# THE IMPACT OF WORSENING STEAM COAL QUALITIES ON THE COAL AND ASH HANDLING PLANTS IN ESKOM

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Eskom

## 1. INTRODUCTION

Eskom is and has always been the main producer of electrical energy for South Africa. Currently there are 13 pulverised fossil fired power stations in Eskom and two new ones are under construction. Historically, the operating life expectancy for a power station has been typically in the order of 40 years and the new stations have a design life expectancy of 60 years. It is a challenge from an engineering perspective to design plant with such a long operational life. The design base has to be formulated at initiation of the project on the basis of the worst real time conditions that could impact on design. These factors include primarily coal qualities (CV, ash content, particle size distribution, abrasiveness index, moisture content, sulphur etc.), type of load base, that is, base load, load following or shifting, load factor stipulated for a unit, and the availability requirement prescribed for the station.

Engineering is set the task together with the nominated plant owner and operator to define the User Requirement Specification that presents the departure and governing document for the design of the plant. At the onset of a new power station, final information regarding the combination of factors that govern the base case design of the plant are often not defined or available with the degree of completeness or accuracy required for functional design specification. For example, issues like coal qualities, which includes the real time variance in coal qualities on the basis of the contractual specification that is normally presented as an average measurement over a predetermined time period, as well as the sustainability of the nominated coal reserve, the lifetime load factor etc.

In reality, Engineering is tasked to apply its mind on the basis of the information available at the time; experience, expertise, engineering processes etc. in order to generate appropriate assumptions for the formulation of the design base. Operating conditions sometimes change during the life of a station to the extent where the original design base is seriously compromised in terms of the application range. In such cases a reformulation of the design base must be undertaken and modifications implemented to the plant where and if required to align the plant with the new design parameters. On existing and often ageing plant, this requirement for Engineering often presents a demand for an innovative approach; a brown field project being more demanding than that of a green field. In this regard it is often required that engineers think outside the box and return to basics. The accepted way of applying science and engineering has to be challenged to enable the optimum solution to problems. It is the intent of this paper to discuss some of these situations.

As far as the coal and ash handling plants are concerned, the peak capacity sizing includes a combination of all the worst anticipated impacts like coal quality, plant capability and mass flow balance. It also includes capacity factors such as level replenishment during operation and backlog recovery ability. Capacity sizing is essential in ensuring sustainable generation capability for all operational conditions; it also implies that the peak capacity rating is greater than the normal average maximum capacity required for most of the operating time. For an operating station, a relatively minor reduction in the energy value of the coal that usually occurs simultaneously with an increase in the ash content can result in a capacity increase typically in the coal and ash plant greater than 10% and 15% respectively, in comparison with the original baseline design.

In past years, Eskom increasingly faced challenges with regards to meeting the demand for additional electrical generation capacity, which in turn is imposing onerous requirements on the ability of both the coal and ash handling systems. The impact of these additional requirements on the performance of the coal and ash systems will be discussed in this paper. The requirements being alluded to are factors such as:

- The generic shift in the steam coal qualities toward the lower end of the range over recent years (i.e. energy value, volatiles, ash content, fines and moisture content). This impacts on the capacity sizing of the plant as well as on the material flowability characteristics
- The increased capacity required on existing materials handling plant and the approach to meet the new circumstances
- The shift in the material flow characteristics and the subsequent impact on current storage facilities, feeders and transfer design
- The real time variance in the coal qualities and the imposed requirement on stockyard plant and design to ensure that the standard deviation is narrowed to mitigate operational problems.

## 2. FORMATION OF COAL

The deposit of continuous layers of decaying plant matter, silt and ash in very swampy areas over a long period of time resulted in the formation of coal deposits. South African coal is in the order of 200 - 300 million years old. Typical factors that affected the formation of coal are climate changes (high temperatures and pressures), plant composition and a sedimentary environment, depth of burial, tectonic movement, swamp acidity and time.

