Industrial Equipment Condition Monitoring

Using Electrical Signature Analysis

Opportunity

If you've investigated the variety of common tools (vibration analysis, oil analysis, thermal imaging, etc.) available for monitoring the operational condition of electro-mechanical industrial equipment, and cannot find one suitable for your needs, consider a robust technology known as Electrical Signature Analysis (ESA). It is particularly powerful for applications where the equipment needs to be monitored from a remote point (due to accessibility or hazardous environments) and/or where non-intrusive techniques are required. This technology has been proven to work with high reliability on a variety of machinery tested at the Oak Ridge National Laboratory (ORNL).

Technology

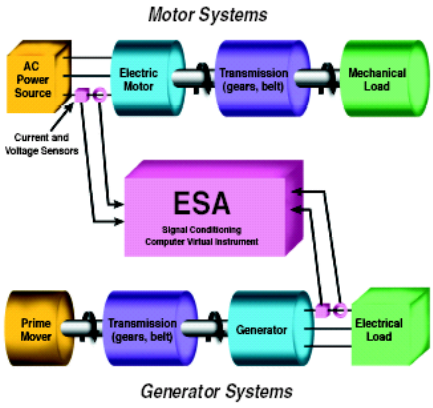
ESA is a versatile and powerful, yet non-intrusive, technology pioneered at ORNL that can be readily integrated into most electro-mechanical equipment to greatly enhance condition diagnostics and prognostics capabilities. ESA provides diagnostic and prognostic information comparable to conventional vibration analysis, but requires only access to electrical lines carrying input or output power rather than to the equipment itself. Thus, either onboard or remote analysis is possible—even continuous monitoring, if desired

Load and speed variations in electro-mechanical systems generally produce correlated variations in current and voltage. ESA analyzes these small perturbations and matches them to their source. The resulting time and frequency signatures reflect loads, stresses, and wear throughout the system and allow an extensive range of mechanical diagnostic information to be obtained from a single sensor attached to an electrical line.

Few available technologies can be so seamlessly integrated into existing maintenance programs. With the addition of a few sensors, ESA diagnostics can pinpoint electrical and mechanical problems and target maintenance on an as-needed basis, thereby increasing equipment reliability and maintenance efficiency and minimizing unexpected downtime.

How It Works

ESA provides a breakthrough in the ability to detect and quantify mechanical defects and degradations in electromechanical equipment and unwanted changes in process conditions. ESA is truly non-intrusive and does not interfere with the operation of the equipment being monitored.

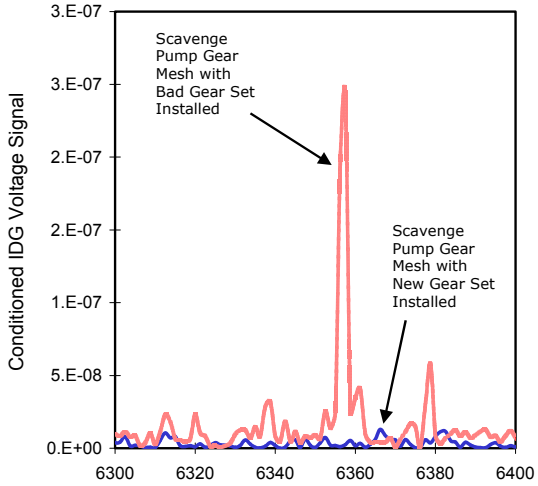


As a result of continued R&D at ORNL, ESA has matured as a diagnostic/prognostic technology. ORNL has developed several signal conditioning and signature analysis methods to capitalize on the intrinsic abilities of conventional electric motors and generators to act as transducers. Time-dependent load and speed variations occurring throughout an electro-mechanical system will generally induce small variations in the motor's and/or generator's electrical response. These variations are observed as a change in current (for a motor) or a change in voltage (for a generator). ORNL researchers have developed the signal

conditioning techniques for extracting these small electrical perturbations and relating them to their source, thus opening a whole new field for diagnostic innovations.

Sample Application

Integrated Drive Generators (IDGs) on certain aircraft experience complete failure, on average, at a rate of four per year; as many as ten have failed in one year. The causes are seizure and destruction of scavenge, drive pump, and axial gears on the generator's main shaft. Traditional re-certification tests do not detect incipient gear failure. If the $17,000 gear sets seize, the $250,000 IDG is essentially ruined. The capability to predict gear failure or incipient failure represents substantial savings for owners in replacement costs.



The scavenge pump gear-mesh peak in the IDG voltage spectrum was used to detect a bad gear set.

IDG units provide power to commercial aircraft (117/208 volts at 400 Hz) for passenger reading lights and galley microwave ovens. To maintain their reliability, effective measures of the onset and levels of gear wear are needed. ORNL has demonstrated both on a test stand and on a jet that ESA techniques provide signature attributes necessary to characterize good and worn gears. The strength of ESA is that current and voltage probes are easy to attach and use for monitoring, with no additional mounting required. Results show that even at extremely low generator loads, ESA provides excellent sensitivity to the gear-related problems.

Other Applications of ESA Demonstrated by ORNL include:

- Large Blowers and Fans
- Water and Fuel Pumps
- Air Compressors
- Vacuum Pumps
- HVAC Equipment
- Textile Production Machines
- Automobile Alternators
- Electric Vehicle Motors
- Diesel Engine Starter Motors
- Large Compressors (Rotating Stall)
- Portable Power Generator Sets
- Helicopter (Rotor and Gear Train)
- Variable Speed Motors

How To Contact Us

If you would like additional information on ESA and would like to find out how ESA can help you minimize unexpected failures, increase equipment reliability, and reduce unscheduled downtime, please contact:

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