ABSTRACT

Dense medium processing of high-ash coals with liquid dense media (water and magnetite) is currently the conventional means of beneficiating coal in South Africa (SA)). Hence, large volumes of waste water are produced along with a high cost of treating this effluent, both factors of which constitute a major disadvantage to this technique. This study presents an experimental account of Air Dense Medium Fluidized Bed (ADMFB) as an alternative dry processing approach for beneficiating SA coals. Magnetite is the conventional medium in ADMFB application this medium material is costly and limited in quantity. Pyrrhotite, granulated blast-furnace slag, silica sand and coal discards were investigated as alternative air dense medium materials to either replace or augment magnetite. Each of the materials utilized was prepared for a specific size range (-425+106 μm) and characterised according to their physical properties. The materials were then tested individually, first as sole fluidized media followed by further tests where the materials were blended in various proportions. The purpose was to establish their fluidization characteristics and suitability for coal separation. Uniformity and stability of the bed density were considered the key performance parameters for facilitating coal quality separations and therefore these were used as the main criteria for selecting the potential best medium material. Initial beneficiation tests with density tracers in lieu of coal were used for the purpose of optimizing operating parameters and separation efficiency for each of the media utilized. Based on the results obtained from the trial tests, coal was then tested in the ADMFB fluidized bed separator.

Magnetite and pyrrhotite, individually, provided the most uniform and stable bed densities with bed density variation less than 0.7% and standard deviation less than 0.0025 g/cm^3. A 100% magnetite bed produced a clean coal product with an ash content of 20.30% and calorific value of 25.24 MJ/kg from a feed coal (-13+6 mm size fraction) of 39.27% ash and CV of 18.76 MJ/kg. The bed's cut-point/separation density (ρ_{50}) was 1.82 g/cm^3 while coal product yield and Ep of 60.26 – 60.89% and 0.070 – 0.075, respectively were obtained. A cleaner coal product with 14.50% ash and a calorific value of 27.30 MJ/kg was obtained from a blend of pyrrhotite and magnetite at a weight ratio (%) of 40:60. The same blend reduced the total sulphur content in the feed coal from 2.49% to 0.41% sulphur at a cut density of 1.63 g/cm^3, with a yield and Ep of 52.67% and 0.083, respectively.

Pyrrhotite appears to be the most superior dense medium material amongst the materials tested as an alternative media to magnetite. More uniform and stable bed densities were achieved using the pyrrhotite-magnetite (40:60) blend, compared to these materials as individual media alone. A cleaner coal product with less ash and sulphur content was obtained from this blend compared to using magnetite as the sole medium. From an economic perspective, the partial replacement of magnetite by blending with pyrrhotite ore, which is considered a reject "no cost rejects material", is likely to reduce the cost of operating a coal ADMFB process to a considerable extent and may well prove this process to be more sustainable in future.