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The impact of coal quality and technical operating conditions on the efficiency of a spreader stoker boiler

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ABSTRACT

In South Africa a considerable number of small and large scale industrial consumers use coal for power generation and production of process heat, and for many years combustion efficiency was assured through the acquisition of high grade steam coals. This is not the case any longer as coal qualities on the inland market have deteriorated and such scenarios have led to unusual and often poor combustion performance and major plant stoppages. In-depth research and new technologies have been necessary to establish the cause of these unusual events.

This research study looks at the combustion behaviour of four different types of coal (coal A, B, C and D) in one particular spreader stoker boiler. Combustion conditions remained constant for all coals. The main focus of the investigation is based on thermographic flame temperature analysis of each coal and the interpreted results together with the physical and chemical properties of the coals. In deciding the best performing coal, factors considered include the steam output, the flame temperature recorded, the combustion efficiency determined and the amount of unburnt carbon registered in the fly and bottom ash samples. Interpretation of the results also included checking possible correlations of the above factors to determine the specific parameters that may have influenced the observed combustion behaviours. Implications and applications of the achieved results are made with regards to the efficiency, safety and environmental conditions of the plant and possible recommendations as to the best coal of choice for the boiler under investigation are presented.

Results obtained indicate that there was a strong correlation between the petrographic properties of the coals and steam output, combustion efficiency, amount of unburnt carbon and thermographic data, particularly the flame shape. On the other hand, association was not established between these parameters and the proximate analyses, calorific values and ash contents of the coals. In terms of combustion efficiencies, all coals yielded relatively high amounts of unburnt carbon in the fly ash (about 36.90 % on average for the four samples). Such magnitudes of unburnt material necessitate improvements on post combustion materials management, i.e. enhanced fly ash reinjection as one of the several options. The thermographic results led to the conclusion that South African low grade Gondwana coals undergo delayed ignition and burn at unusually high temperatures. Generally the coals were found to burn at temperatures between 1500 – 1800^{o}C. Temperatures of this scale are in excess of those projected by fuel technologists, and are often not taken into account by boiler manufacturers whose belief is that combustion temperatures are normally anticipated to be around 1400^{o}C. It is such conditions that now pose serious risk to boiler equipment.

Based on these results it is recommended that a design review be conducted to evaluate the suitability of the existing materials in boiler construction in order to address the high temperatures recorded when burning South African domestic coals. This would allow for equipment retrofitting that guarantee an extended lifespan as well as improved operational efficiencies of currently installed equipment or the acquisition of a more suitable plant in future.