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About This Handbook

The purpose of this handbook is to assist owners, operators and maintainers of front-end process plant assets to:

- Recognize and obtain significant production and cost savings benefits in the, often overlooked, process plant front end through crusher optimization measured using better Crushing Quality KPIs
- Look beyond organizational cost control based mostly on “cost to buy” and move towards more indicative “cost to use” life cycle costing
- Analyze your approach in the use of operational costing and benefit models through more inclusive Total Cost of Ownership (TCO) methodologies
- Use as basis for discussion on how to best partner with MakuriTechnology to unlock this value.



For all owners, operators and maintainers of highly demanding
mining plant & equipment assets.

We invite you to explore the world of crusher and process
plant front end optimization with us.

We look forward to being your safe partners in
delivering measurable, sustainable and
responsible reductions in the Total Cost of
Ownership of these assets.

**We are changing the MINING world
with technically better WEAR
SOLUTIONS.**



Section 1

The Big Picture

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About MAKURI Technology

- Makuri Technology is first and foremost an innovation company that strives to provide real, measurable results with minimal risk.
- We understand the critical importance of supply-side security and fulfill this through strategic relationships throughout the supply chain.
- We continually research, create and adopt new technology within our products and services, while ensuring that solutions provided will perform as expected.
- We appreciate that using new technologies can involve a certain degree of risk and we work with end users to minimise these risks and work towards successful implementation.
- We are willing and able to share our knowledge and technical expertise with those who are seeking advancement in the areas we specialize in.
- Makuri's product support doesn't end at the dispatch gate. We follow through with our claims and make sure that we provide evidence that our products work as expected.
- Where products fall short of expectations, we work alongside end users to produce the desired outcome and lowest TCO.

Business Integrity

The Makuri group aligns to the OECD guidelines on business integrity to build an environment of trust, transparency and accountability for all stakeholders, in particular;

- We pride ourselves on being a transparent, open and accountable group of companies that win and retain business by demonstrating the value of the goods and services that we provide in an ethical manner
- We do not exploit weaknesses in the regulatory environments in which we may be supplying goods and services
- We comply with the laws and regulations applicable to all jurisdictions in which we are domiciled
- We conduct due diligence and risk assessment/risk mitigation, audit, and internal investigations as applicable

Core Business

We specialize in coarse ore, front end, process wear liners & parts applications that are fully optimized via our unique continuous improvement methodology we call the MAK-PROCESS

MAK-PROCESS delivers sustainable and measurable reductions in Total Cost of Ownership (TCO) via a targeted process where individual problems are investigated, and the root cause identified, solutions created, which are then evaluated and re-evaluated and measures suggested to allow for continuous improvement. MAK-PROCESS methodology consists of 5 key steps;

- Understand the Application
- Create the appropriate Design
- Select the correct Materials
- Apply the correct Monitoring, and
- Review and measure in a continuous improvement process, as one or two of these, on their own, may not extract maximum asset value.

Understanding Revenue, Cost drivers and having suitable Key Performance Indicators (KPIs) to measure the asset performance is critical to crushing plant optimization and delivering lowest TCO.

We guarantee what we do



Level 1 – 5F Guarantee

This is a 'best in class' 5F industrial standard covering all Products and guarantees the Fit, Form, Function of such items and that they are also free of defects in Faulty Workmanship & Faulty Materials. Products that fail to meet this guarantee are fully replaced or fully credited.



Level 2 – LC Guarantee

Products that fail or wear out in service that do not meet the mutually agreed Lowest Cost / tonne or Lowest Cost / operating hour targets, after a minimum of 3 design iterations, will be credited on a pro-rata basis.



Level 3 – TCO Guarantee

Products that cannot be demonstrated, after a minimum 3 design iterations, using all mutually agreed inputs, to be the Lowest Total Cost of Ownership, will be credited on a pro-rata basis.

Supply-Side Security

Makuri understands the critical importance of supply-side security and fulfill this through strategic relationships throughout the supply chain. This is achieved via:

- Makuri's primary manufacturing partner operates a world-class foundry that complies with all applicable environmental regulations and is not subject to unanticipated closure by changing environmental standards
- Before accepting orders, we proactively ensure that our manufacturers have the required reserve capacity available to ensure lead times will be achieved
- Full traceability and extensive in-house quality control measures fulfill our quality guarantee of fit, form, function, workmanship and materials
- When operating under Forward Purchase Agreements, we forward-schedule manufacturing around expected deliveries to minimise lead times between order placement and delivery
- We have international logistics and warehousing capability
- Full ownership of intellectual property covering patents and designs, manufacturing drawings, manufacturing procedures and quality control measures
- We maintain a global network of strategic supply partners to minimise sovereign risk and global uncertainties
- We never outsource to unknown and unproven third party manufacturers

Because we know how important this is!

The Basic Mining Business Model

Mining can be a high risk business that is typically conducted in less than optimum situations. It is an ongoing challenge to provide an adequate return on capital commensurate with associated risks.

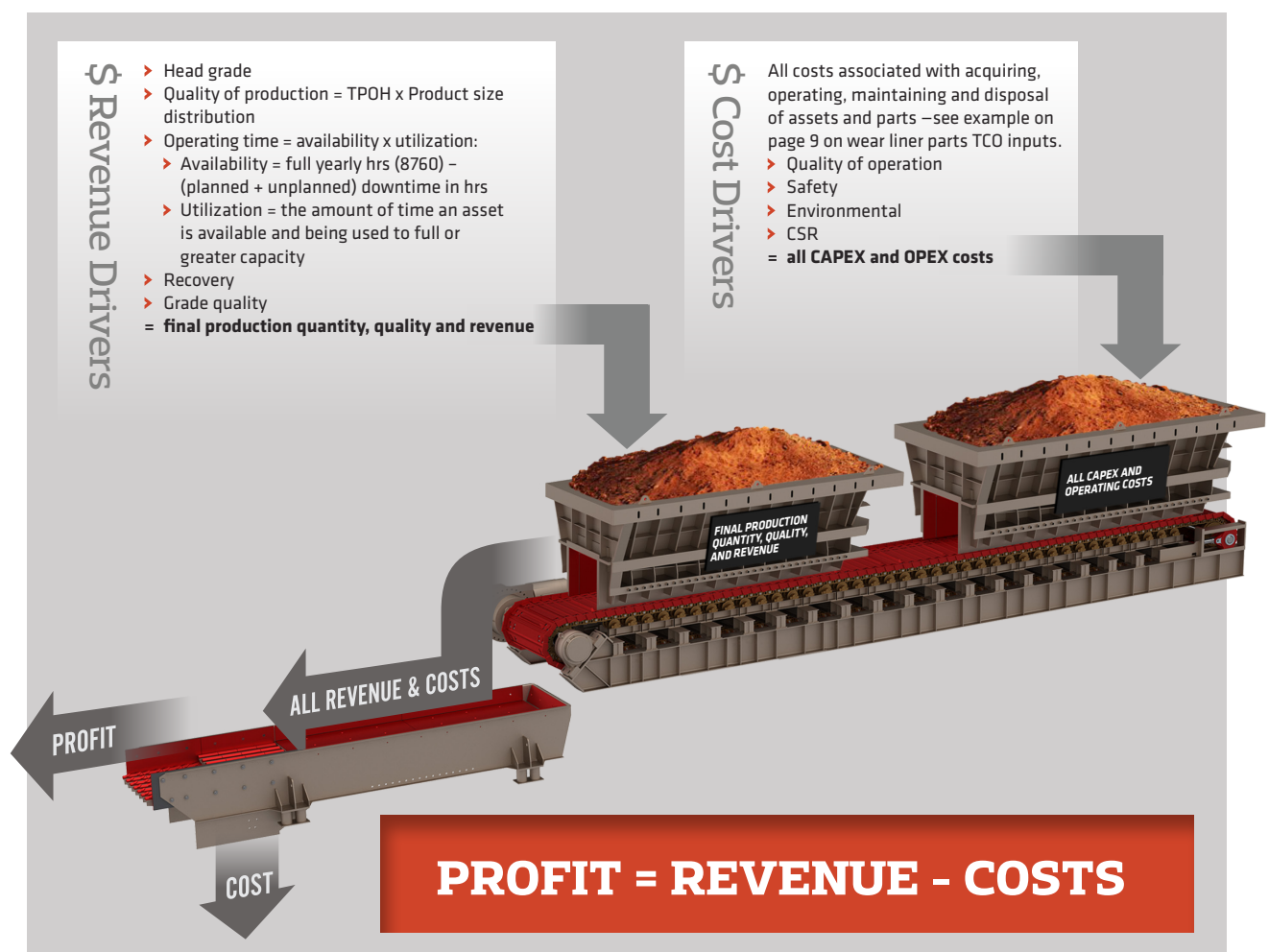
Successful minerals extraction and processing now, and increasingly in the future, will be determined by those who can select, measure, assess and positively change the Revenue and Costs inputs and outputs that will deliver lowest total cost of ownership (TCO) for critical production assets. Full utilization of installed asset capacity in terms of not just operating time but quality of production is a critical part of the TCO model.

Both the revenue and cost side of the equation must be fully explored if profits are to be both made and kept along with minimization of risks.

Ownership

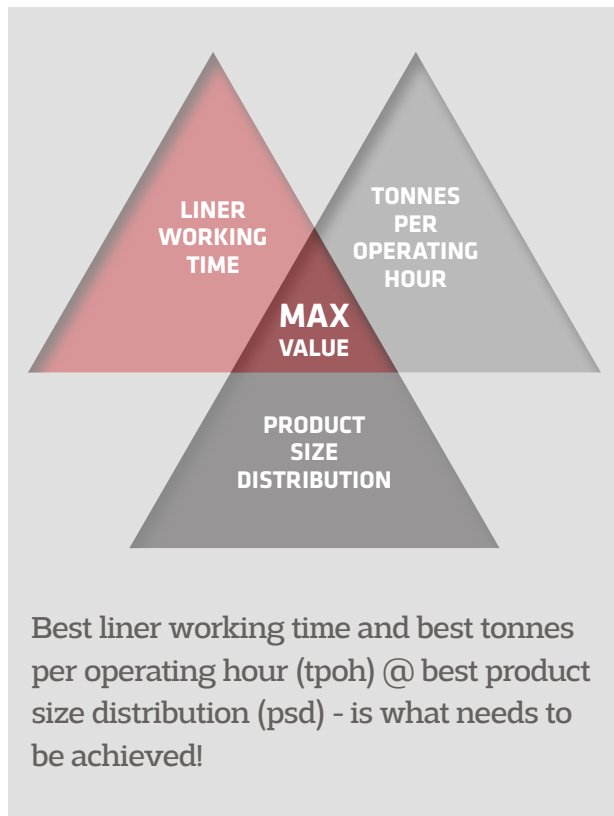
How front-end process plant is handled within mining companies often depends on who is considered to be the owner of the asset. Because issues such as purchase of wear parts and performance measurement will be subject to varying degrees of importance, Makuri applies a hands-on approach to allow these things to be evaluated effectively with minimal end user effort. This ensures that our products make a measurable, reportable contribution to the quality and sustainability of the operation. The 4 major areas for assessment are:

- Direct costs
- Indirect costs
- Life
- Production benefits.



Quality Measures for Crushing Performance

There are few recognized and implemented KPIs that measure crushing equipment quality of production. We suggest that the following measures may be used as appropriate to capture the quality of the asset through its effective utilization.



Where there is equipment redundancy and/or spare capacity to increase production and revenue, this can also then be measured and reported on.

Quality KPIs - Production Asset Utilization

Production asset utilization is typically reported as the utilization of availability to give an operating time in hours or % as an absolute number.

E.g. Availability x Utilization = Operating time

The focus is typically to try to get utilization to 100% whenever the asset is available for use. However this does not capture the quality of this utilization.

Measuring the difference between what the crushing asset is capable of producing with optimized wear liners and other identified operational improvements, against what it is actually producing now, is referred to as the “opportunity gap” or quality measures of production.

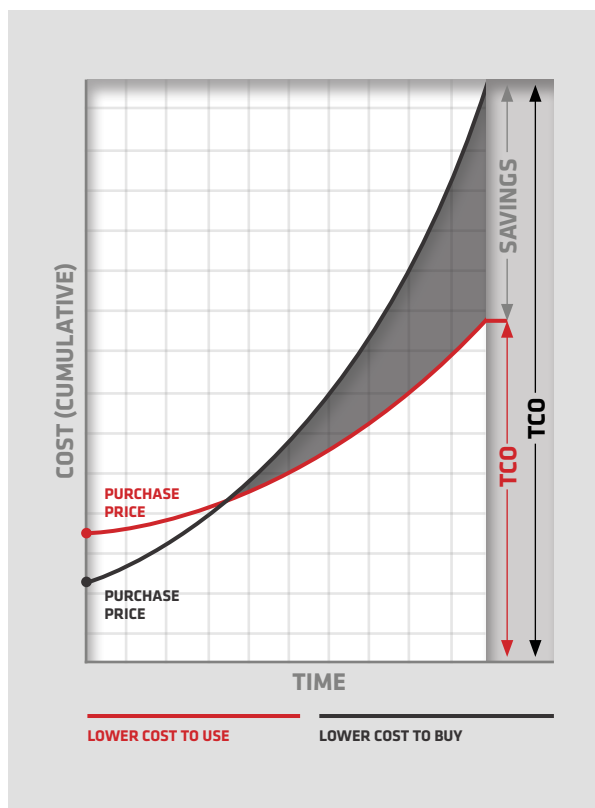
The quality KPI measures below can show the opportunity gap for crushing assets such as:

- **Liner Working time** – Operating time above idle power draw vs. operating time as a %;
- **Power Utilization** – kW / operating time– % of installed power being utilized / operating time;
- **Crushing Power** – kW / tonne - Power to tpoh;
- **Reduction Power** – kW / P80– Power to product size (P80) delivered;
- **Run In Time** – Time to reach target CSS with new liners;
- **Run Out Time** – Time with loss of throughput at the end of liner life and associated inefficient higher power draw; and
- **Residual Weight** – % Weight of liners / new.

Most of these are best measured using:

- PI data analysis
- Split cams.

Total Cost of Ownership Models



Selecting the drivers to be used for any life cycle, or total cost of ownership modeling can be problematic. They have typically been used to assess and compare CAPEX submissions and are rarely done on an ongoing basis during operation. Also typical OPEX “cost to use” models are based around cost / tonne or cost / operating hour only, or even based on simple days, months or years of life regardless of actual operating time, throughput rates and their changes over time.

There is a need to keep it simple but also capturing enough drivers to ensure that a representative cost to use model is created that can then be used for real comparative purposes.

Quality KPIs - Production Asset Utilization

Cost to buy wear liners is only a small part of the overall cost to use and is typically much less than 20% with >80% being all the other positive and negative Revenue and Cost effects associated with using them.

Total Cost of Ownership (TCO) models for wear liners should consider both Cost and Revenue drivers with a Core set being created along with Auxiliary items to be used when needed, with some examples below.

Cost Drivers

Core

- Initial purchase cost of liners – typically <20%;
- Exchange rate;
- Taxes, Shipping, Storage and Handling costs to site;
- Lead time and required stock holding quantity and value;
- Usage rate;
- Installation and Removal frequency and costs including all direct and indirect labor, energy and consumables; and
- Disposal costs.

Auxiliary

- Supply side risk;
- Costs of purchasing, preparing and sending out bids, submission reviews, supplier visits and evaluations;
- Issue costs on site;
- Monitoring costs;
- Supplier support costs and benefits;
- HSE risk to include all work and environment permit types required and skill level of personnel needed to safely and effectively complete liner changeouts; and
- CSR and other HSE issues / costs.

Why is it so hard to get wear liners to work in general?

Many try, few get there because:

- Silo mentality and conflicting KPIs of various groups associated with procurement, operations, metallurgy and maintenance creates a lack of a big picture and what's best for the business to make quality production at lowest total cost of ownership.
- Contributors to wear are numerous and varied, poorly understood and hard to measure and quantify.
- Blasting fragmentation, grizzly bar spacing and taper, tramp metal in feed, crusher PSD, SAG grate size and wear, ore types, weather, operational changes, plant modifications and general wear and tear all effect wear rates.
- Wear materials selection is problematic as testing standards are not based on hard rock, coarse ore, extreme abrasion and impact conditions as found in the front end of a process plant.
- OEMs and materials suppliers generic liner materials and designs do not take into account substantial differences between various mine sites in terms of requirements, operating and service conditions and climate.
- Increases and decreases in operating time will have an almost linear effect on wear rates assuming all other variables remain the same.
- However, increases and decreases in tph will have an exponential effect on wear rates assuming all other variables remain the same.
- As an item wears its profile changes moving wear locations and/or rates of change.
- Most remaining life forecasts are incorrectly based on linear wear projections thereby requiring huge safety margins.
- The effects of acid leaching from sulphide ores and resultant corrosive wear on liners and structural items are poorly understood.
- Running liners to failure and the effects on structural integrity are poorly addressed.
- Multiple and often unknown and/or poorly recorded variances from "as designed" to "as built" and then "as modified" structure and liner design can cause installation issues which can have a significant effect on installation quality, overall performance and reliability.
- Normal mining and process plant variances can mask or exaggerate trial results unless they are fully understood.
- Process data collection and validation using PI and other records is often required.
- Proper wear mapping protocols using 3D laser scanning validated with other measures and checks will produce the most accurate and complete wear results.
- A spread of results is needed to allow for variances.
- Safety margins need to be mutually agreed.



Why is it so hard to get crusher liners to work?

See previous page on issues with wear liners in general, plus:

- OEMs and large suppliers are often unwilling and/or unable to provide site specific cavity profiles and adjust regularly with ore type and operational changes.
- There is a widespread perception in both the mining and quarrying industries that manganese steel is a commodity that can be purchased on price only. As a result, low cost and low quality often becomes the benchmark.
- Mining companies tend to regard crushing as the 'poor cousin' to milling operations, leading to a lack of attention and understanding by many parties regarding how to fully utilize the equipment and how it can have a major impact on both costs and production.
- There are limited liner material choices as foundries prefer to manufacture in full batch lots of common grades with existing chemistry and production capabilities and typically don't have the ability or desire to make custom grades in smaller batches.
- The bulk of foundry feed stocks are typically recycled Mn materials of lower grades and poor metallurgical qualities and impurities which can't be corrected in the melt.
- Second only to proper design, Heat Treatment, composition and material purity are the most significant contributors to wear material performance. Especially for large castings, these are also the most costly and difficult to do correctly and consistently.
- The level of manganese in a casting is only a small factor in the ultimate performance of a liner, although many assume that increasing the level of manganese is the beginning and end of liner optimisation.
- There are many other alloying elements that provide benefits to starting and final hardness and crack resistance but are simply not understood and/or considered too expensive and too hard to use by most foundries.
- Material wear inside a crusher is quite complex and is caused by several different wear mechanisms. The contribution of each of these varies between feed materials and applications and needs to be considered on a case-by-case basis.
- Issues such as how the feed material enters the machine, start-stop events & the extent of choke feeding are often overlooked. While many of these issues can be resolved with proper liner design, some may require more substantial changes.
- Control systems need to address the conflicting requirements of choke feeding and limiting feed on / feed off cycling due to bin levels and tramp metal detections.
- Tramp metal damage is a major contributor to early failures and detection and removal systems are typically poorly specified, installed, controlled and maintained.
- The incremental effects of fretting wear on liner seating faces from Mn growth and the changes to fit and cavity profile are often poorly understood.
- Upstream plant such as primary crushers or screens may be running at sub-optimal levels due to problems in that part of the plant, leading to sub-optimal feed being presented to downstream crushers.
- Inconsistent liner life due to any combination of the above factors results in maintenance plans being structured around worst-case life scenarios to reduce risk. Makuri works with end users to look at the whole plant and correct these issues to ensure that life becomes consistent and maintenance plans can be adjusted with confidence.

Why is it so hard to get transfer chutes to work?

See page 10 on issues with wear liners in general, plus:

- The chute is not treated as a whole piece of plant with a criticality associated with it.
- There is typically no redundancy or ability to bypass a blocked or failed chute.
- Small incremental throughput increases and ore type changes over time can have a significant impact on chute capacity and design requirements but are rarely proactively identified.
- High localized wear in a relatively small area requiring high maintenance and partial liner changeouts.
- Not designed as a liner system to all wear out at once or at set ratios and have major planned liner changeouts rather than many small and/or unplanned ones.
- Blockages and failures due to reduction in open area by installing thicker liner materials at the high wear points inside the chute, which also increases material velocity exponentially thereby increasing wear rates. This in turn requires increasingly thicker liner materials unless an assessment of both design and materials is undertaken to maintain or increase open area and keep weight at safe levels.
- Additional blockages and failures when not designed to take feed materials variances like sticky and/or slabby materials.
- Blockages by overloading from surging feeders caused by slippage from worn and/or low friction design feeder pans.
- Excessively and increasingly thicker and heavier liner materials used to get to planned shutdown intervals which can cause fatigue related failures on suspended chutes and structures.
- Excessive amounts of unplanned downtime and run to failure scenarios allowing liners to wear through and damage the structure and also fall off and get into the downstream process.
- Excessive dust generation from poor design and sealing.
- High vertical material velocities at the discharge point shearing the cover off the receiving conveyor belt.
- Access & lifting problems preventing (safe) use of larger liners.
- Lack of technical focus on chutes as being deemed less important than other downstream process equipment.

Understanding the Process

Makuri Technology takes the time to understand how your process works and develops solutions based on individual site conditions and site targets. We understand that changing one part of the plant to solve a particular issue can have a detrimental effect on downstream processes, and this needs to be taken into account.

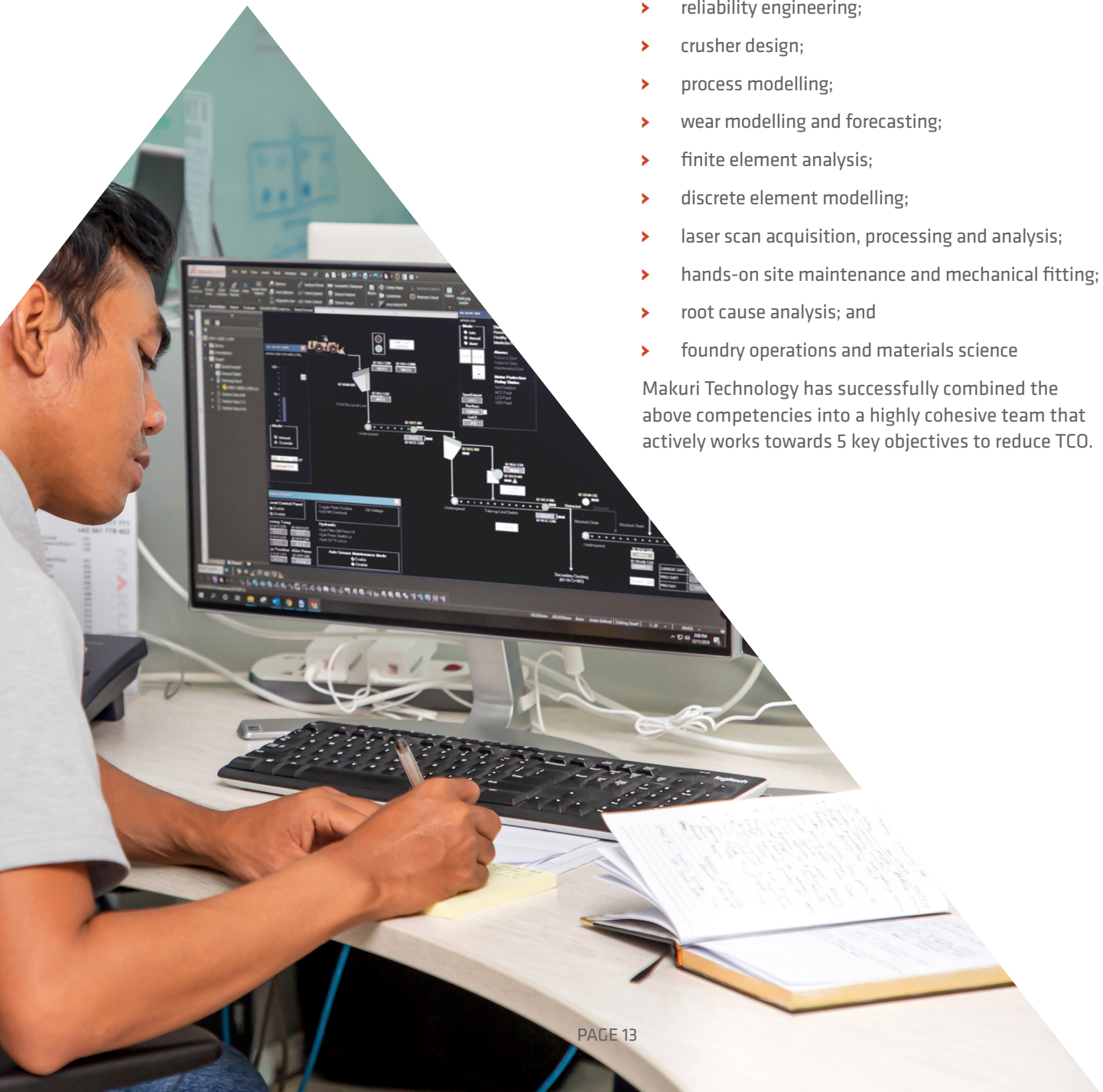
By evaluating all relevant parts of a process, Makuri works to identify the root cause of problems before offering solutions. In some cases, this may be as simple as looking at worn liners, while in other cases a full plant audit may be required.

