STUDY OF CANDIOTA MINE DRY COAL PROCESSING[1]

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Abstract

The aim of this work is to study the feasibility of removal of pyrite and clay nodules from Candiota coal. Candiota is the largest coal reserve of Brazil, which is exploited by Companhia Riograndense de Mineração (CRM). The coal is extracted at from the mine, then is crushed and ground to powder size to supply Presidente Médici thermoelectric plant, located near the mine, where the coal is burned to generate electricity at the Companhia de Geração Térmica de Energia Elétrica (CGTEE). The environmental and economic restraints urge removal of sulfide bearing species and clays, which generate ash. Porosity of coal samples prevents separation of these contaminants by water jigging. Therefore, dry jigging was tested using an AllMinerals air Jig apparatus. The results were highly encouraging.
Key words: Coal; Pyrite elimination; Dry jig.

ESTUDO DE PROCESSAMENTO A SECO DE CARVÃO DE CANDIOTA[1]

Resumo

O intuito deste trabalho foi estudar a possibilidade de remover pirita e nódulos de argila do carvão de Candiota. Candiota es a maior reserva de carvão de Brasil que é explorada pela Companhia Riograndense de Mineração (CRM). O carvão extraído é britado e moído a tamanho fino para alimentar a planta termoelétrica General Médici onde é queimado para gerar eletricidade pela Companhia de Geração Térmica de Energia Elétrica (CGTEE). As restrições médio-ambientais exigem a eliminação de espécies portadoras de enxofre e nódulos de argilas geradoras de cinzas. Entretanto, a porosidade das amostras não permite processa-las por com jigues a úmido. Por essa razão, se estudou a utilização do Jigue a seco fabricado pela empresa AllMinerals de Alemanha. Os resultados foram altamente encorajadores.
Palavras-chave: Carvão; Despiritização; Jigue a seco.

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1 INTRODUCTION

Coal corresponds to 65% of Brazilian non-renewable energy reserves, surmounting 3.1 billion measured tons.(1) Candiota is the biggest mine, which represents about 55% of the total reserves. It is located at Candiota municipality, South of Brazil. The Companhia Riograndense de Mineração (CRM) is the holder of the license to exploit Candiota mine, which supply the Presidente Médici thermoelectric power plant, owned by Companhia de Geração Térmica de Energia Elétrica (CGTEE), located near the mine. The ROM coal is crushed to –75 mm at CRM's crushing facility[2] and then transported to the power plant, where it is ground to powder and burned in a furnace.

Candiota coal presents the following basic characteristics (2-4): (1) It has a large amount of fines with high ash contents; (2) It gives low release of organic matter; (3) It gives relatively high sulphur contents[2] only at relatively high density values, evidencing pyrite liberation; (4) It presents high porosity degree, which makes difficult to apply a wet process to purify it.

Due to the aforementioned properties, samples were treated by dry jigging to eliminates sulphur, clay, as well as fines (fraction -0.1 mm) aiming at producing a combustion fuel giving low emission of toxic gases and fine particulate mater.

2 METHODOLOGOY AND DISCUSSION

2.1 Material Sampling

Coal samples were obtained from Candiota Mine from bottom and top layers, which form the mine. A clay crust separates these layers. For this work, around 3,600 kg of coal were sampled from a universe of 7,300 ton extracted from both seams, about 1,800 kg from each layer. This material was crushed to 500 mm and divided into four lots. An amount of 300 kg from each layer was sent to the Mineral Processing Laboratory of Universidade Federal do Rio Grande do Sul for characterization studies. Another part, about 1,500 kg of each layer, was sent to the Technical University of Aachen, Germany, for dry air jig tests.

2.2 Granulometric Assays

Granulometric analysis were carried out on the following fractions: -50.8+25.4, -25.4+19.1, -19.1+12.7, -12.7+2.0, -2.0+1.0, and -0.1 mm. Each fraction was analyzed by ash and sulphur (total, pyritic, sulfated) and heat capacity was measured. The results are given in Tables 1 and 2 below.