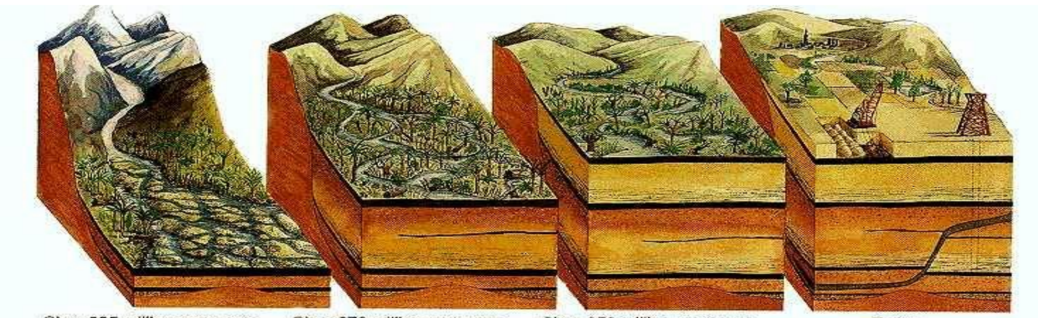


Figure 1. Typical coal formation process

The older the coal the higher its rank. Peat is the youngest followed by lignite and bituminous coal with anthracite and graphite being the highest in rank. The carbon, heating value and burn-out time is the highest for anthracite and the lowest for peat, whilst the opposite applies to these coals for the ignition index, volatile matter and moisture content. The coal seams are labelled from the bottom up, i.e. the lowest seam being One and so forth. The most common coal supplied to Eskom normally comes from the Number Two seam.

It is interesting to note that the net result of the efficiency of the supply chain amounts to only 19% from the time the coal is mined to the time it becomes available to the consumer.

The classification of coal is difficult as coal is a very complex fuel and many methods have been developed to try and quantify the differences in an effort to predict how coals will burn, how they will affect milling processes and how they can be converted into gasses and fuels. Whilst *Rank* refers to the age of the coal, *Grade* refers to the amount of mineral contamination in the coal. Although most of the minerals in the ash are not directly involved in the combustion process, their presence has an effect. The softer coals tend to have a higher reactivity due to swelling when the volatile matter is released.

## 3. LOGISTICS

Most Eskom Power Stations are linked to collieries and most of the coal is delivered to the power station via dedicated overland conveyors. Due to many varied reasons pertaining to the life of the mines, mining conditions, mining methods and global economic demand for similar types of coal for fossil fired power stations, more and more supplementary coal has to be made up to meet Eskom's increasing demands. Due to the nature and availability, this coal is obtained from the spot market and most is either trucked or railed in. This coal supply contains increased contamination through the presence of foreign material, greater amount of fines and increased moisture content. This condition imposes serious challenges to the materials handling systems that support the movement of these coal deliveries from the time it is delivered to the coal stockyard right up to and including the time it is introduced into the boiler as a pulverised fuel.

The three most important aspects that need to be considered in sourcing coal are:

- The *volume* and *quantity* of the resource, taking cognisance of the fact that we normally design a six unit power station which must last for at least sixty years
- The *quality* of the coal with specific attention to the following parameters namely: *CV* value that measures energy, *volatiles*, *moisture, sulphur, ash***,** and finally, the *Abrasiveness* Index. In addition, the design base is limited by the particle size distribution of no more than 20% of the -1 mm fraction and a maximum lump size of -50 mm based on the functional range of the current technologies. Design outside of this range gives impractical applications resulting in excessive capital expenditure.

## 4. ESKOM GENERATING PLANTS COAL STOCKYARDS.

### 4.1 Historical Stockyard Design

In a coal fired power station, a stockyard can be viewed as a buffer storage capacity accommodating the different requirements between the in-feed from the coal source and the out-feed into the power station. The stockyard must provide the capacity to supply the station with the required coal during situations where the supplier is unable to supply coal due to other reasons (plant unavailability, product not meeting agreed specifications, weather conditions, industrial action etc.). It is therefore required that a stockyard has the ability to supply the units directly from the coal source and contain capacity to be utilised during a situation where the coal supply is unavailable.

Historically, there was no requirement for blending or homogenising on stockyards as the quality of the coal supplied by the mine always fell within the quality envelope for the technology choice as well as combustion. The majority of the stockyards are therefore not mechanised and operations rely solely on mobile plant.

### 4.2 Problems Associated with the Current Eskom Stockyards

Eskom made a decision to design its boilers to burn low grade coal in order to produce low cost electricity. Low grade coal was deemed not acceptable for export but this has changed as the global demand for this quality coal has grown significantly. This impacts negatively on the current cost of electricity as primary energy fuel cost has escalated significantly over recent years.

A change in the coal properties towards the worst end of the coal quality range supplied to Eskom has been evident over the past years. This quality is slowly deteriorating on an average basis, however is still within the contractual requirements. The mines are providing Eskom with poor quality coal, particularly in terms of the following:

- Lower calorific value (CV)
- Higher ash content
- Higher percentage moisture coal
- Higher percentage fines
- High clay content.

Although the coal quality variance falls outside of the contractual limits applicable to the average measurement, the stations cannot reject this coal. The stations are required to deal with this coal which currently presents the following operational challenges:

- Blockages of transfer points
- Higher amount of fugitive dust conditions on loading and transfer points
- Machine breakdown due to the nature of the material handled
- Material running back on incline conveyors due to high moisture content
- Blockages on storage bins and silos
- Damages to scrapers due to the excessive amount of material adhering to the belts.

