An Experimental Investigation of Temperature and Aging Effects on Bentonite and Sepiolite Drilling Fluids

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Abstract: The selection and control of a suitable drilling fluid is necessary to successfully drill an oil and gas well. The rheological properties of drilling fluids vary with changes in conditions such as time and temperature. Slight changes in these conditions can cause unpredictable and significant changes in the mud’s properties. This makes it necessary to study the rheology of drilling fluids and how it is affected by these changes. At the rig sites, tests are carried out by the mud engineers to ensure that the properties of the drilling fluids are within the required limits. Similar tests were carried out at the laboratory in this work to determine the plastic viscosity, yield point, gel strength of mud samples at different conditions of ageing time, temperature and concentration of Xanthan gum (X.G) used as an additive. The Experiments carried out were grouped into three. The first was done with the aim to further explain how the Bentonite and Sepiolite water-based drilling fluids behaves after being aged for certain period. The second sets of experiments were conducted to investigate how the rheological properties of water-based Bentonite muds are affected by different concentration of xanthan gum added as an additive to improve the muds properties and the last sets of experiments were done to investigate the ageing effect on Bentonite mud treated with 250mg/L xanthan gum. Effects of temperature were also considered in these experiments with a 10°C variation in the first group and 20°C in the other two groups between readings from 20°C to 60°C . Results obtained indicated that Sepiolite water-based drilling fluid offers better plastic viscosity and yield point as compared to Bentonite water-based drilling fluids. It was also found that the viscosity and yield point of Sepiolite, Bentonite and treated Bentonite muds decreases with increase ageing time and temperature while the gel strength increases with ageing time but similarly decreases with increase in temperature. In the second group, results obtained indicated that plastic viscosity, yield point and gel strength increases as concentration of xanthan gum increases, all of which decreases with increase in temperature.

Keywords: Drilling fluid, Oil and Gas, Bentonite, Sepiolite.

1. Introduction

The oil industry as mentioned in many petroleum engineering books started from the famous Drake well which was believed to be the first oil well. It was drilled in 1859 at Titusville, Pennsylvania. Drake well was drilled with an iron rod and had a depth of 69½ feet. Shortly after that, many other wells were drilled in Pennsylvania to an extent where the oil prices dropped immensely. Ever since then, engineers continue to come up with new ideas to move the oil and gas from the ground to the market. The use of drilling fluid is one of the advancements achieved from these new ideas with the aim to remove the drilled cuttings from the wellbore, stabilize the hole and many others.

Failure of drilling fluid to undertake its required functions may lead to many other problems and eventually cause excessive loss of money. In fact, most drilling problems are affected either
directly or indirectly to drilling fluid. Different types of drilling fluids used by drillers today depending on the formation to be drilled. To avoid any problem, the proper mud must be used with the correct properties [1].

After selecting and formulating the proper drilling fluid, it is also desirable for several reasons to know the effects of temperature and ageing time on the rheological and other properties of drilling fluid in the hole. A reason for this is because most drilling fluid problems °C cur down the hole. Similarly, despite considerable experimental studies over the years, there is relatively little understanding of how the flow behavior changes with down hole conditions.

The most important properties of the mud that the mud engineer is more concerned with are the Mud weight, Funnel Viscosity, Average Viscosity, Plastic Viscosity, Yield point, sand content and water loss. Tests are carried out on the field daily to determine these mud properties. Similar tests were also conducted at the laboratory in this research to determine the effects of ageing time and temperature on fresh water Bentonite and Sepiolite muds.

2. Drilling Fluid

A drilling fluid or mud is any fluid that is circulated or pumped in a drilling operation from the surface through the drill string, through the bit and back to the surface through the annulus. It is made up of three main phases. The Continuous Phase is the base fluid that makes up the bulk of the drilling fluid volume. Non-reactive Phases are chemically inert solids such as weighting materials, drilled solids, lost circulation materials, etc. Reactive Phase consists of those additives and components capable of reacting chemically with each other and the base fluid.