It can be seen from those tables that, Candiota coal presents ash contents over 60% in the finest size range, for both bottom and top layers. On the other hand, sulfur is highest in the middle size fractions. In addition, the middle fractions present high volume of mass.

Table 1: Candiota Top Layer: Mass and chemical analysis by size fractions.

	Mass		Ash	Sulphur				
Fraction (mm)	Grams	%	Content (%)	Total (%)	Pyritic (%)	Sulfated (%)	Organic (%)	Cp kcal/kg
-50.8+25.4	1480.42	22.97	53.60	0.70	0.06	0.12	0.52	2425
-25.4+19.1	365.43	5.67	56.60	1.95	1.05	0.26	0.64	2251
-19.1+12.7	491.11	7.62	52.00	1.98	1.64	0.18	0.16	2576
-12.7+2.0	1891.61	29.35	51.00	2.62	1.44	0.26	0.92	2789
-2.0+1.0	687.04	10.66	51.80	1.45	0.53	0.27	0.65	2879
-1.0+0.10	933.24	14.48	43.80	1.14	0.61	0.22	0.31	3227
-0.10	596.16	9.25	64.90	0.59	0.32	0.14	0.13	2032
Total	6445.00	100.0	52.32	1.57	0.80	0.21	0.56	2662

**HC: Heat of Combustion*

Table 2: Candiota Bottom Layer: Mass and chemical analysis by size fractions.

	Mass		Ash	Sulphur				
Fraction (mm)	Gram	%	Content (%)	Total (%)	Pyritic (%)	Sulfated (%)	Organic (%)	HC* kcal/kg
-50.8+25.4	1863.21	32.08	51.50	1.19	0.33	0.28	0.58	2873
-25.4+19.1	538.98	9.28	53.80	1.59	0.82	0.20	0.57	2464
-19.1+12.7	391.46	6.74	51.10	1.95	1.41	0.21	0.33	2865
-12.7+2.0	1826.62	31.45	53.30	2.91	1.74	0.29	0.88	2513
-2.0+1.0	303.76	5.23	41.90	1.48	0.65	0.23	0.60	2828
-1.0+0.10	599.97	10.33	45.80	1.00	0.59	0.12	0.29	3066
-0.10	284.01	4.89	64.90	0.61	0.30	0.19	0.12	2025
Total	5808.01	100.0	51.82	1.79	0.93	0.25	0.61	2697

**HC: Heat of Combustion*

2.3 Sink and Float Tests

Sink and float tests were carried out in a wide density range, from 1.3 g/cm^3 to 2.4 g/cm^3, at 0.1 g/cm^3 intervals. For each density range, %mass was calculated and ash and sulfur (pyretic, sulfatic and organic) were analyzed. The results are given in Tables 3 and 4.

From those tables it can be seen that the highest content of sulfur (12.21 % and 12.65 % for top and bottom layers, respectively) occurs as pyritic for the highest densities ranges (>2.4 g/cm3). Around 43 % of total sulfur is found at the densest fraction. The elimination of that fraction would reduce sulfur content of coal to around 1%. If tables 1 and 2 are analyzed, it is possible to see that the highest contents are in the size fractions of –19.7+2.0 mm for both layers. It might be concluded that most part of pyrite is found in this fraction, which resulted the densest one, as it is seen from Table 3 and 4.

Separation of size fractions for such a fine carbon size is rather complicated. In addition to that, the highest ash contents are found at the finest size material (<0.1 mm) which corresponds to densest material. For those reason, a density separation process is the most advisable one. However, porosity of Candiota coal does not allow an efficient wet separation. For that reason, a dry jigging was tested.

