Washability Investigations of High Ash Indian Non-Coking Coal for Development of Beneficiation Flow Scheme for Different End Users

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ABSTRACT

Coal continues to play a major role in the economic development of the country. Indian coals contain high ash content and are difficult-to-wash and it is essential to beneficiate them to the required level acceptable to different end users. This article describes the washability characteristics of a typical non coking coal from Talcher Coalfields aiming at 25% ash level for sponge iron in the clean coal and middlings at 40% ash level for power generation through pulverized fuel combustion and rejects for power generation through Fluid Bed Combustion. Conventional float-and-sink testing was used to determine the yield of clean coal. A suitable flow scheme for beneficiation of the non-coking coal was suggested.

INTRODUCTION

Coal, in general and Indian coal of Gondwana origin in particular, is heterogeneous in nature. The term Gondwana originally denoted a geological system comprising a great succession of mainly fresh water sediments in the stratigraphy of the Indian subcontinent. The characteristics of these coals influenced by the origin and mode of formation are dissimilar to that of the coals of Northern Hemisphere in some respects. Gondwana coals are comparatively low in hydrogen and high in nitrogen.

The relative abundance of coal in India compared to other fossil fuels makes it a natural choice as the primary source of fuel, be it for steel making, power generation or for other uses. As of today, the total reserves of coal in India are 265 billion tonnes. Out of which about 85% constitute non-coking coal. The coking coal reserves are very much limited, which constitute about 15% of the total coal reserves [1]. Coal, which currently accounts for more than 50% of total primary commercial energy supply in the country and for about 70% of total electricity generation, is likely to remain a key energy source for India for at least the next 30–40 years. The next important consumers are the metallurgical industries that consume primarily the coking coals. Some industries that find utilization of non-coking coals include cement, smelting-reduction processes of steel making, sponge iron, chemicals, paper, etc.

The state of Orissa contains approximately 23% of India's reserves of non-coking coal, and the major supplier is Mahanadi Coalfields limited (MCL). The state has two major coalfields, namely Talcher coalfields and Ib Valley coalfields. The state is the main supplier of coal to the various thermal power stations and sponge iron plants.

One of the major problems for different end users are the varying and high- ash content in the ROM coals averaging above 45%. The only solution to this problem appears to be setting up of a beneficiation plant to reduce the ash content (2, 3). Keeping this in view, detailed investigations on washability characteristics for a coal sample from Talcher coalfields was carried out. The paper highlights the detailed findings with respect to washability investigations and suggests a suitable flow scheme for beneficiation of the non-coking coal.

SAMPLE COLLECTION

The sample was collected from Opencast Project of Talcher coalfields, Orissa. The total thickness of the seam is about 30 metres and it is having about six working benches. The sample was collected from each bench with the help of a Haulpack and payloader, by scraping the entire cross section of the bench at various places. After proper and thorough mixing, about 10 tons of sample were collected and brought to the laboratory for further studies.

CHARACTERIZATION OF RAW COAL

Characterization tests of raw coal reveal that ash percentage of coal is around 40.6%. Moisture percentage (on as received) of the coal is 6.5%. Ash Fusion temperature of the raw coal is above 1400^0 C.

The raw coal was taken and first screened at 100 mm; the plus 100 mm fraction was crushed in a single roll crusher. The overall combined fraction of the product below 100 mm was subjected to screen analysis. The size distribution of coal crushed to 100 mm is shown in Table 1. It is seen that about 73% of the crushed material was above 25 mm. The - 0.5 mm fraction was less than 2.6%, and its ash percentage varied from 41%.

WASHABILITY STUDIES

The size fractions 100 – 25 mm, 25 – 13 mm, 13 – 6 mm, 6 – 3 mm and 3 - 0.5mm were subjected to float – and - sink tests, and the relative density range was 1.40 to 2.00. The washability data of all the sizes is shown in Table -2 and that of the combined 100 – 0.5 mm is shown in Table – 3. The generated data were used for plotting various washability curves to establish the washability characteristics and it is depicted in Figure 1. The minus 0.5 mm coal fractions were not subjected to float-and- sink tests. The Mayer curves on the whole coal basis for the raw coal were plotted and depicted in Figure 2. The theoretical yield of clean coal at 25% ash level was around 45.0% as depicted in the Mayer's curve.

