MECHATRONIX – CAPABILITY STATEMENT

Mechatronix Pty Ltd was established in 2000, and provides a wide range of specialised engineering consultancy services to Australian and overseas clients, especially within the Resources sector.

Key areas of our expertise include:
- Structural and mechanical design and auditing of materials handling equipment and structures.
- Advanced FEA analyses of stress, fatigue and dynamics.
- Investigation and solution development for stress, fatigue and vibration problems on machines and structures.
- Comprehensive test and measurement and data analysis capabilities.
- Composite materials – analysis and design, and field repair and life extension of fatigue loaded machines and structures.
- Design and auditing of bulk materials handling equipment to AS4324 and ISO 5049.
- 3D modelling and detailed engineering drawings.

Key resources include:
- Ansys FEA software allowing the efficient solution of large linear and non-linear FEA models.
- Multiple licenses of Solidworks for 3D modelling and drafting.
- Rocky DEM software for materials handling simulations.
- State-of-the-art high-speed data acquisition systems for measurement of strain, vibration, displacement, pressure etc.
- MATLAB software for multi-channel data analysis, visualisation and dynamic modelling.

Key factors that differentiate Mechatronix from our competitors include:
- The close integration of advanced FEA m with test and measurement results – field testing is used to measure forces, validate FEA models, verify the accuracy of predictions and ensure the success of proposed modifications.
- The ability and desire to incorporate new ideas and technology to deliver the best possible solution e.g. the use of carbon fibre reinforcements to greatly extend the residual fatigue life of old equipment and structures.

All work is undertaken by, or under the direct supervision of, Andrew Middlin the Mechatronix Principal, harnessing over 35 years of relevant experience to each and every project. Andrew’s CV, outlining even more relevant experience, can be provided at your request.

Mechatronix Pty Ltd.
19/25 Quanda Road,
Coolum Beach, QLD 4573
Ph: +61 7 5446 4844
Mob: +61 418 789 847
Email: andrew.m@mechatronix.com.au
Web: www.mechatronix.com.au

Consulting Mechanical Engineers specialising in-
- Finite Element Analysis
- Vibration & Structural Dynamics
- Strain Gauging
- Stress and Fatigue Analysis
- Composite Materials
PROJECT EXAMPLES:
ADVANCED FEA ANALYSIS

RHIO / SCT/ Duro Felgeura - Design Assistance and Auditing of Rotary Car Dumper.

As part of a wider engineering management and project delivery role, Mechatronix provided detailed design assistance and FEA analysis and auditing of the dual cell rotary Car Dumper delivered to the Roy Hill Iron Ore mine. This auditing included verification of the loads applied by the gravity clamps; detailed modelling of the primary structure using fine element mesh and quadratic shell elements; extraction of the stress distributions at 10 degree increments through the tip and return cycle; extraction of the fatigue stress ranges at all critical locations; and verification of the fatigue life using both nominal stress criteria from AS4100 and the Hot-Spot methods defined in BS7608:2014. Separate FEA models were prepared to address lifting and transportation requirements, encompassing detailed design of the transportation and lashing frames, and the certification of the lifting lugs and hardware to Australian standards.

Road Traffic Authority of NSW – FEA of Cast Iron Truss Shoes – Historic Bridge

Mechatronix provided detailed FEA of alternative truss shoes on an historic timber bridge in NSW. Non-linear contact simulation was used to realistically represent the pressure distributions acting between the cast iron shoe and the inter-connecting timber beams and stabilising rods.
PROJECT EXAMPLES: INTEGRATED FEA AND TESTING

Example 1: Mining Materials Handling / Rio Tinto Iron Ore, Ell Bridge Reclaimer.

FEA based fatigue analysis of a complete Bridge Reclaimer (crab and bridge/leg structures) operated by Rio Tinto. Comprehensive strain gauge and vibration testing was used to confirm the magnitude of loads applied during reclaiming, and to confirm the fatigue stresses at critical locations. Fatigue analysis was undertaken to BS7608, following Rainflow cycle counting.

Strain data was collected over a prolonged period, and analysed in conjunction with SCADA operational data to provide detailed understanding of the machine actions controlling the dominant fatigue stresses and highest load events.

Example 2: Rio Tinto Weipa, Apron Feeder Fatigue Failures.

Detailed investigation of chain link fatigue failures on a large Apron Feeder. Strain gauging was used to quantify the load sharing between the four sets of chain links, and between the East and West drive sprockets. FEA was used to define the stress distributions throughout the chain links and flight pans, and to investigate the significance of different loading mechanisms and loss of bolt preload. Premature fatigue failures were shown to be due to substantial imbalance between the chain tensions.

Consulting Mechanical Engineers specialising in-
- Finite Element Analysis
- Vibration & Structural Dynamics
- Strain Gauging
- Stress and Fatigue Analysis
- Composite Materials
PROJECT EXAMPLES:
INTEGRATED FEA AND TESTING CONTINUED.

