

A large industrial coal processing plant with a tall, green and orange structure and a conveyor belt, situated next to a large pile of coal. The scene is reflected in a body of water in the foreground. The sky is blue with some clouds.

thungela

COAL PROCESSING

ICPC XXI: 2025

DISCIPLINE.
INNOVATION.
IMPACT.



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| Glossary of terms

Acidic mine water	Water that has been exposed to iron sulphide, typically pyrite, a solid waste byproduct of coal mining.
Banana screen	A specialised vibrating screen used in the mining and quarrying industries.
Beneficiation	Any process that improves the value of ore by removing waste.
Calorific value (CV)	A measure of coal quality indicating the amount of energy generated when the coal is burned.
Clarifier sludge	The concentrated solid material that settles at the bottom of a clarifier during the wastewater treatment process.
Dense medium separation (DMS)	A gravity-based mineral processing technique that uses a heavy liquid suspension at a specific density, e.g. magnetite in water to separate valuable particles from waste.
DMS cyclone	A type of equipment used for the dense medium separation process using centrifugal and gravity forces to separate coal from waste.
Middlings products	Intermediate products obtained in the coal sorting process.
Misplacement	Incorrect placement of coal between products and/or discard, either due to incorrect particle size or density separation which leads to losses.
Pure-play producer and exporter	A producer and exporter that focuses exclusively on a single industry, or product, or service.
RB 1, RB2 and RB3	Grades of coal (RB 1 has the highest calorific value and RB3 has the lowest).
Run-of-mine coal	Coal delivered directly from the mine to a coal-processing plant .
Spiral concentrator	A device designed to concentrate low-grade ore and industrial mineral slurries.
State-point analysis	Analytical tool widely used in biological activated sludge processes to optimise clarifier and system performance.
Supernatant water	The clear liquid that remains above a solid precipitate after a mixture has been allowed to settle or has been centrifuged.
Teetered Bed Separator (TBS)	A mineral processing equipment which uses water fluidization to separate fine coal from waste.
Thermal coal	A type of bituminous coal that is used primarily to generate electricity.
Wemco® drum	A type of dense medium separation equipment which uses a shallow dense medium bath in a rotating drum to separate particles based on density.



Message from our Head: coal processing and business improvement

South Africa, like other emerging economies, relies on coal, not just as a source of energy but as a commodity that sustains jobs, industrial growth, economic stability and, as importantly, energy resilience.

Addressing the gap between ambitious clean energy goals and the everyday realities faced by millions of South Africans is therefore essential if we are to ensure an equitable and sustainable energy transition; one in which coal has a vital role to play. The narrative that coal cannot coexist with renewables in a balanced partnership also needs to be re-evaluated.

For us at Thungela, that means conducting our mining and processing operations in a responsible, efficient and sustainable way so that we can obtain maximum value from our coal while simultaneously managing the impacts of mining and processing effectively.

The role of innovation

The coal industry continues to face significant challenges and headwinds. To navigate these effectively amid a shifting macroeconomic landscape, it must respond with scientific rigour, innovation, and technical excellence from within—driving sustainable and meaningful impact.

The coal processing studies that we will present here at ICPC XXI – and which are summarised in this booklet – are testament to that. They illustrate the resilience of our processing teams and how we are developing technical excellence from young metallurgical talent.

What is evident from these studies is that the solutions so often depend on combining sound scientific rigour with innovative thinking rather than just new technologies. That is why we encourage a culture of exploration, which enables us to find solutions where none were thought possible before.

It is a pleasure and a privilege to share these studies with you as we celebrate the ICPC's twenty-first year.

Luke Venkatesan





| About Thungela

Thungela, which means 'to ignite' in isiZulu, is a global pure-play producer and exporter of high-quality, low-cost thermal coal. With global operations in South Africa and Australia, we focus on high-quality coal reserves and marketable production, positioning ourselves as a key player in the global energy market.

In Mpumalanga, South Africa, Thungela operates a diverse portfolio of thermal coal mines connected by a rail network to the world-class Richards Bay Coal Terminal (RBCT).

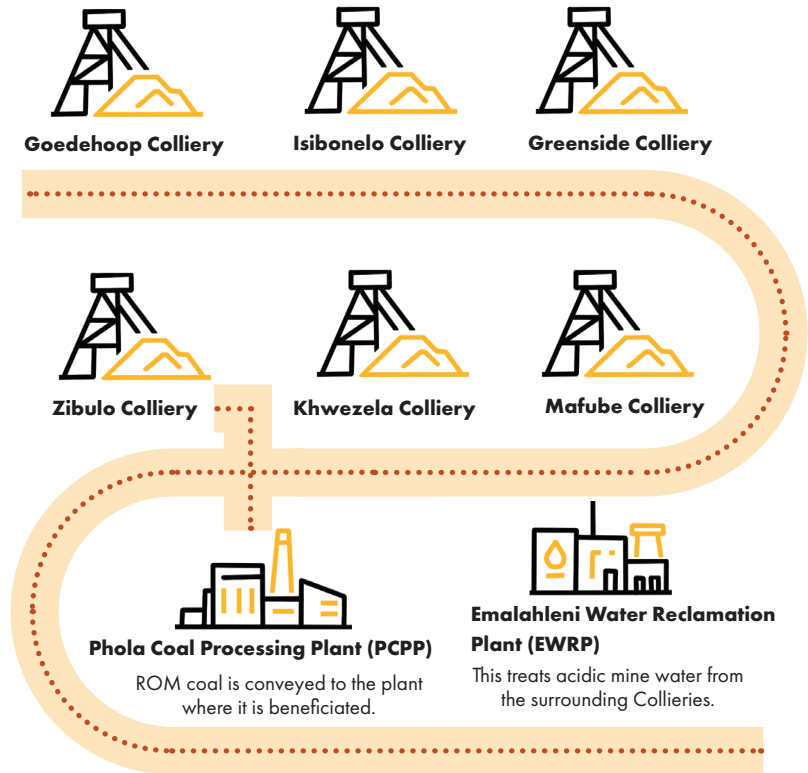
In Australia, Thungela operates Ensham Coal Mine, a high grade thermal coal mine with a dedicated rail network leading to the world-class RG Tanna multi-product blending port in Gladstone.

Coal processing plants, where run-of-mine (ROM) ore is crushed and washed to produce saleable products, are located at five of Thungela's six coal mines, namely Isibonelo, Greenside, Mafube, Khwezela and Goedehoop. The exception is the Phola Coal Processing Plant (PCPP), a joint venture with Seriti Resources, which receives ROM coal via truck and overland conveyor from Zibulo Colliery. The PCPP is equipped with a rail load-out terminal that connects directly to RBCT, enabling efficient export logistics.

