# Dry Processing Versus Dense Medium Processing For Preparing Thermal Coal

**GJ de Korte**

CSIR, Pretoria, South Africa jdekorte@csir.co.za

## ABSTRACT

Dense medium processing is the beneficiation process most widely employed in South Africa. Based on the fact that South Africa (and its neighboring countries) is a water-scarce area, dry processing technologies are being evaluated for implementation in the region. In addition to not requiring water, the technique is less expensive than dense medium processing - both in terms of capital cost and operating cost. An added benefit when preparing coal for use in power stations is the lower moisture content of the final product.
The separation efficiency of dry processes is, however, not nearly as good as that of dense medium and, as a result, it is difficult to effectively beneficiate coals with a high near-dense content. The product yield obtained from some raw coals is lower than expected and control of product quality is not always easy with dry processes. In the case of easy-to-clean coals, dry processing gives good results and becomes a very attractive proposition – especially when the added benefit of low environmental impact is taken into consideration.
The main consideration when implementing dry processing, especially for long-term projects, is whether the low cost of the process will be outweighed by the low recovery efficiency. This paper gives an overview of the performance as well as the economic advantages and disadvantages of dry processing technologies being evaluated in South Africa and compares it to dense medium.

**Key Words: Dry Processing, Dense Medium Processing, Thermal Coal, Capital Cost, Operating Cost**.

## 1. INTRODUCTION

South Africa is reliant on coal for electricity generation and 95% of all the electricity used in South Africa and approximately 45% of the electricity used in Africa is generated in coal fired power stations by Eskom, a South African electricity public utility established in 1923.
In the past, Eskom burned raw coal in their power stations and this coal was supplied from captive collieries. The coal was crushed and screened and sent directly to the power stations. In recent years, many small BEE (Black Economic Empowerment) coal companies have emerged in the country and the supply of coal to Eskom has diversified. Most of the companies supplying coal to Eskom need to process their ROM (Run-of-Mine) coal in order to meet the minimum specification for Eskom coal – which is typically a minimum calorific value of 21 MJ/kg (air-dry) and a minimum volatile matter content of 20% (air-dry). In addition, the coal has to meet other specifications relating to moisture content (maximum 10% total moisture) and a maximum abrasive index of around 500 units. The amount of fine coal in the product is also limited to ensure that the coal remains transportable.
To ensure that the coal supplied to Eskom meets specification, most suppliers process the raw coal using dense medium processing. Although dense medium is the most efficient process available, it is expensive and it produces a wet product which requires dewatering by centrifuging and/or drainage on product stockpiles. South Africa is a water-scarce country and water for coal processing (and other purposes) is becoming scarcer and where it is available it is becoming more expensive. The environmental problems associated with wet coal processing plants, specifically the disposal of slurry, is furthermore becoming more difficult and expensive to manage. New plants built in the country, and even some older ones, are now installing filters to close

their water circuits - to eliminate the need for slurry ponds and to reduce the amount of water used.

Dry beneficiation technologies have been employed in the past, not so much in South Africa, but in countries like the USA where the Stump Air-flow Jig for example was used to process large tonnages of raw coal. These processes were replaced by the more efficient dense medium processes due to more stringent product specifications. In addition, the increased contamination and wet raw coal produced from mechanized mining operations made dry processing of the coal very difficult. However, in recent years there has been a re-evaluation of dry processing in China with the development of the FGX dry coal separator and in Germany with the development of dual-energy X-ray transmission (XRT) sorters for coal.

In South Africa, the potential of dry processing, both for the preparation of thermal coal and the pre-beneficiation or de-stoning of raw coal was realized and an investigation of these technologies was commissioned through Coaltech, a collaborative research program which has Eskom and the main coal mining companies as members. The potential advantages offered by dry processing technologies are low costs (both in terms of capital and operating costs) and the fact that no water is required - which lowers the environmental impact of coal processing significantly. The dry product produced from dry processing plants is a bonus in that this increases the calorific value of the product and removes the necessity for expensive dewatering. Dry processing therefore appears to be very attractive from an economic perspective.

