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QUALITY ASSURANCE EVALUATION OF DRILLING MUDS USED BY SOME COMPANIES IN PORT HARCOURT, NIGERIA

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ABSTRACT

Five drilling mud samples were collected from three drilling companies within Port Harcourt metropolis. The physical and chemical properties were analyzed in the laboratory. Results showed that Density ranged from 9.00 to 11.50 ppg, oil: water ratio ranged from 50:50 to 73:27, Emulsion Stability ranged from 175.00 to 470.00 Volts, static filtration was 15.00 mgL^{-1}, alkalinity ranged from 0.40 to 0.80 mgL^{-1}, excess lime 0.50 to 1.03 mgL^{-1}, whole chloride 48000.00 to 52000.00 mgL^{-1}, whole calcium 2600.00 to 22400.00 mgL^{-1}. These results were compared with the mud engineer's specification and it was found that mud samples from Company A and B met the specification while mud samples from Company C were below specification. It was inferred that some of the samples were contaminated and cannot be used for drilling oil wells to avoid formation pressure which can cause fire hazard in a rig.

Key words Drilling fluid, Filtrate alkalinity, Lime, American Petroleum Institute

INTRODUCTION

The extent of prospective, surveyed and extracted oil and gas reserves and other natural resources determines the energy of a nation. One of the area where the oil and gas sector in Nigeria taps its natural resources on the earth crust is through drilling. This creates access to the desired resources below the earth-crust which is usually extracted by the use of an important mixture known as drilling mud.

Drilling fluid or mud is important in petroleum resource development. A drilling fluid or mud is any fluid that is used in a drilling operation in which the fluid is circulated or pumped from the surface, down the drill string, through the bit, and back to the surface via the annulus (ASME, 2005). Drilling fluids are complex heterogeneous fluids, consisting of several additives that were employed in the drilling of oil and natural gas well since the early 1900 (Moore, 1974). An important condition that affects drilling mud include the cleaning of cuttings from wellbore, controlling subsurface pressures, reducing the formation pressure, and reducing fluid loss into the formation, water. The first drilling fluid and its usage were documented back to the ancient Egyptian and Chinese cultures and simple rotary tool drilling (Mahto and Sharma, 2004).

American petroleum institute has a recommended practice for testing liquid drilling fluid properties at regular intervals. This action helps mud engineers determine proper functioning of drilling fluid (API, 1997; Dhiman, 2012). Physical and Chemical analysis of drilling mud are usually carried out to ascertain properties and effectiveness of the drilling fluids. The different variables that are obtained must be properly checked to know if the fluid can be used in drilling, this action will help to control subsurface pressure, support and stabilize the well bore. The preliminary check on the variables also prevents problems such as damaging of the drilling bit as result of the high concentration of chemicals in the mud, Stucking of the drilling bit, mud weight to mention etc.

A drilling mud must be properly formulated to facilitate penetration rates, reduce some problems in the bohole and minimize formation damage. This allows an operator to reach the desired geologic objectives thereby reducing overall cost. There are other roles played by the drilling fluid include, control of formation pressures, removing drilling cuttings from the hole, suspend cuttings in the fluid when circulation is stopped. It also helps in cleaning, cooling and lubricating the bit, transmitting hydraulic energy, to the bit and maintaining wellbore stability by regulating density and minimizing hydraulic erosion (Growcock and Harvey, 2005; Darley and Gray, 1988).

reactivity and instability of The aim of this research is to appraise some of the drilling muds used for the drilling of oil wells within the Port Harcourt metropolis and to compare with Mud engineer's specification.

MATERIALS AND METHODS

Sample collection and analysis

Five (5) drilling fluids samples (Three Oil Base Mud and two water based mud) were collected from three (3) different drilling companies in the industrial area of Port Harcourt, they are: Company A, B and C. The Physical and Chemical properties of the drilling fluids such as Mud weight, Electrical stability, oil/water ratio, Alkalinity, excess lime, Chloride ion (Cl^-), Total hardness (Ca^{2+} & Mg^{2+}) were analyzed in the laboratory using standard procedures outlined in (Amaco, 1994).

