Shock Pulse goes Spectrum

SPM Instrument AB, Sweden, launches a brand new diagnostic method in connection with Leonova™, a hand-held machine condition analyzer. Called the SPM Spectrum™, it is the result of an FFT on the time signal recorded with an SPM shock pulse transducer from a rolling element bearing. The individual bearing frequencies (BPI, BPO, 2*B2 and FT) and their harmonics are highlighted in the spectrum.

This is displayed together with the measured shock value and a light signal, green, yellow or red that shows the result of bearing condition evaluation.

Lou Morando, managing director of the SPM office in the U.S., explains the background. "I have to mention some elementary physics to explain what we are doing. The shock pulse method was the start of condition monitoring and condition based maintenance, targeting the machine part that causes most breakdowns, the bearings. The scientific task was to find a physical event that mirrored bearing condition, quantify it, and transform the measured value into a condition reading. Next, there is the engineering job of turning the research results into an instrument that can be used by mechanics in all kinds of industrial environments on all kinds of rotating machines.

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The physical events that we are measuring happen inside the material of the bearing, on a molecular level. Pressure variation and impacts in the rolling interface produce shock waves. These shock waves travel at sound speed through the bearing to the housing and on to all machine parts. Their energy levels of the shock waves diminish along the way, mainly when passing material interfaces. In vibration terms, they are known as "transients".

Eivind Söhoel, the inventor of the SPM Method, found that shock wave magnitude increases dramatically when bearing surfaces are stressed or damaged. He verified another very important fact: Shock wave magnitude is also a function of rolling speed but independent of the mass and stiffness of the application in which a bearing is used. That makes the shock wave very different from machine vibration.

Vibration is a complex oscillating movement of a whole body and the amplitudes we measure are very much a function of mass and stiffness, varying with unknown factors in every machine. With shock waves, all we need to know is the rpm and the shaft diameter to determine the bearing's evaluated condition.

Turning a physical event into a measuring result is an engineering feat. We have very little energy to work with. It's like trying to get a good picture of

Many ways to get relevant data: broadband vibration, shock pulses, spectrum analysis, speed, temperature, other signals in voltage or current, all from one instrument weighing only 600 grams. A 206 MHz Intel® StrongARM* processor crunches numbers to work out the easy answer: green for good, yellow for caution, red for bad.

Big money was lost when pump bearings failed during loading/unloading. Cause: vibration damage occurring while the pumps were idle. The Norwegian engineer Eivind Söhoel had a specific task: Find a method to measure bearing condition during test runs, so we can repair at sea and not waste harbor time. He found a way of measuring shock waves.

something very small: you can take the picture from a distance and then blow up a tiny part of it. You can use a zoom objective to enlarge the area of interest before taking the picture. Or you can get close and photograph with a macro lens.

> "The SPM Spectrum will indicate which bearing component is damaged"

To make this short: we use a specially tuned transducer and place it on the load carrying part of the bearing housing, where the shock waves are strongest. Thus we can present values for surface condition and for oil film thickness throughout the lifetime of the bearing, as we have been doing for over 30 years."

Then why the SPM Spectrum? "We do not use SPM Spectrum for condition measurement, not even for trending amplitude values. The bearing condition data is displayed first, together with the green – yellow – red signal. What the user needs is an equally fast verification. By collecting additional information on shock distribution over time and transforming the samples from the time domain into frequency domain, we can clearly show whether the energy input originates from the bearing we are measuring or, for example, from a damaged gear wheel that is also producing shocks. When a yellow or red bearing operation condition is displayed, the operator simply presses the spectrum button and looks at an FFT with the highlighted bearing frequencies. If the lines match, he is on target. The SPM Spectrum will indicate which bearing component is damaged, while the condition values will show the degree of damage.

This instant verification is extremely important. Nowadays less people have to get better results in a shorter time, measuring on machines that do not have the same mechanical redundancies as older, slower and more massive constructions. Working harder cannot do that, so we are making faster tools. Today's maintenance staffs want as much hard evidence as they can to prove that they are preventing downtime costs by stopping a process to replace a bearing.

