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Behaviour of selected South African coals in circulating fluidised bed (CFB) in comparison with Russian coal

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ABSTRACT

South Africa (SA) has an energy-intensive coal mining industry, where coal accounts for approximately 72% of total primary energy consumption in the country, particularly in the electricity sector, where 95% of total electricity generated is derived from coal. Pulverised coal combustion has been the preferred technology adopted for power generation in South Africa for many decades. These coal-fired power plants have no flue gas desulphurisation (FGD) equipment fitted at present. Therefore, these plants account for the majority of annual SO_2, CO_2, and NO_x emissions, making them environmentally unsustainable for power generation. Such environmental issues add to the challenges for the power producer, who is required to meet not only energy demand, but also to compete with the export market for quality coals, and to ensure that electricity generation complies with ever-changing air quality standards.

Circulating fluidised-bed combustion (CFBC), a technology for the combustion of coal, biomass, waste, has not been adequately explored or tested in South Africa previously. CFB combustion is currently under intense scrutiny amongst researchers evaluating its potential as an economic and environmentally acceptable technology, in particular for the burning of low-grade coals.

The main objective of this study is to undertake a case study using CFBC technology and to establish its potential for use in South Africa as a clean and cost-effective method in power generating for high-ash, low-grade coals. Experimental tests were conducted in a CFBC pilot plant in Finland, using two high ash coals, discarded coal from South Africa (SA) and a better quality coal from Russia for comparative purposes. A review was conducted of discard coals in South Africa in order to establish an inventory in support of their potential utilisation for power generation in circulating fluidised bed boilers. A further study established a comparison between pulverised coal (PC), and fluidised bed (FBC) technologies as a future benefit analysis.

All four coals proved to have very high combustion efficiencies, despite significant quality differences in terms of petrographic composition and ash content. More specifically, the SA coals achieved combustion efficiencies of 99.6 %, 99.7 % and 99.8 %, where the Russian coal achieved 98.7 percent. The Russian coal was characterised as being low in ash and high in the reactive maceral vitrinite, the two South African coals possessed high ash content (35 to 45%),

one with relatively high vitrinite, and the other very low vitrinite, whilst the South African discard possessed an ash content of 65-70% and extremely low reactive vitrinite content. All these factors lean towards the suitability of SA coals to the CFB technology.

In terms of NOx emissions, all coals tested showed that their NOx and N_2O emission meet the minimum requirements for small plants as set out by the European and SA standards, i.e. <300 ppm for a plant with generating capacity below 100 MW. This result is in agreement with data from the literature.

The emission of SO_2 depends on the sulphur content in the initial coal, which also has an impact on the Ca/S Ratio. SO_2 emitted from the South African coals was higher than the national permitted standard, due to the low Ca/S ratio used. This was especially the case for South African discard.

Vast reserves of discard coal containing from 2MJ/kg to 14 MJ/kg in calorific value have accumulated in South Africa since the last inventory of 2001, i.e. close to 1.5 billion tonnes are in existence. It is apparent that one of the looming challenges regarding discard coal is putting this ever-accumulating material to use. From the combustion results obtained in this research, it is proposed that such materials can be combusted in a CFBC boiler, and that it produces the same efficiency as other coals from South Africa and a clean coal from Europe. Ash distribution within the boiler was found to change in proportion of bed ash to fly ash, subject to the quality of the coal used. This is also likely to change the proportions of sulphur-absorbing sorbents in future. CO_2 emissions from the coals under review were found to be very close, in the region of 12.8 to 13.8 percent.