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Research Paper

Characterization of coal blends for effective utilization in thermal power plants

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HIGHLIGHTS

- This work will assist utilities to decide on the choice of coals for blending.
- Conventional and advanced analytical techniques were used for characterization.
- Fuel ratio, burnout profile, ash chemistry and carbon burnout are key factors.
- Basic properties were additive while carbon burnout was non additive for the blends.

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ABSTRACT

This paper deals with the characterization of coal blends using various conventional and advanced analytical techniques. There has been an increasing trend in utilizing imported coals for power generation in India and utilities are resorting to blended coal firing for various reasons, both financially as well as technically. Characterization studies were carried out on 2 combinations of Indian and imported coal blends. Conventional characterization such as proximate and ultimate analysis and determination of calorific value were carried out for the raw coals and blends as per ASTM standards. Following this thermal and mineral analysis of the samples were carried out using thermo gravimetric analyzer (TGA), X-ray fluorescence spectrometer (XRF) and computer controlled scanning electron microscope (CCSEM). Combustion experiments were also conducted using drop tube furnace (DTF) to determine the burnout of the raw coals and blends. The selection of technically suitable coal combination for blending, based on these characterization studies, has been detailed.

1. Introduction

Coal based thermal power generation accounts for more than sixty percent of the total power generated in India [1]. With large reserves available, coal will be the predominant source of fossil energy, with thermal power stations continuing to be the largest consumer, utilizing about three fourth of the total coal produced in the country [2]. However, the gap between demand of coal and indigenous supply is rapidly increasing with time and coal production in the country is unable to keep pace with the capacity addition in the power sector. Also, the quality of coal being mined has been gradually deteriorating with time. Therefore to increase the availability of plant with respect to fuel and to reduce the cost of generation, presently power plants are resorting to blending of Indigenous coal with imported coals. Also, blending of low-grade coals with coals having high calorific value and low ash, improves the coal quality and eliminates the necessity to adopt coal washing. Coal is imported to India from countries such as Indonesia, South Africa, Australia and the characteristics of these coals are significantly different [3].

Traditionally, most boiler furnaces have been designed for the use of specific coals as fuels. However, as mentioned above, substitution of the original design coal with imported coals and coal blends has become a common practice in coal-fired plants. The properties of these new coals and coal blends should be known, prior to their utilization, to avoid fuel related issues. But the uncertainties associated with prediction of blended coal properties due to the non-additive nature of certain coal characteristics [4], has been posing challenges for both designers as well as operators. Conventional analyses consider coal as a homogeneous material and provide only bulk properties, while advanced characterization techniques, such as CCSEM and TGA, take into account the hetero-

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geneity of coal and will provide much reliable information. The characterization information from these techniques coupled with pilot plant studies can be used for formulating optimum blend ratios and also for designing boilers efficiently for blended coal firing.

1.1. Issues associated with blended coal firing

Combustion related properties of coal blends may not be proportional to the weighted average values of individual coals. This is due to the non-linear nature of the combustion process and also due to the interaction between some of the combustible constituents in coal. Reactions taking place in the proximity of burner zone become more complex when coals of different ranks are blended or co-fired [5].

Fuel characteristics such as milling, Ignition, flame stability, char burn-out, slagging and fouling are non-additive and the overall boiler performance cannot be predicted from the performance data of component coals. Also, the flow characteristics of blended coal will be different from those of the component coal, changing the overall flow pattern in the bunker. Even if the blended coal composition closely resembles the design coal for the boiler, the blend may not behave as expected. Problems are more likely, when blending different rank coals or coals with different ash chemistries [3].

Therefore, characterization of the coal blends is very much essential for trouble free operation and maintenance of the boiler as well as in the design and sizing of the furnace. Although coal is highly heterogeneous in nature, several advanced analytical techniques [6–11] are available for its characterization.

The work presented here focusses only on characterizing the coal blends using various conventional and advanced analytical techniques and no detailed investigation has been made into the individual issues described above. However the same can be predicted to a reasonable extent based on the characterization studies.

1.2. Impact of coal properties on operation and sizing of power plant components

Fig. 1 shows the impact of coal properties in a pulverized coal power plant [12,13]. Coal properties affect the efficiency, reliability and availability of boilers and thereby impact the economics as well as the short and long-term operation of the plant [14].

