TR17_218-225

R.651 Investigation into the causes of high ash content in washed coal, Fingal

The Cornwall Coal Company N.L. has contracts with consumers requiring the production of a 'standard' coal of between 17.5-18.49% ash on an air dried basis. A penalty of 15 cents/t/1% increase in ash over 18.5% is imposed by the consumers.

Over the past 18 months the ash content of the coal produced at the Company's washery has been up to 5% above that allowed in the 'standard' coal.

Mr C.E. Peck, Secretary of the Company, requested an examination of the washery to find the causes of the high ash content of the washed coal.

WASHERY SAMPLING

The washery was visited in the company of Mr L. Rhodes and the following samples were obtained.

(1) Minus 5 inch jig feed (conveyor belt under surge bunker).

(2) Large nut coal (-5 inch +2 inch) (conveyor to bunker).

(3) Small coal (-1 inch) (conveyor to stockpile).

(4) Slack coal (-1 inch) (conveyor to stockpile).

(5) Fines (oversize from 0.5 mm slurry screen).

(6) Jig middling (middling conveyor belt).

(7) Jig tailing (tailing conveyor belt).

A total of seven cuts were made for each sample over a 3.5 hour period. In addition, timed and weighed samples were taken of all the above mentioned products except the slack coal. From the data obtained and other data supplied by Mr J. McGivern, Plant Engineer, it was possible to calculate an overall weight balance for the various plant products and obtaining the weight balance of the slack by difference. The feed rate was determined at 88 t/hr.

Samples of cone discharge and centrifuge effluent were later supplied by the washery staff.

GENERAL OBSERVATIONS

During the period of sampling the plant was operating normally and continuously. A total of 7.5 hours wash time was achieved on the shift during which sampling took place. The density readings on the jig water showed a steady increase from 1047 kg/m^3 at 8 a.m., to 1065 kg/m^3 at 3 p.m.

Note: Assuming a density of solids at 1500 kg/m^3 then:

1020 kg/m^3 density = 5.9% solids,

1050 kg/m^3 density = 14.3% solids,

1080 kg/m^3 density = 22.2% solids.

SINK-FLOAT (S/F) AND SIZING ANALYSES

All ash determinations were made on a moisture free basis and all sink-float tests were at a density of 1600 or 2000 kg/m^3.

Sample 724308. Large nut (-5 inch +2 inch)

All Float was at a density of 1600 kg/m^3 and the Ash was 18.4%.

Sample 724309. Small nut (-2 inch +1 inch)

Product	*% Wt.*	*% Ash*
F 1600	*98.9*	*20.2*
S/K 1600	*1.1*	*52.3*
Comp.	*100.0*	*20.6*

Sample 724310. Slack (-1 inch) including fines (Slurry screen oversize)

Product	*% Wt.*	*% Ash*
+½ in F 1600	31.7	20.7
S/K 1600	1.4	47.4
Total +½ in	33.1	21.8
+¼ in F 1600	24.4	19.4
S/K 1600	2.0	47.7
Total +¼ in	26.4	21.5
+⅛ in F 1600	15.6	18.8
S/K 1600	1.0	49.8
Total +⅛ in	16.6	20.6
+1 mm F 1600	11.9	17.9
S/K 1600	1.0	52.3
Total +1mm	12.9	20.6
-1 mm F 1600	9.7	20.6
S/K 1600	1.3	65.0
-1 mm	11.0	25.8
(Slack)	100.0	21.8
Total F 1600	93.3	19.7
Total S/k 1600	6.7	52.0

Sample 724306. Jig middling

Product	*% Wt.*	*% Ash*
+2 in F 1600	11.8	29.4
S/K 1600	3.9	49.3
Total +2 in	15.7	34.3

Product	% Wt.	% Ash
+1 in F 1600	13.5	32.3
S/K 1600	11.6	57.4
Total +1 in	25.1	43.9
+½ in F 1600	3.7	34.2
S/K 1600	18.8	62.8
Total +½ in	22.5	58.1
+¼ in F 1600	3.5	29.6
S/K 1600	12.4	65.7
Total +¼ in	15.9	57.8
+⅛ in F 1600	4.0	27.4
S/K 1600	7.6	64.8
Total +⅛ in	11.6	51.9
+1 mm F 1600	2.0	28.6
S/K 1600	5.2	68.3
Total +1 mm	7.2	57.3
-1mm F 1600	0.3	40.0
S/K 1600	1.7	68.2
Total -1 mm	2.0	64.0
Jig middling	100.0	50.1
Total		
+1 in F 1600	25.3	30.9
S/K 1600	15.5	55.3
Total +1 in	40.8	40.2 (Crushed and returned to jig)
Total -1 in	59.2	56.9 (Tailing to shale bunker)

Sample 724307. Jig tailing

Product	% Wt.	% Ash
+2 in F 1600	1.3	30.4
S/K 1600	7.1	84.2
Total +2 in	8.4	75.9
+1 in F 1600	2.0	32.0
S/K 1600	25.7	72.5
Total +1 in	27.7	69.6

