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Comparison of Performance of Standard Water-based and Oil-based Mud For Drilling Purpose During Carbon Dioxide Gas Kick From Adjacent Reservoir

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ABSTRACT

This experimental study compares the effect of carbon dioxide, CO_2, leakage from adjacent storage reservoir on drilling mud being used in a nearby reservoir. Comparison of the effect of CO_2 on Water-based and Oil-based drilling fluids will help in the selection of best drilling fluid for the nearby reservoir. It was observed that the percentage change in the density of both mud after contamination with CO_2 were negligible. Though, there was about 7% increase in oil-based mud density at the end of 25days with a corresponding 17% decrease in water-based mud density within same period but this is negligible as the same mud cannot be used to drill for up to 25days without weighting the mud for deeper depth. Unlike density, there was sharp increase of 242% in viscosity of oil-based mud with a corresponding 35.8% reduction in the viscosity of the water-based mud within the first 3 days of contamination with CO_2. The conclusion is that water-based mud is more stable than oil-based mud when there is serious CO_2 gas kick but a standard mud of midway properties, oil-in-water emulsion, may be ideal as a cheap mud for this purpose. Further study is expected to be carried out on suitable additive that could enhance the properties of the two muds and also on the suitability of the use of oil-in-water drilling mud or synthetic mud for CO_2 contaminated environment.

Keywords- *Oil-based mud, water-based mud, CO_2 contamination, CO_2 kick in mud*

I. INTRODUCTION

The study assumes that the stored Carbon Dioxide (CO_2) could leak out of the storage reservoir due to reaction with the reservoir grains according to a study by Rochelle et al [1]. The leakage could also be as a result of fracturing due to pressure of injection of CO_2 in that reservoir since the gas is injected at high pressure.

Goodarznia I and F. Esmaelzadeh [2] investigated the treatment of drilling mud contaminated drilling cuttings waste with supercritical carbon dioxide. This was applied in the treatment of drilling waste mud of South Pars gas field at a temperatures range of 55 to 79.5 °C and pressure range of 160 to 220 bar. Results obtained show that approximately 28.45 % of cuttings weight at a pressure of 200 bar and temperature of 60 °C can be extracted by supercritical carbon dioxide. This is an indication that supercritical CO_2 may alter the properties of a drilling mud.

Adebayo et al [3] in the experimental study of alteration of oil-based mud during contamination with CO_2 observed that CO_2 contamination of the mud resulted into 3.45% increase in the density of the mud within 8days; 82.79% increase in the viscosity of the mud within the first 5 days and a further 18.55% increase within the next 3 days of contamination and a 96.98% increase in the yield strength within the first 8 days of contamination. As the contamination continued there was reduction in the rate of increase of 18.02% in viscosity; 17.48% in yield strength and a 3.44% in mud density. This shows that the critical stage in the contamination was the first 8days of mud application after contamination with CO_2. The increase in the mud density can be taken as negligible with the attendant dilution with formation fluid during contact, but the drastic increase in the viscosity and the yield strength of the mud is of great concern.

Adebayo et al [4] carried out an experimental study of CO_2 contamination with water-based drilling mud and discovered that there was a 75.23% reduction in the viscosity of the mud within the first 11 days of contact with CO_2 which makes the mud totally and this seriously affected the mud's ability to clean the well and transport drill cuttings to surface and this will result into lower drilling rate and higher drilling cost. There was a 16.3% reduction in the density of the mud within this period. After the first 11 days of CO_2 influx, the density and viscosity of the drilling mud remains constant and this is an indication that a drilling mud, when reconditioned with a viscosifier, can be reused after some days of CO_2 contamination without a further CO_2 kick altering its density and viscosity properties. The research also indicated that the pH of the mud reduces gradually until the 11th day turning an initial basic mud to a slightly acidic mud. This is an indication of possible reduction in equipment corrosion

II. METHODOLOGY

The methodology followed in the course of this research is as follows:

1. Standard oil-based and water-based fluids were prepared.
2. Simple apparatus such as viscometer, density balance and pH were used in the measurement of the initial properties

of the mud such as the density, shear stress, yield point, resistivity and acidity.