These problems also impact on the other parts of the power station causing under performance in mills and boilers.

### 4.3 Future Stockyard Design

The real-time variance in coal qualities on the basis of the contractual specification is normally presented as an average measurement over a predetermined time period. This results in a situation where the real-time qualities often exceed the outer limits of the operational range for both the technology choice and combustion requirements.

The coal stockyard system is complicated when the material properties of the coal needs to be managed before it is conveyed to the station for consumption. When the variations in the coal physical and/or chemical properties are outside of the boiler and bulk handling systems specifications, blending or homogenising must be implemented to reduce the variation in these properties. This will result in the introduction of an intelligent system within the stockyard to be able to quantify the efficiency of the incoming and outgoing coal streams, hence confirming the blending efficiency of the stockyard.

### 4.4 Blending and Homogenising

When conducting blending, the aim is to achieve a final product from two or more coal types with well-defined, different chemical properties into a product with evenly distributed properties. Homogenising provides a product from one type of material reducing the inherent fluctuations in quality and/or size distribution.

To achieve either of the above, the inherent design of the stockyard would have considered these requirements and selected the correct machinery and operational systems for stacking and reclaiming processes required for the best desirable results. With this in mind, Eskom's objective is to achieve *homogenising* at the coal stockyard.

#### 4.4.1 Stacking methods for homogenising

To achieve certain blending/homogenising results, a specific machine with the appropriate stacking method is required. Stacking methods are the specific pattern in which the material is stacked on each stockpile for effective homogenising during the reclamation process. The figure below illustrates some of the different types of stacking methods employed on stockyards.

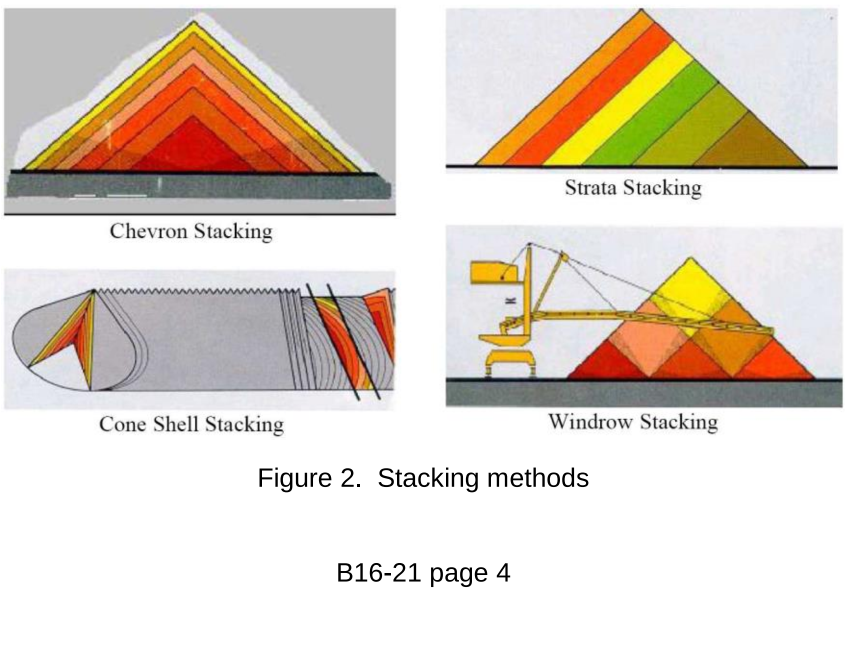


Figure 2. Stacking methods

### 4.4.2 Reclaiming machine technologies

The following machines are used in conjunction with the stacking methods above to achieve the different levels of homogenising required.

Figure 3. Bucket wheel reclaimer (single point reclamation)

Figure 4. Side arm scraper chain reclaimer

Figure 5. Drum reclaimer (Full face reclamation)

### 4.4.3 Stacking and reclaiming methodology impact on homogenising (Kusile Power Station Case Study)

The objective of the stockyard is to narrow the standard deviation of the coal properties, ensuring it always resides within the plant's operating and functional envelope. This is accomplished by a combination of the appropriate stacking and reclaiming methodology and equipment selection.

The graphs below illustrate coal variance on entry and exit from the stockyard.