The theoretical yields as mentioned above may not be achievable in actual plant practice due to dynamic system of the washers. The practical yield to be obtained from the commercial plants varies in quality and quantity depending on the efficiency of the washing system. However, it is possible to predict the yield of the clean coal at desired quality considering the normal efficiency values of the washers by taking the concept of Gaussian equation. The partition data represents the fraction of the feed in a density interval which goes to the clean coal and d50 is the density at which the 50% of the feed in that density that goes to the clean coal. The parameters derived from the partition/Tromp curves are the a) Relative density at the cut point 'd50'; b) Ecarte Probability Moyen 'Ep'; c) Imperfection T d) Error area. In general the partition curves are specific to the separation units for which they are established and are independent of the density distributions of the feed and depend on size composition, feed rate and other operating conditions.

It was assumed that the quantity of misplaced material decreases exponentially with the increase in difference between its specific gravity (X) and the specific gravity of cut (X*).

- $y(X) = 100-50\exp[(X-X^*)/Z]$ for $X<X^*$
- $y(X) = 50\exp[(X^*-X)/Z]$ for $X>X^*$

- y(X) = 50

where y(X) is the recovery of component of the float fraction (%) and Z= Ep/ln0.5

The above three equations can be used for predicting the performance of washer considering normal efficiency of the washer (known Ep).

Taking the washability data of the different size fractions of the raw coal crushed to 100 mm the above model, was used to develop a flow scheme by taking the efficiency values of the washers like Heavy Medium Bath and Heavy .Medium Cyclone.

DEVELOPMENT OF A BENEFICIATION STRATEGY

Figure 3 indicates the proposed beneficiation strategy which may be adopted for such type of coal studied:

a. Run of Mine coal from the open cast mines may be fed to the feeder breaker to crush the ROM coal down to 250 mm. The crushed coal – 250 mm may be conveyed for further crushing.
b. The – 250 mm coal may be screened by using a vibrating screen of aperture 100 mm. The + 100 mm coal may then be crushed down to below 100 mm in a single roll crusher. The coal of below 100 mm size may be conveyed to a raw coal surge bin.
c. From the surge bin, coal will be fed to vibrating screen through feeders for classification into sizes viz., 13 and 3 mm.
d. The coarser fraction i.e., 100 - 13 mm may be washed in a three product Heavy Medium Bath. The Bath may produce 3 products – washed coal, middlings and rejects. Rejects will be dewatered on perforated bucket elevators. Dewatered rejects will be conveyed by means of belt conveyor to rejects stockpile. Washed coal from Bath shall be dewatered and stored in bin. The ash% of the washed coal should be about 25%. The middlings may be dewatered and stored in a middling bunker.

e. The fraction i.e., 13 -3 mm may be washed in Heavy Medium Cyclone. The Cyclone will produce 2 products –washed coal, and rejects. Rejects will be dewatered on perforated bucket elevators. Dewatered rejects will be conveyed by means of belt conveyor to rejects stockpile. Washed coal from the cyclone shall be dewatered and stored in bin. The ash% of the washed coal should be about 25%.

f. HM Bath and cyclone will be equipped with Medium regeneration circuit complete with appropriate density control, size composition of Magnetite for washery, recovery of water and its use in the circuit

g. The fraction below 3 mm may be dewatered in a centrifuge and stored in bins. The ash content of this fraction is 37.4% and needs no further beneficiation as it can be mixed with the middlings of the H.M.Bath and sent to power stations for power generation through pulverized fuel combustion route.

h. The rejects of H.M.Bath and H.M.Cyclone may be mixed and used for power generation through FBC route.

CONCLUSIONS

The washability studies on the coal sample of Talcher coalfields show that the coal possesses good washability characteristics. Washability investigation on 100– 0.5 mm fraction reveals that theoretical yield of clean coal at 25% ash level is around 45% on whole coal basis. However, it may be stressed that the practical yield on industrial scale is likely to be less depending on the efficiencies of washers.

By taking the efficiency values of the washers like H.M.Bath and H.M.Cyclone it was possible to predict the practical yields at the required ash levels. A flow scheme was suggested which gives a yield of 32.8% at 25 % ash level, which may be used for sponge iron industry; middlings at an yield of 39.7% could be generated at an ash level of 39.7% which may be used for power generation through pulverized fuel combustion. The rejects may be used for generation of power through FBC route.

