Sound scientific research informs asset management decisions

Globally, there is a rapidly growing need to manage physical assets optimally over their entire life cycles, from the design phase to the operational and decommissioning phases. To address this need, the University of Pretoria formally established the Centre for Asset Integrity Management (C-AIM) during 2014. This centre functions in the Department of Mechanical and Aeronautical Engineering.

Prof Stephan Heyns, Director of C-AIM, explains that the management of physical assets, such as plant equipment, buildings, aeronautical structures, machinery and vehicles, focuses on establishing, operating and maintaining an asset portfolio that is aligned with the organisation's strategic objectives. This necessitates the need for an in-depth understanding of asset management principles and processes at an operational management and technical level.

During the mid-1980s, the Department of Mechanical and Aeronautical Engineering commenced with research in various fields related to physical asset integrity. This included structural fatigue testing, experimental modal analysis and vibration monitoring. Maintenance initiatives were subsequently launched. In 2008, these initiatives culminated in the establishment of a Centre of Excellence for Maintenance Engineering, with industry support from Sasol, Eskom, Exxaro and Anglo American.

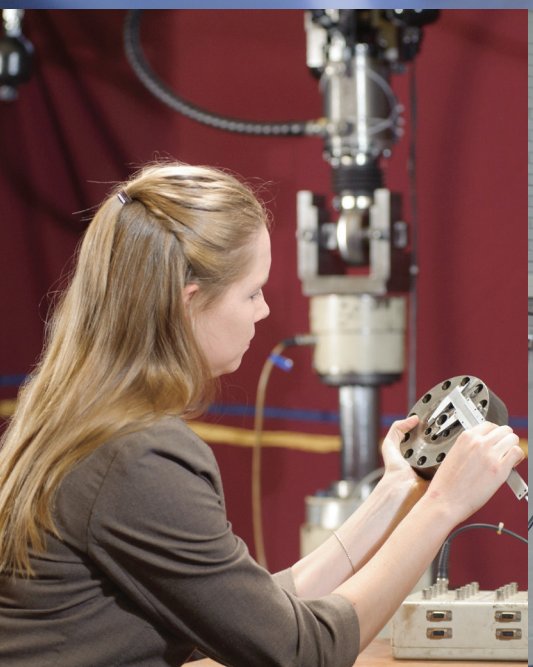
In 2012, Eskom established a Chair for Plant Asset Management as part of the University's Eskom Power Plant Engineering Institute (EPPEI). This was followed by the establishment of the Rand Water Chair in Mechanical Engineering, as well as a collaboration agreement with Weir Minerals to establish a research focus on machine condition monitoring.

Following the growth of knowledge and expertise in this field, C-AIM was eventually established to function as the hub of all asset integrity management activities in the Department of Mechanical and Aeronautical Engineering.

Research focus

C-AIM has identified a number of research focus areas, aimed at setting the standard for asset integrity management in South Africa.

- **The identification of critical assets:** Research in this field concentrates on the assets that may have the most significant and immediate impact. Identifying these assets is important in developing an asset integrity management plan, as companies manage many assets with very diverse attributes.
- **Designing for reliability and performance:** It is essential that sophisticated techniques are used to ensure that asset design is optimal during the manufacturing and operational phases of an asset's life cycle. Techniques that can be utilised include the finite element modelling of complex structures, scanning laser vibrometry and digital imaging.
- **Data acquisition:** The measurement of system parameters, such as solids, liquid and gas flow rates, pressure, temperature, oil condition or vibration, are important. This necessitates detailed data of the operating conditions. Research on data acquisition includes the utilisation of non-contact sensors for condition monitoring, as well as acoustic emissions in specialist applications.
- **Condition monitoring:** There are significant research challenges related to condition monitoring in industry. These challenges include fluctuating operating and process conditions in systems, as well as optimising online condition monitoring and inspection



Prof Stephan Heyns (centre) with some of the staff and students of the Centre for Asset Integrity Management in the Department of Mechanical and Aeronautical Engineering.

techniques for a variety of equipment.

