Metso

Case study

Thickener upgrade incorporating feed system innovations delivers optimized process performance

A modernization of the existing coal product thickener was recently implemented at an Australian metallurgical coal site. This upgrade incorporated significant technology improvements including Metso's leading Reactorwell feed system. As a result, the equipment has been repurposed to operate at a higher capacity, while achieving improved process performance, sustainability and safety – all at the same time.

A thickener upgrade, as well as modernisations within the feed system, has been successfully implemented at a metallurgical coal site in New South Wales, Australia. The plant plays a vital role in producing high-quality hard coking coal for steelmaking. One of its essential processes involves thickeners, which are utilized in coal product and tailings thickening duties. These thickeners have a significant impact on water and energy consumption, as well as adjacent processes.

In today's world, water is becoming an increasingly scarcer and more valuable resource. Thus, the importance of reliable and high-performing thickener technology continues to grow. In addition to that, as society moves towards circularity and reducing waste, the re-use of existing installed equipment through modernization and upgrades is becoming increasingly important in the world of minerals processing.

These growing demands ultimately prompted the site to utilize Metso's vast experience and knowledge to complete a thorough assessment and upgrade of their existing equipment. While the initial focus was asset end-of-life management and reliability, Metso's meticulous audit identified significant potential performance enhancements, such as modifications to the feed system, the inclusion of an external thickener feed tank, and more.

Benefits

- Improved thickener control and performance
- Improved reliability
- Increased flotation reagent dosing flexibility
- Reduced froth loading
- Better overflow clarity
- Improved thickener operational stability
- Increased safety and sustainability
- Reduced wear rates and maintenance

Existing coal product thickener before upgrade (emptied)

Challenges with existing equipment and process limitations

The coal product thickener was initially installed in 1975, making it 47 years old when it underwent the upgrade in 2022. By that time, existing thickener components – including feed system, rakes, drive cage and tank walls – were nearing end of life. This presented challenges in sourcing replacement parts to continue operation into the future.

From a process design standpoint, critical process components like the thickener feed system and overflow launders would experience hydraulic loadings beyond their original design capacity at the proposed future operating conditions.

When the upgrade was initially proposed in 2019, the thickener was handling a nominal feed rate of approximately 50 dry tonnes per hour of solids. The upgrade aimed to boost this capacity to a nominal range of 120 to a maximum of 143 dry tonnes per hour of solids, aligning with the site's proposed overall processing capacity increases.

Managing overflow quality and control

Thickener overflow quaility is important for the flotation circuit's success. At this site, overflow is recycled, so maintaining its quality is crucial. However, excessive froth on their existing thickener posed challenges. Froth events limited flotation reagent dosing, and raised the risk of product spillage.

Metso is in the unique position to predict and gather data that delivers optimized and sustainable flowsheets, thus enabling mining operations to improve recovery, resource efficiency and sustainability.

With advanced and reliable research capabilities, the site trusted Metso to help upgrade their equipment, from scoping feasibility to actual implementation, resulting in an optimized process for the plant.

Original thickener feedwell (prior to upgrade)

Scoping and feasibility: Defining the upgrade path

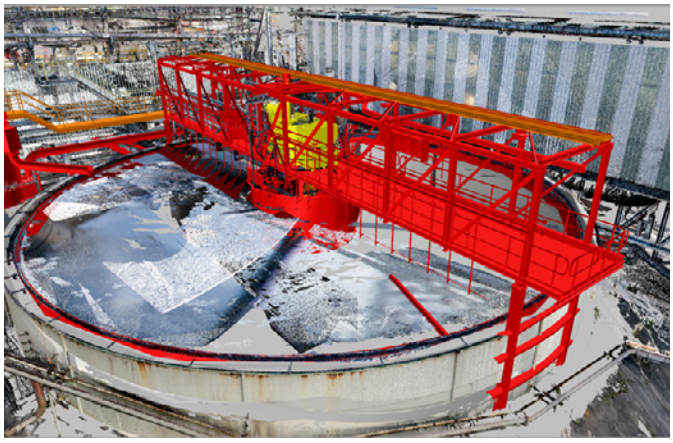
This phase primarily focuses on identifying project goals and requirements, with the Feasibility component addressing both technical and commercial aspects. In collaboration with the project execution team and personnel at the metallurgical coal site, Metso's experts were able to map out key considerations such as technical specifications, operational requirements and more.

