Fast learners

Using vibration techniques to monitor bearings rotating below 100rpm is difficult as the useful signals emitted from spalls or cracks are very low in energy content, which can cause ambient noise to drown out the weaker bearing-related signals within the marine environment

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In the maritime industry, many critical machines are low-speed applications that cannot be monitored with reliable results using conventional monitoring techniques. SPM Instrument's high-definition method (SPM HD) redefines the practice of condition monitoring on equipment running at low speeds. The method is designed to provide instant condition information of rolling element bearings in green, yellow or red in the 1-20,000rpm range. The real challenge lies in low-speed applications, but the sensitivity of the SPM HD measuring technique enables the method to capture the relevant, but weak, bearing-related signals, while suppressing the signals of ambient noise.

During four years of field testing and real-life industrial use worldwide, the method has proved itself in numerous examples of successful bearing fault identification at very low speeds – in many cases well below 10rpm. SPM HD measurements on thrusters, cranes and winches have shown that these applications can indeed be successfully monitored. This technology will have a major impact on the acceptance of condition monitoring on applications that traditionally have been difficult or impossible to measure on.

The SPM HD method

The SPM HD method is further development of the original Shock Pulse Method (True SPM) for shock pulse measurement on ball and roller bearings. The use of high-performance, low-noise electronic components and extensive digital signal processing enables the SPM HD method to detect extremely small shock pulses. Even well-lubricated bearings in mint condition emit very small shocks that can be captured and measured. Right from its very earliest stages, an incipient spall causes distinct shocks that are reliably detected with the SPM HD method. A traditional vibration measurement approach, on the other hand, will not detect these microscopic spalls because the energy is not high enough to trigger the transducer – at least not at low rotational speeds.

The SPM HD method samples the transducer signal and produces four different results:

HDm: This represents the highest shock pulse found during the measurement time, expressed in decibels. Normally the value for indication of the bearing's mechanical condition.

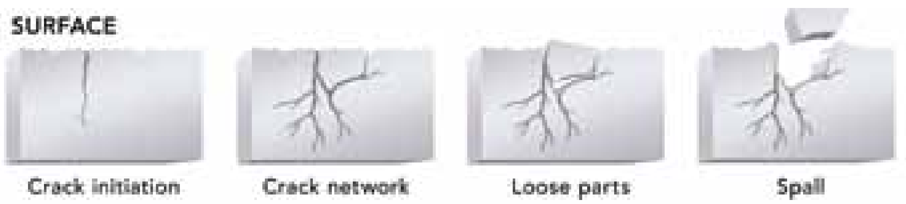
HDc: This is the threshold level, where 200 shocks per second are detected. HDc is expressed in decibels, and is normally the value for indication of lubrication condition.

Time Signal HD: The sampled shock pulse time wave form.

Spectrum HD: The Fast Fourier Transform of the Time Signal HD value.

The reason for measuring in decibels is the inherent high dynamics of the shock pulse signal. To take full advantage of the dynamics, the hardware implementation of the SPM HD method uses a 24bit A/D converter and a resulting dynamic range of more than 110dB with no gain adjustment.

The sampling rate is 102,400 samples per second and using HD Order Tracking, the signal is digitally decimated to fit the analyzing frequency range. The samples are adjusted to the current RPM using a patented order tracking algorithm, then a second algorithm enhances repetitive shocks while suppressing random ones. The resulting Time Signal HD is unusually distinct, mostly due to the above algorithms.



ABOVE: **The typical development of a bearing spall**

LEFT: **SPM HD provides instant information on the condition of rolling element bearings**
ABOVE: **The operating condition of hard-to-monitor applications are now monitored with reliable results**

Detection of early-stage spalling

When a rolling element passes a given point of a bearing surface, the pressure on that point can be extremely high. As each rolling element passes, the high pressure pushes the lubrication media into the microscopic cracks normally found in the raceway surfaces. This is repeated throughout the bearing's lifetime. Over time, the repetitive stress can cause the microscopic cracks to form a network of larger cracks, eventually leading to a spall (see Figure 1). Using SPM HD, a spalling process can be closely monitored over a period of many months. The typical spalling process follows one of two patterns: slowly increasing shock pulse values followed by a slow decrease, typical for metal parts from the raceways that are partly broken loose; or slowly increasing shock pulse values followed by a rapid drop, typically where damages are caused by the sharp edges induced when a spall is completely broken away.

The periods of elevated shock values are indicative of an 'active' spall (i.e. a spalling process giving rise to shock pulses). There are examples of low-speed applications where an active period was followed by low shock pulse values for over a year before the next spall occurred.

A shock pulse trend showing the typical increasing/decreasing pattern followed by a longer period with low values can be a warning sign of imminent bearing failure. The next spall can be sinister, leading to rapidly increasing shock pulse values.

ABOVE: **Severely damaged outer race**

Conclusion

The SPM HD method not only shows the existence of a potential damage, but the unique sensitivity of the method makes it possible to monitor the damage process in great detail, even down to individual spalls. As the damage progresses, the severity can be followed and replacement planned at the best suitable time.\\

About the author

Tim Sundström joined SPM Instrument in 2001 as head of research and development, where he has been deeply involved in SPM HD development and field evaluations.

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