To ensure that all factors are considered, Makuri utilizes a unique range of in-house competencies that are generally not available to smaller organizations and are too cumbersome to utilize in larger businesses.

These include:

- mine & process management;
- maintenance management;
- reliability engineering;
- crusher design;
- process modelling;
- wear modelling and forecasting;
- finite element analysis;
- discrete element modelling;
- laser scan acquisition, processing and analysis;
- hands-on site maintenance and mechanical fitting;
- root cause analysis; and
- foundry operations and materials science

Makuri Technology has successfully combined the above competencies into a highly cohesive team that actively works towards 5 key objectives to reduce TCO.



Continuous Improvement

If we are to continue to deliver lowest TCO over new and changing conditions, we must be able to revisit and assess the current asset performance within our areas of core expertise and look for opportunities for improvement.

This is done using variety of quality KPI measures in conjunction with commercial and proprietary technologies and methods along with close working relationships with selected end users when required.



Quality KPI Measures

Analysing Process Information (PI) Data

To truly investigate how a crusher is operating, careful attention is required to determine what it is doing throughout its liner life. This often involves analyzing over 100,000 sets of data points to isolate trends and identify problems that simply cannot be found through direct observation. To facilitate this process, Makuri utilises a range of in-house analysis tools and data mining techniques to provide objective data on crusher performance.

Crusher Liner Cavity Profile Development

Every application is different and has unique requirements. To demonstrate lowest TCO, liners need to be application-specific and designed to achieve site targets in terms of life, tonnage, crushed product size and power draw. By utilising our proven analysis, design and modelling techniques, we are able to produce liner designs that will perform exactly as expected and achieve site life targets.

3D Laser Wear Mapping

3D laser wear mapping allows us to not only predict remaining life, but also to review material selection and design performance and investigate all available opportunities to provide specific to application bests fit for purpose wear liner systems that deliver the lowest TCO.

Discrete Element Modelling (DEM)

Makuri utilises proprietary in-house DEM modelling techniques for a range of purposes. These include crusher tonnage modelling and material flow simulation within transfer chutes. Where no scan data is available, this also allows us to predict high wear areas and design preliminary wear liner packages to suit.

Finite Element Analysis (FEA)

Any small flaw in the design of components used in mineral processing can lead to rapid failure, so Makuri checks design modifications using FEA before manufacture. This greatly reduces the risk of failure that can lead to unplanned shutdowns and lost production.

Computational Fluid Dynamics (CFD)

Makuri utilises the continuum method as a first pass when verifying chute modifications. This provides a good first check of a design before a full DEM model is produced, which shortens development times significantly.

Research and Development (R&D)

We partner with selected “early technology adopter” suppliers and customers to develop and trial new designs and materials to allow for continuous improvement in the reduction of total cost of ownership and most importantly, getting real field trial results that can be seen and measured.

While all of the above are invaluable tools, the benefits of standing next to a crusher and watching it operate or, if possible, climbing into a chute, whilst complying with all relevant site safety requirements, should never be overlooked.

Many suppliers will avoid this stage, as they are not experienced hands on operatives. Makuri staff show up to site with the correct PPE, ready and willing to look at real applications and happy to get dirty in the process.

Our Specific MAK-PROCESS Core Expertise Segments

If you're engaged in extracting high value minerals, especially in coarse hard rock and/or highly abrasive conditions, then MAK-PROCESS wear liner systems are for you.

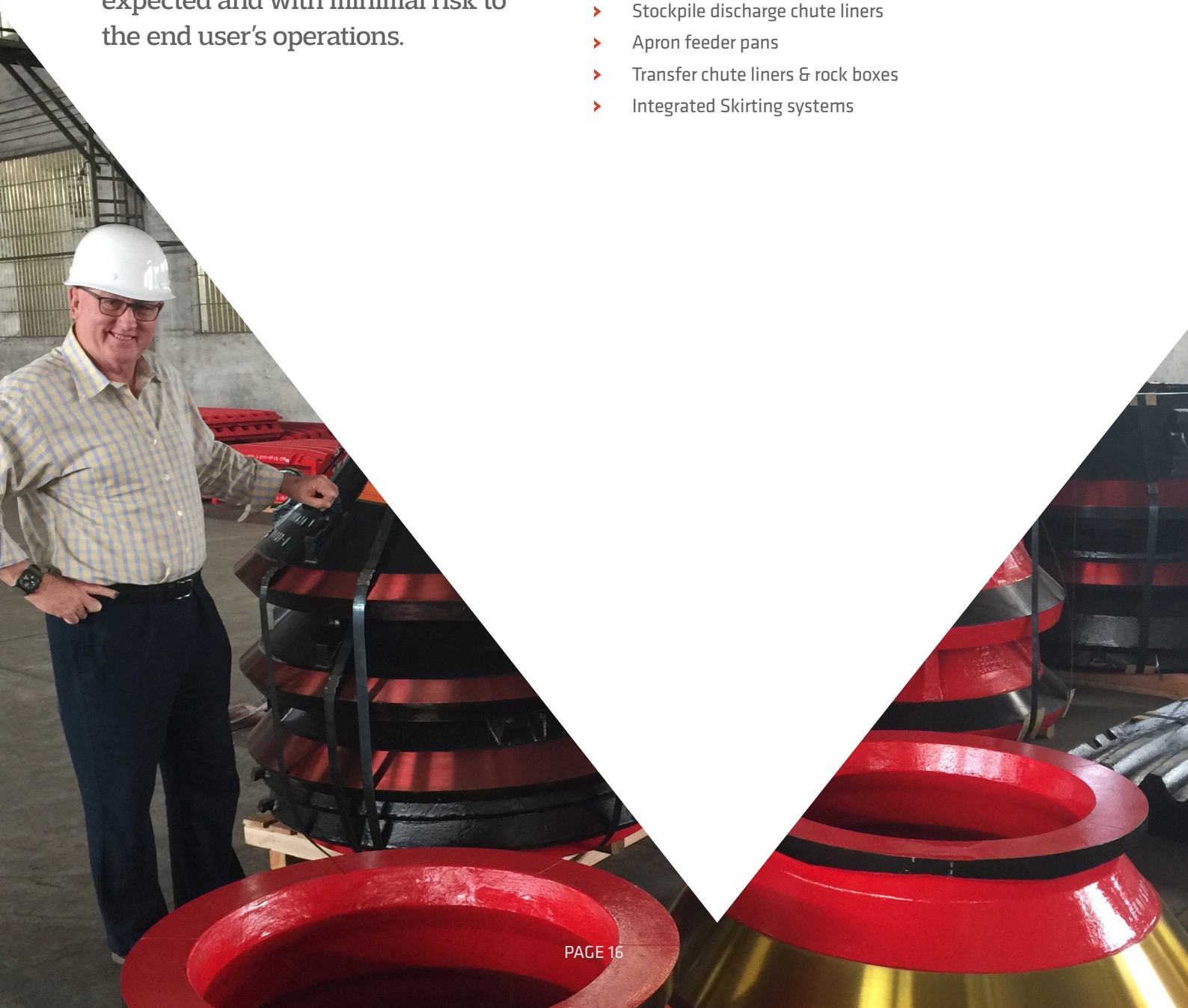
All our products are backed up by our comprehensive technical support capabilities and guarantees to ensure that the products we supply will work as expected and with minimal risk to the end user's operations.

Wear Liners & Wear Parts

- Primary crusher concaves
- Primary mantles
- Jaw crusher & Cheek liners
- Cone crusher liners
- Tower (Verti) Mill screw segments
- Sizer teeth and Picks
- Blow Bars and Impact Plates
- Major bushes and machine parts
- Crusher Backing compounds

Materials Handling Products

- Fixed & vibrating grizzly caps
- Stockpile discharge chute liners
- Apron feeder pans
- Transfer chute liners & rock boxes
- Integrated Skirting systems





PRODUCTS

ON SITE SERVICES

- Site audits
- Root cause analysis
- Installation supervision
- Operator & maintenance training

PROCESS MODELLING & DESIGN

- Chute liner wear forecasting & lifecycle analysis
- Discrete Element Modelling (DEM) material flow analysis
- Crusher performance modelling & crushed product prediction

CONDITION MONITORING & DATA ANALYSIS

- In-situ laser scanning to monitor performance of products
- Highly skilled & cost-effective scan processing
- Process Information (PI) data analysis to identify trends in large datasets

DESIGN & INNOVATION

- Customer-specific solutions to customer-specific problems
- In-house design capability utilising experienced mechanical, process and reliability engineers
- Rigorous design review processes to ensure successful implementation of new concepts

Sustainability

As a supplier to the mining and quarry sector, it is in our best interest to ensure the viability and sustainability of the industries that not only supply our sustenance, but that of the global community too, for all that can't be grown must be mined in some way.

We take a holistic approach to reducing metal usage and associated carbon footprint by not only creating more efficient products and associated, we also work with end users to create the appropriate Total Cost of Ownership (TCO) asset models. This allows for the real costs associated with any process to not only be understood but acted on in the most effective manner too.

We assist directly by;

- Designing longer life and more efficient parts
- Lowering TCO and increasing existing mine efficiency and viability thereby reducing the need for capital outlays on new mines and equipment
- Lower TCO also increases the net amounts available for all stakeholders
- Facilitating scrap recycling when required, and
- Being willing to work with stakeholders to build new and appropriate TCO models to validate the savings where required

We are committed to and support all the 17 United Nations (UN) Sustainable Development Goals (SDG) and in particular SDGs 3, 4, 5, 8, 9, 10, 12, 13, 16, & 17 which are in practice in our companies.

Also, we understand the challenging and difficult nature of our working environments and commit to, in all ways possible, to minimize the negative impact our business and personnel have on the environment.

Finally, we believe that a profitable, safe, healthy and environmentally responsible operation can have a leading and positive impact on all our stakeholders.

To achieve these goals, The Makuri Group has committed to implementing an Integrated Management System compliant with ISO 45001, ISO 9001 and ISO 14001.

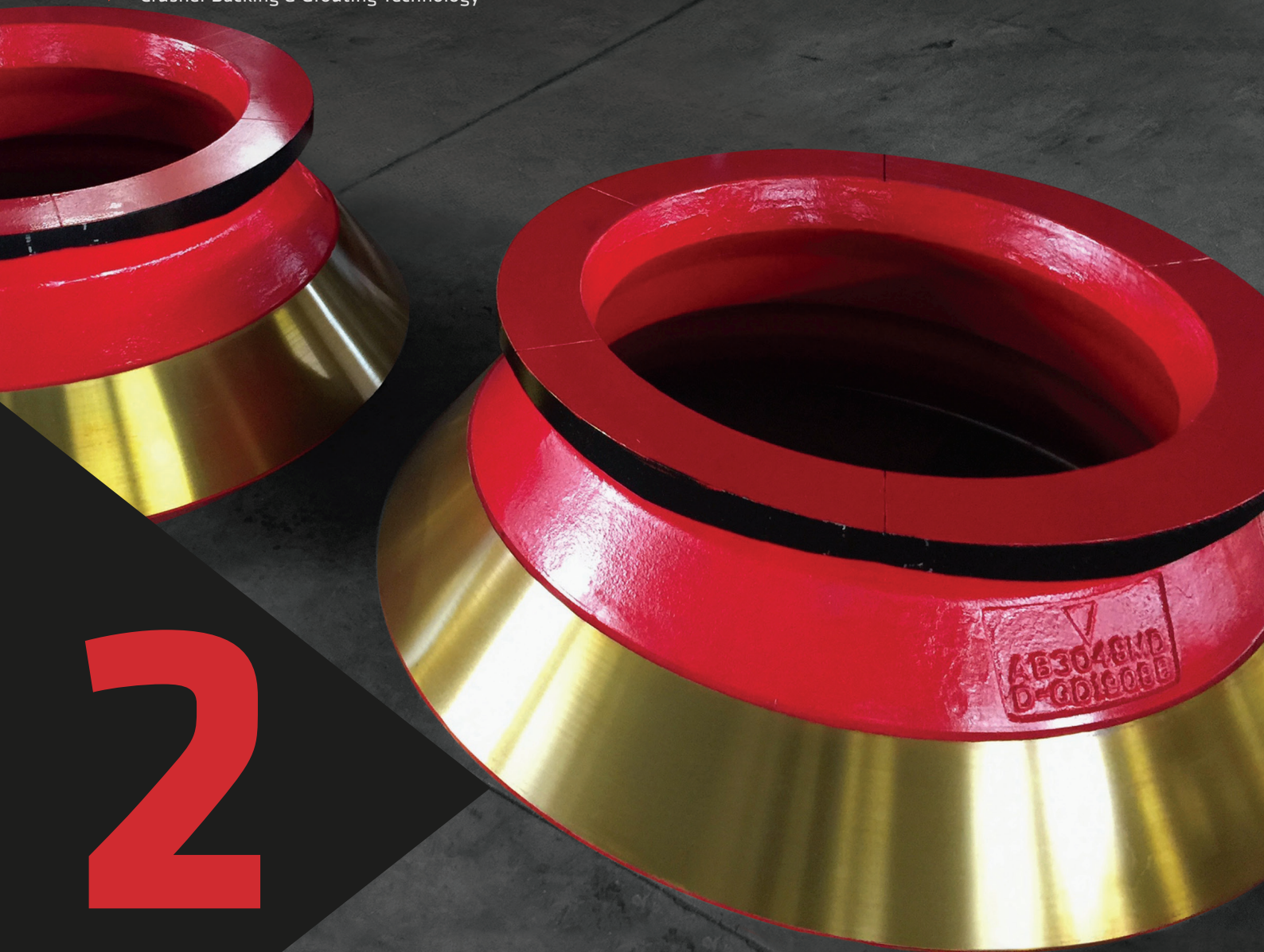


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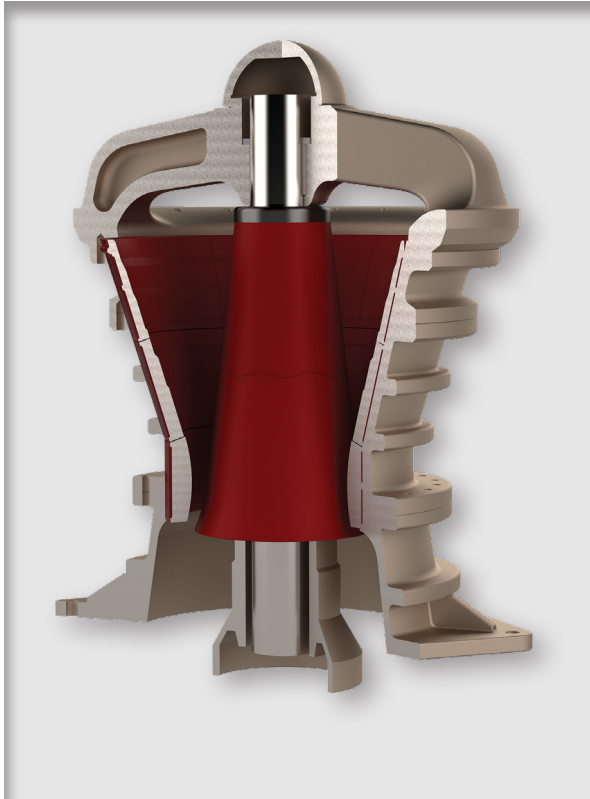
Process Equipment

Wear liners for critical front end
Process equipment

- Gyratory crusher Liners
- Jaw Crusher Liners
- Secondary Cone Crusher Liners
- Tertiary Cone Crusher Liners
- Pebble Cone Crusher Liners
- Crusher Liner Optimization Philosophy
- HSI Blow Bars & Impact Plates
- Tower Mill Shoes & Flights
- Rolls Crusher & Sizer teeth
- Surface miners & Feeder Breaker Teeth
- Crusher Backing & Grouting Technology



Gyratory Crushers



Typical problems

- Inconsistent crushed product size
- Unpredictable throughput rates
- Unstable stockpile size & composition
- Unpredictable liner life
- Poor or excessive power utilization
- Poor throughput in later concave life
- Excessive unplanned maintenance

All of the above can cause mill instability , high costs and less than optimum process throughput

Makuri Solutions

- Design of liner sets around planned shutdown schedules
- Purpose-built chamber designs to suit power draw & tonnage requirements
- Smooth and corrugated mantles to suit varying applications ranging from high clay, high fines and high moisture content through to coarse hard ROM feed
- Multi-mantle sets designed to provide equal throughput over the full mantle set. This results in highly predictable reline scheduling
- A range of concave material options including manganese steels, High Strength Low Alloy Steels, reinforced white irons and bimetallics
- The high predictability provided by our designs removes the need for expensive third-party condition monitoring programs
 - We can predict remaining life based on mantle position alone
- Selected high performance internal machine parts & wear parts also available

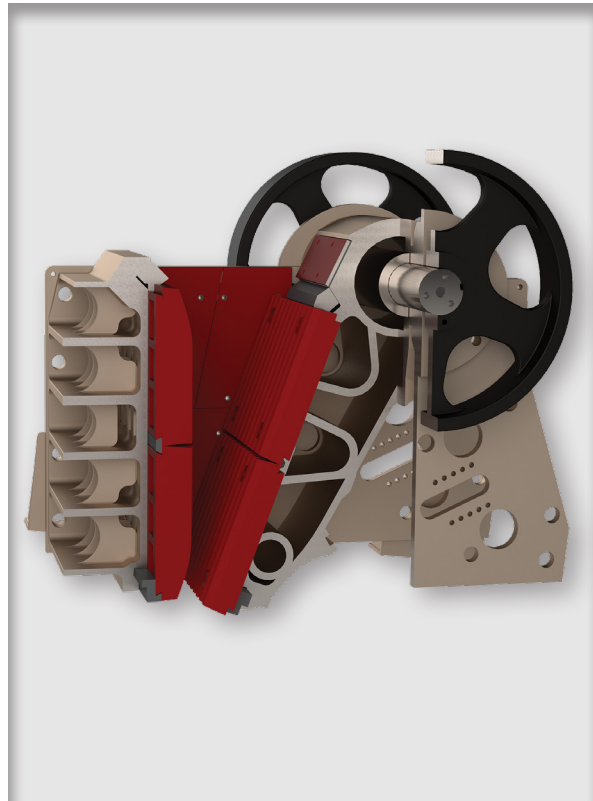


Jaw Crushers

High availability and good product shape are crucial for overall plant efficiency

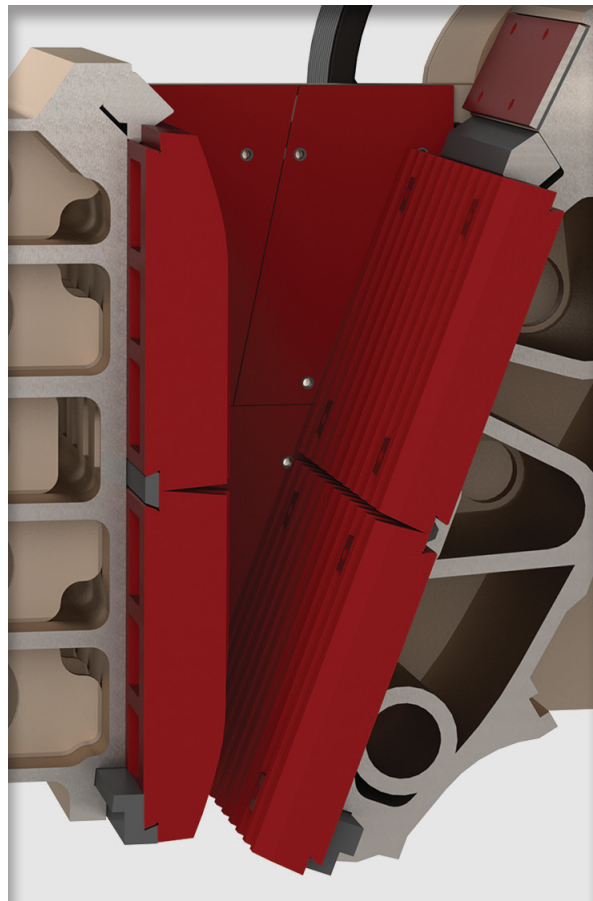
Typical problems

- Jaw liners only wear at the bottom of the fixed jaw & require replacement
- Using 2 fixed jaws for one swing jaw
- Cheek plates don't last the full jaw life
- Slabby crushed product blocking downstream crushers
- Insufficient liner life
- Localised wear at the lower end of the chamber, leading to:
 - Inability to maintain CSS
 - Poor liner material utilisation
- Safety concerns when changing liners



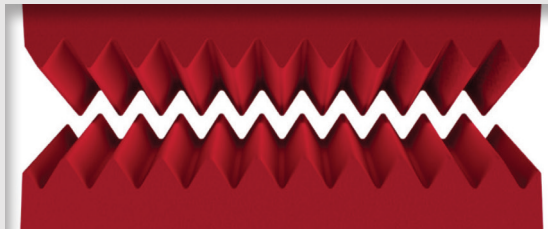
Makuri Solutions

- Purpose-built chamber designs to maximize liner life and material usage
- Life-balanced jaw sets to provide one fixed jaw to one swing jaw
- Bimetallic cheek plates designed to last multiples of jaw life
 - No need to shut down just to change cheek plates
- Cheek plates using our “bolt in from the back” bolting system to reduce maintenance time in the crusher
- Anti-slab jaws to prevent blockages and conveyor belt damage



Customised Jaw Profiles

Variations in ore properties requires jaw profiles to be designed and selected to suit application.



