4 SEAM YIELD OPTIMISATION AT GOEDEHOOP COLLIERY

Dieter Nebbe

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Yield Optimisation of Vlaklaagte Four Seam Coal

Kelly Marsden
Metallurgy Graduate
April, 1999

Dieter Nebbe
Plant Superintendent
April, 1999

ABSTRACT

The main aim of the project was to optimise the yield of 4# Vlaklaagte Coal (export low volatile steam coal) passing through the B-stream plant. This was investigated by varying the banana screen cut-point and noting the effect this had on the coal yield.

Firstly, the cut-point size and efficiency (degree of separation) of the banana screen were calculated. The screen consisted of 15 mm aperture size panels was found to be operating at an efficiency of 92.3%. For the wet screen application this efficiency is not acceptable and possible solutions to increase the screen performance were considered but need to be further investigated.

Washability tests were performed on various size fractions of the 4# ROM coal. The results were used to calculate what yields would be expected at the specified CV of 27.4 MJ/kg and at what medium density the separation process would operate at. The individual size fraction yields were considered. Fractional washabilities above and below various cut-point sizes were combined and used to calculate expected yields and densities separation for each undersize and oversize fraction at each cut-point. These yields were then combined to give the total yield of coal.

The screen is presently running at a cut-point of 14.5mm, on a screen of aperture size 15mm. Results showed that the optimum cut-point size, giving the highest yield, was 8mm.

The cut-point size of the banana screen controls the split of the feed stream to the Wemco drum and the DSM cyclones. This is important as the amount and sizes of the feed either reporting to the drum or cyclones, has an effect on both processes' efficiency and thus overall yield. Thus, when analysing the different possible cut-points, the maximum sizes of then particles going to the cyclones and the maximum flow rate into the cyclones and drum must be considered. Thus ensuring that no bottlenecks appear and that no damage occurs to the equipment.

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1 INTRODUCTION

Goedehoop Colliery mines #2 seam coal and #4 seam coal from the Witbank area and washes it to specification for the export market. The coal preparation plant washes approximately 7.3Mt per annum through three plants namely A, B and C stream.

A stream washes #2 seam coal from Hope mine and Haasfontein mini-pit in a double–stage process to produce both LAC (7.3% ash) and high volatile steam coal (28.15MJ/kg). A double-stage process implies firstly washing at a high medium density to separate the discards from the coal, and then washing at a low-medium density to separate the LAC from the high volatile coal. B stream washes only #4 seam coal from Vlaklaagte mine and is a single stage process producing low volatile steam coal (27.4 MJ/kg). The #2 seam mine from Vlaklaagte is a single-stage washed through C-stream producing a high-volatile product.

The basic coal flow of all the streams is as follows:
The ROM coal is wet screened into size fractions of –150+15mm and –15mm by the banana screens. The larger size fraction is sent to Wemco drums where gravity induced dense medium separation occurs. The –15mm coal is sent to preparation screens where the fines, -0.5mm, are removed. The –15+0.5mm fraction is washed in the DSM cyclones (dense separation induced by centrifugal force), and the fines are treated on the spiral concentrators.

This paper is concerned with the #4 seam ROM coal through the B-stream. The coal is reclaimed from B stockpile and conveyed via 4R4 and 4R5 to F05 banana screen. The overflow from F05 screen gravitates to F10 Wemco drum, the underflow to G02 and G07 preparation screens. From these screens the fines are fed to the fines circuit (spirals), and the small coal fraction to G10 and G15 DSM cyclones.

2 THEORY

2.1 BANANA SCREENS CUT POINT AND EFFICIENCY

The efficiency of screening is determined by the degree of perfection of separation of the material into the size fractions above and below the dimensions of the aperture sizes on the panels. The most common screen performance criteria are based on the recovery of the material at a given cut point size, or on the mass of misplaced material in each product. The size fractions in each stream feed, overflow and underflow streams need to be determined. Knowing these fractions, the efficiency can be calculated from the following equation (see APPENDIX A for derivation):

Equation (1)

$$\text{Efficiency} = (c-f)/[c(1-f)]$$

Where c = fraction material > cut point size in overflow
f = fraction material > cut point size in feed

This equation implies that recovery of the coarse material in the oversize is 100%.

From Equation 1 it can be seen that the screen efficiency can only be calculated once the cut point size (d50) has been obtained. The cut point size for which 50% of the particles in the feed of that size report to the undersize, i.e. particles of this size have equal chance of going to either the oversize or the undersize.

The d50 is obtained from the partition curve. This curve is drawn by plotting the partition coefficient, defined as the percentage of the feed reporting to the oversize product, against the geometric mean of each size fraction.

