Utilisation of Low-Grade Fuels in Fluidised Bed Combustors: Brian North.

ABSTRACT

South Africa has large resources of coal, currently estimated at 33 billion tonnes, the majority of which sits in the Witbank, Highveld, Waterberg and Ermelo coalfields. 250 million tonnes of this are mined annually, of which over 70% is utilised in the domestic market, mostly for electricity and synthetic fuels production. The exported coal (61 million tonnes in 2009) results in large foreign income for South Africa. However, the export market demands coal of a high quality. For many producers to meet this quality (and to meet quality requirements for domestic use), often the coal must be beneficiated to reduce the ash content and increase the calorific value (CV). This results in the generation of waste coal, generally categorised into three main streams, namely discards, duff and slurries. These waste coals represent a financial loss, are often aesthetically displeasing and may result in environmental damage and/or liabilities. It is estimated that in excess of 1 billion tonnes of discard coal has been accumulated.

Fluidised Bed Combustion (FBC) is seen as a key technology to utilise the waste coal in an environmentally acceptable manner. Additionally, co-firing boilers with coal and biomass results in a net reduction in Greenhouse Gas emissions.

This thesis undertook research, development and implementation of FBC technology for the purpose of low grade coal and biomass waste utilisation in South Africa. The research was carried out in an Atmospheric (pressure) Bubbling Fluidised Bed Combustion boiler.

The hypothesis posed is that, due to features of a fluidised bed such as the high "thermal inertia" of the bed and good heat and mass transfer, FBC technology will be able to accommodate fuels of a low grade and of a varying quality.

Duff coal was found to be well suited to utilisation in a Fluidised Bed Combustor, provided that measures are taken to ensure a high combustion efficiency. Despite presenting some materials handling difficulties, duff coal can be transported without a major cost penalty due to its relatively high calorific value.

Bituminous discard coal was also found to be able to be effectively utilised in a Fluidised Bed Combustor. Addition of sorbent to the bed controlled the emission of

sulphur oxides, which are generated from the combustion of the sulphur in the coal. Negative issues with discard coal include transport cost penalties due to its relatively low calorific value.

Anthracite discards, however, were not found to be a suitable fuel for Fluidised Bed Combustors due to low combustion efficiencies.

Coal slurries were successfully burnt, albeit with inherent losses due to the high moisture content. The formation of char-sand agglomerates in the bed allowed some of the coal to have a long enough residence time in the bed to achieve an acceptable combustion efficiency.

Coal and a biomass waste (coffee grounds sludge) were successfully co-fired at pilot-scale level, and an industrial-scale plant was designed based on the research carried out. This has been running successfully in terms of sludge incineration and steam generation for some years.

This research proved that Fluidised Bed Combustion can be employed to utilise a wide range of low grade coals and waste materials, including the over 1 billion tonnes of discarded coal and a range of biomass residues. South Africa could well benefit from the utilisation of these "opportunity fuels".

Estimates of the potential economic value of discard coal show that 11 000 MW of electricity could be generated using all the current arising discards. This would result in an annual revenue of Rbn 36.7 (36.7 billion South African Rands), which is a total revenue of Rbn 1471 over the 40 year life of the power station. Estimated savings (as compared to utilising conventional coal) of Rbn 5.2 per year and Rbn 207 over plant life could be achieved. If the stockpiles were to be recovered, some 6 000 MW of electricity could be generated from these. This would result in an annual revenue of Rbn 20.6 and a plant life revenue of Rbn 823 Estimated fuel savings are Rbn 2.9 per year and Rbn 116 over plant life. An economic analysis of a discard coal-fired power station located at a mine shows encouraging financial indicators.

Environmentally responsible energy will be the path to follow for the future, and Fluidised Bed Combustion has been proven to be a vital technology to help achieve that goal.