

## **Mining and Machinery**

Services and Solutions

# Welcome

BMT has an unequalled reputation for designing bulk materials handling systems that perform; and for solving the more difficult and challenging problems often associated with current and next-generation mining machinery.

Over the past 20 years, BMT has created inspiring engineering solutions that exceed customer expectations. Our unique passion drives our capability to innovate and our thirst for knowledge gives our specialist teams the ability to maintain a reputation for producing world class results.

Mining plays an important role in supporting living standards for both developed and developing nations. Not just by providing access to affordable energy sources but also the critical materials found in everything from smartphones and PCs to cars and household appliances. Extracting these resources safely and cost effectively is therefore vital to global prosperity.

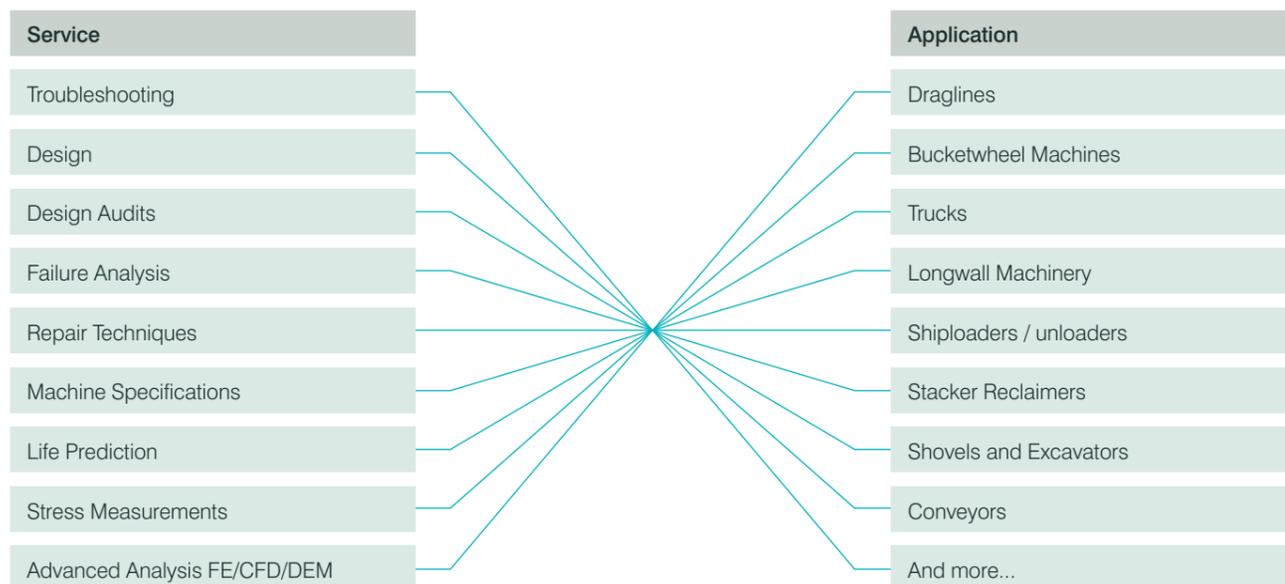
Successful mining operations depend on high-productivity machines and, in an industry with a long heritage of innovation, these are constantly evolving. Yet adopting new machines and

systems brings challenges. As a company with a worldwide reputation in both mining and minerals-processing machinery and bulk materials handling systems, BMT is strongly positioned to help our customers address them.

Mining companies need to carefully specify and design their new systems in order to minimise reliability problems; and we can support this process with our wide range of specialist services (see diagram below). Customers also need any mechanical, structural or electrical reliability issues identified and addressed. BMT

helps mining companies do this effectively, without the need for a trial and error approach to design modifications.

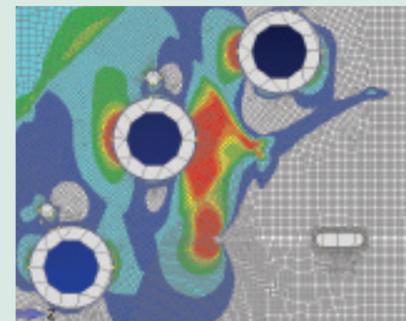
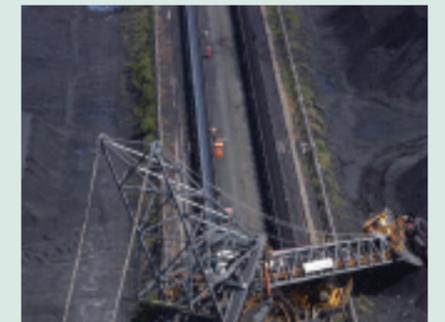
BMT is particularly well known for designing novel bulk materials handling systems; and for solving the more difficult and challenging problems often associated with next-generation larger mining machinery. Globally, BMT is a leading international multi-disciplinary engineering, science and technology consultancy offering a broad range of services and high-value solutions.