At the sixth colliery, Isibonelo, ROM coal is crushed, screened and analysed on-site before being transported via a 22-kilometre overland conveyor to Sasol's Synfuels stockyard.

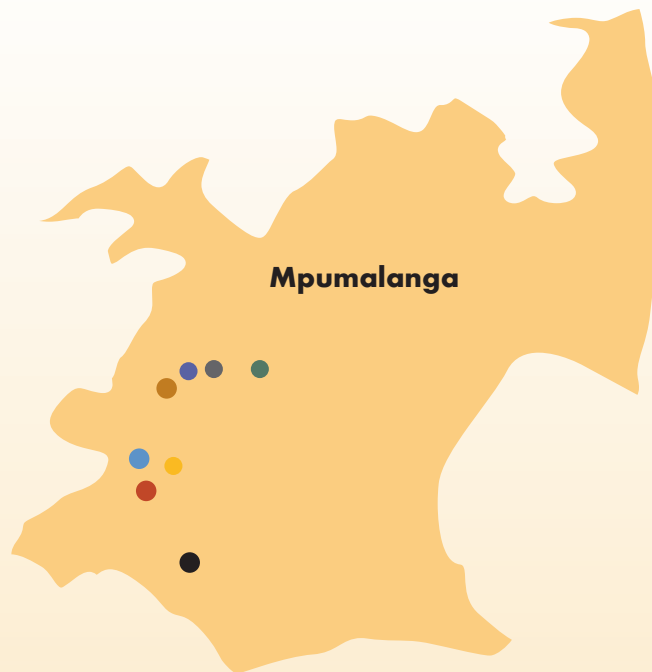
In addition, Thungela operates the Emalahleni Water Reclamation Plant (EWRP) in Witbank, a centralised facility that treats acidic mine water from surrounding collieries in Mpumalanga.

The EWRP converts this water to potable quality, supporting both environmental sustainability and responsible water management.



This booklet provides an overview of operations at Thungela's processing plants and at EWRP. It examines the successful application of the best technologies currently being used in coal processing, gives details of some of the processing challenges we have faced, provides insight into some of the research we have conducted to address these challenges and, finally, gives details of some of the innovations we have implemented to enhance the efficiency and ease of operation at these plants.

All of our operations are framed by our purpose and strategy.



Thungela Collieries

- Isibonelo Colliery
- Goedehoop Colliery
- Greenside Colliery
- Khwezela Colliery
- Mafube Colliery
- Zibulo Colliery
- Phola Coal Processing Plant (PCPP)
- Emalahleni Water Reclamation Plant (EWRP)

Our purpose



Who we are

We are a leading pure-play producer and exporter of high quality, low-cost thermal coal with a global footprint.



Our culture

Our high-performance culture values excellence, agility and accountability and understands that our people are the heartbeat of our organisation.



Ambition

To create real and demonstrable value for all our stakeholders.

To responsibly create value together for a shared future

Our values



Safety

We are unconditional about protecting the lives of all our people – at work and at home – in health and wellbeing.



Care and respect

We show humanity to all through our commitment to make a positive impact where we can.



Accountability

We take responsibility for our decisions, actions and performance, to grow in success and learn in failure.



Excellence

We are passionate about being the best at what we do and always seek to raise the bar.



Agility

We ensure we are well-informed to be responsive, in order to keep things simple and make quick decisions.



Entrepreneurship

We have an owner's mindset in everything we do, because we know that every small change adds to greater impact.

Our strategy

Delivered through five strategic pillars.



Safety is our first value



Maximise the full potential of our existing assets



Create future diversification options



Optimise capital allocation



Drive our esg aspirations

Coal processing methods

Coal processing involves a series of methods used to clean and sort raw coal into various sizes and grades before it enters the commercial market. All processing methods draw on the principle that coal is lighter than the rock from which it is mined and the waste that is discharged after processing.

Our processes therefore separate the lighter coal from heavier rock and waste in a collective process known as 'coal washing'. Depending on processing requirements, various methods and types of equipment are used.

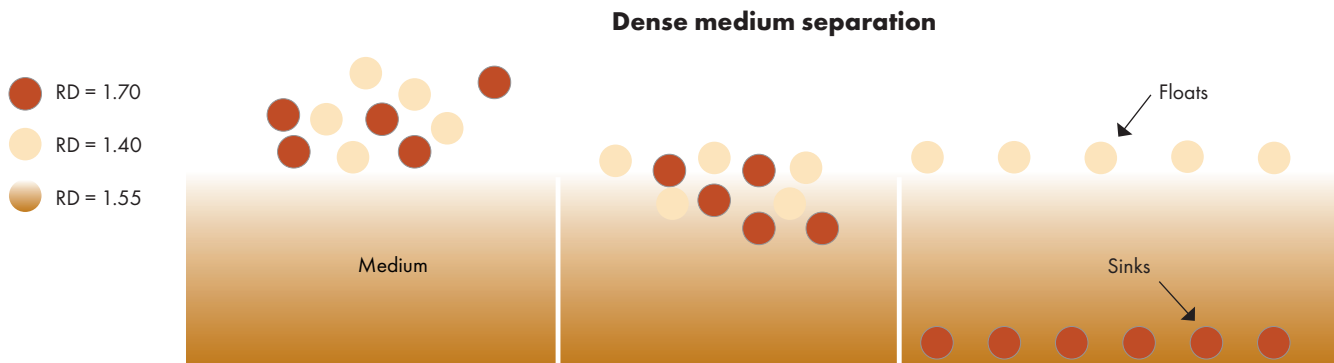


Dense medium separation

Dense medium separation (DMS) is one of the most effective and widely used methods of processing coal of size $> 0.5\text{mm}$. The process involves using a heavy liquid (magnetite medium) of a suitable density. The coal minerals lighter than the medium float and are referred to as floats, while the materials denser than the medium sink and are referred to as sinks. A high degree of efficiency can be achieved with DMS. Even in the presence of high percentages of near-density material,

the separating density can be closely controlled and a wide range of sizes can be treated using different units.

Two types of equipment are used in the DMS process, cyclones and drums (also known as baths). There are, in turn, two types of cyclones and two types of drums, as outlined on the following pages.

