OPTIMAL UTILIZATION OF DENSE MEDIUM CYCLONES

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SUMMARY

The current (1st & 2nd Quarter 2015) world outlook for the coal industry is looking negative with the coal price hovering around $60/metric ton, the environmental pressure piling up to reduce our dependence on coal for electricity supply and the overall world economy growth rate not looking too positive.

In the South African context, over and above the international situation, reliable energy supply dominates the news with load shedding adding to the problems of an already struggling coal industry.

Eskom indicated that there are plans to increase the number of power stations and that an additional 20 million metric tons per annum will have to be sourced for these new power stations (David McKay,2015).

The situation may appear challenging but are we currently maximising our process performance and do we understand the impact of inefficiency when we are ‘sweating our assets’ to above design levels?

In this paper the focus will be on how to maximise the current dense medium cyclone process to ensure optimal efficiencies and maximum product recovery while also considering how the washability characteristics of the coal influences the process performance.

INTRODUCTION

In a recent survey by Ernst & Young Global Limited, 2014, the top risk in many commodity groups including the coal industry, has been identified as productivity improvement.

With specific focus on the coal processing plant some of these productivity improvements and cost reduction factors may include:

- Increase in solids throughput
- Reduced maintenance cycles
- Reduced consumption of consumables e.g. magnetite
- Reduced energy usage.

While these factors are necessary for survival, it is sometimes necessary to stand back and evaluate the effects on the overall process and specifically for this paper, on the effect it could have on dense medium separation cyclones.

THE DENSE MEDIUM CYCLONE CIRCUIT

A typical dense medium cyclone (hereafter referred to as DMC) circuit can be seen in Figure 1 where the location of the DMC can be seen in relation to other process equipment.

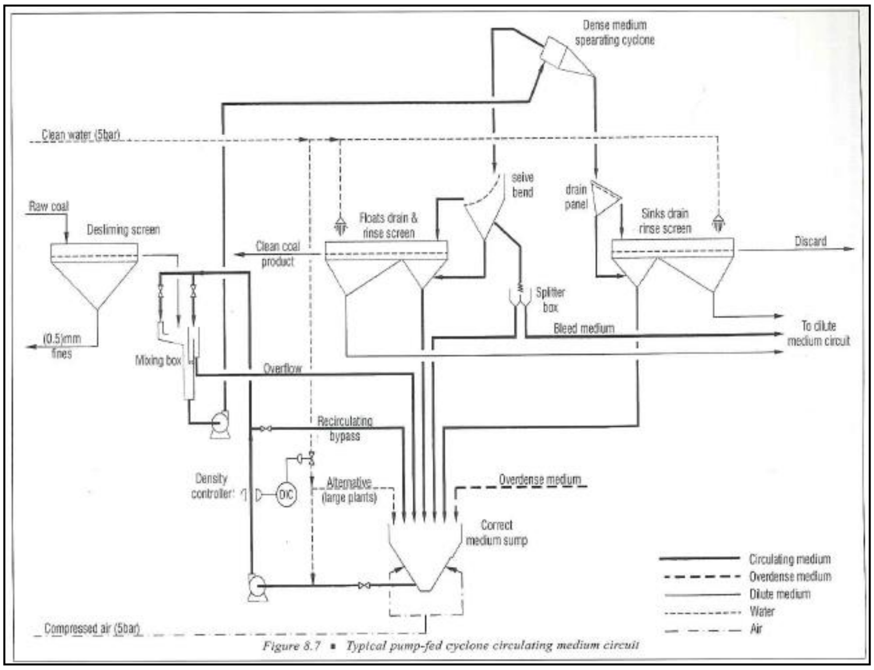

Figure 1: Typical Dense Medium Cyclone Circuit (Source: Coal Preparation in South Africa)

Although the DMC is just another piece of equipment in the overall process, this unit is responsible for separating the incoming ore into valuable and non-valuable fractions as efficiently as possible and within a limited time frame. In Figure 2 an indication is given of the monetary value per second separation time inside a DMC vs. throughput.

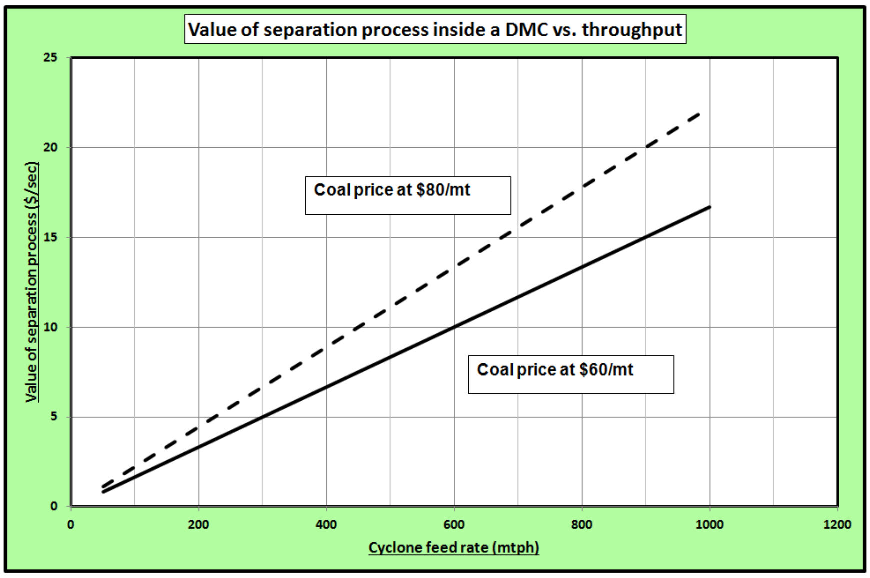

Figure 2: The value of separation inside a DMC at various feed rates

To ensure optimal efficiency from a dense medium process in order to increase productivity and maximise revenue, optimal separation efficiency is therefore required from the DMC as revenue can be generated or destroyed in seconds.

In the following sections the effect of the above mentioned productivity improvement and cost reduction factors will be discussed and its effect on the DMC evaluated against two types of washabilities, one consisting of a high amount of near dense material and one with a low amount of near dense material, both based on the +/- 0.1RD reference.

DETERMINING THE EFFICIENCY OF A DMC

In the evaluation reference is made to terminology that requires a brief description below.

The partition curve and cut density

The efficiency of separation in a DMC is normally expressed via a partition curve generated from sample analyses or tracer tests. An example of such a curve can be seen in Figure 3.

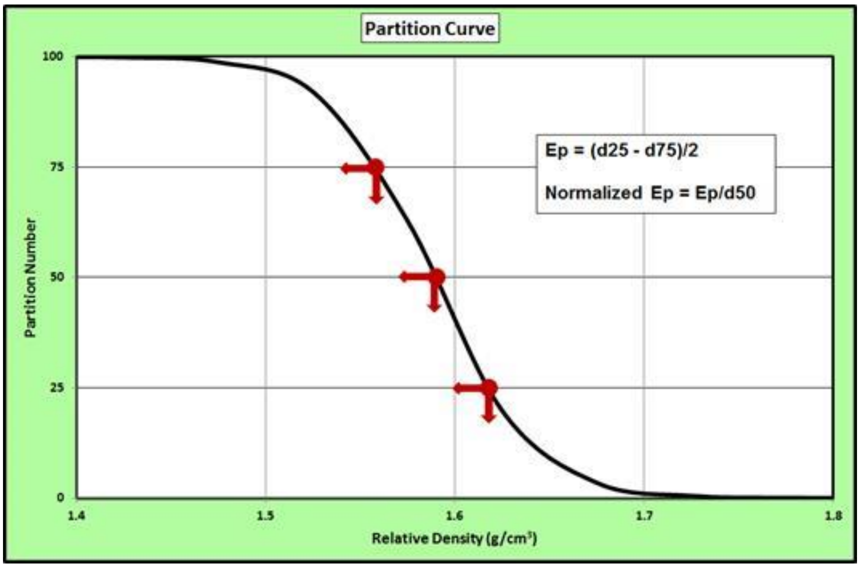

Figure 3: An example of a DMC partition curve

The steepness of the slope of the curve determines the separation efficiency with a steeper slope indicating higher separation efficiency. The reference points are normally the 25/75 partition numbers but it can also be 10/90 or 5/95 depending on the process requirements and this value is referred to as the EP value of the separation and is defined as:

$$EP = \frac{d_{25} - d_{75}}{2}$$

To allow for the evaluation of various dense medium separation equipment or for similar units operating at various separation densities, normalised partition curves are used where the effect of different EP values at different cut densities is being removed by dividing the EP value by the cut density and is defined as:

$$Normalized\ Ep = \frac{d_{25} - d_{75}}{2 * d_{50}}$$

The cut density (d_{50}) then obtains a value of 1 for all the partition curves which allows one to determine the best performing unit or conditions.

The DMC efficiency is therefore not only influenced by the steepness of the partition curve but also the cut density and these factors are seldom considered together when optimising the performance of the DMC as discussed later in this paper.

Organic Efficiency

Organic efficiency is defined as the ratio between the actual yield and theoretical maximum yield for the same ash level and is usually expressed as a percentage. The organic efficiency is an indication of how the actual separation process performs compared to ideal separation conditions.

The organic efficiency is influenced by the washability characteristics of the material in terms of the amount of near density material as well as the equipment separation efficiency (EP).

