Beneficiation and Development of Process Flowsheet of High Ash Non-Coking Coal from Talcher Coalfield, Odisha

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Abstract

In India, Coal is the irreplaceable preferred energy fuel due to its abundance, availability and affordability and it would continue to be so in the foreseeable future. Around 73% of the entire power generated in the country is coal based, which bears testimony to the immense significance of coal in India's economic growth and development. However, Indian coal has been observed to be of low quality on account of its high ash content attribute and non-coking category coal constitutes sizeable quantity of near-gravity materials (NGM), which entails beneficiation, to suit end-users. The objective of the present study demonstrates beneficiation of high ash non-coking coal from Talcher coalfield, Odisha, with 34.31% ash content intended for scaling down the ash content to 25% in obtaining clean coal at a reasonable yield, deploying physical beneficiation techniques. The coal sample was characterised thoroughly in terms of petrography, size analysis, washability and chemical composition. Beneficiation process was initiated at a top size of 6.3 mm due to its high ash content. Tactical combination of gravity separation and flotation techniques yielded clean coal with 23.3% ash at 49.7% yield, an intermediate clean product with 30.9% ash at 12.1% yield and a reject with 49.8% ash at 38.2% yield.

Keywords: Non-**c**oking Coal; Washability; Beneficiation; Gravity Separation; Flotation

1. Introduction

India is experiencing rapid economic and population growth, with consequential rise in demand for energy. Coal is the most widely used energy source for electricity generation and an essential input for steel production. As per Integrated Energy Policy Committee of erstwhile Planning Commission, coal will remain India's most important energy source till 2031-32 and possibly beyond[1]. Indian coal has been observed to be of low quality on account of its high ash content attribute and the high ash non coking category coal constitutes sizeable quantity of near-gravity materials (NGM), that invariably entails beneficiation to suit end-users for meeting application specific qualitative level. Due to deterioration of coal quality and shortage of coking coal in the country, inferior grade of coking coal of high ash percentage and non-coking coal both of which is available aplenty can be used in steel sector, cement industry, thermal power generation and other industries after pre-treatment using coal preparation and beneficiation techniques. The beneficiated coal has immense potential for being used as a blendable mix for metallurgical applications[2-6] and such blend formulation of clean coal facilities maximising the infusion of non-coking coal with scarce coking coal for catering to metallurgical industries, enables lesser dependence on import of high-rank low ash content coke.

The present study demonstrates the physical beneficiation of high ash non-coking coal from Talcher coalfield, Odhisa with 34% ash content intended for scaling down the ash content to 25% in obtaining clean coal at a reasonable yield which can be used as a blendable mix for metallurgical applications.

2. Experimental

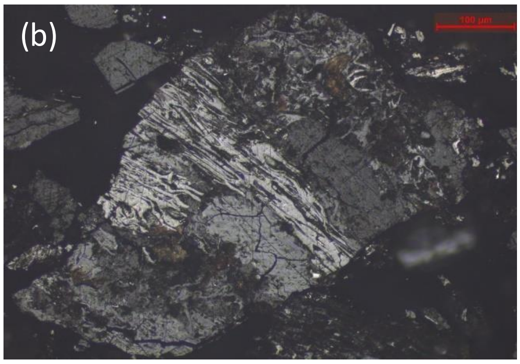
2.1. Raw Material

High-ash non-coking coal sample from Talcher Coalfield, Odhisa was taken up for the present investigation.

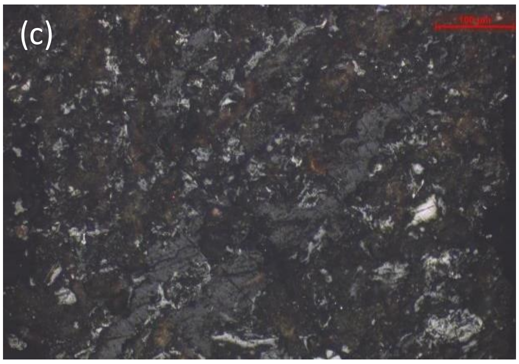
2.2. Petrographic Studies

Micropetrographic characterization of the head sample was carried out in the laboratory to characterize vitrinite, liptinite, inertinite (fusinite, semifusinite, macrinite & micrinite), and mineral matter on visual basis, following the Indian Standards (IS 9127) procedures. It has been observed collodetrinite and collitellinite bands of vitrinite are associated with other macerals of inertinite and liptinites (Figure 1a, b). Semi fusinite grains (Figure 1d) are larger in size while smaller inertodetrinites are found within vitrinite matrix. Liptinite group macerals are deep grey and darkest among all the macerals. They are identified on the basis of their fluorescence property and distinct morphology and occur in association with vitrinite and inertinite. Mineral matters are present in association with different maceral groups. Mineral components are rich in clay minerals, silica (quartz) and carbonates (siderite) (Figure 1b, c). Distributions of Petrographic constituents are given in Table 1.

