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RESEARCH ARTICLE

EFFECT OF DIFFERENT SIZE FRACTIONS ON COAL QUALITY

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ABSTRACT

Coal is one of the main sources of energy in many parts of the world and has one of the largest reserves amongst all the non-renewable energy sources. The effect of different size fractions of coal has been analysed by taking into account three types of coal namely Australian Hard, PCC (Prime Coking Coal), MCC(Medium Coking Coal).Various tests have helped in understanding the effect of different size fractions on coal quality. The bulk density of the master sample of all the three coals was found to be the average of the three size fractions i.e. +6mm, 3.2mm and -3.2mm respectively. The bulk density of all the three size fraction of coal decreases with decrease in size fractions. Also a decrease in void spaces between the coal samples with decrease in size fraction was observed. Proximate analysis, CSN and LTGK tests showed the values of the master sample to be an average of the three size fractions. There was a significant increase in volatile matter with decrease in size fraction. Generally, coal ash tries to retain higher size fraction in case of Indian coal.

INTRODUCTION

A solid carbonaceous material derived from destructive distillation of coal of high quality coal called coke is formed having very high carbon content. Coke formation from coal is a cumbersome process and requires a lot of measures and consideration to be taken into account. It generally begin with coal selection on the basis of quality of the coke required followed by coal beneficiation and proper blending of different quality of coal, followed by numerous tests like CSN or FSI, Thermogravimetric Analysis, LTGK, etc. which determines whether the coal selected can lead to the formation of a high quality of desired coke. Coal quality analysis is important because of its impact on coke production which is of great importance in steel industries as well as its all-embracing use as fuel in power generation yet coal being different from other fuels in terms of structure (Sahoo *et al.*). The other fuels like oil and gas have defined hydrocarbon structure which does not vary widely but coal is a heterogeneous fuel and has no unambiguous structure rather hydrogen and carbon content in a single sample vary widely at different geographical locations (NariSoundarrajan *et al.,* 2013). The selection of coal for a blend to be used in coke making is of utmost significance. Coke quality plays a crucial role in the performance of blast furnaces. Under Indian conditions, the high ash content of coke coupled with the comparatively inferior strength characteristics; adversely affect the coke rate and productivity in the blast furnaces (BF). Well over 70% of the energy requirement of an integrated steel plant is met by coke. Among the major raw materials used to produce a ton of steel, coking coal constitute about 30% of the total feed material. The quality of coke produced is dependent on many factors like coal/coal blend quality, its preparation, carbonization parameters and post quenching treatment (Ghosh *et al.,* 2017). Metallurgical coke, a macro-porous carbonaceous material having enormous strength is produced by carbonization of finely ground coking coal of coal blends in coke oven at temperature approximately 1200^0C (Ghosh *et al.,* 2017; Diez *et al.,* 2002). During carbonization coking coals undergo a series of changes (from coal to coke) as softening, production of plastic mass, devolatilization, resolidification, formation of porous structure, formation of fissures and changes in carbon texture. The extent of transformation depends on temperature and the rate of heating. When the centre mass temperature of 1000^0C is achieved, the process of carbonization is accomplished. The time taken for the entire process is known as coking period. The amount of time beyond coking period for which the coke stays in the coke over is called soaking period (Ghosh *et al.,* 2017).

Experimental Procedure

A coal is characterized by various, physical, chemical and petrographic properties. Proximate analysis is used to determine moisture, ash, volatile matter and fixed carbon.