Before the equipment performance can be judged based on the organic efficiency results the difficulty of separation or amount of near dense material in the feed material should be determined as this influence the maximum obtainable values.

DESCRIPTION OF THE PROCESS PLANT USED IN THE EVALUATION

Plant flow diagram and Financial factors used

In order to evaluate the effect of the productivity improvement and cost reduction factors mentioned earlier, a plant model was used consisting of a basic DMC circuit and with the fines being discarded as seen in Figure 4.

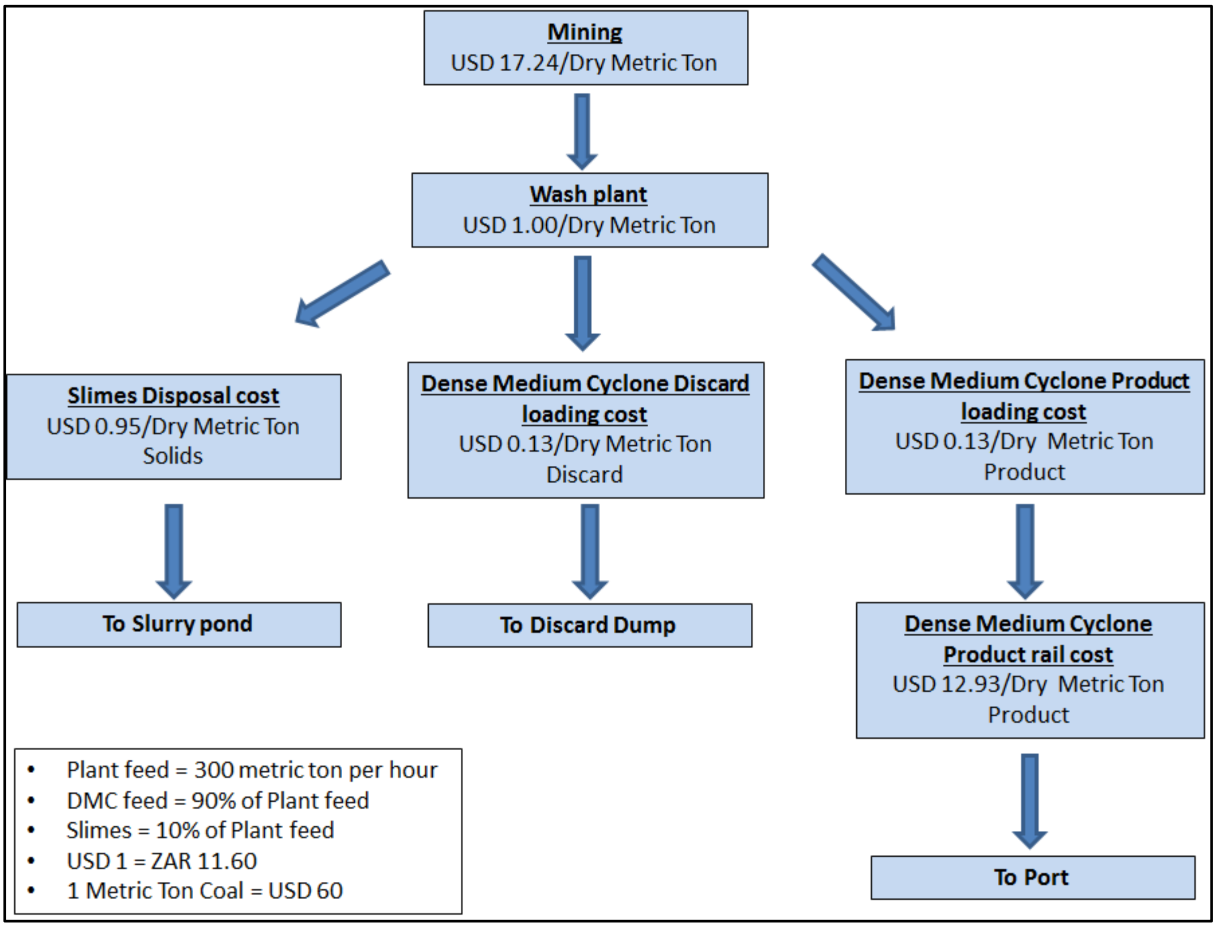

Figure 4: Description of Plant Model used in the simulation

In order to understand the financial implications operational cost were allocated to the main operations. <u>These costs are indicative only and were generated solely for the purpose of the simulations. Where possible, values were checked against the industry norm to try and provide realistic answers.</u>

Washability characteristics of the samples used in the evaluation

To allow for a better understanding of what impact the productivity improvement and cost reduction factors can have on the overall process, two different washabilities were used. The difference is the amount of near density material (+/- 0.1RD) present around the cut densities used in the simulation as seen in Figure 5.

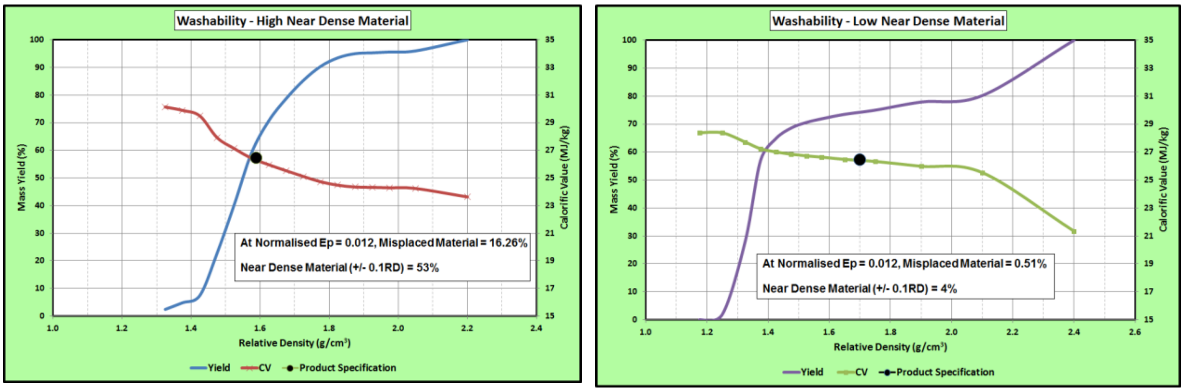

Figure 5: The two washability scenarios used in the evaluation

In all scenarios a product quality of 26.48MJ/kg Gross Calorific Value was used (Net Calorific Value of 6000kcal/kg) which is represented as a black dot on the graphs.

The revenue calculated in this evaluation is based only on the information supplied in Figure 4 and has been used for comparative purposes only. No attempt has been made to calculate the profit in these examples due to lack of information.

The objective of this evaluation is to try and put into perspective the financial impact operational factors have on the process by relating it to the separation efficiency or EP value of the DMC and the effect of changing cut densities. Further down in this paper the relationship of separation efficiency and energy utilization will be explored.

IMPACT OF PRODUCTIVITY IMPROVEMENT AND COST REDUCTION FACTORS ON THE DMC PERFORMANCE AND REVENUE

The effect of separation efficiency with different ore washabilities

The importance of low EP values on dense medium separation equipment is well documented and understood. The current economic climate has also assisted in operations paying renewed attention to maximising equipment efficiency.

Based on the plant parameters provided in Figure 4 the effect of EP on the revenue being generated by this process is shown in Figure 6 and 7 where the two different washabilities have been evaluated.

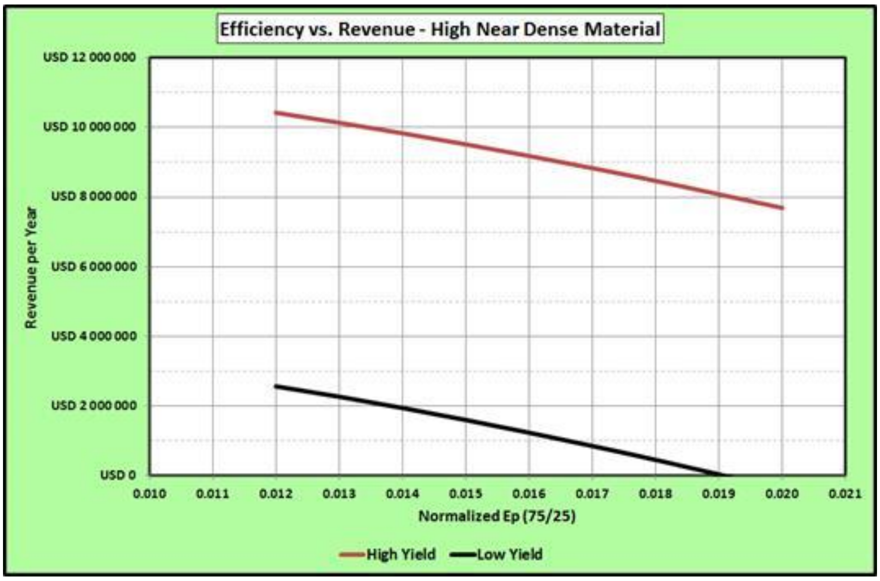

Figure 6: Effect of separation efficiency on revenue for ore containing a high amount of near dense material