Product	*% Wt.*	*% Ash*
+½ in F 1600	0.9	35.0
S/K 1600	26.8	75.8
Total +½ in	27.7	74.5
+¼ in F 1600	0.1	30.7
S/K 1600	14.3	78.5
Total +¼ in	14.4	78.2
+⅛ in F 1600	0.2	29.3
S/K 1600	10.8	77.6
Total +⅛ in	11.0	76.7
+1 mm F 1600	0.5	30.5
S/K 1600	8.4	78.0
Total +1 mm	8.9	75.3
-1 mm F 1600	0.1	36.1
S/K 1600	1.8	77.6
Total -1 mm	1.9	75.4
Jig tailing	100.0	74.1
Total		
F 1600	5.1	31.8
S/K 1600	94.9	76.4

Sample 724311. "Fines" (-1 mm +½ mm) Oversize from slurry screen

Sink-float separation

Product	*% Wt.*	*% Ash*
F 1600	83.3	22.8
S/K 1600	16.7	58.7
Total Fines	100.0	29.8

Froth flotation separation

Product	*% Wt.*	*% Ash*
F2C	70.2	21.9
F2T	16.7	35.1
F1C	86.9	24.4
F1T	13.1	51.7
Total Fines	100.0	28.0

Reagents

H_2SO_4	to pH 5.0
Fuel Oil	0.9 kg/t
M.I.B.C.	9 g/t

Flotation time was 3 minutes.

Sample 724305. Raw coal feed

Product	*% Wt.*	*% Ash*
F 1600	85.3	20.7
F 2000	10.0	54.8
S/K 2000	4.7	81.7
Comp. Feed	100.0	27.0

Flotation Tests

Settling cone discharge (pre-shift dumping)

Product	*% Wt.*	*% Ash*
F3C	84.2	28.4
F3T	1.9	44.0
F2T	5.7	40.5
F1T	8.2	76.4
Head	100.0	33.3

Centrifuge effluent

Product	*% Wt.*	*% Ash*
F3C	59.8	16.6
F3T	1.6	69.3
F2T	3.2	72.9
F1T	35.4	47.8
Head	100.0	30.3

The flotation conditions applied to the two tests above were similar to those in the flotation test on the fines (slurry screen oversize).

OVERALL PLANT MATERIAL BALANCE

From measurements taken during the plant visit and additional information on estimates of flow rates and pulp densities supplied by Mr J. McGiveron, Plant Engineer, it was possible to calculate an approximate material balance for the washery plant. This is as follows:

Product	*t/day (8 hrs.)*	*% Ash (moisture free)*
Large nut (measured)	116	18.4
Small nut (measured)	102	20.6
Slack (by difference)	293	21.8
Jig tailing (measured)	29	74.1
Jig middling -1 inch (derived from measurement total middling)	73	56.9

Product	t/day (8 hrs.)	% Ash (Moisture free)
Cone discharge (pre-shift dump estimated)	50	33.3
Centrifuge effluent (estimated)	14	30.3
Main sump overflow (estimated)	30	37.2
Raw coal feed (measured)	707	27.0

Note: A sample of main sump overflow was obtained and the ash figure given is an actual assay. An ash figure of 66.4% would be required to make the above table balance. This is the result of an accumulation of probably minor errors in estimations and measurements of quantities.

COMMENTS ON PRODUCTS EXAMINED

Large nut

The ash content of this material is 18.4% and is considered satisfactory. As no sink was obtained from sink-float separations at a density of 1600 kg/m^3 it is unlikely that any improvement in quality could be effected without a considerable reduction in the amount produced.

Small nut

Sink-float tests at a density of 1600 kg/m^3 rejected only an insignificant amount of high ash material with a marginal decrease in ash in the float product. Similar comments to those made for the large nut are also applicable to this material.

Slack

This material represents the major portion of washed coal production and also shows the highest ash content. Sink-float tests show an overall ash reduction from 21.8% in the total material to 19.7% in the float at a density of 1600 kg/m^3. This indicates some inefficiency in the washery procedure.

The tabulated results given show the ash in 'as produced' slack in each individual size and also the ash reduction in each size as a result of the sink-float separations. A rearrangement of the table has been made to show the amounts of ash retained by each individual size which has been rejected by the sink-float separations. This is as follows:

Product	% Ash "as produced"	% Ash F 1600	% rejected each size by S/F 1600 Wt.	% rejected each size by S/F 1600 Ash
+½ in	21.8	20.7	4.2	9.2
+¼ in	21.5	19.4	7.6	16.8
+⅛ in	20.6	18.8	6.0	14.5
+1 mm	20.6	17.9	7.8	19.7
-1 mm	25.8	20.6	11.8	29.7

This table shows a clear pattern of decreased washing efficiency in the finer size ranges.

Fines (slurry screen oversize)

This material is derived from continuous screening out of +0.5 mm washed coal from the plant circulating water and is a component of the slack coal. It is of poor quality, 28-30% ash and according to size analyses re-

represents about 11% of the total slack.

