Real Time Monitoring of Fluid Loss in Piezoresistive Smart Well Cement Modified with Gas Migration Additives

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Abstract: In this study, smart cement sensitivity to gas migration polymer additive was tested and evaluated using the piezoresistive smart cement. The high pressure – high temperature (HPHT) chamber was used to perform the test. Smart cement was modified with gas migration additives and the results were compared to verify the additives' capabilities in controlling the fluid loss. Results showed that Smart Cement modified with carboxylated styrene butadiene latex had the lowest value for total fluid loss compared to the other polymer additive.

1. Introduction: Proper cementing and continuous monitoring of cementing operations is critical to ensure the integrity of the wellbore during placement operations and the entire service life of the oil and gas wells (Vipulanandan et. al. 2015). Such technology for real time monitoring, however, does not exist (Vipulanandan et al. 2014) and continuous monitoring becomes very crucial in challenging high pressure-high temperature gas wells, were percolation of gas through cemented annulus becomes an inevitable issue for operators. About 80% of wells in the Gulf of Mexico experienced gas migration through cemented casings (Jennings S. S. et. al. 2003). In order to address this challenge, current cement slurry designs are improved by producing sensing cements that enable the visualization of cement operations by means of measuring the change in electrical resistivity due to induced mechanical stress known as piezoresistive effect. The behavior modeling is based on the nonlinear p-q model which was developed by Vipulanandan et al., 1990. By that, smart cement could facilitate the early detection and identification of short to medium term gas migration in real-time in high temperature high pressure gas wells were cement placement is very critical as it is expected to meet a wide range of short term criteria to form a good seal (Heinold T. et. al. 2002). Hence, reducing the need for unnecessary and preventable costly workover jobs in challenging gas wells and avoiding by that non-productive time and high operational costs. In order to test the smart cement sensitivity to gas flow, a laboratory study is presented using a bench-top high pressure – high temperature (HPHT) chamber. The smart cement was modified with a high potential latex additive in an effort to design a system of detection and prevention of annular gas flow. This study is dedicated to investigate the pathways for gas migration, which has been a problem for the oil and gas industry for many years (Al-Yami et. al. 2009), as well as test the sensitivity of piezoresistive smart cement modified with gas migration additives to verify their applicability in controlling fluid loss and stopping gas migration.

2. Objective: The specific objectives of this study are the follows:

a) Review available well cement evaluation technologies and their limitations for gas migration detection.
b) Describe the piezoresistive smart well cement and present its functions.
c) Test the sensitivity of smart cement to gas flow.
d) Verify the ability of two gas migration additives in controlling fluid loss and gas migration.

3. Materials and Method:

Class G cement (350 g) and water (140 mL) with conductive filler (0.15 g). LCR to measure the resistance variations and nitrogen gas to pressurize the cell containing the cement. Gas migration additives (1% BWOC) (Carboxylated styrene butadiene latex XSB and copolymeric latex). The experimental set up is shown in Fig. 1.