In order to obtain the reconstituted feed, used to calculate the partition coefficient, the percentage of the total feed that reports to the overflow is required. This is calculated from the percentages of each size fraction in the feed, overflow and underflow, obtained from the ACCL sample data (see Appendix B for further derivations and calculations). Once the feed split is known the reconstituted feed is calculated by adding the weight percentage of feed to the overflow to the weight percentage of feed to the underflow, for each size fraction. The weight percentage of feed to oversize is then divided by the reconstituted feed to obtain the partition coefficient for each size fraction. From the partition curve, the d50 is read off at the 50% partition coefficient value.

The efficiency of the separation can be assessed from the steepness of the curve. This is given by the imperfection, I:

Equation (2)

$$I = (d_{75}-d_{25})/2d_{50}$$

The closer to vertical the slope of the curve, the more efficient the separation. The partition curve can also be used to determine the amount of misplaced material, by considering the tails, e.g. the amount of undersize material that reports to the oversize product.

High capacity and high efficiency are opposing requirements for any given separation, and a compromise is necessary to achieve the optimum result. At a given capacity, the effectiveness of the screen (i.e. the probability of a particle passing through the screen aperture) depends on:

- Feed rate – if the feed rate is too high the bed is too thick thus reducing the probability of the particle reaching the bottom of the bed and going through the aperture
- Rate of vibration – in general an increase in the vibration increases the efficiency, but too high a vibration will cause the particles to be thrown too high thus reducing the particle probability
- Angle of screen – Affects the time the particle has on the screen and thus the probability of the particle passing through the aperture
- Percentage open area of the screen
- Nature of feed material (amount of near size material) – more difficult to separate near size material , therefore a large amount of this material decreases the efficiency
- Presence of moisture or clay – fines washed off larger particles in wet screening increases particle passing probability, but clay conditions may clog up apertures

2.2 HEAVY MEDIUM SEPARATION

2.2.1 Heavy Medium Separation (HMS) Theory

Heavy medium separation is used to reject the gangue from a feed stream in order to obtain the required mineral product. In coal preparation HMS is used to produce a commercially graded end product, clean coal being separated from the heavier shale or high ash coal.

It is the simplest of gravity processes in which the heavy liquid (medium) is of suitable density so that minerals lighter than the liquid float, while those denser than it sink. In industrial separations the medium used is a suspension of heavy solids in water, which behaves as a heavy liquid. Coal preparation plants use magnetite to make up the medium. It is of an acceptable viscosity, low cost, wide operating range density range, and can maintain densities up to 2.5 specific gravity.

The advantages of HMS over other gravity separations are:
- Ability to make sharp separations at any required density
- Density of separation can be closely controlled and maintained
- Density can be changed at will and fairly quickly to meet varying requirements
- High degree of efficiency even in the presence of high percentages of near density material

2.2.2 Separating Vessels

Wemco Drum:
This consists of a drum through which the feed and medium flows. Gravity separation is accomplished by the continuous removal of the sink product through the action of lifters fixed to the inside of the rotary drum, which empty into the heavy discard into the internal sink launder. The light product floats through the drum and overflows a weir at the opposite end of the drum from the feed chute. Drums are use in the coal industry because of their simplicity, reliability and minimum maintenance needs.

Dense Medium Cyclone:
Cyclones provide a high centrifugal force enabling much finer separation to be achieved than that in gravitational separations. Feed to these devices is screened at 0.5mm to avoid contamination of the medium with slimes, and to minimise medium losses. The ore is suspended in a very fine medium of magnetite, and is introduced tangentially to the cyclone

under pressure, normally being gravity fed via a constant head. Centrifugal forces cause the denser particles to move towards the cyclone wall, while the lighter particles are drawn to the centre of the vessel. The sink product leaves the cyclone in the apex, while the floats product is discharged via the central vortex finder.

2.2.3 Washability Testing

Washability Tests are important in coal preparation in order to determine the required density of separation and the expected yield of coal of the required calorific value (CV) or ash content. The heavy liquid tests involve splitting the coal sample into density fractions, and obtaining the weight percentage, ash content and CV for each fraction.

3 EXPERIMENTAL PROCEDURE

3.1 COAL SAMPLING

In coal washing operations the sampling, sample preparation and analysis of the coal is important. An analytical result may be used for quality determination, for payment or for plant washing control. The problem with sampling coal is that it is inscrutable, has a wide range of species present (coal and mineral matter), and varies greatly in its' composition (species proportion) from one moment to the next. The objective of coal sampling is thus to take a number of increments from the bulk coal being sampled, called the unit. The cumulated increments should contain all the species present in the unit in the same proportions as are found in the unit, i.e. a representative sample. In order to obtain such a representative sample, there are sampling standards that give for example, the minimum number of increments required I order to get a particular precision level. Precision is the extent to which sets of results from sampling agree among themselves; i.e. a sampling method that gives many results of similar value is a precise method.