Example 3: SKM / Rio Tinto, 195 Tonne Trailer.

Detailed structural and fatigue design of a new, lightweight 195 tonne belly-dump trailer. This new design incorporated very steep sidewalls and very large bottom doors to allow handling of wet and fine bauxite ore. The final design achieved a 25 to 30% reduction in the trailer/payload weight ratio relative to previous designs. Structural analysis was comprehensive and included fatigue, strength and buckling load cases. The first prototype was comprehensively strain gauged, with fatigue stresses measured at over 70 locations identified using the FEA model. Rainflow cycle counting was performed and fatigue life estimates obtained directly using the methods prescribed in BS 7608. A fleet of around 19 trailers has now been operating successfully without any fatigue issues in excess of 12 years, and a mean payload upgrade to 215 tonnes is currently being implemented.

Example 4: MMH / Loy Yang Power, Bucket Wheel Excavator Dynamics and Fatigue.

A comprehensive dynamics and fatigue study was performed on the largest brown coal excavator in Australia, Dredger 16 at Loy Yang Power, in conjunction with MMH. Mechatronix developed detailed FEA models of the tower and underframe structures to determine the required strain gauge locations. Comprehensive vibration and strain gauge testing was used to measure the dynamic responses of the machine, the magnitude of bucket-wheel loads during excavation, and the fatigue stresses at critical locations. Interfaces were installed to obtain analog data for the various motions of the Dredger from on-board instrumentation. Data was collected and analysed for over 70 channels of strain, vibration, load and machine motion over a period of 5-6 weeks. Code based fatigue analysis was undertaken following Rainflow cycle counting. Conceptual solutions to dynamics issues were developed and validated using the final, tuned FEA model of the machine.

Consulting Mechanical Engineers specialising in:
• Finite Element Analysis • Vibration & Structural Dynamics • Strain Gauging • Stress and Fatigue Analysis • Composite Materials
PROJECT EXAMPLES:
INTEGRATED FEA AND TESTING CONTINUED.

Example 5: QAL Ball Mill

Comprehensive FEA and fatigue analysis of a 20-year old Ball Mill, to establish residual fatigue life and to verify the adequacy of the current NDT programs. Strain gauge testing was undertaken to verify the fatigue stress ranges predicted by the FEA model. An area of high stress concentration and fatigue risk was highlighted within the oil seal grooves on the trunnions, an area not being considered during the existing NDT inspections.

Example 6: SKM / Rio Tinto Coal Stacker-Reclaimer

FEA based fatigue and preliminary strength analysis of a complete stacker/reclaimer, confirming suitability for a life extension of 25 years given structural modifications in selected areas. Comprehensive on-site strain gauge testing was used to confirm the magnitude of applied loads during stacking and reclaiming, to confirm the stresses within major structural members, and to calibrate the FEA model. On-board machine signals were brought into the high speed data acquisition by interfacing with on-board control system signals. Fatigue analysis was performed using Rainflow cycle counting to define the stress-range cycle counts at each critical location, with assessment of the total fatigue damage using BS7608. Remedial strengthening was designed in critical areas, and additional strength assessments were made following an unplanned luffing incident.

Consulting Mechanical Engineers specialising in-
- Finite Element Analysis
- Vibration & Structural Dynamics
- Strain Gauging
- Stress and Fatigue Analysis
- Composite Materials
PROJECT EXAMPLES:

DYNAMICS

Example 1: Roy Hill Iron Ore Project, Train Indexing Simulations.
Complex non-linear dynamics modelling of train indexing of rail consists with 120 or 240 ore wagons. The indexer control system was heavily optimised to reduce the in-train dynamic forces. This optimisation included dual Indexers operating with five different Indexing cycles of varying time duration, maximum velocity, and acceleration and deceleration rates. The maximum draft force for each Indexer was also control system limited during the acceleration and constant velocity stages of each Indexing cycle.

Simulations were undertaken using lumped mass dynamic modelling within MATLAB, including all of the variations and complexity associated with the control system, and with non-linear hysteretic frictional modelling of the draft gear between each ore wagon. The results were used to compare against client supplied fatigue design loads for the Indexers and Wheel Grippers.

The actual Indexer fatigue loads were verified by strain gauging during the Car Dumper commissioning.

Example 2: Goro Nickel HPAL Structure, Dynamic Audit.
Design stage dynamic audit of vibration issues associated with the High Pressure Acid Leaching vessels and structure. Detailed FEA modelling of the reaction vessels, structure and foundation was undertaken to quantify the risk of excessive dynamic response and piping fatigue issues arising from low frequency sloshing of the slurry bath at the top of each vessel. Client concerns were due to the tall slender nature of the structure, the large slurry filled chambers at the top of each vessel, and the low modulus of the soil under the concrete raft foundation. The audit demonstrated that the sloshing natural frequencies and fluid loaded natural frequencies of the structure were sufficiently separated to avoid excessive structural vibration.