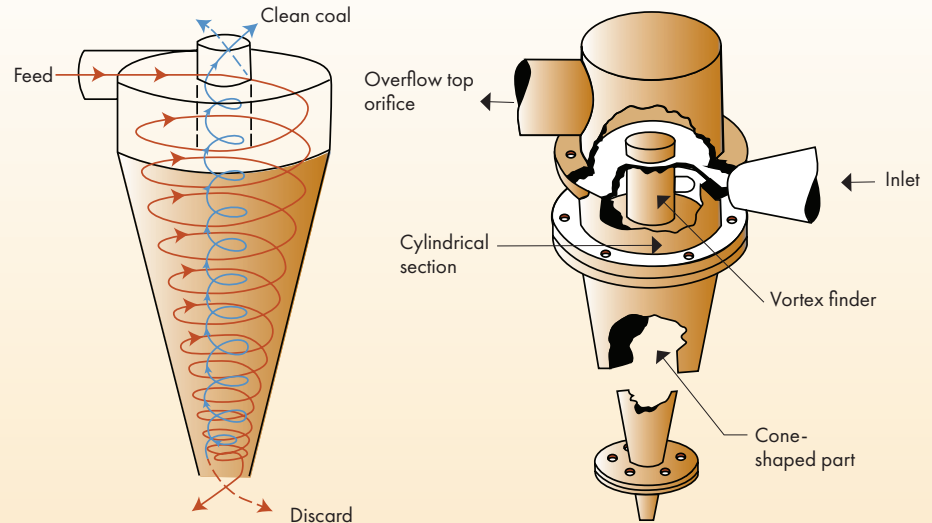


DMS cyclones

DMS cyclones use fluid pressure to create rotational fluid motion. The coal suspended in the medium is introduced tangentially into the cyclone, resulting in a centrifugal force. Due to this force, the heavier material tends to be pushed more towards the walls of the cyclone, causing it to exit through the spigot as sinks. The lighter coal material tends to rotate along the axis of the cyclone, exiting through the vortex finder as floats.

Cyclones are reliable and simple, requiring relatively low maintenance since they have no moving parts. They have been widely used since the 1940s to separate product from discard. Conventional cyclones nevertheless struggle to process a mixture of materials, traditionally resulting in the need for a fines and coarse DMS in most plants. The three-product cyclone, introduced in the 2000s, is more flexible.

DMS cyclone



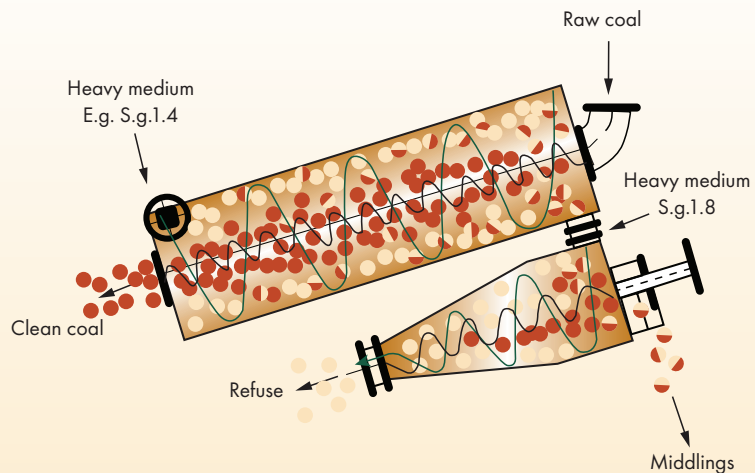
The spiral flow in the cyclone

Three-product DMS cyclones

Three-product cyclones are used to produce not only a primary product but a middlings product as well. Each unit consists of a cylindrical primary vessel, which is attached to a conventional cyclone. Raw coal and medium is fed into the primary cyclone, from which a high CV product is recovered. Discard from this first process feeds the secondary cyclone, from which a middlings product and final discard is recovered.

Three-product cyclones, which can be gravity-fed or pump-fed, maximise the amount of product recovered and reduces the amount of discard produced, reducing the overall discard footprint.

Gravity-fed three-product cyclone



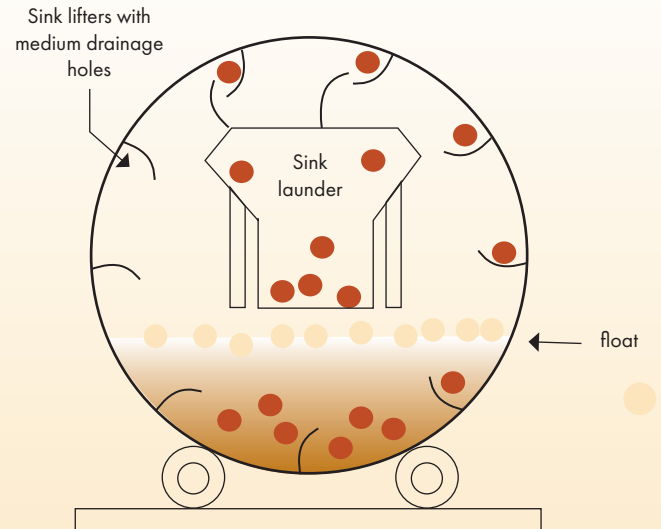
Wemco® drums

Wemco® drum separation makes use of cylindrical drums that rotate on bearings. Inside the drum is a shallow pool of medium at the density required to produce clean coal of the specified quality. Separation is accomplished by the continuous flow of the lighter-floating coal over the dense medium, which exits the drum through the floats stream as the product.

The heavier material sinks to the bottom of the drum, where it is continuously removed by lifters installed inside the drum. Wemco® drums are commonly used in the coal industry as they are simple, reliable and require relatively low maintenance.

Drewboy drums, which are produced by a different manufacturer, operate on the same principle.

The front view of a Wemco® drum





Processing fine coal

While the DMS methodology is suitable for processing coal > 0.5mm, it is not as effective for the processing of fines, which are below 0.5mm. We therefore use other technologies for this purpose. Coarse fines are processed using spirals and teeter-bed separators (TBSs), while ultrafines are processed using flotation tanks.

Spirals are used for the beneficiation of coarse fines with particle sizes ranging from -0.5mm to 0.150mm. During processing, the coal particles move to the outside of the spiral as they are lighter than the other materials in the slurry. Teeter-bed separators (TBSs) are used as a secondary upgrade for the product. They use jets of water to float out the light coal faster, allowing rock and waste to exit the separator at the bottom.

| Challenges in fine coal recovery

While processing methods for coarse coal and middlings are established and efficient, the recovery of fines poses several challenges. This is largely due to the inherent characteristics of fine particles and their impact on various processing stages. These challenges can affect separation efficiency, product quality and overall operational sustainability.