2.1 Functions of Drilling Fluid

The most important function of the drilling fluid is to reduce the number of cuttings from underneath the bit, and throughout the wellbore. Once the mud is not sufficient enough to remove the cuttings from the hole, thick filter cakes are created which can eventually lead to other problems such as a stuck pipe. Drilled cuttings must, therefore, be efficiently and continually removed to enable onsite reuse and recycling of drilling fluid. Below are a few functions of drilling fluids;

Remove Cuttings from under the bit: If cuttings are not removed immediately after they are been cut, they will be reground thus sticking to the bit and retarding the effective rate of penetration. Their removal at the surface will also be difficult and expensive if ground finely[2].

Remove Cuttings from the wellbore: In order to avoid problems such as stuck pipe, excessive torque and drag, and casing and logging problems, it is necessary for the drilling fluid to remove the cuttings from the wellbore to the surface. Previous studies suggested that drilling fluid rheology and the flow rate are the two most important factors that determine the transport of cuttings to the surface. Other factors include; drill string rotation, hole angle and so on [3].

Suspend cuttings after circulation has stopped: A good drilling fluid must have the ability to suspend weight materials and drilled solids during connections, bit trips and logging runs. This property of the drilling fluid is known as the gel strength. Failure of the drilling fluid to fulfill this function will result in settling of the drilled cuttings, reduction in mud density and also kick [4].

Other functions of drilling fluids are; formation pressure containment, aid in formation evaluation, minimizing formation damage, cool and lubricate the bit and the formation of an impermeable filter cake layer on the wall of the borehole. The drilling fluid, however, should not; cause any adverse effects to the formation, cause any corrosion to the drill string and Injure drilling personnel nor be damaging or offensive to the environment.

2.2 Fluid Properties and Filed Tests of Drilling Fluid

“The successful completion of an oil well and its cost depend to a considerable extent on the properties of the drilling fluid”[5]. The total well cost is influenced not only by the drilling fluid cost but also the choice of the right fluid and the maintenance of the right properties while drilling. For
example, the rate of penetration, stuck drill pipe, loss circulation and so on determine the number of rig days required to drill to the total depth, all of which are influenced one way or the other to the properties of the drilling fluid.

Just as the nature of drilling fluid solids affects the ability of the contaminant removal equipment to operate efficiently, the nature of solids plays an important role on the drilling fluid properties, which in turn affects the properties of the drilled solids and also the efficiency of the equipment. That is to say, the drilling fluid, drilled solids and solids control equipment have a dynamic relationship in the sense that any change made to one will affect the other two. Therefore, it is important to understand the drilling fluid properties in order to optimize a drilling operation since it has an effect on the other two parameters mentioned above [6].

**Mud Density:** In drilling engineering, mud weight is mostly used in referring to the mud density. It is necessary to conduct the mud weight test in order to determine the weight per unit volume of the drilling fluid. Mud weight should be great enough to provide sufficient hydrostatic pressure to prevent the flow of formation fluid into the wellbore. At the same time, it should not be so great to cause loss circulation by fracturing the formation. In order to maintain the mud density within a particular range, it is important to constantly monitor the density of the mud going in and out of the wellbore. Mud weight can be determined using a mud balance, which consists of a base, cup, lid, balance arm, knife edge, rider, level glass and counterweight. As shown in table 1, mud weight can be reported in pounds per gallon (ppg), pounds per cubic feet (lb/ft³) or specific gravity (g/cm³) [7].

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**Equivalent Static Density:** Equivalent static density is an expression of hydrostatic pressure exerted by the drilling fluid column. This includes the effects of entrained solids and fluids which may increase or decrease the effective hydrostatic pressure in the annulus.