To ensure accuracy, Metso carefully collected thickener feed slurry samples before any chemical dosing. These samples were then transported to Metso's laboratory in Perth, Western Australia, where testing replicates future design conditions using a lab-scale unit.

The results demonstrated that the material tested could achieve an operating underflow density of 47.3% solids w/w, and improvements in overflow clarity were attainable post-upgrade. However, the test work also revealed that feed solids concentrations exceeding 12%w/w would pose processing challenges, thus necessitating a feed slurry dilution system.

Recognizing the need for modifications, the plant flowsheet was adjusted to reroute low solids concentration filtrate return and cloth wash return streams from coal product filters to a new thickener feed tank. This modification facilitated dilution of the thickener feed stream, reducing it from a maximum of 16.6%w/w to 10.3%w/w feed solids concentration. This simplified both the thickener configuration and the overall operation.

99mm Diameter Lab Scale Thickener used for laboratory dynamic thickener testwork.



Laser scan images showing before upgrade arrangement versus final upgrade design models.

Determining the work scope

To address the existing equipment's condition, several repair options were evaluated. However, it became evident that the current tank overflow system lacked the capacity required for the planned upgrade. To streamline the process and minimize site downtime, the decision was made to replace the entire upper tank wall section, including overflow launders. This solution not only addressed the need for wall repairs, but also met the necessary overflow capacity increase.

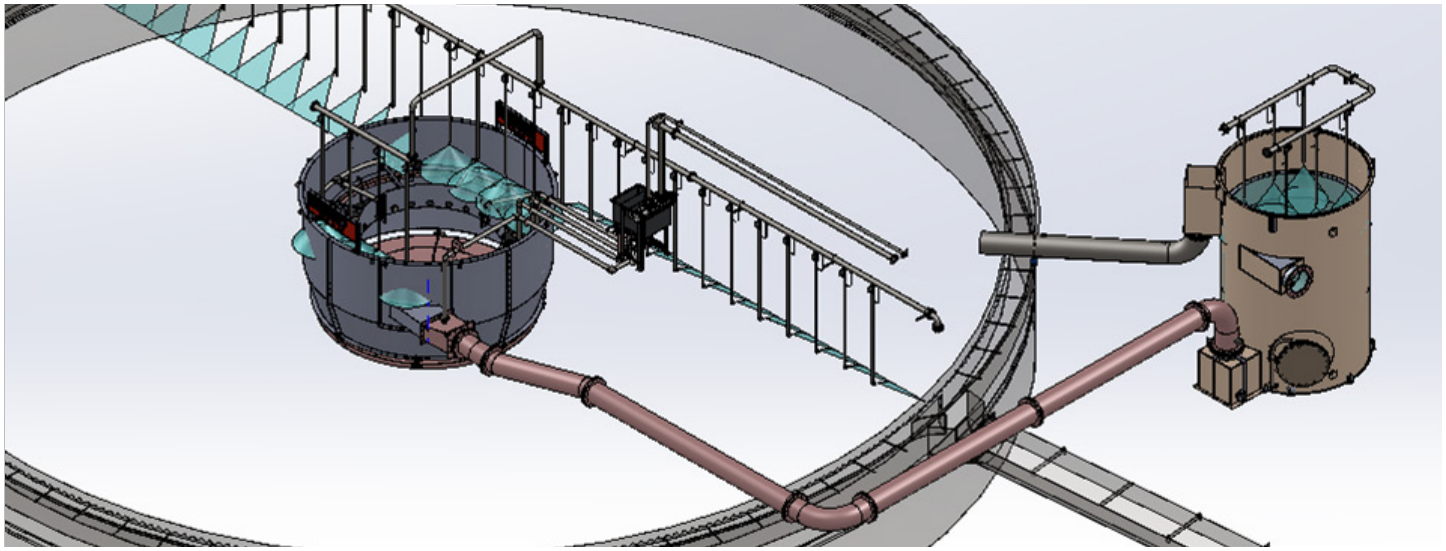
The existing outdated thickener setup had numerous features leading to undesirable thickener feed characteristics at the feedwell. The feed slurry entered the thickener with high-velocity launder flow, carrying substantial volumes of froth and entrapped air. This resulted in surging, burping, splashing, and a challenging froth management issue within the thickener.

