condition monitoring

ViB vibration

Successful Solution *to the Challenge of* Low RPM Bearing Monitoring

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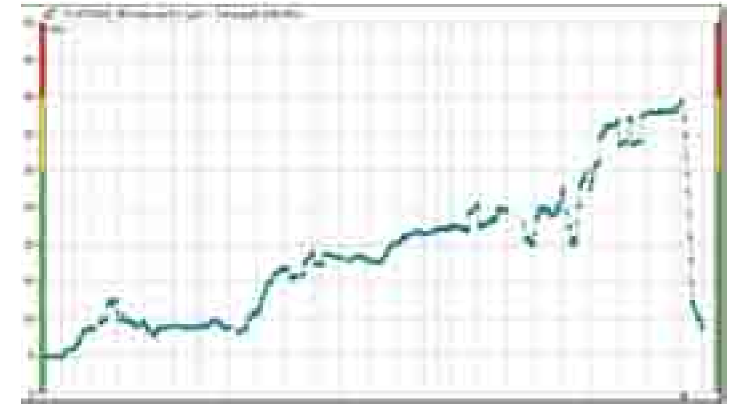
Low RPM applications have been notoriously difficult to monitor with traditional vibration-based techniques. The energy involved at RPMs below 50 is very low, making it a difficult task to extract meaningful information from the measured signal.

Using the newly developed SPM High Definition (SPM HD) method, we have been able to reveal never-before-seen details at very low RPMs (< 5 RPM). The SPM HD method is based on the fact that in the interface between the rolling elements and the raceways in an antifriction bearing, elastic, very short duration waves are generated. Damage—for example, a spall or a crack—will generate a high number of elastic waves due to the metal-to-metal collision when the rolling elements pass the damaged area. Using a transducer sensitive to these elastic waves makes it possible to record and quantify the waves. The transducers should be permanently installed, either mounted in drilled, countersunk mounting holes on the bearing housings, or glued onto the surface. For best results, the transducers should be mounted close to the bearing load zone.

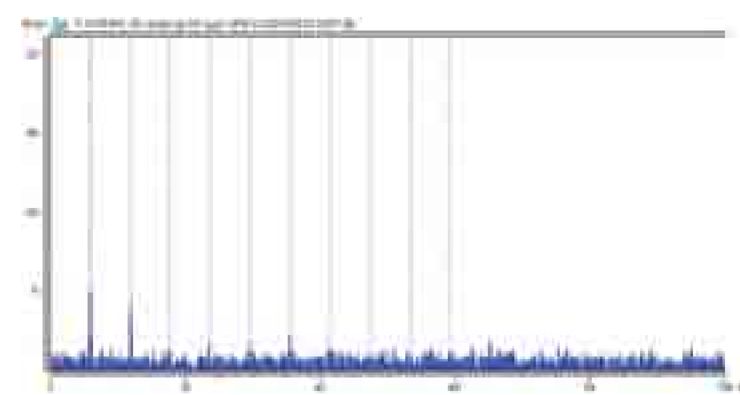
At Holmen Hallsta paper mill in Sweden, a field test on four twin wire presses (used in the pulp industry for dewatering purposes) has been running for nineteen months. During this period, thirteen bearing faults have been successfully identified. There are examples from the test period where the pre-warning time has been over fourteen months between the first damage indication and replacement of the bearing. A more typical pre-warning time is about six months. Typical RPM ranges from 7 to 16. The system is taking measurements every 6 hours and a typical measuring time at this RPM range is about 10 minutes.

Using a real case example from the twin wire press application, Figure 1 is an account of the different stages of the bearing deterioration process, detected with the SPM HD method.

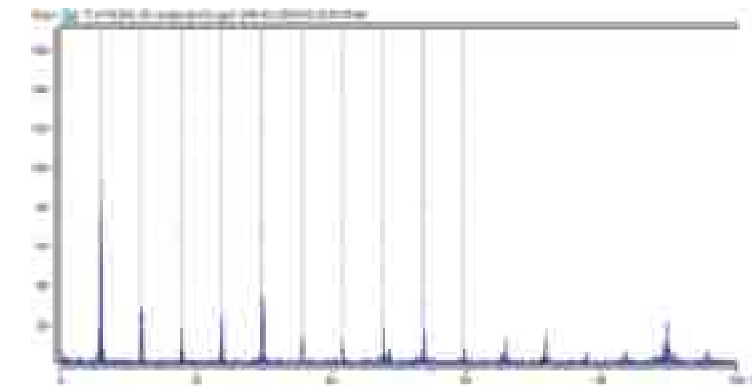


Above: An SPM HD trend spanning between mid-June, 2010 to end of November, 2010, showing 624 readings taken approximately 6 hours apart. The graph shows the primary parameter produced by the SPM HD method: the strongest impact found during the measuring time. The Y scale is logarithmic.