Table 3. Top Layer: Mass (%), ash, sulfur, heat of combustion and volatile matter (%)

Density	Mass		Ash	Sulfur				H.C.*	Volatile Matter
(g/cm^3)	(g)	(%)	(%)	Total	Pyritic	Sulfatic	Organic	kcal/kg	(%)
-1,3	300.23	1.99	10.30	1.01	0.02	0.06	0.93	5,642	32.78
+1,3-1,4	527.60	3.50	17.86	1.00	0.01	0.10	0.89	4,595	31.39
+1,4-1,5	881.80	5.84	30.26	0.88	0.02	0.34	0.52	3,920	26.51
+1,5-1,6	2,085.80	13.82	45.80	0.70	0.25	0.32	0.13	3,196	24.71
+1,6-1,7	5,024.30	33.29	50.40	0.64	0.18	0.12	0.34	2,886	24.77
+1,7-1,8	2,313.70	15.33	51.72	2.47	1.94	0.26	0.27	2,422	17.39
+1,8-1,9	1,391.00	9.22	51.43	1.00	0.40	0.24	0.36	2,057	17.49
+1,9-2,0	535.95	3.55	63.35	0.70	0.10	0.19	0.41	1,647	17.78
+2,0-2,1	254.54	1.69	67.34	1.07	0.73	0.26	0.08	1,344	18.67
+2,1-2,2	229.79	1.52	80.08	1.12	0.79	0.21	0.12	944	14.59
+2,2-2,3	534.14	3.54	80.98	1.11	0.76	0.12	0.23	1,749	23.15
+2,3-2,4	163.17	1.08	84.79	1.08	0.70	0.17	0.21	1,334	13.66
+2,4	850.27	5.63	75.45	13.48	12.21	0.94	0.33	1,153	13.18
Total	15,092.29	100.00	51.01	1.76	1.18	0.24	0.33	2,702	22.12

**HC: Heat of combustion*

Table 4 Top Layer: Mass (%), ash, sulfur, heat of combustion and volatile matter (%)

Density	Mass		Ash	Sulfur				HC*	Volatile Matter
(g/cm^3)	(g)	(%)	(%)	Total	Pyritic	Sulfatic	Organic	kcal/kg	(%)
-1,3	244.90	2.18	9.20	0.99	0.03	0.35	0.61	4,888	53.13
+1,3-1,4	175.70	1.56	17.65	1.08	0.04	0.36	0.68	5,280	53.14
+1,4-1,5	632.70	5.63	33.16	1.06	0.08	0.35	0.63	4,054	41.42
+1,5-1,6	1,645.80	14.63	42.71	1.10	0.36	0.20	0.54	3,378	33.63
+1,6-1,7	4,331.70	38.51	46.97	1.00	0.24	0.38	0.38	2,874	29.20
+1,7-1,8	809.20	7.19	53.05	1.81	1.36	0.19	0.26	2,806	27.09
+1,8-1,9	1,204.80	10.71	55.33	1.53	0.84	0.33	0.36	2,243	25.70
+1,9-2,0	337.20	3.00	64.33	1.67	0.98	0.28	0.41	1,790	22.00
+2,0-2,1	540.70	4.81	79.69	1.58	0.73	0.27	0.58	1,292	18.76
+2,1-2,2	247.20	2.20	82.76	1.62	0.81	0.22	0.59	1,048	15.16
+2,2-2,3	98.80	0.88	84.55	2.41	1.37	0.36	0.68	1,639	15.84
+2,3-2,4	176.50	1.57	90.49	2.48	1.47	0.34	0.71	1,327	14.53
+2,4	802.30	7.13	67.78	13.97	12.65	0.51	0.81	1,043	14.27
Total	11,247.50	100.00	51.00	2.16	1.36	0.33	0.47	2,709	28.47

**HC: Heat of combustion*

To determine the most adequate density separation, Henry-Reinhardt washability curves were plotted with the density data of Tables 3 and 4. The data are plotted in Figures 1 and 2.

The sink-float curves indicate clearly a low release of organic matter in the intermediate density fractions, suggesting a great difficulty at a gravimetric separation of low ash content coal. However, for densities over 2.0 g/cm3, the density curves flatten out, indicating little near-gravity material (NGM). Hence, the densimetric separation of these densities fractions would be easy.

