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Performance Evaluation of South African Coals under Oxy-Fuel Combustion in a Fluidized Bed Reactor

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Abstract

In this study, the experimental results of the oxy-fluidized combustion of three different South African coals (sub-bituminous) are presented. The coal samples were denoted Coal A, B, and C. Three combustion atmospheres—air, oxy (21% O(sub2)/79% CO(sub2)), and oxy (30% O(sub2)/70% CO(sub2))—were studied. A total of 18 tests were conducted in a bubbling fluidized bed reactor at 850 and 925 °C. The results obtained showed that the highest carbon burnout was obtained at 30% O2/CO(sub2), followed by air, and last at 21% O2/CO(sub2). Coals A and B had a higher carbon burnout than Coal C. There was a marginal difference of 1% in the carbon burnout for both Coals A and B in all the conditions except at 21% O(sub2)/CO(sub2) at 925 °C, when the carbon burnout of Coal A was 5% higher than that of Coal B. Carbon burnout in Coal C was about 20% lower than those of Coals A and B. Carbon burnout had a good correlation with the char particle temperature at all the combustion conditions studied for the three coals. The carbon burnout only had a good correlation with the vitrinite random reflectance at 21% O(sub2)/CO(sub2) at 925 °C for the three coals. The highest char particle temperature (1250 K) was obtained in Coal B at 30% oxy-combustion (30% O(sub2)/CO(sub2)) at a 925 °C bed temperature, and it had the highest carbon burnout of 99.34%. The lowest char particle particle temperature (1167 K) was obtained in Coal C at 21% oxy-combustion (21% O(sub2)/CO(sub2)) at a 850 °C bed temperature, and it had the lowest carbon burnout of 65.81%. There was a higher fuel-nitrogen conversion in air combustion than in oxy-fuel combustion than for all the coals. Fuel-S conversion ratios to SOx indicated that air combustion had relatively higher conversions than oxy-fuel, with the highest conversion of 35% observed for Coal A at 925 °C.