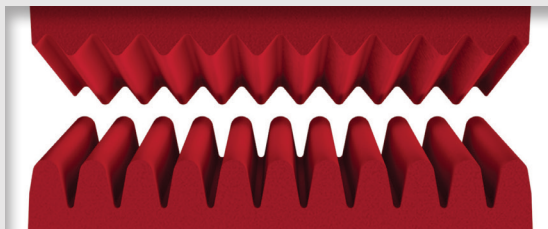
Saw Tooth Profile

- Fine crushing & recycling
- Low power usage but poor life



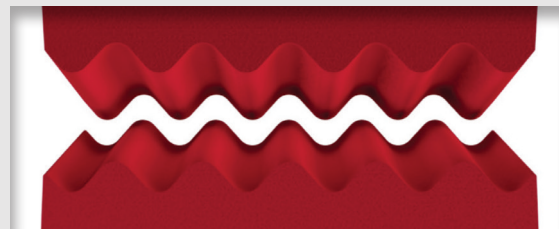
Basic Long-life Profile

- Typical OEM profile for general use
- Improved life but poor throughput



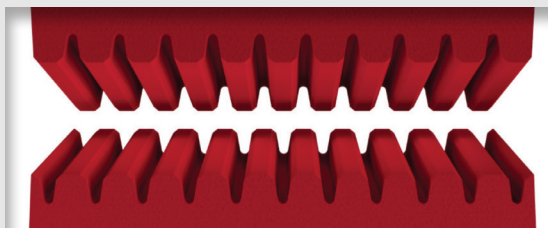
Wear Optimised Profile

- 1:1 wear ratio between fixed and swing jaws
- Allows both jaws to be changed at once with less wastage



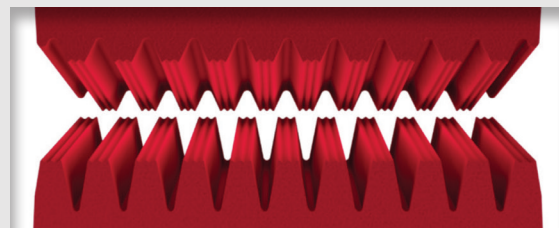
Wave Profile

- Long life & ability to break up slabby material
- Higher power consumption on smaller crushers



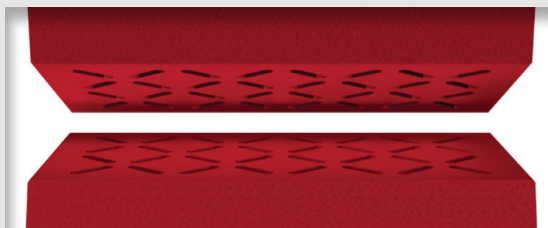
Quarry Profile

- Fine crushing & recycling
- Low power usage but poor life



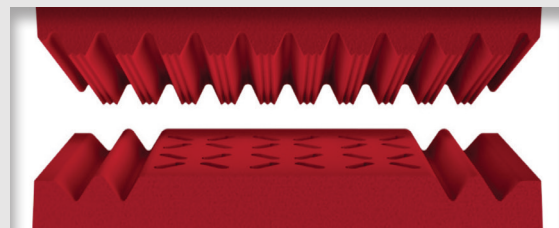
Self-Hardening Profile

- Produces early work hardening to extend life in highly abrasive applications
- Can be combined with wear-optimised design for extra life



Peen Slot Design

- Maximum wear material for maximum life
- High power draw in some cases



Combined Profiles

- Application-specific combinations of the above to maximize performance

Secondary Crushers

Optimized secondary crushing improves overall plant throughput and reduces TCO

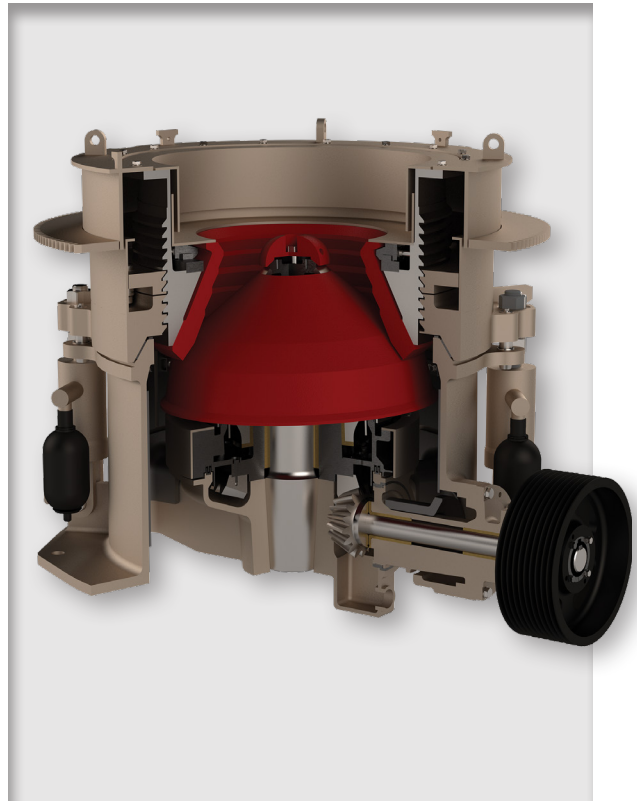
Typical problems

- Blockages due to inability to handle slabby and/or large feed
- Unable to maintain sufficient feed opening as liners wear
- High power draw
- Unable to achieve target gap setting
- Unexpected liner failures
- Uneven wear between bowl and mantle liners
- Excessive wear at the bottom of the chamber
- Cracking heads
- Unplanned shutdowns to change mainframe liners and arm guards –life doesn't match main liners

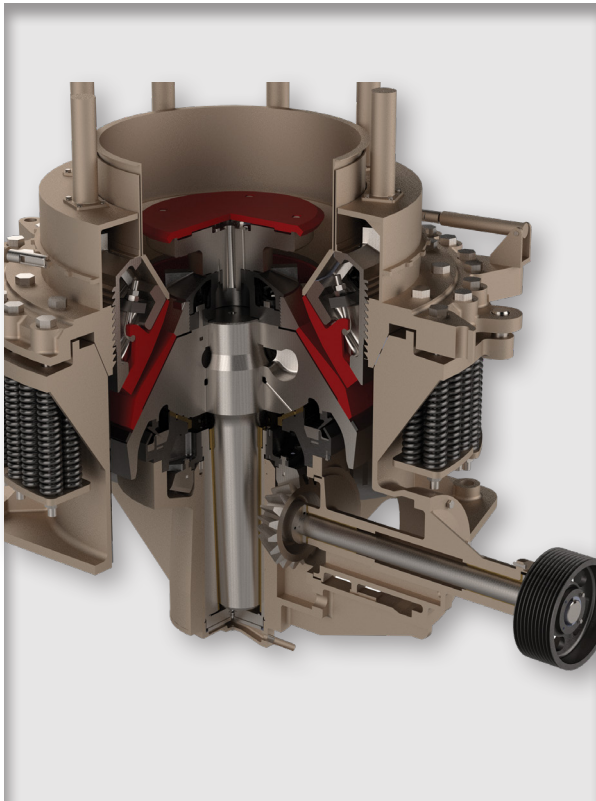
These issues will not be fixed by simply making thicker liners or changing material grades.

Makuri Solutions

- Proper circuit evaluation to identify the true cause of problems
- Design of liners to suit process parameters & required gap settings
- Extended life designs, often with little change in the overall cost of the set
- Process-based design to ensure that liners operate at full tonnage and power draw throughout their life
- Design to provide target life (normally within shutdown schedules) while minimizing material wastage
- Upgraded head designs—see parts section
- High performance, wear-matched mainframe liners and arm guards



Tertiary Crushers



Increasingly smaller feed material & smaller crushed product sizing requirements present a range of challenges

Typical problems

- Tramping due to excess fine material in the chamber
- Unable to achieve the target gap within power limitations
- Lost production rate towards end of liner life
- Unusual wear behavior due to incorrect liner selection
- Unable to achieve a choke-fed condition
- These will not be resolved by simply making thicker liners or changing material grades

These issues will not be fixed by simply making thicker liners or changing material grades.

Makuri Solutions

- Examining the whole process and correcting problem areas such as screening
- Improving the performance of secondary crushers to reduce tertiary crusher load
- Anti-tramp designs to allow for tighter gap settings without damaging the crusher
- Adaptive liner profiles that maintain initial chamber shape for longer periods of time
- Site-specific designs to suit actual feed conditions and crushed product requirements
- Ongoing condition monitoring and design upgrades to keep up with changing feed conditions



Pebble Crushers

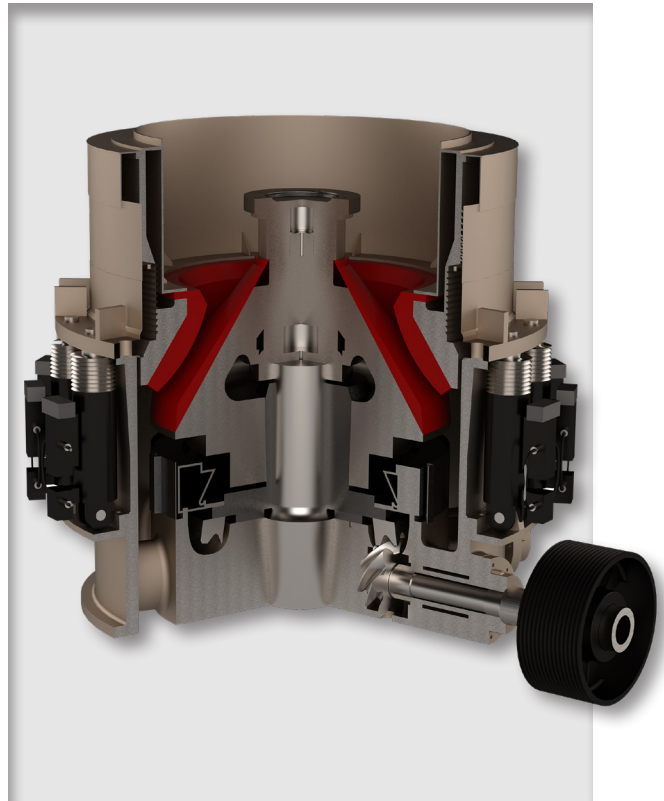
The hardest crushing duty on a mine site is often the pebble crushers. Mill pebbles are tougher than normal ROM feed and often contain wet sticky fines, mill balls and ball fragments. These cause a variety of operational and maintenance issues.

Typical problems

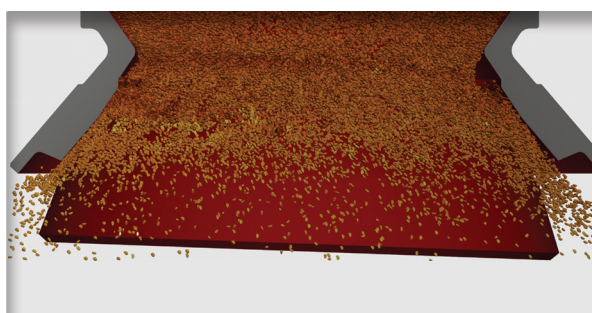
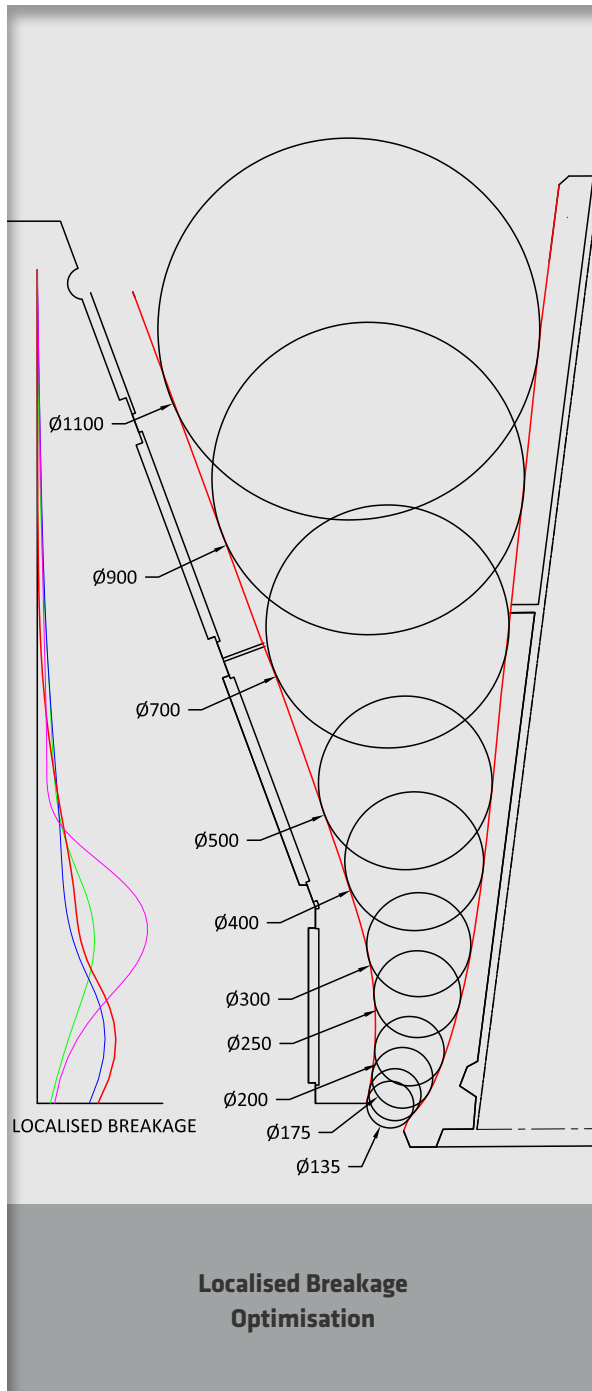
- Unable to achieve and maintain target CSS over the full life of the liners
- Poor availability due to planning based on unpredictable liner life, leading to overly conservative shutdown plans
- Unplanned maintenance due to liner and machine failures
- Poor utilization due to tramp metal detections and low bin levels
- Excessive liner failures due to mill ball damage
- Poor power utilization due to poor cavity profiles over full life of the liners
- Often operating in a ring bounce / bowl flutter condition due to poor cavity profiles
- Operators running machines at a gap setting tighter than the machine is able to handle

Makuri Solutions

- Looking at the whole plant, especially mill liner & grate configuration
- Process-based approach to reduce recirculating load & allow more fresh feed
- Achieve a target crushed product size within power draw limitations
- High resilience materials to reduce chance of liner breakage
- Site-specific designs to control bowl movement
- Liner designs to adjust tonnage, matching SAG mill pebble discharge rates



Crusher Liner Optimization Philosophy



Our business model is to optimize the performance of existing assets and reduces capital expenditure. We use this 5 step process to unlock maximum value

Stage 1 - Evaluation

Before proceeding with any testing, we collect individual crusher data to evaluate current operating parameters and conditions. While some applications can be evaluated with a small amount of data, more complex issues may require investigating factors such as ore type, worn liner profiles, closed side settings, tonnages, feed size distributions, power draw and feeding configuration.

Project goals and performance targets are discussed and agreed to determine future directions.

Stage 2 - Benchmarking

Benchmark testing normally involves using designs and parameters as close as possible to current practice, with improved Makuri material grade. Severe issues may require some design changes before initial testing is performed to ensure improvements are obtained as soon as possible.

Stage 3 - Cavity profile optimisation

Following stage 2, we scan the liners and analyze all results and data using our proprietary software. We then offer an optimized liner profile to provide improvements in line with agreed targets. Unless life is a primary consideration, we normally find it more beneficial to initially address the machine performance prior to embarking on life improvements.

80 to 90% of the required improvements are obtained at this stage, with minor changes required in later stages to fully achieve targets.

Stage 4: Life optimization

Any remaining life and performance requirements can be further optimised with minimal changes once stage 3 is complete.

Stage 5: Monitoring & continuous improvement

To ensure that lowest TCO is maintained and continuous improvement KPIs upheld, Makuri conducts ongoing reviews and reporting to identify further optimisation opportunities due to any ore type variances or operational changes.

Makuri offers this service as part of ongoing supply agreements within agreed cost structures.

Crusher Backing & Grouting Technology

We have developed a range of grouting products and technologies to provide longer life crusher backing and long life mobile equipment wear liners

When crusher liners last longer you need to have a backing compound that lasts longer too!

MAK-BAK Long-life crusher backing

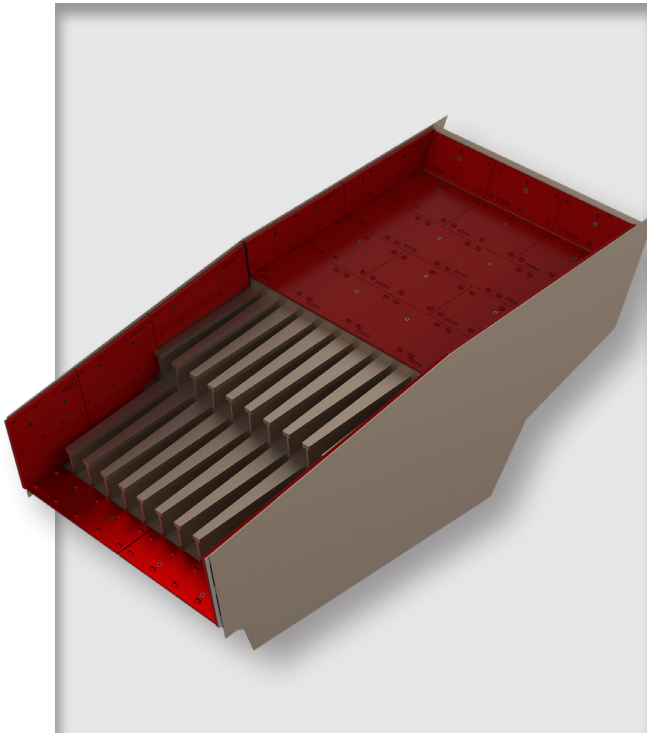
MAK-BAK allows the full life of the crusher wear liners to be reached without premature failure of the backing compound.

Converting Non-backing crushers to backing

We are also able to convert crusher liner design from non-backing to backing style to improve reliability and performance of the liners.



Vibrating Grizzly components

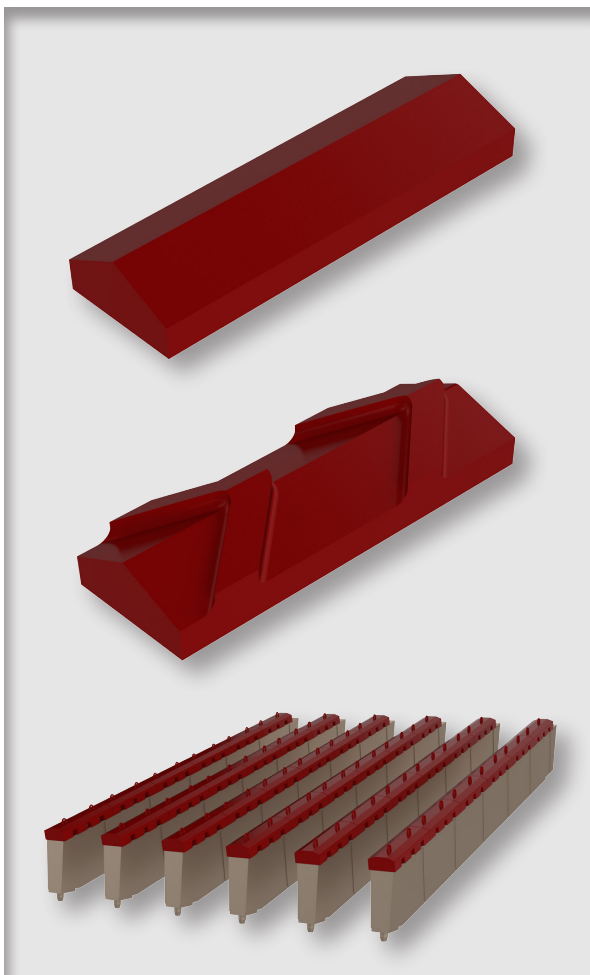


Typical problems

- Plugging between fingers reducing efficiency and throughput
- Open area and passing sizes not designed or adjusted to suit primary or secondary crushing feed sizing requirements
- Fines passing across the face of grizzly fingers & into downstream crushers
- Poor design and life causing premature failure and excessive unplanned downtime of both fingers and wall liners
- Broken / failed fingers and wall liners cause both crusher and belt damage
- Side and pan liners lasting different times to grizzly finger caps

Makuri Solutions

- Makuri grizzly caps can be designed and manufactured to any size, shape or aperture requirements in a range of materials, including our MAK-Hard Bimetallic cast and forged products
- Fitting options include welded, bolted and a unique cartridge assembly suitable for fixed installations
- Optimised longlife packages that reduce maintenance time & provides uniform life for the full set
- Provides for the lowest cost per tonne and overall lowest Total Cost of Ownership



Tower (Verti) Mills

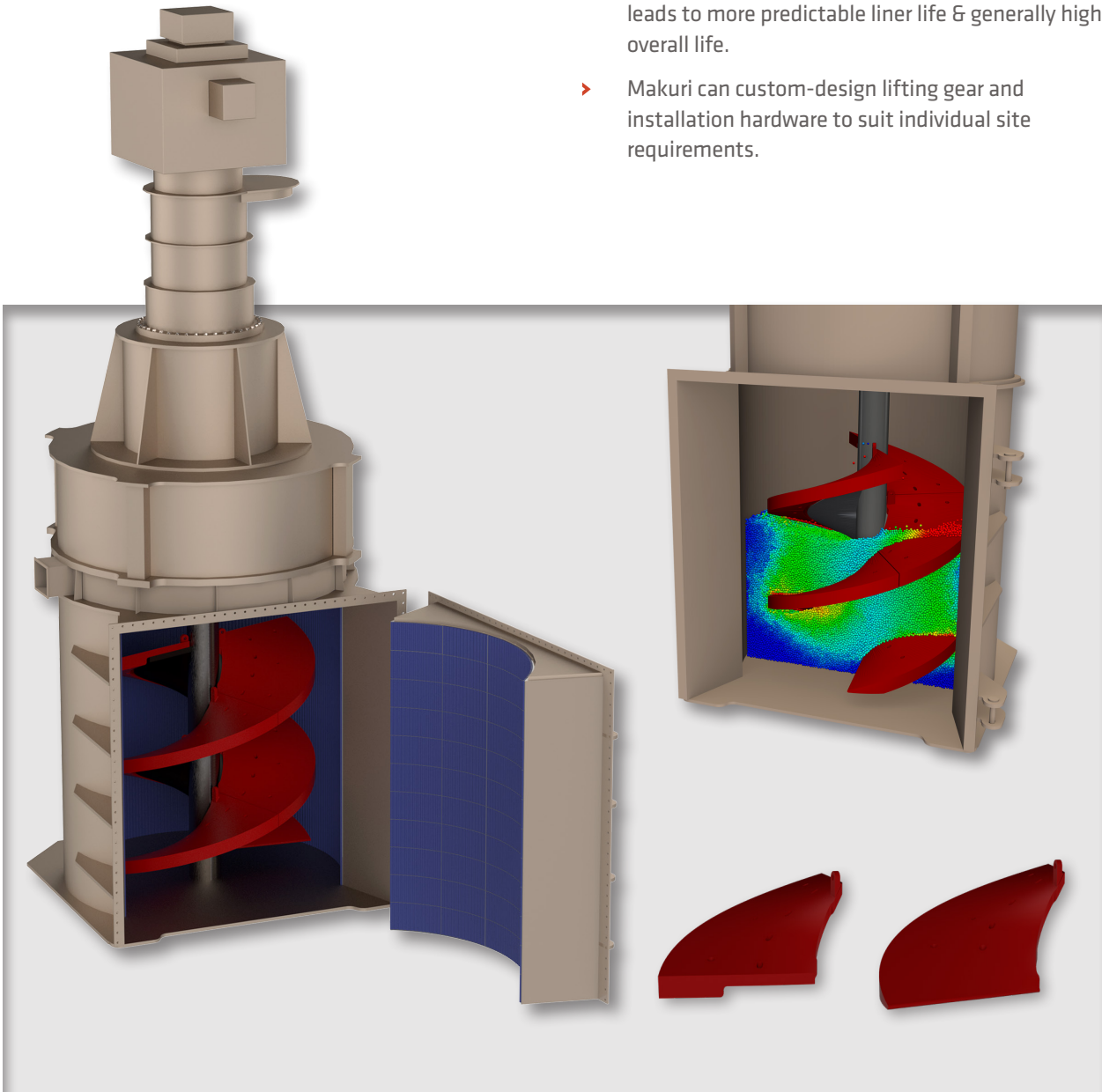
When operated properly, tower mills can be relatively problem-free. However, difficulties in monitoring wear to digging shoes and liner flights can lead to decreased power draw and gradually decreasing production rates. It is no simple task to empty a tower mill to inspect or replace liners, so predictable performance is critical.

Typical problems

- Poorly fitting liners
- Insufficient wear life
- Inconsistent wear life
- Handling issues during installation

Makuri Solutions

- Where possible, Makuri scans both the existing liners and spiral to ensure proper fitment. All patterns are manufactured using 3D CNC pattern making machines to ensure accuracy.
- Higher grade and quality alloy steel composition leads to more predictable liner life & generally higher overall life.
- Makuri can custom-design lifting gear and installation hardware to suit individual site requirements.



HSI Blow Bars & Impact/Breaker Plates

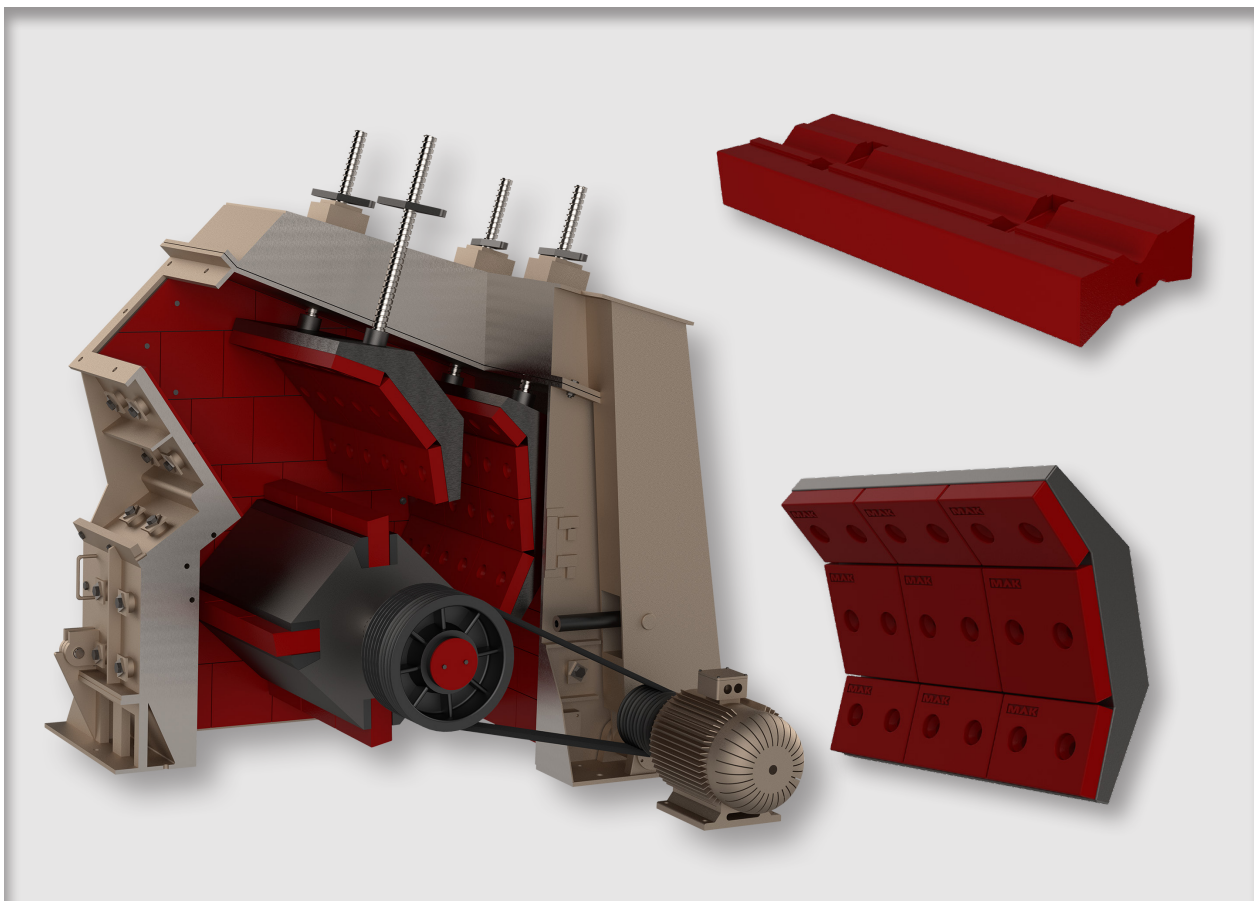
Horizontal shaft impactors are the backbone of many crushing applications where product size is not critical and the feed material is not too hard. However, the simplicity of these machines means that they can often become the forgotten part of the plant, leading to big problems if something goes wrong.