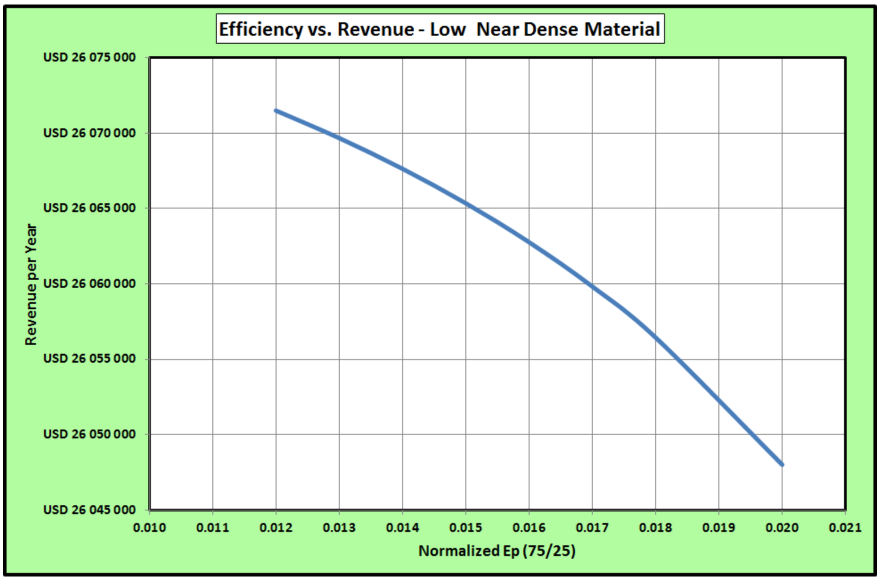

Figure 7: Effect of separation efficiency on revenue for ore containing a low amount of near dense material

From Figure 6 it can be seen that the impact of lower separation efficiencies on operations processing high near dense material ore is significant. With operations operating at lower yields, lower separation efficiencies can easily result in operations starting to operate at a loss as separation efficiency deteriorates. Ensuring optimal equipment performance is therefore of utmost importance for operations processing high near dense ore.

On the contrary Figure 7 indicates that operations processing ore containing ore with low amounts of near dense material could actually tolerate lower separation efficiencies without resulting in a dramatic reduction in revenue.

The objective is obviously to maximise the revenue stream in any process but having a basic understanding of how efficiency impacts on the financial position of an operation can help operational personnel understand why certain cost saving measures might not always provide the desired results.

Increased plant throughput

In order to improve productivity and reduce operational cost one option is to increase the plant feed rate which sometimes exceeds design. These levels are then maintained unless frequent blockages are being experienced which would be an indication that the limitations of the equipment or process has been reached.

By operating at the higher feed rates and assuming no operational problems are being experienced, some other factors can start to influence the efficiency of separation in the DMC process (E.Bekker, 2014).

For the purpose of this discussion two factors will be focussed on namely the medium to coal ratio to the DMC and the effect the desliming process can have on the DMC performance.

Medium to Coal ratios

In the design of a DMC the volumetric flow rate to the unit is dictated by the solids feed rate and the volume of medium required for an efficient separation process. Different medium to coal standards exits for the different industries dense medium separation is used in and it mainly depends on the washability characteristics of the ore, the type of ore and the value of the commodity. In the coal washing industry the medium to coal values typically range from 3.5:1 to 4.5:1.

In designing the dense medium process the design houses typically ensures that the minimum medium to coal ratios are still being adhered to under maximum feed conditions. However, once the plant design feed rate is being exceeded, these medium to coal ratios can drop to values which start to impact on the DMC separation efficiency as can be seen in Figure 8. Similar trends have also been reported by others (Swanson, A & Atkinson, B, 2007)

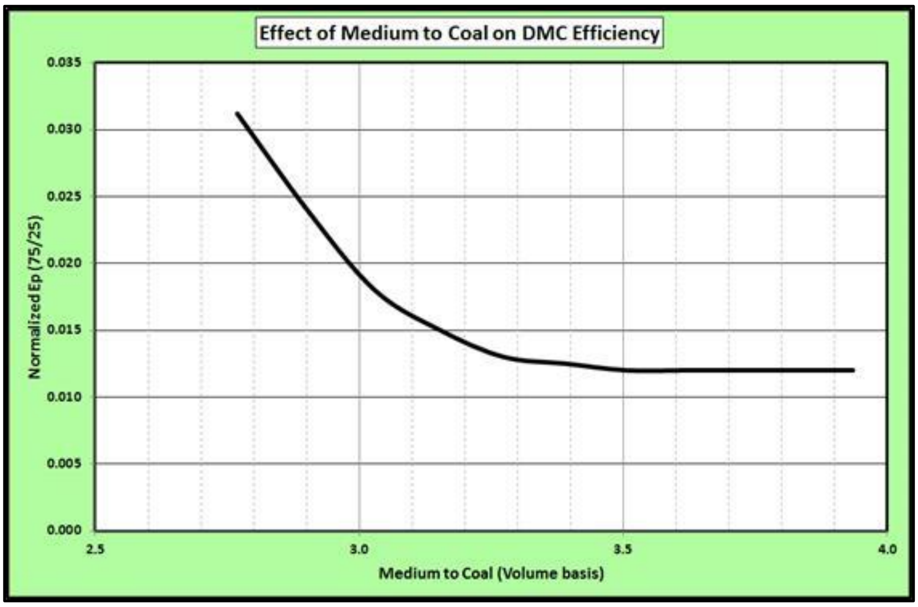

Figure 8: Effect of Medium to coal on the DMC separation

When the feed rate to the process is increased, the medium to coal ratio generally decrease since adjustments are seldom made to the medium flow rate since either pumps have to be changed or the drainage capability of the drain and rinse screens are becoming limiting factors.

The effect of the lower medium to coal ratio is therefore seldom further investigated and the feed rate is increased until a visual problem is identified for example an overloaded DMC spigot when the discharge capacity has been exceeded.

Increasing the feed rate does increase the amount of revenue being generated but as the efficiency of separation starts to decline losses start to appear as seen in Figure 9.

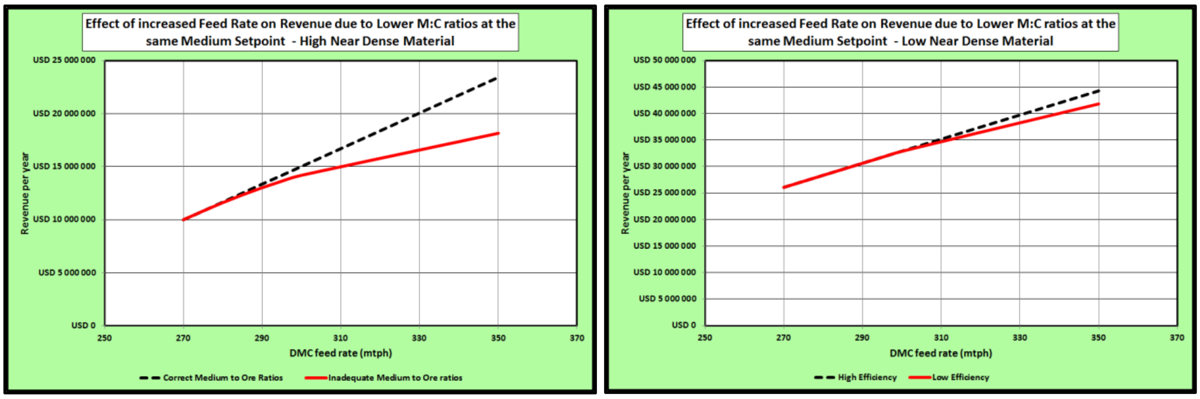

Figure 9: Effect of inadequate medium to coal ratios on revenue for high and low near dense material ore

The data depicted in Figure 9 is based on the plant operating at 3.5:1 medium to coal ratio which decreases as the feed rate is increased. The efficiency of the DMC is based on the information depicted in Figure 8. In this example the DMC spigot capacity has been adjusted to accommodate the larger discard or reject tonnages associated with the larger feed rates.

It is important to note the effect the washability of the material has on the financial performance of the process. The easier the separation becomes the more tolerant the process performance becomes to equipment inefficiencies although financial losses will still be incurred.

Desliming screen performance

With the increase in feed rate to the dense medium process the desliming screen performance can deteriorate due to the screen's capacity being exceeded. This can allow for unwanted fines entering the DMC circuit resulting in lower DMC efficiencies and also possible medium contamination (E.Bekker, 2014).

There is however another problem and that is the effect that the increased water carry-over will have on the actual cut density inside the DMC unit. The medium density is measured normally on the correct medium pipe line before it mixes with the ore and thus any water entering the medium circuit after the densitometer location is not accounted for. This is usually corrected by adjusting the medium set point if the product quality specification is not being met anymore.

The dilution effect mentioned here is not due to a decrease of drainage area that may result in water carry-over from overloading the desliming screen. It is the surface moisture effect that is being referred to which can only be removed by increasing the screen's G forces or adding a surfactant to reduce particle surface tension.

The effect of increased feed density dilution due to increased surface water is shown in Figure 10. In this evaluation the DMC efficiency has remained unchanged to illustrate the dilution effect on the process and no correction has been made to maintain product quality.