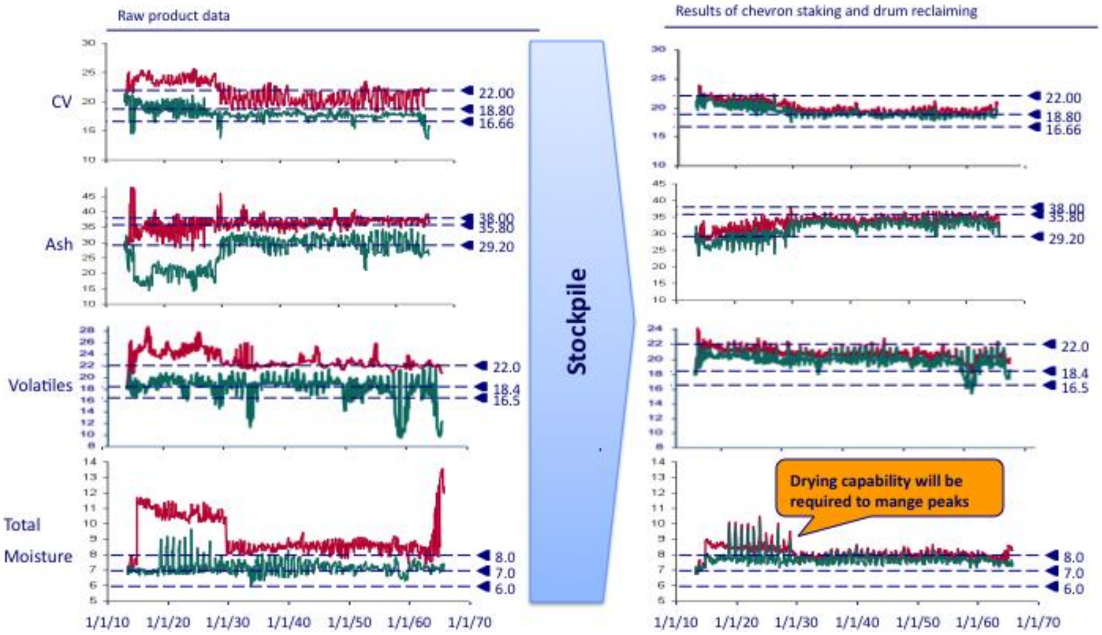


Figure 6. Coal variance on entry and exit from the stockyard

**Kusile Power Station**
**Coal Stockyard Blending Effect**

| Input | | | |
|---|---|---|---|
| Pile capacity | 83000 | Ton | |
| Pile width | 40 | m | |
| Material aqngle of repose | 37 | Degrees | |
| Matrial density | 900 | $kg/m^3$ | |
| Stacking machine capacity | 4000 | TPH | Chevron pattern |
| Stacking machine travel speed | 10 | m/minute | |
| Type of reclaiming technology | | | |
| Portal scraper (2400 TPH) | 40 | % machine blending effect | Scrapers not recommended for fine moist material |
| Combination stacker reclaimer (12000 TPH) | 50 | % machine blending effect | |
| Bridge scraper (2000 TPH) | 80 | % machine blending effect | Scrapers not recommended for fine moist material |
| Bridge type bucket wheel (10000 TPH) | 70 | % machine blending effect | |
| Drum (5000 TPH) | 100 | % machine blending effect | |

| Results | | | |
|---|---|---|---|
| Pile height | 15 | m | |
| Pile volume | 92222 | $m^3$ | |
| Pile capacity per m length | 272 | Ton/m | |
| Pile cross section | 301 | $m^2$ | |
| Pile base length | 325 | m | |
| Pile upper length | 285 | m | |
| Pile average length | 305 | m | |
| Stacker machine discharge capacity per m traveld | 7 | Ton/m | |
| Number of stacking layers in pile | 41 | | |
| Blending effect (efficiency) stacking | 6 | | |
| Blending effect system | | | |
| Portal scraper (2400 TPH) | 3 | Strata Stacking Profile | Scrapers not recommended for fine moist material |
| Combination stacker reclaimer (1200 TPH) | 3 | Windrow Stacking Profile | |
| Bridge scraper (2000 TPH) | 5 | Chevron Stacking Profile | Scrapers not recommended for fine moist material |
| Bridge type bucket wheel (10000 TPH) | 4 | Windrow Stacking Profile | |
| Drum (5000 TPH) | 6 | Chevron Stacking Profile | |

Table 2. Comparison of reclaiming machines regarding homogenising capability

The table above compares the blending/homogenising capabilities of different types of reclaiming machines. To achieve maximum blending/homogenising capability, two types of reclaiming machines, the bridge scraper reclaimer and drum reclaimer were considered. The table also indicates that for a reclaim capacity of 3 400 tph, a bridge-type stacker with two scraper chains is required whilst only one drum reclaimer handles the required capacity.

