Dry Coal Processing- A Suitable Technology for Indian Coals

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Abstract

The need for dry coal cleaning is very evident from both an economic and environmental standpoint when mining occurs in a water-short area. Most of the mining in certain parts of the world occurs in a semiarid to arid climate. For the Indian coals with very high ash content, the dry coal separation offers an excellent economical and environmentally friendly process. Dry coal separators have a long history of application in the coal industry. The dry coal cleaning process typically has lower capital and operating costs, requires no waste water treatment or fine waste impoundment, provides lower product moisture and needs less stringent permitting requirements. Of all the dry coal cleaning processes, the FGX dry coal separator has a successful commercial record; as of today more than 2200 of the FGX units are operating throughout the world. In general, ash content of the Indian ROM coal could be reduced to about 30% with combustible recovery close to 90% and the reject ash averaged 70%. For the US coals, the technology has been very successful in reducing ash in the range of 10% with combustible recovery averaging more than 90%. Even for the low rank coal, a clean coal with 7% ash was obtained from a feed of 30% ash. The cost of processing raw coal was estimated to be about $0.91/ton and $1.56/ton for the clean coal. The payback period was estimated to be about one month.

Introduction

Dry coal processing of coal could be achieved by several techniques, utilizing various properties such as, particle size, composition, color sorting, and density. Of all the techniques the air tables and air jig have been successful in commercial applications. However, by 1985 the coal processing using these methods dramatically dropped to less than 7 million tons per year [1]. An excellent review on earlier dry cleaning processes is given by Symonds [2] and Donnelly [3]. In a pneumatic jig, marketed under trade mark of Allair jig, separator stratification is achieved through pulsating air and an oscillating deck. The FGX air table principle is similar to that of a wet concentrating table. Material to be separated is fed onto the narrow side of a flat deck covered with perforated screen which is sloped in two directions and vibrated with a straight line reciprocating motion. Low pressure air, blown upward through the deck, fluidizes and stratifies the material according to difference in the terminal velocity of the particles. The heavier particles settle to the bottom; where further movement down the table hindered by riffles, travel in the direction of the deck's vibration. The lighter particles lifted by the fluidizing air and assisted by gravity travel down the slope towards discharge end and separate into middling and clean coal at the end by splitter plates. Affected by both the vibration and airflow, the material bed thins as the deck broadens toward the discharge end. Here, the material is arrayed from heaviest to lightest in as a layer on the deck that can be precisely and easily divided in to multiple fractions (Figure 1). FGX air table models accept a top size of 3 inch (75 mm) with a higher capacity of more than 500 tph.

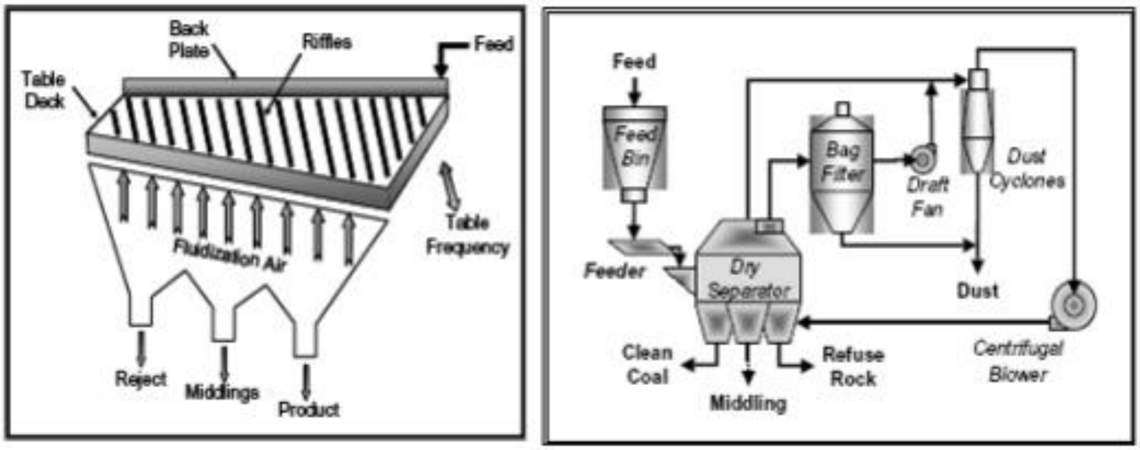

Figure 1. A schematic of the FGX Dry Coal Separator

In general, the FGX dry coal separator has two stage dust control system i.e, a cyclone and dust bags. The bag house dust emissions from a typical 250tph FGX plant has been reported to be <20µg/m^3 , with 98.9% particles capture.

