Artificial Intelligent System for Integrated Wear Debris and Vibration Analysis in Machine Condition Monitoring

Thesis submitted by

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Then you will know the truth, and the truth will set you free.

Jesus in John 8:32 (NIV).

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Date

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Abstract

Machine condition monitoring has become a vital component of maintenance programs in machine intensive operations, such as the mining, mineral processing and manufacturing industries. Vibration and oil analysis have become the two most commonly used techniques for fault detection and tracking. These techniques are generally used independently as expert knowledge is required in each field, and due to a lack of understanding about how to integrate them. However, numerous case studies of machine failures have reported on the benefit of a correlated approach. This project focused on the development of an analytical strategy that, for the first time analyses vibration data in conjunction with oil and wear debris data for machine health assessment.

In order to achieve the goal of developing a strategy for correlated application of vibration, oil and wear particle analysis using artificial intelligence, a number of project objectives were identified. The project objectives were to investigate the fault detection abilities of condition monitoring techniques as a basis for developing a correlated strategy, and finally to implement this strategy using artificial intelligence. These objectives were collated into a project plan that consisted of a comprehensive survey of condition monitoring techniques and correlation investigation, correlation strategy development, expert system development and a testing phase.

The project was performed in a number of stages to allow the progress to be monitored. The first stage comprised a thorough literature review to ascertain the current research status in the condition monitoring field, as well as confirming the project objectives. The second and third stages were concerned with the preparation of spur and worm gearbox laboratory test rigs, and the operation of suitable experiments. The measured condition monitoring data allowed the fault detection of the vibration, oil

and wear particle analysis techniques to be assessed. The data was also used for verification of the correlation strategy developed in stage four. Stage five was concerned with the development of three expert systems for vibration analysis, oil and wear particle analysis, and correlated condition analysis respectively. The expert system for correlated condition analysis was constructed using the correlation strategy of stage four of the project. All expert systems were thoroughly tested using laboratory and industry derived data to verify correct operation.

The outcomes of this research project contribute to the current academic knowledge of the condition monitoring field, as well as provide industry with potential economic and environmental benefits. The novel strategy for correlation of vibration, oil and wear particle analysis techniques, as well as the demonstration of the effectiveness of the developed expert systems are contributed to the academic research community. The expert systems include additional innovative features such as a fault root-cause analysis algorithm, and a new strategy for machine remaining lifetime estimation using a wear approach that can be updated using condition monitoring data. The fully functional expert system software package complete with user interface is contributed to the industry partner Industrial and Technical Services for potential future commercialisation.

The developments of this project can provide significant benefits to the mining, mineral processing and manufacturing industries if the project outcomes are implemented. The correlated condition monitoring strategy allows improved early fault detection, more reliable fault diagnosis and the ability to perform root-cause analysis, compared to conventional vibration, oil and wear particle analysis. These advances combine to improve the efficiency of the maintenance program resulting in increasing machine uptime, reduced maintenance costs and lower environmental impact. The adoption of the project developments could therefore ultimately improve the profitability of the venture, and help Australian operations to remain financially viable on a global scale.

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