EVALUATION OF THE EFFECT OF CEMENT CONTAMINATION ON THE RHEOLOGICAL PROPERTIES OF WATER BASED MUD: SODIUM BICARBONATE AS A REMEDY

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Abstract- *In this paper we present the evaluation of the effect of cement contamination on the rheological properties of water based mud and to ascertain the effectiveness of sodium bicarbonate as a remedy to such cement contamination. Drilling mud ensures smooth and cost-effective drilling operations. However Contaminants are been encountered at every step of the drilling operation. The extent of the drilling mud contamination mostly is attributed to the class or type of the drilling mud used, and the type of the contaminant as well. During drilling, drilling fluids are used in the drilling operation as well as to case and cement the hole, in the process drilling fluids get contaminated and that affects the rheological characteristics of the mud and hinders the drilling operation as well. Three mud sample were formulated that of a fresh mud, cement contaminated mud, and cement contaminated mud with sodium bicarbonate as a remedy. The experimental result shows that when sodium bicarbonate is added to the cement contaminated mud the viscosity both apparent and annular, gel strength as well as the yield point, tends to decrease with an increase in sodium bicarbonate.*

Furthermore the findings proved that sodium bicarbonate is the best remedy to contaminated water based mud. Other solutions too were proved to be viable too but sodium bicarbonate is by far the most effective and cheapest of them all.

Keywords*:* ***water based drilling mud, sodium bicarbonate, rheological properties, yield point, gel strength, viscosity (annular, apparent).***

1.0 INTRODUCTION

Drilling fluid are used to assist in drilling of hole down the earth surface, drilling of holes cannot be carried out in oil and gas production without the use of drilling fluid which can either be oil based mud, water based mud and gaseous based fluid as well [Ali et al, 2013].

Drilling fluid are employed to aid the removal of drilling cuttings, it also balances the formation pressure which prevent excess pressure from finding way into the borehole which can lead to unwanted situation referred to as 'kick'. As drilling is been carried out the drill bits get hot and as such drilling fluid are used to clean and cool the drill bits as well. The drilling fluid to be used are selected based on the geological formation of the site to be drilled.

The term drilling mud includes air, gas, and water or could either be a combination of two or all the above. The common type of fluid most often used in mud suspension of solid clay is a liquid and emulsion mud (suspension of solid and droplets of liquid). The drilling fluid is a term that comprises all the components of clay and additives suspensions used to effect the removal of rock cuttings from the subsurface (bottom hole) to the surface while drilling.

Through the 1920's iron oxide and Barium Sulphate (Barite) was initially employed to increase the density of the drilling mud, thus preventing entry of the formation fluid into the borehole. The use of bentonite in 1930's to suspend Barite formed the basis for today's large commercial drilling mud industry.

1.1 SIGNIFICANCE OF STUDY

The significance of this study is to show how cement will reduce the quality of the drilling fluid, and thus reduce its functions while drilling a hole. Knowing when a contaminant enters the mud system, the type of contaminants in the mud system and treatment techniques will help to;

I. Reduce drilling cost
II. Increase personnel safety
III. Increase productivity
IV. Save time

2.0 DRILLING FLUID CONTAMINATION

Drilling fluid/mud are employed to ease oil and gas drilling operation and maintain the formation pressure while drilling as well. Drilling fluid/mud is contaminated when an unwanted material enters into the mud and changes its initial properties or characteristics. Drilling mud Contaminants mainly change the density as well as the viscosity of the drilling mud when in contact. Another prevalent factor also that pose danger and cause contamination of the drilling mud system is overtreatment of the mud with additives which destabilize and disharmonize the initial properties of the mud.

Drilling mud contaminants can either be predictable and unpredictable at most times the unpredictable once poses serious danger to the drilling mud system as they can only be noticed when they have already damaged the drilling mud system. However the predictable once can easily be identified and remedied within a short period of time. Cement mud contaminant such as gypsum, hydrogen sulfide as well as salt belonged to the predictable class of drilling mud contamination (Mahmood and Khaled, 2012).

Generally some of the contaminants that poses harm to the drilling mud are;

1. Cement or lime ($CaCo_3$)
2. Hydrogen sulphide (H_2S)
3. Carbon dioxide (Co_2)
4. Sodium chloride (Nacl)
5. Carbonate and bicarbonate
6. Salt water
7. Drilled solid

3.0 MATERIALS AND METHOD

3.1 MATERIALS

In the course of this study, the main materials and equipment used for this study are as follows: Fann VG viscometer, Class G cement, Bentonite, Sodium Bicarbonate, weighing balance, Slurry mixer.

