ALTERATION OF OIL-BASED DRILLING MUD PROPERTIES DUE TO CONTACT WITH CO_2 GAS KICK DURING DRILLING

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***Abstract*:** There is a possibility of CO_2 leakage from the storage reservoir during carbon sequestration and storage (CSS) process and this may lead to kick in nearby reservoir being drilled. The CO_2 kick, when it comes into contact with the drilling mud, will tend to alter the properties of the drilling mud. The alteration in the properties of the drilling mud could result into failure of the drilling programme. This experimental research work studied the effect of CO_2 kick on the properties of oil-based (water-in-oil emulsion) mud. It was observed that CO_2 contamination of the water-in-oil drilling mud resulted into 3.45% increase in the density of the mud and 96.98% increase in the yield strength within the first eight days of contamination. It also led to 82.79% increase in the viscosity of the mud within the first 5 days of contamination and a further 18.55% within the next 3 days of contamination. Within the 8^{th} day and the 16^{th} day of mud contamination with CO_2 there was a further increase in density, viscosity and yield strength of the water-in-oil based mud. The rate of increase was less than the preceding days with 18.02% increases in viscosity; 17.48% increase in yield streght 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. Though, there was negligible increase in the mud density, which is easily manageable, but there was drastic increase in the viscosity and the yield strength which greatly altered the effectiveness of the mud as the mud becomes too viscous.

Keywords: CO_2 kick, drilling mud, mud density, CO_2 solubility.

1. INTRODUCTION

Water-in-oil emulsion mud is used for high pressure high temperature zone and has extensive application in drilling. CO_2 sequestration is globally accepted as mitigating factor for the elimination of excess CO_2 in the atmosphere. The acclaimed safest storage is depleted underground oil reservoirs, saline reservoirs and in methane hydrates reservoirs. CO_2 in contact with water is reactive and may alter the rock properties leading to leakages in the storage reservoir. Oil-Based Fluids is used for drilling shale and deviated holes because of their high degree of lubricity and for high temperature/ high pressure wells and because of perceived high resistant to contaminants such as anhydrite, salt, and acid gases such as CO_2 and H_2S.

This research studied the reaction of oil-in-emulsion mud due to contact with CO_2. Invert emulsion mud is water-in-oil fluids that have water as the dispersed phase and oil as the continuous phase. This research considered the possibility of stored CO_2 migration from a nearby storage formation and becoming a gas kick to the nearby reservoir being drilled with a water-in-oil emulsion drilling fluid. It is assumed that the CO_2 will be soluble in the mud as a result of chemical combination with some component of the mud and this will result into formation of new compound that can pose serious danger if it altered the properties of the mud adversely.

Zamora et al [17] in a comprehensive analysis of mud-related drilling problems emphasized the importance of maintaining excellent mud properties such as mud weight and viscosity in preventing bottom-hole instability and gas influx. Hoberock and Stanbery [4] introduced the concept of transmission line to analyze gas kick taken during onshore drilling operations by treating a borehole system as a continuum and this is applicable to a Newtonian fluid in a cylindrical geometry with modifications for application to non-Newtonian fluid flow.

Esmaeilzadeh, F. et al [3] investigated the experimental gas hydrate formation for a mixture of methane, carbon dioxide & nitrogen in a water-based drilling mud under two conditions. These are with or without presence of different concentrations of thermodynamic inhibitors such as pure salt and a combination of salt with methanol or ethylene glycol at different concentrations. The experiments were under the condition of a static loop apparatus consisting of a 800 cm long pipe and at 2200 psia and decreasing temperatures. They concluded that the formation of gas hydrates is critical and that inhibitors should be added to the mud to reduce the presence of free water in the mud. This is an indication that CO_2, in the presence of other gases, may have critical effect on the properties of a drilling mud.

Adebayo Thomas A et al [1] carried out experimental work on the effect of carbon dioxide gas kick on water-based drilling fluid. They concluded that there was a critical 75.23% reduction in the viscosity of the mud within the first 11 days of contact with CO_2 which tends to render the mud useless and that viscosifier is needed to reconditioned the mud but the pH of the mud reduces gradually turning the basic mud to a slightly acidic mud.. The resistivity of the mud also increased 58.8% during this period. This present research carried out similar experiment on oil-based mud (water-in-oil emulsion) in order to investigate the influence of CO_2 kick on the mud.