Results Obtained with FGX separator

Honaker et.al (4,5,6,7) evaluated the potential of dry coal cleaning of various rank coals at various mines in the US. The coals tested varied in feed ash content (i.e., 7-70%). Regardless of the mineral matter type, pure rock removal into the reject stream was achieved in all applications with little or no loss of the coal. Field data obtained processing 2" x 0 size ROM bituminous coal indicated that 70-90% of the >2.0 RD rock was rejected. As a result, a clean coal product having acceptable market quality was produced from several coal sources including both lignite and bituminous coals. Table 1 shows the FGX separation data for the Utah bituminous coal. The data shows that the FGX provided a clean coal with about 11% ash and also removed sulfur at an energy recovery of more than 75%.

Table 1. Effect of feed ash content on the FGX performance (Ref. 4)

Test No.	Ash Content (%)			Total Sulfur Content (%)			Mass Yield (%)	Energy Recovery (%)
	Feed	Product	Tailings	Feed	Product	Tailings		
1	28.38	11.36	81.77	1.58	1.41	3.83	62.1	76.8
2	16.62	10.49	68.16	1.55	1.42	5.93	70.4	75.5

Figure 2 shows the washability data along with results obtained with the FGX machine. Efficient separation performance was achieved from tests that reduced ash content to around 11% as shown by the comparison with feed washality data. This observation reflects the ability of the FGX unit to effectively remove the high density rock while minimizing the loss of coal.

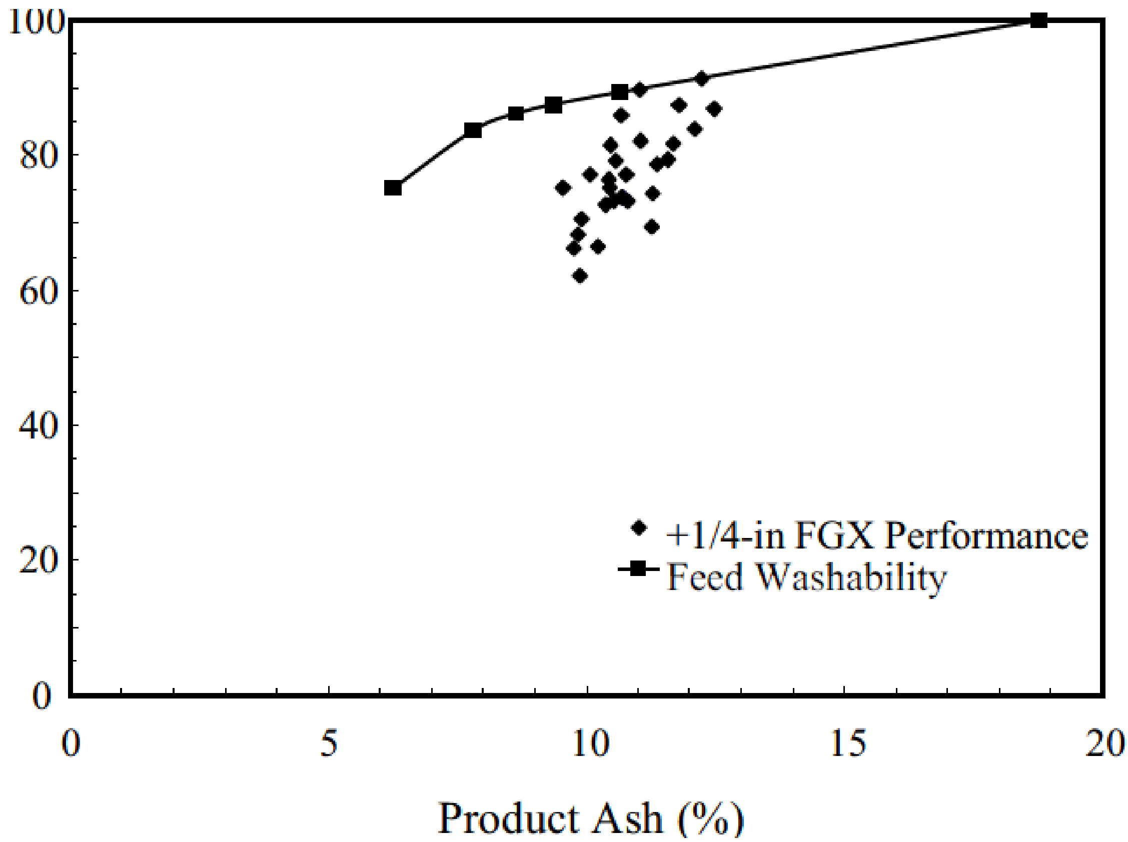

Figure 2.FGX ash reduction performance on the Utah's bituminous coal (Ref.4)

Powder River Basin Sub-bituminous Coal:
Table 2 shows the variation in the separation performance is indicative of the parametric values changes that were studied during the test program conducted on the PRB sub-bituminous coal. The FGX separator proved the ability to achieve a product quality sufficient to meet the market requirements. The ash content was reduced from a feed ash of 21% to 8.4%. In some cases, the mass yield reached 90%, while achieving product ash contents below 10%.