**Equivalent Circulating Density:** This is a term used to express the effects of pressure loss in small diameter wellbores. It can be defined as the sum of hydrostatic head of the fluid column, the additional increment in density due to drilled cuttings contained in the annulus as well as the pressure loss in the annulus as a result of fluid flow. It represents the total actual bottom hole pressure that is been exerted to the formation.

\[
edc = \frac{1}{0.052 \ TVD} (\text{Annular Pressure loss, psi + mud weigh, ppg})
\]

ecd = Equivalent circulating density
TVD = True Vertical Depth depth in ft at which the ECD is being calculated
2.3 Rheological Properties

Rheology is a study that has to do with the deformation and flow of matter particularly in liquids or soft solids. Rheology is very important because it gives an insight of the drilling fluid properties and characteristics [9].

2.3.1 Viscosity

Viscosity is the internal resistance of a fluid to flow (Schubert, 1995). It can be defined as the ratio of shear stress to shear rate. It is expressed in poise but typically expressed in centipoise since poise is a very large number. (1 Poise = 100 Centipoise).

\[
Viscosity (\mu) = \frac{\text{shear stress}}{\text{Shear rate}} = \frac{\tau}{\gamma}
\]

Abnormal conditions downhole can be identified by the by changes in the viscosity and other rheological properties of the mud. Changes can be as a result of contamination of drilling fluid by drilled cuttings, excessive fluid to the formation, formation fluid contaminating the mud or retention of fine solids in the mud. There are two main ways of measuring viscosity. These are:

Marsh Funnel Viscosity: This type of viscosity is measured in seconds per quart. To determine the marsh funnel viscosity, a funnel is filled with to the bottom of the screen with the mud sample. The funnel has a capacity of 1500cc and the marsh funnel viscosity is recorded as the time required for 946 cc (quart) to flow through the 2 inch-long, 3/16 inch diameter tube at the bottom of the funnel. This type of viscosity cannot be used in calculations but rather to tells the mud engineer the consistency of the mud. A continuous increase or decrease in funnel viscosity means that there is a problem with the mud and should be checked with other instruments like the rotational viscometer to determine the exact problem and its cause.

Rotational Viscometers: Unlike marsh funnel, rotational viscometers are driven by electric motors, therefore, need electricity they are used to determine the shear rate/shear stress of a drilling fluid. The reading obtained from these devices can be used to determine the Bingham plastic parameters plastic viscosity and yield point. The apparent viscosity, plastic viscosity and gel strength of a mud sample can also be determined using the rotational viscometers [10].

2.3.2 Gel strength

The gel strength of a drilling fluid is the shear stress measured at low shear rates after the fluid has been static for a period of time [11]. It is measured at 10 seconds, 10 minutes and 30 minutes respectively. It represents the ability of the drilling fluid to suspend drilled solids once circulation is stopped usually during connections and trips. To resume circulation, operators usually increase the pump pressures slowly to prevent the mud from fracturing the formation. To break the gels, additional pressure is usually needed which is dependent on the fluid type and its rheological properties. The gel strength is obtained using a rotational viscometer.

3. Methodology

The main essence of testing drilling fluids is to determine their ability to do required functions [12]. Below is a list of materials used in formulating the mud samples used in this study;

a. Distilled Water: All samples were prepared by mixing 350ml of distilled water with the clay materials and additives
b. Bentonite: 22.5g of Bentonite was mixed as clay mineral to form the viscosity of the fluid
c. Sepiolite: The same amount as the Bentonite was used to formulate the second mud sample.
d. Sodium Chloride (NaCl): 1g of NaCl was added to improve gel strength and viscosity difference in both samples.
e. Xanthan Gum: Different concentrations of xanthan gum were used as additives to improve the Bentonite muds properties
Apparatus used are; Hotplate, weighing balance, measuring cylinder, beakers, stirrer, thermometer, glass bottles, mixer, mud balance, Fan G viscometer, spatula and stop watch.