A further analysis was then conducted to select the most suitable machine of the two. A life cycle cost analysis was one of the tools used in selecting the suitable machine, which the results indicated was the drum reclaimer. A position paper was generated by EED Engineering recommending that a drum reclaimer should be the reclaimer of choice on all new builds.

Therefore, the stockyard will be equipped with two bi-directional drum reclaimers to reclaim coal on the live stockpiles and two stackers to stack coal on all eight piles (live, seasonal and strategic stockpiles). The reason for having two machines for each operation is to increase the availability of the system by creating redundancy and also increasing reliability. All four machines will be remotely operated from the outside plant control room and there will be no physical human intervention required during normal operation.

The strategic stockpile will be built by using mobile equipment to compact the coal as per the storage preparation guidelines to prevent spontaneous combustion. To prevent spontaneous combustion on coal that is to be stored for a long period, it is important that the stockpile is built correctly by compacting the coal in layers while building the stockpile.

This process is very crucial as it can eliminate fires on the stockpile and reduce safety and environmental risks.

Since the strategic stockpile will be stacked using mobile equipment, it will also be reclaimed using mobile equipment. Mobile feeders will be used to reclaim the coal to the stockyard conveyors that will reroute the coal to be stacked by either one of the two stackers and to be reclaimed by the drum reclaimer. The same mobile feeders will be used to reclaim the other four seasonal piles and the rerouting to the drum reclaimers.

This process of rerouting material to the drum reclaimers is to ensure that the original concept of coal being homogenised before feeding into the station is maintained.

### 4.5 Current Stockyard Optimisation Project

#### 4.5.1 Reason for project

During the rainy season most of the Generations' Power Stations were unable to maintain full load capabilities as a result of difficulties experienced with handling wet coal. The stations' ability to reclaim from the stockyard is limited by the requirement to supply coal at MCR (Maximum Continuous Rating) as well as replenishing levels in the storage facilities.

During wet and rainy conditions, some power stations experienced load losses due to the inability to reclaim coal at the required rate from the stockyard even when adequate stock levels were available, because of the limitation of the existing system selection and setup, and not receiving coal from the normal supply source.

These incidents identified the shortcomings of the power stations to maintain full load while recovering coal from their stockpiles. It was therefore essential to initiate a project investigating the feasibility of modifying the current stockyards with the minimum degree of modification and expenditure necessary to enable the supply of coal to the mill bins in the event of zero capacity being delivered from mines or the supplementary spot market.

The reality is that currently power stations cannot sustain full load operation while reclaiming coal from its stockpiles. This makes them vulnerable during rainy seasons should any unforeseen problems occur at the mine or with the road deliveries. Coal stockyard stock levels have been replenished to the correct sustainable operating levels and it is essential to ensure that the system that links the stockyard to the station has the ability to sustain full load operation.

### 4.5.2 Scope of work identified for the current coal stockyard optimisation

The scope of work varied from station to station with several common modifications required at different sites. The list below is given as a general indication of works required:

- Stockyard reclamation belt's mechanical in-loading hoppers will be modified to ensure oversize separation of the supplied coal
- Stockyard reclamation belt's head chutes will be modified for sizing separation of the supplied coal stream in accordance with the maximum mill coal size specification
- All coal staithes will be fitted with air cannons to ensure that coal hang-ups are cleared as and when required
- Several stockpiles' drainage systems will be upgraded to ensure proper run-off of water from the stockpiles during rainy spells. All Eskom stockyards have drainage systems and these modifications are required due to operational changes on specific plants
- Staith by-pass facilities
- Operating methodology generated for wet coal handling conditions.

## 5. ESKOM'S STORAGE FACILITIES.

The coal storage facilities face problems with the current supply of sub-standard coal with poor flow properties. Coal staith suffers from coal bridging and rat-holing above openings. This situation presents a challenge as the storage facilities can no longer sustain coal flow.

The current mill bunkers and mill feeder standpipes often block and need to be cleared to ensure a sustained coal flow that is required for generating electricity.

It is thus necessary to increase the storage containers' opening size beyond the cohesive arching dimension and to reduce consolidation pressure to enhance the flowability of the coal. In certain applications. It is also necessary to increase the hopper wall angles. Since coal time storage also contributes to the consolidation pressure, a time storage management process must be implemented.

### 5.1 Staithes

The staith is a very large enclosed building with many discharge openings. It is difficult to modify and it is not financially viable to convert this structure to facilitate sustainable coal flow. A feasible solution for the poor performance of the coal staith can be achieved by means of a fully mechanised stockyard. This alternative is very expensive and is often not supported by the strategic business plan.