Table 2.FGX separator performance for the PRB sub-bituminous coal (Ref.4)

Test No.	Feed Ash (%)	Product Ash (%)	Reject Ash (%)	Yield (%)	Energy Recovery (%)	Ash Reduction (%)
1	18.86	7.05	71.28	82.11	94.07	62.62
2	15.61	6.77	62.92	78.00	86.17	56.65
3	23.83	9.63	58.45	75.45	89.52	59.58
4	21.25	7.84	61.36	68.71	80.42	63.13
5	21.98	7.67	69.60	82.83	98.03	65.13
6	19.68	10.69	81.93	91.66	100.00	45.69
7	19.60	8.49	79.12	81.10	92.30	56.66
8	13.91	7.41	70.02	82.40	88.62	46.76
9	22.83	9.01	74.38	86.74	100.00	60.54
10	23.60	9.26	69.42	78.38	93.08	60.74
11	21.02	9.06	81.71	89.08	100.00	56.92
12	19.59	7.99	64.69	74.74	85.52	59.22
13	23.03	7.27	52.07	74.22	89.41	68.44
14	23.33	9.29	70.87	69.24	81.92	60.20
15	23.72	8.57	63.12	69.71	83.56	63.88
Average	20.79	8.40	68.73	78.96	90.84	59.08

Gulf Coal Lignite Coal:

The main objective for this coal was to remove sulfur and hence, mercury from the coal and improve the heating value of the coal. As shown in Figure 4 that FGX provided on an average total sulfur reduction of 34.8%, which equates to an average SO2 (lb/M-btu) reduction of 35.8%. the mercury reduction averaged 54.4%. Although mercury content varied significantly throughout the testing program, a Hg content less than 10lb/T-btu was generally achieved.

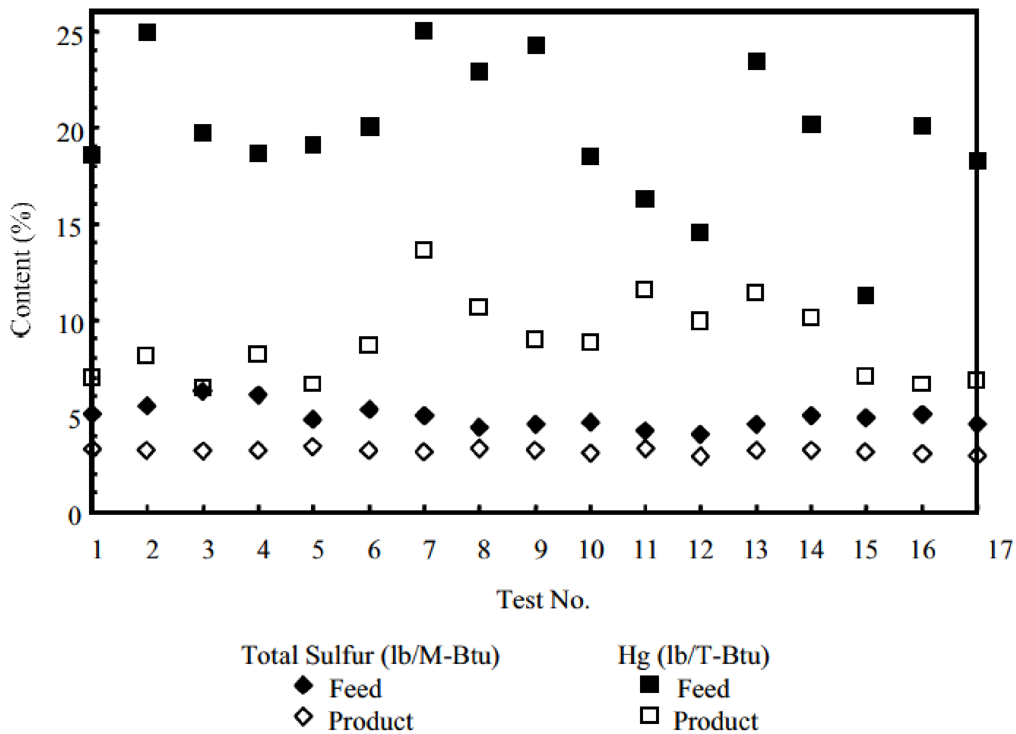

Figure 4. FGX separator performance for sulfur and mercury reductions for the Gulf Coast lignite (Ref.4)

Indian Coals:

Gupta, N.(8) conducted a detailed study of the application of the FGX technology at three different locations in India, namely, Aryan Energy, Bhushan Complex, and Kargali Washery. In all the tests, the FGX dry coal separator was able to remove the liberated rock material (about 20 wt.percent) from the ROM coal. The ash content of rejects were about 70%. Table 3 summarizes the pilot-scale tests results obtained at the Kargali washerry. Note, that depending on the parameter the clean coal ash ranged from 33% to 42%. The reject ash ranged from 71% to 85%. These results clearly indicate the applicability of the FGX technology to Indian coals.