Methods and precautions to be taken when sampling coal:

- Take an adequate number of increments, spacing the increments equally throughout the unit of coal
- Avoid increments from a non-representative part of the coal e.g. the edge of the stockpile
- Belts should have an even load (if variable load, add more increments to sample if the belt is empty at the time of the increment)
- Avoid any coincidence of the taking of increments with a known periodic variation of quality or quantity
- Take care to prevent the occurrence of bias (systematic error)
- When selecting a method and the point of sampling, take into account the safety of the sampler
- When using a mechanical sampler ensure that it is working and taking big enough mass increments at the correct time intervals

3.2 ISO SAMPLING STANDARDS

The ISO (International Standards Organisation) 1988: Sampling of Hard Coal is the most generally followed set of standard rules. Following these rules means that the Reference Level of Precision is attained.

3.2.1 Number of Increments

Raw coal contains a wider range of species and of different proportions, therefore more increments are required than that for clean coal. For sample mass up to 1000 tons:

	Conveyor	Stockpile
Washed coal	16	32
Raw coal	32	64

3.2.2 Mass of Each Increment

The minimum mass of an increment depends upon the particular size coal being sampled:

$$\text{Mass (kg)} = 0.06D$$

Where D is the diameter of the largest particle present.

3.2.3 Scoop Size

While sampling, it must be ensured that the scoop does not impede the passage of any particles. The scoop opening must therefore be larger than the largest particle present:

Minimum scoop size = 3D

3.3 BANANA SCREEN EFFICIENCY SAMPLING METHOD

In order to calculate the screen cut-point efficiency, the size fractions in the feed, overflow and underflow streams need to be determined. Thus, samples were taken from these streams, ensuring that the respective ISO standards were followed.

3.3.1 Feed Stream onto F05 Banana Screen

The stream sample was taken from the conveyor (4R5) directly feeding the even stream of 4 seam coal onto the screen. The sample is raw coal, therefore according to the ISO standards, 32 increments were required, each with a minimum mass of 9kg (maximum particle size of 150mm). This was done by taking periodic belt cuts along the conveyor. The belt was stopped every 10min, at which 2 cuts, 4m apart, of 0.5m were taken. This was performed until 32 increments were taken. It was ensured that all the fines were included in the sample. The raw coal was placed in plastic bags, labeled and sent to ACCL for a size analysis.

3.3.2 Overflow Stream from F05 Banana Screen

The stream sample was taken from the end of F05 screen, i.e. the overflow from the screen into the oversize chute. According to ISO standards 16 increments, 9kg each, of the screened coal were required. These were taken using a sampling scoop, minimum width 450mm (maximum particle size of 150mm). A wooden platform was placed over the grizzly for the sampler to stand on. The scoop was then passed from either side of the width of the screen (to get a representative sample of the whole width of the flow). This was repeated every 10min. Samples were taken a few minutes after the belt had been restarted after the belt cuts had been taken. This was in order to sample similar coal as that from the feed stream, the few minutes allowing for the coal to travel along the conveyor and screen. The coal sample was then placed in plastic bags, labeled and sent to ACCL for a size analysis.

3.3.3 Underflow stream from F05 Banana Screen

The stream sample was taken from the banana screen sieve underflow discharge chute onto sieve bends feeding the preparation screens (G02 and G07). ISO standards specify 16 increments, 9kg each, of the screened coal, 1kg each (maximum particle size of 15mm). A 3 inch PVC pipe was used to collect the sample (coal and water) and direct it into a large bucket or dustbin. The pipe was moved across the coal flow of the sieve bend, and increments were taken from G02 and G07 alternately. The samples were taken at the same time as the overflow screen samples. Since the final sample contained water as well as coal, it firstly had to be dewatered before being packed into bags and sent to ACCL.

The size analysis (fractional weight percentage) was done for the following size fractions in millimetres:
+100, -100+75, -75+50, -50+32, -32+25, -25+19, -19+15, -15+12, -12+6, -3+0.5, -0.5

3.4 FOUR SEAM ROM SAMPLING METHOD

The sample of 4 seam ROM coal (required to perform washability analysis) was obtained using the mechanical sampler. The sampler was set to take samples every 5-10 min, the sample bucket passing through the falling stream of coal from conveyor 4R4. 32 increments were taken from the raw coal, each with a minimum mass of 9kg. When working with the mechanical sampler, it was ensured that a sufficient amount of coal was taken for the total sample. This was a problem as sometimes the belt (4R4) had stopped and the sample bucket did not collect any coal. When taking the ROM sample, the coal was not reclaimed from the ends of the stockpile where unrepresentative samples would be obtained, but from the middle portion of the stockpile. The whole sample was sent to ACCL for a fractional washability analysis on each of the following size fractions, in millimetres:
+50, -50+25, -25+19, -19+15, -15+12, -12+9.5, -9.5+8, -8+6, -6+3, -3+0.5

The +50mm fraction was split into two. The one half was used to perform the abovementioned washability, while the other half was crushed to –50mm. A washability analysis was then performed on this fraction.