Broadly, the challenges in fines recovery fall into five categories:



Cost/loss of revenue

High cost of processing and the resulting discarding of fines: Fine coal is frequently discarded due to the high cost of handling and processing it, which results in a loss of revenue.



Separation efficiency

Poor separation efficiency: Ineffective removal of fines can lead to a reduction in separation efficiency of up to 20%, increasing ash content and lowering the overall calorific value (CV) of the coal.

- **Misplacement of material:** There is often a high misplacement rate during processing as the coal is too fine for dense medium cyclones and too coarse for froth flotation.



Product quality

Degraded product quality: Fine particles tend to report to the product stream due to their lower settling rates, which causes dilution effects and suppresses the overall CV of the final product.

Inability to meet export specifications: The presence of ultrafine particles, particularly those of less than 150µm, consistently lowers the overall CV and means the final product does not meet stringent export specifications.



Process limitations

Wemco® drums: While effective for processing coarse coal, Wemco® drums are not ideal for fine material. The presence of fines in the Wemco® circuit requires optimisation of feed particle size distribution. At Goedehoop North Plant, for instance, fine coal material was inadvertently fed to the Wemco® section, which is designed for coarser material, leading to high misplacement values. This issue made it challenging to identify the source of misplacement in composite samples.

Spiral concentrators: Although widely used for fine coal beneficiation, spirals pose several challenges. These include difficulty in feeding multiple starts with uniform material and difficulty in achieving strict separation targets for high-grade products, which then require secondary beneficiation.

Teetered Bed Separators (TBS): While capable of upgrading spiral product, initial tests have shown poor separation in the TBS due to low bed density.

Three-Product Cyclones: These require continuous optimisation of operational settings, such as vortex finder length and water injection flow rates, to prevent either feed from short-circuiting into the overflow or heavier discard material from reporting to the product, both of which reduce product quality.



Operational and maintenance issues

Gypsum formation and scaling: A significant challenge is the build-up of gypsum (calcium sulphate) in pipelines and on screen decks. This occurs due to the neutralisation of acidic mine water with limestone. Gypsum formation restricts water flow to drain-and-rinse screens, blinds screen panel apertures and blocks spray nozzles, which leads to high magnetite losses and under-recovery of the medium used in dense medium separation.

Water quality management: The contamination of return process water by seepage, requiring additional limestone treatment, further accelerates gypsum precipitation. Ensuring high-quality process water is crucial for efficient magnetite recovery and overall plant performance.



| Research and optimisation

To address these challenges, we conduct ongoing research and optimisation trials related to various aspects of our coal processing and water management operations. A summary of recent studies, which will be presented in full at ICPC XXI, is given here. These examples demonstrate our commitment to continuous improvement, cost reduction, and environmental compliance.

Management of clarifier sludge at Emalahleni Water Reclamation Plant (EWRP)

ICPC XXI Session 1

Researcher: Maryke Malan

Head of the Emalahleni Water Reclamation Plant, Thungela Operations

Purpose: To address significant clarifier performance issues at the Emalahleni Water Reclamation Plant (EWRP) resulting from drastically deteriorated water quality, increased acidic water feed volumes, and high iron loads of between 450 mg/l and 850 mg/l. This was causing poor settling, clarifier rake trips, and gearbox damage. The severe impact of excess water even led to mining operations having to be almost completely halted between November 2023 and January 2024.

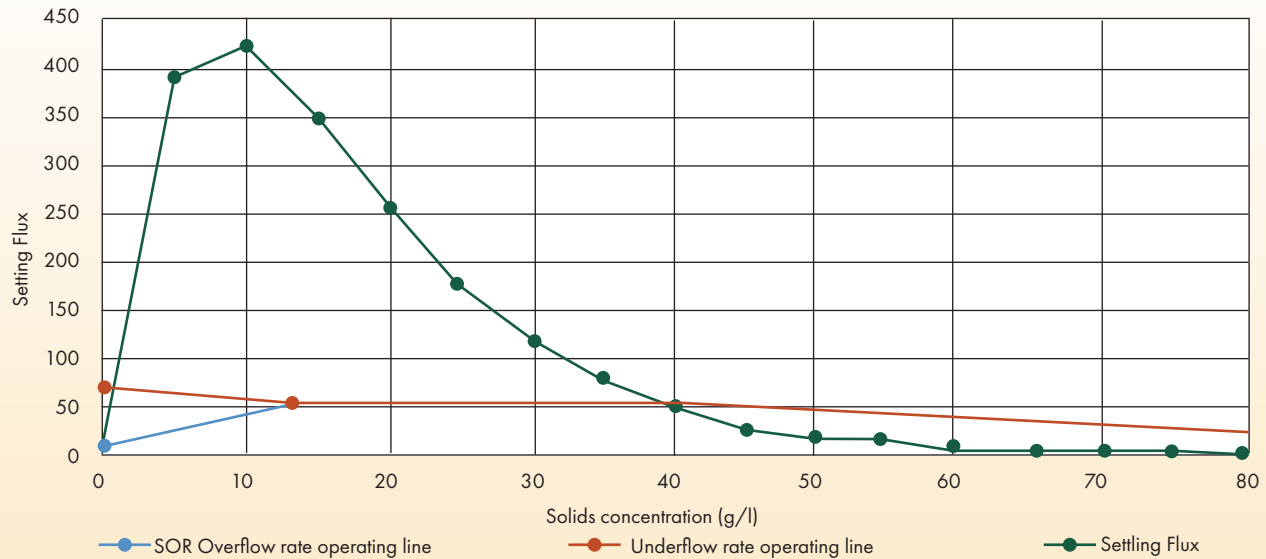
Methodology: An eight-month process that included trialling alternative polymers, implementing stringent controls on feed blending based on iron concentration, and developing a mass balance control tool was undertaken. A state-point analysis, typically used in biological water treatment, was also conducted to optimise clarifier performance.

Results: By the end of April 2024, all water-related stoppages had been resolved and by June 2024, the mine was dry, allowing operations to continue. The mass balance and state-point analysis tools prevented any further clarifier rake trips, which had previously been occurring every three to six weeks.

Process innovations: Several innovations were introduced as a result of this study:

- Feed variance control was made more stringent, shifting the focus from managing acidity to controlling iron concentration in the incoming feed.
- A mass balance control tool was developed for precipitates to prevent sludge buildup and inform operators on required feed or dump rates.
- State-point analysis was unconventionally applied to optimise clarifier performance for acid mine water sludge, providing a graphic representation of settling flux versus solids concentration and guiding operating states.