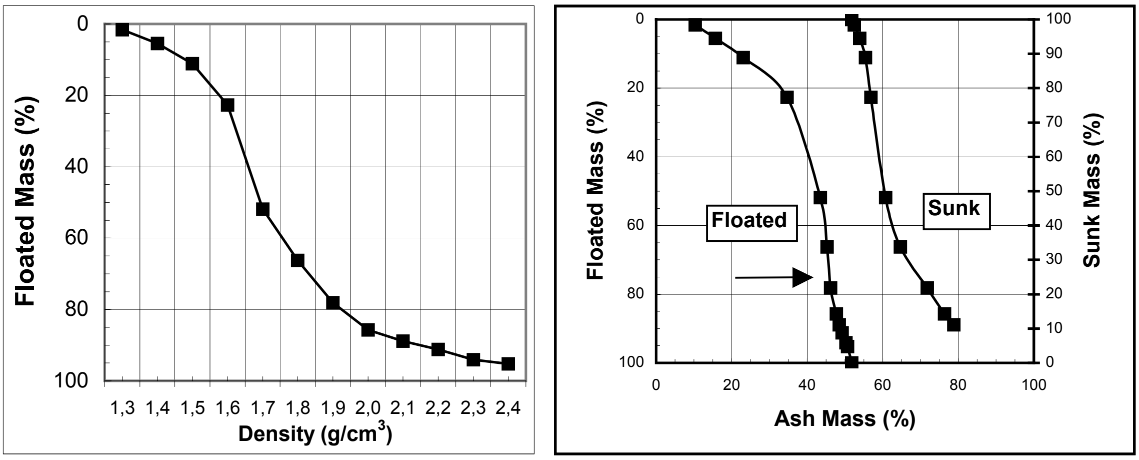

Figure 1: Henry-Reinhardt washability Curves - Top layer Candiota

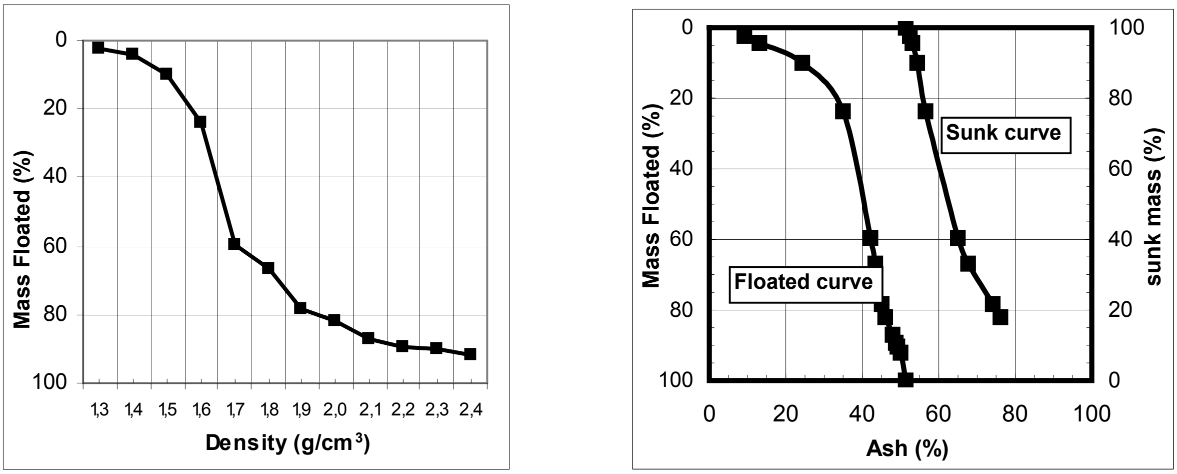

Figure 2: Henry-Reinhardt washability Curves – Bottom Layer Candiota.

If a density of 2.2 g/cm^3 is taken as cut value, the NGM value would be around 3%, indicating a very easy cut. The fraction to be separated (density over 2.2 g/cm^3) would have ash contents over 75% and hence would have most part of pyrite nodules.