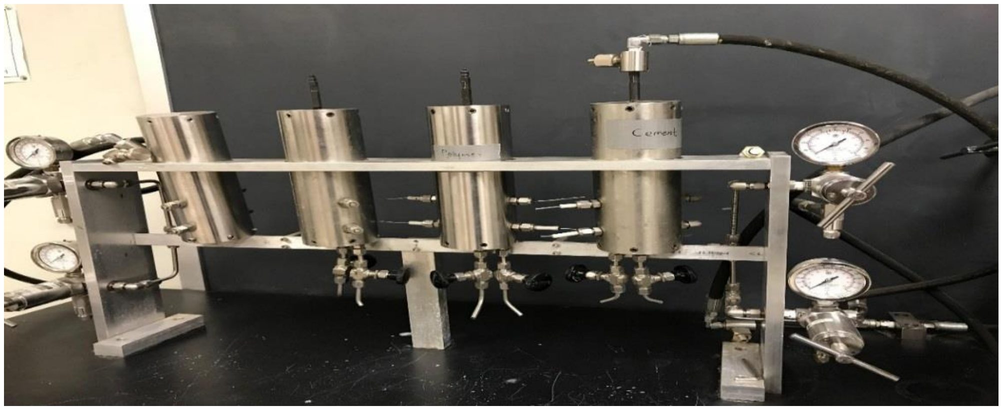

Figure 1. High Pressure and High Temperature Fluid Loss Testing Apparatus

4. Results and Discussion: Smart cement was very sensitive to pressure applied and carboxylated styrene butadiene latex had the lowest value for total fluid loss which makes it a good candidate for gas tight cement design considerations. The fluid loss results are summarized in Table 1 and shown in Figures 2-4.

Test Sample	Total FluidLoss	Change in Resistivity (Δρ/ρ) (%)
Smart Cement (Control)	100	825
% BWOC Copolymer Latex (COP)	90	720
% BWOC Carboxylated Styrene Butadiene Latex (XSB)	75	390

