


Machinery Diagnostic/ Prognostic Products Ready for Commercialization

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I wanted to share with the MFPT membership some news about several innovative products that entered into commercialization by the end of 2018. These are products that I worked on in some capacity, and in most cases were publicly funded.

1. VibVue™ - This is a vibration magnification system that makes videos of the actual vibration of machinery photographed with a high speed camera. The system is able to amplify motion in the played-back slow-motion video, amplifying motion up to 500x. Frequencies of 3100 Hz are possible, and motion of 20 millionths of an inch peak-to-peak can be made visible. This system can be used to observe transient shaking (e.g. a cannon firing, or a machine casing natural frequency mode shape response from an impact hammer strike), or steady state vibration. In the latter case, it can be used to replace or at least supplement formal operating deflection shape (ODS) testing, that otherwise could take days to thoroughly perform. Loose foundation bolts, cracks in bearing housings, and overhead piping vibration are just some of the uses. Research is now underway to “marry” the video vibration detection to a continuous monitoring system. However, the camera/ software is already available for use for troubleshooting. Depending upon frequency of the need, the system may be purchased outright, or else leased, or may be accessed as an as-needed service. The background science behind the system was funded by the US Navy and US Air Force, which had the purpose of high-speed camera scene acquisition and interpretation. The associated projects, performed by the author’s company, included video-based missile launch detection, tracking, and attitude determination, and munition explosion characterization to determine lethal ranges thereby enabling armed forces to ensure sufficient stand-off from civilian targets.

2. Sentry® - This is a physics-based software system that can operate using various hardware platforms. The software was written in LabVIEW, and consists of thousands of person-hours of programming at this point, thanks to substantial funding from the US Air Force, as well as company IRAD funding. Experimental applications included US Navy fuel pumps and aircraft carrier arresting gear, as well as at USAF and NASA wind tunnel facilities. On the commercial side, the system is now installed at a large number of paper-making plants, and is regularly used for troubleshooting turbine generators and large pumps at nuclear and fossil fueled plants. The basic concept of the package is an “experienced machinery engineer in a box”. Time and frequency based data from one or more available sensors (such as accelerometers, proximity probes, pressure transducers, and oil or bearing temperature detectors) calculate condition indicators based on the combination of time waveforms, time transients, and frequency spectra. Data interpretation is performed in the context of machine operating point, ISO/API/HI specifications, and data trending history. Laboratory validation testing has documented good correlation between diagnosis and actual state of health, and field predictions of remaining useful life in the various applications have been able to avoid premature shut-downs. The system has been successfully applied to a wide variety of equipment, including machinery in the power, petrochemical, defense, paper, and water industries.

Unlike other systems that have been developed, Sentry® uses mechanical engineering physics at its core, and uses data-driven statistical methods and machine-learning as an important supplement, rather than the primary method, for its advice. As I have said in the past, would you want to go to a physician who had never studied physiology?

3. DCoMS™ - This is a "Distance Communication Maintenance System" that has been funded by the US Navy for use on ships at sea. It's uniqueness includes its ability to provide real-time audio-video maintenance data to shore-site personnel and subject matter experts (SMEs), do this while operating at very low information bandwidths, and meet Navy/DoD strict Information Assurance (cyber-security) requirements. DCoMS™ also provides a semi-automated videotape archive of lessons-learned and maintenance procedures. The system minimizes the need to transport SMEs from shore-site bases to ships that otherwise would require scarce-quantity (and over-worked) SMEs to fly-in in order to access.

4. Blade Fatigue Detector – This is a microwave sensor system that essentially is a close-coupled radar system that observes turbomachinery blade tip vibration over a "swath" of rotational angle, as opposed to the point-location-detection capability of previous "tip-timing" sensors. Use of one of these BFD sensors in combination with one tip timing sensor per stage avoids the previous need for many tip timing sensors in order to satisfy the Nyquist Criterion in determining the frequency content of blade tip motion, satisfying the goal of an accurate Non-Contact Stress Measurement System (NSMS). It accomplishes this though application of a Short Fourier Transform applied to the vibration of the blade during its motion through the finite angle over which the blade is within the microwave sensor's line-of-sight. Applications include aircraft gas turbines and other turbomachinery within test cells, on-wing engine fatigue and FOD detection, installed turbomachinery fatigue and surge mechanical severity detection, and incipient cavitation detection in pumps and valves. The BFD sensor system has been applied to a variety of DoD and commercial applications, through funding provided by multiple US government agencies, including the Navy, Army, Air Force, and NASA. Applications have been in government test call, as well as test cells of aircraft engine manufacturers, and OEMs of ground-based turbines.

If anyone has an interest in any of this research (discussion must be compliant with ITAR requirements), or in the associated publicly available products, please contact me at your convenience at wdm@mechsol.com.