Typical problems

- Unexpected breakage in blow bars and impact/breaker plates
- Unable to achieve correct product size
- Uneven wear across bar length
- Failures due to not changing bars on time
- Poorly fitting bars
- Rotor damage due to insufficient condition monitoring

Makuri Solutions

- Material selection from a wide range of alloys to ensure the material matches the application
- High quality and reliable composite materials for improved life
- Material flow modelling into the crusher to ensure feed arrangement is optimal to reduce uneven wear across bars
- Fully machined seating faces on all contact points to ensure proper fitment and reduce the opportunity for breakages
- Site-based condition monitoring services to allow early failures to be predicted in advance



Sizer Teeth

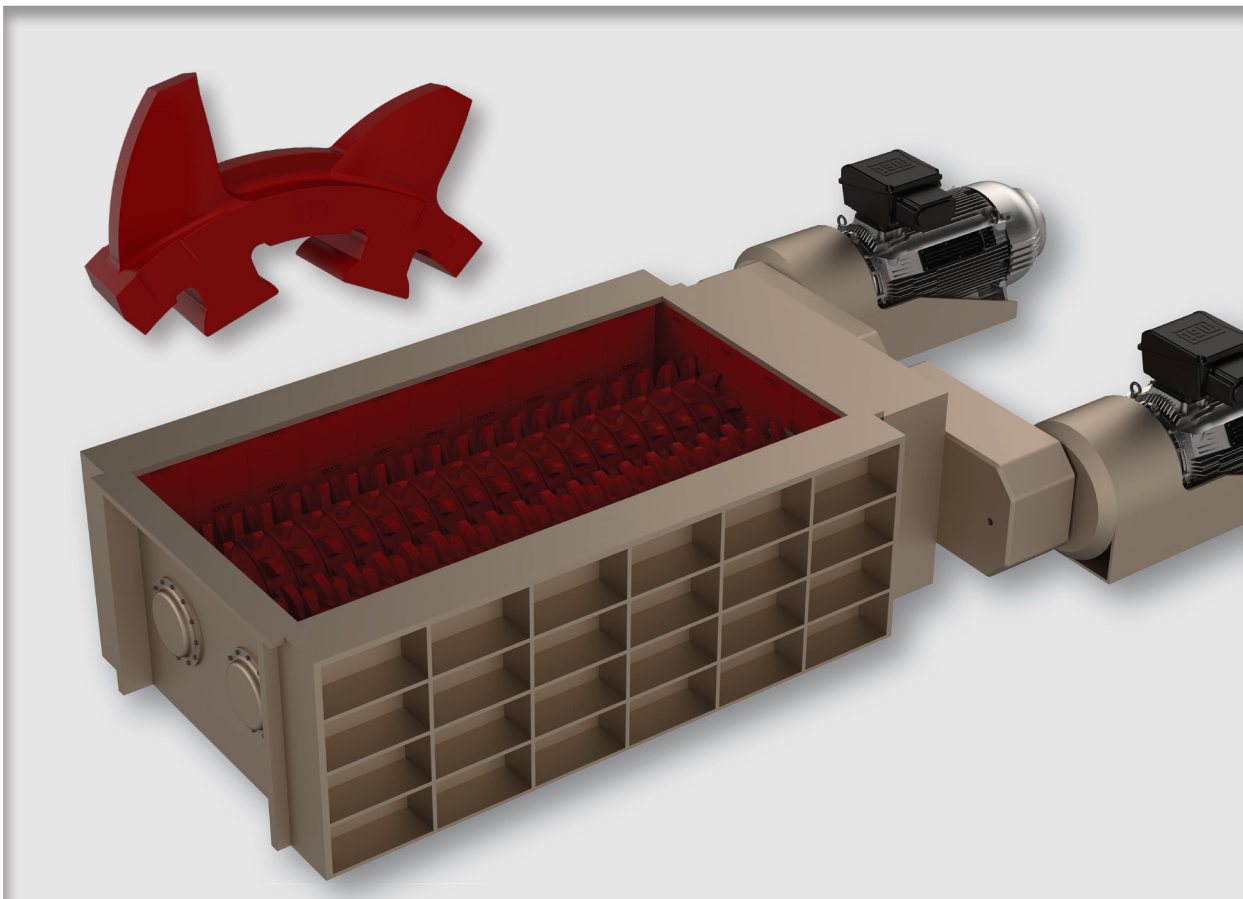
Makuri offers a range of solutions for sizer teeth including alloy steels and ceramic composites.

Typical problems

- Tramping due to excess fine material in the chamber
- Unable to achieve the target gap within power limitations
- Lost production rate towards end of liner life
- Unusual wear behavior due to incorrect liner selection
- Unable to achieve a choke-fed condition
- These will not be resolved by simply making thicker liners or changing material grades

Makuri Solutions

- Examining the whole process and correcting problem areas such as screening
- Improving the performance of secondary crushers to reduce tertiary crusher load
- Anti-tramp designs to allow for tighter gap settings without damaging the crusher
- Adaptive liner profiles that maintain initial chamber shape for longer periods of time
- Site-specific designs to suit actual feed conditions and crushed product requirements
- Ongoing condition monitoring and design upgrades to keep up with changing feed conditions





We supply custom wear liner systems for dippers, buckets and haul trucks that are typically both longer life and, in many cases, also lower in weight than standard OEM and aftermarket offerings.

We have a number of patented installation systems and designs covering liners and GET (not teeth or adaptors). These products excel when you're engaged in extracting and high value minerals, especially in coarse hard rock and extremely abrasive conditions.

These technologies unlock the door to maximum equipment operational performance and significant, measurable and sustainable reductions in the TCO (Total Cost of Ownership)



Ask for a
download of our
MAK-MINING Handbook
from www.makuritech.com

SECTION 3

Chutes and Transfer Points

- MAK-Bund Liners
- Stockpile Reclaim chute liners
- Apron feeder pans
- Transfer chute liners
- Liner design philosophy Pros & Cons
- Liner mounting options
- Proprietary mounting system
- Liner packing and installation system
- Internal & external skirting systems

The critical connections
across the production plant

3

MAK-Bund Liners

MAK-Bund drop-in blocks provide a low cost and convenient means of creating rock boxes and ledges in chutes, stockpile discharges and similar applications. The liners are retained on a simple mounting rail and require no welding once the rail is in place.

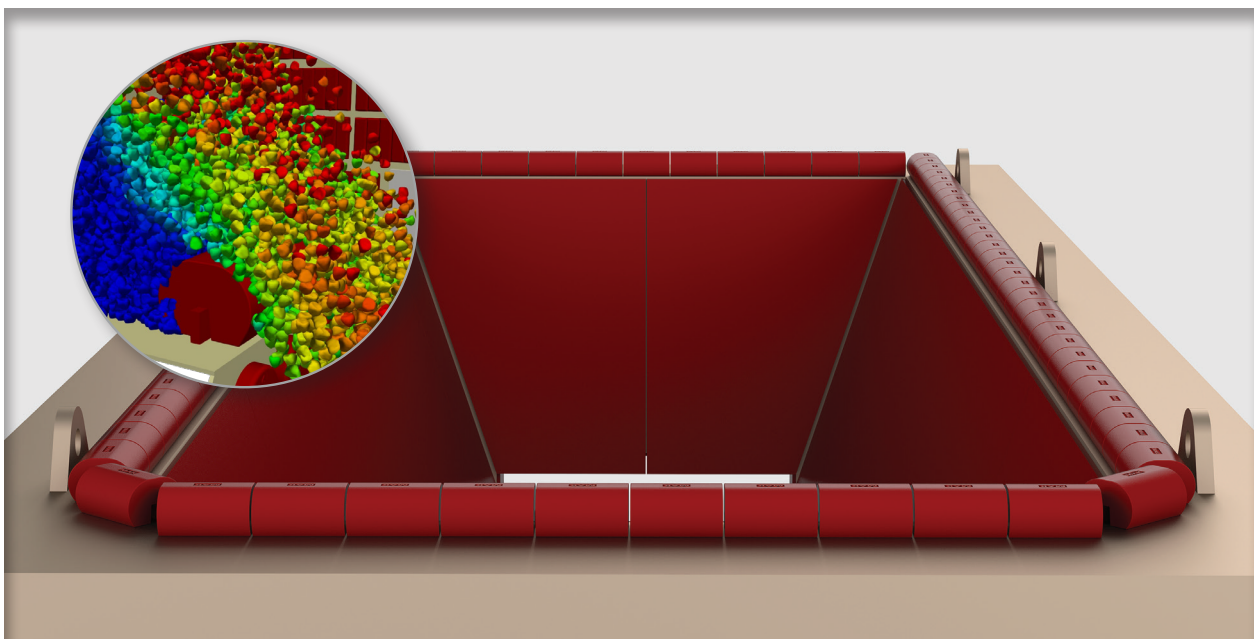
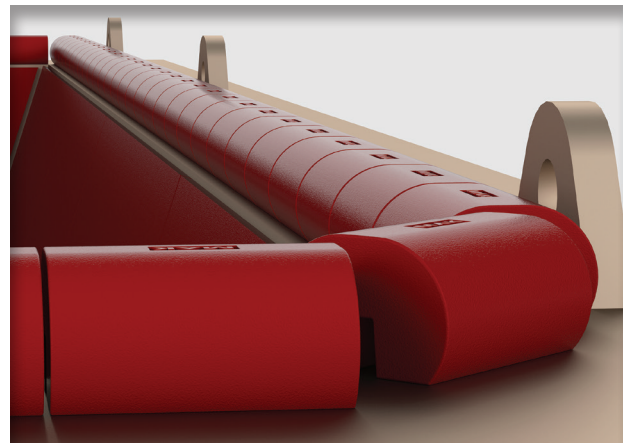
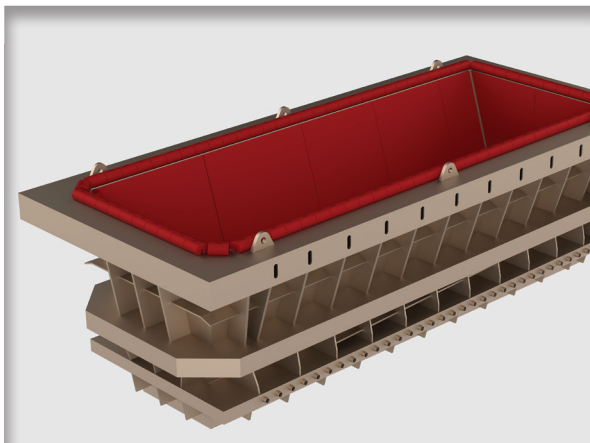
MAK-Bund blocks are available in a range of sizes to suit a variety of applications, and prefabricated rails can also be supplied to simplify retrofits.

MAK-Bund blocks are available in a range of materials, depending on life requirements and impact conditions:

High impact: For high impact applications, manganese steel MAK-Bund blocks provide a low cost, resilient option that is almost indestructible & provides good wear resistance

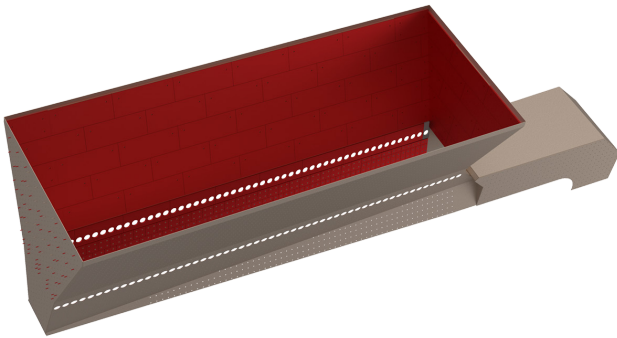
Fine particle abrasion: Where impact is low & abrasive wear is high, we are able to offer ceramic-impregnated MAK-Bund blocks that provide extremely long life under fine particle abrasion.

All-purpose applications: In applications where neither impact or fine particle abrasion are extreme, Makuri offers alloy steel MAK-Bund blocks in varying grades. These do not require work hardening and are more resilient than ceramic impregnated components and offer a good universal option.



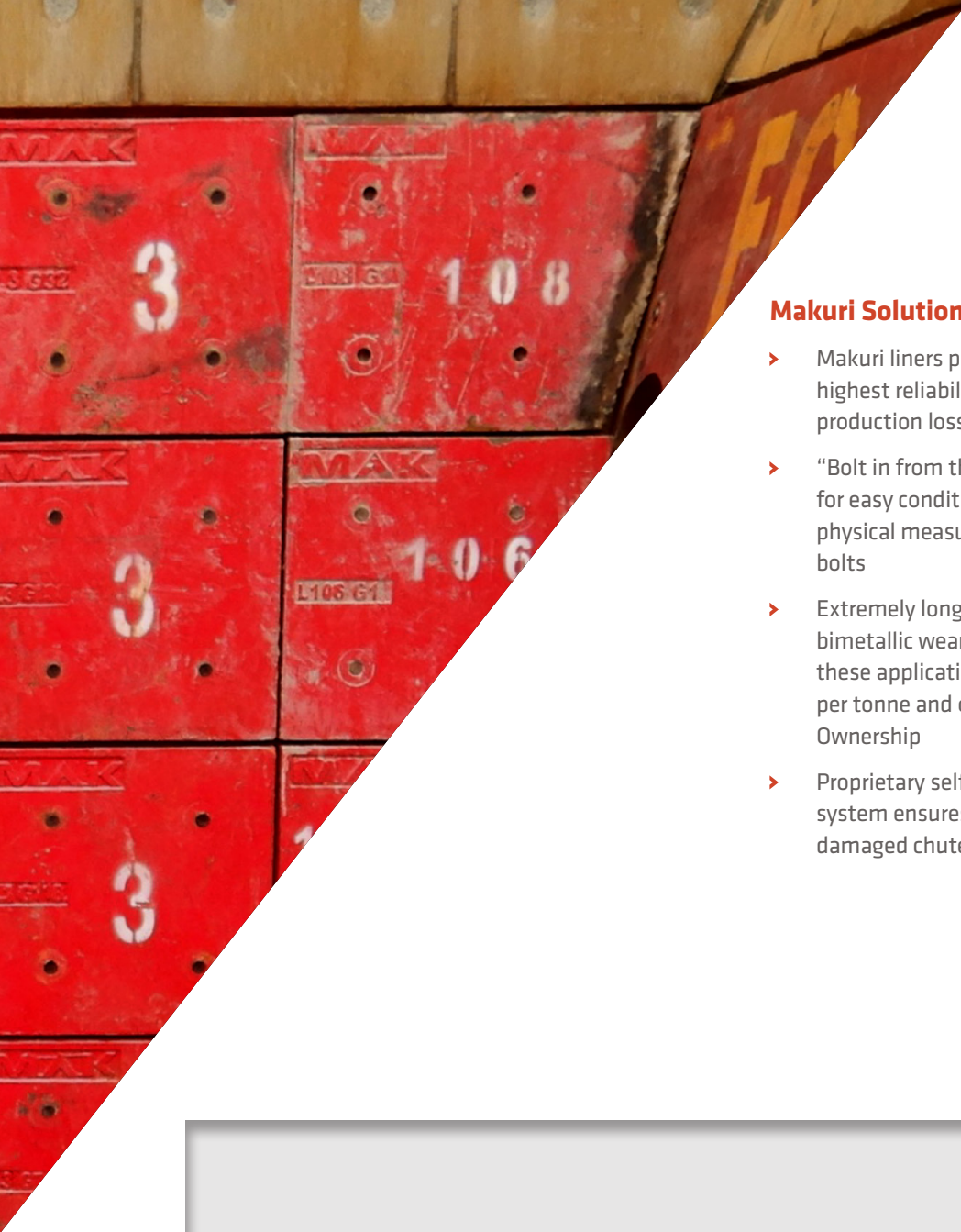
Stockpile Reclaim Chute Liners

Reliability & long life of stockpile reclaim chute liners is critical as significant production losses occur when the stockpile is raised and dropped.



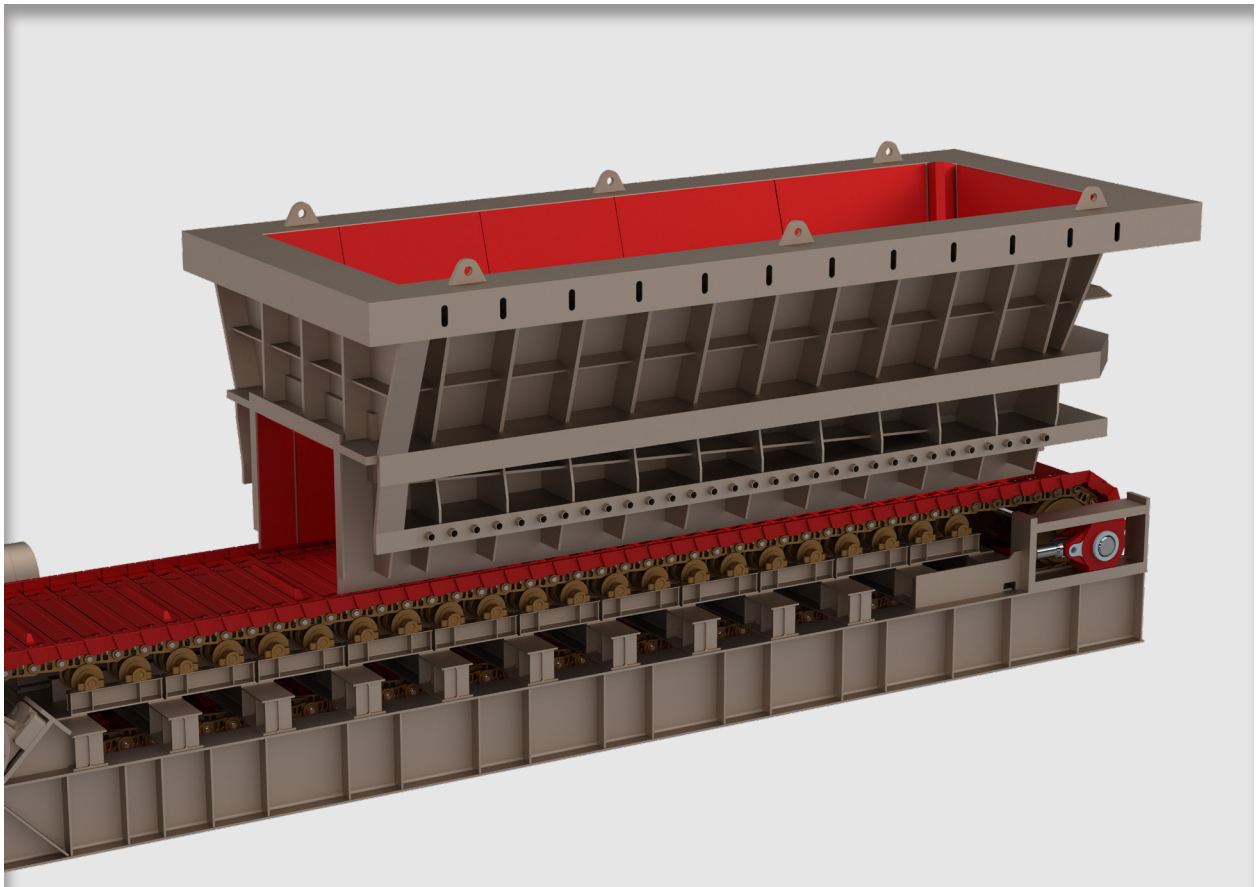
Typical problems

- Serious safety risk if chutes fail due to poor liner management
- High manpower usage, high urgency and detailed forward planning required when changing hundreds of components
- High risk working environment, involving:
 - Confined spaces
 - Working at heights
 - Hot work
- Liner design life does not coincide with stockpile management plans
- Difficult to assess overall liner condition when in operation
- Wear rates between feeders varies significantly with different feeder speeds and stockpile locations due to ore segregation
- Complex high pressure gouging abrasion causes rapid damage to liners and chute frames once the liners are worn through
- Corrosive wear when sulphide ore and water is present, causing acid leaching



Makuri Solutions

- Makuri liners provide the longest liner life and highest reliability. This is critical to reducing production losses and increasing safety.
- “Bolt in from the back” liners that allow for easy condition monitoring via UTT or by physical measurement by removing one of the bolts
- Extremely long-life Makuri cast and forged bimetallic wear liners have been proven in these applications. They provide lowest cost per tonne and overall lowest Total Cost of Ownership
- Proprietary self-aligning, fail-safe bolting system ensures tight fitment, even on damaged chutes.



Apron Feeder Pans

Apron feeder pans are an often-overlooked but critical part of the production process.

Typical problems

- Pans are typically bought on price and not performance
- Pans are typically run to failure and not ordered in time
- Worn pans / low friction designs causes ore slippage and hysteresis in the feeder speed mill control loop
- Pan life that does not correspond to major shutdown intervals
- If pans are not replaced as a complete set, life forecasting and shutdown scheduling are negatively impacted
- Difficult to monitor condition and predict remaining life
- Poor pan profile leads to high abrasive wear during material discharge
- Fine/sticky material flowing between pans on discharge can damage drive components and jam the feeder

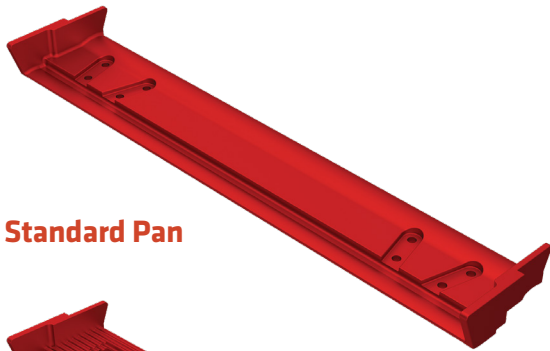


Makuri Solutions

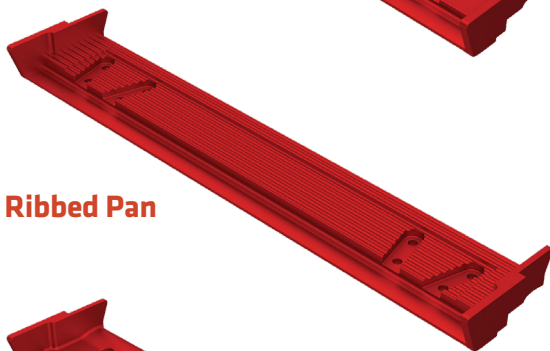
- Unique ribbed and grouser bar apron feeder pan designs reduce wear to improve frictional properties and SAG mill feed control
- Proprietary designs that reduce abrasive wear during discharge
- Lowest cost per tonne and overall lowest Total Cost of Ownership
- Site-specific evaluation of existing components to ensure proper fit and compatibility with stock items when required
- Optimised designs that prevent material flowing between pans on discharge, improving feeder reliability and reducing wear on drive sprockets and support rollers
- We can also supply standard designs for less demanding applications
- We work with end users to predict change-out interval and ensure on-time delivery to allow for planned maintenance.