References

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Table – 1 Size distribution of raw coal crushed to 100 mm

Size, mm	Wt. %	Ash%
100-75	29.7	42.5
75 - 50	25.0	40.8
50 - 25	19.0	41.1
25 - 13	11.2	39.7
13 - 6	6.0	37.8
6 - 3	2.8	37.3
3 - 0.5	3.7	34.9
- 0.5	2.6	41.0
	100.0	40.6

Table – 2 Size-wise float and sink data of raw coal crushed to 100 mm

Size, mm	100-25		25-13		13-6		6 - 3		3-0.5		100-0.5	
	Wt%	Ash%	Wt%	Ash%	Wt%	Ash%	Wt%	Ash%	Wt%	Ash%	Wt%	Ash%
Sp. Gr.	73.7	42.2	11.2	39.9	6.0	37.0	2.8	35.6	3.7	34.4	97.4	41.1
<1.40	20.0	20.9	29.9	17.8	30.5	12.7	29.5	9.3	27.9	6.2	22.3	18.6
1.40-1.50	22.0	32.1	17.7	32.0	15.9	28.0	14.7	24.7	15.5	20.5	20.7	31.4
1.50-1.60	19.2	41.5	14.8	41.4	14.6	38.0	15.9	35.7	14.7	32.3	18.1	40.9
1.60-1.70	10.9	48.2	8.3	47.9	7.6	45.8	3.5	43.8	2.7	37.4	9.9	47.9
1.70-1.80	11.5	54.7	9.5	53.6	10.8	52.2	9.1	47.4	12.3	45.5	11.2	53.9
1.80-2.00	9.4	62.5	10.7	61.9	11.9	61.3	17.0	58.1	10.3	55.5	10.0	61.8
>2.00	7.0	78.8	9.1	78.1	8.7	77.4	10.3	76.8	16.6	74.7	7.8	78.2
	100.0	42.2	100.0	39.9	100.0	37.0	100.0	35.6	100.0	34.4	100.0	41.1

Table – 3 Washability data of coal crushed to 100 mm (size 100-0.5mm)

Sp. Gr.	Float	Dry	Cum. Float		Cum. Sink		Ch. Wt%	Mayer's
	Wt.%	Ash%	Wt.%	Ash%	Wt.%	Ash%		pt.value
<1.40	22.3	18.6	22.3	18.6	77.7	47.6	11.2	4.1
1.40-1.50	20.7	31.4	43.0	24.8	57.0	53.4	32.7	10.6
1.50-1.60	18.1	40.9	61.1	29.5	38.9	59.3	52.1	18.1
1.60-1.70	9.9	47.9	71.0	32.1	29.0	63.2	66.1	22.8
1.70-1.80	11.2	53.9	82.2	35.1	17.8	69.0	76.6	28.8
1.80-2.00	10.0	61.8	92.2	38.0	7.8	78.2	87.2	35.0
>2.00	7.8	78.2	100.0	41.1		83.0	96.1	41.1