Metso conducted a comprehensive review of the upstream hydraulic arrangement from the thickener inlet flange to the cyclone overflow hopper. It was concluded that an alternative piping route and the installation of an external feed de-aeration tank were necessary for optimal thickener upgrade performance and maintainability.

In addition to these modifications, replacing the entire bridge, rake drive, and raking mechanism was deemed the most cost-effective solution to address condition and end-of-life issues with the existing drive unit. A decision was also made to replace the existing center column style bridge and drive combination, featuring a multi-pinion drive with a modern full-span bridge design incorporating a single planetary gearbox. This substitution offers an economical upgrade solution for the center column thickener.

The project team collaborated closely to identify and incorporate additional components such as air and water services and walkway lighting into the equipment supply package. This inclusion enabled higher equipment operability, minimized site installation efforts, and reduced the need for adhoc post-installation modifications.

To bring their vision to life, Metso's meticulous and detailed engineering converted conceptual ideas into comprehensive designs and fabrication drawings. One of the tools used – 3D laser scanning – proved to be extremely useful, offering an accurate representation of the existing infrastructure.



Upgrade feed system and froth management components. Including Reactorwell™, external feed de-aeration tank and froth suppression sprays (bridge, drive and raking mechanism omitted for clarity)

Detailed engineering: From concept to configuration

Efficient design for quick installation is paramount in upgrade projects aiming to minimize shutdown durations and mitigate installation risks. The project team planned installation sequences, methodologies and resources carefully to align with the shutdown schedule.

Through advanced accurate auditing and testwork, Metso identified numerous opportunities to significantly enhance thickener performance. These included upgrading the feed system, froth management, advanced flocculant dosing, and implementing Metso's latest Reactorwell™ technology.

External feed de-aeration tank

Metso's upgrade design incorporates a new external feed de-aeration tank to efficiently manage feed hydraulic energy and froth separation, thus optimizing the feed stream for the thickener. It also serves as an effective location for dilution by combining low-solids streams from coal product filters and ensures proper mixing before the thickener feedwell.

Gravity slurry systems often struggle to maintain high residence times due to solids settling. However, the low settling velocity of coal thickener feed slurry (approx 1m/s) offers design flexibility due to factors like low solids density, low feed solids concentration, and particle size.

Other key design features include a tangential slurry inlet for energy dissipation without increasing froth, a bottom outlet nozzle below the thickener free surface to prevent short-circuiting, and a large residence time and surface area for effective froth separation and suppression.

The feed tank is designed for safe and effective maintenance including upper and lower maintenance platforms and a manhole through the tank sidewall. Wear rates in the downstream slurry system are significantly lower due to the energy dissipation in the feed tank. The Australian metallurgical coal site saw this to be beneficial to operations since the maintenance occurs in the accessible feed tank, which is much simpler than maintenance of the suspended feedpipe and feedwell within the Thickener.

Metso Reactorwell™ technology

Like many mining operations, this site operates in a sensitive environmental area, so they are cognisant of the importance of optimising water management and recovery through employing best technologies and practices. Recognizing the potential to operate with reduced flocculant dosing rates, as well as cutting operational costs and reducing the carbon footprint, the site embraced this innovative technology.

The new Reactorwell™ design retains key elements from Metso's previous feedwell designs, including sections for mixing and energy dissipation, aggregate growth, proven gravity dilution systems, and a closed bottom design. Additionally, Reactorwell™ features a unique feed inlet trough equipped with multiple slurry nozzles, creating a highly effective slurry distribution system. This system harnesses incoming feed's rotational energy to generate vertical flows, fostering an evenly mixed, lower-energy zone outside the feed trough where flocculation and aggregate growth occur.

3D rendering of the new Metso Reactorwell™ technology. Reactorwell is part of our Planet Positive offering.