Apron Feeder Pan Options

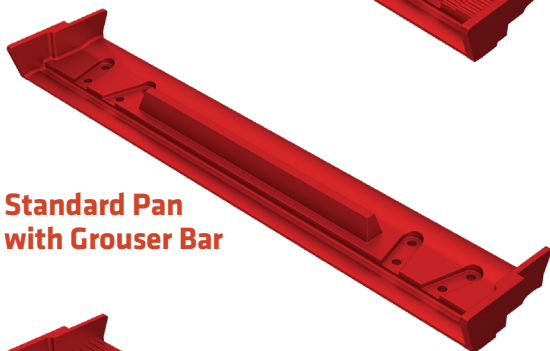
Standard Pan



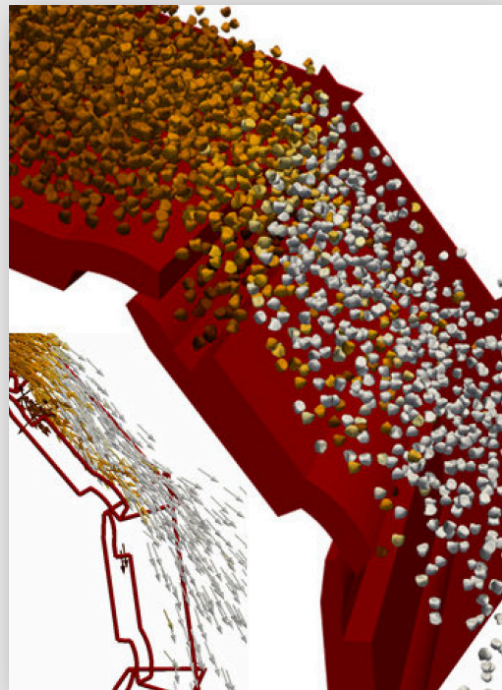
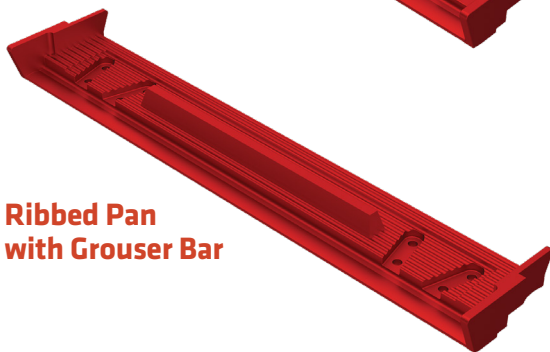
Ribbed Pan



Standard Pan with Grouser Bar

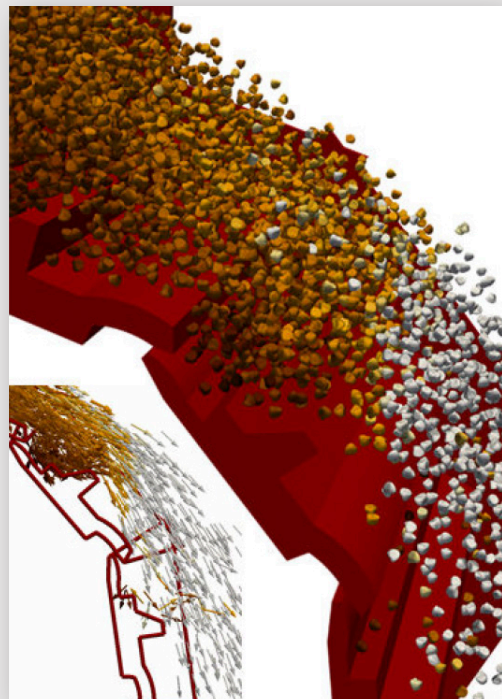


Ribbed Pan with Grouser Bar



STANDARD PAN

High velocity and abrasive wear across pan face on discharge. Material can flow between pans and into drive components



GROUSER BAR PAN

Material retained on pan for longer and falls away from pan face. Abrasive wear is reduced and materials is less likely to fall between pans.

Transfer Chute Liners

The significance of transfer chutes is often overlooked at the design stage. The resulting issues are not easy to correct, creating ongoing operational and maintenance losses with associated high costs.

Typical problems

- Localised wear in a relatively small area
- Poor design requires frequent shutdowns to replace the high wear point liners
- High material velocities damaging receiving belts
- Blockages & buildup due to sticky materials
- Excessive dust generation
- Access & lifting problems preventing use of larger liners
- Patch repairs interrupting design material flow and relocating wear points
- Fugitive materials causing environmental concerns

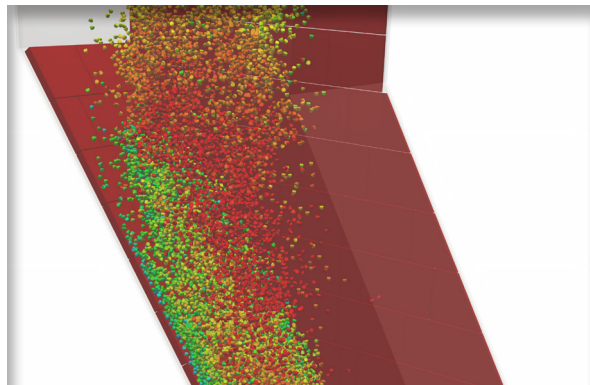
Makuri Solutions

- Correcting wear problems through redesign rather than trying to control them with thicker liners
- In-house DEM modelling on existing liners to understand trajectories, velocities, material buildup and wear areas
- Advanced scanning and wear modelling allows for accurate condition monitoring and predictive maintenance
- Liner materials and design based on localised wear rates, allowing the full set to be changed at once with minimal wastage
- Makuri cast and forged bimetallic liners can be manufactured to any shape, size or thickness required
- Long-life MAK-SAFE 'bolt in from the back' liners provide simple fastening methods and a simple condition monitoring system
- MAK-SAFE liner thickness can be checked by simply removing the bolt and measuring its remaining length or by thickness testing

Design Options

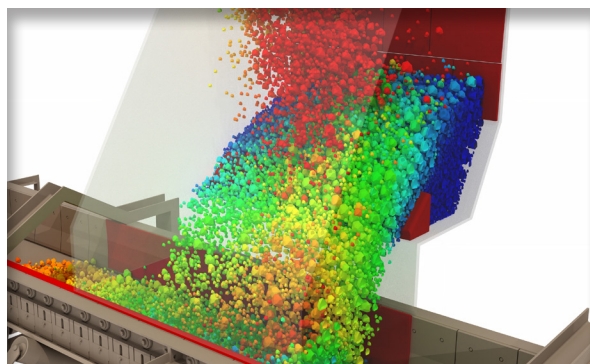
Free Flow Types - Pros & Cons

- Material velocity and open area maintained
- Less risks of blockages
- No impact fatigue of chute frames
- Can create a better receiving belt presentation if designed that way
- High abrasion of liners where material contacts hoods and deflectors



Rockbox Types - Pros & Cons

- Reduced material velocity and open area
- Creates a self replacing wear surface
- Relation to ore presentation critical in effectiveness
- Discharge edge hard to design and maintain
- High energy absorption and chute frame fatigue
- Higher risks of blockage
- Often needs steps or staging to complete the transfer
- Final presentation to receiving belt not optimum
- See Section 4—Supporting Products & Services, for details of wear parts for rock-boxes

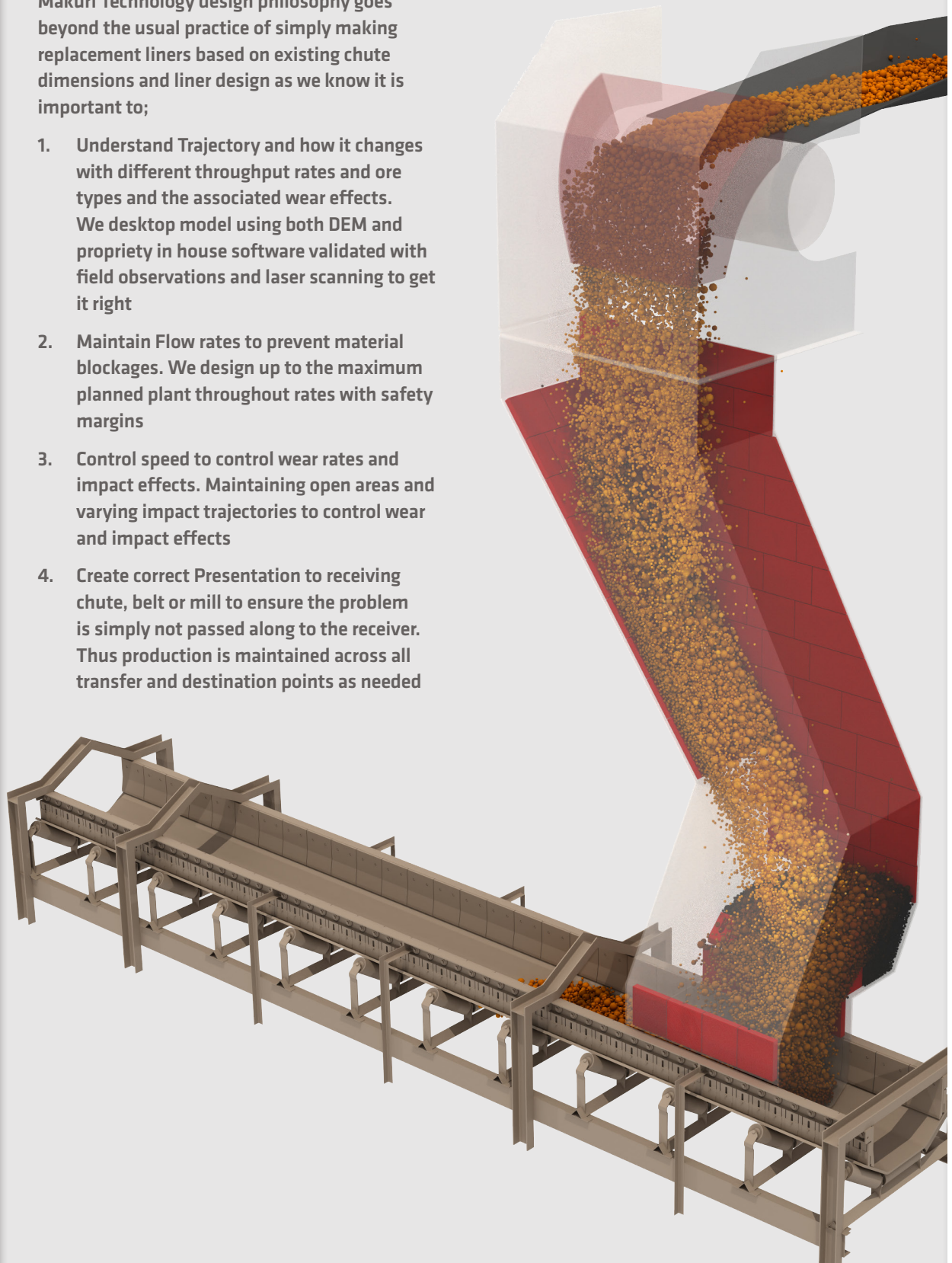


Transfer Chute Liners

Design Philosophy

Makuri Technology design philosophy goes beyond the usual practice of simply making replacement liners based on existing chute dimensions and liner design as we know it is important to;

1. Understand Trajectory and how it changes with different throughput rates and ore types and the associated wear effects. We desktop model using both DEM and propriety in house software validated with field observations and laser scanning to get it right
2. Maintain Flow rates to prevent material blockages. We design up to the maximum planned plant throughput rates with safety margins
3. Control speed to control wear rates and impact effects. Maintaining open areas and varying impact trajectories to control wear and impact effects
4. Create correct Presentation to receiving chute, belt or mill to ensure the problem is simply not passed along to the receiver. Thus production is maintained across all transfer and destination points as needed



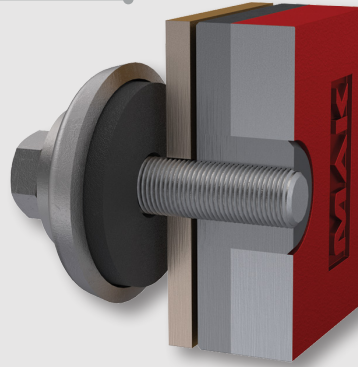
Chute Liner Mounting Options

Pick and mix the best options that work for you with existing, modified or new installations.

MAK-Safe Bolt in From The Back

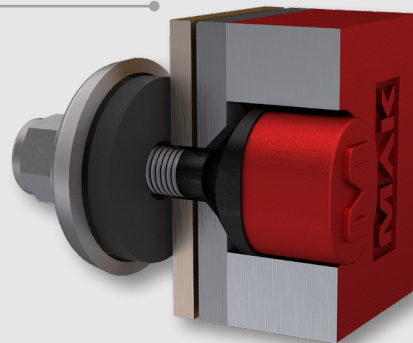
- Allows for the full life of the liner to be obtained
- Allows for flat packing
- Fast, safe and versatile mounting and lifting options
- Simple condition monitoring
- Can be used with Makuri's 5-step installation system

See page 45 for details of this new and very safe installation system



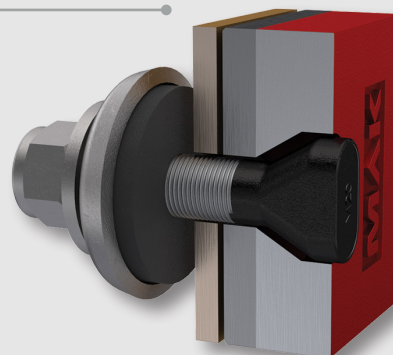
MAK-CB Bolts (Capped Bolts)

- Unique Makuri bimetallic bolts with MAK-Hard white iron caps
- Prevents wear to the structural part of the bolt
- Prevents streaming wear in the bolting hole
- Allows for flat packing



MAK-FT Bolts (Fishtail Bolts)

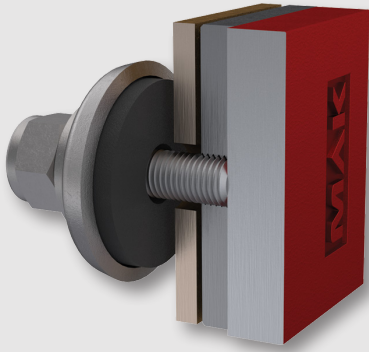
- Makuri liners can be manufactured to suit any bolt profile
- Fishtail bolts are readily available and do not turn inside the hole
- Allows for some degree of misalignment
- Liners can be flat packed



All bolting options can be supplied with Nyloc nuts, standard hardened washers, self-aligning sealing washers and self-locking washers

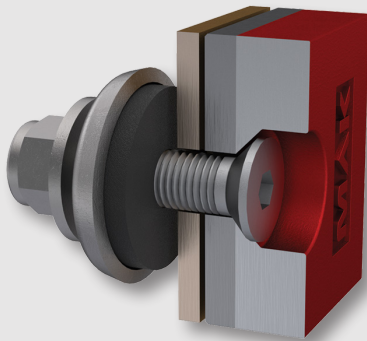
Chute Liner Mounting Options

Pick and mix the best options that work for you with existing, modified or new installations.



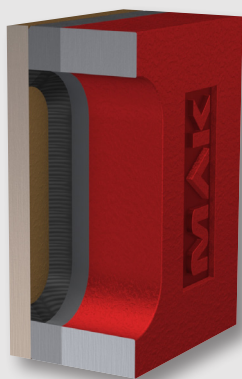
MAK-HT Studs (High Tensile)

- Provides for simple installation, but requires additional space for packing
- Weld-free design ensures tensile strength of studs is maintained
- Allows for studs to be fully tensioned in critical applications



MAK-CS Bolts (Countersunk)

- In some applications, use of these can allow the full thickness of wear material to be utilised without damaging the bolt head
- Liners can be manufactured to suit any standard bolts available on site
- Liners can be flat packed



MAK PW Slots (Plug Weld)

- Can be used where installation conditions do not allow for use of bolts, or where chute conditions are not acceptable for bolting

All bolting options can be supplied with Nyloc nuts, standard hardened washers, self-aligning sealing washers and self-locking washers

Packing & Installation, We take it seriously!

Integrated Lifting Points

- MAK-Safe liners use cast-in tapped lifting points as standard, allowing the use of common lifting gear and eyebolts

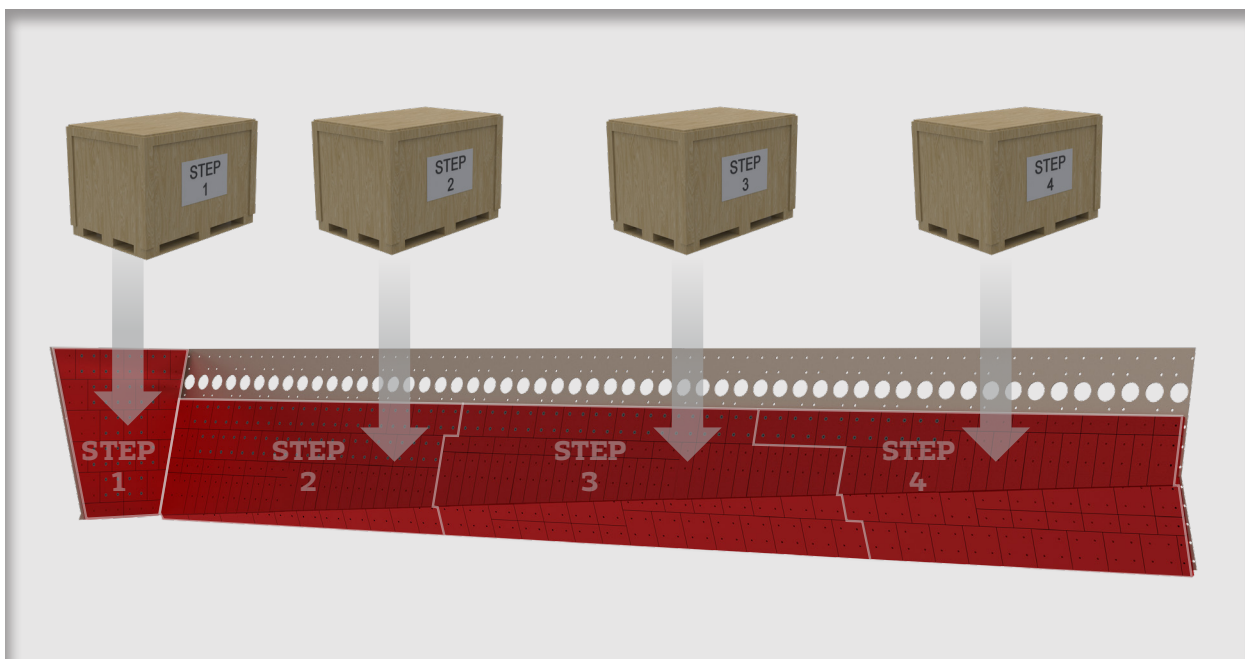
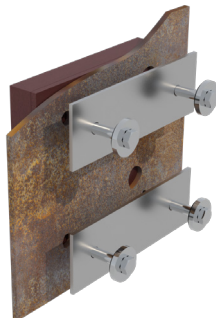


Maintenance Focused Packing

- Crates packed in line with installation step sequence.
- Also can be supplied packed into purpose-built lifting frames in ready-to-install packing sequence
- Crate # matched to step #
- Crates and liners color coded when the same sets of liners are being installed in different chutes
- Each liner marked with a part #
- Each liner marked with an installation ID #
- Step by Step installation plans provided
- Installation training is available upon request

Temporary backing plates for damaged chutes

- Makuri can provide purpose-built backing plates and self-aligning washers to compensate for worn and/or damaged chutes
- This should be regarded as a temporary fix only!



The MAK-Safe Proprietary 5-Step Installation System (For use with MAK-Safe liners only.)



Fit lifting plate and aligning bolts onto liner. Ensure that the handle is central on the liner plate and that the aligning bolts are hand tight.



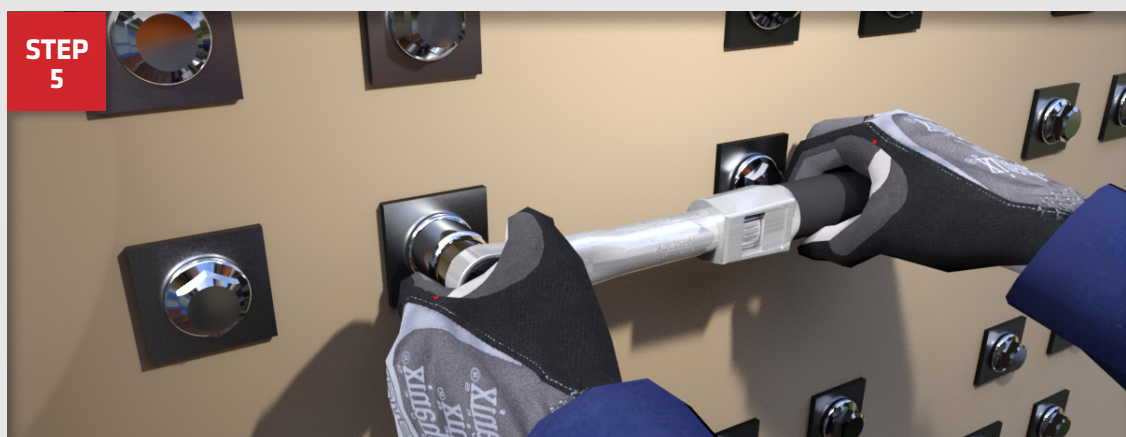
Lift the liner into place on the chute wall, using the aligning bolts to locate the liner in the upper holes



Loose fit lower bolts from the outside. Use compensating plates where needed if holes are in poor condition.



Remove lifting plate and fit upper bolts



When all liners are installed and gaps are correct, tension bolts to the specified torque

Simplifying condition monitoring with MAK-Safe

MAK-Safe bolt in from the back system allows condition monitoring activities to be performed easily and without expensive equipment.

Checking liner thickness by measuring bolt lengths

- The MAK-Safe bolt from the back system allows liner thickness to be checked by simply removing a bolt from the area being checked and measuring the length of the bolt shank.

In many cases, condition monitoring operations can be performed while the chute is in operation.

Ultrasonic testing of bolt lengths

- Modified hex head bolts can be supplied with liners to allow simple coupling with ultrasonic probes
- COMO plugs can be added to additional holes as required



New technology to replace old Ni-Hard liners

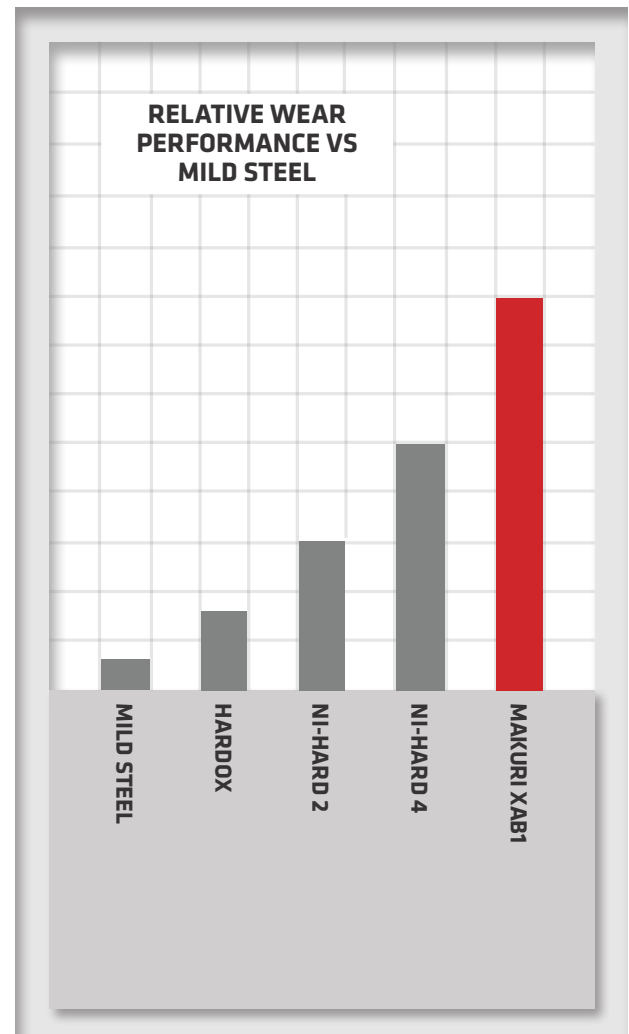
Ni-Hard is an established cast material that has been around since the 1960's and is still extensively used today, despite there being better options in both materials and design. The brittleness of Ni-Hard leads to a high likelihood cracking, with the whole casting then failing once the section thickness has reached a minimum thickness. While some users have been able to wear ni-hards down to around 10mm, impact loading had been a severe limiting factor. As a result, the liners are typically changed out at around 50% worn.

In the Countersunk bolt hole or Oval (fishtail) bolt hole configuration, the bolt heads can be worn off once exposed to wear, causing the liner to fall out. In addition, the brittle nature of the ni-hard material means that cast-in holes need to have plenty of meat underneath the bolt head, reducing the amount of wear material available before these issues become a problem. Typically, the useful thickness of a 50mm ni-hard liner with cast-in holes is around 25mm (50%).

The poor wear performance of Ni-Hard and the above limiting factors make these materials obsolete when compared to what can be achieved with high quality cast alloy steels like Makuri XAB1 in bimetallic liner configuration.