Stephens and Keith [6] considered the geochemical reactions that enhance transformation of CO_2 gas into dissolved or solid phase carbon. This involves liberation of cations to neutralize carbonic acid. They carried out the assessment of potentials and limitations of various geochemical techniques.

Monteiro et al [15] and White and Walton [16] compared the effects of gas solubility in oil- and water-based mud on the gas kick detection rates. They concluded that there is delay in mud-pit gain when oil-base mud is used as compared to when water base mud is used. This is based on the assumption that gas could readily dissolve in oil based mud than in water based mud, and the gas will be librated out of the oil-based mud at surface condition than that of water-based mud system resulting to slower rate of mud gain in oil-based mud system..

2. METHODOLOGY

The following methodology was followed in this research work.

1. Water-in-oil mud was prepared with 36% diesel and 64% water.
2. Initial properties of the mud were measured such as the density, shear stress, yield point, resistivity and acidity. From this the apparent and plastic viscosity were calculated. The initial measurement is as stated in Table.1.

3. Filter press was remodeled to serve as a high-pressure reaction vessel. Mud sample was placed the temporarily modified filter press in form of a closed system.
4. CO_2 gas was injected into the mud sample at an average pressure of 850psi and temperature of 29^0C. The mud was allowed to react with the CO_2 for three days before the properties were measured thereafter injection was done daily.
5. The following mud properties were measured before CO_2 injections:
   - The density of the mud.
   - Shear stress and gel strength of the mud using rotary viscometer. The viscosity of the mud was then calculated form the measured properties.
   - The filtration properties of drilling fluid.
   - The resistivity of the mud.
   - pH of the mud.
6. Test for mud filtration properties using the filter press were carried out along with tests of (6) above.

For accuracy and prevention of data interference, the sample used for viscosity monitoring is different from the one for density monitoring. Mud Sample A was used to monitor variation in density while mud Sample B was used to measure variation in viscosity.

3. RESULTS

The measured and calculated parameters are as follows:

3.1 INITIAL TEST

Table 1: Measured Shear Stress of Mud Before Contamination With CO_2

RPM	Shear Stress of Mud
600	122
300	114
200	110

Mud cake thickness was 0.11cm

Mud resistivity of the mud was 0.47Ω

Mud pH was 11.

From the above table 1, calculations were made and the Yield point was 6 lb/100ft and apparent viscosity was 61cp. The measured Gel Strength was 15 and gel strength after 10-minutes was 14. Mud cake thickness was 0.11cm, room temperature was 29.5°C; measured mud resistivity of 0.47Ω and pH was 11. CO_2 was then injected into mud sample A at room temperature and 500psi for I minute. The mixture was left for the next seven days to allow for all chemical reactions to take place to simulate CO_2 gas kick during drilling breaks.

- SAMPLE A.

Table 2: Measured Density of CO_2 contaminated Mud

Time (days)	Density (ppg)
0	8.7
7	8.9
10	9.1
15	9.2
17	9.3
19	9.32
21	9.35
23	9.4
25	9.4