The only major drawback associated with dry processing is that the efficiency of these processes is much lower than that of dense medium processing – the EPM (Ecart Probable Moyen) value of a dry process, such as the FGX or X-ray sorter, is typically between 0.20 and 0.30 whilst that of a dense medium process would be of the order of 0.02. In addition to this, the dry processes exhibit high relative density cut points – usually between about 1.80 and 2.0. Because the dry processes are less efficient, product yield will be lower than that of the more efficient processes and at the same time, control of product quality will be more difficult – especially when difficult raw coals with high amounts of near-dense material are processed. In choosing a process to beneficiate raw coals to power station quality, the lower efficiency of dry processing needs to be weighed against the lower cost of the process as this may well affect the economic outcome in the longer run.

## 2. DRY PROCESSING TECHNOLOGIES EVALUATED IN SOUTH AFRICA

Two dry processing technologies, the FGX separator and XRT sorters, have been evaluated in South Africa to date. These processes are complimentary in terms of the size range of raw coal that can be processed – XRT sorters are most effective on coal coarser that about 50 mm whilst the FGX operates well on coal with a top size of about 50 mm. It was found in tests conducted on the FGX that the finer sized coal, smaller than about 6 mm, is not effectively upgraded in the FGX. It proves more productive to dry-screen the feed at 6 mm and only feed the plus 6 mm coal to the FGX unit. This results in the added benefit of increasing the capacity of the plant since only the plus 6 mm size fraction needs to be processed via the FGX. Removal of the fine coal from the FGX feed also reduces the amount of dust that has to be captured in the dust-handling system. The raw minus 6 mm coal is added directly to the product stream.

Tests were carried out on the FGX and XRT on pilot-scale as well as full-scale units operating in a production environment and the results obtained proved that these technologies are capable of upgrading coal to Eskom specifications provided suitable raw coals are fed to the units. The XRT sorter also proved to be capable of effectively removing stone from ROM coal.

At present there are two full-scale FGX plants in operation in South Africa as well as two XRT sorters. One of the FGX units is employed to prepare coal for Eskom whilst the second plant processes a high-grade raw coal to yield a product for inland industrial use. The XRT sorters are presently used to de-stone ROM coal and recover coal from a discard dump respectively.

Figure 1 below shows a view of one of the FGX plants in operation in South Africa and Figure 2 is a photograph of an XRT sorter in operation.

Figure 1: FGX plant at Middelkraal Colliery

Figure 2: XRT Sorter in operation at Arnot Colliery

## 3. EFFICIENCY CONSIDERATIONS

As previously mentioned, the efficiency of the dry processing equipment is not as good as that of dense medium processes. Typical performance data for a full-scale FGX[1] as well as that of a XRT sorter in a de-stoning operation[2] are shown in Table 1. One can see from Table 1 that both units exhibit EPM values between 0.20 and 0.30 and cut-point densities in excess of 2.0. Misplaced material is high, especially the sink in float for the XRT unit but one should keep in mind that the unit was set to remove stone from a very low-grade ROM. The objective was to obtain a barren discard which could be discarded and a product which was sent to a dense medium plant for re-processing. In this capacity, the unit successfully removed more than 50% of almost pure rock from the feed. The FGX unit, on the other hand, managed to reduce the ash content of the feed coal from 40.4% to 31.9% which made the coal saleable as thermal coal.

Table 1: Typical performance data for dry processing equipment

| Parameter | FGX | XRT |
|---|---|---|
| Feed % Ash | 40.4 | 71.0 |
| Product % Ash | 31.9 | 59.5 |
| Discard % Ash | 60.2 | 81.4 |
| Product Yield % | 70.08 | 47.58 |
| D50 cut-point RD | 2.007 | 2.062 |
| EPM | 0.2168 | 0.2878 |
| Organic Efficiency % | 86.8 | 79.4 |
| Sink in float % | 6.78 | 27.54 |
| Float in sink % | 10.94 | 3.83 |
| Total misplaced % | 17.73 | 31.37 |
| Near-dense material | 8.4 | 1.9 |

The FGX is successfully employed in China and some Chinese coals are relatively easy to process. As an example, the washability of a Chinese raw coal is shown in Table 2.