Because Makuri XAB bimetallic liners contain a construction steel backing plate, they have a higher impact toughness than Ni-Hard and are far less prone to failure.

In addition, the superior wear material used in XAB1 liners can produce a life improvement of >50% that of standard Ni-Hard materials and >30% over the best modified Ni-Hard alloys on a mm/mm wear comparison basis.



300x300 MAKURI Bimetallic Wear Plate Options

Makuri manufacture this popular size of liners in bimetallic construction and offer all the following benefits;

- Standard and proprietary mounting options that can be a direct replacement into existing chutes using existing hardware,
- Can be manufactured in almost any thickness necessary to achieve the life and weight targets as needed
- Our wear-resistant nib bolting option provides a hard, wear-resistant surface that prevents streaming in holes, while the structural part of the bolt sits in a modified countersunk hole in the backing plate.
- This allows full utilization of the wear material without risk of fastener failure, providing a life around 2x that of similar thickness Ni-hard 4 liners with fishtail bolts.
- Nib bolts do not turn in the liner holes, allowing tightening to be performed from one side

MAK-Skirt Liner Systems

Introducing the first internally and externally integrated skirting liner systems. Complete frames can be supplied and designed to fit existing mounting structures to allow full and easy replacement with new internal and external skirts on new frames.

Internal Hard Skirts

Makuri can manufacture internal skirts to any design or profile, using our MAK-Hard bimetallic liners. In addition, our adjustable and reversible designs allow clearance between the belt and skirts to be maintained, reducing belt damage and material leakage.

The bimetallic design provides a massive increase in impact toughness, allowing harder, long-life materials to be used – even with side loaded conveyors.

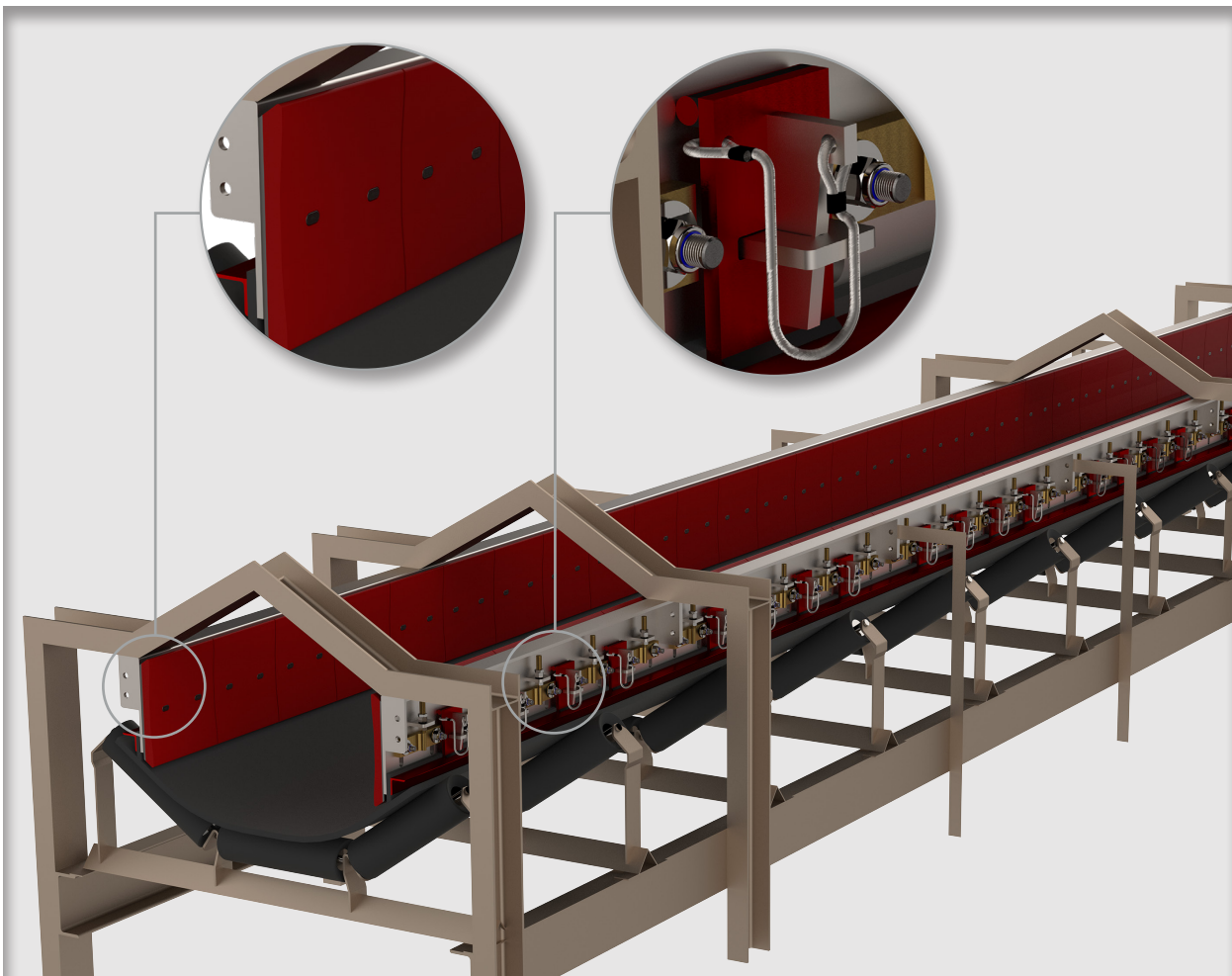
External Sealing Systems

Makuri can supply replacement rubber for many common skirt sealing systems, manufactured from high quality rubber in varying profiles. These can be adapted to individual site requirements to ensure proper performance and life is achieved.

Frame Fabrication

We can manufacture direct bolt-in complete replacement frames designed to take both our internal and external liner systems and clamping systems. These can include our own Makuri designed systems or can integrate with existing clamping systems to allow for common inventory.

Standard coatings are two pack epoxy acid resistant paint



MAK-Skirt Liner Systems

Clamping Systems

Makuri designs and manufactures standard clamping systems to individual customer requirements, and also offer standard wedge-based designs that can often be retrofitted to existing steelwork, or supplied as part of a bolt-in modular system

Makuri Adjustable hard skirt system

Makuri's adjustable hard skirt system allows individual skirt plates to be adjusted to compensate for wear and greatly reduces the chance of skirts becoming dislodged and damaging the belt due to bolts loosening.

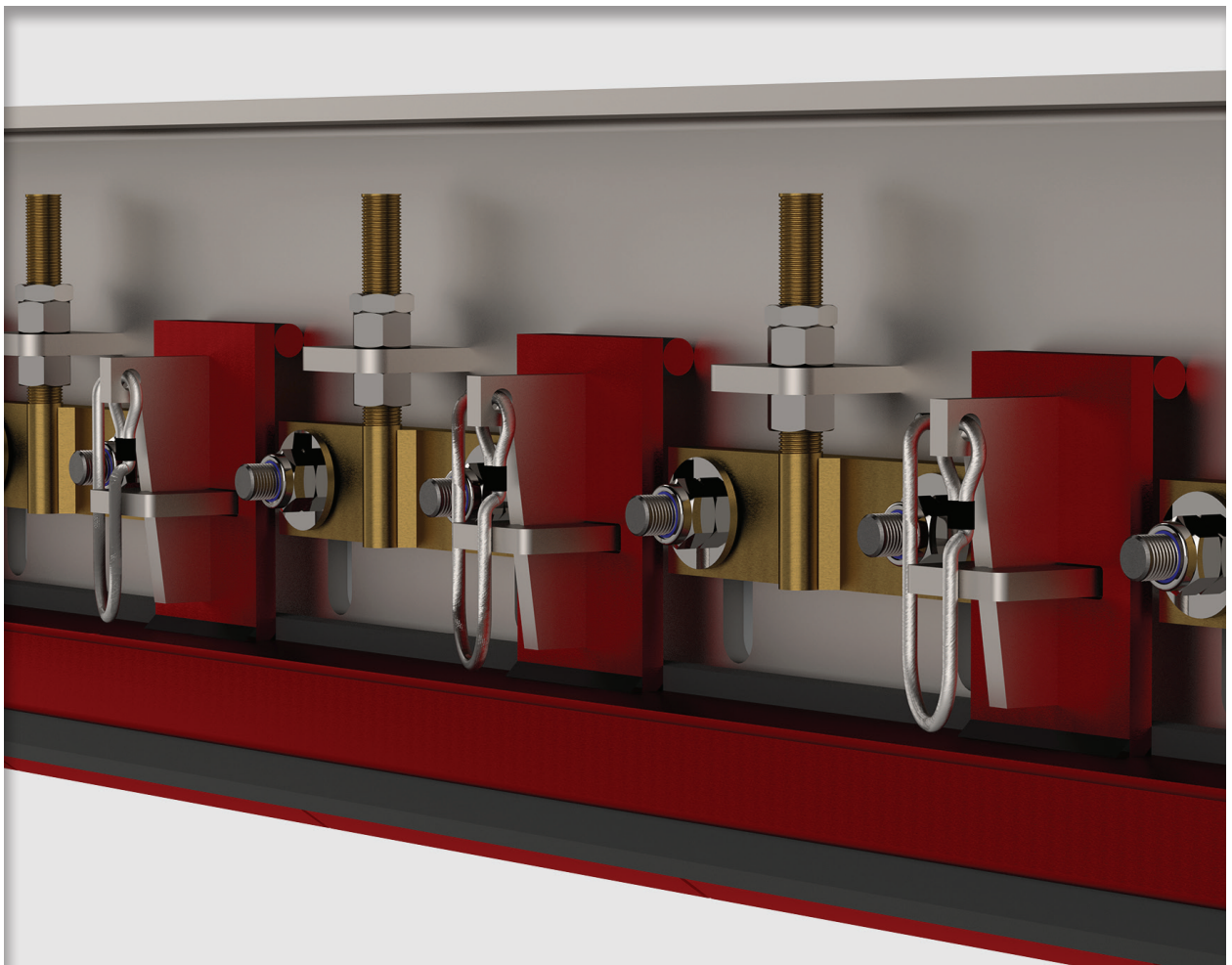
Our positive locking system allows skirts to be adjusted gradually and in small sections to provide a consistent gap between the skirts and the belt.

Skirts are then clamped to the main structure using Makuri bimetallic capped bolts, our unique bolt-in-from-the-back system or the end user's preferred bolting system. The adjustment mechanism then acts as a fail-safe to ensure the skirts stay in place.

Always look at the whole picture

Of course, the life of skirt liners should always be considered against the rest of the plant. By targeting skirt life to match that of adjacent components such as transfer chutes, shutdown frequency can be reduced.

Makuri can assist with proper evaluation and condition monitoring to ensure that lowest TCO is achieved throughout the entire plant.



A large industrial SAG mill is the central focus of the image. It is a massive cylindrical machine with a large circular opening at the front, revealing a bright red interior lining. The mill is supported by a complex metal frame and is situated within a larger industrial facility. In the background, there are various pipes, walkways, and structural elements of the plant. A worker in a hard hat is visible on a high platform in the upper right. The overall scene is industrial and brightly lit.

**The
SAG mill
is often the most
critical part of any
process plant. Don't risk
losing availability
by ignoring the
feed chute.**

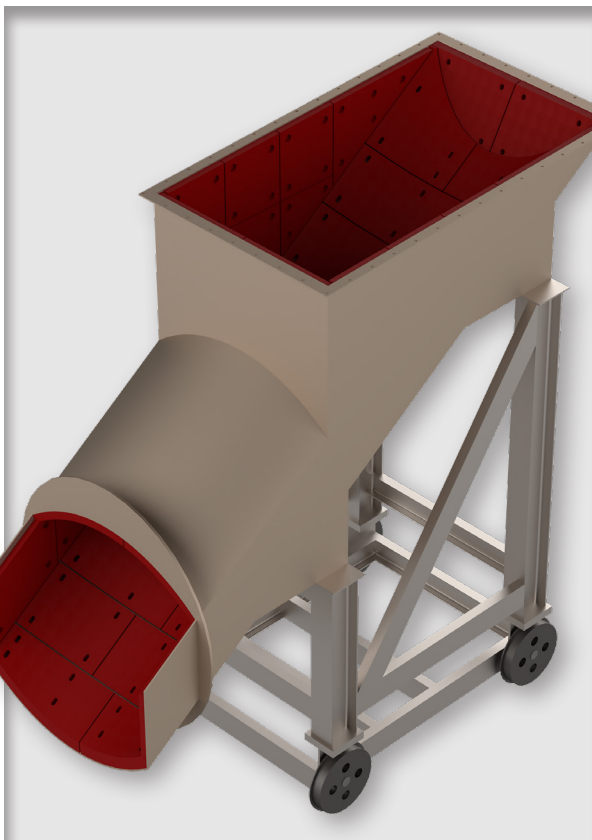
SAG Mill Feed Chutes



The critical water-slurry interface in SAG mill feed chutes is poorly understood and difficult to model.

Typical problems

- The effects of high velocity water addition into the ore path and the resultant turbulent flow cause wear paths that can rapidly and unpredictably wear out the chute.
- Liner change intervals that don't match mill shutdown intervals
- Blockages & material hold-ups
- Localised wear on a few liners only
- Long & cumbersome liner change process
- High wear rates result in thick liner materials reducing open area and increasing the risk of blockage
- These issues in SAG mill feed chutes are responsible for significant unplanned downtime and lost production.



Makuri Solutions

- Site-specific designs to allow liner changes to coincide with SAG mill shutdowns with a safety margin
- Modified geometries distribute slurry flow and associated wear
- Long life, extreme abrasion-resistant materials maximise life and minimise risk
- DEM-based flow verification of designs is used before manufacture

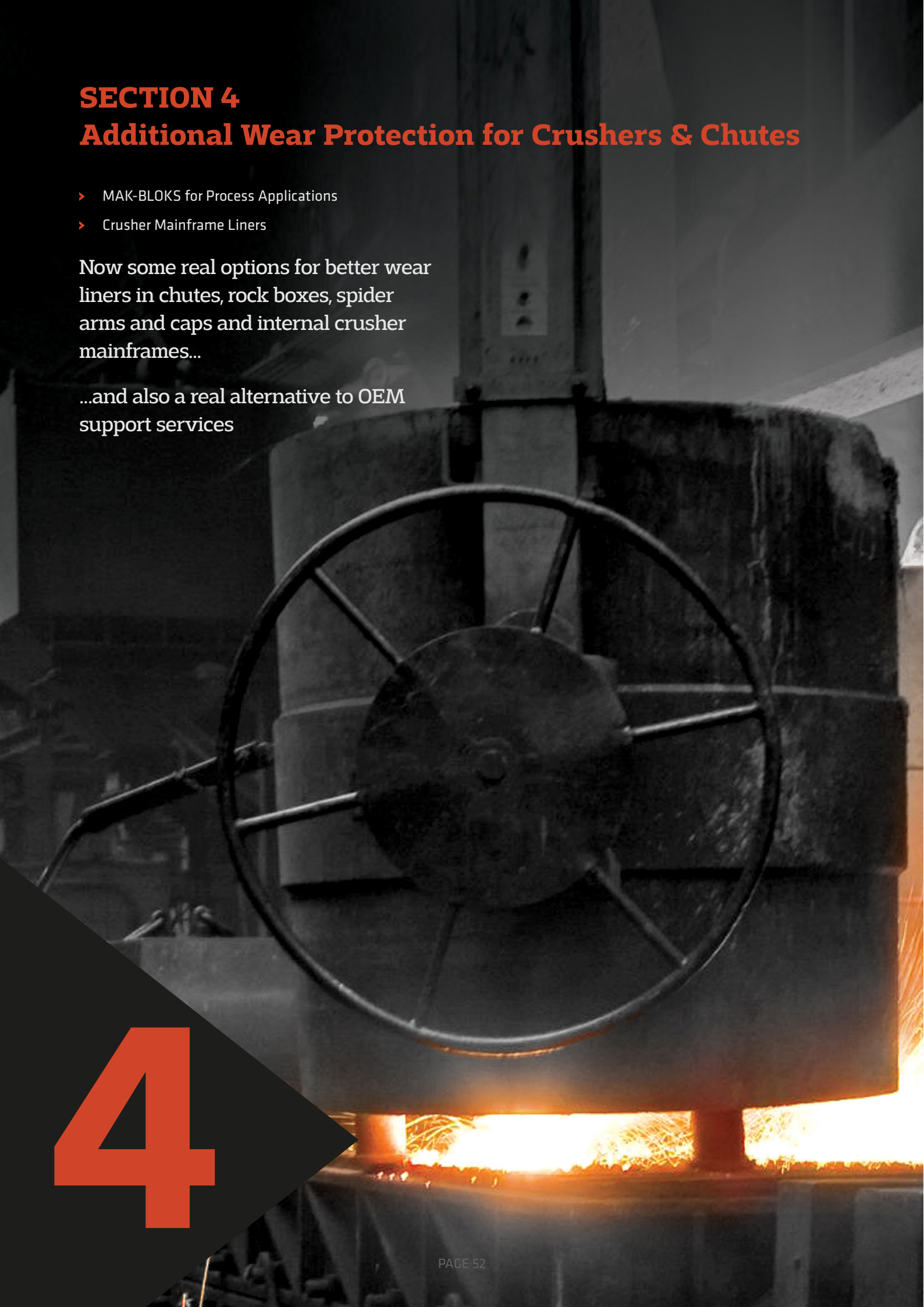
SECTION 4

Additional Wear Protection for Crushers & Chutes

- MAK-BLOKS for Process Applications
- Crusher Mainframe Liners

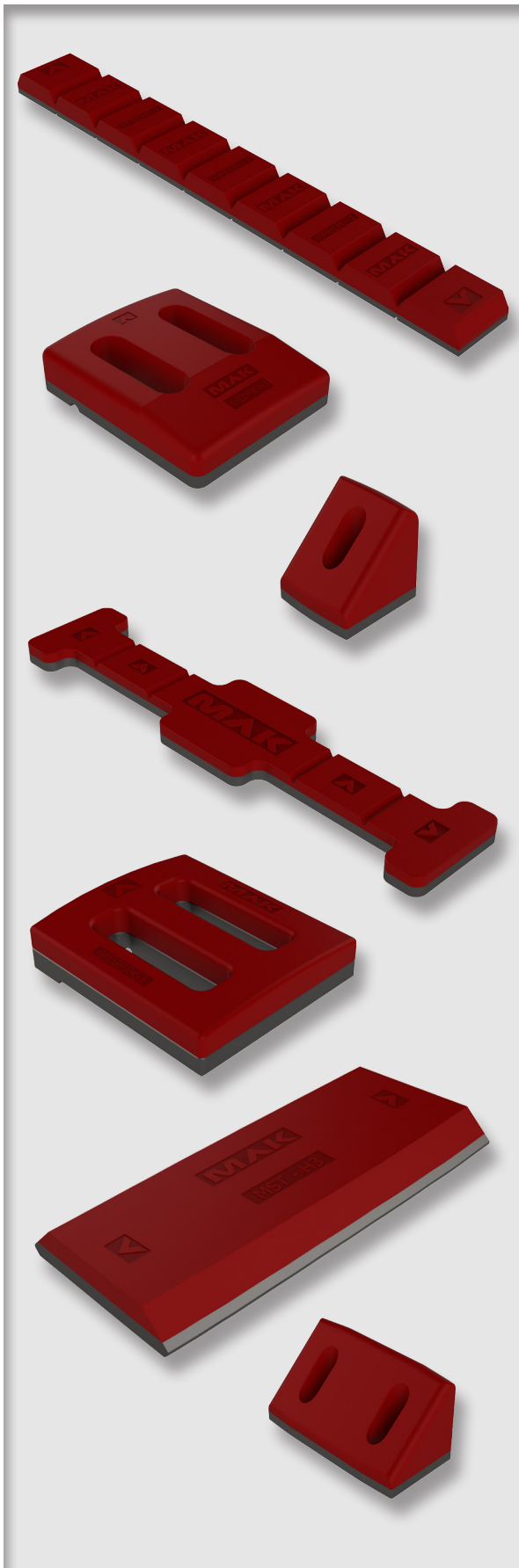
Now some real options for better wear liners in chutes, rock boxes, spider arms and caps and internal crusher mainframes...

...and also a real alternative to OEM support services



4

MAK-BLOKS Wear Protection Systems



The Problem

There is a lack of off-the-shelf wear part solutions for all types of exposed wear areas in the process plant. These include rock-boxes or impact plate applications in chutes, exposed crusher mainframes, spider arms, screen underflow and side walls, reclaimer buckets and many others.

The Solution

Makuri has designed a range of specialty bimetallic wear parts that can be easily installed into a wide range of wear applications. These are typically longer life and lower weight than existing wear materials. Makuri MAK-BLOKS are easily installed using standard welding consumables. For other custom Makuri wear liners using different mounting options, refer to section 3.

- Standard wear blocks
- Extra-large **MEGA-Chok** for use as both impact and rock box creation and edge protection especially on spider arms
- **Plug Plates** for use as wall liners and bash plates
- **Deflektors** for use as both impact and rock box edge protection
- **Stiffeners** are used to strengthen chute corners and also have a wear surface
- **Lip & Cheek Protectors** for use as front edges in rock boxes and other areas as best suited
- **Trak Bloks** for use as a lighter weight chute liners and where internal and external radius are present that need coverage

MAK-Blok applications: Emergency chute repairs and modifications

Chute liners can be difficult to monitor and even more difficult to shut down for sufficient time to allow for replacements. While Makuri works to ensure that its chute liners will last the distance without risk of failure, we still appreciate that sometimes things just don't go as planned.

Our MAK-Blok designs go above and beyond the usual weld-on chocky blocks available from other manufacturers, ensuring that chute repairs can be carried out in an effective manner and with a minimum amount of welding.

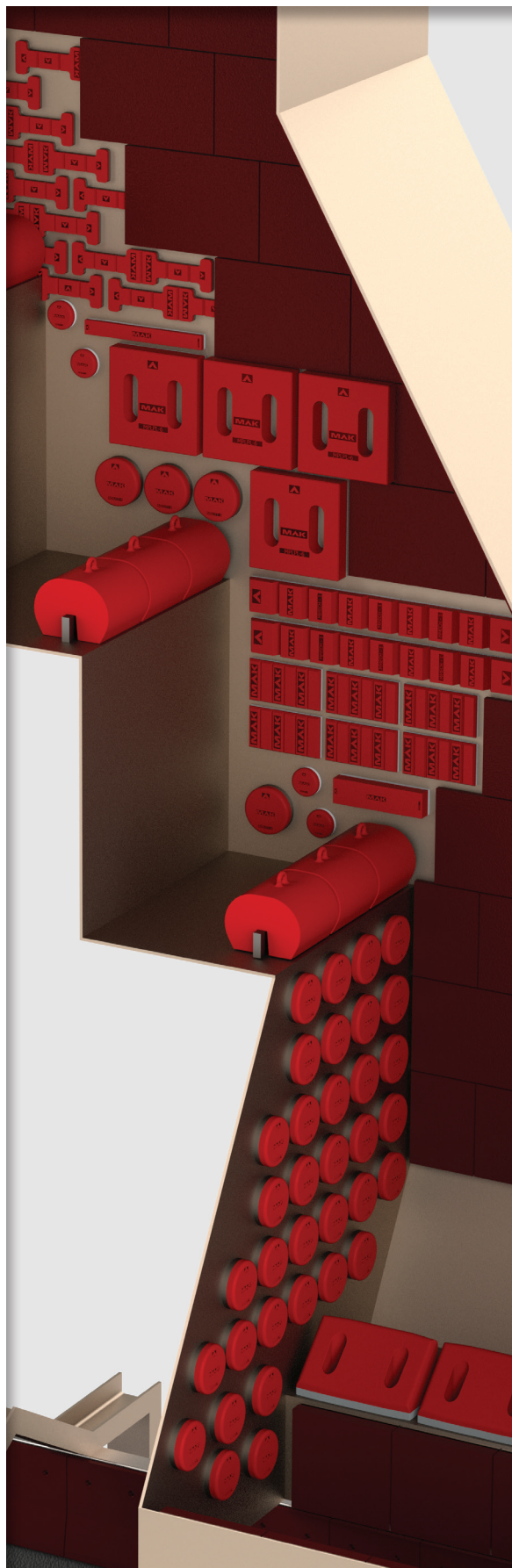
Site modifications such as rock boxing are best implemented after proper modelling, and Makuri can assist in this to ensure the greatest amount of success. However, where this is not necessary or fixes appear obvious, purpose-built components will be a better choice than items obtained from scrap piles, such as gas-axed worn mill liners and jaw plates. Makuri MAK-Bloks provide a longlife solution to these issues and are available in a range of sizes and configurations to ensure that no compromises need to be made.

