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A DISCUSSION OF THE PAPER "THE HYDRATION OF SALINE OILWELL CEMENT" BY X. ZHOU, X. LIN, M. HUO AND Y. ZHANG*

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Drs. Zhou et al. have written an important paper on the hydration of saline HSR Class G oilwell cement (1). As they correctly point out, if undertaking well cementing through salt layers in the rock formations with a cement slurry prepared with freshwater, wellbore collapse tends to arise as a consequence of the large quantities of salt from the formations becoming dissolved in the freshwater slurry being pumped downhole. Such undesirable collapsing can be at least minimised or better thwarted by utilising either lower saline or high saline slurries. The presence of a saline slurry in the wellbore reduces considerably the rate of dissolution of the salt formations. This enables the cement slurry to harden in the annulus to give a protective sheath without producing undesirable wellbore collapse, and thus to secure the well in question. For the lower saline slurries the NaCl content is lower than 15% by weight of water (BWOW), whilst for the high saline slurries the NaCl content can be as high as the saturation level of 36% BWOW.

The properties of the freshly prepared saline slurries (like thickening time, rheological parameters, fluid loss control, free fluid etc.) differ from those experienced with corresponding freshwater slurries, as also does compressive strength. The compressive strengths obtained at 93 °C and 20.7 MPa curing were found to be similar at 5% BWOW NaCl as in freshwater, but lower at the greater saline contents. However, at 160°C and 20.7 MPa curing, the compressive strengths decreased with increasing salt content at the longer curing periods above 12 hours (1). Curing above 100°C (in this latter case 160°C) normally results in the onset of an appreciable strength retrogression with the passage of time, due to the unwanted formation of large crystals of α-dicalcium silicate hydrate α-C_2SH of low compressive strength and high permeability. Hence, different hydration products should be expected when the temperature rises from 93 °C to 160°C. For well cementing under hydrothermal conditions, it is normal to employ *ca.* 35 to 40% by weight of cement (BWOC) silica flour or silica sand. By such employment, the formation of tobermorite, a crystalline calcium silicate hydrate of high compressive strength and low permeability, arises at the expense of α-dicalcium silicate hydrate, so that more durable wells can be completed (2-5).

In the U.K. continental shelf area of the southern North Sea, the drilling of wells through weak salt formations has been a common occurrence. Lightweight extended well cementing

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slurries have often been employed for the successful cementing of such wells. Saline slurries have regularly been employed here to stop wellbore collapse, with 18% BWOW NaCl a popular choice. These slurries have been checked in the laboratory either by special well simulation schedules or by suitable API Schedules (6) for approximating to the downhole conditions. Such API Schedules have included 3g5 (bottom hole circulating temperature-BHCT-38°C) and 6g5 (BHCT 70°C) to give a suitable thickening time of 3-4 hours, which would enable pumping into position in the annulus to take place so as to achieve a good cementing job. The southern North Sea wells involved in this testing were not more than *ca.* 9000 ft (2745 m) deep and hydrothermal changes in the poorly crystalline calcium silicate hydrates formed in the annuli were not observed, as expected at these temperatures.

As an example, for oilwell cement slurry extension using bentonite in 18% BWOW saltwater to s.g. 1.62, it was found preferable, when utilizing prehydrated rather than preblended bentonite normally at 2% bentonite by weight of cement (BWOC), to prehydrate the bentonite in freshwater (instead of saltwater) prior to mixing in the saline cement slurry. This enabled better slurry properties like the rheological characteristics to be obtained with the addition of appropriate dispersants (such as SMFC or SNFC), if necessary, in these saline slurries of freshwater-prehydrated bentonite and HSR Class G cement, hence permitting the operating free fluid (free water) and the rheological properties to be optimized (7). In addition, investigations of the effect of calcium chloride upon prehydrated bentonite-HSR Class G extended cement slurries of s.g. 1.62 in freshwater revealed that the $CaCl_2$ (optimally 3% BWOC in this G + 2% BWOC bentonite slurry) needed to be added to the slurry after prehydration and not beforehand, otherwise a very unstable slurry resulted (8).

Thus, although Drs. Zhou et al. have worked under different conditions for examining the effects of hydration of saline HSR Class G cement (1) in comparison with those I undertook in my investigations (7,8), the results in both instances usefully complement each other. Their findings (1) are a valuable contribution to our understanding of the hydration behaviour of saline oilwell cement.

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