Effect of Oil Contamination on the Rheology and Electrical Properties of the Smart Spacer Fluid for Wellbore Cleaning Applications

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Abstract: In this study, the effects of oil contamination on the rheology and electrical properties of highly sensing smart spacer fluid was investigated. Spacer fluid was contaminated with up to 2% oil were investigated. With the 2 % Oil contamination of spacer fluid, the plastic viscosity increased from 16.4 to 23 cP and the yield point increased from 2.6 Pa to 4.8 Pa. The rheological properties of the smart spacer fluid have been quantified using the new Vipulanandan rheological model and compared with Bingham-Plastic model with two parameters. The Vipulanandan rheological model has a maximum shear stress limit were as the other model did not have a limit on the maximum shear stress. The maximum shear stress limit for smart spacer fluid was 23 Pa and it increased to 31 Pa with the contamination of 2% oil, a 35% increase. Similarly the impedance and bulk resistance were found to increase with the 2% oil contamination.

1. Introduction:

One of the aspects of ensuring an annular seal during a cementing operation after achieving the bulk displacement of drilling mud is bonding of cement to the formation and wellbore surfaces. Spacer fluids` and flushes are effective displacement aids because they separate and enhance the removal of gelled mud allowing a better cement bond[1]. Oil-based drilling fluid can leave thin layer of oil on the casing and the formation. This layer of oil can contaminate the spacer fluid leading to unacceptable fluid that may cause emulsion blockages and particle plugging. By adding in surfactant mixtures in the spacers, it is possible to form in-situ oil in water microemulsions, allowing the surfaces to be water wet[2]. Spacer density and rheological properties are designed inorder to obtain a system with density and rheological profile between those of drilling fluid and the cement slurry.

2. **Objective** The overall objective was to quantify the effect of oil contamination on the rheology and electrical properties of smart spacer fluid system.

3. Experiment

Materials

The smart spacer fluid was designed with the following additive packages. The base fluid was considered to be water with rheology modifying additive as 0.75% Guargum. The surfactant package used was 0.5% UH Bio-Surfactant (UHBS) with 3% KCl as reaction inhibitor.

Methods

The rheology tests for smart cement with different foam contents at temperature of 25 C were tested using a viscometer in the speed range of 0.3 to 600 rpm (shear strain rate of 0.5 s^{-1} to 1024 s^{-1}). The bulk resistance and impedance were measured using LCR device.

Modeling

Vipulanandan Rheological relationship between shear stress and shear strain rate for the smart spacer fluids was investigated (Vipulanandan and Mohammed 2014). The relationship is as follows:

$\tau - \tau_{o2} = \frac{\dot{\gamma}}{C + D * \dot{\gamma}}$, where τ: shear stress (Pa); C $(Pa.\ s)^{-1}$ and D $(Pa)^{-1}$: are model parameters;

4. Results and Discussion

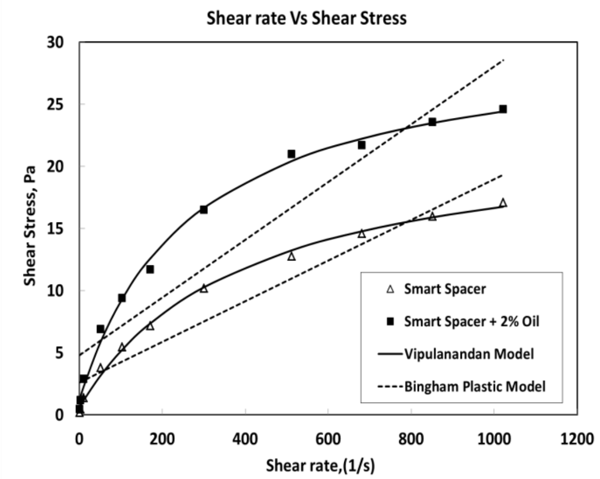

Fig.1: Shear Stress Vs Strain for smart spacer

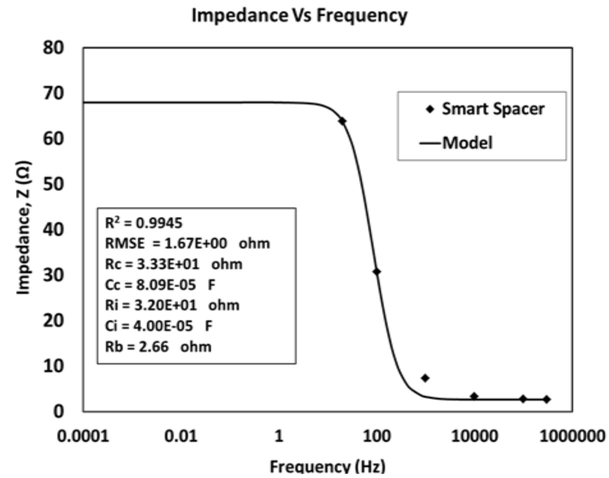

Fig.2: Impedance Vs Frequency curve for smart spacer

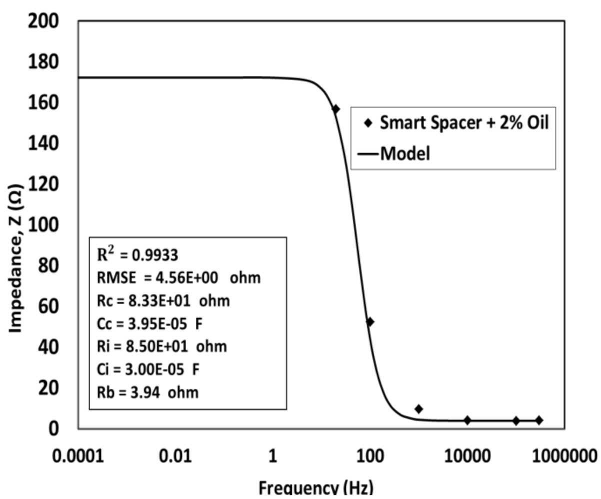

Fig.3: Impedance Vs Frequency curve for smart spacer with Oil

The smart spacer fluid had a density of 1.04 g/cc with a bulk resistivity of 0.1 Ω.m. The smart spacer had a plastic viscosity of 16.4 cP and yield point of 2.6 Pa. With 2% oil contamination, the plastic viscosity was 23 cP, a 40% increase and the yield point was 4.8 Pa, 85% increase. From the Vipulanandan Rheology model, the maximum shear stress increased from 23 to 31 Pa, a 35% increase with 2% Oil contamination (Fig.1). Impedance of the smart spacer exhibited case 2 behavior. The Bulk resistivity of the spacer increased from 0.1 Ω.m to 0.15 Ω.m, a 50% increase with the contamination. Also the resistance-capacitance parameter increased showing the formation of microemulsions in the spacer (Fig.2 & 3)

5. Conclusion

With 2% Oil contamination, the plastic viscosity increased 40% and yield point by 85%. The Vipulanandan rheology model had the best fit which showed a 35% increase in maximum shear stress. The electrical resistivity increased by 50% with the 2% contamination. From this study it can be concluded that resistivity of the smart spacer fluid was sensitive to the oil contamination.

6. Acknowledgements

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7. References

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