COAL PREPARATION –RECENT TRENDS

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INTRODUCTION

Indian coal reserves constitute about 1% of the world reserve; the gross reserve is 1,92,884 million tonnes as on 01-01-1990, including Gondwana coalfields of tertiary coals (with high organic sulphur of North Eastern Coalfield) and tertiary lignite in Neyveli area etc., as shown in Table 1. Out of this, the coking coal reserve is only 28,690 million tonnes which is only 15% of the total. Again, out of the total coking coal (Table 2), hardly 18.5% is prime coking coal and about 27.5% is high volatile medium coking coal, a part of which is presently beneficiated for utilisation as blend charge for the coke ovens. But the low volatile medium coking coals comprising about 47.7% of the coking coal reserves remain unutilised or used in thermal power plants for want of suitable technology for their beneficiation.

In the early years, mainly due to non-availability of proper technologies and ignorance good quality prime coking coal was selectively mined and used for not only metallurgical purposes but also for other purposes including domestic, where inferior quality coal could have been used. This has resulted in fast depletion of prime coking coals.

Coal preparation has completed about 50 years in India, since the inception of the first washery at West Bokaro in 1951. There are 25 coal washeries with the total installed capacity of over 35 million tonnes of coking coal. Indian coals are conspicuous for their highly intergrown nature of mineral matter, which has made their washability characteristics substantially different from those in other countries. The coal deposits in America & Europe are in general of low ash & high sulphurcontent compared to Indian coal of very high ash and low sulphur content.

Table 3 presents the details of coal washeries in India with their year of commissioning, feed top size and washing circuit.These washeries can be grouped into three categories:

The first group of washeries commissioned between 1950-1970 mostly uses the feed top size of 75mm and mainly empty crushing to 75mm, followed by classification at +25 or +13mm as coarse coal, -25 or -13mm +0.5mm as small coal and -0.5mm as fine coal. The coarse fraction is treated in Heavy Media baths while the small coal is treated in jigs or HM cyclones. The fines, after recovery, are generally mixed with the clean as the ash content remains within the acceptable limit. Presently some of these washeries have incorporated flotation circuit for the fines.

The second group of washeries, commissioned between 1970-1980, has reduced feed top size to 38mm/20mm, and the circuit mostly consists of cyclones and jigs, for coarse/small coal beneficiation. Another aspect is that a pre-washer is incorporated to eliminate the free dirt.

The last group of washeries, commissioned after 1980, has feed top size generally below 13mm and washing scheme uses first deshaling followed by after recrushing and recovery of cleans and middlings using hydrocyclones. In all cases, wherever fine coal treatment is present, froth flotation is employed, excepting two cases where water-only cyclones are used.

Table 1: RESERVE OF COAL IN INDIA

In million tonnes

Gondwana Coals:

Prime Coking	....	5300.00
Medium Coking	....	21590.87
Semi/weakly Coking	...	1799.71
Non Coking	....	157353.66
	Total:	186044.24

Tertiary Coals (North-East Coalfield):

Coking Coal (Makum & Namchik)	....	325.89
Non Coking		535.90
	Total:	861.79

Lignite:

Neyveli		4900.00
Rajasthan		564.00
Gujarat		324.00
Kashmir		90.00
Kerala		100.00
	Total:	5978.00

Table 2: COKING COAL RESOURCES IN INDIA

Type of coal	Net Geological	%Of total coal	Net Mineable (Resources in million tonnes)		Cleans at 17% ash		% Of total coal
Prime	5300	18.5	3672		1836		24.1
Medium:							
High Vol.	3345	11.7	2042		1062		14.0
Med.Vol.	4561	15.8	2804	12875	1371	4978	18.0
Low Vol.	13684	47.7	8029		2545		33.4
Semi	1800	6.3	1328		787		10.5
Total:	28690	100.0	17875		7601		100.0

Table 3 presents the details of coal washeries in India with their year of commissioning, feed top size and washing circuit.

Table 3: EXISTING COMING COAL WASHRIES IN INDIA AND DESIGNED CIRCUIT

Sl no.	Washery	Coal type	Comm'ed year	Input t/hr	Washery circuit	Feed top size
1.	West Bokaro	MC	1951	160	HM,float	76(13)
2.	Jamadoba	PC	1952	350	HM,float	76
3.	Lodna	PC	1955	70	Jig	13
4.	Kargali	MC	1958	650	HM,Jig	76
5.	Durgapur	PC	1960	360	HM,Jig	76
6.	Dugda 1	PC	1961	600	HM,Jig,Float	76
7.	Bhojudih	PC	1962	500	HM,Jig	76
8.	Patterdih	PC	1964	500	HM	76
9.	Durgapur	PC	1967	360	HM	13
10.	Chasnala	PC	1968	550	HM	76
11.	Dugda II	PC	1968	700	HM,float	13
12.	Kathara	MC	1969	800	HM,Jig,float	76
13.	Sawang	MC	1970	250	HM,Auto cycl	20
14.	Gidi	MC	1970	800	HM,Jig,float	80
15.	Nandan	MC		250	Jig,float	
16.	Rajrappa	MC	600		Jig,Float	
17.	Sudamdih	PC	1980	700	HM,Float	37
18.	Munidih	PC	1981	700	HM,Autocycl	37
19.	Barora	PC	1984	100	HM,Float	13
20.	Mahuda	MC	1989	160	Jig,HM,Float	13

Table 4 present the generation of fine coal at different washeries.