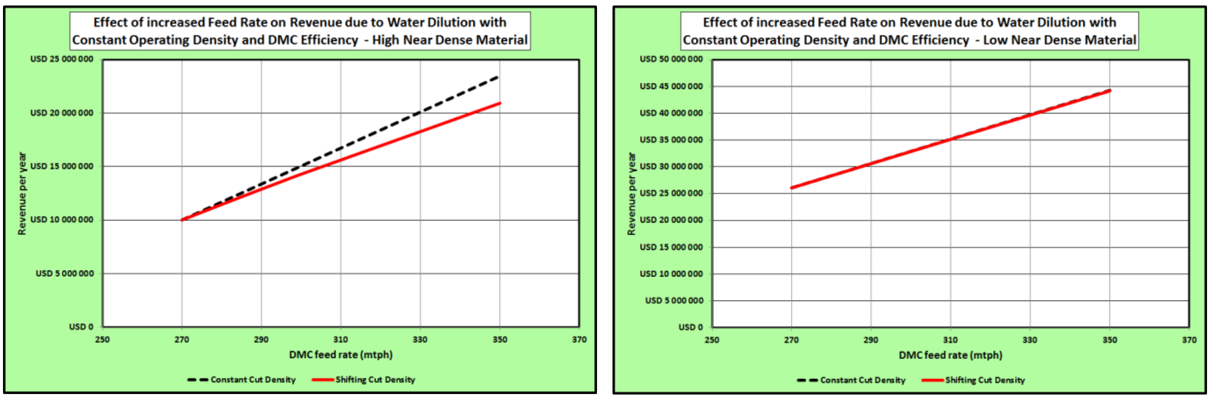

Figure 10: Dilution effect of surface water with increased feed rate on the DMC performance

The increased dilution that occurs from the surface water being introduced has a more pronounced effect on the high near dense material ore due to the sensitivity of shifting cut densities on the yield achieved.

Note that these changes occur without the adjustment to the medium set point. Operational personnel may therefore still believe that the DMC is operating at the correct cut density.

The combined effect of medium to coal and dilution

With increased feed rates the combined effect of reduced medium to coal ratios, which reduces the DMC efficiency, and the dilution effect that shifts the actual cut density inside the DMC cyclone is shown in Figure 11.

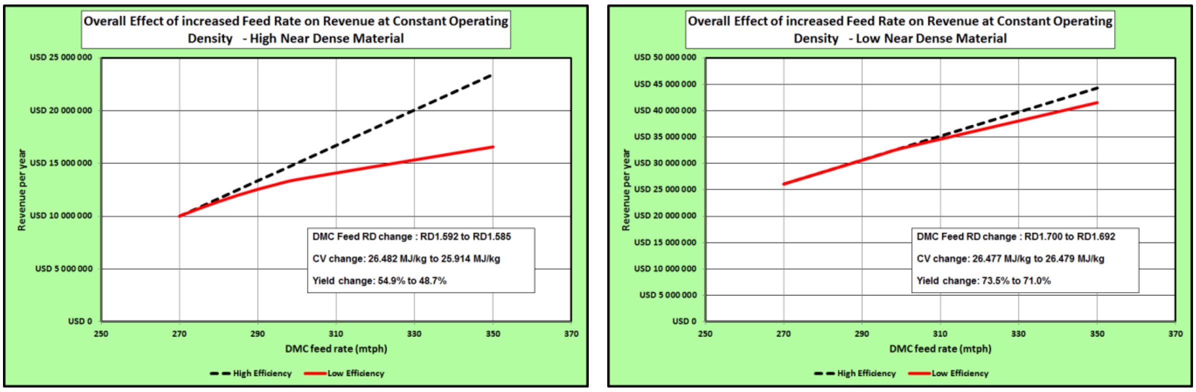

Figure 11: Combined effect of reduce medium to coal ratios and increased dilution due to increased feed rates for high and low near dense material ore.

The argument can well be that this situation can be compensated for by adjusting the cyclone feed density to correct for the deviation from the product specification and this is true provided this change can be noticed.

In Figure 12 two hourly results from a typical operation which uses mechanical sampling is shown together with the change in quality that results from the increased feed scenario for the high near dense material. The mechanical samplers employed by this mine are well maintained and serviced and the spread in results is attributed to the variability of the ore being treated.

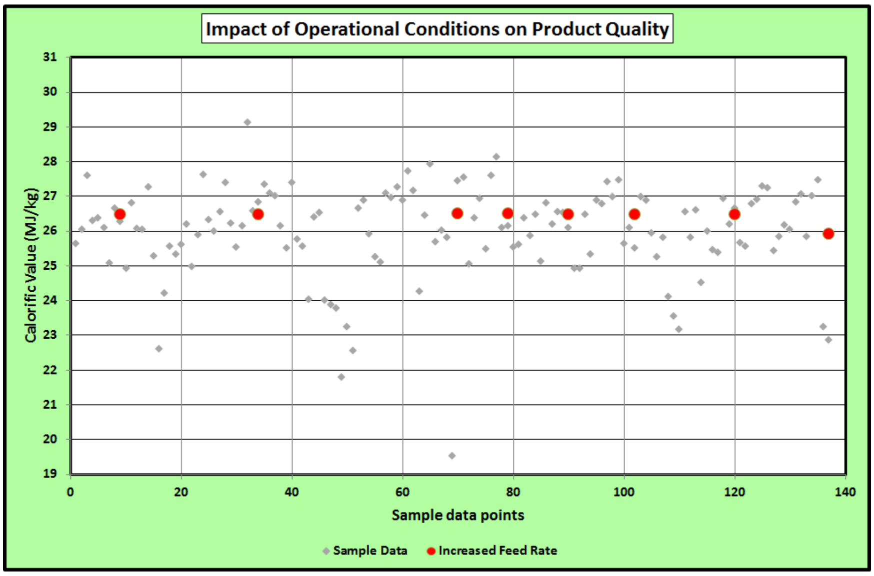

Figure 12: Effect of increased feed rates to the DMC and product quality, superimposed on actual plant sampling data

The low near density results has not been shown due to the small change in product quality across the feed rate range as can be seen in Figure 11.

It would therefore be a very difficult if not impossible task to correct for changing product qualities with increasing feed rates because of the spread in results that occurs on a day-to-day basis.

It is therefore important to understand the effect that increased feed rates have on the plant performance and the financial implications associated with these actions to then try and mitigate these effects via proactive changes like measuring desliming screen moisture contents and adjusting densities accordingly even though the actual sampling data may not show any deviation.

The effect of medium quality

In order to reduce cost operations has started to focus in more detail on magnetite medium usage and consumption. Operations try to increase the make-up intervals of fresh medium into the circuit and operate for as long as possible on current medium inventory.

Since the recovery efficiency of finer magnetite is lower compared to the coarser size fractions the magnetite medium grade inside the dense medium operation progressively becomes coarser over the time period that it remains in the circuit.

The effect of a coarser magnetite medium on the DMC efficiency is shown in Figure 13 based on data presented by others (G.J. de Korte and J. Engelbrecht, 2007).

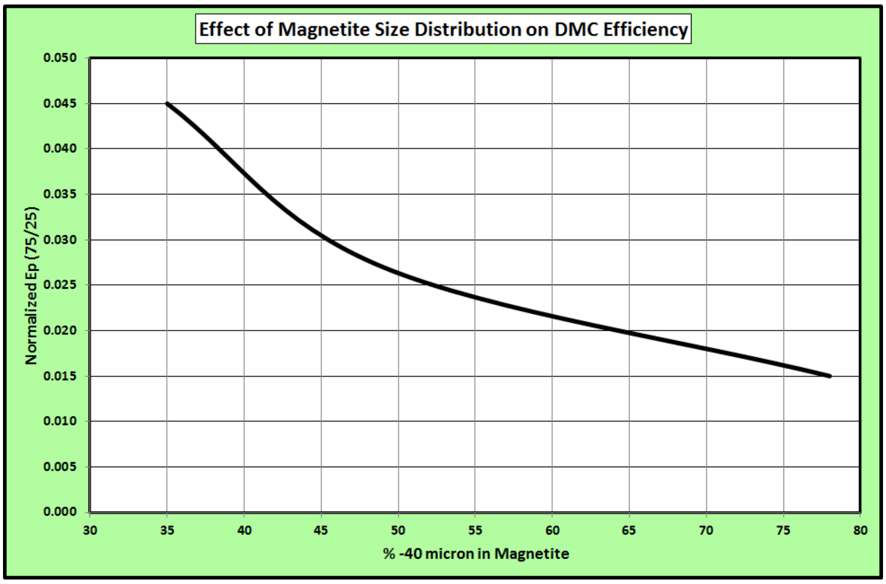

Figure 13: The influence of the magnetite size distribution on the efficiency of the DMC

As seen in Figure 6 & 7, the financial impact of poor DMC efficiency can be substantial and will easily offset the cost of replenishing the magnetite inventory on a more regular basis.

One of the reasons for the deterioration of the DMC efficiency with coarser medium grades is the change in medium differentials that starts to occur across the DMC. In addition to the changes in the differentials across the separation unit, changes to the cut density also starts to occur which will start to influence the final product specification (E. Bekker, 2014). These changes are expected to be too small to be measured via standard sampling techniques and a situation similar to that depicted in Figure 12 is expected.

Regular determinations of the cyclone differentials are encouraged in order to drifting DMC cut densities. The determination of the differentials can be done by obtaining either the feed and overflow medium densities or the overflow and underflow medium densities. The calculation will then be as follows:

$$\frac{Feed\ Rd - Overflow\ RD}{Feed\ RD} * 100 \ = 3\%\ to\ 12\%$$

Or

$$Underflow\ RD - Overflow\ RD \ \geq 0.4$$

Using the feed and overflow density provides a range of values and the reason for this range is shown in Figure 14.