3. The apparent and plastic viscosities for the fluids were then calculated.

III. RESULTS

The result obtained in the cause of the experiments are as stated in the tables below: Table 1 is the table of the fraction change in the density of the mud as days of exposure to CO_2 increases while Table 2 gives information on the calculated Yield point and apparent viscosity obtained from gel strength and shear strength data obtained with the use of viscometer.

Table 1: Fractional Change in Mud Density Due to Contamination by CO_2

Time (days)	Fractional Change in Mud Density	
	WBM	OBM
0	0.0000	0.0000
3	-0.1111	0.0110
6	-0.1259	0.0300
7	-0.1407	0.0320
8	-0.1481	0.0370
9	-0.1593	0.0440
10	-0.1630	0.0460
11	-0.1704	0.0480
12	-0.1704	0.0520
13	-0.1704	0.0570
15	-0.1704	0.0595
17	-0.1704	0.0690
19	-0.1704	0.0713
21	-0.1704	0.0747
23	-0.1704	0.0805
25	-0.1704	0.0805

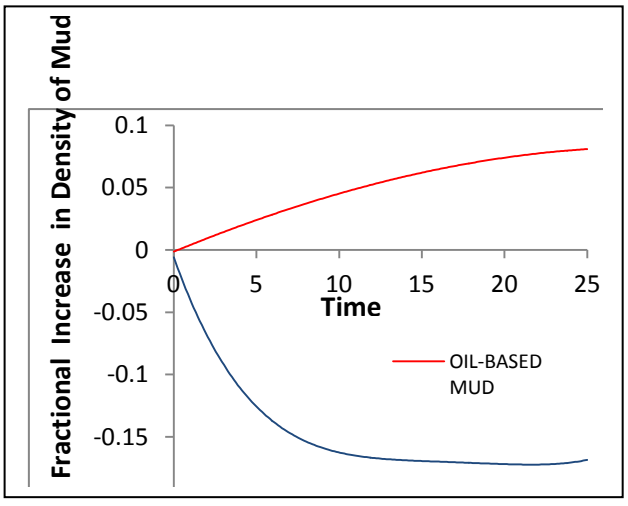

Figure 1: Fractional Change in Densities of Drilling Fluids As Days of Contamination With CO_2 Increases

Table 2: Fractional Change in Yield Point and Apparent Viscosity of Drilling Mud Due to Contamination by CO_2 Gas

Time	Fractional Change In Yield Point		Fractional Change In Apparent Viscosity	
(days)	OBM	WBM	OBM	WMB
0	0.000	0.000	0.000	0.000
3	1.000	-0.573	2.423	-0.358
6	1.852	-0.787	2.981	-0.585
8	2.279	-0.840	3.189	-0.604
9	2.410	-0.893	3.226	-0.660
10	2.541	-0.920	3.340	-0.717
11	2.639	-0.920	3.415	-0.755
12	2.770	-0.920	3.566	-0.755
13	2.836	-0.920	3.642	-0.755
14	2.902	-0.920	3.774	-0.755
16	2.967	-0.920	3.943	-0.755
18	2.967	-0.920	3.943	-0.755

Figure 2 below shows the fractional (percentage) change in the yield point of the mud when it was contaminated with CO_2 gas.