3.2 METHODS

Three mud samples were formulated, the first one for fresh mud, the second for contaminated mud and the third for the remedied mud with sodium bicarbonate. For each of the mud sample formulated the rheology of the drilling fluid was determined i.e. yield point, and gel strength using the Fann VG viscometer. The results obtained was then computed into the equations below to ascertain the plastic viscosity, apparent viscosity and lastly the yield point:

$$Plastic\ Viscosity\ (cp) = \mu_p = 600\ RPM\ reading - 300\ R.P.M\ reading$$

$$\mu_p = \theta_{600} - \theta_{300}$$

$$Apparent\ Viscosity\ (cp) = \mu_a = \frac{600\ RPM\ reading}{2}$$

$$\mu_a = \frac{\theta_{600}}{2}$$

$$Yield\ Point\ \left(\frac{lb}{100} ft^2\right) = YP = 300\ R.P.M\ reading - Plastic\ Viscosity$$

4.0 RESULT AND DISCUSSION

Experimental result, data analysis, and discussions are presented. It provides a thorough examination of experimental observations and test. As the well is drilled deeper, the mud encounters different formations and may be contaminated in the process. Hence, requires a careful monitoring of the parameters that enable the mud to perform its required functions adequately.

Based on the results obtained from the laboratory experiments of this study, it was found that the rheological properties of the water based drilling mud formulated were affected by cement mud contamination. It was deduced that these contaminant increase the drilling mud properties which are pH, plastic viscosity, yield point, and finally gel strength.

5.0 CEMENT CONTAMINATION

The following results were gotten from the laboratory for fresh mud, cement contaminated mud and the remedied contaminated mud, and its various effects.

Table 4.1: Readings of a fresh formulated water based mud:

Weight of fresh mud [g]	Viscosity [cp]					Gel strength (lb/100ft²)	
	θ_{600}	θ_{300}	μ_p	μ_a	Y_p (lb/100ft²)	Gel strength initial 10 sec.	Gel strength final 10 min.
60	24	16	8	12	8	12	14

Table 4.1: Readings of a formulated cement contaminated mud:

Weight of contaminants (g)	Viscosity [cp] With contamination					Gel strength (lb/100ft²)	
	Θ_{600}	Θ_{300}	μ_p	μ_a	Y_p (lb/100ft²)	Gel strength initial 10sec	Gel strength Final 10 min.
15	29	20	12	16	8	13	15
30	32	21	11	16	10	15	17
45	36	24	12	18	12	17	19
60	42	27	15	21	12	20	20

Table 4.3: Readings of a formulated remedied cement contaminated mud.

Weight of sodium bicarbonate	Viscosity [cp]					Gel strength (lb/100ft²)	
	Θ_{600}	Θ_{300}	μ_p	μ_a	Y_p (lb/100ft²)	Gel strength Initial 10 sec.	Gel strength Final 10 min.
15	28	18	10	14	8	16	17
30	27	18	9	13.5	9	15	16
45	25	17	8	12.5	9	13	16
60	25	16	9	12.5	7	13	15

5.1 GRAPHICAL INTEPRETATION OF THE RESULT

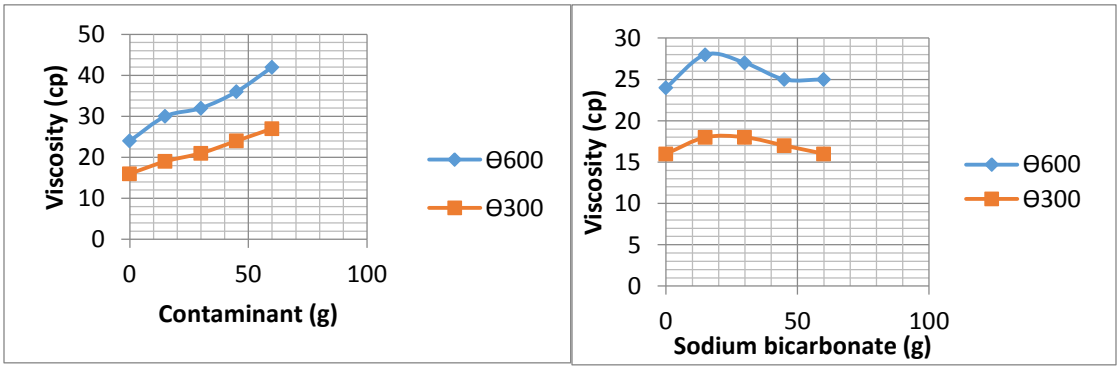


Fig 4.1: Indicates the Viscosity of a contaminated mud/ with viscosity of a remedied mud