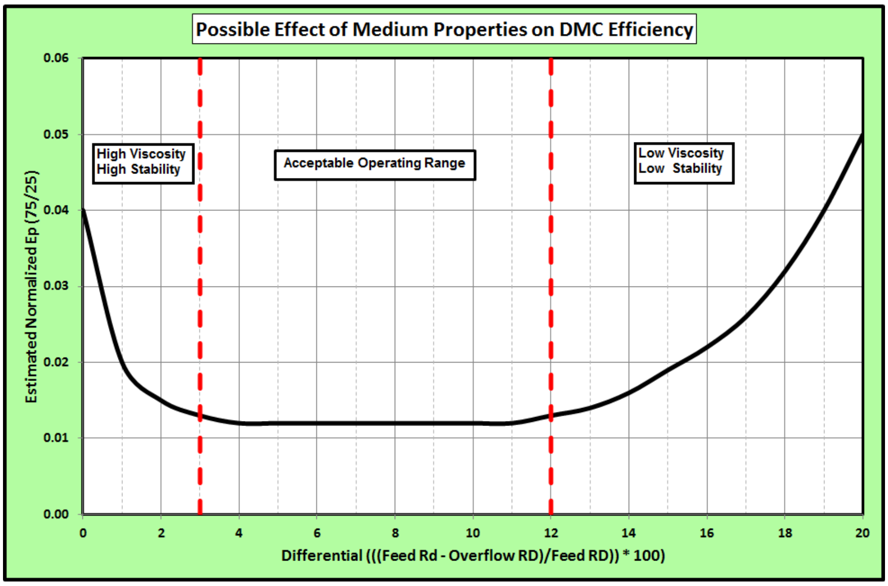

Figure 14: Indication of optimal range of differentials inside a DMC

As seen in Figure 14 the coarser medium effect can start to lead to medium stability problems inside the DMC which will negatively impact on the separation efficiency. The main reason is due to the high degree of medium classification that takes place inside the DMC when becoming coarser.

Another problem that can be experienced in terms of medium quality is that of viscosity or too high stability. This can occur due to a build-up of non-magnetic material inside the medium circuit as a result of misplaced fines to the DMC circuit via ineffective desliming, worn drain panels on the drain and rinse screen or due to fines generation inside the DMC as a result of attrition.

Ineffective desliming could be due to too high feed rates onto the screen, ineffective use of the screen spray water, incorrect panel apertures or the ineffective operation of the screen itself. Worn panels can be associated with an increase in maintenance intervals to reduce downtime, extended replacement intervals of screen panels to try and reduce operational cost or incorrect screen panel aperture selection.

The DMC spigot

The DMC spigot selection is based on the required sinks discharge rate and forms an integral part of the performance of the DMC. Since this portion of the DMC is housed within the underflow discharge collection system frequent inspections are seldom carried out on some of the mines, mainly due to shortage of staff or inaccessibility to this section. Replacement of the spigot only happens then when the complete cyclone is being replaced.

In order for the DMC to operate effectively it is recommended that the spigot diameter do not exceed 85% of the vortex finder diameter. If the spigot is only being replaced when a new DMC unit is installed, there is a good chance that this spigot to vortex finder ratio had been exceeded. The effect of spigot diameter on the DMC efficiency is shown in Figure 15.

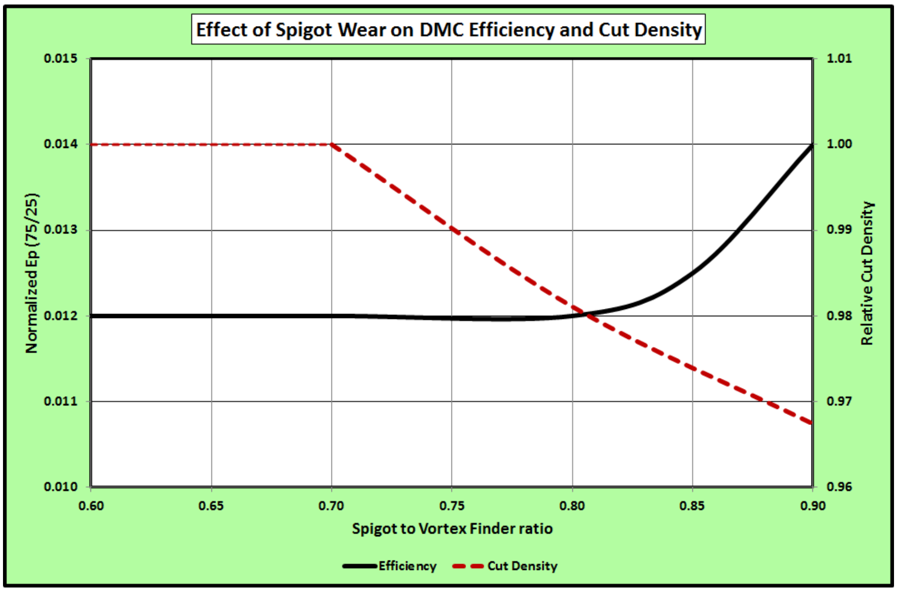

Figure 15: The effect of the DMC spigot diameter on efficiency and cut density

In Figure 15 the effect of a larger spigot to vortex finder ratio is shown and it is generally accepted that as the spigot diameter becomes larger the efficiency starts to drop. A less common known phenomenon is that the cyclone cut density also starts to decrease as the cyclone spigot diameter starts to increase (E.Bekker, 2014).

The combination of both the lower efficiency and change in cut density is shown in Figure 16 for high and low near dense material scenarios.

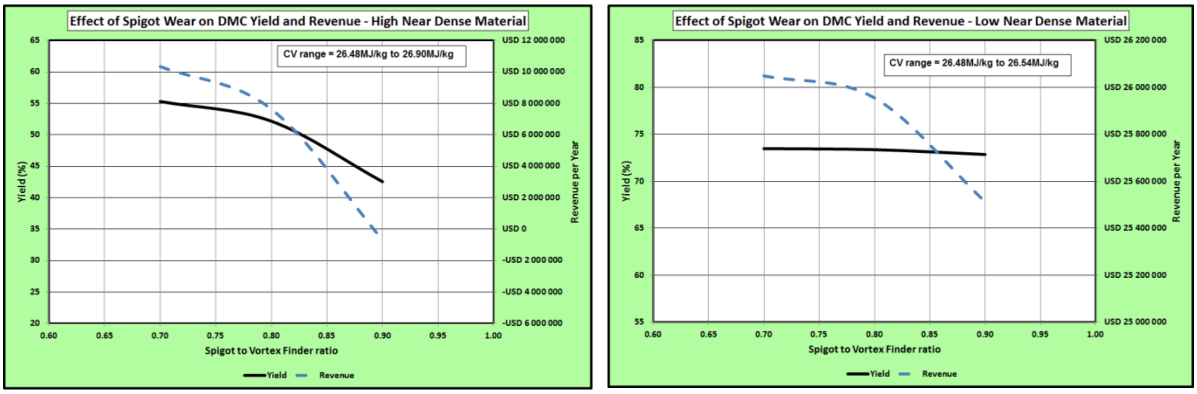

Figure 16: The expected operational impact a worn DMC spigot can have on the process for both high and low near dense material

Form Figure 16 the financial impact on the performance of the operation due to the decrease in yield can be seen. The situation is again similar to that depicted in Figure 12 where this change can occur without being noticed in the sampling results. This change in cut density manifests itself within the DMC without any outside influence from the density set point.

It is normally recommended that the spigot be replaced once it has worn 10% of the original diameter. In many instances the thickness of the wear surface is still sufficient for further operation and therefore the spigot remains in operation for a longer period approaching then the conditions shown in Figure 16.

In the event of using the spigot over an extended period, medium differentials or % misplaced material tests can be used to determine if the unit is still performing adequately. If the spigot to vortex finder ratio is still acceptable, small incremental changes to the medium set point can help to offset the expected deviations that occur within the DMC.

THE IMPACT OF THE DMC PERFORMANCE AND ENERGY UTILISATION

The impact of DMC efficiency on energy recovery

The purpose of mining and the beneficiation of coal is to provide the correct quality product to the various industries that is being served. One of those industries is the supply of coal to power stations, both locally and international. Energy is therefore being recovered from within the earth to be supplied to the population. The aim of any coal mine operation is to do this as efficiently as possible and as profitable as possible.

The impact that the DMC efficiency has on revenue has been assessed on a high level (Figure 6 & 7) in the preceding section but how does the DMC efficiency impacts on the efficiency of energy recovery?

As the DMC efficiency deteriorates the rate at which product is misplaced into the discard stream increases and thus also recoverable energy. This recoverable energy represents energy lost that could have been used to generate electricity. Figure 17 represents the effect for both high and low near dense material.