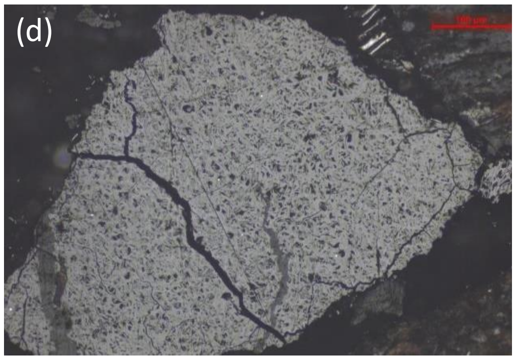
a) Single vitrinite grain (grey), with mineral matter (dark) under reflected light.



b) Vitrinite grain (grey), inertinite (white) and mineral matter (dark) under reflected light



c) An association of mineral matter (dark) and organic matter mainly vitrinite (grey) and inertodetrinites (white) under reflected light.



d) Inertinite maceral (white) and mineral matter (dark) under reflected light.

Fig. 1. Photomicrographs of macerals and mineral matter studied under DM4500 polarizing coal petrological microscope (studied under oil immersion using 20 X objective).

Table 1. Distribution of petrographic constituents of head sample

Petrographic constituents	**Vol. %**	**Vol. % (Vmmf basis)**
Vitrinite	42.0	64.0
Inertinite	21.0	32.3
Liptinite	2.0	3.07
Mineral matter	35.0	-

Coal rank is the most important property required for assessing its application. Rank of the coal has been determined by measuring the reflectivity of clean vitrinite grains under microscope. The mean vitrinite reflectance of Coal calculated is 0.6. The gross calorific value of the coal was found to be 4364 kcal/kg. Chemical constituents through proximate analysis of head sample are shown in Table 2.

Table 2. Proximate analysis of the head sample

Constituents	**(%)**

Moisture	6.32
Volatile matter	35.17
Ash	34.31
Fixed carbon	24.20

2.3. Size Analysis

The size analysis of high ash non-coking coal received from Talcher coalfield, Odhisa was carried out by dry sieving techniques to identify the percentage of ash, volatile matter and moisture content at various size fractions.

Table 3. Size and chemical analysis of raw coal crushed to 50 mm

Size (mm)	**Wt %**	**Ash %**
– 50 + 40	12.1	35.92
– 40 + 30	27.3	35.79
– 30 + 20	16.2	35.65
– 20 + 10	15.5	33.08
– 10 + 6	10.1	34.88
– 6 + 1.68	8.0	30.16
– 1.68 + 0.85	3.8	30.40
– 0.85 + 0.5	2.4	29.98
– 0.5 + 0.21	1.7	29.70
– 0.21 + 0.15	0.9	29.14
– 0.15 + 0.10	0.2	29.04
– 0.10 + 0.075	0.3	28.70
– 0.075 + 0.063	0.1	28.46
– 0.063 + 0.045	0.2	28.61
– 0.045	1.2	32.79
Total	100.00	34.21

The raw coal was initially screened at 50 mm; the plus 50 mm fraction was crushed in a single roll crusher. The overall combined fraction of the product below 50 mm was subjected to screen analysis. The size distribution of coal crushed to 50 mm is shown in Table 3. It is observed that about 71% of the crushed material was above 10 mm and below 0.5 mm fraction was about 7%, and its ash percentage varied from 36% to 27%.

2.4. Washability Studies

In order to study the feasibility of deploying gravity based techniques for coal cleaning, washability studies were carried out on the coal sample from Talcher coalfield, Odisha. Considering the high ash content of this coal, the washability characteristics were determined at a top size of 6.3 mm. The size fractions −6.3+3 mm, −3+1 mm, −1+0.5 mm and −0.5 mm were subjected to float and sink tests in the relative density range from 1.4 to 2.0. The generated data was used for plotting washability characteristics. The theoretical maximum yield at 25% ash level was observed to be around 67 %. The washability characteristics are shown in Fig. 2.