The resultant washability samples were then analysed for the ash content and calorific value (CV).

4. RESULTS AND DISCUSSION

4.1 SCREEN EFFICIENCY AND CUT-POINT

4.1.1 Feed Split

From ACCL sizing results on the feed, overflow and underflow streams:
Percent of the feed to the overflow = 51.3%
Percent of the feed to the underflow = 48.7%

See Appendix B (i) and (ii) for calculations.

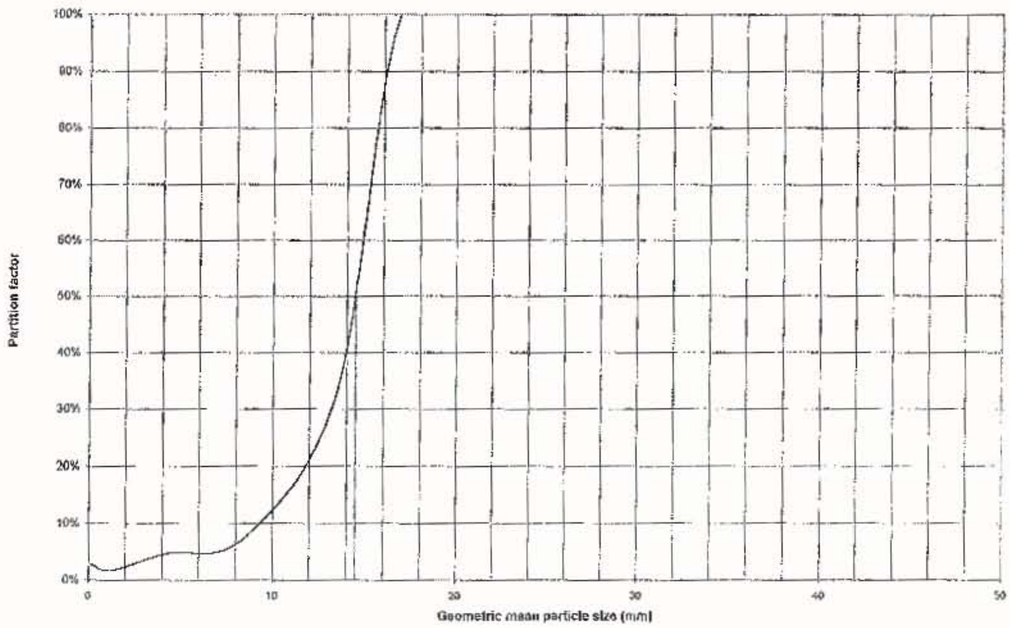
4.1.2 Cut-point – Partition Curve

From Figure 1 the cut-point is read off at 50% of feed reporting to the oversize product, i.e.
d_{50} = 14.5mm

See Appendix B (iii) for table of curve construction data.

The partition curve indicates that the screen is operating at a cut-point size of 14.5mm. The actual aperture size on the panels on the screen is 15mm. This is as expected.

FIGURE 1: Partition Curve for FO5 Screen



4.1.3 Screen Efficiency

The imperfection is obtained from the curve and equation 2:

$I = 0.09$

The screen cut-point was calculated to be 14.5mm. Since size fraction data was available only at 12mm and 15mm, Equation 2 is solved using a cut-point of 15mm:

Efficiency = 92.3%

See Appendix B (iv) for calculation.

The calculated imperfection does not take the tails into account but considers the main bulk of the feed material (between 25 and 75%). The steepness of the line between the 25 and 75% partition factors indicates the effectiveness of separation, with ideal slope of zero. The curve shows that there is good separation of the particle sizes in the bulk material, there is a large misplacement of fines in the oversize stream (tails portion of the curve). The curve also shows that no coarse material is recovered in the undersize stream.

The result of the misplacement of the fines has an effect on the performance of the screen and could account for the loss in efficiency of the screen (92.3%). The presence of the fines in the oversize stream is undesirable as it causes a decrease in yield. This is due to the fact that in the drum section (treating the oversize stream), there is not sufficient time for the fine particles to separate, i.e. the heavier particles do not settle into the sinks but are carried over in the floats stream. Therefore, the presence of fines in the drum separating section must be minimised. This is done by increasing the screen efficiency.