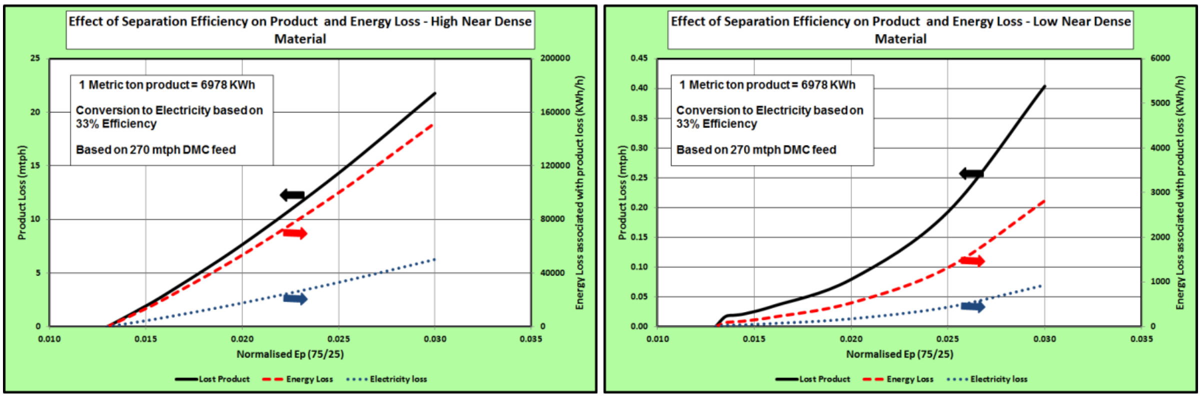

Figure 17: The relationship of lost product and energy available for electricity generation

The product lost contains a certain amount of energy available and based on an efficiency conversion factor of 33%, the electricity amount available from this lost energy source has been calculated.

This therefore represents energy wasted that could have been used to generate electricity. This type of situation can also lead to environmental problems like spontaneous combustion on discard dumps and it also strengthens the negative view that environmentalists have of coal mining.

In addition to this energy loss there is another impact that lower DMC efficiency has on energy and that is the energy required to replace the product that has been lost to waste. The amount of energy required for mining and processing coal has been estimated to range between 18 - 55 kWh/metric ton depending on the mining method (Donald I. Bleiwas, 2011). Based on the product lost depicted in Figure 17, the amount of energy required to replenish this material is depicted in Figure 18.

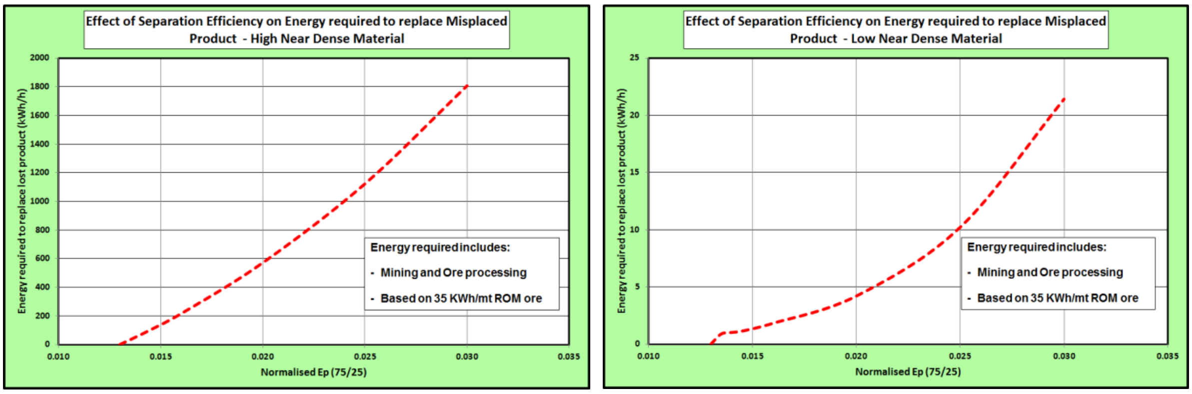

Figure 18: Estimated energy required to replace product lost due to poor DMC efficiency

As expected the energy requirement is much lower for low near dense material due to the small amount of product being lost to discard while high near dense material treatment requires a significant amount of energy due to lost product.

The combined effect of energy loss from both misplaced product and the additional energy required to replace the misplaced product to discard is shown in Figure 19. This energy loss has been put into perspective by relating it to the number of people that could have been supplied with electricity based on an average usage rate.

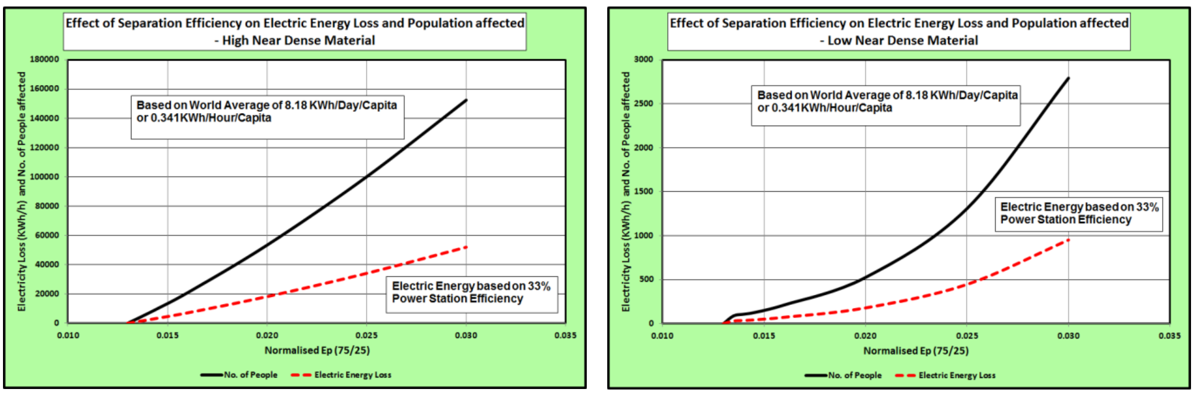

Figure 19: The amount of electric energy lost and number of people affected as a function of DMC efficiency for a 300 mtph coal operation

Poor DMC efficiency therefore not only affects the financial position of an operation but can also affect the social environment by way of energy wastage.

The impact of reducing the DMC operating head

Due to increasing electricity costs some operations has explored the options of reducing the power draw of the DMC pump by reducing the operating head.

A first response would be to advise against this option but in the case where the operation is operating at higher than standard medium to coal ratios and operating heads, there could be merit in exploring this option.

For a constant feed tonnage and a specific cyclone diameter a relationship exists between the medium to coal ratio and DMC operating head as seen in Figure 17.

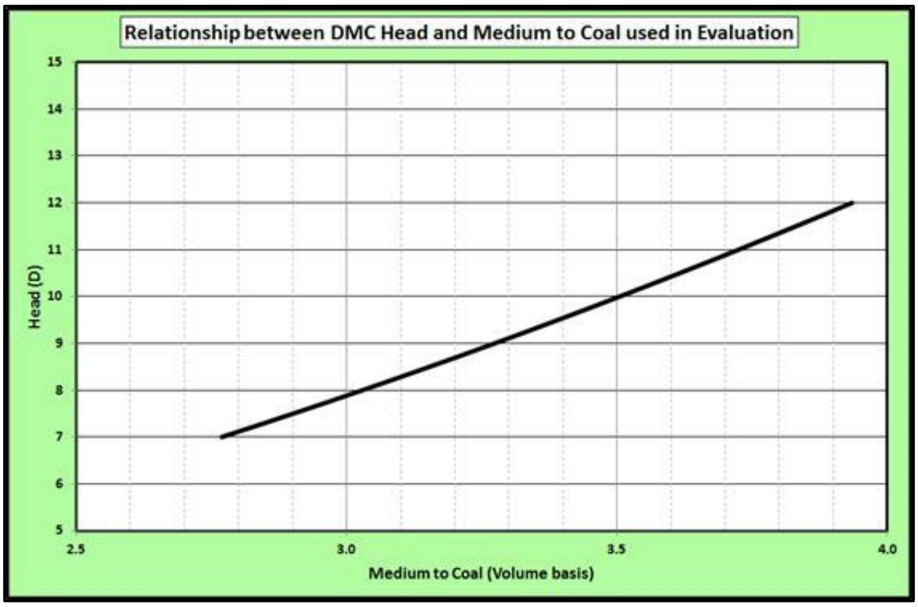

Figure 17: Relationship between the DMC head and medium to coal ratio for constant solids feed rate and fixed cyclone diameter

As seen in Figure 8 there is a minimum medium to coal ratio where after separation efficiency inside the DMC becomes negatively affected but operating at higher medium to coal ratios eventually result in no further efficiency gains.

Should there thus be a situation where the DMC operating head is above recommended standard levels which results in a high medium to coal ratio, the option exists to reduce the operating head and therefore the medium to coal ratio as well. Obviously care must be taken not to reduce the medium to coal levels to below recommended minimum standards.

In this example, using the information in Figure 17, the impact of reducing the operating head to lower levels without sacrificing DMC efficiency was explored. The impact on power draw is shown in Figure 18.