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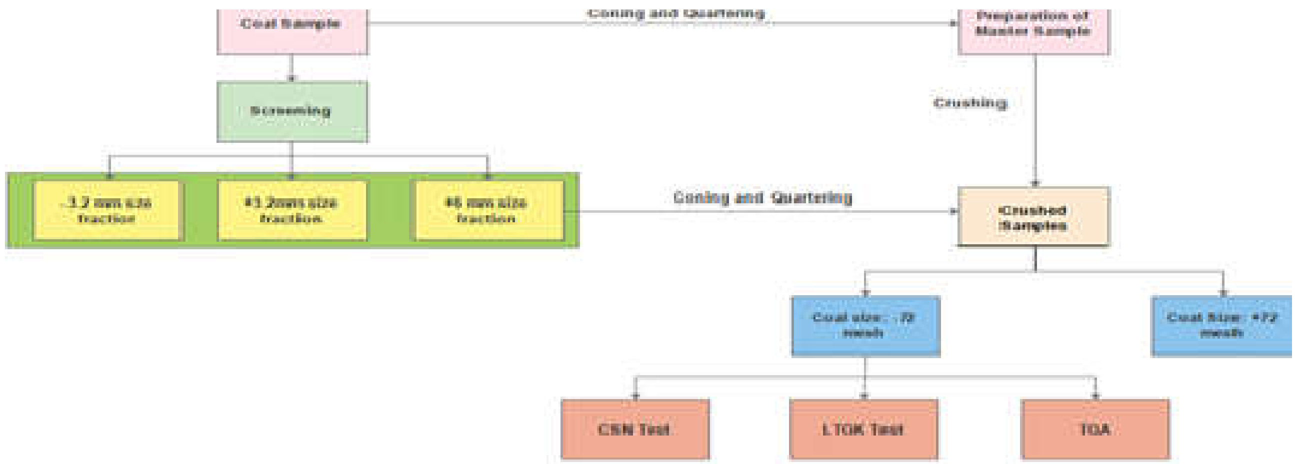

Fig. 1. Flow sheet for analysis of coal

Cokeability of coal is yet another crucial parameter of coal during its reduction in furnace (generally, electric furnace), is usually determined by the Crucible Swelling Number (CSN). Hence, is the simplest test to determine whether a coal is suitable for production of coke. High ash content is undesirable for the operation of thermal power stations as inert increases transport and waste disposal costs, and also means that the heat exchangers have to be cleaned more frequently. A flowsheet for the detailed analysis of the coal sample has been illustrated in Fig.1 depicting all the processes involved.

Bulk Density: Density is an crucial parameter, as it depicts the nature and structure of a material. It depends on the closeness of the molecular structure and the molecular arrangement. The density can also be used for structural analysis of coal, using statistical methods. The bulk density of coal particles in a sample is the ratio of the total mass of the coal to the volume that the coal particles occupy (Zhu *et al.,* 1984; Van Krevelen, 1954). The BD is used while determining the mass of a coal pile or estimating the coal capacity of a coke oven. The density of coal containing about 85 % carbon is 1.3 g cm^{-3}. The density increases sharply for the coal having carbon content greater than 90 % because of increasing amount of more compact aromatic structures (Zhu *et al.,* 1984). The tests to determine BD are conducted in either small or large container. Un-compacted bulk density is not an intrinsic property of a coal pile as it can change depending on how the coal is being handled, the moisture content in coal at the time of testing, and the final geometric arrangement of the particles.

Crucible Swelling Number (CSN or FSI): CSN involves heating a small sample of coal in a standardized crucible to around 800^{o}C (1500 °F). The free swelling (FSI) or the crucible swelling index number (CSN) is a measure of increase in the volume of coal when heated, with the exclusion of air. The parameter is essential for determining the coking ability and degree of oxidation of coal. Coals with a low free swelling index (0-2) are not suitable for coke manufacture also coals with high swelling numbers (+8) cannot be used to produce coke, as a result coke is usually weak and will not sustain the loads imposed within the blast furnace. Crucible swelling number gives a measure of the swelling properties of a coal when heated in a converted crucible (Khoshjavan *et al.,* 2010; Loison *et al.,* 1989). It is the size of the coke button produced when 1 gram of coal is heated under specified condition as compared with a set of standard profile. The results may be used as an indication of the caking characteristics of the coal when burned as a fuel. The sample is ground, not more than two hours before testing as coal may get oxidized and errors can be generated. 1 gram sample of coal of size -72 meshes was taken and heated in a covered crucible under standard conditions to a final temperature of 820±5°C for 2.5 min. The crucible is removed from the furnace and allowed to cool. Coke button obtained is classified by comparing with the outlines of a set of standard profiles. The number of the profile most likely matching to the coke button obtained is the CSN.