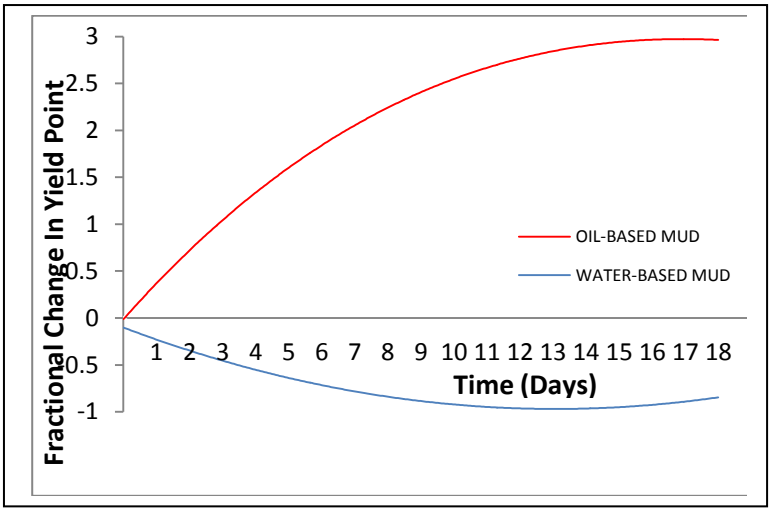

Figure 2: Apparent Viscosities of Drilling Fluids As Days of Contamination With CO_2 Increases

The corrensponding change in the apparent viscosities for both the oil-based mud and the water-based mud is as shown in Figure 3 below.

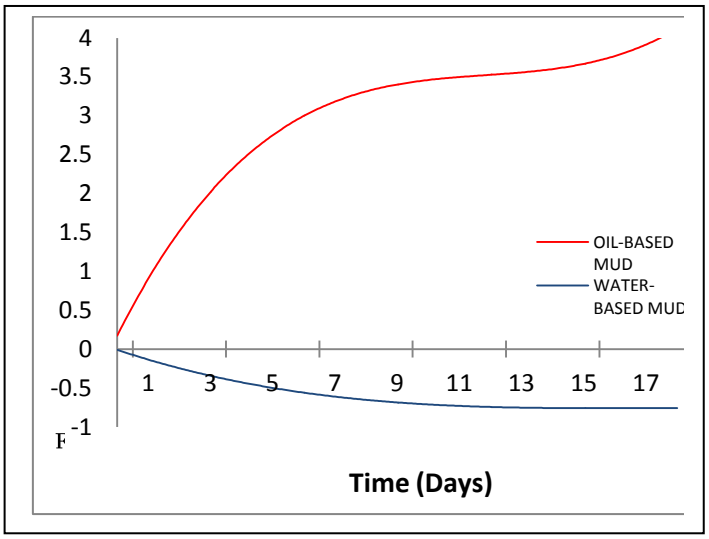

Figure 3: Calculated Yield Strength of Drilling Fluids As Days of Contamination With CO_2 Increases

IV. CONCLUSION

It was observed that contamination of water-based mud by CO_2 resulted in reduction in the mud density. The change in density was 15% in the first 7 days and stabilized at 17% on the 15th day. For the oil-based mud, there was increase in its density of 3% in first 7 days and a 7% increase by the 25th day. This made the oil-based mud density to be more stable in CO2 contamination than that of the water-based mud.

It was observed that there was 100% increase in the Yield Point for oil-based mud within the first 3 days of CO2 contamination. This went up to 250% increase by the 10th day and 296% increase by the 16th day. The yield point of that of water-based mud actually reduced by 57.3% within first 3 days and stabilized at 75% reduction by the 11th day. Same trend was observed for the apparent viscosities. For oil-based mud there was an increase of 242%, 334% and 394% by the 3rd, 10th and 16th day respectively while the corresponding reduction in that of the water-based mud was 35.8%, 71.69% and 75.4% respectively.

Since increase in density can be compensated by contamination with reservoir fluids while reduction in density can be compensated by density of drill cuttings, the change in mud density for both oil-based and water-based mud can be negligible.

Hence, water-based mud is found to be more stable in CO_2 contamination than the corresponding oil-based mud and is recommended for such but with some additives required to enhance its viscosity.

Further study is recommended to find a more suitable mud for this type of heavy CO_2 contaminated reservoir.

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