We also want the extra data to improve on low RPM applications like drying cylinders in paper machines, where the typical shock pulse levels are low – more data is better to make an accurate evaluation. With the SPM Spectrum, we first record more measurements, then apply FFT mathematics to give our users the best of both worlds: a fast, field tested evaluation of the most relevant signal, and a graphical confirmation that they are precisely on target."

SPM has marketed vibration analyzers for several years, always in connection with its Shock Pulse Method for rolling bearings. "We have measured broad band vibration for twenty years, basing the condition indication on the international ISO standard limit values for vibration severity. In this field, we are adding the new ISO 10816 standards as fast as they are published. The RMS vibration values are now displayed as velocity, acceleration and displacement.

> "With Leonova, SPM has a state of the art platform bringing this new instrument into the world-class vibration analyzer market"

We developed our own variation of vibration analysis five years ago. We wanted the wider application range, data on more machine parts than bearings. In the process we realized that the best vibration analyzing technique available for measuring bearing condition, the enveloping technique, has always been an integral part of the Shock Pulse Method. We simply did not squeeze it for more data until now."

Does she know what she measures? Frankly, most condition inspectors do not care. They have more important questions: Is this good or bad? How bad? Can you give me proof to justify a production stop?

> "For example, take our trademark, the green – yellow – red. That is extremely simple – everybody understands a traffic light. "

With Leonova, SPM has a state of the art platform bringing this new instrument into the world-class vibration analyzer market. Leonova has true zoom, enveloping and produces a 6400 line vibration spectrum over frequency ranges up to 20 000 Hz. Lou Morando: "Far more than is needed for our main purpose, which still is condition monitoring under industrial field conditions. The high ranges are mainly for bearings, for which we have always used our tuned transducer with the 32 kHz resonance frequency. The power of the 206 MHz Intel® StrongARM* processor, the 64 Mb RAM and the large touch screen enables us to present a friendlier user interface, to store more historical data and show trend curves, and to easily add new functions.

Many process parameters, like flow rates and motor amps, are available as processsed signals, so we now measure analog signals 4 to 20 mA and 0 to 10 V. Leonova is also a balancing computer, giving a combination of graphics/text instructions for single and dual plane rotor balancing."

Listening to the feature list makes Leonova appear as a very complex tool indeed, something like a computerized Swiss army knife for people with engineering degrees. Lou continues, "We try to package our functions more neatly – like a one blade knife you can switch to most things. Leonova weighs only 600 grams (less than1.4 lbs.) and is very easy to operate. The more technology you have, the less it has to show at the user interface. For example, take our trademark, the green – yellow – red. That is extremely simple – everybody understands a traffic light.

The techniques used to produce this signal are very complex indeed, but they are invisible, working in the background. You can take Leonova to a machine, enter in two numbers and immediately see if anything is wrong with a bearing. The inputs for vibration analysis and SPM Spectrum are loaded from the PC into Leonova. The field operator needs only two buttons, "Measure" and "Save". To assist in setting up the measuring points, basic data, like a bearing catalogue complete with the manufacturers' frequency factors and our pre-calculated fault symptoms, are an integrated part of our software.

We realize that Leonova has more functions than many users will need. But as always, we leave it to our users to make the feature selection that suits their needs, technically and financially. Selling "function and use" are the key – if you need more functions later, simply add the desired features to your Leonova and the software. ○○○

With a normal vibration transducer, one uses its linear frequency range, so that measuring results are analog to the energy input at both ends of the specified range. SPM turns that around – they exploit the magnification effect occurring at the transducer's "useless" resonance frequency.

The upside down vibration transducer, specialized on picking up shock waves. It uses a dampened reference mass, precisely tuned to produce a mechanically amplified output when excited at a high frequency. The measuring circuit passes nothing outside of a narrow band around 32 kHz. The result: a train of pulses resembling the high pass filtered, demodulated result of enveloping a vibration.