Effect of Micro-MgO-based Expanding Agent on Rheological and UCS Properties of Well Cement at Early Age

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Well integrity issue is a major concern not only in the Oil and Gas industry but in the geo-storage field. For CO₂ sequestration, in particular, poor quality cement jobs render wells to suffer from possible CO₂ and formation fluid migration issues. In some cases, this migration issue maybe caused by the micro-fracture or micro-channel created during the chemical shrinkage and bulk shrinkage processes. Using some expandable cement system to cope with this issue is a promising way to mitigate this issue. In this study, we are exploring the effect of a kind of micro-MgO based expanding material on some principal properties of CO₂ sequestration well cement.

In these experiments, a typical cement formulation including various additives was used. Our focus of this pilot study was to investigate the effect of expandable materials on some typical physical-mechanical properties of Portland cement with different concentrations such as 0%, 1.0%, 2.0%, 3% by weight of cement (BWOC). Meanwhile, the pure Class G Portland cement slurry was also investigated as the base experiment. By use of API standard (RP 10B) procedures, those physical-mechanical properties of the cement slurry and set cement have been studied which mainly cover such aspects as rheology, fluid-loss of the cement slurry and uniaxial compressive strength (UCS) through experimental measures.

The experimental results indicate that UCS decreases gradually with increasing concentrations of the expanding additive. The density, free fluid, and rheology of cement slurry show consistently with the variation of expanding additive concentration. In addition, the fluid loss will increase relative gradually with the increment of expansive additive concentration. By increasing the concentration of expansive additive from 0% (w/w) to 3% (w/w), cement slurry's rheological properties consistently behaved as the main properties as plastic viscosity (PV), yield point (YP) and gel strength (GS) of 10-seconds and 10-minutes with values varied around 262.33 cP, 5.25 lb/100ft², 6.33 lb/100ft², and 15.26 lb/100ft² respectively. However, the UCS value behaves contrary to the rheology properties, which gradually decreased from 63.33 MPa to 33.54 MPa with the concentration, increased from 0% to 3%. As the UCS test conducted under the curing conditions as 150 ℃, 3000psi and 24hrs, this gradual decrease of UCS maybe because of the delayed hydration characteristics of micro-MgO. Despite this decrease in USC is not positive to prevent any stressed-induced micro-channel, these results are still interesting for further corresponding study and will
make the understanding of MgO based expansive additive's effect on Portland cement matrix more completely. As per other research results and our future experimental study plan, the delayed expansion of micro-MgO hydration will compensate for the chemical and bulk shrinkage issue after enough curing.

According to the literature review, there are few publications reporting results on micro-MgO based expandable cement systems based on Class G cement. Through this study, we are expecting to manifest a trend between the concentration of expanding additive and the cement slurry properties. This will provide the technical reference and guidance for further study and application of expanding cement systems in the industry.