Economic Benefits of a Deslime Flotation Circuit Using StackCell Technology at Patriot's Kanawha Eagle Coal Preparation Plant

Robert DeHart[1], Peter Bethell[2], Gerald Luttrell[3], Jaisen Kohmuench[4] and Michael Mankosa[5]

[1]Blackhawk Mining, LLC, Lexington, Kentucky USA, RDehart@blackhawkmining.com
[2]Cardno, Inc., Bluefield, West Virginia USA, peter.bethell@cardno.com *(corresponding author)*
[3]Virginia Tech, Blacksburg, Virginia USA, luttrell@vt.edu
[4]Eriez Australia, Epping Australia, jkohmuench@eriez.com
[5]Eriez Flotation Division, Erie, Pennsylvania USA, mmankosa@eriez.com

ABSTRACT

In 2011, a fine coal flotation circuit was installed at the Kanawha Eagle coal preparation plant using the Eriez StackCell™ flotation technology. Laboratory testing indicated that this system would successfully recover a significant amount of fine coal currently lost as waste. However, after installing the by-zero flotation circuit, it was found that sufficient frother could not be added on a continuous basis to maximize combustible recovery. As frother was increased, the plant became unstable due to froth handling issues manifesting in the thickener and magnetic separator circuits. Based on a detailed engineering analysis of the plant, it was determined that significantly more product tons would be recovered by desliming the feed slurry to remove ultrafine slimes smaller than about 0.045 mm. This circuit change, instituted in 2014, resulted in a higher concentration of frother being utilized in the 150x45 micron flotation circuit, which in turn improved the froth characteristics of the StackCell™ flotation system. This approach also complemented the existing dewatering technology and ultimately resulted in an improvement in global combustible recovery by adding about 10 t/hr of high-quality clean coal to the saleable product.

Keywords: Fine Coal, Column Flotation, StackCell™ , Deslime Cyclones, Froth Handling.

1. INTRODUCTION

The Kanawha Eagle mining complex is one of several coal production facilities owned and operated by Blackhawk Mining, LLC. The company mines and sells metallurgical, thermal, PCI, stoker and specialty coals from the Central Appalachian Basin (Kentucky and West Virginia) and thermal coals from the Illinois Basin. The Kanawha Eagle complex is located in Kanawha County in southern West Virginia. Kanawha Eagle is home to a 600 t/hr coal preparation plant (Figure 1) that is supplied run-of-mine feed by three underground mines operating in the Peerless and Eagle seams. The cleaned products generated by this facility are primarily sold into the metallurgical (coking) market. The cleaned coals are shipped via CSX rail directly to customers or by private railroad lines serving barge loadouts along the Kanawha River.

Figure 1. Kanawha Eagle preparation plant.

A simplified flowsheet for the historical design of the Kanawha Eagle plant is provided in Figure 2. The plant was designed to receive coarse run-of-mine coal that was sized and crushed to below 50 mm using a raw coal screen in combination with a roll crusher. The material passing the raw coal screen was fed to a deslime screen configured with 1 mm openings. The 50x1 mm oversize material from the deslime screen was combined with the minus 50 mm crusher product and fed to a dense medium cyclone (DMC) circuit. The DMC products were passed across drain-and-rinse screens to recover the dense medium and to dewater coarse particles. Smaller particles from the lower deck of the clean coal drain-and-rinse screen were passed to a centrifugal dryer to reduce the surface moisture of the clean coarse coal product. The fine minus 1 mm particles passing the deslime screen were pumped to raw coal classifying cyclones to generate a nominal 1x0.15 mm underflow as the feed material for a bank of spiral concentrators. The minus 0.15 mm particles in the cyclone overflow were passed to the refuse thickener and discarded as waste. The clean coal product from the spiral was dewatered/deslimed using sequential stages of clean coal cyclones and static sieves. The spiral refuse was dewatered using a high frequency

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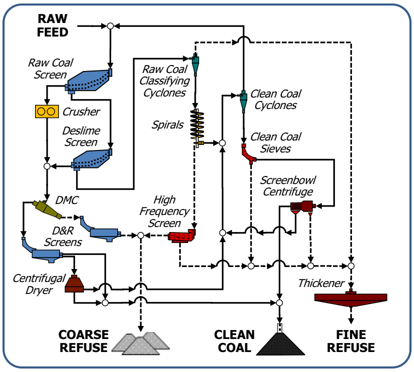