Table 2: Washability data for a Chinese raw coal

| | | Fractional | | Cumulative | |
|---|---|---|---|---|---|
| Relative Density | | Yield % | Ash % | Yield % | Ash % |
| F @ | 1.400 | 71.36 | 6.0 | 71.36 | 6.0 |
| F @ | 1.500 | 3.84 | 16.7 | 75.20 | 6.5 |
| F @ | 1.600 | 0.72 | 30.9 | 75.92 | 6.7 |
| F @ | 1.700 | 0.42 | 36.3 | 76.35 | 6.9 |
| F @ | 1.800 | 0.45 | 44.9 | 76.80 | 7.1 |
| F @ | 2.000 | 0.89 | 56.6 | 77.69 | 7.7 |
| S @ | 2.000 | 22.31 | 87.1 | 100.00 | 25.4 |
| Raw | | 100.0 | 25.4 | 100.0 | 25.4 |

This coal contains very little near-dense material and, as shown in Table 3 below, can be effectively beneficiated using the FGX.

Table 3: Simulated FGX processing results on Chinese coal

| d50 | EPM | Product yield % | Product ash % | Organic Efficiency % |
|---|---|---|---|---|
| 1.8 | 0.252 | 73.8 | 14.5 | 88.3 |
| 1.9 | 0.279 | 79.1 | 16.3 | 92.1 |
| 2.0 | 0.307 | 84.0 | 17.9 | 95.3 |

Some South African raw coals, especially the coal from the Number 4 Seam of the Witbank coalfield, are difficult to beneficiate and contain high amounts of near-dense material. A typical washability for the No. 4 Seam coal is shown in Table 4.

Table 4: Washability of No. 4 Seam coal

| Relative Density | | Yield % | C.V. MJ/kg | Ash % |
|---|---|---|---|---|
| F @ | 1.40 | 0.3 | 25.61 | 10.5 |
| F @ | 1.50 | 1.5 | 24.20 | 14.5 |
| F @ | 1.60 | 5.5 | 22.04 | 20.6 |
| F @ | 1.70 | 14.3 | 19.71 | 27.1 |
| F @ | 1.80 | 32.4 | 17.68 | 32.8 |
| F @ | 1.90 | 21.0 | 14.25 | 42.5 |
| F @ | 2.00 | 6.4 | 11.50 | 50.3 |
| F @ | 2.10 | 7.3 | 9.22 | 56.7 |
| F @ | 2.20 | 3.0 | 7.57 | 61.3 |
| F @ | 2.30 | 3.9 | 2.98 | 74.3 |
| F @ | 2.40 | 1.5 | 2.04 | 76.9 |
| S @ | 2.40 | 2.7 | 0.18 | 82.2 |
| Raw | | 100 | 15.00 | 40.4 |

One can see that the raw coal contains a large amount of material in the density range between 1.70 and 1.90. In order to produce a product containing a calorific value of 21 MJ/kg the coal will need to be processed at a density below 1.80 and this falls right in the zone where much of the coal will become 'near-dense' material. The results obtained by 'processing' this coal using a simulation model of the FGX are given in Table 5.

Table 5: Simulated FGX processing results on No. 4 Seam coal

| d50 | EPM | Product yield % | Product CV MJ/kg | Organic Efficiency % |
|---|---|---|---|---|
| 1.8 | 0.252 | 48.8 | 16.89 | 58.1 |
| 1.9 | 0.279 | 57.9 | 16.62 | 66.5 |
| 2.0 | 0.307 | 65.8 | 16.38 | 73.3 |
| 2.1 | 0.335 | 72.5 | 16.17 | 78.9 |
| 2.2 | 0.362 | 78.3 | 16.00 | 84.0 |

One can see that the highest possible CV that the FGX can produce from the No. 4 Seam coal is about 17 MJ/kg at a cut-point density of 1.80. The near-dense material at this density is some 53%. The yield and organic efficiency values obtained are both low. At higher cut-point densities the yield and organic efficiency both increase but the product CV becomes even lower. One can therefore conclude that this coal cannot be successfully beneficiated using dry processing techniques.

South African raw coals in general are difficult to process but some, such as the coal from the Witbank No. 1 and No. 2 Seams, are less difficult and can be upgraded to thermal coal quality with dry processing equipment. It is, however, necessary to understand the washability characteristics of the different coals and the limitations of the available dry processing technologies.

