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Extraction of aluminium from coal fly ash using a two-step acid leach process

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ABSTRACT

Hydrometallurgical extraction technologies provide a process route for resource recovery of valuable metals from both primary as well as secondary resources. In this study, the possibility of treating coal fly ash (CFA), a residue formed as a result of coal combustion in coal-fired power plants, was investigated. Eskom CFA contains significant amounts of alumina typically, 26-31%, in two dissimilar phases, namely amorphous and crystalline mullite, which may be processed separately. Due to its high silica content, however, CFA cannot be treated through the Bayer process route. Therefore, a leach-sinter-leach process was formulated that employed a two-step acid leach technique to extract alumina from CFA using sulphuric acid.

In the preliminary test work, the effect of parameters on CFA leaching characteristics was investigated. From the experimental results, appropriate factor levels were found to be 6M acid concentration, 6 hours leaching time, 75°C temperature and 1:4 solid to liquid ratio. Calcium sulphate precipitate formation was found to inhibit aluminium extraction and activation energy-based kinetic results showed that aluminium extraction from CFA was a product diffusion layer controlled mechanism.

By leaching the CFA, and using design of experiments (DOE) and response surface methodology strategy for screening and optimization of significant factors, it was found that temperature and leaching time significantly influence the aluminium extraction process. The theoretical optimum conditions established from the statistically based optimization model, for a maximum aluminium extraction of 23.9%, was found to be a temperature of 82°C and a leaching time of 10.2 hrs.

Using the optimum conditions, the first stage leaching was done, followed by sintering at 1150°C for 180 minutes to liberate the mullite phase aluminium and then second stage leaching. An aluminium extraction of 24.8%, representing 89.3% extraction from the CFA amorphous phase, was obtained from first stage leaching. The second stage leaching yielded an aluminium extraction of 84.3%. A combination of the two leaching stages gave a total aluminium extraction of 88.2%.

This work has shown that by employing a leach-sinter-leach method based on a two-step acid leach technique, CFA can be optimally leached.