Example of a state point analysis graph for EWRP Clarifier A



Maryke Malan

Maryke Malan is one of a new generation of young engineers and metallurgists driving real innovation and solving problems once considered too complex, too costly or too entrenched to be solved. On this project, she set out to address clarifier performance issues resulting from increasingly acidic feed volumes entering the EWRP for treatment.

"The state-point analysis we used is typically used in the sewerage industry," she explains. "It's quite a technical process – and it took some time to review the academic literature on the subject in order to understand how it could be applied at the plant."

The EWRP was facing significant challenges with regards to iron concentration in the water from Thungela's Navigation plant. This required constant dewatering at maximum rates, which resulted in a clarifier being overloaded on a monthly basis. It also meant that the plant was operating outside of its design parameters.

"Luke Venkatesan, our head of coal processing and business improvement, suggested that I look into state point analysis and assess whether it could be used at plant," says Maryke. "I was doubtful at first since the process of treating acidic mine water is so different from sewerage water treatment. After investigating the process more thoroughly, though, I realised that a process is simply a process and the same fundamentals can be applied in different operational settings."



💡 It was very rewarding to work on this project. 💡

"Mining requirements change and that affects the business case for active or passive treatment. There is never a dull moment when it comes to water treatment!"

Optimisation of the three-product cyclone at Greenside Colliery

ICPC XXI Session 5

Researcher: Tsireledzo Maliehe

Metallurgical engineer, Greenside Colliery

Purpose: To optimise the three-product cyclone at Greenside Colliery to meet a new business requirement of 21 MJ/kg middlings product thereby reducing the amount of discard produced.

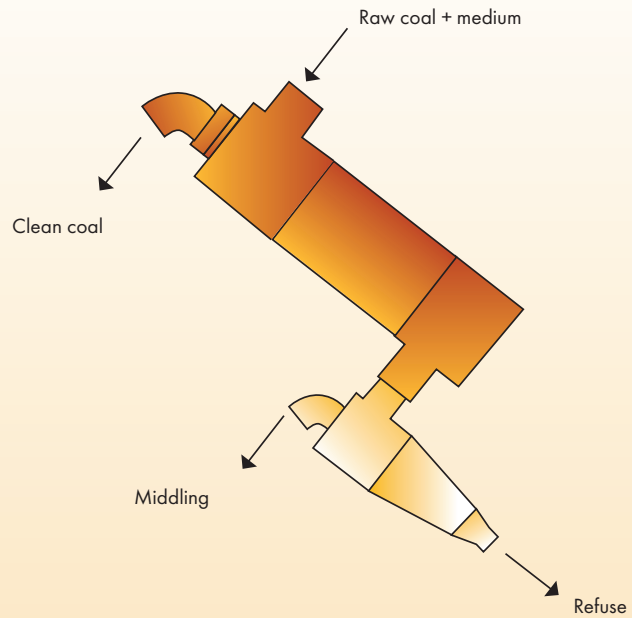
Methodology: The study involved manipulating the vortex finder length and testing different water injection flow rates in the secondary cyclone to achieve a middlings product CV of 21 MJ/kg. This test work included daily composite sampling and analysis.

Results: A 75% (10.5 cm) vortex finder length was identified as the ideal setting, achieving a CV of 20.70 MJ/kg. For water injection, 50 m³/hr was found to be the ideal flow rate, resulting in a CV of 21.30 MJ/kg and an ash percentage of 34.35%. Optimising the process based on these findings significantly increased the CV of middlings from an average of 19.02 MJ/kg to 21.30 MJ/kg.

Process innovations: Due to evolving material characteristics, the operational settings of the secondary cyclone in the three-product cyclone needed to be optimised. This involved testing different vortex finder lengths and a 75% (10.5 cm) vortex finder length was identified as the ideal setting. Increasing the length of the vortex finder helped to prevent the feed from short-circuiting into the overflow, which degrades product quality.

However, excessive length can cause discard material to report to the overflow, which also reduces product quality. Various water injection flow rates were therefore tested in the secondary cyclone, with 50 m³/hr being determined as the ideal flow rate. Injecting water tangentially into the cyclone cone reduces the cut-point density, resulting in a higher-quality product.

Diagram of a three-product cyclone



Tsireledzo Maliehe

Tsireledzo Maliehe is one of several young metallurgists who shone on our recent coal processing optimisation projects.

"For the Greenside project to succeed, we had to integrate input from multiple departments and address a range of DMS-related issues," she says. This collaborative approach was critical to resolving the challenges related to density control."

The most significant outcome of this process was the automation of the water injection system at the plant, which minimised the need for human intervention and reduced the risk of operator error. Together with the improvements made to density control, this enhancement has enabled us to maintain tighter control and achieve more stable operations.



💡💡 **Improving the quality of the middlings not only reduced the amount of discard in the final product but also contributed to increased revenue for the business. 💡💡**



Optimisation of magnetite recovery circuits at Navigation Coal-washing Plant

ICPC XXI Session 8

Researcher: Pervaan Pillay

Senior plant metallurgist, Khwezela Colliery

Purpose: To reduce high magnetite consumption at the Navigation plant, which was largely caused by scaling due to gypsum formation from limestone-treated acidic water. Gypsum build-up restricted water flow, blinded screen panels, and impacted efficient magnetite recovery.

Methodology: The aim of the project was to optimise the primary magnetic separators (drum height, operating level, magnet height, and squeeze gap), to enhance spray-water pressure, and to select suitable screening media on the drain-and-rinse screens. This included increasing maintenance routines for high-pressure jetting, pipeline modifications, increasing header tank operating levels, recommissioning redundant manifolds, upgrading screening media to rubber, and installing self-flushing spray nozzles.

Results: Magnetic separator efficiency increased from 95% to 99% and magnetite adhesion losses decreased by an average of 4.85 kg per tonne. Despite these improvements, magnetite consumption remains above budget and ongoing optimisation initiatives are in progress. These include progressively reducing limestone dosing, introducing scaling inhibitors, and re-using supernatant water from the active slimes compartment without neutralisation to further mitigate pipe scaling.

Process innovations: A comprehensive strategy was developed to optimise the primary magnetic separators by adjusting drum height, operating level, magnet height, and squeeze gap. Spray-water pressure was enhanced and suitable screening media selected for the drain-and-rinse screens. Self-flushing spray nozzles were installed to combat blockages from gypsum accumulation and alternative treatment methods to reduce limestone dosing were introduced to mitigate gypsum formation upstream.