The amount of near size material affects the screen performance, the higher the amount the more difficult the separation. The amount of near size material in the feed stream is 3.5% of –19mm + 15mm and 3.6% of –15mm + 12mm, in total 7.1%. This could have a small negative impact on the screen efficiency.

4.2 FOUR SEAM ROM WASHABILITY TESTING

4.2.1 Individual Size Fraction Washability Results

The data obtained from the ACCL analysis can be found in Appendix C (i). From these results, the yield and density of separation (corresponding to a CV specification of 27.4 MJ/kg), are obtained for each size fraction. The organic efficiency of the dense medium separation is taken to be 95%, i.e. 95% recovery of the theoretical yield prediction.

Table 1: Individual Size Fraction Washability Results

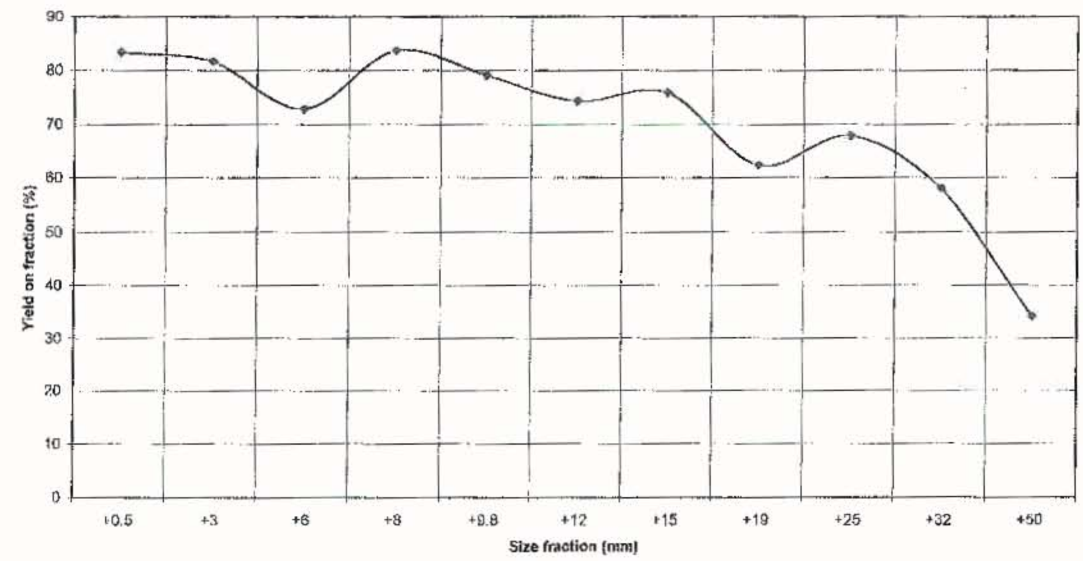
Size fraction (mm)	ROM feed size distribution (%)	Yield on fraction (%)	Coal Yield (%)	Density of separation (sg)
-0.5	3.4	-	-	-
-3+0.5	9.6	83.34	8	1.8
-6+3	11.3	81.68	9.2	1.74
-8+6	8	72.85	5.8	1.7
-9.5+8	7.6	83.66	6.4	1.8
-12+9.5	12.4	79.09	9.8	1.71
-15+12	2.2	74.34	1.6	1.62
-19+15	2.9	75.9	2.2	1.64
-25+19	6.1	62.37	3.8	1.55
-32+25	6.7	67.9	4.6	1.58
-50+32	13.9	57.28	8.1	1.56
+50	15.9	34.17	5.4	1.56
Total	100		64.9	

Table 2: Crushed +50mm Size Fraction Washability Result

Size fraction (mm)	ROM feed size distribution (%)	Yield on fraction (%)	Coal Yield (%)	Density of separation (sg)
-50	15.9	39.24	6.2	1.56

From Figure 2 (next page) it can be seen that the smaller size fractions have a higher yield than the larger size fractions. This could be due to the higher degree of liberation. That is the smaller particles have a high degree of liberation of coal, therefore more effective separation, while the degree of separation in the larger particles may be reduced by the presence of mineral matter in the particles. Up to particle sizes of 15mm, the yield is above 70%. Above this size fraction it can be seen that the fractional yield increased by just over 5%. This is accounted for by the increased coal particle liberation on crushing. It is a substantial increase in the yield especially when considering the amount of coal washed and sold annually.

