

Detailed Speciation by SEM-EDX of Sulphur-Containing Species in Fly Ash from Air Fired and Oxyfuel Fired Samples with and without Additive Addition

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Abstract

Oxyfuel firing of coal is an attractive potential option for the reduction of CO₂ emissions from large-scale power stations, however a number of technical issues remain that must be addressed. It is well documented that SO₂ concentrations may increase up to five-fold in the flue gas with an associated increase in SO₃, raising concerns that this may condense in the system, corroding the recycle loop and downstream process equipment. This work was concerned with performance trials of two in-furnace and two in-duct injection sorbents for SO_x capture.

Doosan Power Systems conducted a test programme at their 160 kW_{th} Emissions Reduction Test Facility (ERTF) to determine SO₃ behaviour and the performance of SO₃ sorbents during air and oxyfuel fired combustion, with two in-furnace and two in-duct sorbents assessed. The sorbents were alkali metal based in nature. A loss in weight sorbent feeder and a sorbent injection probe were used to control the sorbent injection rates with reactive species: S-input ratios of 0.1-0.7. During each sorbent assessment, samples of fly ash were extracted from the electrostatic precipitator (ESP) and analysed using microscopic techniques, and these were compared to fly ash samples extracted from non-sorbent injection periods to assess the nature and extent of mineral liberation and sulphur interaction.

Analysis of the fly ash specimens involved measurement on 50,000 particles for each sample. A mineral liberation analyser (MLA) processed signals from a backscattered electron detector and an EDX X-ray detector for each discrete particle. The mineral segments were classified by pattern-matching the associated X-ray spectra with predetermined spectra for the indigenous minerals. The resulting data was further processed to statistically quantify mineral percentages, grain size distributions, associations and liberation of the sulphur containing species.

Sixteen discrete species were classified during the analysis; seven of which were S-containing species along with a number of glassy phases containing varying fractions of SiO₂, Al₂O₃, CaO and FeO. The main sulphur containing species were alkali sulphates with a quantitative amount present in alkali enriched aluminosilicates. In both air and oxyfuel firing conditions significant amounts of sulphur was present as sulphate particles with < 10% involved in the aluminosilicate melts. For oxyfuel conditions there appeared to be a slight increase in the interaction between sulphur and the aluminosilicate particles compared to air firing (~5 %) and this may be attributed to the slight increase in alkali metals present, particularly sodium, in the aluminosilicate species during oxyfuel firing. Under oxyfuel firing 40 % of sodium was involved within the aluminosilicates while under air firing this was < 10 %. Induct and in furnace sorbent injection both show a similar level of interaction of sulphur with the aluminosilicate particles.