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## Specifications and Design Audits of Machines and Systems

Mining companies around the world constantly strive to improve productivity by investing in innovative and complex mining machines and systems. BMT assists mining companies in maximising the reliability of these new systems, by preparing and contributing to detailed technical specifications and by auditing the designs of new machines prior to construction.

### Specification

We advise clients on the essential requirements for planning and implementing the audit, to ensure the process delivers achievable benefits, without undue impact on cost or benefits or program. In particular, we specialise in writing concise technical specifications to define the standards against which the machine is to be audited and the procedural rules for conducting the audit.

### Design Audits

A world leader in auditing the design of large and complex machinery, BMT has completed audits on a range of major machines for customers in many countries throughout Africa, Asia, North and South America as well as Australia.

Specialising in fast track audits, we can deliver: improved safety; extended life of structure and machinery; verification of conformance with specification and; identification of operational risks.

### Stackers and Reclaimer Audit

BMT audited the design of stackers and a reclaimer for a project in Western Australia. Our audit identified non-compliances to Australian standards and inconsistencies between the design

calculations and drawings. As a result, structural changes were required, as well as additional fatigue assessments and an increase in safety factors for certain items.

### Dragline Purchase

Draglines provide essential stripping capacity at open cut coal mines. Being high capital plant (~ AUD200M) it is crucial they perform reliably for the life of the mine. BMT assisted a major mining company with the preparation of the technical specification for the purchase of a new machine. After the order was placed on the successful bidder, BMT audited the design against the requirements of the specification and non-complying aspects of the design were corrected before construction was complete.

## Machine Design

BMT provides a complete design capability for new bulk handling systems, and related machines such as stacker-reclaimers. We also have extensive experience in re-designing and re-engineering existing machines to extend service life and to improve reliability.

Whatever the application, we have the expertise to integrate all of the required skills to develop a cost-effective machine for the task. Whether a customer requires the management of an entire process or assistance with particular aspects, BMT delivers from concept development, through detail design, manufacture and installation, to final commissioning.

### A complete integrated service

BMT has in-house capabilities in all design related disciplines including:

- Mechanical
- Structural
- Control systems, PLCs
- Electrical
- Fluid power hydraulics



### Conveyor Design, Loy Yang Mine – Conveyor L310

Loy Yang Mine in Victoria's Latrobe Valley, Australia required a new trunk conveyor for its long term mine development. State of the art, variable speed drives were used for the first time, together with modular electrical switch rooms. BMT's methodology provided special design

features which improved conveyor availability and reliability and reduced the risks associated with breakdown and disruptions in coal supply to a power station. On completion of the concept, BMT commenced detailed mechanical, structural and electrical design.



## Problem Solving / Troubleshooting, Test and Measurement

In relation to mining and bulk handling machinery BMT has unique capabilities in terms of being able to diagnose problems and early failures by recording critical parameters such as loads, stresses and hydraulic pressures during operation. The effects of real-world operation, the actual operating environment and various operating styles can be captured and design-office assumptions eliminated.



### Machinery Problem Diagnostics

BMT has a very comprehensive range of sophisticated instrumentation and recording equipment for measuring critical parameters such as loads, stresses and hydraulic pressures. Measurements of this kind often provide the key to diagnosing the cause of mining machinery problems or failures. Moreover they provide the best possible basis for re-engineering to fix a problem. BMT has long experience in designing custom transducers to measure machine behavior when suitable off-the-shelf transducers do not exist.

### Performance, Safety and Design Verification Testing

For mining companies wishing to verify the performance, safety or design of new or existing machines we provide performance and design verification testing independent of OEMs.

### Vibration Monitoring

Advice, interpretation, hardware or software supply, or total program management, for the more complex and difficult vibration problems, BMT provides powerful multi-channel measurement and analysis to identify the source of problems and their solutions.

### Long Term On-line Monitoring, Data Logging

For problems which only occur intermittently, and for capturing long term trends, BMT provides on-line monitoring instrumentation, coupled to data loggers programmed for the specific requirements of each machine or system problem.

### Remote Interrogation

For critical items of equipment, a low cost communication link to a site or to one of BMT's offices allows rapid, effective interrogation and very cost effective management of a condition monitoring program.

### Testing of Rotating Machines

BMT specialises in measurement of torque, stress and vibration on rotating machines, using radio telemetry links to transmit the measurement data to a recording station. To understand machine performance, it is often useful to quantify real torque levels rather than rely on damped electrical signals.



