Effect of Polyvinyl Alcohol on the Rheological and Piezoresistive Properties of Oil Well Cement Slurry

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Abstracts: The effect of polyvinyl alcohol (PVA) on the rheological properties and electrical resistivity during curing of class H oil well cement slurry was investigated. 1% PVA was used with cement slurry and found that PVA increased both the apparent viscosity and the yield point of the cement slurry. The electrical resistivity was increased and both the piezoresistive behavior and compressive strength after 24 hour curing was decreased with PVA.

1. Introduction:

Polyvinyl alcohol $[CH_2CH(OH)]_n$ is a synthetic polymer and is water soluble (Hallensleben, 2000). Due to its film forming, emulsifying and adhesive properties, it is used as a fluid loss controlling additive for oil well cement (Plank et al. 2009). They reported that PVA had very good performance as a fluid loss additive with class G oil well cement from ratio of 0.4%-2% by weight of cement (bwoc) and it controls the fluid loss by forming a polymer film which reduces the filter cake permeability. But the rheological characterization of cement slurry with the addition of PVA has not been studied. Also whether the electrical properties like electrical resistivity of the cement slurry is affected or not should be studied in order to advance the recent days monitoring technology.

2. Objectives:

To study the effect of PVA on the rheological properties (shear stress-shear strain rate, apparent viscosity and yield point) and the electrical resistivity of class H oil well cement slurry.

3. Materials and Methods:

Commercially available class H oil well cement was used to prepare the cement slurry. The water cement ratio used was = 0.4. PVA (1% bwoc) were used with water to make solution. The PVA was first dissolved in water (with appropriate amount) and then the solution was mixed with cement. 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.

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

4.1 Rheological properties:

Shear stress –shear strain rate relationship shows that the PVA increased the shear stress of the slurry which increased the apparent viscosity of the slurry. The apparent viscosity at 600 RPM for slurry without any PVA was 105cP which becomes 169 cP with addition of 1% PVA. And the yield point was 0.5 lb/100ft2 which increased to 11 lb/100 ft2 (determined using Herschel-Bulkley model) with 1% PVA (Fig. 1).

4.2 PVA on resistivity:

The effect of PVA on the resistivity of the oil well cement slurry with curing time up to 24 hrs was determined. The results showed that the resistivity increased with addition of PVA. The initial resistivity increased by about 30% with addition of 1% PVA and the resistivity after 24 hours of curing was increased about 10% (Fig. 2).

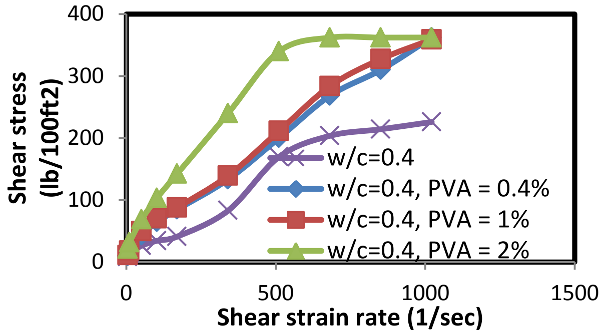

Figure 1. Shear stress-shear strain rate relationship with PVA

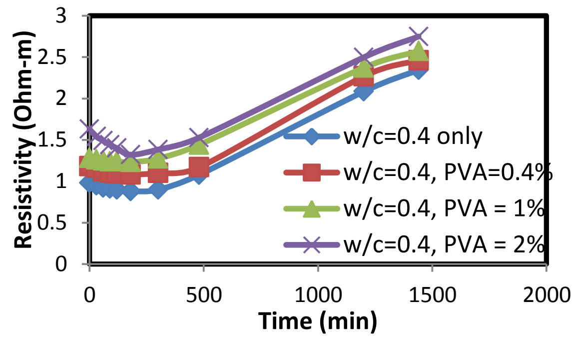

Figure 2. Resistivity with curing time of cement slurry with PVA

4.3 Piezoresistive Properties:

The resistivity of the cement specimen with compressive stress was determined after 24 hours of curing and found that the addition of PVA reduced the piezoresistive properties of the oil well cement (Fig. 3). One day (24 hour) strength was also reduced by the addition of PVA. The 24 hour strength without PVA was about 510 psi which was reduced to 320 psi with addition of 1% PVA, a reduction of 35%. The piezoresistivity without and with 1% PVA were 325% and 85%, a 75% reduction in piezoresistivity.

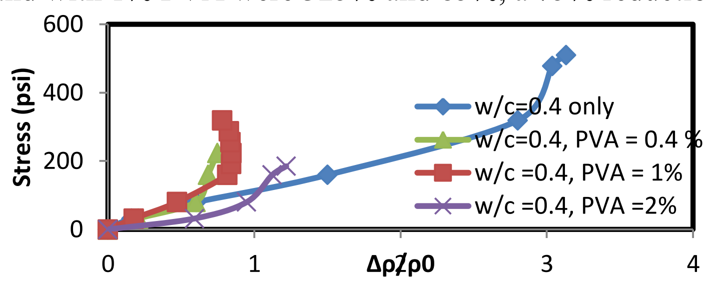

Figure 3. Stress-Piezoresistivity relationship after 24 hours for cement with and without PVA

5. Conclusions

1. PVA increased both the apparent viscosity and the yield point of the cement.
2. PVA increased the electrical resistivity of the cement slurry. About 1% PVA increased the initial resistivity about 30% and 24 hour resistivity about 10 %.
3. The piezoresistive behavior of cement specimen and the 24 hour strength was reduced with addition of PVA.

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7. References:

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3. Dugonjic-Bilic, F., Tiemeyer, C., and Plank, J., (2011). "Study on Admixture for Calcium Aluminate Phosphate Cement Useful to Seal CCS Wells". Proceedings, SPE International Symposium on Oilfield Chemistry, Woodlands, TX, April, 2011.