Pervaan Pillay

Pervaan Pillay knew how significant the challenge of optimising magnetite recovery from Navigation plant's DMS circuits was, as they had the highest magnetite consumption rate of all of Thungela's processing plants. The core issue was that poor in-circuit magnetite recovery was being caused by gypsum scaling and sub-optimal equipment settings.

"The coal-washing process produces acidic water," he says "and, in order to neutralise this water, limestone is used. During the neutralisation process, excess calcium from the limestone reacts with sulphates in the water to form calcium sulphate (gypsum) and this builds up everywhere in the system, preventing magnetite from being recovered back into the circuit. The net result is that the plant has to use more magnetite, which impacts on operating costs."

A multi-pronged strategy, which included operational, maintenance and small-scale engineering solutions, was therefore developed and applied. This delivered quantifiable results and significantly improved the efficiency and sustainability of the coal-washing operations.

Instead of just mitigating the effects of poor water quality downstream through labour-intensive descaling, our focus is now on eliminating the contamination source upstream."



💡💡 **This is a very important outcome as it represents a shift towards detecting and optimising deviations at the source in coal processing. 💡💡**

Treatment of acidic mine water at Blaauwkraanz South Mineral Residue Facility (MRF)

ICPC XXI Session 14

Researchers:

Mulweli Yolanda Mafukata

Metallurgical engineer, Khwezela Colliery

Bonginkosi Mgweba

Metallurgical manager, Khwezela Colliery

Purpose: To evaluate treatment capabilities and potential management options for highly acidic 'kopseer' (headache) water at the decommissioned Blaauwkraanz South Mineral Residue Facility (MRF). This water, with a high concentration of heavy minerals (Fe^{2+} ions), was difficult to treat and was being unsustainably recirculated.

Methodology: An engineering capability study was conducted to assess water quality across the site, measuring pH, acidity, total iron and sulphates. The existing infrastructure was reviewed and baselined, and process modelling was conducted by means of blending trials. 'Kopseer' water was blended with fresh seepage from the active Blaauwkraanz North MRF at varying ratios and effluent water qualities were analysed.

Results: The findings showed that 'kopseer' water could be successfully neutralised through the existing Toeseep liming plant without major modifications to a pH greater than 6. The plant demonstrated the capability to reduce iron content by 250%, acidity from over 7,000 mg/l to less than 20 mg/l, and sulphates by over 50%.

Process innovations: The operation of existing water treatment plants at the site, specifically the Toeseep liming plant, were optimised to treat over 100 ML of highly acidic water. This was achieved without requiring structural modifications to the plants themselves.

Optimisation processes involved descaling the aeration tanks, which were found to be operating at only 50% effectiveness, and resolving leaks in the clarifier's feed well, which were causing contamination.

The key innovation was the development of a sustainable treatment recipe and operational practices to establish an effective management routine for handling residual gypsum. The plant is now running a trial of anti-scalant inhibition to manage gypsum precipitation.

Mulweli Mafukata ○

Mulweli Mafukata took on the challenge of processing highly acidic 'kopseer' water at Blaauwkraanz South with focus and dedication. The key challenge was to deplete over 100 ML of this water stored in the dormant slurry compartment at the facility, which had been impacted by continuous recirculation over the years.

Collaborating with industry experts from Proxa Water and with colleagues at the Emalahleni Water Reclamation Plant, who assisted by treating some of the 'kopseer' water at the plant, Mulweli and fellow researcher, Bonginkosi Mgweba developed an effective water management strategy that enabled them to significantly reduce the environmental risk associated with the water and to reduce the potential impact of acidic mine water on other water resources.

"It is rewarding to understand that the work I do is part of something bigger," she says. "The fact that everything impacts on everything else is a real motivation. I knew how important it was to achieve our objectives so that the challenge of processing this water wouldn't be passed on to others in the future."



💡 **Water is life, and all of us have a responsibility to care for this precious resource and to ensure that it is not only available to but also usable for future generations. 💡**

RB1 product optimisation using the Optima® classifier at Phola Coal Processing Plant

ICPC XXI Session 16

Research team:

Karabo Malekutu:

Metallurgical engineer, Phola Coal Processing Plant

Franco van de Venter:

Metallurgical engineer, Gravitas Minerals

Mpho Ramudzwagi

Metallurgical engineer, Gravitas Minerals

Yorkabel Fedai:

Metallurgical engineer, Gravitas Minerals

Purpose: To determine whether the existing spiral product, which did not consistently meet primary export product specifications, could be upgraded using the Optima® Classifier 500 (OPC 500) pilot unit to meet the primary RB1 export product specification of a minimum 27.20 MJ/kg.

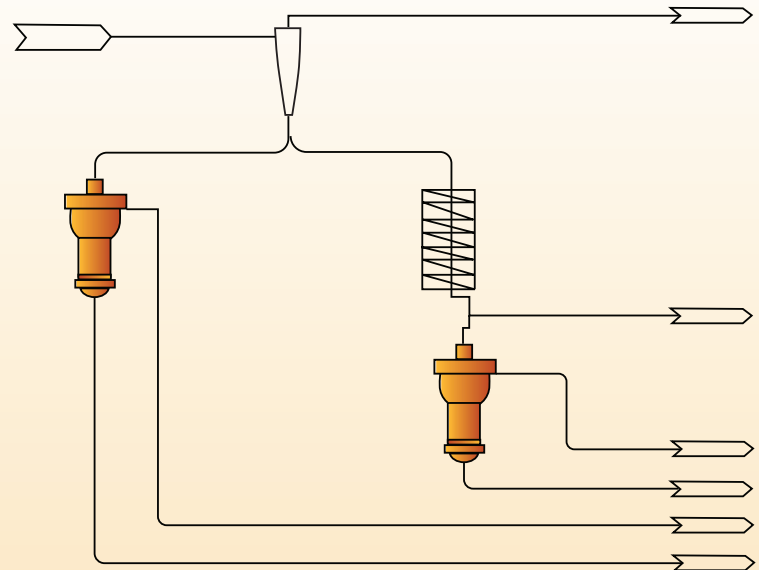
Methodology: The study involved experimenting with two different scenarios of feed to the OPC 500 – including direct cyclone underflow and a combination of spiral product and middlings – in order to assess their impact on product quality and yield.