Mud samples were prepared by mixing 22.5g of clay sample (i.e. Bentonite or Sepiolite), 1g of NaCl with 350ml of distilled water using the mud mixer at 20 degrees for 10 minutes. Static ageing was used in these experiments where by the prepared samples were stored in a covered container and allowed to age at room temperature (20℃) for the days required. Rheological properties of the samples were determined by rotational viscometers at different ageing time and at temperatures of 20℃ to 60℃ with 10℃ or 20℃ interval between each measurement. Measurements where done once, likewise, gel strength was taken after 10 seconds only. This is due to the limitation of the equipment used which easily enables the mud samples to loosen heat.

Test conducted were divided into three parts;

i. Comparison between the rheological properties of Bentonite and Sepiolite water-based drilling muds and how their properties are affected by ageing and temperature.

ii. Effect of xanthan gum concentration on the properties of Bentonite water-based drilling mud.

iii. Effect of ageing and temperature on the properties of Bentonite treated with 250mg/L xanthan gum.

The mud was tested for the following properties; Mud weight, Plastic Viscosity, Yield point and Gel strength.

3.1 Mud Weight Procedure

1. Before beginning, calibrations were checked (calibration mark provided on the scale for fresh water, 8.33 lb/gal or 1.0 S.G.), and the cup was cleaned and dried.

2. The lid was removed from the mud cup and the filled with the mud sample. The cup was taped by the side to ensure all entrapped air bubbles were removed.

3. The lid on the cup was replaced and rotated until it was firmly seated. Some mud was allowed to squeeze through the vent hole in the lid.

4. Excess mud was washed and wiped from the exterior of the mud balance covering the vent hole. The balance was dried with the vent hole covered.

5. The balance was placed in its base with the knife edges on the fulcrum rest.

6. The rider was then moved until the beam is balanced. The spirit level bubble was set on the center line.

7. The mud weight and hydrostatic pressure or mud gradient at the edge of the rider nearest the fulcrum (toward the knife edge) was taken.

3.2 PV and YP Determination Procedure

1. The test cup was filled to the scribed line with mud sample.

2. The temperature of the mud sample was measured and recorded.

3. The leg l°C k nut was loosened, and the rheometer assembly was raised.

4. The cup filled with mud was then placed below the rotor sleeve.

5. The rheometer was lowered, and the rotor sleeve was immersed to the scribed line on the rotor sleeve.

6. The leg l°C k nut was then tightened, and the motor was started by placing the switch to high speed position with the gear shift all the way down. A reading was taken at 600 RPM after the indicator dial value was steady.

7. The switch was changed to the 300 RPM speed and the reading was also recorded after the dial value became steady.

3.3 Viscometer Readings

\[
\text{Plastic Viscosity (cp) = Reading at 600} - \text{Reading at 300} \\
\text{Yield Point (lb/100sqft) = Reading at 300} - \text{Plastic Viscosity}
\]
3.4 Accuracy of Readings

Due to the limitation of equipment used in the lab, readings were taken once at each temperature. A test was conducted at room temperature to determine the closeness of the measurements reported to the actual true value. Twenty readings were taken and from that, the percentage error was found to be equal to 1.125%. This means that all readings reported in this work are accurate to a good extent.

4. Results

Results of plastic viscosity, yield point, density, gel strength and pH of bentonite and sepiolite drilling muds are presented as a function of aging time at different temperatures in Figure 1 through Figure 5. Graphs of each property mentioned above as a function of xanthan gum concentrations (250mg/L, 500mg/L, 750mg/L and 1000mg/L) are presented in Figure 6 and Figure 7. Figure 8 and Figure 9 gives the graphs of the same properties of a mud treated with 250mg/L of xanthan gum as a function of aging time at different temperatures.

