Effect of some operating variables on the performance of a 150 mm Heavy Medium Cyclone treating high ash Indian Coking Coal

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Abstract. Tests were carried out on a 150 mm heavy medium cyclone test rig treating coal in the size range - 13 +0.5 mm. A total of twenty seven experiments were carried out by varying the parameters like vortex finder diameter, spigot diameter and inlet feed pressure. The effect of these variables on the performance of the 150 mm Heavy Medium Cyclone was investigated. The results indicate that it is possible to achieve about 30.1% clean coal at an ash content of 18.5% at a feed pressure of 10 lb/in2, vortex diameter of 63.75mm and spigot diameter of 31.5mm. The tromp curves obtained from operating the cyclone gave a probable error of 0.04, indicating good separation efficiency.

1 Introduction

The Indian Coking coal constitute about 14% of the total reserves and the domestic availability for steel industry is limited and therefore the Indian Steel industry has to depend heavily on imported coking coal to meet its needs. Currently, domestic steel makers meet 80% of their coking coal requirement through imports. The quantum of imports may go up significantly in the near future as steel production in a large number of new projects is likely to be through the BF-BOF route and also to meet the requirement of existing steel plants.

Coking coal is an essential input for production of Iron & Steel through blast furnace route. To save steel industry facing acute dependence on imported coking coal, domestic availability of coking coal in desired quality has become imperative. The good quality coking coals of the upper seams are fast depleting leaving behind the inferior quality lower seam coal or Low Volatile Coking (LVC) coals. The cleaning of the Indian coals requires crushing to a reasonable size for liberation of ash forming minerals and suitable technology adopted for washing this size fraction is processing them through Heavy Medium Cyclone. Further for processing of the LVC (Low Volatile Coking) coals or lower seam coal, the coal is to be first deshaled and crushed to 13 mm and for processing the coarser fractions (- 13 +0.5 mm),HM Cyclones are the only efficient washers. It has been established worldwide that coal washing of intermediate sizes (- 13 +0.5 mm), HM cyclone is the best separator. (1-4)

Around seventy percent of the existing Indian coal washeries use heavy medium cyclones (HMC) as the main unit operation in the washing circuit. Most of these washeries are old and feed characteristics had drastically changed over the period, as a result it has become difficult to optimize the process which ultimately reduced efficiency. With this view, tests were carried out to study the performance of 150 mm heavy medium cyclone test rig treating LVC coal in the size range -13+0.5 mm.

2 Experimentation

The LVC coal from operating coking coal mines of Jharia Coalfields was taken for the study. For beneficiation by HMC scheme, the “as received” sample was crushed to below 75 mm in a double roll crusher and a representative portion of crushed coal was screened at 13 mm. The screened fraction of -75+13 mm was deshaled at density of 1.80 .The deshaled product of -75+13 mm size fraction was crushed to below 13 mm and crushed product was then mixed with untreated minus 13 mm fraction to form the sample of -13+0 mm.

Fig. 1. H.M. Cyclone Test Rig.

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The -13+0 mm size fraction was screened at 0.5 mm. Thereafter, Tests were carried out on a 150 mm heavy medium cyclone test rig treating coal in the size range -13+0.5 mm. Detailed washability studies were carried out for size - 13 +0.5 mm .The experimental set up of 150 mm diameter H M Cyclone test rig is shown in Figure 1.

The medium of desired specific gravity is prepared in the slurry tank. Finely ground magnetite (95 percent passing through 44 micron) was used to prepare the heavy medium. The medium is fed to the cylindrical vessel and Coal is fed from the top at the rate of desired quantity to maintain pulp density and suitable media to coal ratio. The media and the coal particles are mixed in the slurry tank and the mixture is fed to cyclone. There is a by-pass arrangement also to find out the specific gravity as well as ratio of media and coal fed to the cyclone. The by-pass line in the slurry tank is adjusted to feed the cyclone at definite pressure. The products of the cyclone are passed over launder divided into two parts for cleans and sinks.

The coal particles (cleans and sinks) coated with magnetite are water sprayed, cleaned and collected. The dilute media is collected in a separate tank where the media settles and is reused. The cleans and rejects weights were recorded and analyzed for its ash content and also to study the efficiency of the cyclone float & sink tests on the products were carried out.

Twenty seven experiments were carried out to study the effects of Vortex Finder Diameter (VFD), Spigot diameter (SPD) and Feed Pressure (P) on the quality and quantity of the cyclone products (5). The level of the parameters studies is shown in Table-1, while Table-2 shows the ash content of the cleans and rejects and efficiency data with respect to organic efficiency, d50 and Ep is shown in Table -3.

Table 1. Parameters for operating the cyclone.

Sl.No.	Feed Pressure, lb/in^2	Vortex Finder Diameter, mm	Spigot Diameter, mm
1	5	52.5	31.5
2	7	63.75	42
3	10	75	52.5

3 Results and discussion

From the washability data of coal size 13-0.5 mm the theoretical yield at 18 % ash level is 35.1%, where the corresponding rejects being at ash of 45.2 %.The cut density is 1.59 and the NGM at this gravity is 31 %, which categorize the coal as difficult-to-wash coal.

Table 2. Experimental data for 150 mm diameter H.M. Cyclone treating coal of size - 13 +0.5 mm.