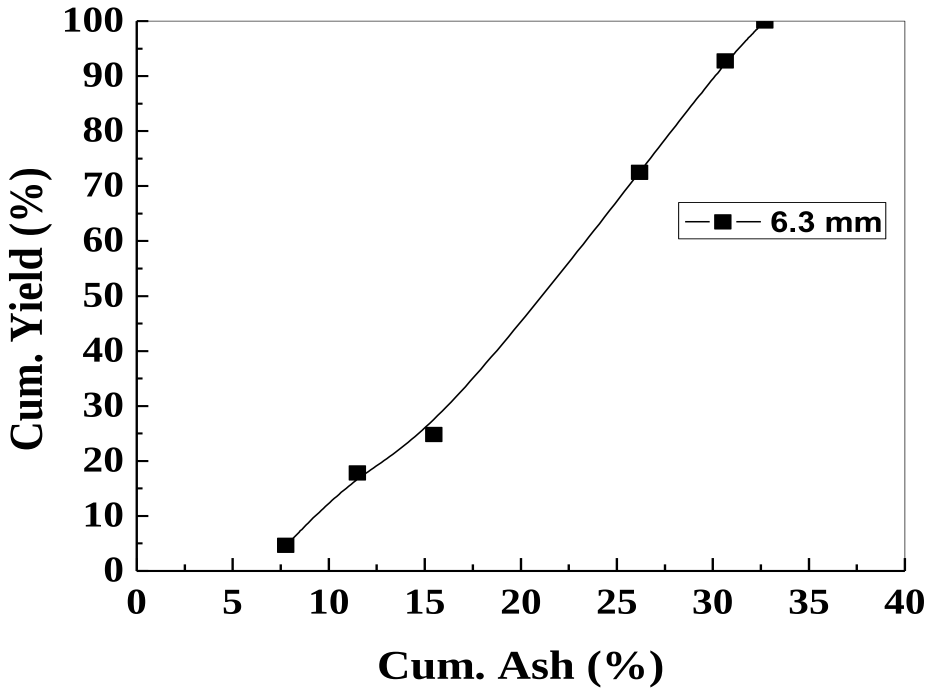


Fig. 2. Washability curve of Talcher coal crushed to a top size of 6.3 mm

3. Physical Beneficiation

3.1. Jigging

Jigs are widely used in coal cleaning. It is a mechanical concentrating device in which a bed of mineral particles of mixed sizes, shapes and specific gravity is intermittently fluidised. The fludisation is accomplished by pulsating water and jigging process forcing the heavy mineral to become stratified on the bottom while the lighter particle rises to the top. The coarse heavy particles are typically drawn off by gate-&-dam arrangement and the fine heavy particles passes through the screen into the lower or hutch compartment. The jig used in this case was Denver Pulsating Mineral Jig. The screen used in jigging has been selected depending upon the top feed size. Steels balls were used for ragging. Jigging operation has been carried out at –6.3 + 3 mm and –3 + 0.5 mm size fractions at optimized conditions.

3.2. Froth flotation

Froth flotation process utilizes the differences in Physico-chemcial surface properties of various minerals. The treatment of the ore pulp with the reagents create favorable conditions for the attachment of certain mineral particles to air bubbles. The air bubbles carry the selected minerals to the surface of the pulp and from a stabilized froth which is skimmed off while the other minerals remain in the suspension. Bench scale flotation studies were performed in Dorr-Olvier laboratory cell type with a capacity of 6L. Flotation studies have been carried out with the combine –0.5 mm size fraction at optimized conditions.

4. Results and discussion

4.1. Physical beneficiation

As the objective was to achieve 25% ash in the clean coal, considering the high ash of the feed it was decided to initiate the beneficiation process at a top size of 6.3 mm. The coal was crushed and the size analysis of the crushed feed is shown in the Table 4 illustrates the ash distribution in the size classes as indicated for the process feed.

Table 4. Ash distribution of process feed in different size classes

Size (mm)	Wt %	Ash %
– 6.3 + 3	23.84	37.58
–3 + 0.5	61.47	32.57
– 0.5	14.69	35.61
Total	100.0	34.21

In order to avoid the size effect the ROM coal, crushed to 6.3 mm top size, was fractionated into three fractions, namely – 6.3 + 3, – 3 + 0.5 and – 0.5 mm size classes. The coarse and intermediate fractions were treated by gravity techniques while the fine fraction was treated through flotation. The tailings from the coarser fractions were ground and treated through flotation along with the fine fraction.

The coarse fraction – 6.3 + 3 mm size was treated in jigging operation at optimised conditions to recover a relatively cleaner product with ~21% ash at ~6% yield. The jig tailing contained ~43% ash was crushed to –3 mm and screened at 0.5 mm. The size fractions – 3 + 0.5 and – 0.5 mm were mixed with original.