Froth management

Leveraging their extensive expertise in Thickener froth management systems, Metso engineered an effective spray arrangement for the site. This system incorporates high-volume full cone spray nozzles strategically placed in the external feed tank and feedwell, areas where froth is confined in a compact space without mechanical transport by booms or similar. The system is also designed with accessible fittings for each individual spray nozzle to allow for easy maintenance.

On the thickener surface, where froth is less contained and mechanically transported by rotating froth booms, inclined flat fan sprays were employed. These sprays concentrate froth destruction, effectively targeting the froth pushed by the booms as it passes beneath the bridge-mounted sprays.

Supply and installation

The final phase of the upgrade is materializing the scoping and design work into tangible results through fabrication, purchasing, QA, installation and commissioning.

Safety remained paramount for the project team and site installation contractors. They shared a strong commitment to safe practices, recognizing the need for careful planning and management during site shutdown activities to ensure work proceeded without injury.

To optimize safety and efficiency, the installation was divided into two shorter-duration shutdowns, with increased pre-works conducted while the plant was operational.

The first shutdown focused on upgrading the tank wall top section, including the overflow discharge system, and was successfully completed in 5 days and 4 hours.

The second shutdown centered around thickener component upgrades, involving significant demolition and installation work, and was also successfully completed in 5 days.

While this approach extended the overall shutdown duration to approximately 10 days, it mitigated risks through additional isolation, cleanout, preparation and mobilization tasks.

Coal Product Thickener at completion of installation

Thickener operating after upgrade, note overflow clarity and low levels of froth on thickener surface.

Implementation and results

Following the successful commissioning of the upgrade, the process and operations team of the metallurgical coal site quickly recognized the positive impact. Key improvements in thickener performance included:

- Underflow density consistently meets specification
- Lower flocculant dosing rates compared to pre-upgrade levels.
- Reduced froth and enhanced overflow clarity
- Faster recovery from frothing events during flotation circuit upsets. This presented an unanticipated benefit, as the site has been able to optimise flotation recoveries through increased reagent dosing without process water quality becoming an issue
- Elimination of the need for makeup water to improve overall water quality in the circuit.
- Compatibility with like-for-like spares with the previoulsy upgraded tailings thickener.
- Improved, safer access to the thickener feedwell compared to the original design.
- Enhanced plant access due to the rerouting of the thickener feedpipe within the washery building.

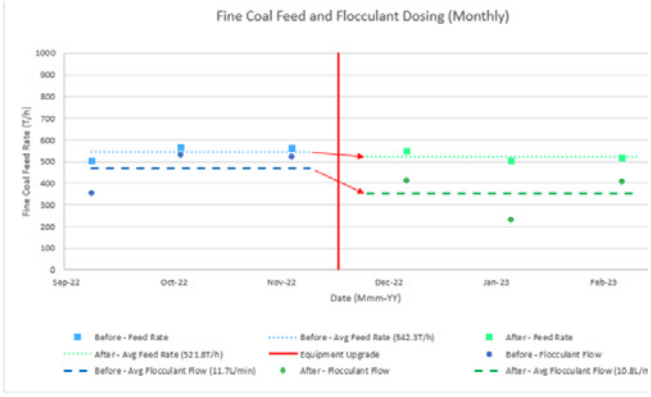


Figure 1: DCS data analysis demonstrating comparable feed rate with step change reduction in flocculant dosing after upgrade

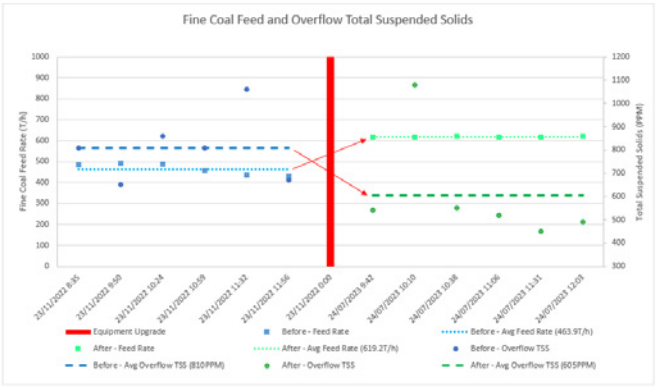


Figure 2: Field sampling and lab analysis of Thickener overflow total suspended solids (TSS) combined with DCS data for feed rate demonstrating increased feed rate with step change reduction in overflow TSS after upgrade.