From the above graphs, the first graph shows how viscosity keeps increasing with increase in cement mud contamination. The second elaborate how such mud contamination is decreased with the addition of sodium bicarbonate, so we can deduced from the second graph that sodium bicarbonate is effective in resolving cement mud contamination.

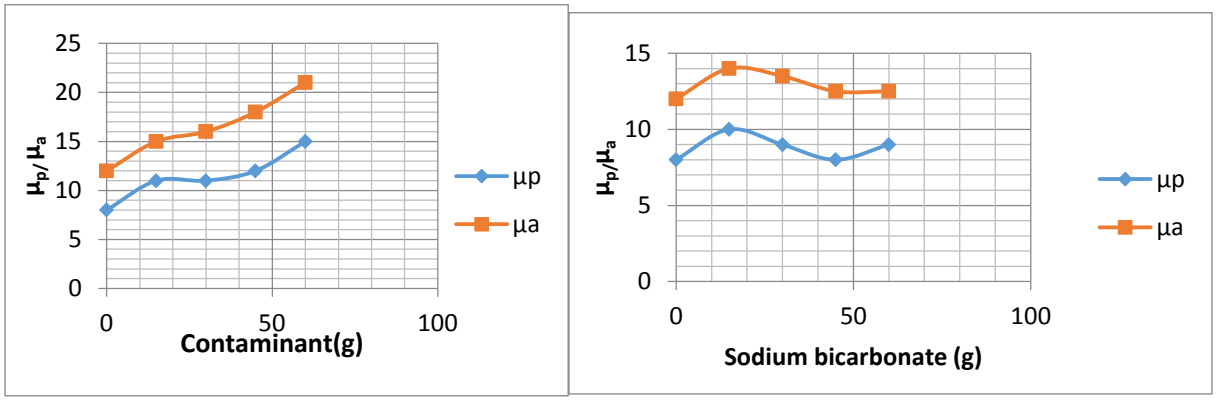


Fig 4.2: indicates the Annular Viscosity and Apparent Viscosity of a contaminated mud/ that of a remedied mud

From the two graphs, the first shows how that cement mud contamination alters the annular viscosity and apparent viscosity as well which in turn hinders drilling operation and can lead to drilling operation consequences such as loss circulation, stuck pipe and the rest. Upon the addition of sodium bicarbonate the alterations keeps reducing/decreasing with increase in the addition of sodium bicarbonate. Sodium bicarbonate is far the best remedy to cement mud contamination as we can see vividly from the plotted graph.

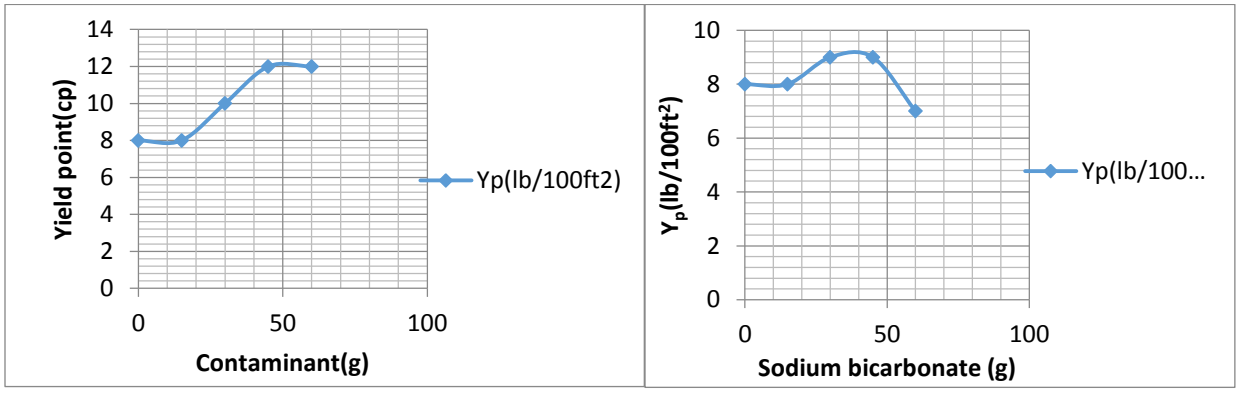
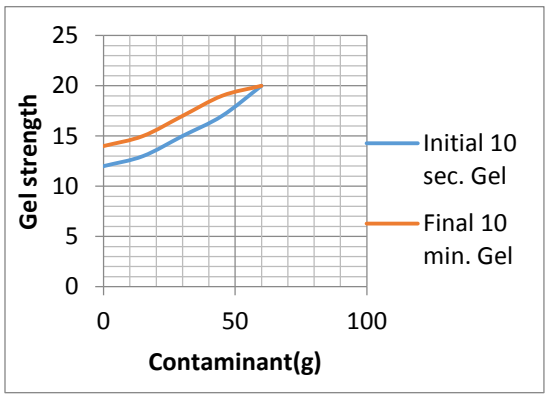