## 4. NEAR-DENSE MATERIAL

The conventional definition of near-dense material is the percentage of coal within the density range of +- 0.1 density units from the cut-point density. This definition may not be appropriate in the case of dry processing. Consider the partition curve of a conventional jig, which typically would have an EPM value of around 0.08 when operating at a cut-point density of say 1.90.The near-dense material, per definition, is all the material within the density range 1.80 to 2.00. The graph shown in Figure 3 illustrates this.

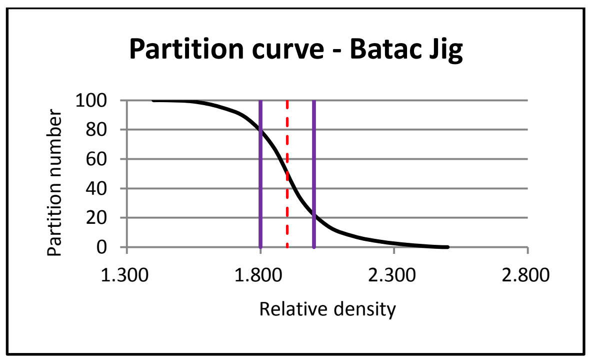


Figure 3: Jig partition curve and near-dense range

It can be seen from Figure 3 that about 80% of the partition curve falls within the density range between 1.80 and 2.00 – about the same range spanned by the EPM. The partition curve of a dense medium vessel, which has an EPM value of 0.026, is shown in Figure 4.

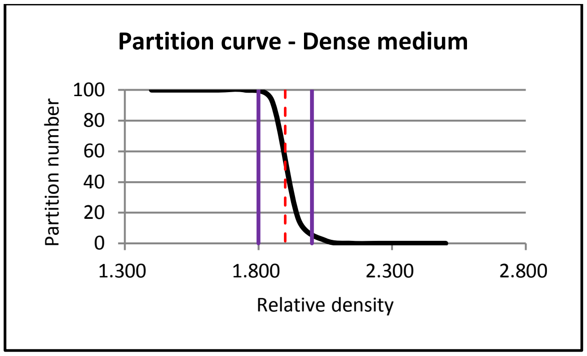


Figure 4: Partition curve for dense-medium separator

The dense medium vessel is capable of a sharper separation than the jig and one can see that the partition curve now falls almost entirely within the range 1.80 to 2.00. Material outside of this range will be separated perfectly. Coal of density lower than 1.80 will be completely placed to product since all the partition numbers in this density range are 100. Coal in the density range above 2.00 will be placed to rejects since the partition number is 0 for this density range. Coal that falls within the range 1.80 and 2.00 can be either placed to product or discard – this is thus the range of densities where probability reigns. This range is a function of the sharpness of separation and is defined by the EPM. The EPM does not include the complete density range but only the middle 50% between the 75 and 25 partition numbers. The higher the EPM value the poorer the sharpness of separation and the wider the range of densities where the separation is 'unsure'. When a large proportion of the raw coal falls in this density range, the separation becomes difficult. The definition of near-dense material was most probably established in the days when jigging was the processing technique of choice. The range of densities (+- 0.1 from the cut-point density) used to define the amount of near-dense material thus closely relates to the EPM of a jig. Van der Walt proposed[3] that near-dense material be defined as the percentage of coal that falls within the range +-2 x EPM from the cut-point density. This definition automatically compensates for the fact that more efficient processes are only influenced by the near-dense material within a narrow range of densities. Applying this definition to the dense medium vessel, the range of near-dense material becomes 1.85 to 1.95. The graph shown in Figure 5 illustrates this.