### Dragline Boom Cracking

A dragline in Australia suffered premature cracking in the boom structure. There were a range of causal theories, including the possibility of wind-induced vibration. BMT carried out extensive stress measurements under a range of operating conditions, and established that the cause was a combination of operating loads and the detailed design of joints.

### PULSE TerraMetrix for Rope Shovels and Draglines

PULSE TerraMetrix Systems for Rope Shovels and Draglines provide a range of options for logging of payload, machine health, and production information to optimise machine productivity.

### Longwall Roof Supports

The leg cylinders in a particular longwall installation suffered from numerous and early failures of the internal wear bands, requiring replacement of a large number of cylinders. BMT measured operating loads and stresses in operation and gained insight to the loading conditions which were responsible for the failures. The understanding gained led to a revision of the cylinder design.



## Special Purpose Machines

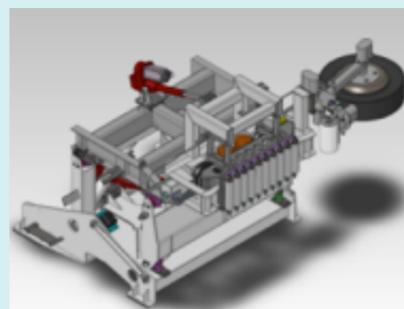
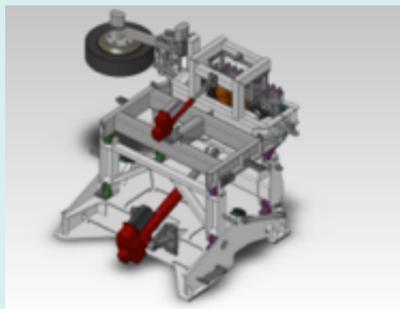
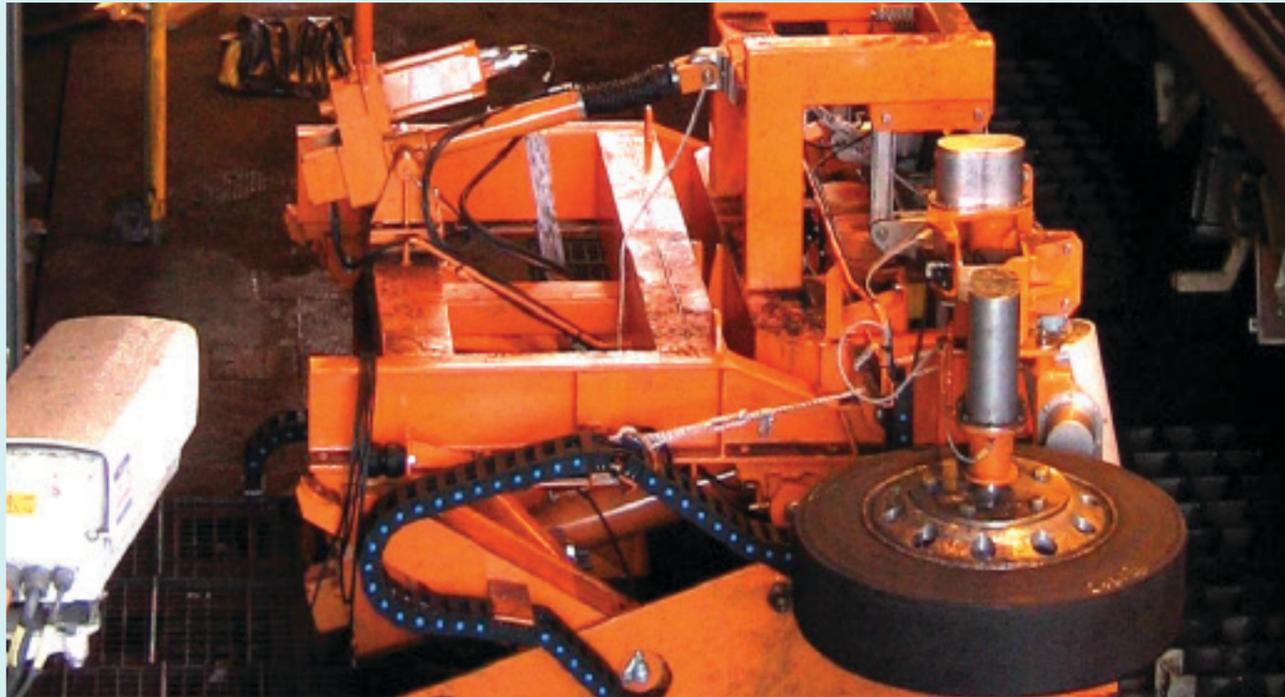
BMT has designed many 'special purpose' and automated machines for customers with specific requirements. These include the design and production of robotic wagon vibrators for releasing coal from bottom dump rail wagons to portable, numerically controlled grinders for removing high loads from dragline roller circles.