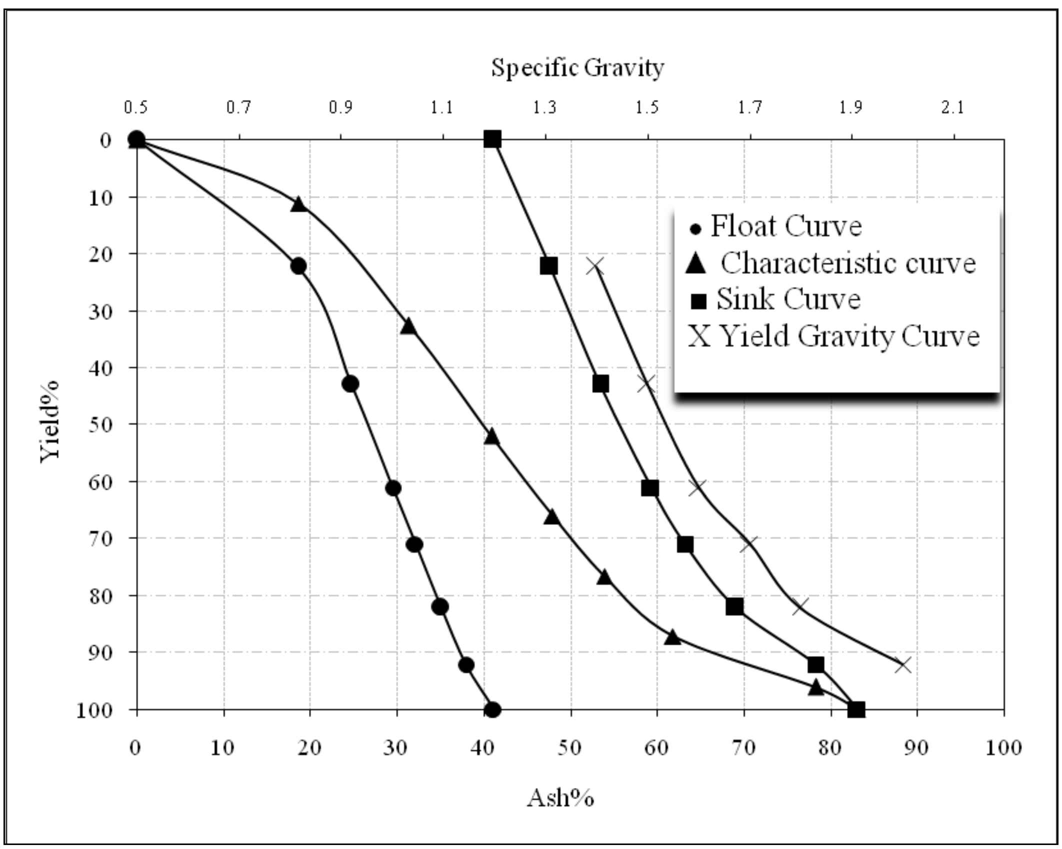

Figure – 1 Washability Curves

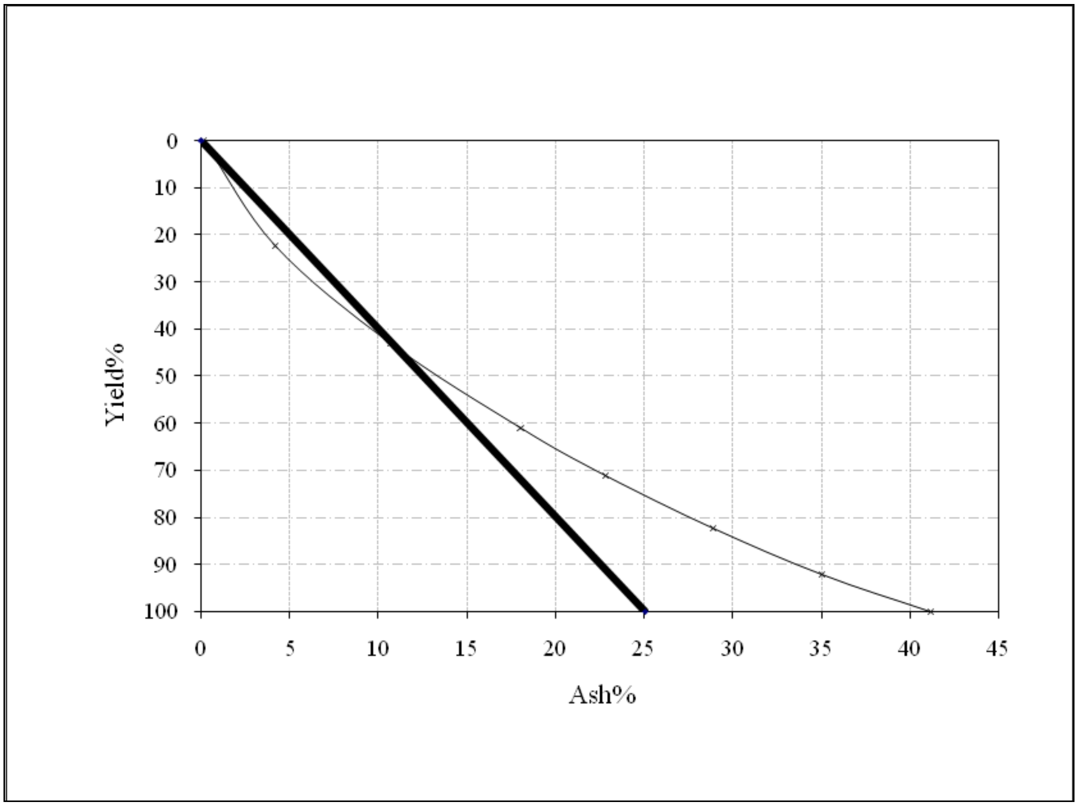