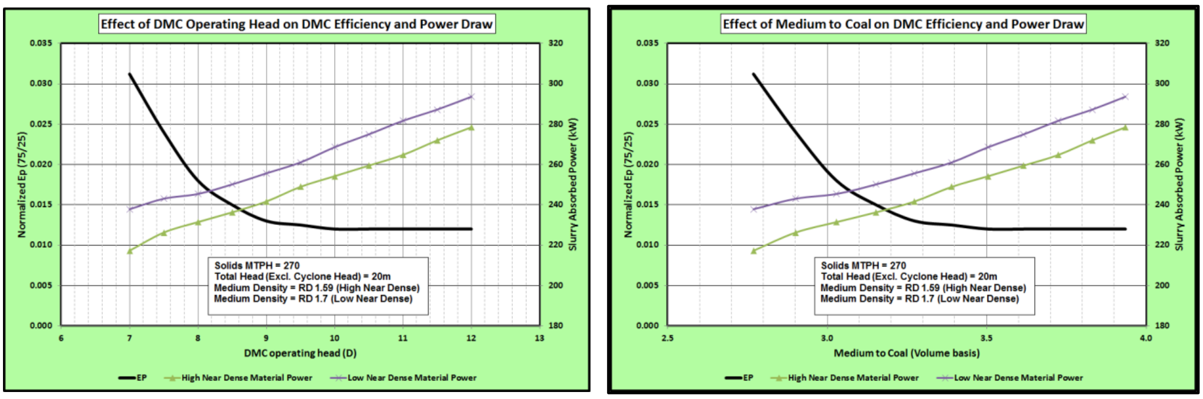

Figure 18: Example of the effect that reduced DMC operating head and associated reduced medium to coal ratios have on the DMC feed pump power draw

Based on an electricity cosy of 6.9 cent/KWh (US) the estimated cost saving is shown in Figure 19. Note that this cost saving is based on two pumps namely the DMC feed pump and the correct medium pump since less medium will be required as the DMC head is reduced.

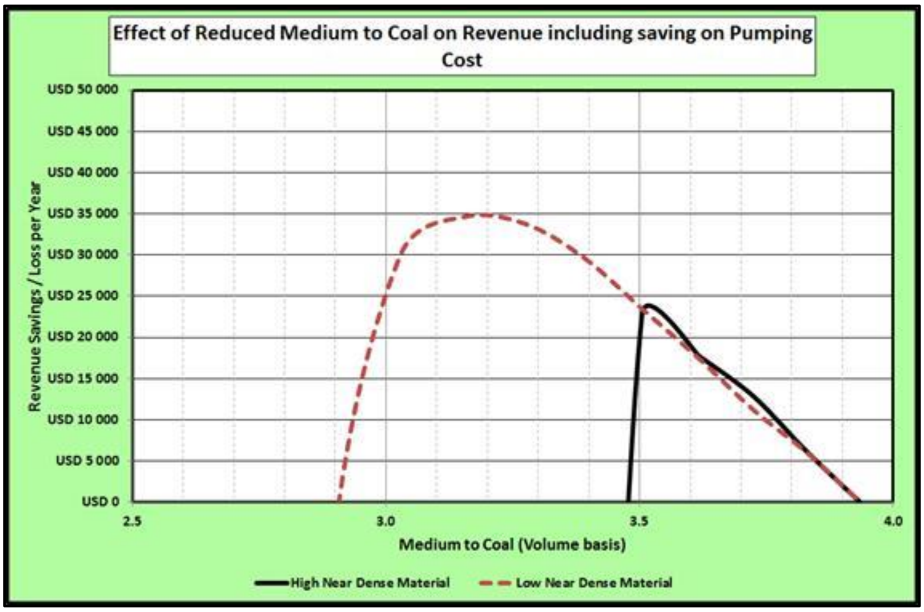

Figure 19: The effect of reduced operating head or medium to coal ratio on revenue

Figure 19 provides an indication of expected revenue saving as the DMC operating head and associated medium to coal ratios are being reduced from the maximum levels depicted in Figure 17. Although the energy saving continues to increase as the DMC head continues to be reduced, the associated loss in revenue due to poorer DMC efficiencies eventually makes this option uneconomical.

The effect that different levels of near dense material has on this option can also be seen in Figure 19 with the low near dense material showing a higher resilience before revenue loss sets in.

The impact of the DMC inlet design

The original Dutch State Mines used a tangential inlet design on the DMC and over the years the DMC inlet design has undergone various changes with the latest design that of a scrolled evolute design. Figure 20 shows the comparison between the DSM type inlet design and that of the Multotec scrolled evolute design.

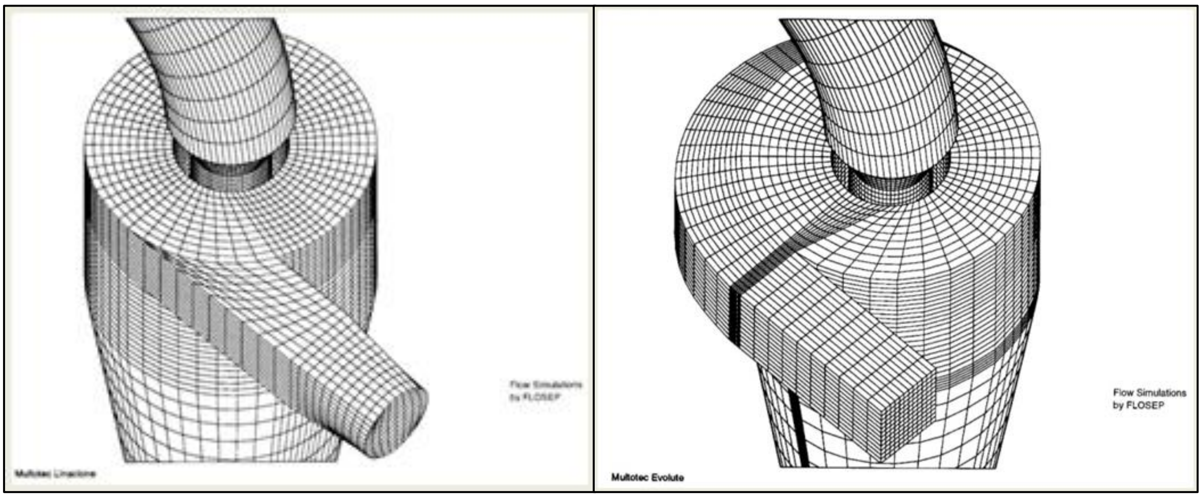

Figure 20: Comparison of the DSM inlet design (left) and the Multotec scrolled evolute design (right)

Over the years some people has perceived this inlet change to be irrelevant but the increased capacity and improved separation efficiency has convinced many others over the years. In addition, the configuration flexibility that can be incorporated into the Multotec design led to increased volumetric capacities as seen in Table 1 based on information supplied by others (ACARP, 2013).

Table 1: Comparison of DMC capacity with different inlet and configuration designs

	Volume (m^3/hr)	Cyclone diameter (m)	DMC Head (D)	Total delivery head (m)	Absorbed power - Slurry (Kw)	Operating hours per year	Energy usage (kWh/year)	Cost per year @US 6.9 cent/kWh	Saving per year	Saving per year (1 USD=11.6 ZAR)
Dutch State Mines DMC design	420	0.80	12.3	29.8	224	6800	1526328	USD 105 317	USD 0	R 0
Multotec DMC (Standard Capacity Design)	420	0.80	9.0	27.2	199	6800	1353540	USD 93 394	USD 11 922	R 138 300
Multotec DMC (High Capacity Design)	420	0.80	6.1	24.9	179	6800	1216792	USD 83 959	USD 21 358	R 247 753

With DMC cyclones capable of higher capacities, smaller diameter units can be used in order to operate again at the correct head. Although it may not be considered a significant cost saving, it is still worth consideration in light of the current economic environment the coal industry is operating in.

FUTURE IMPROVEMENT ON THE DMC PERFORMANCE

The question is sometimes asked as to what the next dense medium separation vessel will look like or when a new improvement in the DMC design can be expected. These questions are normally being asked since operations are looking for ways to improve its operational efficiencies and the DMC is generally the focus point since that is where the separation takes place. The on-going effort to improve separation efficiencies or performances should always be one of the priorities in a process but realism is also required. Expecting significant improvements from a single piece of equipment may not be realistic anymore simply because the developments in the DMC design is reaching maturity.

Over the years various versions of centrifugal dense medium separation vessels has been developed as seen in Figure 21 and each one has advantages and disadvantages but it was and could still be able to perform the duties it was designed for.