Table No. 4: Generation of Fines at different washeries

Sl. No.	Source & location	Size (mm) & coking Non-coking	Ash, content in feed	App. avvailibilty /generation Mill.Ton/yr
1	Kathara	<0.5 MC	25-30 Ash	0.42
2	Dugda I & II	<0.5 PC	20-25 Ash	0.90
3	Patherdih	<0.5 PC	20-25 Ash	0.32
4	Moonidih	<0.5 PC	15-17 Ash	0.42
5	Bhojudih	<0.5 PC	22-30 Ash	0.32
6	Gidi	<0.5 MC	25-30 Ash	0.50
7	Sudamdih	<0.5 PC	25-40 Ash	0.42
8	West Bokaro	<0.5 MC	22-25 Ash	0.08
9	Jamadoba	<0.5 PC	25-30 Ash	0.15
10	Chasnala	<0.5 PC	25-30 Ash	0.36
11	Sawang	<0.5 MC	20-25 Ash	0.16
12	Barora	<0.5 PC	20-25 Ash	0.10
13	Durgapur	<0.5 PC	25-30 Ash	0.19
14	Rajrappa	<0.5 MC	20-25 Ash	0.25
15	Durgapur	<0.5 PC	20-25 Ash	0.30
16	Nandan	<0.5 MC	25-30 Ash	0.10
17	Kargali	<0.5 MC	22-27 Ash	0.32
	Total		5.31	

PC=Prime Coking, MC=Medium Coking

1) Except Nandan and Durgapur (DSP & DPL), all washeries are located in the three districts viz., Dhanbad, Giridih and Hazaribagh under the aegis of BCCL, CCL, CCWO and TISCO and Nandan is under WCL.

2) The total fines generation is around 5.3 Million Tonne per year and the amount of beneficiated coal is 60% of it i.e., about 3 million Tonne per year with an average ash content of 16-19%. Presently this beneficiated coal fines are blended with the lump clean coal before being sent to coke ovens.

3) Each of the washeries is fed from a number of sources of coal, information on VM and carbon content is not readily available and the Ash % given in the above Table indicates the average ash content of the feed to the washery.

CURRENT STATUS

With the increase in demand for more amounts of better quality coal, the demand for coal preparation continues to grow to the following factors:

1) Stringent Specification
2) Increase in production
3) Depletion of higher quality seams
4) High cost of transportation making the transport of inert materials uneconomical.
5) Environmental requirements
6) Higher mining cost
7) Obsolescence of existing plants and processes.

The present day Indian Iron and Steel Industry is faced with a number of problems which currently restrict its productivity. Some of the most important problems relate to the depleted reserves of good coking coal, deteriorating quality of available coking coals etc.

Similarly, the foundries also need coke of good grade for use Cupola for Pib Iron Ka. Normally the specific coke quality as mentioned in the given table is desirable.

Table No. 5: Specification of Foundry Coke

Constituent %	Special grade	Grade 1	Grade 2
Ash	20.0	24.0	28.0
Volatile Matter	2.0	2.0	2.0
Fixed Carbon	78.0	74.0	70.0
Sulphur	0.7	0.7	0.7
Phosphorous	0.3	0.3	0.3
Shatter index	85.0	85.0	-
Porosity	40.0	40.0	-

The above table indicate that good quality coking coal is needed to obtain the above coke quality. Even obtaining coal for special grade is difficult and met through blending of imported low ash coal.

Besides above quality of coke, petroleum coke is used for the purpose of carburisation in ferrous melting and low ash coal dust is used as additives to moulding and for mould dressing alongwith graphite. The coal/coke is used for also general heating purposes like laddle heating, mould drying chamber and pit furnaes for non-ferrous melting.

Indian coal as such is difficult to use due to its high ash content and needs processing. The processing again is difficult due to the peculiar nature of mineral matter association in coal and also due to presence of high amount of Near gravity Material (NGM). The following table gives a broad relation of NGM and processing ease.

Table No. 6 ; Classification of coal based on NGM

NGM %	Nature of Coal
0 – 7	Easy to Wash
7 – 10	Marginally difficult
10 – 15	Difficult to wash
15 – 20	Highly difficult
20 – 25	Extremely difficult
Above 25	Nearly Impossible

Most of the Indian coal falls under last three catagories. These necessitates the development of better coal cleaning technologies.