In the process of trying to find a suitable way to manage the coal flow within the current staith design, the use of air cannons has been employed at Grootvlei Power Station. The air cannon assists by breaking down the consolidated coal and thus allows material to flow easily. Initial tests were conducted and positive results were achieved to justify a complete installation of air cannons on selected areas along the staith.

The use of inverted cones as well as lining the bottom section of the hoppers with glass lining aided in creating a draw-down pattern significantly bigger than in the past.

### 5.2 Coal Bunkers

The current design of the mill bunkers allows for few modifications to be implemented to promote material flow. Modifications which include installations of an inverted cone (bunker insert) to reduce the consolidation pressure around the bunker opening and the enlargement of the bunker opening are all possible. However, the hopper wall angles cannot be modified, thus a selection of suitable liners becomes crucial.

This approach was followed at Komati Power Station, where a bunker insert was installed and new, larger bunker openings created. This resulted in a need for a larger standpipe and finally a suitable mill feeder, in this case a belt feeder, to maintain the material flow profile created in the bunker. The combination of all these modifications resulted in sustainable material flow in these storage facilities.

However, there are cases where the Komati modifications cannot be fully applied, like the case of Camden Power Station. Camden presented the following challenges:

- The mill bin's opening dimensions were less than required for prevention of a cohesive arch
- The mill feeder standpipe is excessively long (12 m) with a small cross-sectional dimension of 450 x 450 mm
- The interface from the standpipe opening into the current spiral mill feeder was greatly restrictive (450 x 450 mm).

This resulted in performance deficiencies such as cohesive bridging at the bin opening and inside the standpipe, frictional choke flow (where the frictional forces on the standpipe becomes greater than the gravitational flow of the material), inside the standpipe and blockage on the inlet to the mill feeder.

Based on the storage and flow theory, the obvious solution to the above challenges was to increase the mill bin opening and standpipe dimensions to prevent a cohesive arch from forming. All the current, newly procured mill feeders would then have required replacement with feeders with an inlet dimension similar to that of the standpipe.

The replacement of the existing mill feeders was not feasible due to the number of feeders required (36 feeders) with their associated replacement cost. It was therefore necessary to seek a solution by investigating the application of the storage and flow theory in an unconventional manner. A flow channel or any opening dimension is proportional to the consolidation pressure of the material, therefore by reducing the consolidation pressure a smaller opening dimension would be required.

$$B = \frac{\overline{\sigma}_1 \, H(\alpha)}{\rho \, g}$$

To achieve the reduction in the consolidation pressure on to the mill feeder, a transition hopper was installed. The transition hopper acted as a consolidation pressure reducing mechanism as it created a radial stress field from the linear stress field generated by the standpipe. The validation of this theory was confirmed by an Engineering Research and Development Project undertaken at Kendal Power Station on a prototype.

These challenges where then resolved as follows:

- Mill bin modification increased the mill bin opening from 600 x 600 mm to 1 200 x 1 200 mm and an inverted cone was installed
- Standpipe was replaced a 1 200 mm diameter pipe
- A transition hopper was installed above the mill feeder
- The feeder inlet was modified to suit the transition hopper.