### Robotic Wagon Vibrator

Many high-capacity coal export terminals, which receive coal by rail in bottom-dump wagons, experience major delays due to discharge failure when handling sticky coal. These delays can have a serious impact on the capacity of the rail system feeding the port and on the terminal inloading capacity. To address this problem, BMT has developed a fully automatic robotic wagon vibrator.

Vibrators are installed in a dump station, at fixed locations adjacent to the track. As the wagons roll past, the vibrator lands on and tracks the lower sill of each wagon, retracting automatically at the wagon end. Failure of the coal to discharge when the bottom dump doors are opened is detected automatically, activating the vibrator, which dislodges the coal.

Use of the robotic vibrator brings significant benefits to coal terminal inload operations by reducing unloading delays, increasing throughput, reducing manning levels, improving safety, as well as eliminating possible structural damage to the wagons themselves.



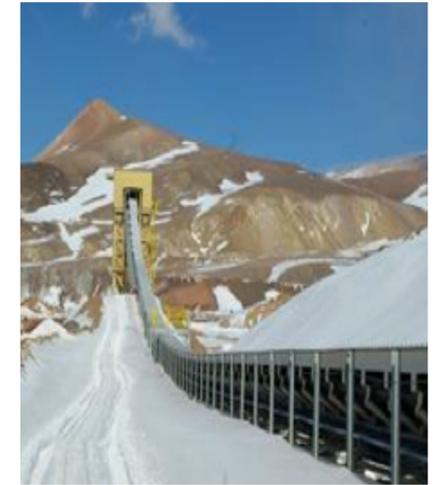
## Bulk Materials Handling Engineering

For many years BMT has been helping customers to optimise the performance of bulk material handling equipment. This includes bucket-wheel excavators, stackers, reclaimers, shiploaders, ship unloaders, conveyors and conveying systems, mills, crushers, screens, draglines and mining shovels. Our experts offer a complete service from initial investigations and design of machinery to project management, specialist electrical services, procurement and technical support.

### System Design

BMT designs highly efficient material handling systems for both mines and ports. Our experienced experts provide a comprehensive range of specialist studies and design services from concept development to fully detailed design. An addition to this BMT has specialised material handling system capabilities to assess performance, reliability and maintainability, access and system flexibility. We also can assist with capital and operating estimation, lifecycle cost estimation, system control philosophy design and system simulation and modelling.

BMT uses specialist design tools to undertake finite element analysis, computational fluid dynamics, discrete particle modelling, fatigue and conveyor analysis. Our experts provide an efficient and reliable assessment of problems, supported by software specially developed in-house to carry out complex, state-of-the-art analysis for conveyor dynamics. We are involved with both the industrial and commercial aspects of port equipment from shiploaders and unloaders to grab cranes and passenger gangways. From design to advice, BMT offers quality engineering services that benefit day-to-day, short-term and long-term operations.



### Concept and Materials Handling Design, Abbot Point, Queensland, Australia

The expected yearly output of 70Mtpa of product coal from Carmichael, mostly for export to India for use in power generation, should make the Carmichael/Abbot Point project the single largest contributor to coal exports in Australia. BMT oversaw all facets of the project governance including project management, lead technical input, and design supervision of a team of client appointed engineers and drafting resources based in India. BMT was awarded the detailed engineering design phase of the Adani Abbot Point T0 Expansion project.



### Mine Expansion Prefeasibility Study Indonesia

BMT was commissioned to complete a prefeasibility study to assess the commercial, technical and environmental viability of a mine expansion project in Indonesia. With reserves partly under the sea, it will require open cut mining in water immediately adjacent to existing mining operations. This raises many technical challenges with regard to protecting the operation from the sea, as well as water management issues within the working pit. On completion of the study, the client was armed with a basis for making its future business decisions and a road map to develop the opportunity further.



## Project Engineering Services

From project inception, through concept development, feasibility studies, financial projection, design procurement, contract administration, construction, commission to completion – BMT provides total project management for any project.

### Project Management

Procurement and Expediting In the purchasing of technically complex equipment, BMT assists customers in obtaining a better outcome in terms of cost and delivery, while meeting required quality standards.

### Quality Assurance, Inspection

With a long history of equipment failure investigations and in subsequent re-engineering, BMT is uniquely positioned to assist customers acquiring new or replacement machine components of better or guaranteed quality.

BMT writes detailed technical specifications, inspection and test plans and provides independent inspections to achieve the required product quality.

### Commissioning

Specialists in structural, mechanical, electrical, or automatic controls are available to manage or assist with the commissioning of complex machines or machine systems.