Test Procedures for Oil Base Mud

Determination of mud weight using mud balance

The mud balance was calibrated with fresh water at $70^o \pm 5^o$. The mud sample was poured into a mixing cup and stirred in Hamilton Beach Mixer for five (5) minutes. The mud sample was poured into the mud balance and allowed to stabilize before the cap was steadfastly placed to ensure some mud flows through the hole in the cap to expel any trapped air or gas. The rider was moved along the graduated scale until the level bubble was centered under the center line. The density (weight) of the mud was taken and reported to the nearest 0.1 lb/gal. Note that the standard weight of water using mud balance is 8.33ppg.

Determination of water to oil ratio using retort kit

The retort kit was set and heated to 950^oF. The retort cell was filled with mud sample to be tested. The cells were greased, padded with steel-wool and well tighten. The

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condenser was connected to the top pipe of the retort cell and carefully put inside the retort jacket. At the base of the condenser, 50mls cylinder was placed to collect the oil and water and timed for 45mins. Layers were noticed on the cylinder showing two liquids water and oil.

Using $V_{water} = 100 \dfrac{(V_{oil}, cm^3)}{\text{Total } V_{water} + V_{oil}}$ … (1)

$$V_{water} = 100\frac{(V_{water}, cm^3)}{\text{Total } V_{water} + V_{oil}}$$

V_{oil} = 100 (volume of oil, cm^3)

Determination of Electric stability using Emulsion Stability Meter

Electric Stability Meter is used to check the emulsion stability of the mud. The batteries in the Electric Stability meter were properly fixed. At 120°F the probe of the Electric Stability meter was inserted into the mud and stirred for some seconds, leaving part of the probe in the mud, such that it does not touch the walls of the cup. The start button on the meter was pressed on, to take the readings. The experiment was repeated thrice to derive the mean.

Determination of Mud Alkalinity (P_M)

1ml of mud was measured into a beaker using a 3.0 cm^3 syringe. Also 100mls of distilled water was poured in, and then 15 drops of phenolphthalein indicator were added until a pink colour was observed. Then it was titrated with 0.1M of tetraoxosulphate (vi) (H_2SO_4) till the pink colour disappears. The reading was recorded.

Calculations

Alkalinity= $\dfrac{\text{Vol of 0.1M } H_2SO_4}{\text{Vol } (cm^3) \text{ of mud}}$ …… (2)

Excess lime = alkalinity x 1.295 (constant)

Determination of Whole mud chloride (Cl_{om})

Using the same sample from the whole mud alkalinity test, thirteen (13) drops of potassium chromate was added, and then titrated with 0.3N Silver nitrate ($AgNO_3$) until salmon pink color appears and become stable. The end point was noted and recorded.

Calculation

$V_{sN} = \dfrac{\text{Vol. of } 0.3AgNO_3}{\text{Vol. of mud used}}$…………………(3)

Cl_{om}, mg/L = (V_{SN}) (10,000) API standard.

Determination of Whole mud calcium (Ca_{om})

50mls of xylene and 1ml of drilling mud were poured into the beaker. 100 mls of distilled water was added to the mixture. 3mls of 1M Sodium Hydroxide (NaOH) and 0.1g of calver II was added into the beaker, the sample mixture was stirred for 5mins on magnetic stirrer until it turned muddy-red. 0.1N ethylenediamine-tetraaceticaid (EDTA) was used to titrate the solution until the color turn blue – green. The titre value was recorded.

Using mls of EDTA × 4000

Determination of Static Filtration Using Low Pressure Low Temperature Filtration

The air valve was opened; regulator was adjusted to read 100 psi. Half of the mud sample was poured in from the top cell and the cell was pressed into fitter press rack. The cell lid was positioned on top of cell body. It was sealed by turning the filter press handle clock wise until hand-tight.

A dry-cleaned graduated cylinder was placed under the drain tube of the filtration cell assembly. The bleeder valve was closed and maintained in a closed position while the test was going on, time was set at 30 minutes interval.