- **Diagnostics:** Research focuses on understanding failure modes and criticality, which is crucial in identifying approaches to optimal condition monitoring. Detailed models to link features extracted from system response and performance measurements are indispensable to diagnose system faults.
- **Prognostics:** Maintenance decisions based on the outcomes of time-to-failure estimates often contain a strong element of uncertainty. This suggests a need to integrate traditional condition assessment and statistical reliability models. This research requires one to move away from intuitive decisions and adopt more sophisticated prognostic models capable of dealing with complex equipment that has many interrelated failure modes.
- **Life cycle decision support:** When considering life cycle management decisions, research extends beyond immediate failure. It also focuses on understanding the long-term operational and maintenance implications. Therefore, the current research on life cycle decision support entails the integration of condition information with an improved understanding of the degradation mechanisms that manage maintenance interventions, risk, inventory and end-of-life decisions.
- **Standards and databases:** The optimal utilisation and life cycle management of expensive physical assets is becoming more important in a competitive cost-sensitive society. As a result, new asset management standards, such as PAS55 and ISO 55000, have been implemented. Research conducted on standards and databases aims to understand the implications of such standards.

Industry collaboration

In addition to its research activities, C-AIM strives to achieve scientific excellence and industry relevance by working closely with industry partners. The approach utilises the establishment of industry-sponsored chairs in specific research areas.

- **The EPPEI Chair in Plant Asset Management** was established in 2012 and will be active until 2017. At the end of this period, C-AIM would have supervised 20 to 30 Eskom staff members who will have studied towards a master's degree. High-impact research projects that deal with issues ranging from mill maintenance optimisation to fatigue life prediction of steam turbine blades are underway.
- **The Chair in Maintenance Engineering** was established in 2009 in collaboration with Anglo American, Sasol, Exxaro and Weir Minerals. This Chair has enabled C-AIM to considerably expand its capacity in the area of maintenance engineering.
- **The Rand Water Chair in Mechanical Engineering** was established in 2014 and strongly focuses on the development of asset integrity analysis and management techniques for water distribution.

These collaborations not only play a vital part in the improvement of asset management, but may also afford postgraduate students the opportunity to join collaborators once they have completed their studies.

Postgraduate programme offering

Two unique postgraduate programmes are offered in asset management to provide the mining and engineering industry with sufficiently qualified individuals.

The Multidisciplinary Postgraduate Programme in Physical Asset Management (PAM) is managed in collaboration with the Graduate School of Technology Management (GSTM) and is ideal for candidates who prefer a stronger management focus. The Mechanical Engineering Postgraduate Programme in Asset Integrity Management is managed through the Department of Mechanical and Aeronautical Engineering, and is preferred by candidates with a stronger technical focus.

Both these programmes are course-based honours degree programmes, followed by a research dissertation for master's degree purposes, designed to achieve specific objectives. They allow students to choose modules from different departments within the School of Engineering, including the departments of Civil Engineering, Industrial and Systems Engineering, Mechanical and Aeronautical Engineering, and Mining Engineering, as well as the GSTM.

Laboratory facilities

Research and academic programmes relating to asset integrity management require state-of-the-art laboratory equipment. The Sasol Laboratory for Structural Mechanics was established in the Department of Mechanical and Aeronautical Engineering in the early 1980s. It is home to C-AIM's structural fatigue, structural dynamics, vibration monitoring, diagnostics and prognostics research activities.

The laboratory's unique capabilities include its ability to conduct durability (fatigue) tests on structures with masses in excess of 15 tons, various certifications of large equipment (such as mining machinery), large-scale rotating machinery dynamics simulators for gear, as well as bearing and turbo machine blade damage investigations.

The laboratory has unique capabilities in terms of the optical measurement of vibration and structural dynamics, which enables cost-effective studies in applications that would otherwise have been difficult to deal with.

Resource development

To ensure that all its activities run smoothly, C-AIM has appointed a strong staff complement. It proudly employs 10 specialised academic staff members, who conduct research on critical aspects of asset integrity management.

Knowledgeable full-time researchers, engineers and technicians support the academic staff and help C-AIM to engage with industry partners.

As part of the EPPEI agreement with Eskom, C-AIM also has a formal agreement with the Tshwane University of Technology (TUT). C-AIM and TUT share resources to develop research expertise in asset integrity management related to power generation, transmission and distribution.

Since there is a rapidly growing need to manage physical assets optimally over their entire life cycle, C-AIM intends to be recognised locally and internationally for its academic excellence. It strives, in particular, to integrate its analysis and testing expertise in the assessment of the structural integrity and performance of mechanical and other physical assets with the ability to make short-, medium- and long-term asset management decisions in the context of asset life cycles.

→ *Taking optical measurements on structures with complex deformation modes.*