By 3 sets	Sub-Sample Collected in Grams (g) and Dissolved 350ml of De-ionized Water
LC1	Latitude 4.97086° Longitude 6.10794° Heading = 114° (SE)	LC01	42.0
		LC02	45.5
		LC03	49.0
		LC04	52.5
		LC05	56.0
		LC06	59.5
LC2	Latitude 4.97077° Longitude 6.11389° Heading = 310° (NW)	LC07	42.0
		LC08	45.5
		LC09	49.0
		LC10	52.5
		LC11	56.0
		LC12	59.5
LC3	Latitude 4.96060° Longitude 6.10015° Heading = 283° (NE)	LC013	42.0
		LC14	45.5
		LC15	49.0
		LC16	52.5
		LC17	56.0
		LC18	59.5

Firstly, out of the 18 beakers; 350ml of de-ionized water were poured into 6 beakers that each contained 42.0g, 45.5g, 49.0g, 52.5g, 56.0g, and 59.5g (equation 3.1). Subsequently, each of these mud mixtures in the beakers was mixed properly with the mud mixer. Secondly, 350ml of de-ionized water were poured into another set of 6 beakers that each contained 42.0g, 45.5g, 49.0g, 52.5g, 56.0g, and 59.5g. Also, 5g of hydroxyl-propyl-modified starch additive were added to each of these beakers (equation 3.2). Finally, another set of muds were prepared in 6 beakers. But water, clay and cassava starch were used (equation 3.3). In conclusion, the aforementioned procedures were also used to formulate drilling mud from sample LC2 and LC3.

DM = DIW + LC ... 3.1

DM = DIW + LC + HPMS ... 3.2

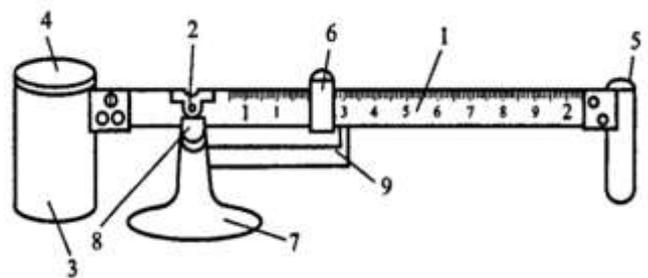
DM = DIW + LC + CS ... 3.3

Where:

- DM = Drilling Mud
- DIW = De-ionized Water
- LC = Local Clay
- HPMS = Hydroxyl-Propyl-Modified Starch
- CS = Cassava Starch

3.1.2.4 Experimental Procedure

The mud balance (figure 3.1) was calibrated with de-ionized water. To conduct the equipment calibration process, the lid was removed from the cup, and the cup was completely filled with water. The lid was replaced and the top was wiped dry. The balance arm was also replaced on the base with knife-edge rested on the fulcrum. The level vial was ensured to be centred when the rider was adjusted and it was set on 8.33 ppg. Furthermore, the investigations were conducted using the various muds formulated. Consequently, mud densities were conducted for each of the formulated drilling muds at the mud age of 1hr and 24hrs at 60°C were recorded. Accordingly, the lid was removed from the cup, and completely filled with the mud to be examined. Subsequently, the lid was replaced and rotated until firmly seated, and it was observed that some of the mud got expelled through the hole in the lid. And, some of the mud that got expelled through the hole in the lid was wiped from the top of the lid. Then, the balance arm was replaced on the base, with knife-edge rested on the fulcrum. The rider was moved until the graduated arm is level, as indicated by the level vial on the beam. At 60°C readings of mud density in pounds per gallon (ppg) were taken from the graduated arm in equilibrium, from the left-hand edge of the rider. Same experimental procedures were conducted intermittently for all the formulated water-based drilling muds at the research recommended mud age of 1hr and 24hrs at 60°C. Results and discussion are presented subsequently.



1-Arm; 2-Knife; 3-Cup; 4-Lid of the cup; 5-Calibration tank; 6-sliding weight(rider); 7- Base; 8- Fulcrum

Figure 3.1: Mud Balance (Adopted and Modified from [10])

IV. RESULTS AND DISCUSSION

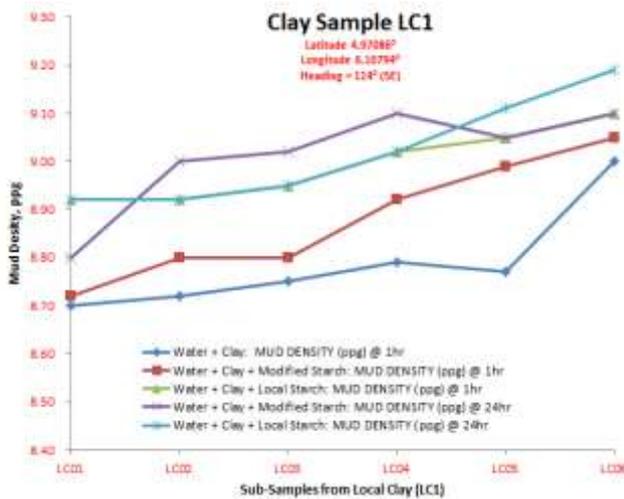


Figure 4.1: The Independent Effect of the Modified Starch and Local Starch Additives on the Mud Density of Local Clay-LC1 at Different Periods.