TRENDS IN CLEAN COAL TECHNOLOGY

Indian coal is conspicuous due to its inherent highly intergrown nature of mineral matter. Finer crushing becomes essential for proper liberation. While in the initial stages of coal preparation coarse coal processing was followed to provide suitable feed to coke making with reduced fines, present day coal preparation emphasizes on fine coal preparation to maximise the yield at low ash. Many developments have been noticed in fine coal processing some of which are described below :

Batac Jig

Some coal Washeries in India still use coal jig or Baum Jig for beneficiation of coal in coarse coal segment. The jig can accept particles down to 0.5 mm but efficiency of separation is not very good. The Batac jig has been developed to incorporate the coal upto 0.1 mm with greater efficiency.In Batac Jig the air is introduced from the bottom for proper dispersion along the bed.

Heavy Media Cyclone

While coarse coal was processed in heavy media bath, the fine coal is processed in heavy media cyclone. In this process the coal alongwith a media of suitable density is introduced tangentially in a cyclone. The particles lighter than the effective media inside the hydrocyclone report to the overflow and heavies report to the underflow. Both the products are collected over a vibrating screen of aperture finer than the finest particle of feed coal. The heavy media is removed as screen undersize and recycled back to the process. The coal particle is then washed over the screen to remove the adhering media particle. This washed media is passed over a magnetic separator and then recycled back to the process. The washed coal and tailings are collected separately.The heavy media cyclone can effectively separate coal down to 1/0.5 mm from top size of 25/13 mm.

Water only cyclone

The water only hydrocyclone is working in the same line as that of heavy media hydrocyclone with the exception that no media other than water is used. The cyclone geometry is different. The higher density solid particle in water itself creates a density for separation of coal particle from others. Water only hydrocyclone in general used in 2-3 stages.

Shaking Table

The shaking table consists of an inclined deck with riffles running parallel to the edge. The feed slurry is introduced from the top corner of the sloped deck and is allowed to flow perpendicular to the riffles nad the vibrating to & fro motion of the deck. The wash water carries the lighter coal particle to the edge to be discharged and the heavies move alongwith direction of the deck movement and separate out. Since during the process, the coarse and fines also tend to separate, it is always preferred to feed classified close size fraction for better efficiency.

Spiral

The spirals are also a type of flowing film concentration device. The spirals are extensively used for mineral separation. But modified spirals have been found to be increasingly used for coal also. The feed size is mostly in the range of 3-0.1 mm. The slurry when introduced from top move downward along the spiral and generate very high centrifugal force. Due to this the lighter coal separates outs towards outer periphery of and the heavies remain near the inner periphery and thus the coal and ash forming gangue are collected at end of the spiral.

Flotation

The flotation utilises the physico-chemical properties. Some selective reagents are employed to selectively depress the ash forming minerals and some other reagents known as collector & frothers are added next to float coal in presence of air. In case of coal, the diesel oil, kerosene oil etc. are used

-- Co-current (Conventional)

as collector and pine oil, MIBC, cresylic acid etc. are used frothers. In conventional flotation the froth and air bubble move in co-currently from bottom of the cell to top. In india most of the flotation plants are having conventional flotation system for treating coal of –0.5 mm fraction.

-- Jameson Cell

This new development is presently used in many plants in Australia. This also involves co-current flow of air and coal slurry but from top to bottom and cells are long vertical. There is no such unit in India. A lab model of the same is being porcessed by NML to study Indian coal.

-- Counter current

Column Flotation are just opposite of conventional flotation as the coal slurry and air bubble move in opposite direction.The air is introduced from the bottom of the column and reagent conditioned feed slurry is introduced somewhere above middle of the column and is allowed to flow downward. This increases the probability of bubble particle adhesion. From top of the column a spray of wash water is allowed to flow downward which prevents trapped mineral gangue particle in froth to move upward and the clean coal froth is discharged from top. The tailing is or reject is discharged from bottom.

Oleo flotation

In this process excess oil is used to coat the coal particle with oil and then floated. Although this process consumes more oil but the moisture content in coal is reduced substantially.

Flash flotation

The flash flotation is reported to be quite useful for coal due its flotability characteristics. The advantage of this is much reduced time required for flotation.

Oil Agglomeration

In this process excessive oil is used to selectively agglomerate the lighter coal particle and separate the same from ash forming minerals. Here the oil is recovery from the agglomerate is maximised for recirculation and reduce cost.

Selective Flocculation

Selective flocculation is used for separating very fine coal particles utilising the phyico –chemical and flocculating prperties of coal and other ash forming minerals. Selective reagents are added to enhance the flocculation of coal particle and the flocs are separated by means of flotation or any other process.

Air Sparged hydrocyclone (ASH)

Some works are reported in this area. The reagentised coal slurry is introduced in modified hydrocyclone where air is also introduced. The ligher coal particles float out through overflow.

Dyna Whirlpool

This unit is basically a heavy media separator for fine coal. Lot of research has been carried out. Development is still in progress.

The following Table indicates the availability of coal fines. The data on volatile matter and carbon content are not readily available. The average ash analysis of the beneficiated coal fines obtained from these washeries is around 16-19%.

CONCLUSIONS

Demand of quality Coking coal is ever increasing for the growth of industries and to meet international quality. Imported low ash coal is being blended with Indian coal as sweetner for obtaining low ash coal.With limited resources of good quality coking coal it is essential to develop technology for judicious utilisation of our resources to maximise the benefits.

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