2.4 Gravimetric Processing Assays

Air jig tests were carried out at the Mineral Processing Laboratory of the Technical University of Aachen, Geramany. The equipment used was a 300-kg/h capacity jig made by the German AllMineral company. The assays were carried out separately for each coal layer (Top and Bottom Candiota).

The air jig consists of a closed structure that distributes the air uniformly in a chamber below the mineral bed. A pulsing air jet is also added to the constant rising airflow, allowing independent control of jet, frequency, and acceleration of airflow. In this way, stratification of particulate matter is optimized. The discharge system is done through a star gate with a radiometer to control waste discharge automatically. The jig can keep a constant reserve of high-density material close to the start gate, thus avoiding contamination of the product at the bed end section. The layer of sunk material creates a barrier for the low-density fraction which is stratified above the bed minimizing short circuits (mix of light and heavy materials). A diagram of the equipment used is given in Figure 3.

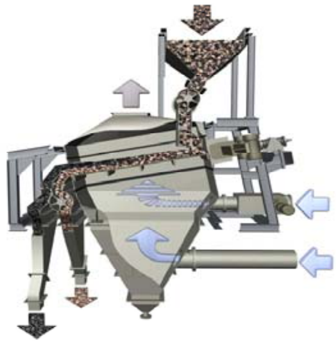

Figure 3: Diagram of the air jig used.

The particle separation in the pneumatic jig results from the pulsing airflow, which stratifies the particles bed in the apparatus. While a dense material layer formed at the bottom of the bed moves towards the openings, the top layer with light material keeps moving over the slower dense particle layer and is removed at the opposite end of the apparatus. The dust generated by the air pulse is drawn and recovered by means of pneumatic cyclones and sleeve filters.

The dense material is extracted with the help of a star gate type of valve similar to some hydraulic jig produced now a day.

The densimetric assays aimed at producing a waste with about 10% mass for the removal of pyrite nodules and free clay and lime particles. Several tests were carried out and the best results are shown in table 5 below.

Table 5 – Best dry jig test results

10% Mass Recovery of Heavies				
Coal Layer	**Ash (%)**		**Total Sulphur**	
	Concentrate	**Waste**	**Concentrate**	**10% Waste**
Top Layer Candiota	47.11	60.69	0.73	4.04
Bottom Layer Candiota	45.62	62.61	1.09	4.01

The fine coal, which has a high ash content, was removed from the jig through a rising air jet used to stratify the bed.

From the table, it can be observed that is possible to obtain a concentrate with 47.11% ashes and 0.73% total sulphur for Top Candiota layer, and 45.62% ash and 1.09% total sulphur for Bottom Candiota layer. In turn, the wastes present ash contents higher than 60% and total sulphur content over 4%.

Tromp curves were plotted for the cuts done for the Top and Bottom Candiota coal layers. In the top layer, Tromp imperfection was 0.30 and the probable error was $0.26/cm^3$. In the bottom layer, Tromp imperfection was 0.30 and the probable error was $0.27/cm^3$.

3 CONCLUSIONS

- The introduction of the new dry coal process, non-existent in Brazil up to now, might significantly reduce Candiota sulphur and coal ashes levels at affordable costs and yields;
- It is also expected a reduction in the emission of particulate matter (fly ash) to the atmosphere due to a higher efficiency of electrostatic precipitators as a result of a low coal ash content achieved;
- Also, it would reduce the amount of bottom ashes;

- A reduction of sulphurous gases thrown to the atmosphere due to the reduced sulphur content in coal;

- Reduction of NOx due to optimization of combustion operational parameters;

- The cost of removing sulphur by dry jigging result small if compared with combustion gas washing.

- In addition, improvement of quality of coal would give a higher aggregated value (lower ash and sulphur contents);

- The processed coal would present a higher heat capacity;

- The viability of dry processing may open new markets for Candiota coal.

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