The ratio of fixed carbon to volatile matter, commonly referred to as fuel ratio, indicates the combustion characteristics of the coal [15]. The lower this ratio is, better is the combustion efficiency [16]. Imported coals with high volatile matter require careful handling under high ambient atmospheric temperatures as it is prone to catch fire. Lower mill outlet temperature needs to be maintained for such coals as compared to the regular 75–90 °C temperature for Indian coals. Upon firing blended coal with high volatile matter, mill inlet temperature has to be carefully maintained, to ensure drying of coal as well as to avoid mill fire. When firing medium volatile and high inert (ash and moisture) coals, the tempering air quantity can be reduced to increase the heat pickup in air heater which in turn will lead to an increase in the boiler efficiency [3].

Ash content in coal influences the sizing of boiler furnace as well as its performance. High ash content leads to requirement of more number of mills and also influences sizing of primary air fans, air pre-heaters, electro static precipitators as well as coal and ash handling systems. By blending higher proportion of low ash coals and firing it in boilers designed for high ash coals, the heat transfer profile between the radiative and convective sections of the boiler gets affected and may lead to difficulty in attaining the rated steam parameters [3]. Indian coal ashes are generally abrasive in nature [17] and necessitate liberal sizing of furnaces with lower flue gas velocities and larger spacing of pressure parts with cassette baffles at bends to overcome the tube erosion [3]. However, when imported coals, that are generally low in ash content compared with Indian coals, are fired, the boiler can be made compact, as the pressure parts can be closely spaced. Ash content of blends determined by the standard test methods can be higher than the ash values calculated from the individual coals, particularly for blends between coals of widely differing ranks (lignite or sub-bituminous coals with bituminous coals). The higher than predicted ash values are due to the increase of sulphate in the ash from sulphur oxides trapped by the alkaline minerals in the lower rank coals [18]. With high sulphur coals, the ash resistivity decreases due to the increased adsorption of conductive gases on the fly ash and enhances the collection efficiency of electro static precipitators [19].

The calorific values of Indian coals are generally less compared with those of imported coals due to high ash content [20]. There-

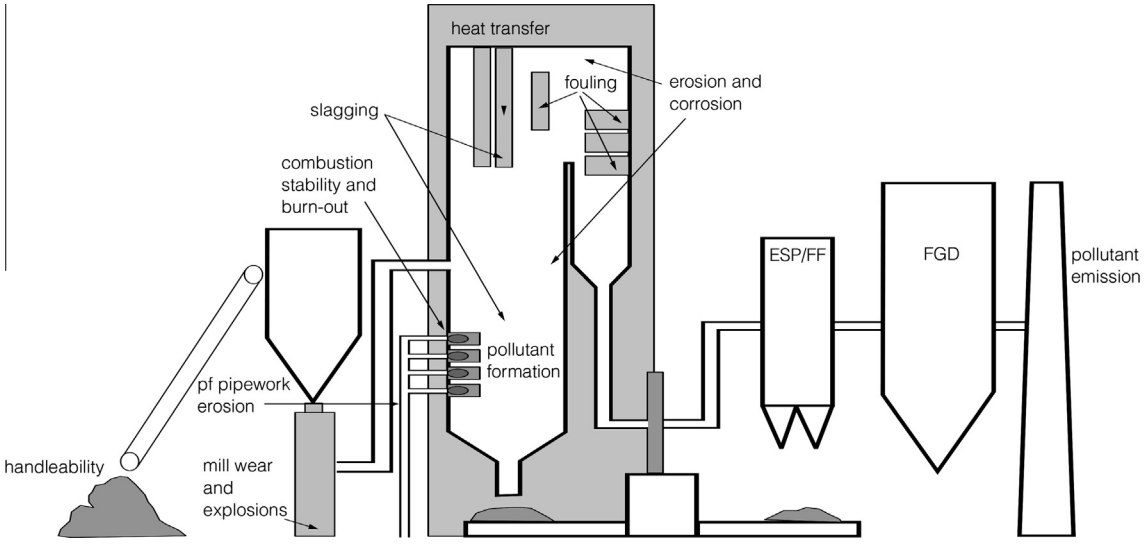

Fig. 1. Impact of coal properties in pulverized coal power plant.