Results: The study concluded that eliminating fines below 150µm could enable the OPC 500 to achieve the required RB1 target. The OPC's role in enhancing coal product quality and maximising financial returns by shifting material from middlings to export grade was critical.

Process innovations: The primary process innovation, specifically for evaluation in test work, involved the installation of the OPC 500 pilot unit. This technology, developed by Gravitas Minerals, represents one of the latest innovations in the fine coal processing industry.

The introduction of the OPC 500 aimed to address the challenge of upgrading fine coal material, particularly the spiral product, to meet higher product specifications. While Phola already used triple-start spirals for fine coal beneficiation, producing product, middlings, and discard streams, the spiral product alone did not consistently satisfy the primary product specifications.

Diagram of the experimental set-up



Karabo Malekutu

Like the other young metallurgists in our Technical Department, Karabo Malekutu's contribution to our operations is helping to reshape them. On the Phola Coal project, her objective was to maximise the value of Thungela's fine coal.

"The aim of the project was to find a way to upgrade this coal into a higher-quality primary product, one that could command a better price and contribute more significantly to the company's revenue."

While reviewing the plant's spiral circuit performance, Karabo noticed the effect that ultra-fine material was having on product quality and yield. She decided to conduct a trial to see whether removing the ultra-fine fraction could improve the product grade.

Extensive sampling and analysis revealed that the existing spirals could achieve the same product quality as new technology if the ultra-fine fraction was removed from the feed beforehand. This innovation saved the business from having to make a significant capital investment in new technology.



💡 Fine coal was being processed into a secondary product with lower market value. 💡



Fines circuit performance evaluation at Mafube Colliery

ICPC XXI Session 17

Researchers:

Peace Mahlangu

Metallurgical engineer, Mafube Colliery

Thabo Nhlapho

Plant superintendent, Mafube Colliery

Purpose: To investigate potential yield losses in the DMS plant at Mafube Colliery's processing plant and evaluate the performance of the fines circuit, specifically the LC3 spirals and Teetered Bed Separator (TBS). The aim was to determine if an overall CV upgrade of 5 MJ/kg was achievable.

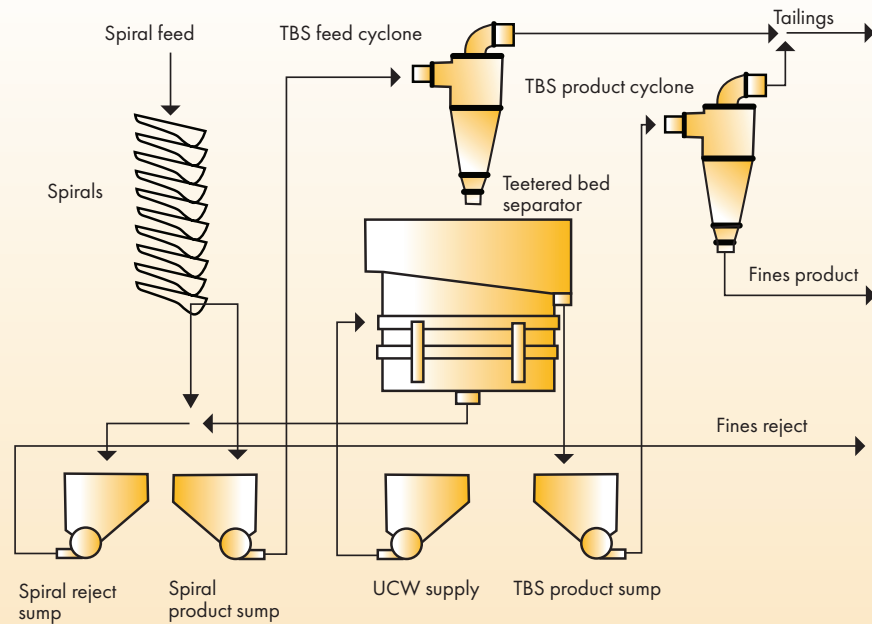
Methodology: A sampling campaign in accordance with ISO standards was conducted on the fines circuit. Samples from the LC3 spiral feed, the TBS feed, the product and the discard were collected under varying operational conditions, and fractional CV and ash analyses were performed.

Results: Tests revealed that ultra-fine material in the feed and the final product was limiting the coal's quality, indicating that we needed to adopt a dual product strategy for fines beneficiation.

Process innovations: Operationally, this indicated that we needed to use the Teetered Bed Separator (TBS) to produce both a middlings product and an export-quality product. This would maximise the value recovery from fines that previously might have been classified differently or discarded.

A TBS used as a spiral product upgrade (B Drummond, 'TBS handbook')

Removing the ultra-fine fraction (below $150\ \mu\text{m}$) of the material in the feed proved that product quality could be improved using the existing spirals. This innovation enabled us to achieve an overall upgrade of $4.75\ \text{MJ/kg}$ without having to invest in new technology.



Peace Mahlangu

As a young engineer working on some of the most challenging issues in coal processing, Peace Mahlangu relished the opportunity to work on the fines circuit at Mafube as it is relatively more complex than the circuits for coarser size fractions.

The TBS at the plant was unable to consistently upgrade the fines fraction to the required export specification. As a result, the material could not be continuously blended into the export product stream to support yield improvement.

“What surprised me most during this practical investigation were the initial results, which unexpectedly showed that the TBS product had a lower CV than the TBS discard. However, after systematically altering the TBS operating parameters, particularly the cut density and feed rate, the unit is capable of efficiently beneficiating fine coal material and producing a higher-quality product.”

He says he learnt a great deal from working with more experienced colleagues on the project, which helped him to grow and to build on the theory he had studied at university.



💡💡 **At the time of implementation, the Mafube processing plant was experiencing some discrepancies between actual product yield and the yield projected by the geological model.💡💡**

Misplacement investigation at Goedehoop Colliery's bank 2 coal-washing plant

ICPC XXI Session 19

Researchers:

Davis Phasha:

Metallurgical engineer, Goedehoop Colliery

Irvin Vilakazi:

Plant manager, Goedehoop Colliery

Martha Gwambe:

Metallurgical manager, Goedehoop Colliery

Purpose: To investigate and address misplacement challenges at the Bank 2 plant, which was struggling to balance production and classification, often feeding fine coal to the Wemco® section, resulting in high misplacement values.

Methodology: The research involved modular sampling on discard from individual circuits to understand the source of the misplacement. It also involved trialling changes to panel apertures on banana screens and reviewing the philosophy on the Wemco® feed bin flopper.

