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Thermomechanical Behavior of Cement Slurries for HPHT Oilwells

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Abstract – High-temperature high-pressure (HPHT) oilwells cross pressurized producing formations also characterized by high temperature gradients. Under such adverse conditions, the thermomechanical behavior of cement slurries containing cement/silica/ polymer was evaluated. The results showed that the strength of hardened slurries containing 40% silica along with a polymeric admixture was higher than that of plain Portland slurries. X-ray diffraction analyses showed the transformation of hydrated calcium silicate gel (C-S-H) to Xonotlite and Truscottite. The use of a polymeric admixture improved the mechanical behavior of the slurry and maintained thermal stability at temperatures as high as 200 ºC.

High-temperature high-pressure (HPHT) oilwells are drilled along pressurized producing formations characterized by high temperature gradients [1]. These wells depict high stress concentrations originated during drilling and hydraulic fracture. Variations in temperature and pressure as well as dynamic forces in solid formations some of the main aspects that can result in mechanical failure of the cement sheath of HPHT oil wells [2]. Fracture or microcracking of the cement sheath affect the mechanical stability of the well as well as the zonal isolation of oil and gas producing formations. Adequate slurries must withstand particular service conditions of each oilwell. HPHT slurries must withstand severe thermo-mechanical scenarios. At temperatures that exceed 110 ºC, cement slurries harden to maximum strength and thereafter depict strength retrogression [3]. To prevent that, cement is partially replaced by silica to improve the pozzolanic reaction that transforms hydrated calcium silicate gel (C-S-H) to Xonotlite and Truscottite, which yield high strength. Polymers are added to improve the plastic behavior of the cement thus improving the fracture energy of the material [4].

The present study aimed at analyzing the thermo-mechanical behavior of oilwell slurries containing Portland cement, 40% silica flour and different concentrations of a polymeric admixture (1.5 to 10 %). The slurries were cured at 180 ^{o}C and 27.58 MPa during 3 days to simulate HPHT well conditions. Strength tests were carried out using a Shimadzu Autograph AG-I testing machine. X-ray diffraction patterns were also collected to evaluate the nature of crystalline phases present in the hardened slurries. Finally, Thermogravimetric analyses were carried out to verify the stability of the slurries at service temperatures.

The results revealed that the strength of slurries containing 40% silica and a polymeric admixture was superior than that of the standard slurry. X-ray diffraction confirmed the transformation of C-S-H gel into Xonotlite, that yields high strength. Slurries containing a polymeric admixture revealed the presence of a lower strength phase, Truscottite. Nevertheless, both slurries depicted similar strength values, however, the formation of polymeric nets improve the fracture energy of the slurry. The thermal stability of the slurries was constant at temperatures as high as 200 ºC. Therefore, improved slurries for HPHT well conditions could be prepared using a combination of Portland cement, silica and a temperature resistant polymeric admixture.

References

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