The upgraded feed system's efficiency in handling coal flotation product and consistently delivering superior performance also led to a significant reduction in flocculant dosing, as confirmed by DCS data analysis in Figure 1.

Improved overflow clarity, verified through field sampling and lab analysis, has also enhanced process water quality by reducing recirculating fine solids in the plant, thereby improving washing efficiency (see Figure 2 for reduced total suspended solids concentration in the overflow).

Analysis of plant DCS data and field sampling, both pre and post-upgrade, provides further evidence of improved operation in both the Coal Thickener and Flotation circuit. For example, lab analysis of field samples affirms an underflow solids concentration exceeding 40% (w/w), surpassing the 35% threshold required for satisfactory downstream filtration performance.

Benefits to the flotation yield were also realised. The improved froth management within the Thickener has unlocked the potential for optimizing the flotation circuit. This includes the ability to increase flotation reagent dosing rates without experiencing Thickener froth out events.

An analysis of flotation yield rates, with comparable feed ash content, revealed a positive shift in the Flotation circuit's performance following the Coal Thickener upgrade.

As depicted in Figure 3, the improved trend in flotation yield corresponds to the enhancements achieved in the flotation circuit operation, made possible by this upgrade.

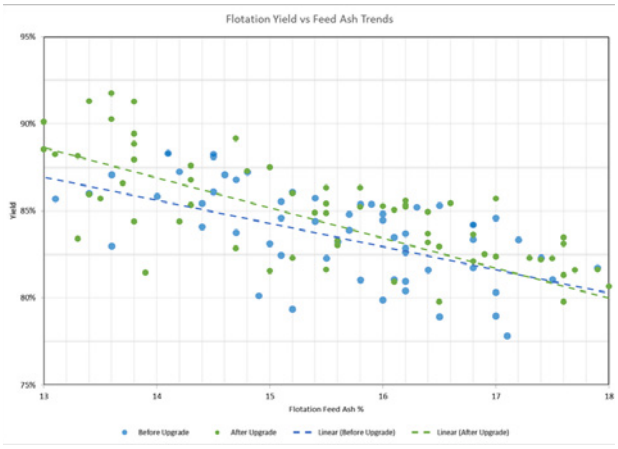


Figure 3: Improved trend in flotation Yield vs. feed ash resulting from improved coal thickener froth management after upgrade.

There's strength in partnerships

Here at Metso, our commitment to R&D and innovation drives us to consistently explore innovative solutions for our customers. We adopted a holistic approach, leaving no aspect of the upgrade process to chance. Input from plant operations personnel was instrumental in this collaborative process, specifically in refining designs and scope inclusions, accommodating site-specific procedures, leveraging lessons from past projects, simplifying installation, and reducing the need for post-installation modifications.

Metso seized the opportunity to enhance process performance by upgrading critical internal Thickener components with the latest technological advancements. These upgrade options deliver valuable insights for maintenance and reliability-driven improvements that become necessary as equipment ages over time.

As we commission the control loop, it is believed that there is potential for further optimization and reduced flocculant dosing. Our successful collaboration with the site sets the stage for continued partnership and future endeavors, building upon the achievements of this upgrade project.

Retrofitting with latest technologies also enables more socially and environmentally friendly processing through factors such as reducing embedded carbon via reduced flocculant consumption and improving water quality and reuse. Thus, with Metso's meticulous audit, engineering and installation, the site is increasing their productivity whilst decreasing their environmental footprint – all at the same time.

Through the choices we make together with our customers, we enable sustainable modern life and influence the outcomes. Together, in collaboration with operations, we can take the industry towards a more responsible use of the world's natural resources. That is why we are the **partner for positive change.**

This case study is an abbreviation of the paper "Optimized process performance through the modernization of an existing thickener with recent innovations in technology' (McIntosh, Hodsden et al) during the MetPlant 2023 conference in Adelaide, Australia.

Metso is a frontrunner in providing sustainable technologies, end-to-end solutions and services for the aggregates, minerals processing and metals refining industries globally. By helping our customers increase their productivity, improve their energy and water efficiency and environmental performance with our process and product expertise, we are the **partner for positive change.**

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