Results: Modular analysis revealed that the Wemco® drums were the root cause of the misplacement rather than the DMS cyclones, which demonstrated efficient classification. Using modular rather than composite sampling, which had been obscuring the root cause of the misplacement issue, enabled us to introduce process interventions to address the issue.

Process innovations: These interventions included changing the Wemco® banana screen panel apertures from 16mm to 20mm in order to eliminate fines. We also implemented an automatic process control (APC) system for a 50% split on banana screen feeding and a revised flopper philosophy for Wemco® feed bins to ensure even distribution.

Davis Phasha

Davis Phasha is a young metallurgical engineer who was excited by the prospect of ensuring that misplacement values at Bank 2 were kept within budget.

"Product coal misplacement in discard is often overlooked and it isn't recognised as an opportunity to enhance yield," he says. "So our focus as a team wasn't just on reducing misplacement but on optimising yield as well."

He says the project brought home how important it is to understand the original design specifications of the equipment in order to optimise performance. Based on that, continuous circuit monitoring and optimisation can then be used to deliver sustained results.

"The project also demonstrated that young engineers and metallurgists have an important a role to play in introducing new and enhanced methods of beneficiation into the mining industry," he says.



💡💡 **We have to continuously look for new technology and improved methods that can yield the better results.** 💡💡

Martha Gwambe

Martha Gwambe says that managing a plant with colleagues who are focused on the vision of securing high-quality outputs in a safe way excites and affords her the opportunity to build up and be part of a team that is resilient, innovative and cohesive.

“On this project, we focused on examining modular losses and understanding the root causes in each case. It was also important to gain insight into the various coal feed properties that were influencing the behaviour of each module so that the solutions we developed would be fit for purpose.”

A high level of collaboration and acceptance of the changes by the engineering team was a key success factor, she says. Changes to equipment and maintenance strategies to accommodate a new way of thinking were undertaken with very little resistance.



💡 It was fulfilling to see our values of excellence and entrepreneurship being lived in real time. 💡

| Environmental impact and water management

Environmental impact and water management were critical components in each of these studies. One of the greatest challenges in mining is the management of acidic mine water, particularly water with high iron and sulphate loads. This results in significant operational challenges, such as gypsum scaling, problematic sludge formation, damage to infrastructure, and compliance risks.

Continuous innovation in water treatment and beneficiation technologies is required to ensure both operational efficiency and environmental sustainability.



I The future of coal processing at Thungela

The future of coal processing for Thungela will be centred around a dynamic and technologically driven approach that is designed to extract maximum value from our resources while always ensuring that we operate in a sustainable and environmentally responsible way and are able to adapt to evolving market demands and environmental regulations.

We will continue to focus on continuous optimisation, advanced beneficiation technologies, automation, sustainable water management practices, and adaptive strategies to maximise product value and operational efficiency.

Key aspects of our strategy will include:



Continuous optimisation and adaptation to changing conditions

At Thungela, we recognise that our coal processing plants require continuous process optimisation as ore types, material characteristics, and business requirements change. This indicates a future of ongoing fine-tuning rather than static operations.

Similarly, operations at the Emalahleni Water Reclamation Plant (EWRP) highlight the need for teams to remain vigilant and to constantly update models and operating procedures to manage ever-changing input conditions, especially fluctuating iron loads in mine water.



Advanced fines beneficiation and multi-product strategies

There is a growing need to convert fine coal, often previously discarded due to handling costs, into marketable products. We will continue to address this through equipment and process optimisation as well as by introducing new technologies whenever required.

- At Mafube Processing Plant, for example, making use of the Teetered Bed Separator (TBS) to produce both a middlings product and an export product has maximised the recovery of value from fines. An additional feasibility study is currently being conducted to determine the need for additional infrastructure, such as an extra TBS product tank and a dewatering cyclone.
- At the Phola Coal Processing Plant, we are exploring advanced technologies such as the Optima® Classifier 500 pilot unit (OPC 500) for second-stage beneficiation in order to upgrade fine coal to meet RB1 export product specifications. The future here involves optimising desliming to eliminate ultra-fines and potentially also the implementation of a two-product strategy to produce an RB1 export-quality coal (a coarse fraction of ~27 MJ/kg) and an RB3 domestic product (fines of ~23 MJ/kg) to align with market demands and maximise revenue. This approach is a strategic beneficiation tool for RB1 export-driven coal processing.



Sustainable water management and scaling mitigation

Addressing issues like gypsum scaling and acidic mine water is a critical future focus.

- The Navigation Coal-Washing Plant is actively pursuing alternative water treatment methods to reduce limestone dosing, introducing scaling inhibitors and re-using supernatant water from the active slimes compartment without neutralisation to mitigate gypsum formation upstream. The goal is to improve water quality to render limestone treatment unnecessary on-site.
- For highly acidic water sources like 'kopseer' water at the Blaauwkraanz South Discard Facility, the future involves exploring blending with other softer water qualities and continuing trials with anti-scalant inhibitors to prevent gypsum precipitation. This is an intrinsic part of establishing sustainable treatment recipes and operational practices.
- The management of clarifier sludge at EWRP will continue to focus on stringent feed variance control, mass balance control tools, and the application of state-point analysis to optimise performance and prevent operational stoppages caused by high iron loads.



Enhanced efficiency and cost reduction

A core driver for all these innovations is to improve overall plant efficiency and optimise the cost-per-tonne profile.

- The ongoing efforts at Navigation Plant, for instance, are specifically aimed at reducing magnetite consumption to increase efficiency and reduce costs.
- The Bank 2 Coal Washing Plant's implementation of modular sampling and automatic process control (APC) for even feed distribution and improved classification aims to ensure the plant runs optimally, leading to proper recovery of coal product and an increase in saleable tons. The downward trend in misplacement from 2020 to 2025 indicates our commitment to sustained efficiency.



Conclusion

At Thungela, the future of coal processing will always be informed by our primary objective, which is to responsibly create value together for a shared future.

We will do this by being uncompromising about safety, which is the first consideration in everything we do. We also hold ourselves to the highest standards of corporate governance by mining responsibly and managing our impacts. This includes being a good neighbour. We mine responsibly to ensure that host communities benefit from the positive impacts we aim to create.

We will also share in the value we create. From shareholders and employees to host communities, we want all our stakeholders to be better off because of our business.

We recognise that this is something we cannot do on our own, which is why we will continue to collaborate, engage and build meaningful relationships with all our stakeholders.

Finally, we intend the value we create to contribute to a bright future for all. By working to achieve our goals together, we can all look forward to a future worth sharing.





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