Example 3: Road Traffic Authority, Bridge Dynamics
A number of measurement and FEA based dynamic studies were undertaken on aging steel bridges on the Pacific Highway near Grafton. These studies included: multi-channel on-site vibration testing to extract the dominant modes of bridge response; tuning of dynamic FEA models of the bridge and approach spans to match the measured natural frequencies and mode shapes; analysis of modifications to reduce low frequency noise radiated from the bridge structure; design of vibration isolated personnel access systems, de-coupled from the primary bridge structures; measurement of dynamics stresses, correlation with FEA results and fatigue life assessments.
PROJECT EXAMPLES: COMPOSITE MATERIALS

Example 1: Rio Tinto Weipa, Rail Wagon Repairs.

Mechatronix has had an on-going program over the past 3 years installing carbon fibre reinforcements on Rio Tinto Weipa’s aging fleet of aluminium rail wagons. Carbon fibre patches were developed as an effective means of substantially extending the remaining fatigue life of these rail wagons, and as an alternative to their replacement with only 10-12 years of service life required. The use of carbon fibre followed detailed FEA analysis and strain gauging, with alternative all-metal repairs being impractical.

Carbon fibre reinforcements are installed at the four corners of the wagon following traditional weld repairs, effectively wrapping this corner both externally and internally with highly fatigue resistant carbon fibre patches. These patches are continuously adhered to the aluminium substrate following surface preparation techniques used in the aerospace and defence industries, and are cured in-situ using purpose built ovens and heating controllers. Additional patches are installed at the wagon centre, where the transverse bulkhead intersects the bottom beam on the sidesheet.

The carbon fibre reinforcements are proving to be highly effective, with the first repaired wagons having now been in operation without recurring fatigue cracking for over 5 years. Wagons continue to be repaired at a rate of 18 units per year, and to date roughly half of the fleet has been treated.

Example 2: Goro Nickel, Composite Pulse Columns and Reaction Vessels.

Mechatronix has analysed a number of GRP Pulse Columns and reaction vessels operating at the Goro Nickel mine. Detailed FEA studies have been undertaken using solid element representation of the vessels, and using either orthotropic material properties calculated from the fibre lay-up details or using layer-by-layer material representation and analysis. Strain levels are predicted for the principal hoop and axial directions and compared to acceptability criteria defined using BS EN 13121 “GRP tanks and vessels for above ground use”. These studies have been used to help identify the reason for structural integrity concerns, ensure that effective modifications are installed, and to audit additional reaction vessels.
PROJECT EXAMPLES: DESIGN AND PROJECT DELIVERY

Example 1: RHIO / SCT/ Duro Felgeura - Design Assistance and Auditing of Rotary Car Dumper.

As part of a wider engineering management and project delivery role, Mechatronix provided detailed design assistance and FEA analysis and auditing of the dual cell rotary Car Dumper delivered to the Roy Hill Iron Ore mine. This auditing encompassed the Rotary Cell, Indexers and new, very high capacity Wheel Grippers.

Mechatronix provided detailed structural design advice, including the elimination of welds on the jaws and their replacement by shrink fit components to meet fatigue life requirements. On all three items the Mechatronix design assistance and auditing encompassed independent load verification, detailed FEA modelling, fatigue life estimation and strength and buckling checks. Mechatronix also undertook detailed dynamic simulations of the complex Indexing scheme and control system, in order to check the client supplied in-train forces and resultant fatigue loads. Separate FEA models of the Rotary cell and Indexers were prepared to address lifting and transportation requirements, encompassing detailed design of the transportation and lashing frames, and the certification of the lifting lugs and hardware to Australian standards.

In addition to being the main engineering resource on the Car Dumper, Mechatronix played a much wider engineering management role within the core, small team that controlled the construction, delivery and commissioning of the DHHI balance machines and Car Dumper to the RHIO project. A large and complex project involving nine large bulk materials handling machines was delivered in a short timeframe.

Example 2: SKM / Rio Tinto, 195 Tonne Trailer.

Mechatronix develop the structural design for the main body of a new, lightweight 195 tonne belly-dump trailer. This new design incorporated very steep sidewalls and very large bottom doors to allow handling of wet and fine bauxite ore. The final design achieved a 25 to 30% reduction in the trailer/payload weight ratio relative to previous designs. Structural analysis was comprehensive and included fatigue, strength and buckling load cases, analysed using detailed FEA models.
SKM / Rio Tinto, 195 Tonne Trailer Continued.
The first prototype was comprehensively strain gauged, with fatigue stresses measured at over 70 locations identified using the FEA model. Rainflow cycle counting was performed and fatigue life estimates obtained directly using the methods prescribed in BS 7608. A fleet of around 19 trailers has now been operating successfully without any fatigue issues in excess of 12 years, and a mean payload upgrade to 215 tonnes is currently being implemented.