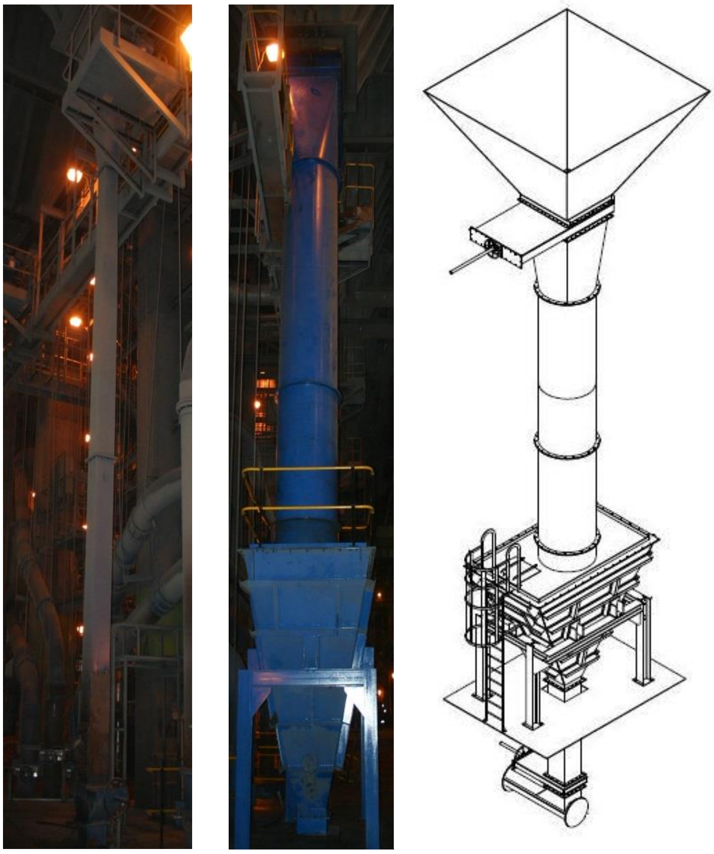

Figure 7. Camden bunker and standpipe modification

This modification was implemented at Camden and the performance exceeded expectations. Prior to the modifications, Camden suffered severe load losses during the wet season and after the modification no load losses were experienced as a result of mill feeder problems.

### 5.3 Chutes

#### 5.3.1 Design philosophy and design optimisation on current retrofits and new builds

The real challenge with variable speed operation of conveyors is the design of the transfer stations. The geometry of the chute is based on the material flow characteristics, momentum of the material, boundary friction implications and the expertise and experience of the designer. Optimisation is then applied by means of discrete element modelling (DEM) of the material as it moves through the chute.

The DEM tool has to be an integral part of the chute design. This model is dynamic and requires continuous upgrading and fine tuning of the inputs and assumptions to ensure that the actual circumstances are simulated. This is the only way that the best possible value is added with the optimisation process. Our experience currently is that the integration of this DEM tool as explained has not reached this desired level.

Often the chute design and the DEM modelling are undertaken by different companies resulting in an inadequate integration and thus a non-optimised design.

For the successful design of a transfer point it is essential to ensure central loading onto the receiving conveyor for all operating conditions. It is also a priority to define the chute geometry in a manner that meets sustained coal flow for worst case coal qualities, and this takes precedence over flow velocity optimisation.

### 5.3.2 Review of chutes designed for the Eskom New Build Projects

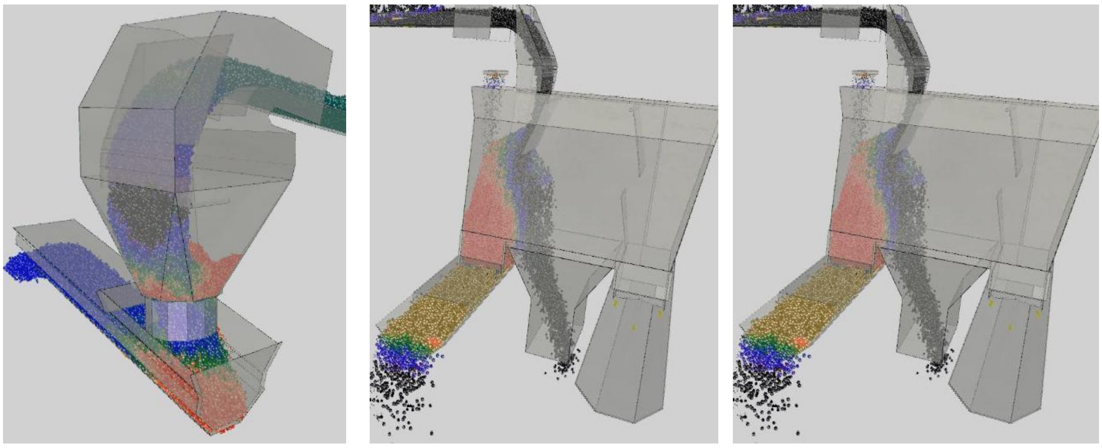

Figure 8. DEM predictions of material flow behaviour

The majority of conveyors in all the new builds will be driven by variable speed drive systems to enable varying of conveyor speeds when required. This introduces a design challenge that is different from the norm, where varying material speed, trajectories and throughput must be considered. The DEM should assist the designers in predicting the behaviour of material at different operating conditions and to optimise their design to suit the operating range. As illustrated in the figure above, the modelling can predict potential blockages, behaviour of material during different operating procedures and loading of material onto the receiving conveyor.

However, the reviewing process of DEM requires an in-depth understanding of material flow behaviour, including relevant operational experience, to be able to either challenge or confirm the results.

## 6. CONVEYORS

Conveyor system modification due to the change in coal qualities and operating base results in increased capacity requirements on current plant. The Camden Case Study is presented as an example.