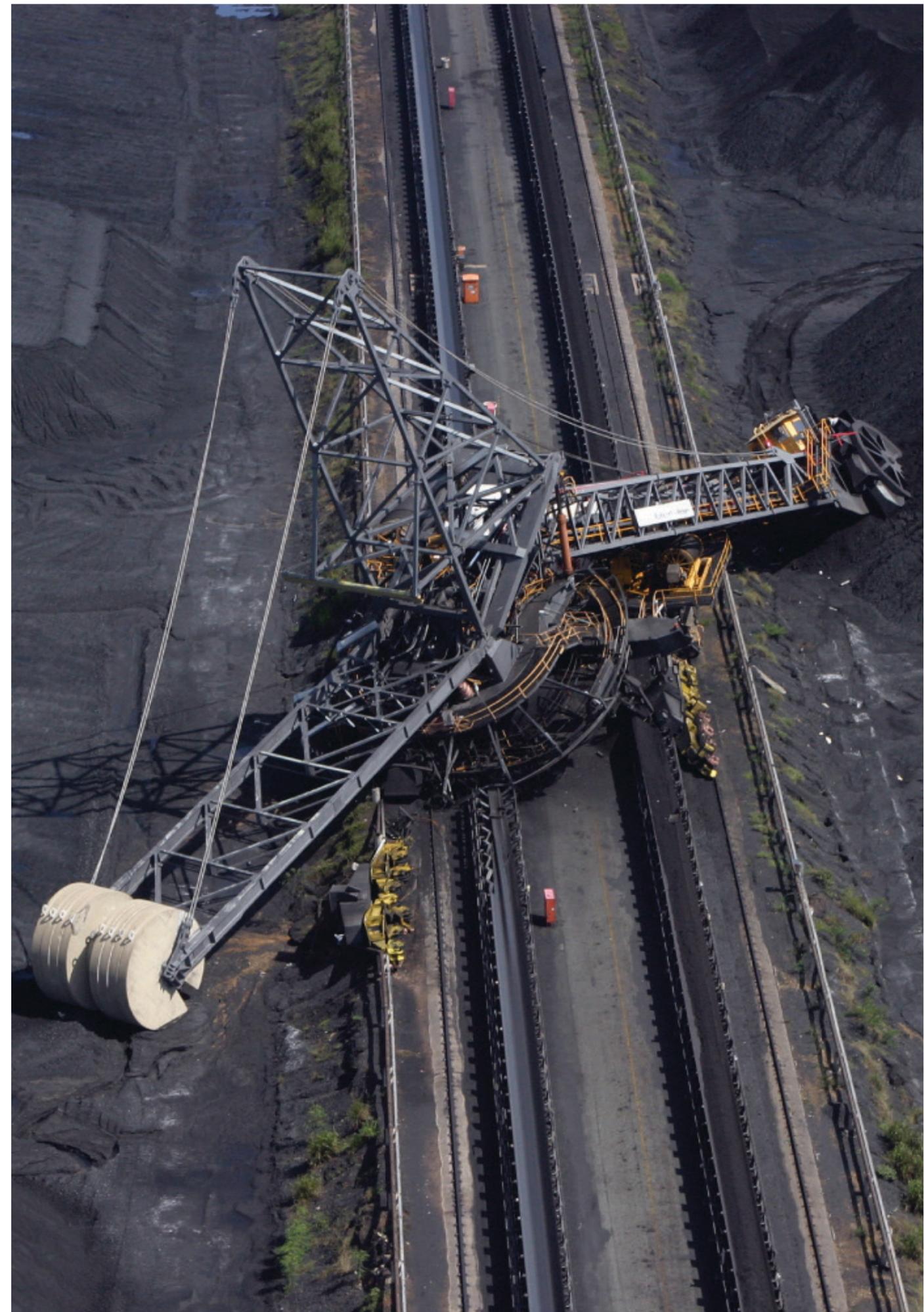
### Accident Investigation, Failure Analysis