Common problems

- Haphazard site modifications using whatever scrap can be found on-site
- Unexpected liner failures due to poor compatibility between liner life and shutdown frequency
- Inventory control issues leading to required liners not being available on-site

Makuri solutions

- Makuri MAK-Deflektors, MAK-Bars, MAK-MegaChoks and MAK-Bunds can create instant rock boxes of varying depths
- Makuri MAK-Trak liners to create a nested array of liners resistant to fine particle streaming
- A wide range of additional components to suit many other applications



MAK-BLOK Applications:

Gyratory crusher feed opening protection

The upper end of a gyratory crusher can be an ongoing source of problems. Spider arm guards and rim liners can be difficult to obtain, require long lead times and will often be subject to fitting problems due to the wide range of spiders in use.

Overly worn rim liners can wear down the upper concaves and displace locking pins – in severe cases, this can result in the upper row falling into the crusher.

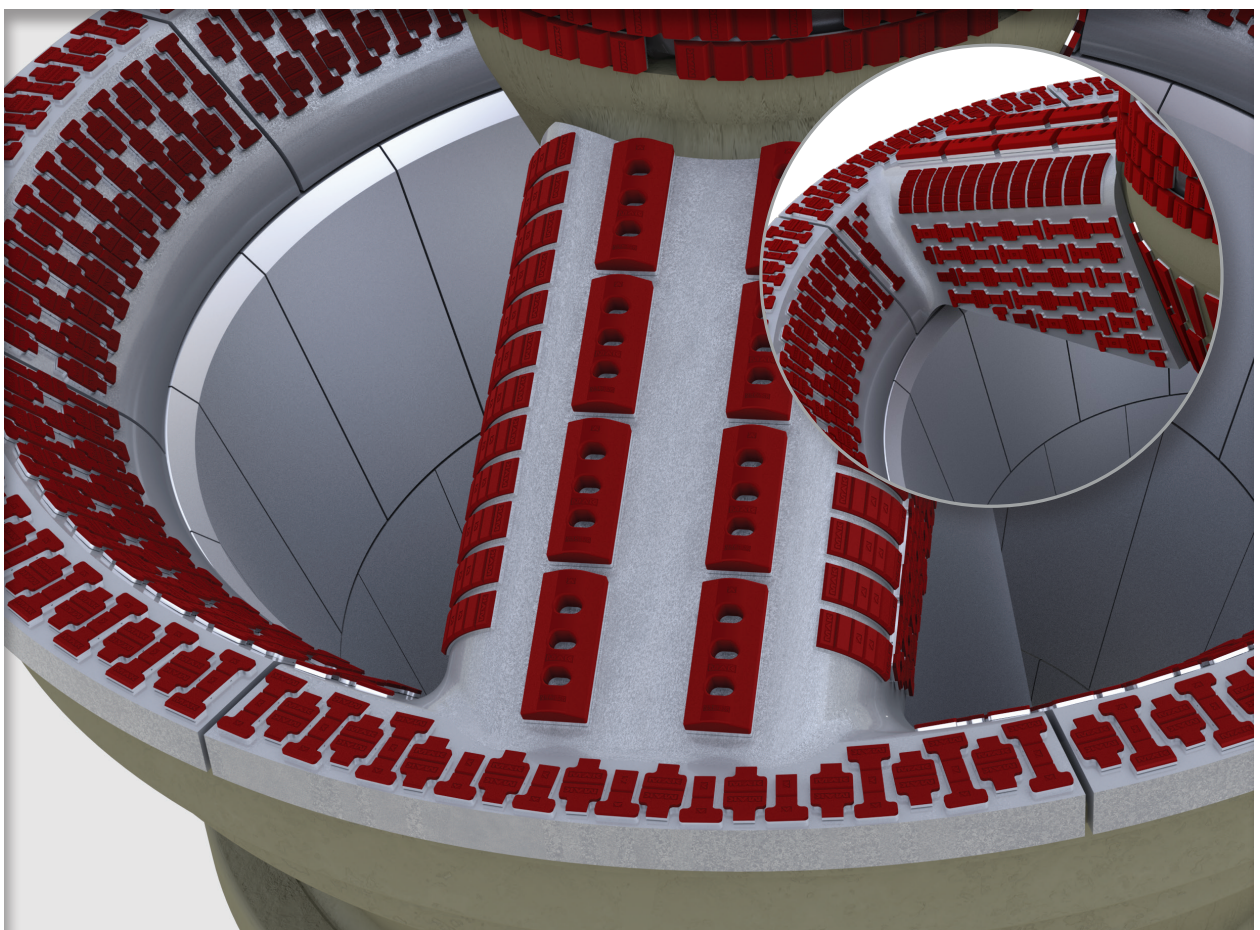
Makuri MAK-BLOKS offer a cost-effective, long life solution to wear issues on spider arm guards, rim liners, ledge liners and spider caps. Purpose-built and standard blocks are available that will often outlast cast manganese components many times over.

Common problems

- Lack of availability and long lead time on feed opening parts
- New liners often require site modifications to allow for proper fitment
- Abrasive wear on rim liners can damage upper concaves and lead to catastrophic, unplanned failures

Makuri solutions

- An extensive range of MAK-BLOKS, available at short lead time, that can be used to protect critical components
- Anti-streaming properties of MAK-TRAK blocks allow blocks to overlap in all directions, allowing for material build-up between liners and further protecting the topshell & spider
- Where required, Makuri can manufacture purpose-built MAK-BLOKS to allow for comprehensive coverage of feed opening wear components.



Feed hopper protection for cone crushers

Feed cones & feed hoppers are often manufactured from mild steel or fabricated from Q&T plate that will require regular replacement.

Unpredictable wear on feed cones or uneven buildup in hoppers can have a detrimental effect on crusher performance as the chamber will not fill symmetrically.

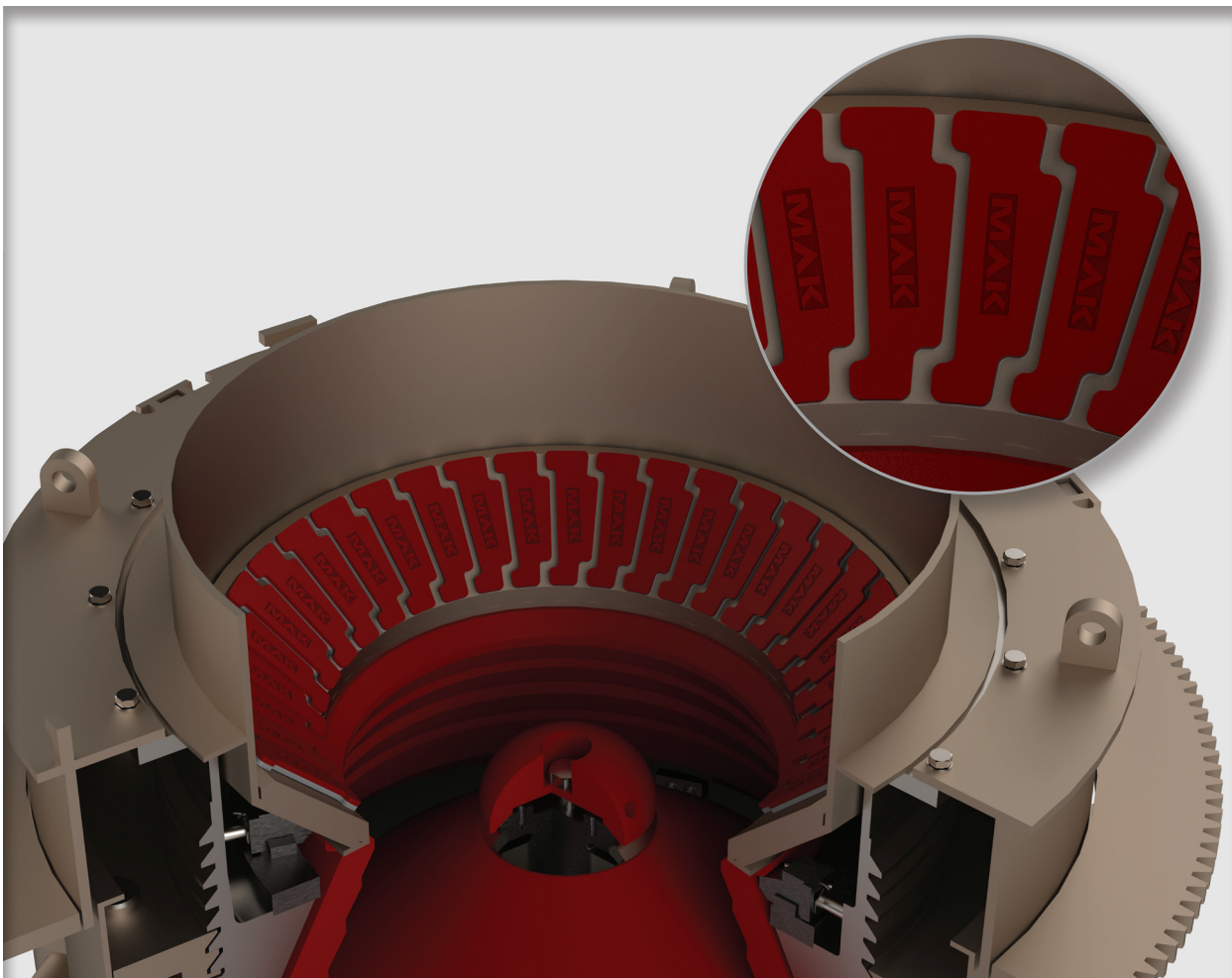
In addition to designing purpose-built feed assemblies for cone crushers, Makuri can supply feed cones cast from manganese steel, fitted with long life MAK-Bloks on the wearing surface. These can be designed to suit individual requirements and include features such as our anti-streaming design as standard.

Typical problems

- Hopper assembly above the crusher does not direct material centrally into the chamber
- Uneven wear on feed cones results in performance changing over time
- Ongoing cost to replace feed components

Makuri solutions

- Purpose-built, anti-streaming feed cone linings supplied as weld-on parts or assembled on a cast feed cone
- Site-specific feed hopper arrangements using MAK-Bloks as ledges & feed tubes to control feed presentation on tertiary crushers
- Bimetallic rock-boxed feed plates for high feed velocities



Makuri Forged Bimetallic Mainframe Liners

Properly designed mainframe liners should last many times longer than that of the crusher liners and should never need to be changed outside of a normal liner change shutdown.

The Problem

Mainframe liners are not a highly visible liner system and are often run to failure. These items are time consuming to remove and replace and the best longest life solution that can withstand both impact and extreme abrasion is required.

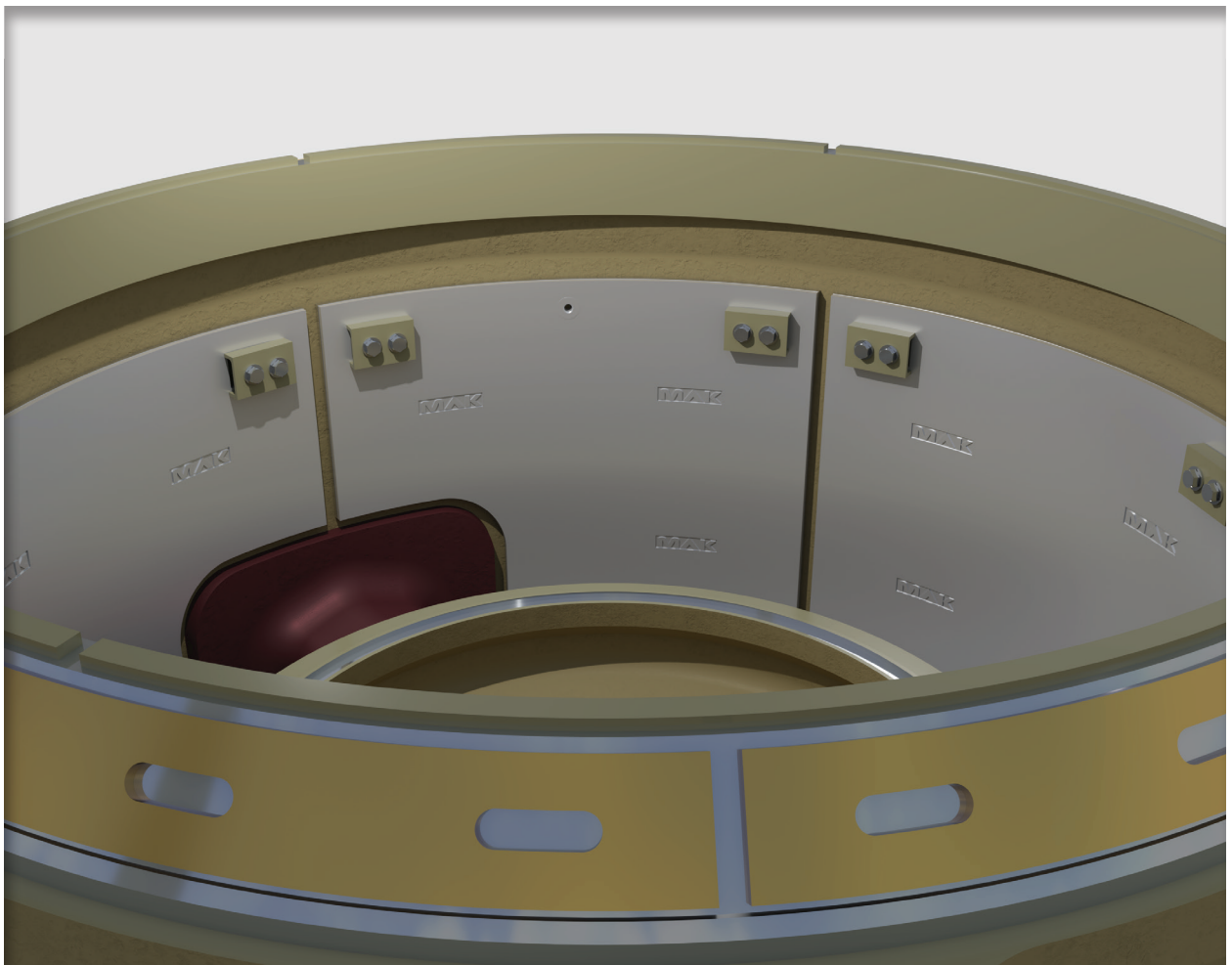
Holed out and failed liners can not only fall off into the crusher potentially blocking it and/or damage the receiving conveyor belt, but also allowing for wear and major damage of the crusher mainframe, which is difficult and costly to repair and must be done off line.

The Solution

Makuri MAK-HARD long life, low friction Forged Bimetallic wear liners will not only last many times longer but will also resist hang ups and blockages.

Often, mainframe liners will only exhibit a relatively small area of wear. This can result in high material wastage if the entire liner is replaced.

Makuri also offers weld-in and bolted mainframe liner inserts as a solution to this problem. Thickness, size and location of these can be modified to suit individual requirements to ensure lowest TCO is maintained.



SECTION 5

MAKURI Materials

Makuri cast and forged materials are made from the absolute best possible feed stocks and manufactured in new industry leading foundries that are committed to meeting and exceeding the highest levels for both safety, quality and environmental protection. This results in products that are renowned for their consistency, wear resistance and durability and also meeting or exceeding international health, safety and environmental standards.

- About manganese steels
- MAK-TUFF Cast Manganese Steels
- About alloy steels & white irons
- MAK-HARD XAB Wear-resistant alloys
- Gyrotrory Crusher Concave Manufacturing
- MAK-HARD XAB Bimetallic Wear Materials
- General Wear Comparisons



5

All About Manganese (Mn) Steel

Manganese steel was originally invented in 1882 by Sir Robert Hadfield and is widely regarded as the first commercially available high impact-resistant alloy. Its basic composition has been subject to minimal change since its commercial release and has been used in applications from army helmets to crusher liners. The material has been so successful because it is incredibly tough and pliable but will develop a thin work-hardened layer on the surface. This occurs due to movement of atoms at an atomic level on the material surface, resulting in the atoms re-stacking into a hardened layer which exhibits much higher wear resistance. The extent of this work hardening will be dependent on composition, heat treatment and method of loading.

A basic manganese steel can contain anywhere between 11-24% manganese and 0.7-1.45% carbon, although the primary international standard governing the material (ASTM A128) only covers manganese grades between 11 and 14%, with higher grades being proprietary to individual manufacturers. Adopting industry conventions and defining manganese grades as 14, 18 and 21% provides a simple point of reference, but can be deeply misleading. This is because manganese content on its own does not improve wear resistance.

Manganese simply acts as an austenite stabilizer and assists in keeping carbides within the grains of the

material, while the carbon content will determine both the work hardening rate and the final hardness of the work hardened layer. The consequence is that an 18% grade from one manufacturer may outperform a 21% grade from another. For maximum wear life, carbon content must be maximized relative to the manganese level and casting thickness used, without producing precipitated carbides at grain boundaries which will make the material extremely brittle.

A range of other elements including chrome, molybdenum, nickel, titanium, vanadium, and aluminium have been added to materials by various researchers & manufacturers over the years, with varying degrees of success and for a range of purposes. While some additions are included to act as grain refiners, others will be included to deoxidize the raw materials while others will be there to simply improve wear resistance. In general, addition of the above elements results in improvements in wear properties but have a detrimental effect on toughness and resilience.

Chrome and molybdenum would be the main exception to this rule, and Makuri uses varying levels of these in our standard grades to achieve the required properties. In general, chrome will improve wear resistance of the base material, reducing dependency on work hardening. Molybdenum produces a number of changes that result in better carbide absorption, increased tensile strength and improved toughness.



All About Manganese (Mn) Steel (Continued)

Adding other elements

Other elements, such as silicon, phosphorous and Sulphur are usually present in manganese steel, but are normally there as a by-product of the manufacturing process and don't improve performance. In many cases, excess levels of these elements will lead to a severe deterioration in the reliability of the finished product, and as such they are generally just specified with maximum values.

One element in particular, phosphorous, can seriously reduce the integrity of castings by creating a weak film between grains that will significantly reduce the structural strength. The ASTM standard specifies maximum phosphorous levels, but this can be difficult to control in practice as most manufacturers use scrap manganese steel from a range of sources.

Manufacturing factors such as the type of sand used in the moulds, melting practices, pouring temperatures, pouring methods and heat treatment all play a part in the quality of a final casting. While just about any foundry can melt a pot of steel with a composition compliant with ASTM standards, few can provide the necessary control over all of the above factors to produce a consistent product.

Makuri Technology, together with its foundry partner QSteel, has addressed all of the common problems that can occur in the manufacture of manganese steel to produce a product that outperforms both the OEMs and market leading aftermarket foundries.

Our standard material grades are tolerance within much tighter limits than ASTM and OEM standards, with world's best practice for maximum phosphorous levels

being used. The majority of our feedstock comes from clean, low-phosphorous sheet metal sourced from the automotive and whitegoods industry & the only scrap manganese we use comes from our own factory. Levels of chrome and molybdenum have been fine-tuned to maximise the desired properties while minimizing the detrimental issues that come with adding these materials if not controlled correctly. This provides a level of control that we have not encountered in any other manganese foundry worldwide.

The process controls in place at the foundry exceeds those used by competing manufacturers. These include multiple dye penetrant checks and microstructural examination of each and every casting. Pouring temperatures are maintained within tight limits and quenching is performed in purpose-built quenching baths that ensure the liners produced will provide maximum structural integrity with consistent wear performance between castings.



MAK-TUFF Cast Manganese Steels

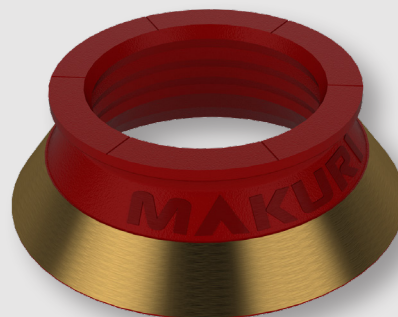
Adding other elements

The world's premium grades of manganese are now available with the correct quality, design and support at globally competitive pricing.

All MAK-TUFF materials have optimum levels of manganese, carbon and other elements alloyed to produce premium, high performance manganese steels in a variety of grades to suit specific applications.

This along with our proprietary heat treatment processes, produces unique steels of high toughness that can withstand impact, while their work hardening characteristics resist abrasion.

These properties make the liners suitable for use in the most demanding coarse ore, hard rock, loading, crushing and processing applications where extreme impact and abrasion occur along with tramp metal passage.



MAK-TUFF GRADE	Nominal Mn%	Chrome	Moly	Hard Rock Performance	Abrasive Rock Performance	Crack Resistance	Relative Cost Indicator
Mn1A	14%	•	•	1.0	1.0	1.0	1.00
Mn1B	14%	✓	•	1.0	1.1	0.9	1.05
Mn1C	14%	✓	✓	1.0	1.1	1.0	1.08
Mn2A	20%	•	•	1.2	1.2	0.9	1.08
Mn2B	20%	✓	•	1.2	1.3	0.8	1.10
Mn2C	20%	✓	✓	1.2	1.3	0.9	1.12
Mn3A	22%	•	•	1.4	1.4	0.8	1.12
Mn3B	22%	✓	•	1.4	1.5	0.7	1.14
Mn3C	22%	✓	✓	1.4	1.5	0.8	1.16
Mn4	23%	Unique Makuri crack-resistant grade		1.2	1.3	1.1	1.20

About Alloy Steels and White Irons

Alloy steels is a relatively broad term that normally refers to High Strength Low Alloy (HSLA) steels with less than 1% carbon and below 7% of other elements. Different compositions and heat treatments can be used to provide fine controls over mechanical properties such as strength, hardness, toughness, wear resistance and hardenability.

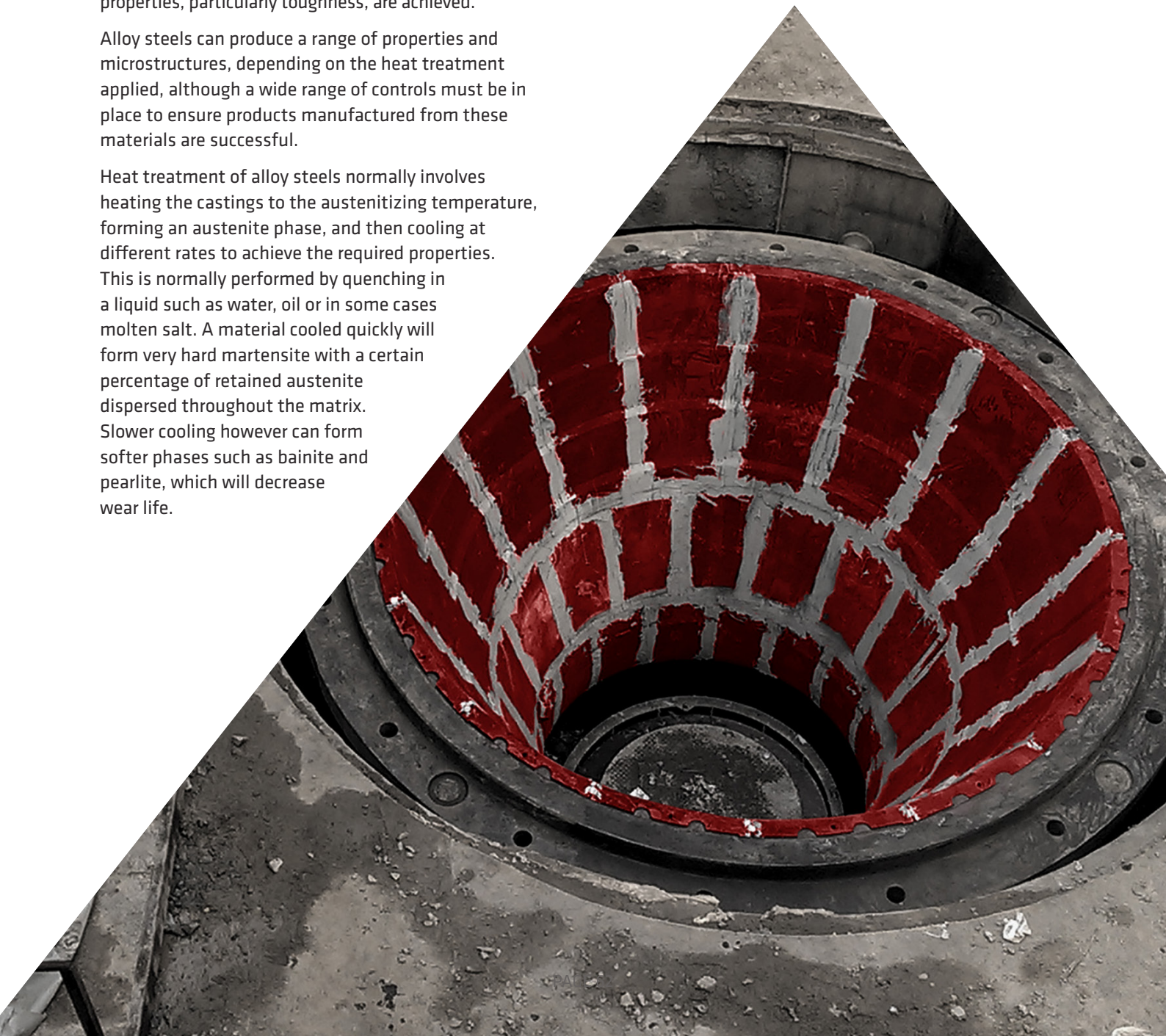
For the purposes of producing wear materials, the use of alloy steels tends to be focused on martensitic chrome moly and nickel chrome moly grades & the most common use is gyratory crusher concaves. Due to the extreme requirements of this application, our preference is to only use nickel chrome moly grades for these applications to ensure that the required mechanical properties, particularly toughness, are achieved.