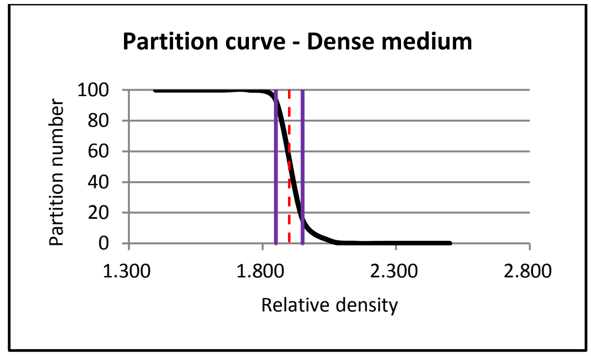


Figure 5: Near-dense material range for a dense-medium vessel defined as +- 2 x EPM

The FGX unit's EPM values typically range between 0.20 and 0.30. The traditional definition of near-dense material does not aptly apply in the case of the FGX as can be seen in Figure 6

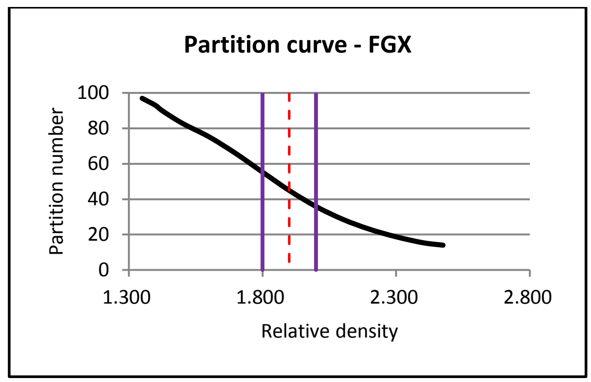


Figure 6: FGX partition curve showing traditional near-dense material range

For a FGX with an EPM value of 0.250 the partition curve spans a wide range of densities and falls completely within the range of partition factors below 100 and above 0. Re-defining the amount of near-dense material as the range between +- 2 x EPM results in the range of densities between 1.40 and 2.40 – in other words, virtually 100% of the coal becomes 'near-dense material' in the case of the FGX.

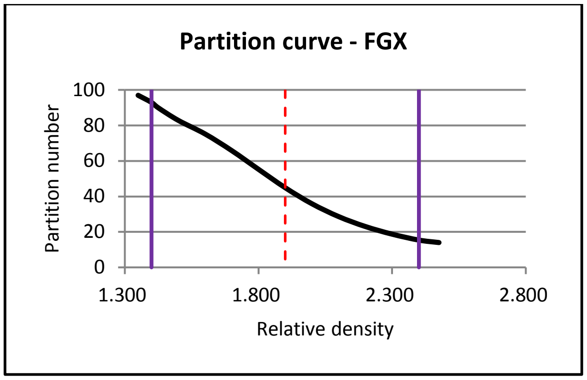


Figure 7: FGX curve showing near-dense material range as +- 2 x EPM

The amount of material misplaced in a coal washer is a function of the amount of near-dense material present in the raw coal fed to the washer. In the case of dry processes, the amount of near-dense material, as defined by the amount of material present in the density range +- 2 x EPM is typically very high and, as a result, high amounts of misplaced material result. This must be taken into consideration when dry processing of raw coal is contemplated since the misplaced material will result in a lower product yield compared to dense medium processing and will furthermore make control of the product quality difficult.

## 5. IMPLEMENTATION OF DRY BENEFICIATION PROCESSES

The advantages offered by dry processing, especially the low cost, the low environmental impact as well as the fact that these plants can be constructed and commissioned in a short time, make it a very attractive proposition for a coal producer – especially for a small company with limited funds available. Modern dense medium plants in South Africa, used to prepare thermal coal for Eskom , typically employ dense medium cyclones to process a de-slimed feed. The feed to the plant is de-slimed at about 1 mm and the minus 1 mm coal is processed with spirals. Due to the restriction placed by Eskom on the amount of fine coal in the final product, the spiral product is often not included in the Eskom product and is sold into other markets. Some mines even discard the minus 1mm raw coal. It is fairly common practice to crush the raw coal to a top-size of 50 mm prior to processing.