Test	Pressure	Vortex	Spigot	Cleans		Rejects	
No.	lb/in2	mm	mm	Wt %	Ash %	Wt %	Ash %
1	5	52.5	31.5	59.7	34.3	40.3	32.5
2	7	52.5	31.5	46.0	30.4	54.0	36.8
3	10	52.5	31.5	62.0	31.3	38.0	37.7
4	5	52.5	42	8.4	19.0	91.6	35.6
5	7	52.5	42	7.9	17.9	92.1	36.0
6	10	52.5	42	19.8	25.8	80.2	36.5
7	5	52.5	52.5	3.5	21.1	96.5	34.7
8	7	52.5	52.5	4.6	19.1	95.4	35.0
9	10	52.5	52.5	4.0	19.0	96.0	35.3
10	5	63.75	31.5	19.1	21.2	80.9	38.0
11	7	63.75	31.5	19.1	22.7	80.9	36.4
12	10	63.75	31.5	30.1	18.5	69.9	40.5
13	5	63.75	42	6.4	15.4	93.6	35.0
14	7	63.75	42	5.3	14.3	94.7	35.0
15	10	63.75	42	3.1	11.8	96.9	34.6
16	5	63.75	52.5	3.8	12.5	96.2	37.0
17	7	63.75	52.5	3.9	12.8	96.1	34.9
18	10	63.75	52.5	3.0	12.5	97.0	37.0
19	5	75	31.5	31.1	24.6	68.9	39.5
20	7	75	31.5	43.9	27.1	56.1	38.9
21	10	75	31.5	74.7	31.6	25.3	41.2
22	5	75	42	23.3	22.2	76.7	38.0
23	7	75	42	25.9	22.2	74.1	38.0
24	10	75	42	22.6	23.2	77.4	36.5
25	5	75	52.5	13.8	21.8	86.2	36.5
26	7	75	52.5	11.9	18.8	88.1	36.0
27	10	75	52.5	12.9	19.3	87.1	36.1

Based on the findings the cyclone parameters in terms of yield and ash content of the cyclone cleans and sinks at different operating conditions and also considering the efficiency parameters the H. M. Cyclone was standardized and the final parameters which meet the required quality is shown in Table 2.

Table 3. Standardization of H. M. Cyclone Parameters.

Cyclone diameter:	Pressure, lb/in^2(g)	Vortex diameter, mm	Spigot diameter, mm	Cleans wt.%	Cleans ash%	Rejects wt.%	Rejects ash%
150 mm	10	63.75	31.5	30.1	18.5	69.9	40.5

Table 4. Efficiency data for 150 mm diameter H.M. Cyclone treating coal of size - 13 +0.5 mm.

Test No.	Pressure lb/in2	Vortex mm	Spigot mm	Organic Efficiency	d50	Ep
1	5	52.5	31.5	76.70	1.69	0.095
2	7	52.5	31.5	60.00	1.63	0.181
3	10	52.5	31.5	72.10	1.73	0.158
4	5	52.5	42	46.00	1.44	0.035
5	7	52.5	42	55.30	1.45	0.035
6	10	52.5	42	42.30	1.46	0.079
7	5	52.5	52.5	18.40	1.33	0.043
8	7	52.5	52.5	20.90	1.32	0.025
9	10	52.5	52.5	21.30	1.31	0.019
10	5	63.75	31.5	64.30	1.52	0.065
11	7	63.75	31.5	48.80	1.47	0.113
12	**10**	**63.75**	**31.5**	**56.40**	**1.59**	**0.044**
13	5	63.75	42	48.70	1.41	0.057
14	7	63.75	42	48.20	1.40	0.055
15	10	63.75	42	45.30	1.37	0.046
16	5	63.75	52.5	64.80	1.42	0.041
17	7	63.75	52.5	41.80	1.37	0.054
18	10	63.75	52.5	24.70	1.33	0.023
19	5	75	31.5	24.70	1.33	0.023
20	7	75	31.5	70.70	1.59	0.021
21	10	75	31.5	70.70	1.59	0.021
22	5	75	42	65.80	1.54	0.062
23	7	75	42	72.50	1.55	0.048
24	10	75	42	54.30	1.50	0.119
25	5	75	52.5	43.70	1.41	0.087
26	7	75	52.5	54.60	1.44	0.085
27	10	75	52.5	49.00	1.42	0.099

4 Conclusions

Hence, it may be concluded that for recovery of clean coal at desired ash level, the lower seam coal may be deshaled and the deshaled cleans may be crushed to 13 mm, followed by washing of 13 – 0.5mm fraction in 150 mm dia HM Cyclone for optimum recovery. The effect of these variables on the performance of the 150 mm Heavy Medium Cyclone (HMC or HM Cyclone) was investigated. The results indicate that it is possible to achieve about 30.1% clean coal at an ash content of 18.5% at a feed pressure of 10 lb/in^2, vortex diameter of 63.75mm and spigot diameter of 31.5mm. The tromp curves obtained from operating the cyclone gave a probable error of 0.044, indicating good separation efficiency. Since, the NGM of the lower seam coal is very high, it is always beneficial to wash the coal in Heavy medium cyclone. The rejects which is as high as 69.9% at 40.5% ash level can be used for power generation.

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