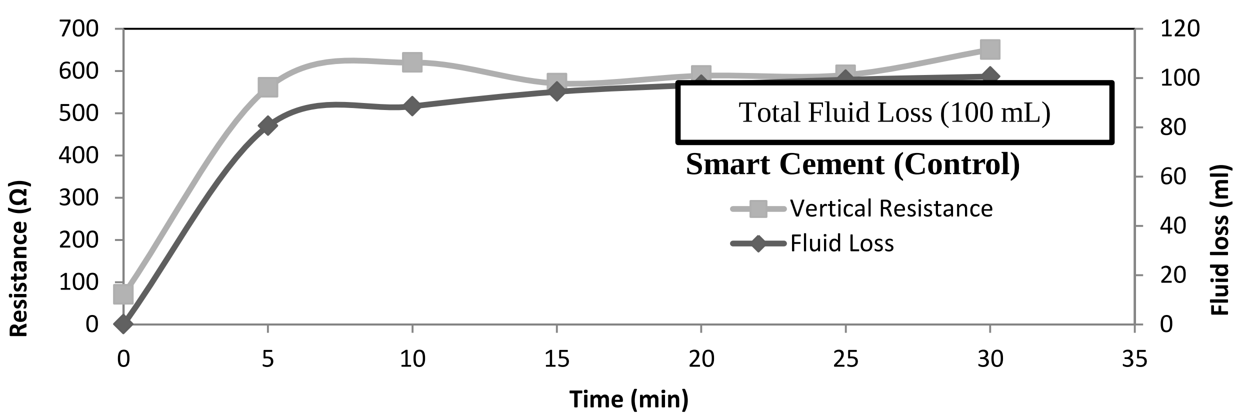

Figure 2. Smart Cement Control Vertical Resistance and Fluid Loss versus Time

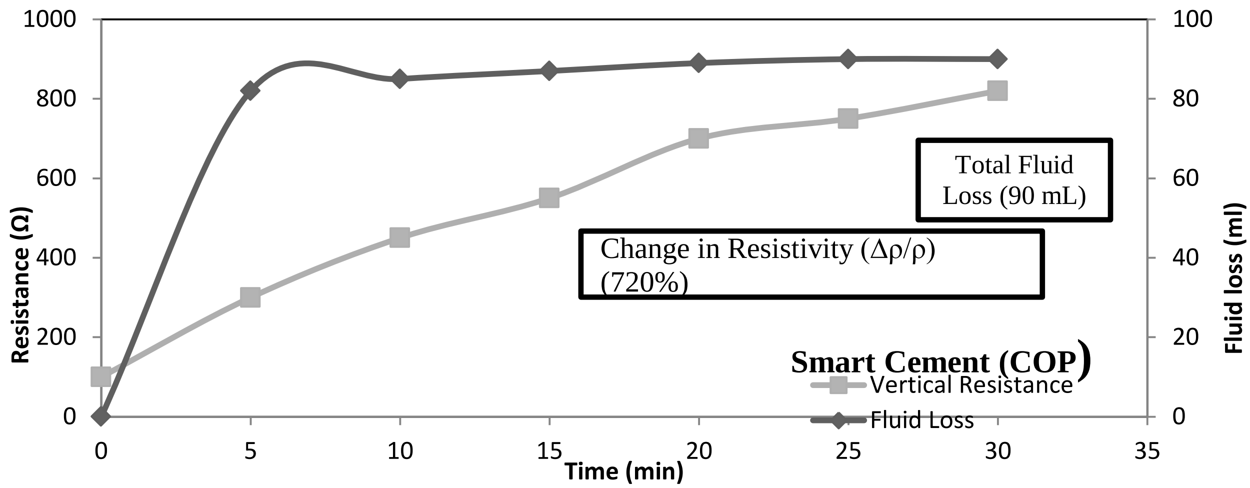

Figure 3. COP Vertical Resistance and Fluid Loss versus Time

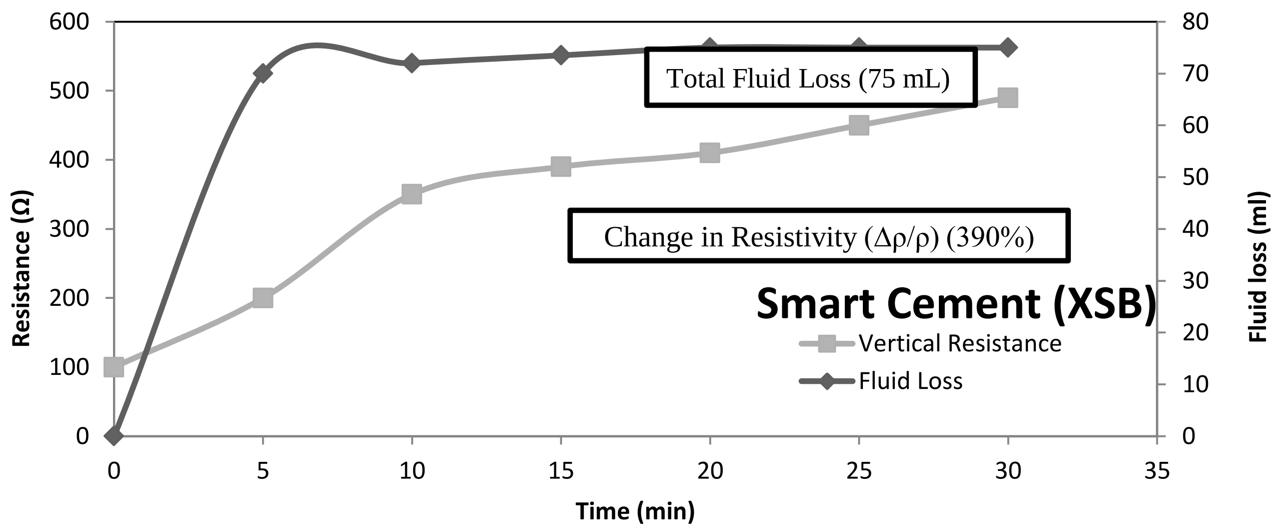

Figure 4. XSB Vertical Resistance and Fluid Loss versus Time

5. Conclusion:

1. Smart Cement's resistivity change by 825% with the fluid loss of 100 mL.
2. Addition of 1% BWOC copolymer latex (COP) yielded 90 mL fluid loss and the increase in resistivity change was 720%.
3. Addition of 1% BWOC carboxylated styrene butadiene latex (XSB) gave the lowest value for total fluid loss (75 mL) and the increase in resistivity change was 390%.
4. Carboxylated styrene butadiene latex (XSB) used as gas migration additive in this study has a promising application in producing a gas tight system and controlling fluid loss.

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