A dry beneficiation plant may consist of a XRT sorter and a FGX unit. In this case, the raw coal to the plant would be crushed to say 100 mm top-size and dry screened at 50 mm and 6 mm. The 100x 50 mm size fraction would be sent to the XRT sorter, the 50x 6 mm coal to a FGX and the minus 6 mm coal would be routed to the product conveyor. The sorter product would be crushed to minus 50 mm top-size to meet the size specification. An alternative arrangement is a FGX-only plant in which case all the raw coal is crushed to 50 mm top-size prior to processing. The minus 6 mm may still be removed from the FGX feed. This arrangement is presently used at one of the FGX plants in operation in South Africa

The capital cost of a dry beneficiation plant is approximately one quarter to one third of that of a dense medium plant of equivalent capacity. The operating costs are also about one third to one half that of a dense medium plant. It should be appreciated that the capital and operating costs of plants depend to a very large degree on the specific configuration of the plant and it is therefore difficult to provide exact capital and operating costs for the different types of plant. Other than the fact that dry processing does not require water and the advantages arising from this, the main motivation for its use is that dry processing is less expensive than conventional processing. As shown earlier, dry processing is less efficient than wet processes and hence it is necessary to consider the economic impact of the lower product recovery from raw coal mined and processed.

## 6. ECONOMIC COMPARISON

A comparative financial evaluation was carried out to illustrate the potential economic advantage/disadvantage of using dry processing to prepare coal for power station use when processing raw coal from the No. 2 Seam of the Witbank coal field. The evaluation compares dry processing to dense medium processing of the same coal. A hypothetical mine with a ROM production of three million tonnes per year was used as the basis. It was assumed that the mine produces a product with a calorific value of 21 MJ/kg (air-dry) and that this is done by crushing the raw coal to a top-size of 50 mm, screening the coal to remove the minus 6 mm and processing only the plus-6 mm fraction. The minus 6 mm size fraction constitutes 30 % of the feed coal. The raw minus 6 mm coal is assumed to have an ash content of 30% and a calorific value of 21 MJ/kg. The plant is taken to be in operation for 6000 hours per year and therefore the nominal capacity of the plant will be 500 tonnes per hour. Of this tonnage, 30% (150 tonnes per hour) is minus 6 mm coal which will be screened from the feed and sent directly to final product. The plus 6 mm coal will be beneficiated and the required capacity of the coarse coal processing equipment is therefore 350 tonnes per hour. For the dry processing option, a FGX will be employed and for the dense medium option, a dense medium cyclone. The washability of the plus-6 mm size fraction coal is given in Table 6.

Table 6: Washability data for 50 x 6 mm coal

| Relative Density | | Yield % | CV MJ/kg | Ash % |
|---|---|---|---|---|
| F @ | 1.4 | 2.8 | 28.2 | 10.7 |
| F @ | 1.5 | 14.1 | 25.4 | 18 |
| F @ | 1.6 | 18.3 | 23 | 22.7 |
| F @ | 1.7 | 17.9 | 19.6 | 32.2 |
| F @ | 1.8 | 10.3 | 16.6 | 39.3 |
| F @ | 1.9 | 6.8 | 15.2 | 44.4 |
| F @ | 2.0 | 4.9 | 12.5 | 50.1 |
| F @ | 2.1 | 3.5 | 7.8 | 61 |
| F @ | 2.2 | 4.2 | 5.9 | 66.2 |
| F @ | 2.3 | 5.6 | 2.6 | 72.7 |
| F @ | 2.4 | 3.3 | 2.2 | 76.5 |
| S @ | 2.4 | 8.5 | 0.3 | 78.7 |
| Raw | | 100 | 16.18 | 40.4 |

Simulated processing of the coal with a FGX and a dense medium cyclone respectively results in the following yields, qualities and efficiencies.

Table 7: Comparative processing results on + 6 mm size fraction

| Parameter | FGX | DM |
|---|---|---|
| Feed % Ash | 40.4 | 40.4 |
| Product % Ash | 30.65 | 28.56 |
| Product CV (MJ/kg) | 20.12 | 21.00 |
| Discard % Ash | 52.3 | 69.5 |
| Product Yield | 55.0 | 71.0 |
| D50 cut-point RD | 1.80 | 1.91 |
| EPM | 0.252 | 0.023 |
| Organic Efficiency % | 71.1 | 99.8 |
| Sink in float % | 8.9 | 0.6 |
| Float in sink % | 17.1 | 0.3 |
| Total misplaced % | 26.0 | 0.9 |
| Near-dense material | 17.1 | 11.2 |

The final product, inclusive of the raw minus 6 mm coal, has the following qualities