The valve was opened being located on filter press manifold by turning black knob counter clockwise. The time arm was pulled down and timing begins immediately.
After 30mintes, the graduated cylinder was removed the filtrate volume collected, was recorded. Then the valve was closed by turning black knob clockwise and the bleeder value was opened and released trapped line pressure.

Determination of Filtrate Alkalinity (P_F)

1ml of Low Pressure Low Temperature filtrate was put into titration vessel using a 2.5 cm^3 syringe. Then 3 drops of phenolphthalein indicator were added. The indicator was observed to turn pink; it was titrated with 0.02N of tetraoxosulphate (vi) until the pink color disappears. The readings were recorded.

Determination of Filtrate Alkalinity (M_F)

1ml of filtrate was measured into a breaker, then 3 drops of methyl orange indicator was added and a yellow was observed. It was titrated with 0.02M of tetraoxosulphate (vi) till the color changes to pink. The readings were recorded.

Determination of Chloride (Cl^-)

1ml of filtrate was measured into a beaker. Four (4) drops of potassium chromate indicator solution was added, it was observed that the color changed to yellow. It was titrated with 0.3M of silver nitrate ($AgNO_3$) until the color changed to red. The readings were recorded.

Determination of Total Hardness

1ml of filtrate was poured into a beaker also and 20 mls of distilled water added. 20 drops of Versenate hardness buffer solution was also added to the solution. Also 10 drops of Versenate hardness indicator solution was added. It was noted that the colour changed to wine-red which showed the presence of Ca^{2+} and Mg^{2+}, while stirring the solution was titrated with Ethylenediaminetetraaceticacid (EDTA) (standard Versenate) until the solution color changes from wine-red to blue. The endpoint was recorded.

Total Hardness (mg/L) is calculated as: $\frac{\text{Vol (cm}^3\text{of EDTA) (400)}}{\text{Vol (cm}^3\text{) of filtrate}}$ …………………(4)

RESULTS

Table 1. Results of Physical and chemical properties of Oil Based Mud.

Parameter	Company A	Company B	Company C	Mud engineer's Specification
Mud weight (ppg)	10.00	11.50	9.00	10.00
Electrical stability(volts)	414.00	470.00	175.00	300.00-500.00
Oil/water Ratio	67:33	73:27	50:50	72:28
Alkalinity	0.40	0.80	0.50	1.00 – 200
Excess lime	0.50	1.03	0.60	1.00 – 2.00
Whole chloride (mgL^{-1})	52000.00	48000.00	4 8000.00	70000.00
Whole calcium mgL^{-1}	2240.00	2600.00	1520.00	2800.00

ppg = pounds per gallon

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Table 2. Results of Physical and chemical properties of Water Based Muds

Parameter	**Company A**	**Company C**	**Mud engineer's Specification**
Mud weight (ppg)	11.70	11.40	11.00-12.000
Static filtration test (API filtrate) mgL^{-1}	15.00	15.00	15.00
Mud Alkalinity (P_M) mgL^{-1}	1.40	1.60	1.00 -2.00
Filtrate Alkalinity (P_F) mgL^{-1}	0.20	0.20	1.00 – 2.00
Filtrate Alkalinity (M_F) mgL^{-1}	0.70	0.40	1.00 – 2.00
Chloride ion (Cl^-) mgL^{-1}	17.30	18.30	20.0- 30.00
Total hardness (Ca^{2+} & Mg^{2+})	480.00	1160.00	1600.00

ppg = pounds per gallon, (P_M,P_F, M_F), P_M = Mud Alkalinity; P_F = Filtrate Alkalinity

DISCUSSION

The specification of drilling muds varies from one company to another. This is as a result of the nature of the well, soil condition, true depth of the well as well as the well performance of the mud. The results of the chemical analysis of the oil and water based drilling used in Port Harcourt are presented in Tables 1 and 2. Companies A, B and C were adopted to avoid disclosing the identity of the companies.