Thermo gravimetric Analysis: Thermo gravimetric analyser is an instrument with substantial utility for analysing coal samples. The analyser is very useful in making logical predictions of physical and chemical properties of coal. Its principle advantages are the precision, speed, and ease that help in analysing the sample (Sen *et al.*). In Thermographic analysis of coal the sample is heated in a nitrogen atmosphere to 110°C at a rate of 50°C/min and a constant temperature is maintained for 5 minutes so as to achieve constant weight. The temperature of the SDTA thermal analyser is then raised to 900°C at 50°C/min and maintained for 24 min. A separate timing device is set at 0.62 h at the beginning of the test run, which automatically switches the operating atmosphere from nitrogen to air. The volatile matter reading is taken as the weight loss occurring from the end of the moisture loss to 7 min after reaching 900°C. The fixed carbon reading is taken as the weight loss occurring after the volatiles have been driven off till combustion is complete. The residue at the end of the combustion process is the ash content of the coal which can be measured by reweighing. The volatile matter and fixed carbon contents are recalculated for buoyancy effects. Thermo-gravimetric, in addition, allows drying and combustion behaviour to be investigated and different coal types to be characterized.

Low Temperature Gray King Coke Type (LTGK) [10]: The purpose of the test is to assess the caking properties of a coal or a blend of coals and the yield of the various by-products by carbonization in a laboratory under standard conditions at a maximum temperature of 600°C. The coke residue from the carbonization of finely ground coal at 600°C is classified by comparison with a series of described coke types.

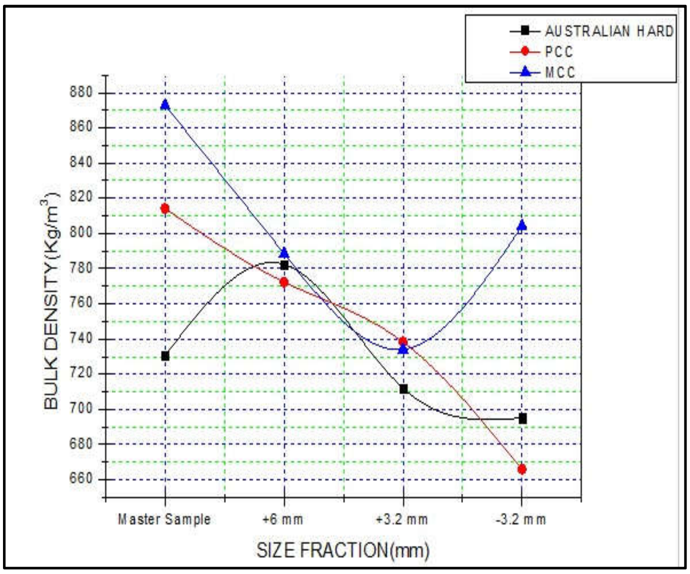

Figure 2. Bulk Density data obtained for different Coal Qualities plotted against different Size Fractions

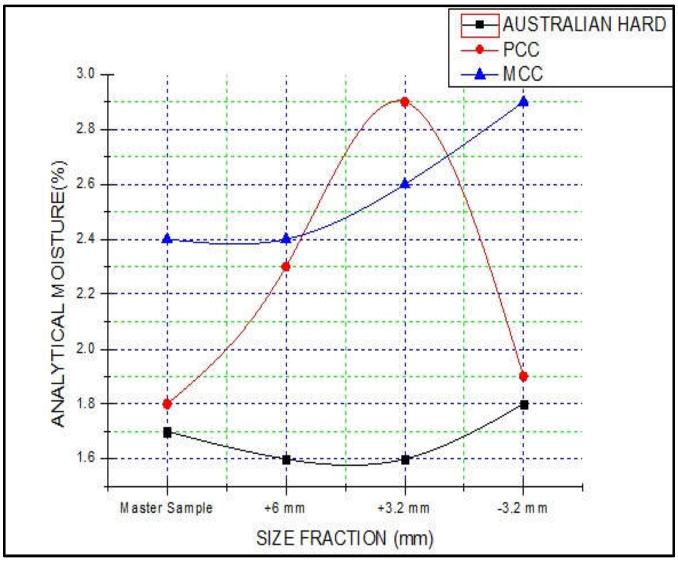

Figure 3. Analytical Moisture data obtained for different Coal Qualities plotted against different Size Fractions