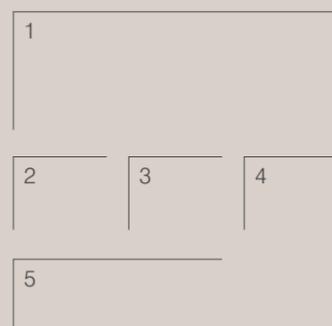
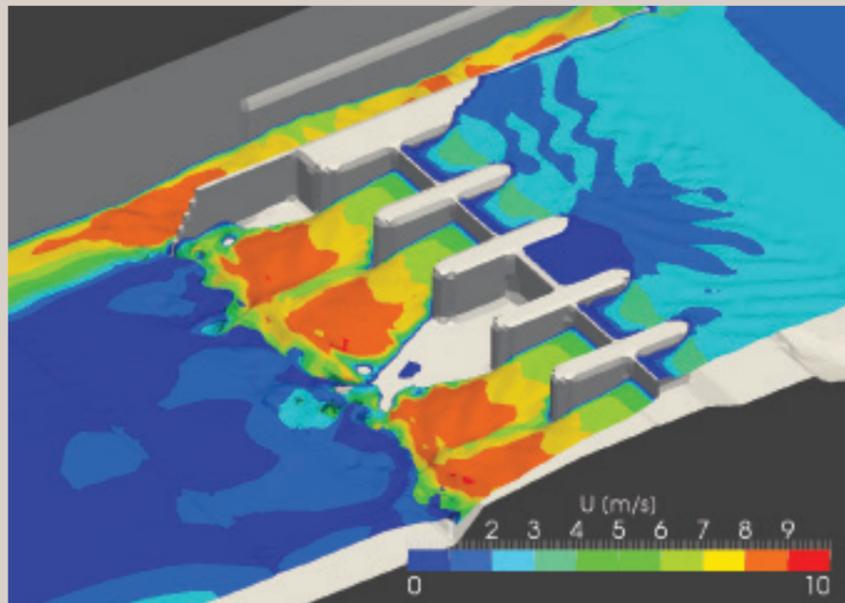
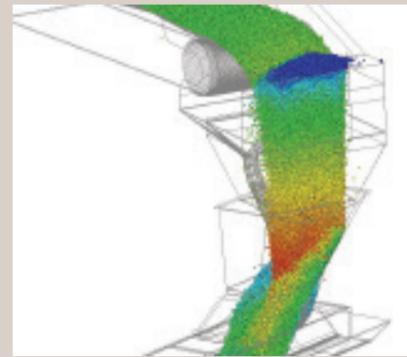
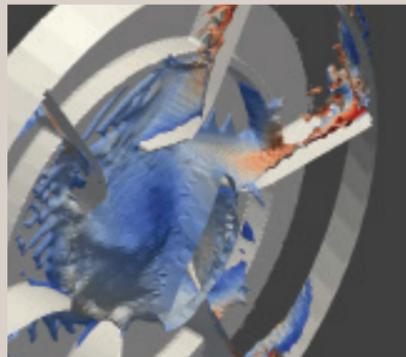
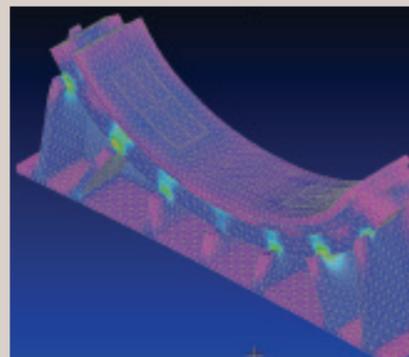
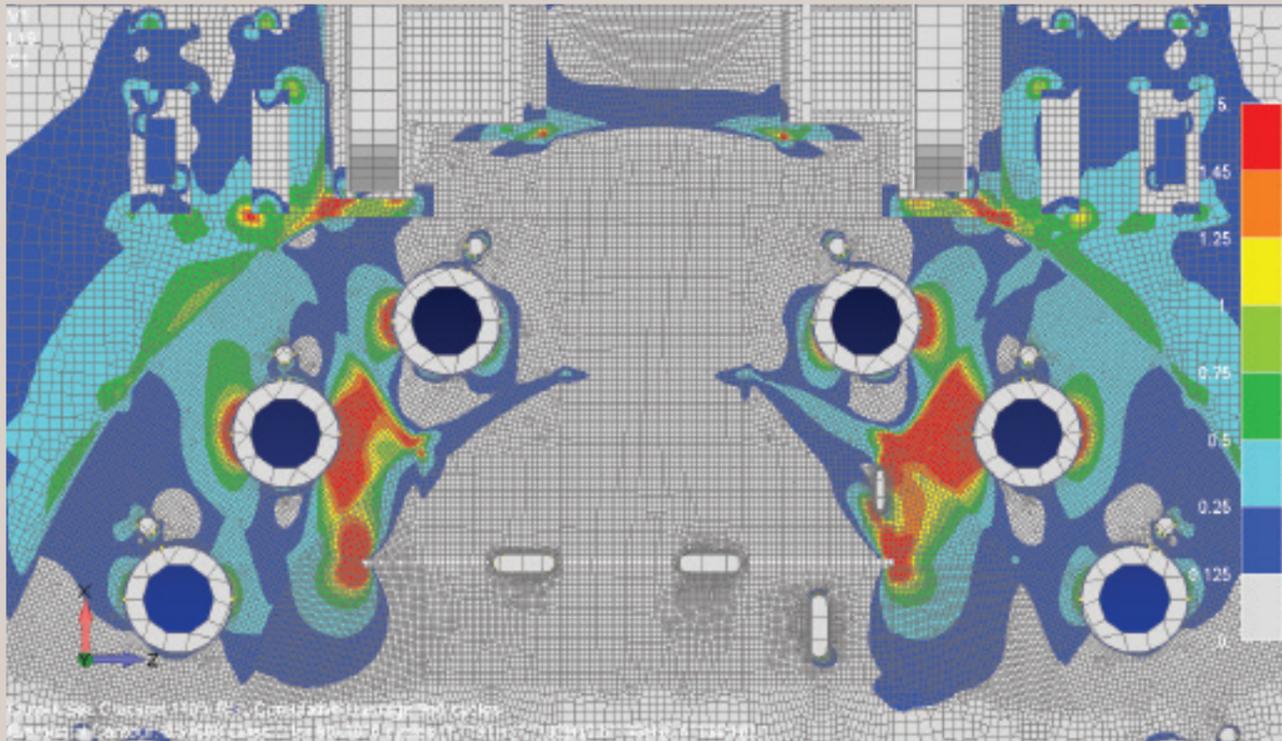
The company had been involved in many accident investigations, especially with large bulk handling machines. These investigations often involve detailed analysis (structural modeling, fracture mechanics, accident dynamics) or measurements on similar operational machines.