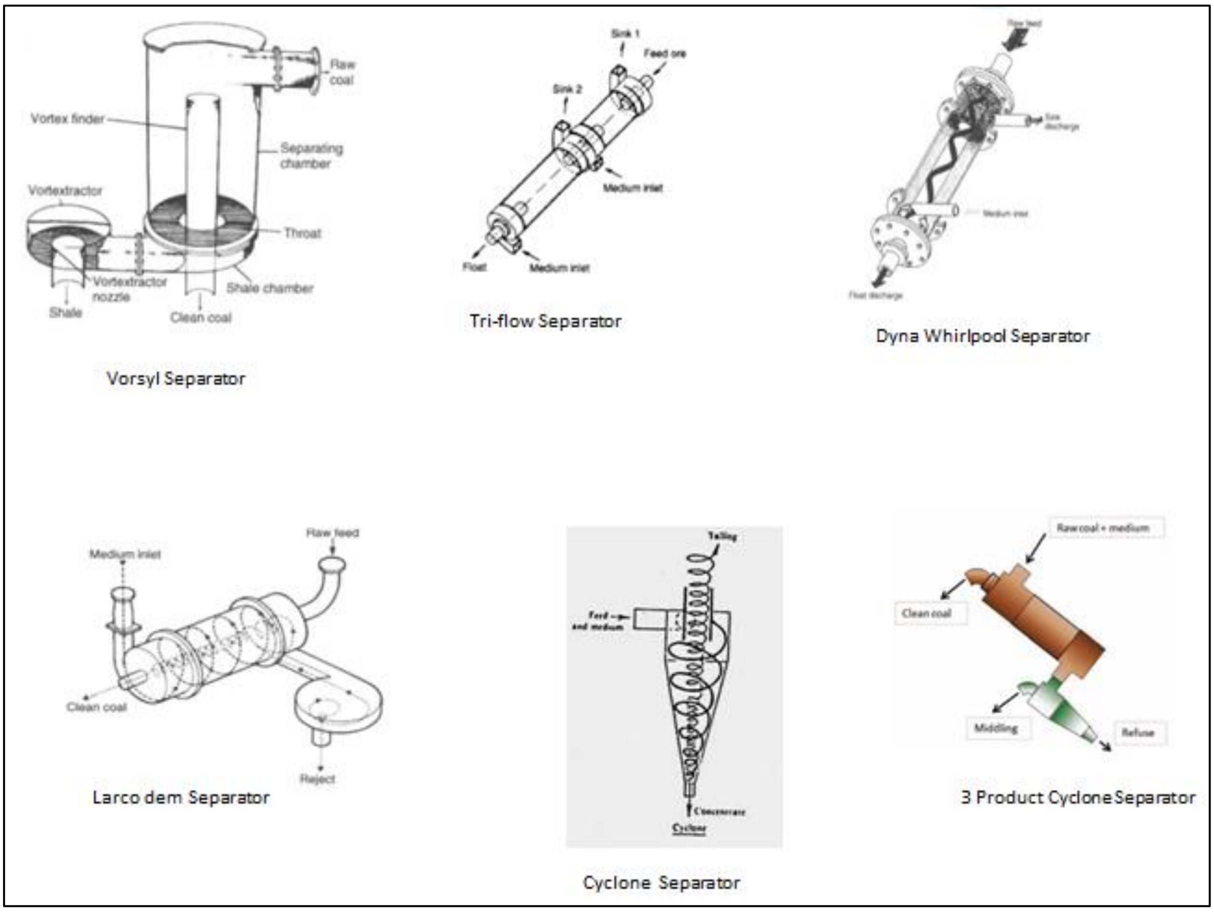

Figure 21: Various dense medium separation designs

The one common denominator for the equipment picture in Figure 21 is that it forms part of an overall process which, if not optimised, will affect the separation efficiencies negatively.

Thus further improvements in dense medium separation efficiency are expected to come from focussing on the entire process in real time rather than focussing on a single piece of equipment.

One such example is from a project done by the Australian Coal Association Research Programme (ACARP) and the Julius Kruttschnitt Mineral Research Centre (JKMRC) at New Acland mine in Australia (B. Firth, 2013). By installing instrumentation on various streams, see Figure 22, the researchers were able to monitor the performance of the DMC circuit in real time.

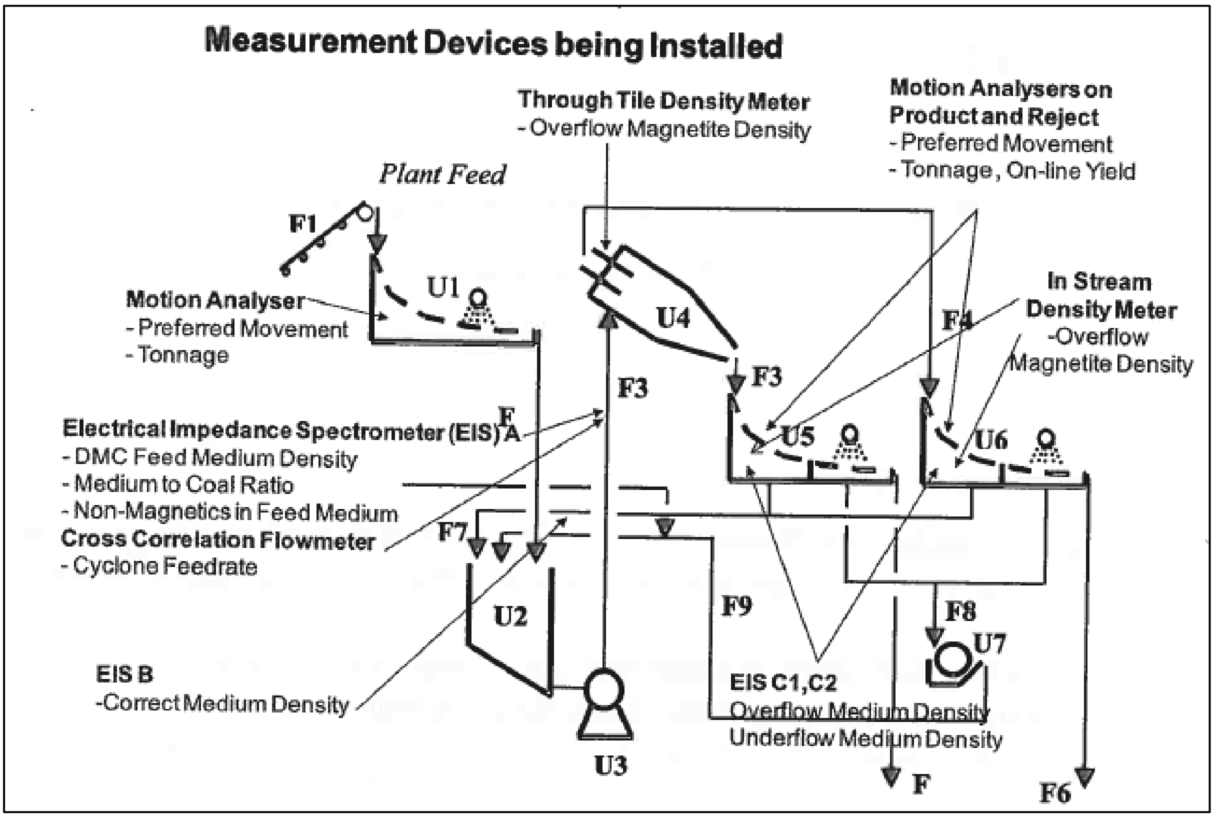

Figure 22: Instrumentation installed on the New Acland plant

This type of monitoring may seem excessive but with operations minimising their operational staff it becomes difficult to maintain optimal performance even with experienced personnel. In other operations the operational numbers may be there but the experience levels may still need improvement and thus online measurement can assist in optimising the operation.

Areas where changes in the DMC design can still be expected are:

- Possible larger diameters if required in future
- Different materials of construction
- Internal condition monitoring

- Alternative methods of conducting maintenance

Although there will always be on-going investigations into improving the DMC efficiency, improvements are expected to be smaller and any benefit from these improvements may only be realised if combined with total process optimisation. More pronounced improvements are expected on the mechanical and maintenance side in future.

As discussed in this document the separation efficiency is strongly influenced by the washability characteristics of the feed. For the separation of run of mine material with a low amount of near dense material any improvement in separation efficiency may not yield significant improvements compared to high near density material treatment.

To separate high near dense material efficiently a narrow size distribution and increased separation time is required and both factors will require a number of DMC units which is not economical.

Since the DMC design is entering maturity, with smaller incremental improvements in separation efficiency expected, further increases in efficiency will have to be a holistic approach towards the total process.

FACTORS THAT CAN INFLUENCE DMC PERFORMANCE

In this paper the importance of optimum DMC efficiency and the impact it has on the business has been discussed. Although there are no substitute for experience some guidelines are presented below to assist operational personnel in maintaining optimised conditions.

When problems are being experienced or optimisation is required it is suggested to start at the DMC and progressively move outwards until the whole process has been investigated or optimised.

The DMC unit

There are many factors that can influence the performance of the DMC of which some could be:

- Internal damage or the formation of excessive grooves leading to turbulence inside the unit

- Inlet or internal blockages which can lead to an erratic performance

- Incorrect spigot to vortex finder ratios which can affect the medium differentials

- Incorrect fitment of parts leading to inward steps between joints which can cause misplacement

- Incorrect instrumentation readings

- Equipment capability inadequate for process requirement

The operation

Some factors from an operational perspective that can influence the separation efficiency could be:

- Surging due to low medium sump levels or air entrainment into the pump

- Poor differentials being formed inside the DMC due to viscosity or stability problems with the medium normally associated with poor medium cleaning practise

- Incorrect operating head leading to too low medium to coal ratios or particle misplacement

- Incorrect feed particle size distribution due to possible desliming screen panel blockages or increased tonnages

- Inaccurate medium density control resulting in incorrect separation densities

The process

From a process perspective the following factors can play a role in the performance of a DMC, namely:

- Changing ore washability characteristics leading to different yields and DMC spigot loadings

- Different size distributions of the run of mine material due to changing mining methods leading to different solids loadings and equipment mass splits

- Incorrect screen panel apertures on drain and rinse screens leading to a build-up of non-magnetic material in the medium

- Incorrect magnetic separator operation affecting the medium quality and size distribution

- Higher than design feed rates leading to overloading of various processes

- Inconsistent feed rates or erratic feed rate fluctuations to the process which prevents the process from stabilising

- Incorrect spray water addition or inadequate spray water addition when high clay content material is being treated

CONCLUSION

In an on-going effort to try and reduce operating cost and maximising efficiency, understanding the factors that influence the DMC separation efficiency and how it impacts on the overall process is important.

Focussing on a single piece of equipment is not enough, a holistic approach is required. A thorough understanding of how the equipment is impacted on by the process is therefore a prerequisite for maximising the performance of the assets while maintaining optimal separation efficiency.

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