The Faculty of Engineering

POPULAR SCIENTIFIC ABSTRACT

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[Wear Particle Analysis in Oil Systems by Modelling and Interpretation of Optical Sensor Data]

Particle counters relying on the light extinction measurement scheme are widely used in industrial applications and provide valuable information regarding the particle contamination level in the lubricating oil of operating machinery. In spite of its usage, little information of the internal workings of this sensor type can be found in the literature today. This thesis addresses the lack of documentation by combining analytical, empirical and simulated results obtained through the development of a light extinction based optical particle counter (OPC) and corresponding simulation tool to elucidate the influence of sensor design and operational parameters on particle detection in oil systems.

The key research areas and contributions addressed in the thesis can be divided into two parts:
Part 1:
Analytically derived relationship between particle size and sensor response have been utilized in the development of a novel simulation tool for modeling the output of an OPC. The model has been used to investigate the influence of different design and operational parameters on sensor output and aid in the design of an OPC prototype. Explicitly, the probability of assessing the correct size of individual particles was found to increase with the size of aperture, and high particle concentrations was shown to cause simultaneous sampling of particles. The simulated results contributed to the development of a minima detection algorithm which have been used throughout the project for extracting particle induced signal variations in both simulated and experimentally obtained signals.

Part 2:
Revolves around interpretation of OPC raw output signals in different experimental settings.
First, the influence of high particle contamination level on raw output signal was investigated and found to cause multiple particles to be sampled simultaneously, thus causing them to appear as a single larger particle. Additionally, results from this experiment showed an imminent saturation point in terms of particle counts.
Second, optical absorption measurements of mono-dispersed metal-coated particles was combined with OPC measurements from a peristaltic pump test setup. Including the absorption properties in the conversion from sensor output to particle size showed to reduce the deviation between true and estimated particle diameter with up to 7 percentage points.

This work contributes to the understanding of how light extinction based OPCs perform when detecting wear debris in oil systems. Correlation between modeled and experimental results suggests a simulation tool can be used to further optimize sensors relying on this measurement scheme. The developed OPC were successfully used to detect spherical metal-coated particles as small as 5 μm and a methodology for incorporating optical absorption properties of particles into signal interpretation was shown.