Table 8: Final product quality and yield

| Parameter | FGX | Dense medium |
|---|---|---|
| Product total moisture % | 7.5 | 10.4 |
| Product CV (MJ/kg air dry) | 20.51 | 21 |
| Product CV (As received) | 19.69 | 19.54 |
| Product yield (% of plant feed) | 68.54 | 79.75 |

As expected, the dense medium process product yield is significantly higher than that of the FGX. The FGX also fails to produce a 21.0 MJ/kg product, since a cut-point density of less than 1.80 is required which is normally not possible with this type of equipment. Due to the lower moisture content of the FGX product, though, it has a slightly higher as-received heat value than the dense medium product. The lower yield obtained from the dry process may be, to some extent, off-set by the lower capital and operating cost. However, the question is whether it is economically viable in the longer term to implement dry processing. The following analysis aims to answer this question.
To facilitate the comparison, approximate capital and operating costs are assumed and listed in Tables 9 and 10.

Table 9: Approximate capital and operating cost (South African Rand values)[a]

| Type of Plant | Capital cost (Rand/tonne per hour feed) | Operating cost (Rand per feed tonne) |
|---|---|---|
| FGX | R 50 000 | R 5.50 |
| Dense medium | R 200 000 | R 17.00 |

[a] *These costs relate only to the processing plant and exclude crushing/screening of raw coal and disposal of rejects*

Table 10: Other operating costs

| Item | Cost (Rand) |
|---|---|
| Mining cost - Rand per ROM tonne | R 100.00 |
| Crushing/screening of ROM | R 2.50 |
| Disposal of discards – Rand per tonne | R 2.50 |

The capital and operating costs shown in Table 9 relate to the processing plant only. The raw coal preparation and handling as well as the product handling systems will be similar for both types of plant – it is assumed that the capital cost of the raw coal crushing and screening section and the product handling section amounts to R15 million. Operating costs are as shown in Table 9. Using the capital cost as shown in Table 9, the comparative capital cost for a FGX plant and a dense medium cyclone plant to process 350 tonnes per hour of plus 6 mm raw coal will be:

Table 11: Capital cost (South African Rand)

| Dry processing | Dense Medium |
|---|---|
| 17 500 000 | 70 000 000 |

It is assumed that the product coal is sold on a FOR (free-on-road) basis at a price of R 8.70 per gigajoule. The product from the FGX, due to the lower moisture content, has a heat value of 19.69 GJ per tonne (on an as-received basis) compared to that of the dense medium product at 19.54 GJ per tonne. The FGX product selling price is thus slightly higher than that of the wetter coal from the dense medium process – R 171.28 per tonne versus R170.00 per tonne. Using the data shown above, and an interest rate of 12% for borrowing capital, the following values result from an economic analysis of the two processing options:

Table 12: Outcome of financial calculations

| Case | Dry processing | Dense medium |
|---|---|---|
| Product t/annum | 2055000 | 2391000 |
| Discard t/ annum | 945000 | 609000 |
| CV of product (MJ/kg) | 20.51 | 21.00 |
| Ash content of product | 30.37 | 30.00 |
| Surface moisture of product | 4.0 | 7.0 |
| Inherent moisture of product | 3.6 | 3.7 |
| Total moisture of product | 7.46 | 10.44 |
| FOR price/tonne | R 171.28 | R 170.00 |
| *Sales revenue per annum x 1000* | R 366 646 | R 437 064 |
| *Operating cost per annum: x 1000* | | |
| Mining | R 300 000 | R 300 000 |
| Crushing & screening | R 7 500 | R 7 500 |
| Processing | R 11 550 | R 35 700 |
| Discard disposal | R 2 362 | R 1 522 |
| Total operating cost per annum | R 321 412 | R 344 722 |
| *Capital expenditure:* | | |
| Processing plant | R 17 500 000 | R 70 000 000 |
| Raw coal / product handling | R 15 000 000 | R 15 000 000 |
| *Total capital cost* | R 32 500 000 | R 85 000 000 |
| Contribution per annum | R45 233 750 | R92 342 016 |
| Payback Period (years) | 0.72 | 0.92 |
| Return on Investment ratio | 0.39 | 0.09 |

The results show that the FGX option has a shorter payback period than the dense medium option and it furthermore has a higher return on investment ratio. The contribution per annum, due to the lower product yield, is however much lower than that of the dense medium option. The net present value (NPV) of the two investments over time is summarized in Table 12 and shown graphically in Figure 8.