FIGURE 2: Individual size fraction yields for CV 27.4 MJ/kg



4.2.2 Combined Size Fractions Washability Results

In order to calculate the total yield results obtained at different cut-point sizes of the screen, combinations of the washability data of the size fractions above ('+ cut-point') and below ('- cut-point') the chosen cut-points were required. These combinations predict the yield of the '+ cut-point' fraction reporting to the drum process, and the yield of the '- cut-point fraction reporting to the cyclones. The ash percent and the CV values for the combined fractions were obtained by firstly calculating the ash and CV points for each individual size fraction. Then, adding the in proportion to the weight percent of each fraction and dividing the results by the feed weight percentages of the combined fraction. The total yield predictions were obtained by adding the coal yields (combined fraction yield multiplied by the feed weight percentage of the combined fraction) for the + cut-point and the – cut-point combinations at each cut point.

See Appendix C (iii) for an example of data obtained for combined fraction washability (specifically the size fraction above the 8mm cut-point).

Yield results are for the + and – cut-point fractions, taking the specification CV of 27.4 MJ/kg and an organic efficiency as 95%. Note that the –0.5mm fraction is screened out by the preparation screens, therefore it does not report to the cyclones and this fraction's washability results are not included in the fractional combination. As a general application, the 0.5mm size fraction percentage of the feed is multiplied by1.7, and the equivalent amount subtracted from the –3+0.5 size fraction.

Note: The cut-point size refers to the size of the particle that has 50% chance of reporting to the undersize product. It is an indication of the screen aperture size and screen efficiency. It splits the feed into two distinct oversize and undersize product streams.

Table 3: Predicted yields for the combined size fractions above and below the cut-point sizes (Yields on 27.4 MJ/kg CV specification)

	+ cut-point fraction			- cut-point fraction			
Cut-point (mm)	Fraction yield (%)	Feed size distribution (%)	Total yield (%)	Fraction yield (%)	Feed size distribution (%)	Total yield (%)	Total yield (%
3	68.3	87	59.4	83.4	9.6	8	67.4
6	66.1	75.8	50.1	82.5	20.8	17.2	67.3
8	64.2	67.8	43.5	81.7	28.8	23.5	67.1
9.5	60.9	60.2	36.6	82.1	36.4	29.9	66.5
12	54.4	47.8	26	81.3	48.8	39.7	65.7
15	53.1	45.6	24.2	81.1	51	41.4	65.5
19	51.2	42.6	21.8	80.8	53.9	43.6	65.4
25	49.4	36.5	18	79.3	60.1	47.7	65.7

FIGURE 3: Yield of combined size fractions at various cut points

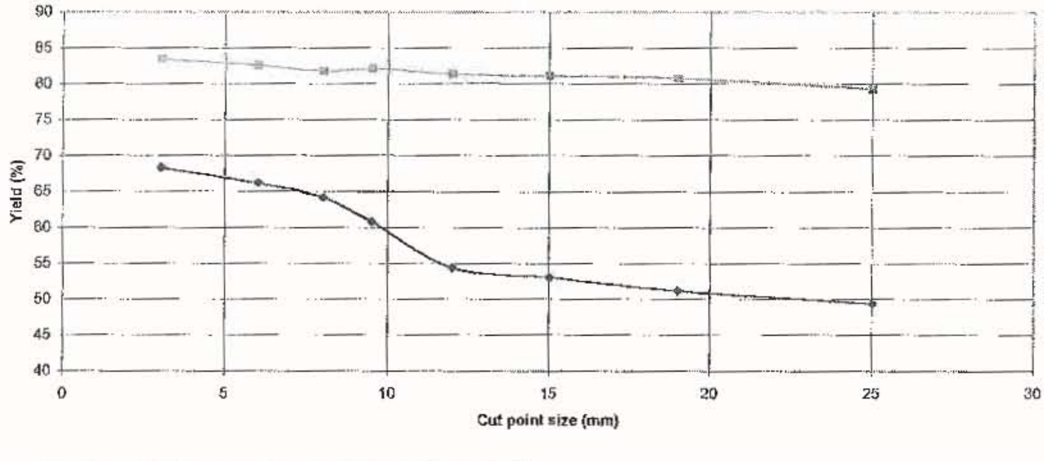
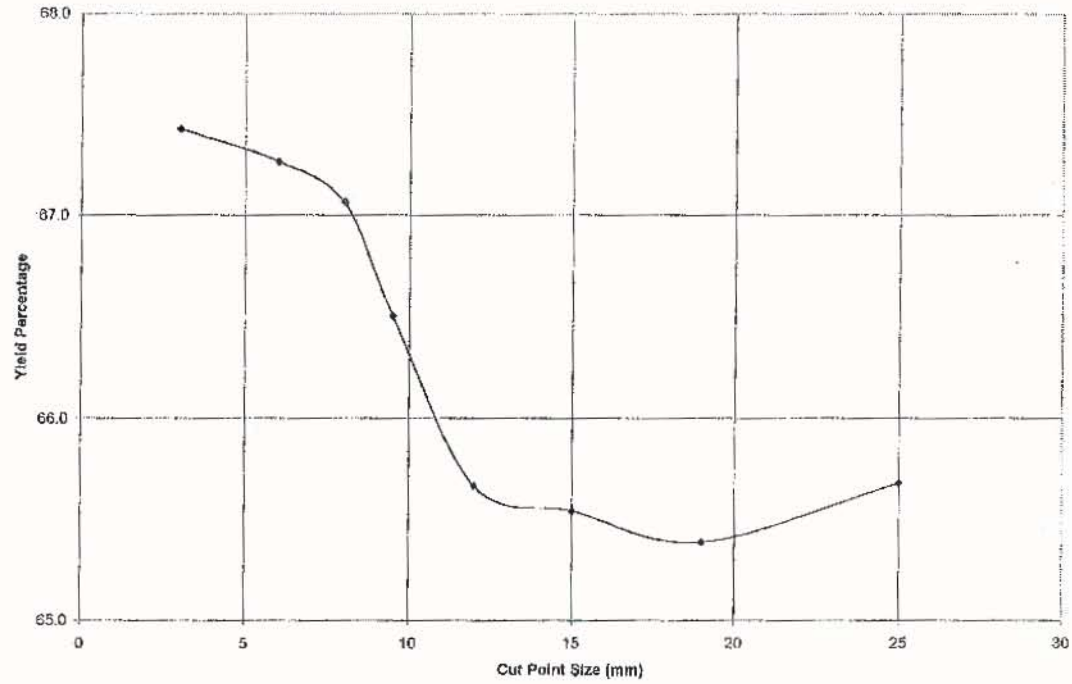