Alloy steels can produce a range of properties and microstructures, depending on the heat treatment applied, although a wide range of controls must be in place to ensure products manufactured from these materials are successful.

Heat treatment of alloy steels normally involves heating the castings to the austenitizing temperature, forming an austenite phase, and then cooling at different rates to achieve the required properties. This is normally performed by quenching in a liquid such as water, oil or in some cases molten salt. A material cooled quickly will form very hard martensite with a certain percentage of retained austenite dispersed throughout the matrix. Slower cooling however can form softer phases such as bainite and pearlite, which will decrease wear life.

In cases where wear resistance is required, it is desirable to produce as much martensite as possible during the quenching phase to give the best possible hardness. This requires careful consideration of the quenching process to ensure that the material cools quickly enough throughout its full volume to achieve a full martensitic transformation.

We ensure the quality and performance of our cast products through the use of casting simulation software, extended soak times, specialized heat treatment cycles and thorough pre-production testing.



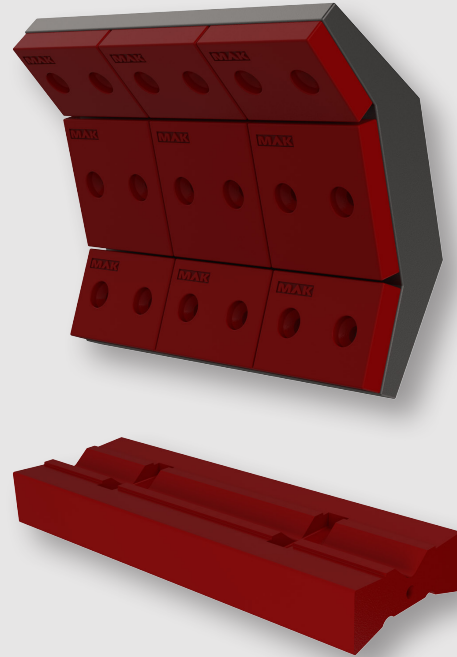
MAK-HARD Wear Resistant Alloys

Alloy Steels and White Irons

When it comes to wear-resistant alloys, one size definitely does not fit all. Composition and heat treatment need to be carefully considered to ensure that the required properties are achieved, and these requirements can vary between different castings made from the same base material grade.

Makuri offers a carefully selected range of wear-resistant alloys based on proven ASTM and EN standards. World-leading quality control procedures provide chemical and microstructural tests for each and every casting produced, and composition is carefully determined to provide the desired balance between hardness and toughness.

An example of our range covering critical applications is shown below.



Material Code	Description	Abrasion Resistance	Impact Resistance	Typical Applications
Mn1A	14% Manganese Steel (reference)	3	10	Crusher Liners
XAB1	15-18% Chrome White Iron	6	8	MAK-BLOKS
XAB2	15-18% Chrome White Iron	7	9	HSI Blow Bars and Impact Plates
XAB3	23-28% High Chrome White Iron	8	7	SAG Mill Feed Chutes
XAB4	23-28% High Chrome White Iron	9	5	Vertmills
XAB5	Reinforced high chrome white iron For gyratory concave applications	9	7	Lower Concave Rows Very high wear applications
XAB6	High Strength, Low Alloy Steel High abrasion resistance grade	4	9	Middle and lower concave rows
XAB7	High Strength, Low Alloy Steel High abrasion resistance grade	5	8	Lower concave rows

Material performance and application data is indicative only and subject to change. Individual factors such as casting shape and size, duty and quantity requirements will affect final specifications

Gyratory Crusher Concave Manufacture

Air Quenching vs Liquid Quenching

Concaves can be manufactured via both air quenching or liquid quenching processes. Air quenching involves allowing the casting to cool in air, often using a series of fans to accelerate the process, while liquid quenching involves immersing the casting into a quenching medium such as oil or water.

Air quenching is often used by low-cost foundries for manufacturing gyratory crusher concaves, as it is a simpler process. However, it results in a casting that has a hard outer casing, but poor through-hardening. These castings are often sold based on their initial outer hardness, with most end users being unaware of what lies beneath the surface. In general, air quenched castings are not tempered. While this reduces the overall manufacturing cost, it can lead to cracking problems during service as a result of residual stress.

Liquid quenching results in a full martensitic transformation through the casting, leading to more consistent hardness throughout. Once a martensitic

casting has been liquid quenched, tempering is often required to relieve internal stresses, which reduces overall hardness and increases toughness.

Producing a successful through-hardened casting is a complex process and one that requires careful consideration. Issues such as material composition ranges, proper quenching facilities & practices, proper tempering practices and controls must be carefully managed. This level of control is often outside the capabilities of many foundries and outside of the cost structure required to produce lower cost products.

Given the critical nature of the applications these products are used in, Makuri has decided to focus on quality and consistency rather than cost. This ensures that customers obtain lowest Total Cost of Ownership through improved reliability and longevity, even though initial cost may be higher than cheaper alternatives.

Material	Application			Typical Hardness (BHN)	Relative Life	Crack Hardness	Relative Cost
	TOP ROW	MIDDLE ROW	BOTTOM ROW				
MAK-TUFF Mn3A	X	X	X	400-450 ¹	1.0	1.0	1.0
MAK-TUFF XAB6		X	X	440-480	1.5	0.8	1.5
MAK-TUFF XAB7			X	500-540	2.0	0.7	1.7
MAK-TUFF XAB5			X	600+	2.5	0.5	2.0

Material	Advantages	Disadvantages
MAK-TUFF Mn3A	More able to withstand tramp events, including shovel teeth and adapters	Manganese growth in operation can cause concaves to become dislodged unless trimmed
MAK-TUFF XAB6	- Cracked liners usually don't fall out - Doesn't rely on work hardening for wear resistance - High impact resistance	Requires high quality welding for lifting lugs
MAK-TUFF XAB7	- Cracked liners usually don't fall out - Doesn't rely on work hardening for wear resistance - Very good wear resistance & good impact resistance	Requires high quality welding for lifting lugs
MAK-TUFF XAB5	Long life where tramp metal can be controlled	- Prone to cracking from tramp events - Cracks propagate in multiple directions, leading to pieces falling out - Unable to weld on lifting lugs

MAK-Hard XAB Bimetallic Wear Materials

First there was Q&T plates, then there was weld overlay plates, now there are bimetallic cast and forged wear plates.

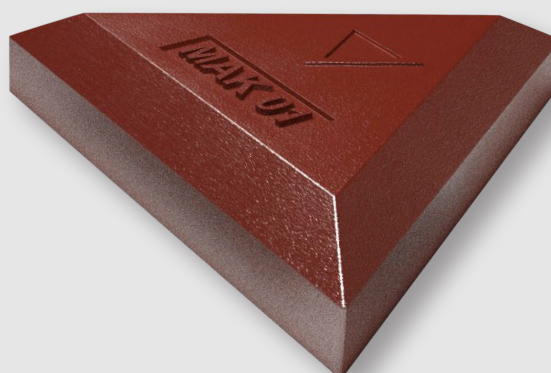
Quenched and Tempered plates are regarded as the universal, all-purpose wear plate but rarely exhibit lowest Total Cost of Ownership. They are low cost and able to resist both moderate abrasion and impact ,but are limited to around 500 BHN maximum hardness before cracking becomes a problem. The 400-450 grades have now become the benchmark for these types of steel in impact and abrasion conditions. These are often used as both the structural and the wear member in assemblies, making for lighter weight. However, once the structural integrity is compromised they become economically unrepairable and a throw-away item with poor Total Cost of Ownership metrics.

Weld overlay plates typically have a higher surface hardness and consist mostly of chrome carbide hard-facing wire welded in various layers onto a mild steel backing plate. Prone to heat shrinkage cracking and delamination of the weld overlay from the backing plate and especially the upper layers in thicker overlay sections. They have typically higher abrasion but less impact resistance.

MAK-HARD eXtreme ABrasion resistant (XAB) wear materials are a new generation of advanced bimetallic technologies with significant benefits over both Q&T and weld overlay plates as they withstand both extreme impact and abrasion.

They are a high carbon, high chrome and high exotic alloy content which allow resistance to both extreme abrasion and extreme impact conditions and is has little to no stress cracking and no porosity.

They comprise different grades of XAB wear materials; Cast bonded or Forged bonded onto a selected steel backing plate.



Material	Hardness (HRC)	Max Available Thickness	Abrasion Resistance	Impact Resistance	Applications
Q&T 400 Plate	43	50	1	10	General, less critical applications
Chromium carbide Weld overlay plate	57	17	4	6	General purpose, higher wear applications
Makuri XAB1 Cast Bimetallic	63	150	6	8	Extreme abrasion and impact applications
Makuri XAB8 Forged Bimetallic	60	20	5	8	General purpose, higher wear applications
Makuri XAB9 Forged Bimetallic	63	20	6	8	Heavy duty, higher wear applications

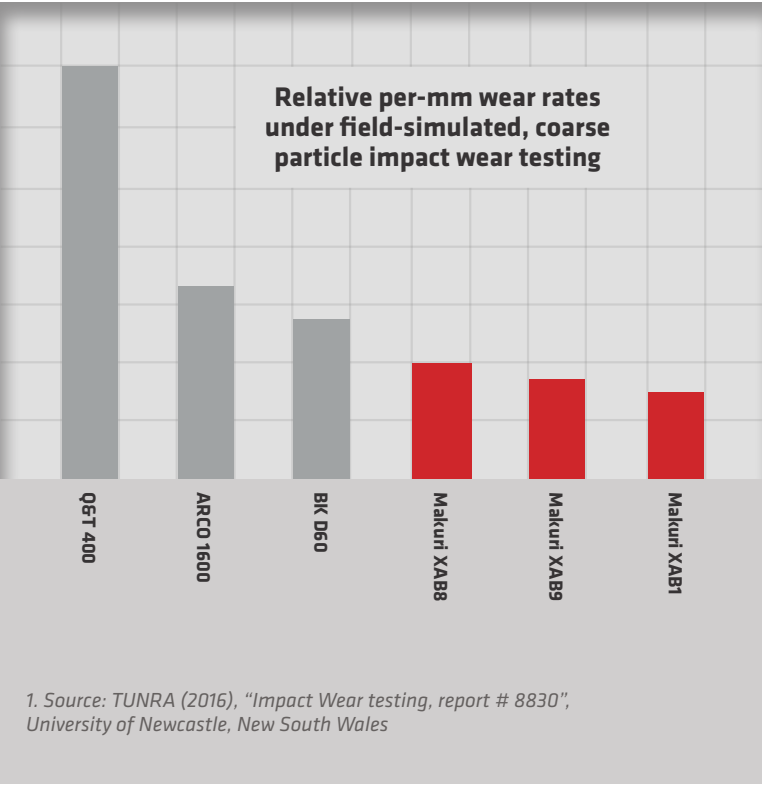
General Wear Rate Comparisons

The following test results were performed under field simulated, coarse particle impact wear testing conducted by TUNRA¹.

Coarse particle impact wear testing

This is a purpose-built test developed by the TUNRA laboratories at the University of Newcastle and is intended to provide a more realistic indication of wear performance than standard ASTM-G65 wear tests, which can underestimate wear rates in real chute lining applications. It is Makuri's preferred method of wear rate testing and conforms relatively well to site observations.

As can be seen, Makuri materials significantly outlast common materials such as quenched and tempered plate, but also industry standard clad plates. There is a common misconception that the difference between various clad plates is relatively minor, although our independent test results show that this is not the case. Makuri wear products can outlast competing product by 2-7x, providing the lowest Cost of Ownership in every case.

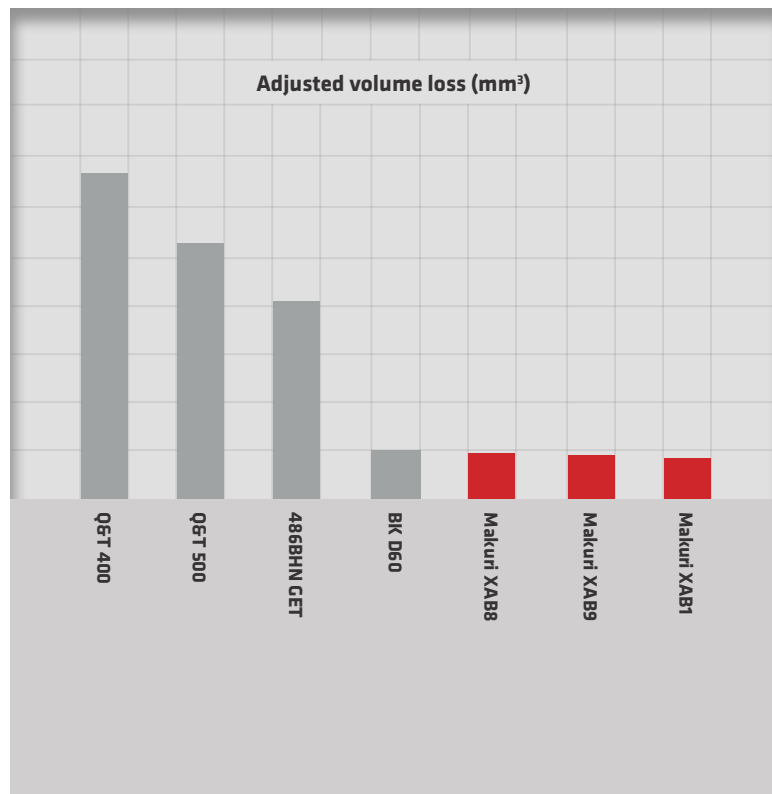


The following test results were performed under field simulated, coarse particle impact wear testing conducted by ASTM G-65¹.

Standardised fine particle abrasion tests

ASTM G-65 tests are often used as a benchmark for wear life, although they often don't accurately reflect site conditions. The tests are performed by dragging fine abrasives across the wear surface with a rubber wheel, but do not take into account factors site factors such as incident angle, material velocity, impact energy, cohesion and particle shape. All of these factors have an effect on wear life.

Regardless of the above limitations, Makuri products still outlast the competition under fine particle abrasion testing. However, wherever possible, wear performance should be compared using coarse particle impact tests or real site testing for greatest accuracy.



SECTION 6

Machine Parts

Makuri specializes in components where we add value through improved designs and by exceeding normal OEM specifications

In addition, our manufacturing capabilities allow us to focus on items which are:

- Difficult to manufacture;
- Have long lead times from the OEM; and
- Are often subject to supply shortages.

Makuri's aim is to assist in reducing Total Cost of Ownership for critical spare parts rather than offering complete range of spares that are more readily available

- MP1000 Case Study
- Cone Crusher Parts
- Gyratory Crusher Parts
- Jaw Crusher Parts
- Visual Example of Parts



6

MP1000 Case Study

MP1000 crushers are well known for their high tonnage capacity and will produce crushed product at or near their rated load 24/7 without issues when operated correctly. Consumables such as wear liners are always going to require replacement eventually, but structural components such as heads are not generally regarded as consumable items. On these machines however, cracking in the head can be a source of ongoing frustration and lead to unplanned downtime.

It is normally uneconomical to repair these components as the cost of doing so often outweighs the cost of replacement. To further compound issues, there are very few manufacturers worldwide able to manufacture these parts reliably. This results in very long lead times on new components, forcing users to resort to expensive repairs that are unlikely to provide similar life to a new item.

In keeping with our core values of providing lowest Total Cost of Ownership, Makuri made a decision to not just supply copy parts that would perform in the same manner but instead produce a superior product that would be expected to run for longer. To achieve this, our engineering team analysed cracking issues on a wide range of failed heads

and implemented changes to reduce these problems. These included increasing thicknesses in problem areas, removing stress raisers and upgrading finishing requirements in several areas.

Process control at the manufacturing stage was taken to a level above and beyond anything which Makuri has needed to do in the past. Extensive controls were put in place covering all the usual parameters, but also added checks such as solidification simulations and mould design, multiple levels of NDT tests and independent dimensional checking of both the mould and the finished components.

The initial batch of two heads was manufactured for a large gold and copper mine and completed within the requested lead time which was less than a third of what the major manufacturers were able to achieve. Subsequent deliveries can be accomplished much quicker as initial patterns are now made and verified.

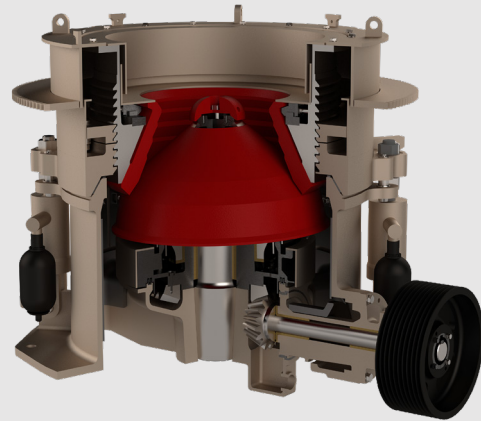
The result of this project is a high-quality product that exceeds OEM specifications & one that Makuri can proudly call its own. Following successful validation of these components, Makuri looks forward to extending the range to other machines with similar problems, all manufactured to the same high standards.



Component Guide

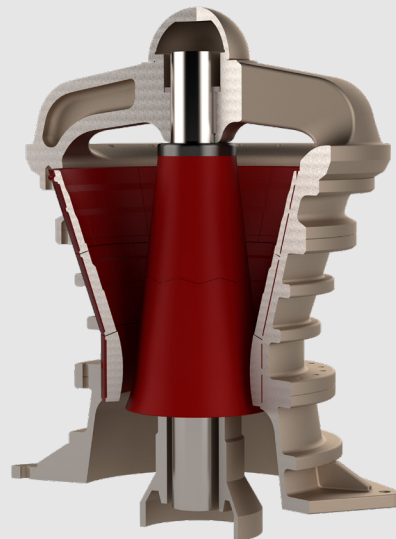
Cone Crusher Parts

- Heads
- Bowls
- Adjustment rings
- Bushes
- Shafts
- Eccentric & mainframes
- Mainframe liners
- Arm guards and countershaft guards
- Mainshafts
- countershaft and Pinion Assemblies



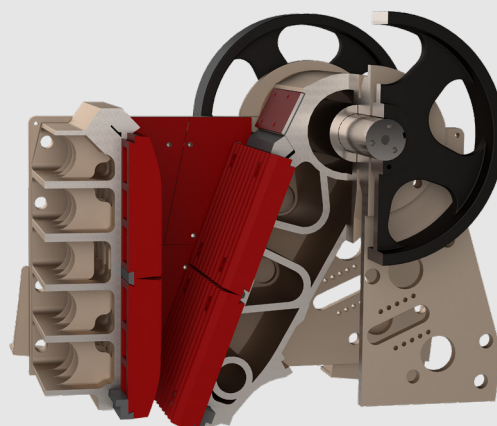
Gyratory Crusher Parts

- Mainshafts
- Spider arms
- Spider bushes
- Eccentric bushes
- Bevel gears and pinions
- Spider and crusher shells
- Rim liners and spider caps
- Vault liners

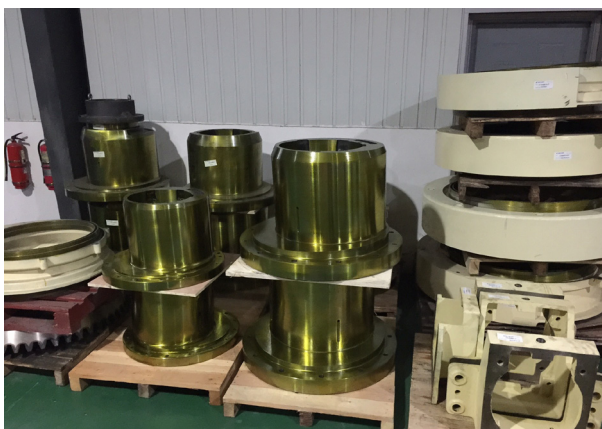
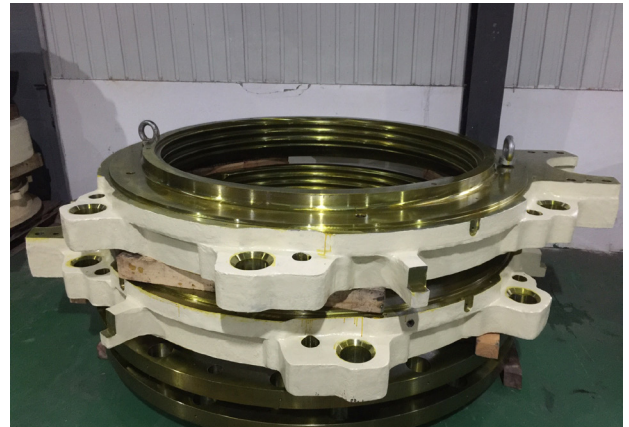
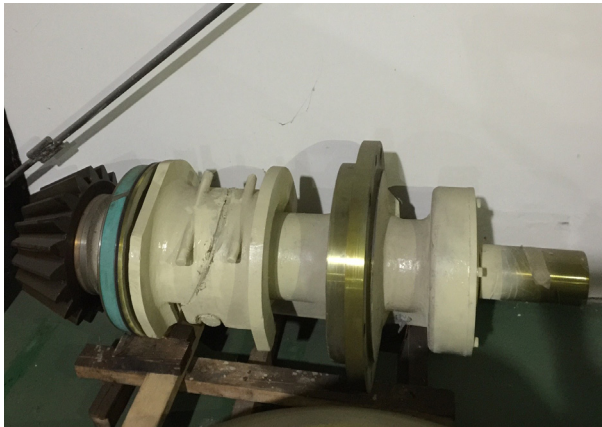
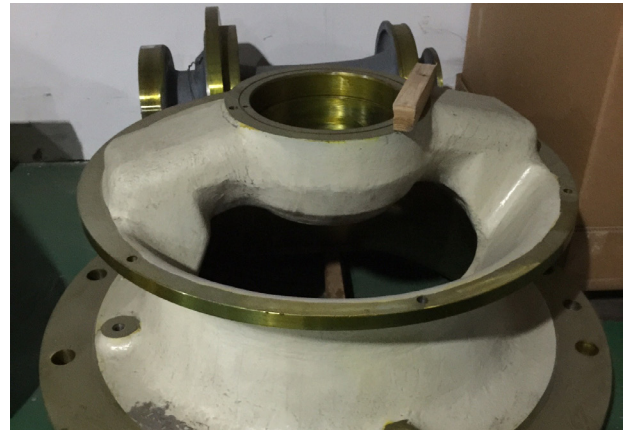
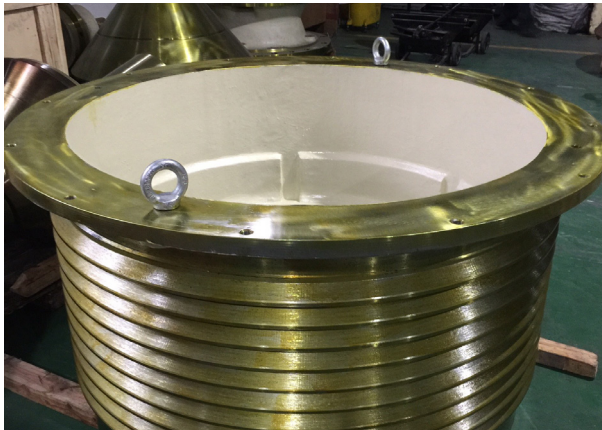


Jaw Crusher Parts

- Jaws
- Cheek plates
- Bash plates
- Pullback rods
- Flywheels
- Pitmans
- Jawstocks
- Toggle plates
- Toggle seats
- Eccentric shafts



Visual Example of Parts



SECTION 7

Disclaimer & Legal Statements



Disclaimer & Legal Statements

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on our website www.makuritech.com**



Extracting Maximum Asset Value

- Your purpose is to extract the maximum mineral value.
- Our purpose is to partner with you to extract maximum front end asset value.
- Fully optimizing installed assets should be considered before spending capital to increase plant performance.
- We focus on the, often ignored but still critical, process front end up to the SAG feed chutes including all crushing assets in the system.
- We understand the need to extract maximum asset value for all stakeholders.



MAKURI
TECHNOLOGY

Your safe partners in delivering; measurable, sustainable and responsible reductions in the Total Cost of Ownership of process front end assets.



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