THE USE OF SOUTH AFRICAN COAL FLY ASH (CFA) AS AN ADDITIVE TO OIL WELL CEMENT DURING CEMENTING OPERATION

By

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ABSTRACT

This work reports for the first time in open literature, the beneficiation of South African coal fly ash (CFA) in oil well cementing operation. Firstly, CFA was characterized using X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Scanning Electron Microscopy (SEM), proximate and particle size analyses. Silica (SiO_2) was then extracted from the CFA through acid leaching using 3M hydrochloric acid (HCl) at 100 ^oC for 6 hours. The extracted SiO_2 was filtered out, purified through successive demineralized water washings and dried in an oven at 200 ^oC for 2 hours. The physicochemical properties of the extracted SiO_2 were analyzed using XRD, SEM and Fourier Transform Infrared spectroscopy (FTIR).

Furthermore, the extracted SiO_2 was reacted with sodium hydroxide (NaOH) at 80 ^oC and atmospheric pressure to produce sodium silicate, a commonly used oil well cement (OWC) slurry extender. The physicochemical properties of the synthesized sodium silicate (CFA-Na_2SiO_3) were compared to those of a commercial sodium metasilicate (com-Na_2SiO_3) using SEM, XRD and FTIR analyses.

Moreover, OWC slurries with varying compositions of cement, distilled water and 2 % $CaCl_2$ by-weight-of-water (BWOW) were prepared and extended using the synthesized CFA-Na_2SiO_3 and com-Na_2SiO_3 at compositions ranging from 0.25 – 2.5 % by-weight-of-cement (BWOC). A comparative study to evaluate the densities, compressive strength, and rheological properties of the slurries was carried out in accordance with the specification for materials and testing for Well Cements (API, 1990).

The results obtained showed that the South African CFA belongs to Class F and contains 58 % SiO_2, which is the desired component in this study. The physicochemical properties of the extracted SiO_2 indicate that it is amorphous in nature. In addition, the synthesis protocol for making CFA-Na_2SiO_3 using the extracted SiO_2 and NaOH, which was at a mild temperature compared to the traditional energy-intensive method, indicate the possibility of energy saving of the method used. Moreover, the physic-chemical properties of the synthesized CFA-Na_2SiO_3 are consistent with that of com-Na_2SiO_3, indicating the purity of the as-prepared CFA-Na_2SiO_3.

Results obtained from the comparative study between the OWC slurries indicate that the slurries extended with CFA-Na_2SiO_3 have slightly lower densities, lower viscosities and higher compressive strength compared to those extended with com-Na_2SiO_3. This indicates that CFA-Na_2SiO_3 slurries would be easier to pump and preferable where early strength development is critical. Evaluation of the thickening times of the slurries could not be done at the time when this study was carried out due to the non-availability of the HPHT consistometer. This evaluation is therefore recommended for future studies.

This report thus opens up a way for the beneficiation of South African coal fly ash in the petroleum, oil and gas industry. Evaluation of the performance of the CFA-Na_2SiO_3 in remedial cementing as a complement to a cement squeeze and for blocking gas migration is recommended for future studies. Furthermore, the

evaluation of the performance of the CFA-Na_2SiO_3 as an additive to drilling fluid is also recommended.