FIGURE 4: Total yields at various cut points



From Figure 3 it can be seen that the combined fractions lower than the cut-point size (- cut-point) give high fractional yields, while the combined fractions higher than the cut-point give much lower fractional yields. This can be accounted for by the expected higher degree of liberation of the coal particles in the smaller size fractions.

The figure also indicates that for –cut-point size combinations from 8mm up to 25mm, the fractional yield does not vary much, experiencing only a slight drop with increased cut-point size. The combined fractions +cut-point size show a large decrease in yield with cut-point size, especially from sizes 3mm to 12mm where the drop is more than 10%. This drop could be due to the fact that at lower cut-points larger amounts of smaller particles are included in the +cut-point fraction. This corresponds to with the individual fractional yield results which imply that smaller particles give higher yields (coal liberation), therefore with an increase in the amount of smaller particles in the +cut-point fraction, the higher the yield. These results imply that varying the cut-point size in the range 3mm to 25mm does not affect the –cut-point fraction yield to such an extent as it affects the +cut-point yield.

Figure 3 suggests that since yields of the combined fractions –cut-point are much greater than those of the +cut-point fractions, it would be more beneficial to increase the amount of feed material reporting to the –cut-point fraction thus operating at higher cut-point sizes.

Figure 4 combines the yields predicted for the –cut-point graph and +cut-point fractions by taking the feed size distribution into account. The graph indicates the total yield increases as the cut-point decreases (up to 3mm in this exercise), this being due to the higher yields expected in the +cut-point fraction at lower cut-points (see figure 3).

Although the results show higher yields at the smaller cut-point sizes, the separation efficiency of the drum and cyclones has not been considered. At the lower cut-points there is an increased amount of smaller material reporting to the drum plant. It is known that the performance of the drum decreases with an increased amount of finer material (residence time of the smaller particles in the drum is insufficient to allow for efficient separation). Also, cyclones are generally more efficient than drums. Knowing this, it would seem to be more beneficial to operate at the higher cut-points, thus reducing the amount of smaller particles reporting to the drum, and increasing the load to the cyclones. In this case, the cyclone operating limits must be noted, and Horsfall[2] states that the preferred minimum particle size reporting to a drum is 15mm.