Fig 4.3: Indicates Yield Point of a contaminated mud/ that of a remedied mud

Cement mud contamination increases the yield point of drilling mud. Increase in yield point is hazardous to drilling operation as it reduces the strength and strength of the drilling mud to drill the hole as well as penetrate the formations, decisively a point where drilling can no longer proceeds. The second graph vindicates that addition of sodium bicarbonate at various weight respectively drastically reduce the effect and stabilize the drilling mud.



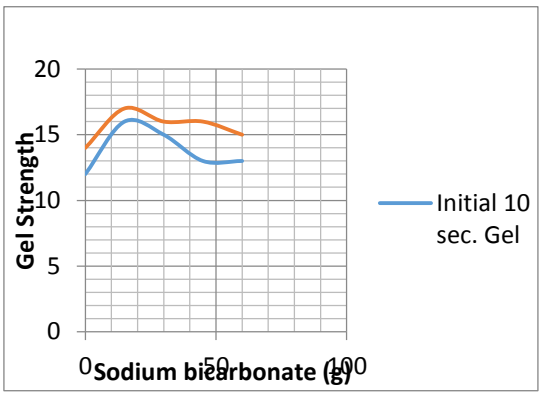


Fig 4.4: indicates Gel Strength of a contaminated mud/ that of a remedied mud

Similarly, from the two graphs the first indicates how gel strength keeps increasing with increase in cement mud contamination. Increase in gel strength can cause improper circulation of mud and inability of the drilling mud to bring drill cuttings to the surface through the annulus and inadequate sealing of the walls of the wellbore. The second graph shows how such alteration is resolved by the addition of sodium bicarbonate at different weight.

5.2 DISCUSSION OF RESULT

From the result plotted above, it was deduced that a water based mud of 60(g) was formulated and contaminated by various weight (15g, 30g, 45g, and 60g) of cement. From the graph, the viscosity, gel strength, plastic viscosity and apparent viscosity of the mud keeps increasing with a corresponding weight of the cement incorporated in the formation.
From the laboratory experiment, when a water based mud is contaminated with cement(less than or equal to 30g) it will fall in the viscosity range of 25-30cp. At this point, the cement is no longer a contaminant rather serves the function of a viscosifier, but with cement contamination above 30g, the viscosity shows an increase excessively above 30cp. At this point, treatment should take place using sodium bicarbonate.

6. CONCLUSION AND RECOMMENDATIONS

The experiment conducted proved that sodium bicarbonate can be used as a remedy to cement mud contamination. The oil and gas production is a lucrative business which requires much expertise and as such proper care and consideration must be put in place to ensure a safe and accident free operation. The properties of the drilling mud has to be intact at every step of the operation to ensure adequate performance of the drilling mud. When a drilling mud is contaminated with cement it poses serious dangers which can lead to unwanted situation and can even claim the lives of personnel.

Furthermore this project proved that sodium bicarbonate is the best remedy to contaminated water based mud. Other solutions too were proved to be viable too but bicarbonate is by far the most effective and cheapest of them all.

The recommendations are highlighted below;

1. Solid removal equipment are the key to achieve desired drilling operations and as such drilling operations should be equipped with the aforementioned to ensure smooth drilling operations without much cement mud contamination.
2. In case of cement mud contamination drilling mud has to be remedied instantly to tackle the contamination and to preclude the damage of subsurface machinery.
3. The drilling mud crew as well as the mud engineer must be able to proper feasible solutions based on their experiences and prior knowledge.

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