Table 13: NPV versus time

| Years | FGX | Dense medium |
|---|---|---|
| 1 | R 7 887 277 | (R 2 551 771) |
| 2 | R 43 947 345 | R 71 062 719 |
| 5 | R 130 557 546 | R 247 872 302 |
| 10 | R 223 080 776 | R 436 752 986 |
| 15 | R 275 580 942 | R 543 928 959 |
| 20 | R 305 370 946 | R 604 743 484 |

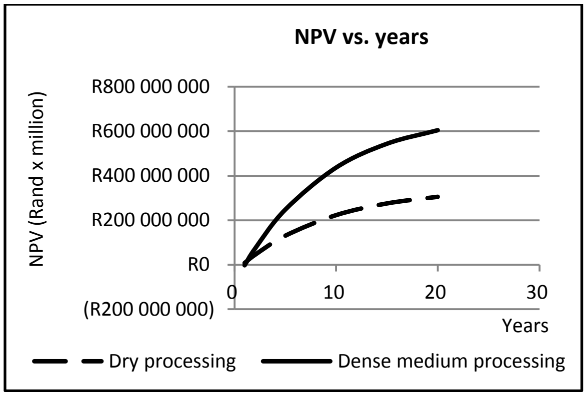


Figure 8: NPV versus Time

The low capital and operating cost of the FGX option result in a positive NPV value at the end of year 1 whilst the dense medium option still shows a negative NPV. However, after year 2, the dense medium option has a higher NPV value than the dry processing option. The dense medium option's NPV continues to increase as a higher rate than that of the dry processing option due to the higher annual contribution.

It therefore seems, from the analysis carried out, that dry processing of coal is a good choice for short-term projects – for example re-working of discard dumps or processing of small coal reserves. For longer term projects, dense medium processing is more economical, despite the higher capital and operating costs.

The example presented here is intended only to illustrate that low capital and operating costs alone are not always reason enough to implement specific technologies since the loss of product yield due to low recovery efficiency can more than offset the advantage of low cost. The case presented is very specific and should not be considered the norm since a number of other considerations should be kept in mind namely:

- The availability of water for processing
- The location of the mine and the customer
- The specific nature and washability characteristics of the raw coal
- The specifications and price of the product coal
- The degree of control of product quality required and the implications of delivering out-of –specification coal
- The availability of electricity and other infrastructure
- The cost and availability of labor in the area
- The duration of the project

Dense medium offers the best control over the product quality whereas it is very difficult to control the quality of the product from the FGX and this should be taken into consideration when deciding on the appropriate processing technique to opt for in a specific case. If no water is available for wet processing of coal, then the FGX becomes the only viable option. In the case of projects where the duration is short, for example the reclamation of coal from a discard dump, which may last only a few months, the FGX becomes a logical choice for a number of reasons listed below:

- The FGX plant can be constructed in a very short time
- The necessary environmental clearance is much less complicated than for wet processing plants
- Almost no infrastructure is required – a small FGX plant can be run from a portable diesel generator
- The plant can be easily and inexpensively re-located after completion of the project

## 7. CONCLUSION

Dry processing equipment is inexpensive to purchase and operate but does not provide efficient separation. It will not always be able to upgrade raw coal to the required quality – especially when the coal contains high amounts on near-dense material. In specific cases, where the coal is easy to process, where there is a shortage of water and when only de-stoning of the coal of the coal is required, dry processing technologies may prove the most viable processing option. It is, however, necessary to consider all aspects of each application.

## 8. REFERENCES


1. de Korte, G.J. 2010. Report on a test conducted on the Middelkraal FGX dry coal separation plant on 22 November 2010. CSIR/CMI/NMM/ER/2010/0021/B

2. de Korte, G.J. 2012. Report on a test conducted at Msobo Coal to determine the de-stoning potential of the Commodas X-ray sorter. CSIR/CMI/NMM/ER/2012/0022/B

3. Van der Walt, PJ. 1982. Advances in Coal Washery Performance in South Africa. Thesis submitted to the University of Cape Town in fulfillment for the degree of Doctor of Philosophy. June 1982.