There are limits to increasing the undersize (-cut-point) fraction, these being the maximum load and particle size restrictions on the operating conditions of the cyclones. G10 and G15 are 510mm DMS cyclones supplied by Multotec. The maximum top size is 24mm, the maximum ore capacity 41-47.3 m^3/hr and the maximum pulp capacity 138-159.3 m^3/hr (ranges depending on operating head, 9D-12D).. The range of cut-points is thus satisfactory, not exceeding the 24mm limit. This is especially relevant in the smaller size ranges. For example in a 510mm cyclone, the presence of particles of sizes smaller than approximately 2mm causes a dramatic decrease in cyclone performance. The minimum size being fed into the cyclones remains constant (approximately 0.5mm) in the present situation, therefore it is not considered. The top size does not have such an effect on the efficiency, as long as it is within the specified size range for the particular cyclone. (Reference Bosman, J. & Engelbrecht, J.[1])

When calculating the combined washabilities for the +cut-point fraction, the uncrushed +50mm size fraction was added with the other size fractions used in the combination. Then for comparison the crushed to –50mm fraction was added to instead of the +50mm fraction:

Table 4: Comparison of coal yields (for combined size fractions) of the crushed and uncrushed +50mm size fraction

Cut-point (mm)	+Cut-point fractional yield		Total coal yield	
	Uncrushed	Crushed	Uncrushed	Crushed
8	64.2	65.4	67.1	69
9.5	60.9	62.4	66.5	68.6
12	54.4	56.2	65.7	67.8
15	53.1	55.1	65.5	67.8
19	51.2	53.3	65.4	67.5
25	49.4	52	65.7	67.8

Table 4 again indicates that by crushing the +50mm material to –50mm, there is an increase in the yield.

The theoretical washability results for the +5mm size fraction were compared with the +5mm washability results obtained from Greenside Colliery #4 seam coal. The samples were taken over the same period, i.e. January to March:

	Theoretical yield (%)
Greenside Colliery	72.82
Goedehoop Colliery	83.34

The densities of the dense medium in the drum and cyclone separation processes were obtained from the combined washability results. From the Table 5 it can be seen that both processes operate within reasonable densities, i.e. RD 1.56-1.77. The drum operating at densities that decrease slightly with cut-point size, and the cyclones operating at higher densities than the drum, also slightly decreasing with cut-point size.

Table 5: Required densities (RD) of separation for the drum and cyclone separation processes.

Cut-point (mm)	+Cut-point fraction (drum)	-Cut-point fraction (cyclone)
8	1.61	1.77
9.5	1.59	1.77
12	1.57	1.75
15	1.57	1.75
19	1.56	1.74
25	1.56	1.71

5. CONCLUSIONS AND RECOMMENDATIONS

The combined washability results predict that the smaller cut-point sizes give higher yields. These results used the feed size distribution obtained from the ROM sample to calculate the combined washabilities and thus yields. It is assumed that there is a definite split i.e. the size separation (screen efficiency) is 100%. No allowance (in the washability results) has been made for the inefficiency of the screen and the amount of undersize material reporting to the oversize product. The performances of the drum and cyclone processes have also not been taken into consideration. As has been stated the separation efficiencies, as well as the feed size distribution, have a large effect on the overall coal yield. Thus, no concrete conclusion can be made as to the optimum screen cut-point.

The operating conditions of the drum and cyclones are limited by particle size, the minimum particle size being that to the drum (15mm), and the maximum particle size being that to the cyclones (24mm). The yield within these cut-point limits varies only slightly. It was therefore resolved to maintain running the screen at the cut-point of 14.5mm, and further investigate improving the screen efficiency, calculated to be 92.3%.

Possible solutions to increase the screen performance include:

- Spraying of screen wash water. By considering the spraying force, direction and position, the probability of the finer particle to pass through the apertures may be increased. Ensuring that the bed across the whole width of the screen is exposed to the wash water spray will eliminate fines being carried to oversize due to insufficient wetting.
- Installation of L-panels. This would increase the particle residence time on the screen, and the amount of movement of the bed. Thereby increasing the probability of reaching the bottom of the bed and passing through the screen apertures.
- The angle of the screen or the angle of the coal stream when it 'hits' the screen. This will affect the particle probability of reaching the bottom of the bed and passing through the screen.
- Sectional samples were taken across the width of the screen and it was found that the majority of the fines in the oversize stream were carried over the middle sections of the screen. This could be due to the restricted coal distribution, onto the middle of the screen, from the chute. The larger particles move towards the outer edges while the smaller particles remain in the centre. Therefore, the exposed area of the screen apertures is reduced and the particle probability of passing through the screen decreases. It is recommended to change the coal discharge to cover the whole screen width.

Crushing the +50mm size particles to –50mm was found to be beneficial, increasing the fractional yields by up to 5%. This is a substantial increase especially when considering the annual coal production. It leads to additional sales and profit. Further investigation into the crusher type, cost and installation is recommended, as well as the effect of generation of fine particles with crushing.

It is recommended to investigate the effect of changing the aperture size (thus cut-point size) of the preparation screens (G02 and G07) from 0.5mm to 2mm. This would theoretically increase the minimum particle size reporting to the cyclones, thus maintaining cyclone efficiency.

6. REFERENCES

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