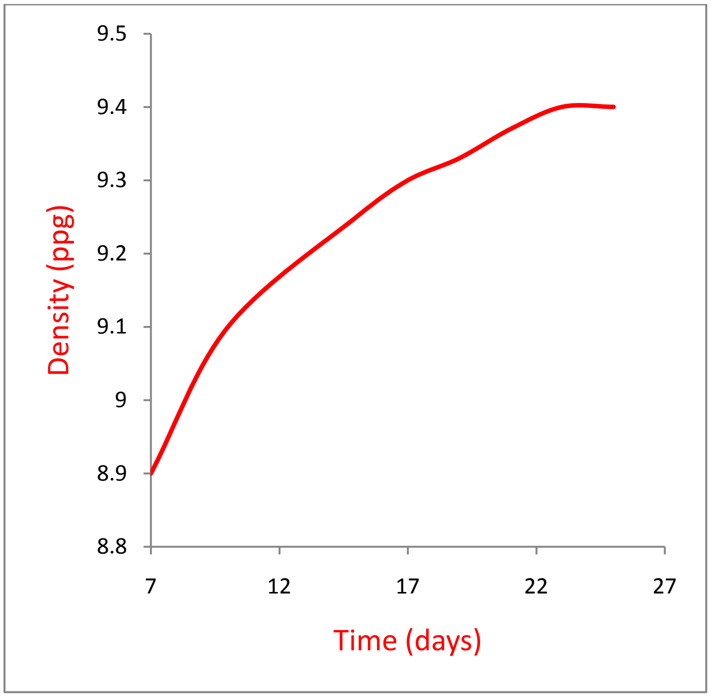

Figure 1: Density of CO2 contaminated Mud

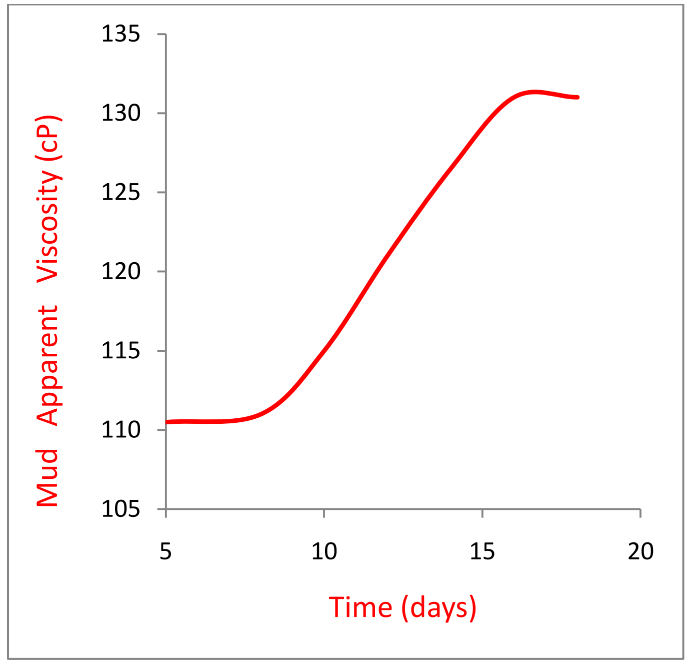

Figure 2: Apparent Viscosity of CO_2 Contaminated Mud

- SAMPLE B

Table 3: Shear Stress of CO2 contaminated Mud

Time (days)	Shear stress		Yield point	Apparent viscosity
	600 rpm	300 rpm		
0	122	114	6	61
5	221	210	199	110.5
8	222	214	206	111
10	230	222	214	115
12	242	236	230	121
14	253	241	219	126.5
16	262	255	242	131
18	262	258	234	131

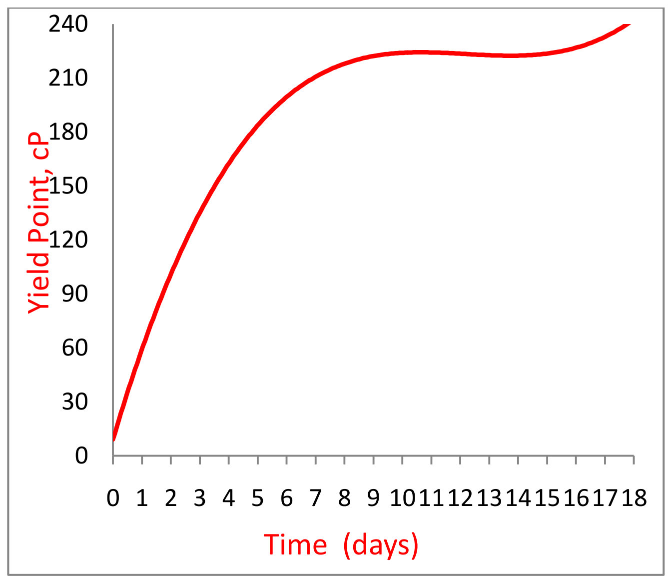

Figure 3: Variation In Water-in-oil Mud Yeild Point With Time of Contamination with CO_2

4. CONCLUSION

From Fig.1, it was observed that the density of the CO_2 contaminated drilling mud increased rapidly for the first 10days after which there was lower rate of increase for the next 13days and then remains constant. This implies that the mud become heavier for the first 10days with 4.6% increase.