![Figure 1: Plastic viscosity as a function of aging time at different temperatures for Bentonite mud (Left) and Sepiolite mud (Right)](image1)

![Figure 2: Yield Point as a function of aging at different temperatures for Bentonite mud (Left) and Sepiolite mud (Right)](image2)
Figure 3: Density as a function of aging time at different temperatures for Bentonite mud (Left) and Sepiolite mud (Right)

Figure 4: Gel strength as a function of aging time at different temperatures for Bentonite mud (Left) and Sepiolite mud (Right)

Figure 5: pH as a function of aging time at different temperatures for Bentonite mud (Left) and Sepiolite mud (Right)
Figure 6: Plastic viscosity and Yield point as a function of concentration of X.G at different temperatures of bentonite mud

Figure 7: Gel strength and pH as a function of concentration of X.G at different temperatures of bentonite mud

Figure 8: Plastic viscosity and Yield point as a function of aging time at different temperature of bentonite mud + 250mg/L X.G
5. Discussion

From the results shown in Figure 1 - Figure 5, it can be seen that the rheological properties of both bentonite and sepiolite water-based drilling fluids are affected by aging and temperature. A comparison of how the two muds vary and the reason why these properties change with time and temperature will be explained below;

As it can be seen on Figure 1, the plastic viscosity of bentonite and sepiolite muds are different even though equal amount of clay materials were added in equal amount of water and mixed for the same period of time. The plastic viscosity of bentonite mud at day 0 at 20°C was found to be 10cp while that of sepiolite was found to be 15cp. For the same temperature, as the aging time increases, the viscosity of both muds decreases. This clearly shows that at the rig sites where the mud is formulated based on the desired properties, a lesser amount of sepiolite will be required to obtain a particular viscosity as compared to the bentonite.

The same can be said for the muds carrying capacity. The yield point of bentonite mud was found to be 22lb/100sqft at day 0 at 20°C while that of sepiolite was 26lb/100sqft. This means that sepiolite mud offers a better hole cleaning capacity than the bentonite mud. The yield point of both muds is also affected by aging time and temperature. This can be seen in Figure 2 where an increase in aging time results in a decrease in yield point at the same temperature. Also, an increase in temperature leads to a decrease in the yield point for both muds at the same aging time.

The density of bentonite mud was found to be 8.6ppg while that of sepiolite was found to be 8.7ppg. Therefore, the sepiolite mud exerts a slightly higher pressure to the formation in trying to contain the subsurface pressures. Densities of both muds were found to be unaffected by neither aging time nor temperature as shown in Figure 3.

With regards to gel strength, Figure 4 shows that both muds show an increase in gel strength as aging time increases. Similarly, for the same aging time, gel strength decreases as temperature increases. Gel strengths of both bentonite and sepiolite are very similar to that of bentonite a little higher. This means that bentonite muds have the ability to contain more solids once circulation is stopped but at the same time the higher gel strength has a negative effect since the higher pressure is needed to break the gel to resume circulation of the mud. Care must be taken in breaking this gel. Application of too much pressure can cause formation fractures which can result to loss circulation or kicks. From this, it can be deduced that though the bentonite mud offers higher gel strength it is preferable to use sepiolite mud since it also offers a good gelling property.

The effect of temperature on the pH of drilling muds has been reported [13-15]. In this work, pH of both muds was found to be almost the same at day 0 at 20°C. Results obtained from the pH test of
bentonite mud shows that the pH turns slightly alkaline from its neutral initial reading of 7.8 to 9.95 at 20°C after been aged for 4 days. With sepiolite mud, the initial pH was 8.1 and there was no much difference even after been aged. Both muds show a decrease in pH at the same aging time as temperature increases.

In the second part of the experimental work conducted, the rheological properties of drilling mud were investigated on a bentonite mud sample with respect to the concentration of additives. The additive used to improve the properties of the mud was xanthan gum and from the results presented in Figure 6 and Figure 7, it can be said that;

The plastic viscosity of bentonite mud increases with increase in the concentration of xanthan gum in the sample. It was found that for the same concentration of additive, plastic viscosity of the mud decreases as the temperature increases. Similarly, the yield point of bentonite mud increases as the concentration of additive increases. As shown in Figure 6, there is a step increase in yield point of the mud as the concentration of xanthan gum increases from 500 to 700 mg/L. Also, from the same graph, it can be seen that as the concentration of Xanthan gum increases, the effect of temperature on yield point diminishes.