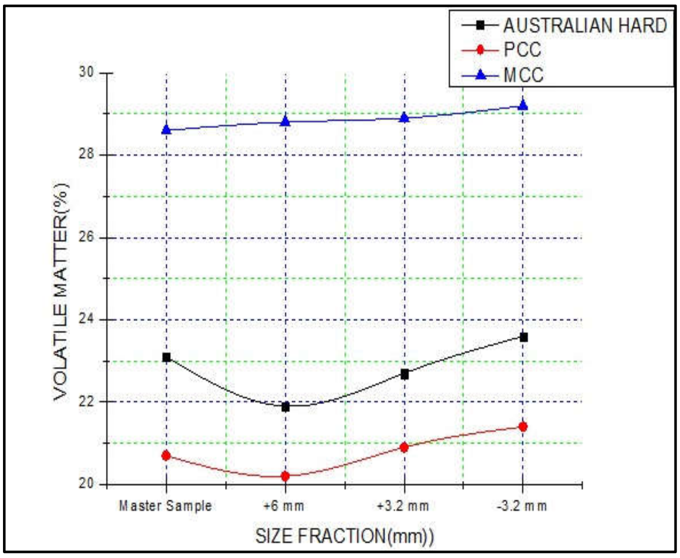

Figure 4. Volatile Matter data obtained for different Coal Qualities plotted against different Size Fractions

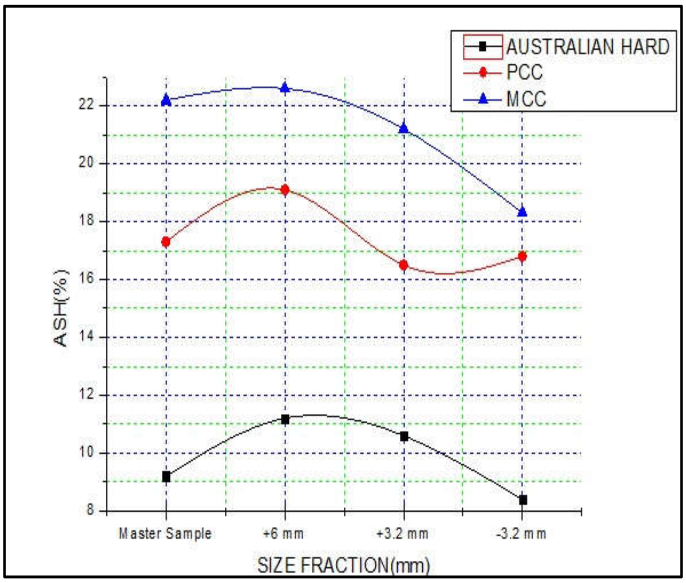

Figure 5. Ash content data obtained for different Coal Qualities plotted against different Size Fractions

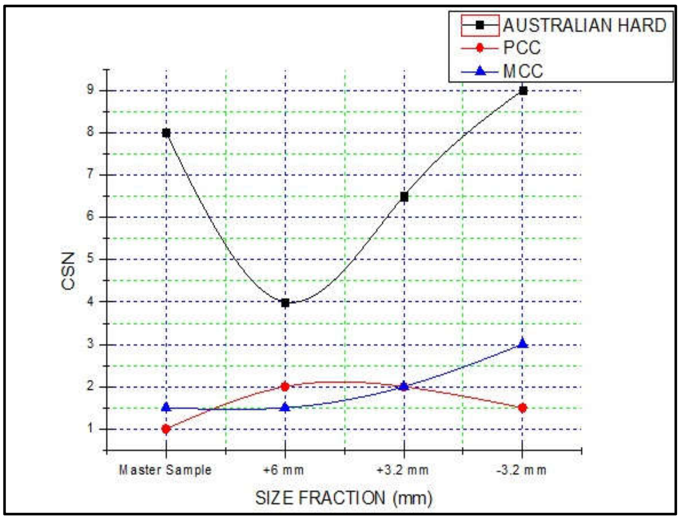

Figure 6. CSN data obtained for different Coal Qualities plotted against different Size Fractions

Table 1. LTGK Test Data

Size	Mater Sample	+ 6 mm	+ 3.2 mm	-3.2 mm
Australian Hard	G_3	G_6	G_3	G_6
PCC	F	F	F	F
MCC	F	F	F	F