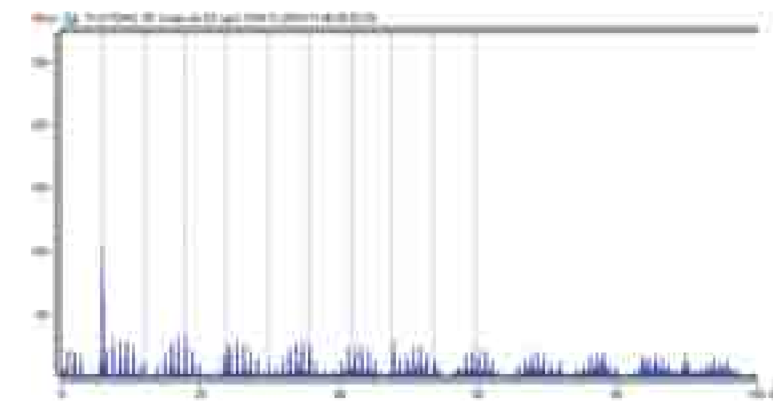
The difference between the lowest and the highest value in the trend graph is about 30 dB (30 times on a linear scale). The drop in the value from 40 dB to 8 dB is after bearing replacement. A moving average filter has been applied with 10 average values. This explains why the values seem to decrease slowly after the replacement. Note the typical pattern of increasing values followed by a period of decreasing values. This behavior is caused by fresh spalling followed by a period of mechanical softening of the sharp edges around the spall. When the rolling elements collide with the sharp edges of the spall, strong elastic waves will be generated at the point of collision. After some period of time (a couple of weeks in this application) the sharp edges wear down and the metal-to-metal collisions become less strong, hence decreasing the strength of the elastic waves. The next spall will then generate a similar pattern.



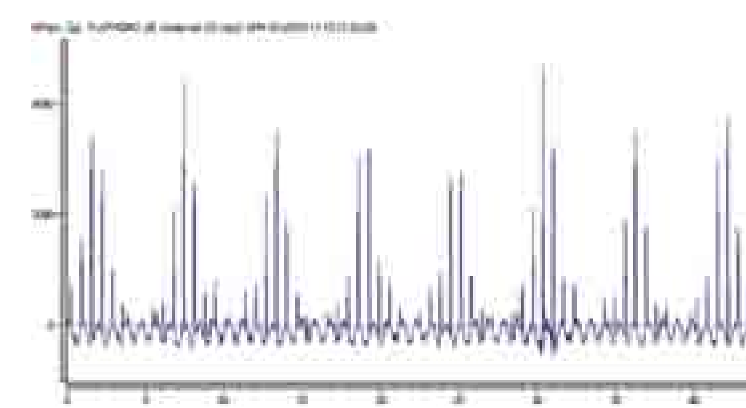
Above: An SPM HD Spectrum taken in a very early stage of the bearing deterioration process. The Y scale is linear and 5 harmonics to the BPFO line can be seen. The reading was taken on August 23, 2010 and RPM on this occasion was 9.39.



Above: An SPM HD Spectrum measured on October 29 at 10.84 RPM. The outer race signal is clear, with several harmonics. The amplitude has increased 20 times indicating more severe outer race damage.



Above: On November 6, 2010, a new frequency component becomes visible in the spectrum, directly corresponding to the BPFI. The outer race frequency is still there, and the typical 1X modulation of the inner race signal is obvious. This measurement is at 10.85 RPM. This behavior of an initial steady increase of the outer race signal, followed by a distinct inner race signal, has been found in several places on this application.