Table 3. Kargali Test results

Kargali Test Results (75 x 6 mm)

Pilot-scale dry deshaling air-table test results (on dry basis)

Test Run	Feed Ash%	Clean Coal		Middlings		Reject	
		Yield	Ash%	Yield	Ash%	Yield	Ash%
7	55.63	28.58	33.02	43.65	52.76	27.77	83.40
8	48.69	54.96	34.24	28.87	59.19	16.17	79.00
10	57.39	9.44	39.41	63.36	51.28	27.19	77.89
11	60.72	40.74	40.31	38.53	68.74	20.73	85.92
12	56.49	26.94	36.80	56.91	57.71	16.15	84.99
13	49.37	25.93	36.76	48.94	44.89	25.13	71.09
14	57.86	26.25	34.28	48.68	57.69	25.07	82.87
15	49.72	37.65	33.64	45.71	51.37	16.64	81.55
16	58.70	33.62	33.34	34.84	67.99	31.54	75.47
17	55.62	37.33	32.34	50.04	66.03	12.63	83.10
18	52.59	68.44	42.20	11.49	68.64	20.07	78.81
19	52.90	26.83	43.72	52.03	48.00	21.14	76.55
20	49.46	42.97	35.10	36.88	49.50	20.15	80.00
21	54.03	22.81	37.87	52.45	49.14	24.74	79.25

Commercial Applications:
Currently there are more than 2200 FGX units are operating through out the world. In the USA, a FGX plant (FGX-24A) capable of processing 240 tph of a high ash and high sulfur coal was installed at the Eagle River mining, Harrisburg, IL in the year 2011. Figure 5 shows the installed plant. Table 4 shows the average of data obtained over a period of three years of operation. For this plant from the coal containing a feed ash of about 18% and sulfur content of 5.5% ; a clean coal with ash content of 8.5% and sulfur content of 3.5% is being produced. The yield has been close to 80%, with a combustible recovery of more than 90%. The plant is operating since 2011 without any interruptions.

Table 4. Performance data of the FGX-24A at the Eagle River Mining

Product	Ash%	Sulfur %	Heating Value(btu/lb)
ROM	~18.0%	~5.5%	12,000
Clean Coal	~8.5%	~3.5%	12,900
Middlings	~11.0%	4.2%	12,000
Rejects	~30%	~8.5%	~8,000

Figure 5. FGX-24A in operation at the Eagle River Mining

Economic Analysis:

A preliminary cost estimate for the FGX-12 machine processing about 100 tph of ROM Illinois coal was published by Mohanty,et al (9). In summary,

For FGX-12 machine capital expenditure will be = $550,000

Total CAPEX (capital and installations) = $882,000

Given a recovery factor of 0.1468(12% rate of return and 15 years plant life) annualized CAPEX are estimated at $129,478.

Total operating and maintenance cost = $413,000

Annual ownership and operating cost for the FGX-12 are estimated at $542,978

Payback Period:

Assuming, a minimum sale price of $30.00 per ton of clean coal and a product yield of 58.07%; 6000 hrs of operation, processing 100tph of ROM coal.

Annual Revenue = $10.45 million (350,000 tons of clean coal)

FGX Dry Separator cost per ton of coal:

Ownership cost = $129,478/600,000tons =$0.22/ton of raw coal

$129,478/350,000 = $0.37/ton of clean coal

Operating/Maintenance cost = $413,500/600,000 tons = $0.69/ton of raw coal

Or $413,500/350,000ton =$.1.19/ton of clean coal

Total ownership and operating cost = $0.91/ton of raw coal

Or = $1.56/ton of clean coal

It is estimated that the operating and other costs for India will be much lower.

Summary

The FGX dry coal separator provided a dry, density-based separation that utilizes the combined principles of an autogenous fluidized bed and a table concentrator. The FGX separator provided a relatively efficient separation at a high density of 1.8 RD. For the US bituminous coal FGX provided a low ash clean coal, rejecting all rocks without any loss of coal. For example, from a feed containing 28.4% ash , a clean coal with 11.4% ash, at an yield of 50% was obtained. The reject material averaged 82% ash. FGX was also efficient in cleaning the sub-bituminous and lignite coals to a low ash content.

For the Indian coals, FGX was efficient in removing all the liberated rocks providing a clean coal containing ash ranging from 33%to 40%.

For the US coal, a preliminary economic analysis indicated that it will cost about $0.91/ton of raw coal and $1.56/ton of clean coal using the FGX machine. The payback period was estimated to be approximately one month.

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