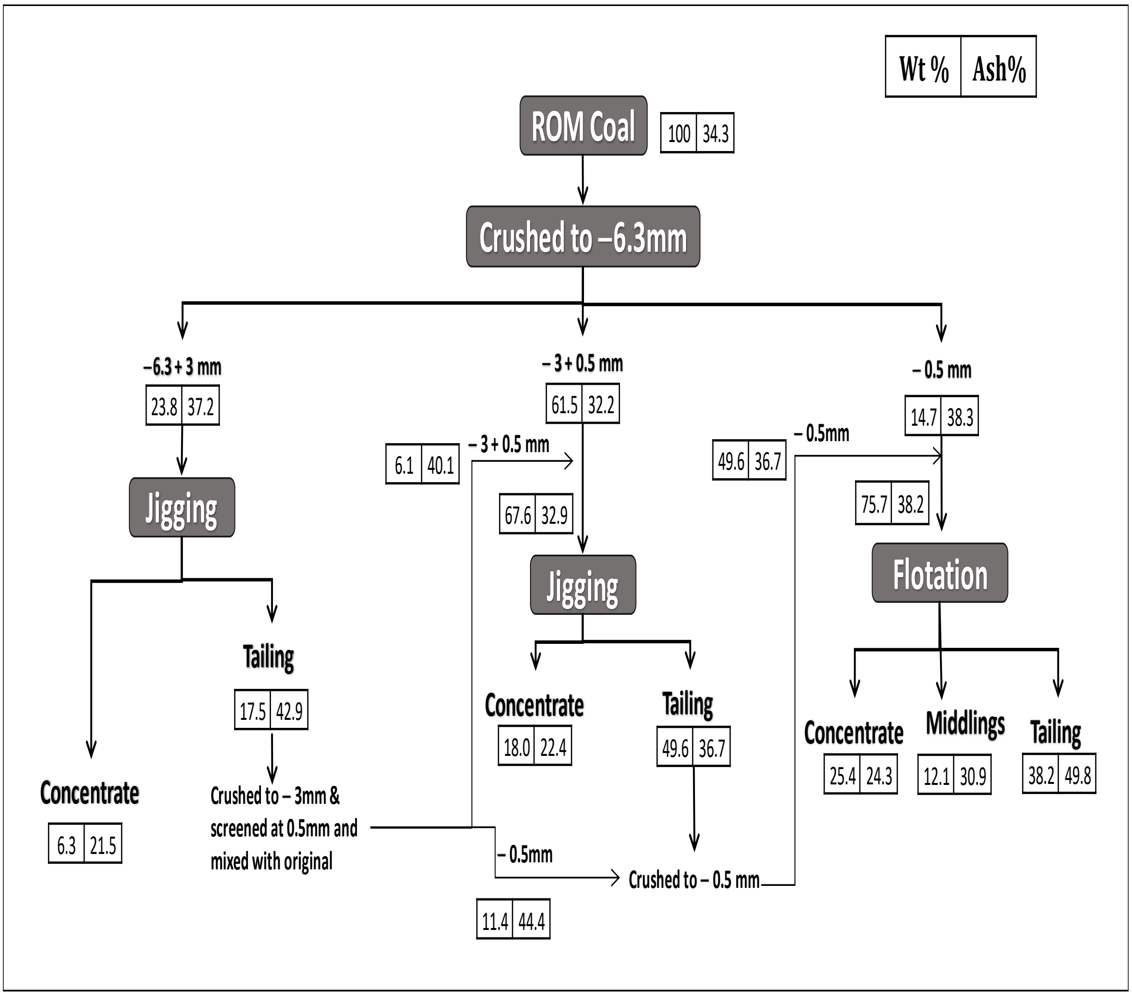


Fig. 3. Physical processing flowsheet of Talcher coal

The intermediate size fraction i.e., the total – 3 + 0.5 mm sized material having an ash content of ~33% was also treated in jigging operation to recover a clean coal at ~22% ash with 18% overall mass yield. The jig tailing contained ~37% ash was crushed to – 0.5 mm and mixed with the original – 0.5 mm fraction.

The combined – 0.5 mm size fraction i.e., the total material having ash content of ~38% was treated in flotation at optimised conditions. The flotation tailing was a reject with ~50% ash with ~38% yield, while the flotation concentrate with ~24% ash with a mass yield of ~25%. The middling product with ~31% ash can be recycled as cleaner feed. All the clean coal streams with around 25% ash are combined to give a mass yield of ~53%. The process flowsheet is shown in Fig. 3 and the product streams of physical beneficiation are summarized as follows:

- Clean coal with 23.3% ash at 49.7% yield
- Intermediate clean product with 30.9% ash at 12.1% yield
- Reject stream with 49.8% ash at 38.2% yield

5. Conclusions

Most of the Indian non-coking coals have high ash content which are not suitable for direct utilization. The high ash non-coking coal from Talcher coalfield, Odhisa was characterised thoroughly in terms of petrography, size analysis, washability and chemical composition and the gross calorific value of the coal was observed to be 4364 kcal/kg. Tactical combination of gravity separation and flotation techniques yielded clean coal with 23.3% ash at about 49.7% yield and an intermediate clean product with 30.9% ash at 12.1% yield. A suitable process flowsheet was suggested for beneficiation of high ash non-coking coal from Talcher coalfield.

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