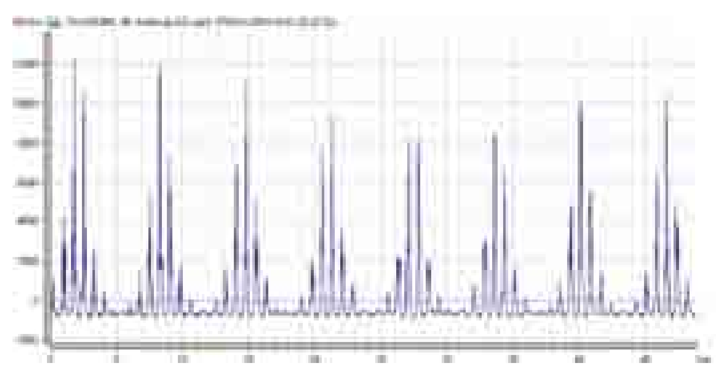


Above: An SPM HD Time signal with extraordinary sharpness.

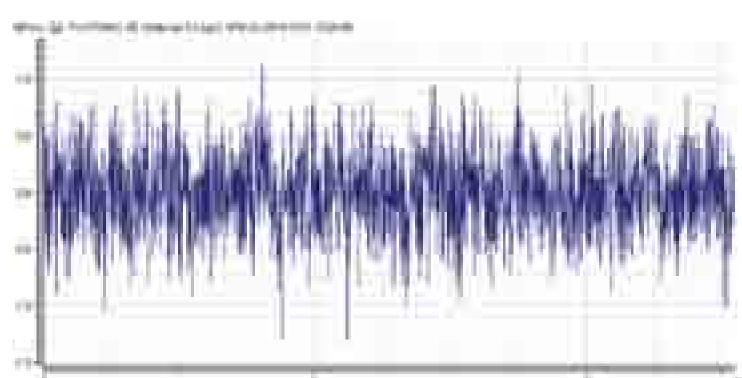
The reading was taken on November 12, 2010 and clearly shows an inner race and an outer race signal in combination. The RPM is 10.84. Note the inner race modulation where the distance between the "bursts" is exactly 1 revolution. Also note the smaller signals from the outer race.

The typical time signal pattern from an inner race damage as seen in this picture is explained by studying a bearing load zone. When the inner race damage enters the load zone, it will collide with the rolling elements. In the middle of the load zone, the forces are strongest, hence producing the strongest impacts. When the damaged area of the inner race leaves the load zone, the impacts will decrease again.

The fact that the strongest impacts are not constant in amplitude is an interesting observation. Studying the picture above, it is clearly seen that the strongest impact from each "burst" exhibits a cyclic change. The explanation can be found in bearing geometry. Sometimes, the damaged area, the maximum load zone force, and a rolling element coincide, producing a strong collision. Sometimes they will not coincide, resulting in a lower amplitude impact.



Above: SPM HD Time signal immediately before bearing replacement.



Above: SPM HD Time signal immediately after bearing replacement.

In the two figures above, note the amplitude compared with the picture from before bearing replacement. The amplitude difference between a damaged bearing and a new one is obvious.

As mentioned earlier, this is but one example from the twin wire press application. The other twelve cases are similar to this one. In most of the cases, the increasing/decreasing trends are more pronounced. Based on the twin wire press application as well as other low RPM applications, our experience is that due to the increasing/decreasing trends, measuring with handheld equipment is not advisable for low RPM applications. There is an obvious risk that the measurement was taken during a period where the edges of a possible spall are "soft," and therefore produce low amplitude impacts. Unless measured very frequently with handheld equipment, we strongly recommend continuous measurements using online equipment.

Disassembled bearing with spallings.

Conclusions

The SPM HD method enables measuring results with exceptional clarity. Even on low RPM applications, spectrums and time signals are crisp. In field tests running for more than nineteen months, we have been successful in the identification of bearing damages, typically with six months pre-warning time before the actual bearing replacement.

Tim Sundström, born 1964 in Sweden, has a M.Sc. degree in Applied Physics and Electrical Engineering from Linköping University, Sweden. For over twenty years, he has been specializing in electronics development and has held managerial positions in the field since 1992. In 2001, he joined SPM Instrument as head of Research and Development, where he has been deeply involved in SPM HD development and field evaluations. Visit www.spminstrument.com