From Fig.2, it was observed that the viscosity of the CO_2 contaminated mud was constant for the first 8days and then increased gradually until the 17^{th} day.

From Fig.3, it was observed that the yield point of the CO_2 contaminated increased gradually for the first 8days and then remained constant for the next 8 days.

REFERENCES

1. Adebayo, Thomas A. Harrison Oluwaseyi Olusoga Opeyemi and Igweze Augusta, 2011, *Experimental Study Of The Effects Of CO_2 Gas Kick On The Properties Of Water-Based Drilling Fluid*, International Journal of Engineering & Technology IJET / IJENS, vol.11, issue 4
2. Berger ,R. L.; Young,J. Francis (1979), *Reaction of Calcium Silicates with Carbon Dioxide and Water*, Final report of Jan 1976-Jan 1979 researches, Illinois University At Urbana-Champaign, US.
3. Esmaeilzadeh, F, Y. Fayazi, and J. Fathikaljahi, 2009, *Experimental Investigation of a Mixture of Methane, Carbon Dioxide & Nitrogen Gas Hydrate Formation in Water-Based Drilling Mud in the Presence or Absence of Thermodynamic Inhibitors*, World Academy of Science, Engineering and Technology 56.
4. Hoberock, L.L., & Stanbery, S.R., 1981, Journal of Petroleum Technology. Volume 33, Number 8, Pages, 1367-1378
5. Houston, S. J., B.W.D. Yardley, P.C. Smalley and I. Collins; *Rapid fluid-rock interaction in oilfield reservoirs*, Geology 35 (12) December 2007
6. Jennie C. Stephens and David W. Keith , June 2008, *Assessing geochemical carbon management*, Springer on line publications, (http://www.clarku.edu /faculty/jstephens/ documents/)
7. Max R. Annis and Martin V. Smith, *Drilling Fluid Technology*, Exxon Company, U.S.A., July 1974, pp.13-35.
8. Odd Magne Mathiassen, "CO2 as Injection Gas for Enhanced Oil Recovery and Estimation of the Potential on the Norwegian Continental Shelf" May 2003.
9. Pal Skalle, *Drilling Fluid Engineering*, Pal Skalle and Ventus publishing ApS, 2010, 8,9.
10. Peter Zweigel, Rob Arts, Ane E. Lothe & Erik B. G. Lindeberg, 2004, *Reservoir geology of the Utsira Formation at the first industrial-scale underground CO_2 storage site (Sleipner area, North Sea)*, Geological Society, London, Special Publications, v. 233; p. 165-180.
11. Ran Qi, 2009, *Simulation of Geological Carbon Dioxide Storage*, Ph.D. dissertation, Department of Earth Science and Engineering, Imperial College London, UK.
12. Rochelle, C. A., I. Czernichowski Lauriol & A. E. Milodowski, 2004, *The impact of chemical reactions on CO_2 storage in geological formations: a brief review*, Geological Society, London, Special Publications; v. 233; p. 87-106.
13. http://www.columbia.edu/~vjd1/carbon.htm
14. http://www.science.howstuffswork.com
15. Monteiro E.N., P.R. Ribeiro, and R.F.T. Lomba, 2010, *Study of the PVT Properties of Gas—Synthetic-Drilling-Fluid Mixtures Applied to Well Control*, SPE Drilling & Completion, March 2010, vol.25, no.1, pp.45-52
16. White D.B. & I.C. Walton, *A Computer Model for kicks in Water- and oil-based muds*, SPE/IADC Drilling Conference, 27 February-2 March 1990, Houston, Texas
17. Zamora, M., Lai, D.T., Dzialowski, A.K., 1990. Innovative devices for testing drilling muds, SPE drilling. Eng. J. 5, 11–18 March.

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