The muds ability to form gel once circulation is stopped was found to increase as the concentration of xanthan gum increases as shown in Figure 7.

pH was found be slightly basic between 8 to 10 for all aging time and temperatures studied.

In the last part of the work, the mud rheological properties of a sample treated with 250mg/L of Xanthan gum were studied with respect to aging time at different temperatures. The result obtained shows that;

The plastic viscosity of the treated mud decreases with aging time similar to the untreated discussed earlier, but in this case, since treated, the mud offers a higher viscosity at all aging time. From Figure 8 and Figure 9 it can be seen that the mud treated with 250mg/L of xanthan gum gives a viscosity similar to that of the sepiolite mud. A rise in temperature causes the plastic viscosity to reduce.

The yield point of bentonite mud treated with 250mg/L xanthan gum as shown in Figure 8 decreases slightly with aging. For the same aging time, an increase in temperature causes a decrease in the yield point.

The inverse can be said with gel strength. An increase is obtained from Figure 9 as the aging time increases. Therefore, as aging increases, the internal structure of the mud becomes stronger and will require more pressure to initiate flow. Secondly, gel strength is greatly affected by the temperature of the treated mud.

pH was found to be slightly alkaline between 8 – 10 where a gradual increase is obtained as the aging time increases. In addition, an increase in temperature leads to a decrease in the pH for the same aging time.

As it can be seen in the results obtained, aging, temperature and additive all have effects on the rheological properties of drilling mud. An in-depth explanation as to why such changes occur requires a good knowledge of colloid chemistry and clay mineralogy which is a very broad area in itself. However, some of the reasons why these changes occur will be explained below.

5.1 Effects of Aging

As stated above, all the rheological properties of drilling mud have an effect on aging with the exception of mud density. Viscosity and yield point decreases as aging time increases while gel strength increases as aging time increases. Some of the reasons for such changes are;

Mechanical interaction of solids and liquid: According to Anis, “All solids in suspension tend to behave as uncharged inert particles at high shear rates, and the viscosity of the suspension is due to the mechanical interaction of the solids and liquid”. The viscosity of the drilling mud at high shear rate is a function of the viscosity of the liquid the clays are dispersed in and the shape and concentration of the solids. Viscosity decreases when the concentration of the solids decreases or when the shapes of the particles become more symmetrical. Equally, as aging time increases, the shape of the suspended particles becomes more symmetrical thereby cause a reduction in the
viscosity of the mud. Increase in temperature will cause the viscosity of the liquid fraction to decrease. Similarly, at high shear rate, viscosity of the mud should decrease proportionately so far, the nature of the solids is not affected by temperature [16].

Electrical Interaction of solids: Both bentonite and sepiolite clays are highly dispersible, leading to a large surface area per volume of solids present in the mud. The suspended clays are the gel builders particularly in water-based drilling fluids. The ability of drilling mud to form gels is largely controlled by electrical forces. The forces exist between the negatively charged faces and the positive edges of the clay plates. As shear rate is decreased, the electrical interactions of the solids begin to influence the viscosity more and more [16].

5.2 Effects of Temperature

The elevated temperatures downhole causes the rheological properties of drilling muds to vary from those measured at ambient temperatures. Several causes some of which dominate over others can make the mud thinner or thicker than it is at the surface. Similarly, additives that increase viscosity at the surface might perform differently downhole and rather decrease the fluid’s viscosity. At high shear rates, the plastic viscosity of clay suspension decreases with increase in temperature because the plastic viscosity of water decreases. The reason for this is because as temperature increases, the intermolecular attractive forces increase. This same effect is what causes increase in gel strength as the temperature increases.

Another reason for change in the rheological properties of drilling mud under high temperatures is the degradation of the solids, polymers and other additives added to formulate the mud. This degradation will cause expansion of the molecules and hence lowers the fluids resistance to flow [14].

