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Wireless Sensor Development for Machinery Condition Monitoring

Thomas Antoine, ACOEM Group, Limonest France

Figure 1. FALCON data collector and wireless sensor.

Wireless sensors for machinery condition monitoring can be permanently located in normally inaccessible mounting locations, do not require connecting cables and can improve the safety and productivity of vibration data collection. Yet developing a transducer that can replace its wired counterparts comes with design challenges to meet metrology and frequency response objectives.

OneProd, a brand of the ACOEM Group, is focused on providing smart and simple-to-use solutions for condition-based monitoring of rotating machinery. The systems include a powerful supervisory tool to communicate global indicators of machinery health, the FALCON portable data acquisition and analysis system shown in Figure 1, the EAGLE wireless sensor and the MVX solution for permanent monitoring.

The Metravib division of the ACOEM Group, which specializes in NVH engineering, provided the development, modeling and material testing expertise to achieve the superior characteristics of the FALCON wireless sensor.

The FALCON portable monitor has been carefully designed to ease the workload of maintenance technicians performing their inspection routes throughout plants and production sites. It comes with a smart software suite, touchscreen technology, embedded camera, pyrometer, QR code reader, stroboscope, and setup/diagnosis software. The wireless sensor contains a three-axis accelerometer, signal processing electronics, power management electronics, and rechargeable battery. Design features include global ergonomics, resistance to harsh environments and outstanding frequency response.

Sensor Design. The active elements of the FALCON wireless sensor are located as close as possible to the surface to be measured. The remainder of the sensor housing volume is occupied by the battery and electronic circuitry. The assembly is much heavier than its wired counterparts, which introduced dynamic response issues of the inner components. In particular, the behavior of any elastomeric materials under real conditions of temperature and vibration excitation had to be taken into account.

A Metravib DMA (dynamic material analysis) system shown in Figure 2 was used to measure the properties of elastomeric materials used in the wireless sensor. A sample of the material to be tested is placed in a specially designed fixture within a temperature- and humidity-controlled enclosure. A sinusoidal excitation is then applied to one side of the fixture and the transmitted force is measured. Subsequent analysis combined with the sample dimensions led to a complete knowledge of the material modulus and damping factor, as shown in Figure 3.

Figure 2. Metravib Dynamic Analysis System and close-up of sample fixture.

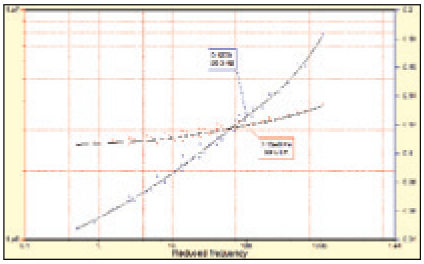

Figure 3. Dynamic modulus and damping factor of the elastomeric material used in the FALCON wireless sensor.

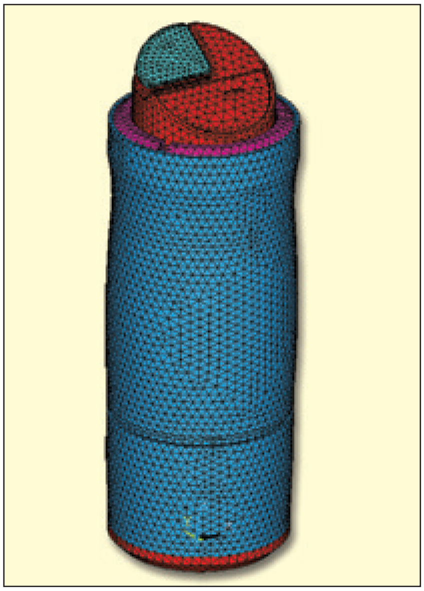

Figure 4. Original finite-element model of the FALCON sensor.

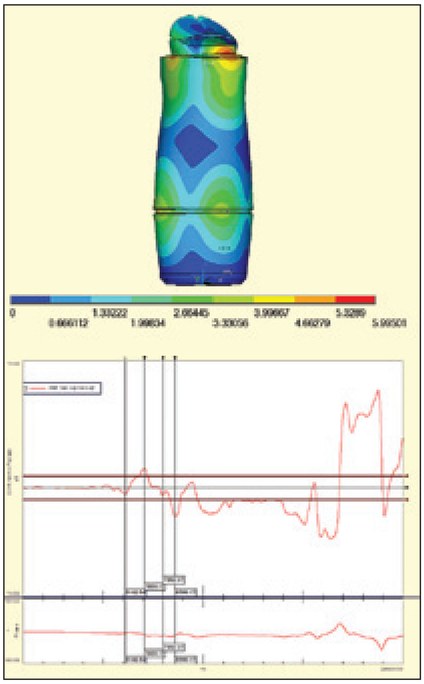

Figure 5. Modal analysis of the FALCON sensor at 7.5 kHz (top) and frequency response to 20 kHz.

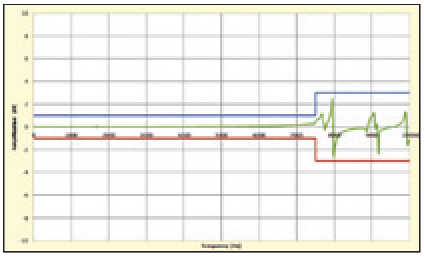

Figure 6. Z-axis dynamic response of the FALCON sensor after design improvement.

The initial finite-element model of the FALCON sensor is shown in Figure 4. The finite-element model was updated with the results of the elastomeric material tests and a modal analysis was run on the finished sensor. The objective of the sensor design was to obtain a 10 kHz flat frequency response in the Z axis. The modal analysis showed that design goals were not fulfilled at particular frequencies, as shown in Figure 5.

A sensitivity analysis of the stiffness and damping of different parts of the sensor optimized its frequency response. The finite-element model was updated with the new design parameters, and they were implemented in the design of the sensor. The dynamic response of the sensor was then tested under typical operating conditions. Other axes were tested with dedicated fixtures and alternative test methods. Final tests shown in Figure 6 were performed on a metrological test bench.

Conclusions. Thorough control of material properties combined with FE model updating led to a successful design of the FALCON sensor. The engineering skills of the ACOEM Group have made a new high-performance wireless machinery monitoring system available to the market.

For more information on the FALCON and other ACOEM products, please visit www.acoemgroup.com. Contact: thomas.antoine@acoemgroup.com.