For strongly swelled coals the coke is blended with electrode carbon or high temperature coke breeze in a proportion which gives on carbonization a strong hard coke of the same volume as the original coal and electrode carbon / coke breeze mixture. A 20 gram of (100%) coal was taken. Again, a sample(coal is air dried and ground to pass -72 meshes) of 4 gram coke & 16 gram coal were properly mixed for 15 minutes and kept in an another retort. Another sample of 6 gram coke & 14 gram coal were mixed for another 15 minutes in the third retort. An another sample of 8 gram coke & 14 gram coal were mixed for another 15 minutes and placed in the fourth retort. Then, all the samples were flattened in such a way that they were 6 inch in length. The retorts were placed in the furnace till the temperature reached 600^0C from 320^0C. Retorts were left for an hour retort for an hour. The retorts were allowed to cool and compared with a series of described coke types.

RESULTS AND DISCUSSION

Table 1 illustrates the results of LTGK values obtained for different coal samples at different size fractions. It is inferred that LTGK value for PCC and MCC coals did not change whatsoever. The change in the value was noted in the case of Australian Hard coal. As per our expectation the BD increases with increase in particle size (Fig.1). Volatile matter content tends to increase with decrease in size fraction. Moreover, it was constant in case of MCC can be inferred from Fig. 4. Fig. 5 illustrates the composition of ash content increases with increase in particle size. Fig.6 illustrates the CSN obtained for coal samples at different size fractions. The CSN value of PCC is in the range of 1-2 and that of MCC is 1-3. On the other hand the CSN value of Australian Hard is high enough as compared to PCC and MCC, in the order of 4-9.

Conclusion

The detailed experimental investigations have been carried at RDCIS, for high ash Indian coals and Australia hard have helped in determining the effect of different size fractions on coal quality. The extensive analysis determined the bulk density of the master sample to be the average of the three size fractions i.e. +6mm, 3.2mm and -3.2mm respectively. BD of all the samples increases with increase in size fractions. Proximate analysis showed that the ash content increase with increase in particle size (Sahoo *et al.,* 2010). Also, increase in the values of CSN and LTGK was observed as the size fraction decreased. Coal with index 0-2 along with index above 8 cannot be themselves suitable to produce coke, as a result coke is usually weak and cannot withstand the BF load and must be blended with coals with lower index.

REFERENCES

Coal- Determination of Caking power- Gray King Coke test.

Diez M.A., R. Alvarez, C. Barriocanal, 2002. “Coal for Mettallurgical Coke Production: Prediction of Coke Quality and Future Requirements for Cokemaking”, *International Journal of Coal Geology,* 50, 389-412.

Ghosh B., B.K. Sahoo, O.S. Niyogi, B. Chakraborty, K.K. Manjhi, T.K. Das and S.K. Das, 2017. “Coke Structure Evaluation for BF Coke Making”, *International Journal of Coal Preparation and Utilization,* (IN PRESS).

Khoshjavan S., M. Heidary, B. Rezai, 2010. “Estimation of Swelling Index based on Chemical Properties of Coal Using Neutral Networks”, *Iranian Journal of Materials Science and Engineering,* 7.

Loison R., P. Fouch, A. Boyer, 1989. “Coke Quality and Production” 2.

Nari Soundarrajan, Nandkumar Krishnamurthy, Sarma V. Pisupati, 2013. “Characterization of Size and Density Separated Fractions of a Bituminous Coal as a Feedstock for entrained slagging Gasification”, *International Journal of Clean and Energy,* Number 2, pp 58-67.

Sahoo B.K., S. De, M. Carsky, B.C. Meikup, 2010. “Enhancement of rheological behavior of Indian High Ash coal-Water Suspension by Using Microwave Pretreatment”, *Ind. Eng. Chem. Res.,* 49, 3015-3021.

Sahoo, B.K., S.K. Das, A. Gupta, P.K. Pankaj, M.P. Reddy, “A new coal preparation scheme to improve coke quality”.

Sen L., N. Whitely, W. Xu, W.P. Pan, “Characterization of Coal by Thermal Analysis Method”.

Van Krevelen D.W. 1954. “Fuel”, (33), 79.

Zhu P.Z., J.S. Gao, 1984. “Coal chemistry”, Shanghai Science and Technology Press, 74.

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