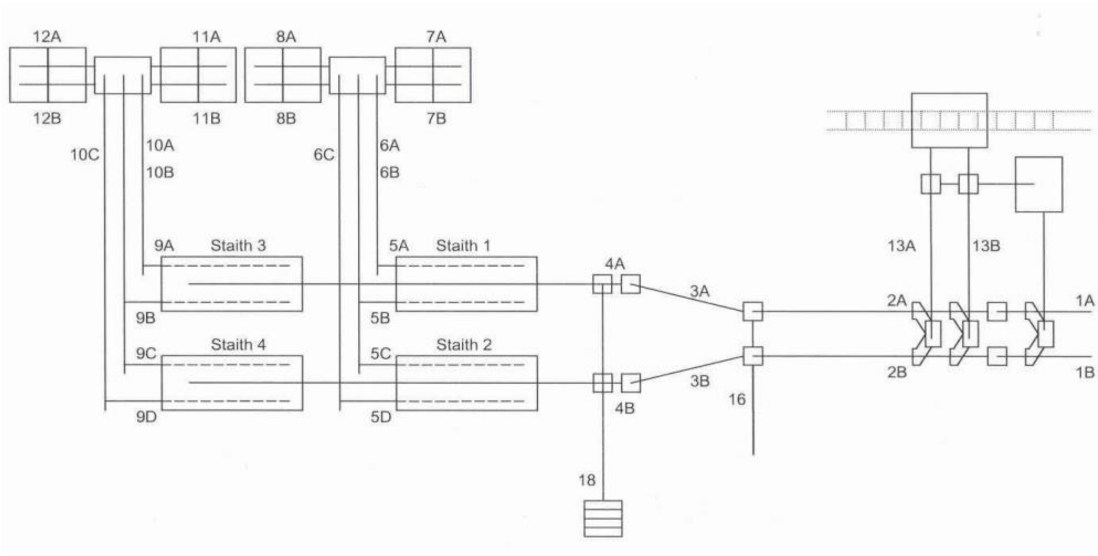


Figure 9. Coal handling plant layout

### 6.1 Under-Staith Conveyors (5A to 5D and 9A to 9D)

#### 6.1.1 Original design

The station was designed with four staith facilities each comprising two sets of under-staith conveyors. The under-staith conveyors were designed to transport coal at a rate of 400 tonnes per hour. The coal is deposited into the mill bins via the incline conveyor and the over mill bin distribution system.

#### 6.1.2 Capacity increase requirement

The future operation of the station requires an increase in the capacity of the terrace conveyor system from 400 to 800 tph.

#### 6.1.3 New design

For this application of doubling the original design capacity, the following options were considered:

- Evaluation of belt speed
- Evaluation of belt width
- Evaluation of belt class
- Evaluation in the troughing angle from 35 to 45 degrees
- Review of the implication on the current drive assembly
- Evaluation of conveyor pulleys for required duty
- Evaluation of the conveyor pre-tensioning requirements
- Transfer points design for required capacity
- Evaluation of safety requirements.

| | Conveyor | | | | | |
|---|---|---|---|---|---|---|
| | Under Staith | | Incline | | Mill Bin Distribution | |
| | Original | New | Original | New | Original | New |
| Capacity (tph) | 400 | 800 | 400 | 800 | 400 | 800 |
| Belt Width (mm) | 900 | 900 | 900 | 900 | 900 | 900 |
| Belt Class (kN/m) | 640 | 800 | 640 | 800 | 640 | 800 |
| Idler Through Angle (Degree) | 35 | 45 | 35 | 45 | 35 | 45 |
| Drive Motor (kW) | 32 | 55 | 85 | 185 | 28 | 75 |

Table 2. Modification effected to accommodate the capacity increase

## 7. CONCLUSION

Life is dynamic and conditions constantly change. It is therefore difficult to predict future conditions that may affect the design of plant in cases when it is expected to operate over a long period of time, such as a power station.

From an engineering perspective, one can design adequately for known worst case scenarios. It is however, not always possible to establish worst case conditions upfront during the design phase of plant that is expected to operate for many decades beyond the initial commissioning date. So, when conditions change to a status that requires aging plant to operate beyond its original design base, the challenge to Engineering is to be innovative and to ensure that the plant is modified to meet the challenge/s. These modifications to the plant have to meet criteria like investment requirements, performance requirements and suitable and sustainable performance for the duration of the expected life. Thus it is often necessary to apply an innovative approach and in some cases to challenge the established ways of applying engineering and to revert back to basics.

In this paper we have attempted to demonstrate how engineers' live up to these requirements and in our case, how we have developed certain technologies that are somewhat out of the ordinary, like the guided flow transfer systems. We have also attempted to explain that sometimes one has to think outside of the box and do things differently by applying basic principles and to stretch the application of science. The development of the modification to the mill feeder in-feed system is a typical example.

Concerning long duration plant life operation, this will often require a renewed focus by Engineering, and we as engineers must be able to meet the challenge.