Figure 2. Original plant flowsheet incorporating only dense medium cyclones and spirals.

screen and back-blended with the coarse refuse from the DMC circuit. Final dewatering of the spiral/cyclone/sieve clean coal product (1x0.15 mm) was accomplished using a screenbowl centrifuge. The effluent from the screenbowl, which consisted of a dilute slurry of ultrafine (minus 0.045 mm) particles, was passed to the thickener and discarded as waste. The clean coal product from the screenbowl was back-blended with the coarse clean coal product generated by the DMC circuit prior to shipment to customers.

2. PLANT UPGRADES

StackCell™ Installation

It had long been recognized that a major shortcoming of the original Kanawha Eagle plant was the loss of fine coal in the minus 0.15 mm raw coal cyclone overflow. To eliminate this problem, plant management investigated several options for recovering clean coal from this stream. While froth flotation seemed to be an obvious choice, there were several issues that complicated any retrofit to the

Table 1. Size and quality analysis of plant feed.

Size (mm)	Mass (%, dry)	Ash (%, dry)	Sulfur (%, dry)
Plus 100	0	0	0
100 x 50	5.01	85.74	0.49
50 x 12.7	23.83	74.37	0.27
12.7 x 9.5	6.44	58.45	0.5
9.5 x 1	42.62	43.09	0.72
1 x 0.5	5.21	35.14	0.79
0.5 x 0.15	5.66	31.83	0.79
0.15 x 0.045	3.16	37.38	0.78
Minus 0.045	8.07	65.16	0.22
Total	100.00	54.22	0.56

existing plant circuitry. The first issue was the large amount of ultrafine clay slimes present in the plant feed. As shown in Table 1, the minus 0.045 mm (325 mesh) fraction of the plant feed represented over 8% of the total feed mass and contained more than 65% ash (dry basis). The ash content of the minus 0.045 mm material was much greater than that present in the other size fractions between 1 and 0.045 mm, which ranged from about 31% to 37% ash. The presence of high-ash ultrafine slimes in the feed forced the plant to adopt column flotation technology for recovering lost coal in the fine (minus 0.15 mm) waste stream. Column machines utilize froth washing systems to eliminate the hydraulic carryover of high-ash clay slimes into the clean coal product (Finch and Dobby, 1990; Rubinsetin, 1995). To evaluate the potential of column technology, a series of flotation release analysis tests were conducted on slurry samples from the fine waste stream at the plant. This experimental method provides a series of froth concentrates that are essentially free of entrained material (Dell, 1963; Dell et al., 1972). As such, a release analysis test mimics the separation performance expected from a column cell equipped with a well-designed and properly operated froth washing system (Luttrell et al., 2001). The release analysis data, which are summarized in Table 2, indicate that the waste fines fed to the Kanawha Eagle plant could be upgraded from a feed ash content of about 56% ash to a clean coal product of less than 8% ash at a combustible

Table 2. Flotation release analysis conducted on fine (minus 0.15 mm) feed coal.

Product Stream	Individual				Cumulative			
	Mass (%, dry)	Ash (%, dry)	Sulfur (%, dry)	Recovery (%)	Mass (%, dry)	Ash (%, dry)	Sulfur (%, dry)	Recovery (%)
Froth 1	25.66	6.31	0.88	55.30	25.66	6.31	0.88	55.30
Froth 2	5.21	6.83	0.67	11.16	30.87	6.40	0.84	66.46
Froth 3	2.98	7.12	0.76	6.37	33.85	6.46	0.84	72.83
Froth 4	8.26	13.89	0.68	16.36	42.11	7.92	0.81	89.19
Froth 5	1.08	24.98	0.74	1.86	43.19	8.35	0.80	91.05
Tail 1	1.02	71.31	1.56	0.67	44.21	9.80	0.82	91.72
Tail 2	55.79	93.55	0.08	8.28	100.00	56.52	0.41	100.00
Total	100.00	56.52	0.41	100.00	--	--	--	--