BMT can draw on a broad range of engineering or metallurgical skills which may be required to identify the cause of the accident or failure.

### Life Extension

BMT was commissioned by China Light and Power (CLP) – Hong Kong, to carry out a detailed assessment of the complete coal handling conveyor system. As part of the work BMT was further commissioned to carry out two significant design and construction projects associated with their stacker reclaimer. Following the assessment project BMT contracted and supervised a local construction firm in the implementation of the life extension works.





- 1: Stress analysis of dragline revolving frame
- 2: Coupled modelling mill bearing
- 3: Fluid motion within a coal centrifuge
- 4: Discrete Element Modelling of conveyor transfer
- 5: Modelling of modernisation of sluice gates

## Advanced Engineering Analysis

At BMT, analysis is a key element in the overall approach to solving problems in mining machinery. It is an integral part of the design, troubleshooting, failure analysis, performance enhancement and life extension services which BMT provides.

BMT specialises in mathematical modeling and simulation of all types of engineering problems. It uses leading edge software and computing hardware to provide rapid answers to complex problems involving stress analysis, fluid flows, heat transfer, structural and drive dynamics and control systems.

BMT has special expertise and experience in a number of key areas including:

### Stress Analysis and Finite Element Modelling

The company uses a range of FEA software packages to analyse complex machine structures and components for stress, deflection, buckling, fatigue and related assessments.

### Structural Dynamics

Dynamic and vibration problems involving large machine structures are routinely addressed using FE Analysis. We have particular expertise in analysing non-linear and transient problems; in modelling interactions between control systems and structural response; and in analysing and designing structures to withstand explosions.

### Heat Transfer, Temperature and Fluid Flow

BMT specialises in analysing complex thermal problems, involving radiation, conduction, and free and forced convection, using state-of-the-art CFD. Problems involving reaction or combustion can be solved. BMT can simulate explosion events in underground mines.

oil providing the fluid film essential to bearing survival. Assessing the design of these bearings is complex, as the oil film pressure and thickness interacts with stiffness and shape of the structures above and below the film. BMT developed a model of the structure coupled with code simulating the film behaviour.

### FEA modelling

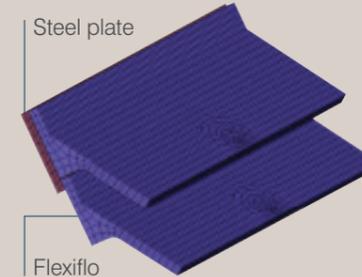
BMT had been commissioned by Skellerup Gulf Rubber Australia to investigate the working mechanism and possible optimisations of the Flexiflo

### Coupled modelling

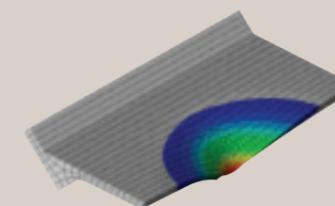
Ball and SAG mills frequently used in gold and copper mines rotate on hydrostatic bearings with a continuous flow of

Livewall System using advanced analysis techniques. The main concern of the mining operator is chute blockages and hence unproductive stoppage and downtime caused by the adhesion of the material to the chute surface, leading to large build-up of material. BMT developed a special finite modelling approach to enable the analysis of the dynamics of hyperelastic chute and hopper lining with bulk material adhesion for bulk material handling applications. The analysis results were directly used for product design.