Other factors such as decrease in the hydration of counter ions, increase dispersion of assiated clay micelles, changes in electrical double layer thickness and increased thermal energy of the clay micelles also takes place simultaneously as the temperature is varied. An interpretation of the observed results will only be possible in cases whereby some of the effects mention are predominant thereby easily identified [17].

Lastly, temperature affects pH of drilling mud by causing dissiation of water into $H^+$ and $OH^-$. Increase in temperature will cause a shift of the reaction’s equilibrium to the right thereby increasing the number of $H^+$. This results in the reduction of pH since $pH = \log [H^+]$

5.3 Effects of Additive (Xanthan Gum)

The viscosity of drilling muds largely depends on the shape and concentration of solids particles in the mud. Hence, the addition of polymers in any concentration to a drilling fluid will increase its viscosity. As mentioned in the previous chapter, xanthan gum was added to improve the bentonite mud’s properties. Several other additives could have been used but this was chosen in particular because of its unique properties. Some of which includes;

- Its ability to withstand high temperatures
- Its ability to improve rheological properties as explained below
- Its ability to improve the wall building properties of the mud

The structure and conformation of xanthan gum explains many of its unique properties. Solution of xanthan gum is highly Pseudoplastic. Viscosity is reduced when shear stress is increased. Once shear is removed, the viscosity is regained almost instantaneously. This special behavior results from the ability of xanthan gum to aggregates in solution via hydrogen bonding and polymer entanglement which causes high viscosity of xanthan gum and also accounts for its suspending ability as it can be seen in the results shown in Figure 6 and Figure 7. Xanthan gum solutions have the ability to retain their properties as temperature increases until a definite temperature known as the melting temperature is reached. At this temperature the viscosity drops sharply due to a reversible molecular conformation change [18].

Increase in viscosity and yield point as xanthan gum concentration increases is due to the increase in dispersion and $\text{fi}^\circ\text{C}$ulation it caused. Dispersion as stated earlier is the subdivision of
large clay particles into smaller larger number of particles containing fewer platelets per particle due to hydration [19].

5.4 Effect of salt

Clay particles contains charged surfaces, addition of electrolytes may alter the rheological properties of the mud depending on the type and concentration of the electrolytes. The different modes of particles interaction may take place simultaneously or one may dominate over others. Introduction of high temperature can further complicate the situation. This is because the solubility of many salts varies with temperature. A shift in the relative concentration or a change in the ion concentration of various salts may results from increase in temperature. Therefore, changes in temperature can results to any of the electrolyte – clay interaction that “ C cur at room temperature when the electrolyte content of the mud changes. Hence, the introduction of electrolyte makes it more difficult to predict the mode of particle ass“ iation that prevails [16].

NaCl was added to the mud for compatibility against salt formations. Salt is known to have a high water holding capacity. This can even be seen when it is exposed to the atmosphere. Due to this hygroscopic nature of the salt, it can be said that there is an increase in absorption of water molecules by the salt from the surroundings as aging time increases and thus causes reduction in viscosity and yield point [17].

6. Conclusions

Drilling fluids are an important aspect that has to be formulated and controlled properly to successful drill an oil and gas well. Test conducted in this work shows that most of the properties of water based drilling mud are affected by aging and temperature. From the results obtained, it can be concluded that;

i. The plastic viscosity and yield point of bentonite and sepiolite water based drilling fluids decreases as aging and temperature increases.

ii. Sepiolite water based drilling fluid produces higher viscosity and yield point values as compared to bentonite muds. This therefore shows that it offers a greater hole cleaning capacity than bentonite water based drilling mud.

iii. Density of both bentonite and sepiolite is not affected by aging and temperature.

iv. The plastic viscosity, yield point and gel strength of bentonite mud increases as concentration of xanthan gum added as an additive to the mud increases.

v. Higher values of plastic viscosity and yield point were obtained after treating the mud with xanthan gum. Both of which decreases with aging and temperature.

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References


