Effect of Bentonite Mud Contamination on the Behavior of a Smart Cement Slurry Modified with Sodium Meta-Silicate

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Abstracts: The effect of bentonite drilling mud contamination on the rheological properties and electrical resistivity during curing of class H oil well cement slurry containing 0.2% Sodium meta-silicate (SMS) was investigated. Effect of 5% and 10% Bentonite mud (6% w/w) contamination was investigated with cement slurry and found that mud decreased both the apparent viscosity and the yield point of the cement slurry. The electrical resistivity was decreased and the piezoresistive behavior after 7 days curing was increased with Bentonite mud contamination.

1. Introduction: During the construction of oil wells, even if the drilling mud removal before the cementing is done nearly ideal displacement conditions, the drilling mud may contaminate the cement slurry(Morgan et al. 1952). The mud used for drilling forms a layer of mud cake on the borehole rock as a result of the reaction between the mud and the formation materials at elevated temperature and pressure (Oyibo et al. 2014). Some of the residual mud contaminates the cement altering its properties (Yong et al. 2007). For the recent days advance monitoring technology, it is critical to quantify the changes such as rheological properties and electrical resistivity due to bentonite mud contamination.

2. Objectives: To study the effect of bentonite mud contamination on the electrical resistivity, piezoresistive properties and rheological properties of a smart cement slurry containing 0.2% sodium meta-silicate.

3. Materials and Methods: Smart cement was prepared by adding 0.075% carbon fiber with class H oil well cement to make it piezoresistive. Sodium meta-silicate solution was prepared adding 0.2% w/w SMS with water. The water cement ratio used was 0.4. Commercially available bentonite was used with water to prepare a 6% (w/w) drilling mud. Various amount of Bentonite mud (5% and 10% mud by weight of cement slurry) was added to the cement slurry to determine the effect on the slurry properties.

Rheological properties were determined using a rotational viscometer at room temperature and pressure for different RPMs from 3 to 600 RPM. To determine the resistivity, two probe method with fixed 2 electrical wires were used to measure the resistance. Cylindrical specimens were prepared with 2 inches diameter and 4 inches height. Two wires were placed at 2 inches apart.

Mold Calibration: The resistivity (ρ) is defined as RA/L (where, R = measured resistance, A = area of the electrical flow, L = distance between the probe). The two probe test mold was first calibrated by determining the resistivity of the cement slurry with a direct resistivity measuring device and the corresponding resistance measurement by an AC resistance measuring device. Then from the resistivity relationship, the A/L ratio of the test mold was determined. This ratio was used to determine the resistivity of hardened cement.

4. Results and Discussion

4.1Rheological properties: Shear stress –shear strain rate relationship shows that the Bentonite mud contamination decreased the shear stress of the slurry which decreased the apparent viscosity and the yield point of the slurry. The apparent viscosity at 300 RPM for slurry without any mud was 143 cP which becomes 116 cP and 103 cP with addition of 5% and 10% Bentonite mud respectively. The yield point was 13.7 lb/100ft^2 which decreased to 7.3 lb/100 ft^2 and 3.8 lb/100 ft^2 (determined using Herschel-Bulkley model) with 5% and 10% Bentonite mud respectively (Fig. 1).

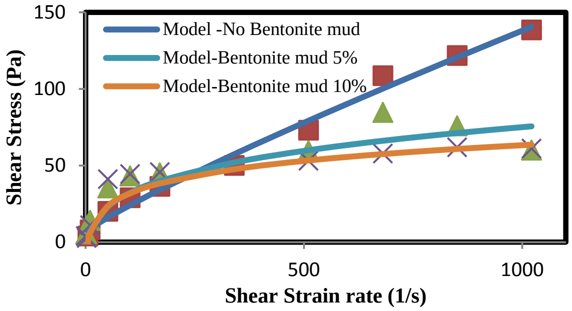

Figure 1. Shear stress-shear strain rate relationship of cement slurry with Bentonite mud

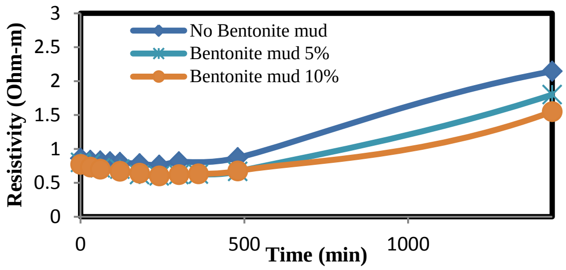

Figure 2. Resistivity with curing time of cement slurry with Bentonite mud

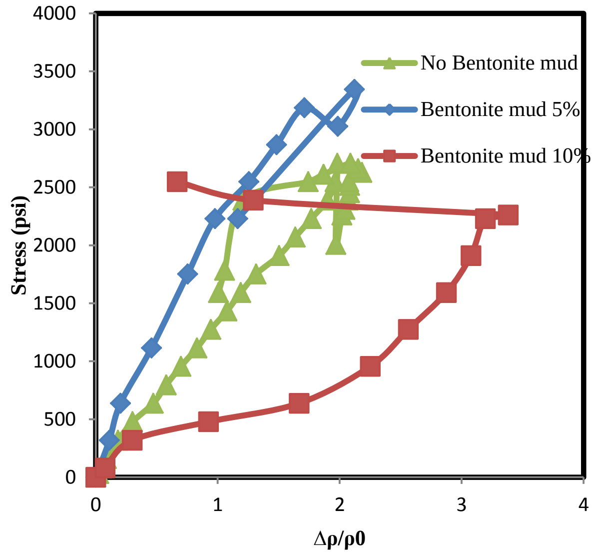

Figure 3. Stress-Piezoresistivity relationship after 7 days for cement with and without Bentonite mud

4.2 Bentonite mud on resistivity: The effect of Bentonite mud on the resistivity of the cement slurry with curing time up to 24 hrs was determined. The results showed that the resistivity decreased with addition of Bentonite mud. The initial resistivity decreased by about 7% and 10% with addition of 5% and 10% Bentonite mud respectively; and the resistivity after 24 hours of curing was decreased about 15% and 27% respectively (Fig. 2).

4.3 Piezoresistive Behaviour: The resistivity of the cement specimen with compressive stress was determined after 7 days of curing and found that the addition of 10% Bentonite mud changed the piezoresistive properties of the cement slurry (Fig. 3). The piezoresistivity without Bentonite mud was 215% which increased to 350%, a 60% increase in piezoresistivity.

5. Conclusions: 1). Bentonite mud reduced the apparent viscosity and yield point of the cement slurry.
2). Bentonite mud reduced the resistivity of cement slurry. An addition of 5% Bentonite mud decreased the initial resistivity of the cement slurry by about 7% and the 24 hour resistivity by about 15%. The piezoresistive behavior of cement specimen after 7 days was increased with addition of 10% Bentonite mud.

6. Acknowledgements: This study was supported by the Texas Hurricane Center for Innovative Technology (THC-IT), University of Houston, Houston, Texas with funding from the Ultra Deepwater Program DOE/NETL/RPSEA (Project No. 10121-4501-01).

7. References

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