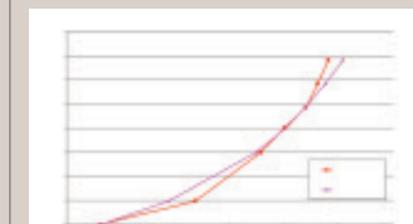
### FE Model



### Dynamic modeling initial condition



### Typical hyperelastic material stress and strain curve



### Shed CFD modelling

Australian industry is building a number of export sheds in which to store fine minerals and materials before loading and transporting to overseas destinations. The dust generation while handling fine materials is a very important environmental problem. BMT developed an advanced flow modelling technique which uses on-site measurement of the dust generation rate. As a result the dust collection design has been optimised to minimize the shed downtime and potential risks on the workers.

## Asset Management Services

To assist owners and operators of equipment to better manage and maintain capital assets over their operational lifetime, the company offers a comprehensive range of services including:

### Maintenance Support

For its experience with the operation, repair and maintenance of large machine and machinery systems, BMT can assist operating companies in making maintenance more effective and in reducing total life-cycle costs. At any level, from provision of advice to total implementation or management, BMT can support operating companies in a number of areas including:

- Whole of life maintenance plans
- Repair-replace decisions for major equipment
- Strategic spares inventories
- Documentation
- Maintenance systems
- Vibration monitoring

### Risk Assessment, Reduction and Management

Based on a long involvement in machinery failures and accidents, BMT is uniquely positioned to provide machinery operators with advice on assessment, management and reduction of risk.

Delivery of this service can involve measurements on an operating machine analysis to assess design adequacy, machinery inspection and condition monitoring; all key areas of BMTs expertise.

### Condition Monitoring

An effective condition monitoring program is a primary tool for managing both risk reduction and maintenance. BMT can assist at all levels of planning, implementing or interpreting condition monitoring programs or, where appropriate provide a total service, running and managing the entire program.

### Machinery Inspections

BMT has an extensive background worldwide in carrying out independent machine inspections: structural, mechanical and electrical.

These inspections are usually undertaken to assess safety or operational risk, or as part of an overall risk management strategy.

### Life Extension

In many cases, the operational life of a machine can be extended by some minor modifications to the structure of mechanical equipment. As a result, the life extension option often provides a cost effective alternative to replacing an existing machine. At BMT, the process usually involves measurement or analysis to identify potential failure areas, prediction or component life, and development of appropriate structural or mechanical upgrade strategies consistent with the client's objectives and constraints.



### Repair or replace

Dragline tubs deteriorate in service due to various factors including wear of the bottom plate, distortion due to walking on poor ground and cracking of structural welding due to high roller loads. Repairs can be implemented to correct the accumulated damage, but these are costly and can involve significant downtime for the machine. There can sometimes be a case for replacement in lieu of repair, particularly when the cost of lost production is considered. BMT has experience in costing the repair and replacement options and in undertaking Net Present Value analysis to examine which alternative is favored.

## Environment

We have a long history servicing mine industry customers in a range of regulatory and planning contexts.

### Multidisciplinary Team

A key to our success is our unique multidisciplinary team that can develop solutions to complex challenges which may arise during the course of mining activities, as well as deliver reliably on the routine environmental management and reporting requirements of mining.

### Concept to Closure

Our ecologists and engineers routinely assist mine customers with solving often complex environmental issues, from the conceptual phase to closure. This includes baseline assessments of green-field sites, environmental impact assessment studies, project approvals, environmental monitoring studies, development of rehabilitation strategies and modelling of pollutants in mine affected waters. This has allowed customers to effectively respond to government requirements and to identify and manage other water and environment issues during planning, construction, operational and de-commissioning phases.

### Management of Final Void Waterbodies

Final voids are key post-mining landscape features. BMT WBM has assisted several mines with an understanding of the long-term effects of final voids on aquatic ecosystems.

In one study, mine void water levels were modelled to predict the likelihood of pit waters overtopping and entering downstream environments. The

study demonstrated that there was a low likelihood of overtopping, and therefore management effort was better invested in other rehabilitation activities. Another study considered the long term beneficial uses of a final void waterbody. Modelling demonstrated that active management of mine water flow paths would ensure that the pit would maintain a healthy, self-sustaining aquatic ecosystem in the long-term.



### Environmental Monitoring at Stradbroke Island

Sand mining operations on North Stradbroke Island (south-east Australia) occur adjacent to internationally significant wetland systems that provide habitat for many threatened species.

BMT WBM developed a Management Plan to manage potential impacts of mining activities on a highly sensitive threatened fish species, Oxleyan Pygmy Perch, which was discovered by BMT WBM adjacent to the mine path during baseline studies.

A reactive environmental monitoring program formed a core component of the Plan. Early warning 'triggers' were developed for water quality, hydrological and biological indicators, which provided a means to quickly identify and manage any impacts. The program was a success and no impacts to Oxleyan pygmy perch or their habitat occurred.