It does, however, respond to beneficiation, both by sink-float and froth flotation techniques, again indicating deficiencies in washing in this size range. Adequate beneficiation of this product alone would effect an overall ash reduction in the total slack coal of up to 0.5%. Complete removal of the fines from the slack would reduce the overall ash by about one percent.

Jig middling

There is a marked change in the character of this material between the plus and minus one inch fractions. The current practice of screening the product on a one inch grizzly, and rejecting the minus one inch to waste and crushing and returning to the jig the plus one inch material, appears to be justified. However the evidence is only superficial as no recent work on sink-float tests have been carried out on plus one inch jig middling. It is likely that this material is an inferior quality coal which will not respond to beneficiation even after crushing and hence could be source of high ash material contaminating the slack coal. This aspect of washery operations warrants further investigation. It should be noted that the lowest ash product from sink-float tests on the sized jig middling contains 27.4% ash. This is the F 1600 of the $+\frac{1}{8}$ inch fraction and may be representative of the best material which can be extracted from the middling.

Jig tailing

This product is considered to be satisfactory. Sink-float tests at a density of 1600 kg/m^3 resulted in the recovery of only minor amounts of poor quality coal in any size range.

Cone discharge

This material appears to consist essentially of poor quality fine coal, retained in the circuit because of inadequate slurry cleaning and inefficient washing in the fine sizes. The possibility of some reasonable beneficiation by froth flotation is indicated by the test reported.

Centrifuge effluent

The product is obtained from the dewatering of the washed slack coal. The test reported shows the possibility of recovery of a high quality coal product. The product is extremely fine, the coal concentrate being of the order of 60% -75 µm.

SUMMARY AND CONCLUSIONS

The investigation has shown that there is a progressive decrease in washing performance, grading from acceptably good in the +2 inch material to extremely poor in the $-\frac{1}{8}$ inch material in the jig feed. The slack coal which constitutes the major part of washed coal production is most susceptable to this condition and the sink-float tests show that the ash content of this material can be reduced by 2.1% by an efficient separation at a density of 1600 kg/m^3.

The progressively increasing density of the circulating water in the plant, (the jigging medium) was judged to be the main contribution factor to the poor jig performance in the fine sizes. Consultation with Company staff, resulting in an analysis of the washery log sheets from October 1971 to August 1972, has shown a consistent fall off in washed slack coal quality with high jig water density readings. In addition to this evidence, the suppliers of the equipment, Parbury Henty (Mining) Pty. Ltd., Sydney, recommend a maximum density reading of 1050 kg/m^3 with between 1025-1050 kg/m^3 for average conditions. The washery log sheets show that only on rare occasions is the density reading less than 1050 kg/m^3 and frequently in excess of 1080 kg/m^3.

Clearly then, the high density of the jig water is generating a situation in which it is impossible for the washery to perform at anything approaching maximum efficiency.

A sample of overflow from the settling ponds taken subsequent to the plant visit showed a density reading of 1020 kg/m^3. This is probably typical of the water taken into the plant at an estimated rate of 320 l/min to replace the water lost from the circuit through the centrifuge effluent and the main sump overflow.

The amount of slurry which can be bled off from the plant is limited by the capacity of the settling dams and ponds to retain the solids and overflow a reasonably clean water for return to the plant at the rate required to keep the jig water density down to acceptable levels. For the same reason it is not feasible to take new water from the river for make up purposes, for such a practice would pollute the South Esk River with coal and shale.

The function of the settling cone, which is continuous clarification of plant circulating water to an acceptable degree, has therefore been nullified except for the pre-start up dumping of solids accumulated during the previous shift.

The situation in the plant is therefore one of a continuous build up of fines in the circulating water to levels which prohibit efficient washing of the coal, particularly in the finer sizes. The environment in which the washery is situated prevents any positive action being taken to alleviate this situation by means already at hand, that is, the continuous removal from the circuit of a great deal more slurry than is presently being done. There is possibly little or no economic advantage in the return of the plus one inch jig middling under the present conditions.

RECOMMENDATIONS

An immediate start should be made to vary the jigging conditions in an attempt to reduce the ash content of the slack coal. It is suggested that a decrease in water to the jig and an increase in pulsation would open the bed and induce more bed plate suction. The likely result of this would be the elimination of more fine shale and poor quality fine coal from the washed product. Probably the jig middling would improve in quality also, but inevitably, coal recovery would decline by an unpredictable but probably minor amount.

Acidification, to about pH 5, of the slurry going to the dams will tend to flocculate the solids, and thence promote more rapid settling. This may offer a temporary solution to the problem of dirty dam overflow.

In the longer term, an investigation into ways of continuously eliminating fine material from the circuit and hence providing jig water of acceptably low density levels should be undertaken. Presently, much fine coal of good quality is entering the dams and overtaxing the capacity of an already inadequate settling system. Preliminary tests indicate that incorporation of a froth flotation system for the treatment and recovery of fine coal from the circulating slurry offers good prospects for a permanent solution to the problem.