The results in table 1 show that the mud weight and the electrical stability for
for oil based mud are within the mud engineers specification of 10 ppg and 300 - 500 volts for Companies A and B while the drill mud sample from Company C falls below specification. The implication is that the surface pressure will not be controlled and the wellbore and mud will not be stabilized. This may be due to contamination of the drilling and may not be fit for drilling purpose (Bourgoyne *et al.*, 1986; Petri, and de Queiroz Neto, 2010).

The Oil to water ratio is the ratio of the volume oil to water in percent (%) in an oil drilling fluid compared to the total liquid in the mud. The results obtained from the analysis in table 1 show that the drilling muds are within the specification except the sample collected from Geo-fluids which have a 50:50 Oil/water ratio. Precise information on the amount of water to oil ratio provides basic information for control of drilling fluid properties. Some researchers have postulated that oil based muds should always have more oil as much as three times greater than water in the liquid content of the mud to give an excellent lubricity and stability (Khodja *et al.*, 2010). The results of the alkalinity test for all companies fall below the Mud engineer's specification. The Water based mud alkalinity (P_M) for the two companies are within the specification of the mud engineer while the results of Filtrate alkalinities (P_F and M_F) are below the mud engineer's specification (Tables 1 & 2). The Mud alkalinity (P_M) is applicable to liquid and solids are used to calculate approximately the amount of undissolved lime, which is used in controlling lime muds and in treating out cement[1]. Filtrate alkalinities (P_F and M_F) are applicable to only liquids. Alkalinity can indicate presence of hydroxyl (OH^-) and trioxocarbonate iv (CO_3^{2-}) ions in most mud systems (Amaco, 1994). The low values of alkalinity is an indication that the drilling fluids will lack the capability to reduce the effect acid contaminants in the process of usage. Only Company B value for excess lime is within the mud engineer's specification of 1.00 – 2.00 mgL^{-1}. Excess lime and alkalinity are interrelated. It serves as a measure of the alkalinity that are available as Ca^{2+} and OH^{-} ions are used up as drilling progresses, in other words, it serves as alkalinity control and prevents fermentation of the drilling mud and control corrosion (Dhiman, 2012; Petri, and de Queiroz Neto, 2010). The importance of mud and filtrate alkalinities (P_F) is very significant because they guarantee the mud chemistry control of a drilling fluid. Hydroxyl alkalinity is essential for solubilizing some filtration control additives that lignite-based while carbonates (CO_3^{2-}) and bicarbonate (HCO_3^{-}) alkalinities negatively affect performance of clay-based muds (ASME, 2005; Amaco, 1994).

The chloride ions (Cl^{-}) content of drilling fluids is used as indicators to check the amount of salt water that flow in and for checking the quality of composition water used for makeup. The Whole chloride test for oil based mud and the chloride ions test for water based mud are all below the mud engineer's specification for all companies (Tables 1 & 2). This invariably implies that amount of salt water that flows may not be accurately checked.

The presence of certain ions such as calcium (Ca^{2+}) and magnesium (Mg^{2+}) determines the hardness of water or mud filtrate[11]. The results in tables 1 & 2 shows that nearly all research samples fall below the specification of the mud engineers for whole calcium and total hardness for oil and water based muds respectively. The Ca^{2+} and Mg^{2+} ions decrease efficiency of most polymers and make it extremely difficult for many chemicals used in drilling to function thus adversely affecting the properties of the drilling mud (Dewu, 2011).

This research has shown that most of the physicochemical characteristic of the drilling fluids such as alkalinity, filtrate alkalinity, Cl^{-}, Ca^{2+} and Mg^{2+} for oil and water based mud were below the mud engineers specification, which is pointer to the fact that the drilling muds may have been contaminated. The practice of testing drilling fluid properties helps mud engineers determine quality of the drilling chemicals to ascertain their proper functioning. It also helps drilling fluid to optimize the performance of the muds, thus and producing efficient and professional drilling operations thereby avoiding formation pressure which can cause fire hazard in a rig. The mud engineer should report any observable alteration in the quality of the drilling fluid to the laboratory analyst and also propose solution on how to improve the system to suit a designed drilling operation.

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