Figure – 2 Mayers Curve

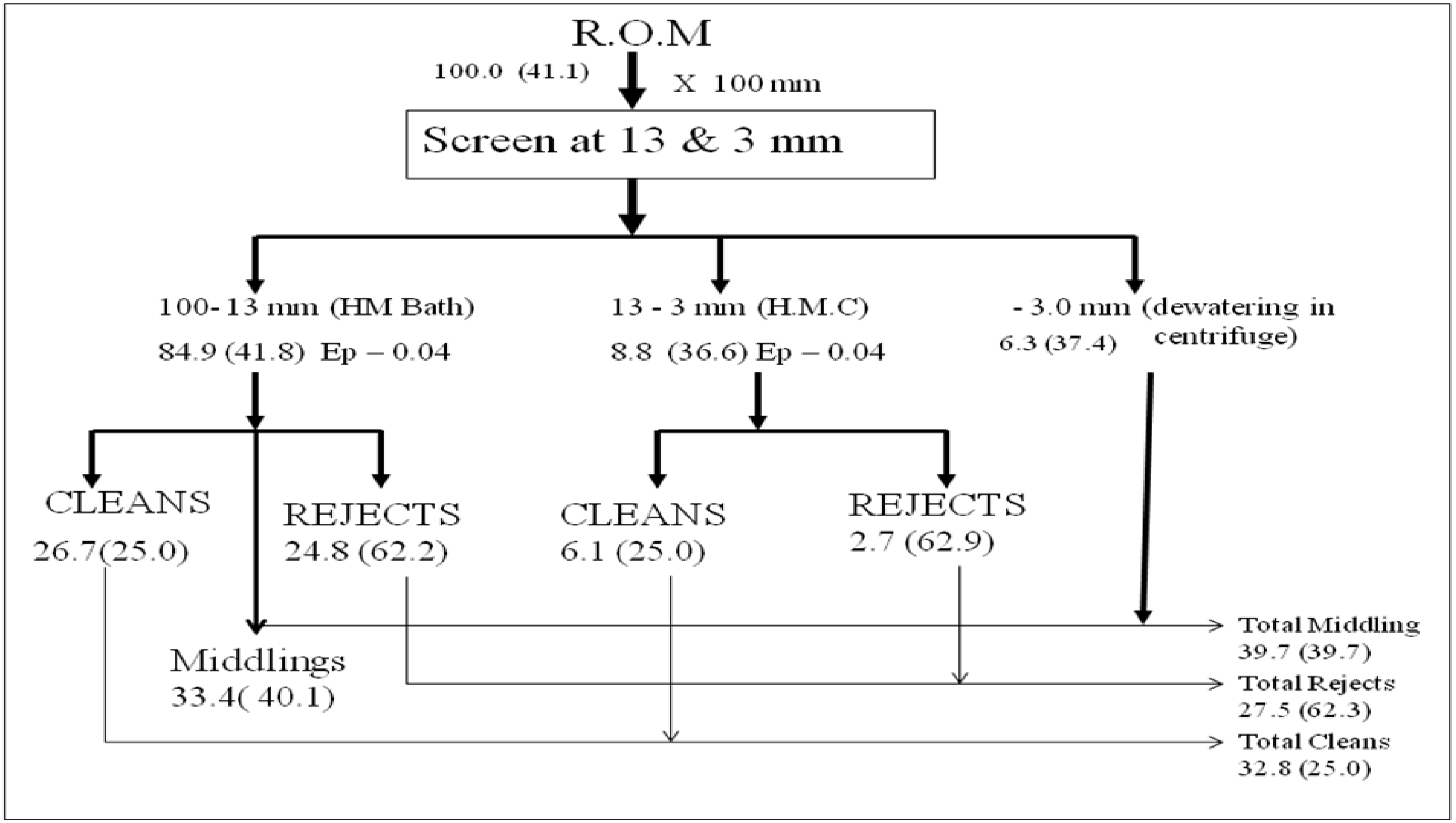

Figure 3 Flow Scheme for Beneficiation of the non coking coal sample