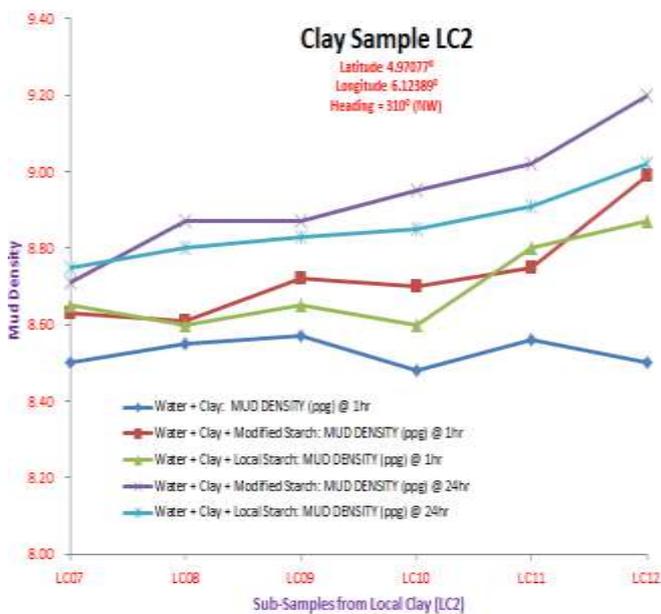


Figure 4.2: The Independent Effect of Modified Starch and Local Starch Additives on the Mud Density of Local Clay-LC2 at Different Periods.

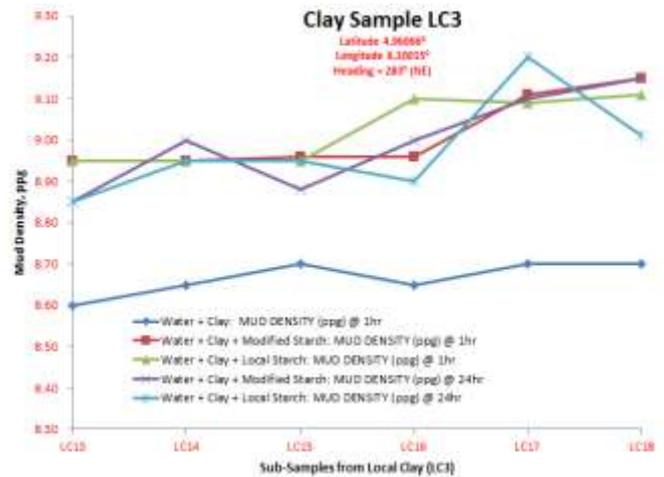


Figure 4.3: The Independent Effect of Modified Starch and Local Starch Additives on the Mud Density of Local Clay-LC3 at Different Periods.

Figures 4.1, 4.2 and 4.3 show the individual impact of hydroxyl propyl-modified-starch and local starch additives on the mud density of a water-based drilling mud formulated from local clay and left to age between 1hr to 24hrs. Furthermore, from these figures, it has been observed that the aging of the various formulated polymer water-based drilling mud had significant impact on the mud density. Nevertheless, the figures illustrated that the independently hydroxyl propyl-modified-starch and cassava starch increases the mud density of the formulated drilling mud. Explicitly, these figures depicted the increase in mud density under the prevailing aging at ambient conditions in each of the investigations, which were substantial. In addition, this demystified that barite, iron oxide, calcium carbonate, dissolved salts, and galena as listed by Azar and Samuel (2007) are not the only weighting materials that can be used to control mud density. Consequently, in figure 4.1 the highest reading of the mud weight value was observed to be estimated as 9.19 ppg. This value is associated with the formulated local starch water-based drilling mud which aged for 24hrs. In contrast, the highest mud weight values in figures 4.2 and 4.3 which aged at 24hrs are 9.20 ppg and 9.15 ppg, respectively. In addition, these values were associated with the formulated hydroxyl propyl-modified-starch water-based drilling mud instead of the formulated local starch water-based drilling mud as reported earlier. Therefore, hydroxyl propyl-modified-starch and cassava starch can now be considered as weighting materials during water-based drilling mud formulation.

V. CONCLUSION AND RECOMMENDATION

From the results of this research the following conclusions have been drawn;

- It was observed that the impact of hydroxyl propyl-modified-starch on the mud density of the

formulated water-based drilling mud was more effective than that formulated with local starch.

- Hydroxyl propyl-modified-starch and cassava starch have the potential to be used as weighting materials during the formulation of water-based drilling mud.
- Primarily hydroxyl propyl-modified-starch and cassava starch very fine particles will not be abrasive to bottom-hole equipment.
- Hydroxyl propyl-modified-starch and local starch additives now belong to the category of weighting materials. Though, most petroleum literatures have reported that starch additive belongs to the fluid loss reducer's category.

Subsequently, to effectively formulate the polymer water-based mud, de-ionized water, local starch should be used and allowed to age for at-least 24hrs before usage. Furthermore, the research recommends that other sources of native starch should be used to further investigate the impact of starch additives on the weighting effect on mud density and compare results obtained to those obtained from barite.

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