Checking the pulse of bearing health

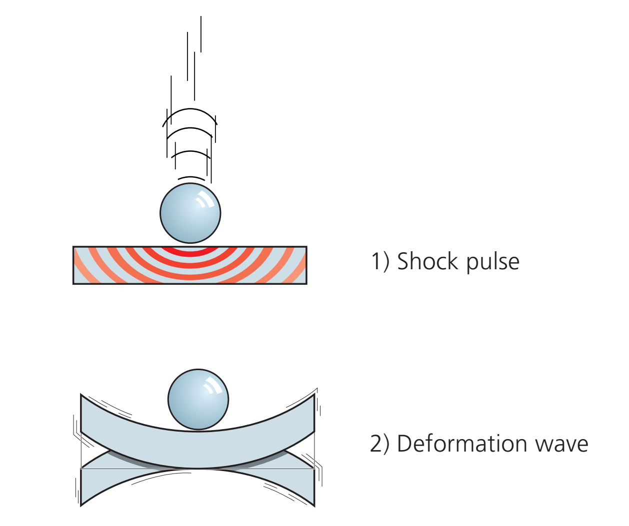
Reliable shock pulse evaluation of anti-friction bearing condition

Introduction

Of the various methods used to assess the operating condition of anti-friction bearings, one of the most successful and popular techniques is that of shock pulse evaluation. Shock pulses are a special type of vibration which must be clearly distinguished from ordinary machine vibrations:

1) The actual shock pulse is the pressure wave generated at the moment when one metallic object strikes another.

2) The bulk of the impact momentum, however, acts to deform the target object, which then oscillates at its natural frequency. This vibration ultimately dissipates primarily as heat due to internal friction (material damping).

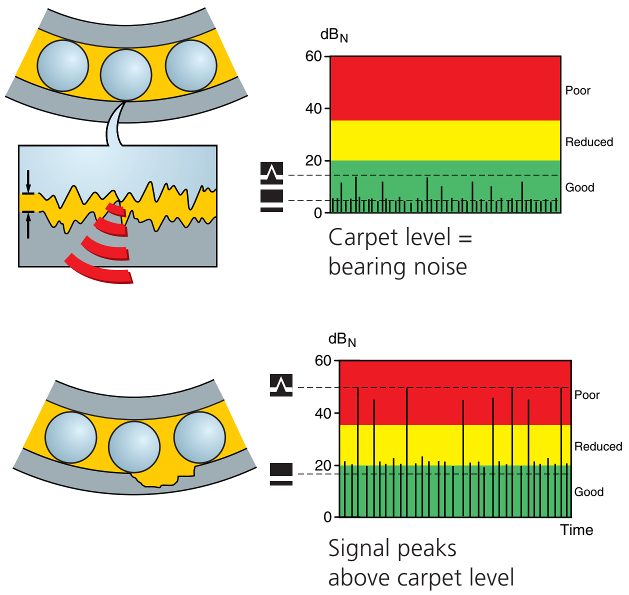


Shock pulses in bearings

Shock pulses occur during bearing operation when a rolling element passes over an irregularity in the surface of the bearing race. Of course, there is no such thing as a perfectly smooth surface in real life, and so even new bearings emit a signal of weak shock pulses in rapid succession. This 'carpet level' rises when the lubrication film between rolling elements and their races becomes depleted.

A defect (pit or crack) on the surface of a rolling element or bearing race produces a strong shock pulse with up to 1000 times the intensity of the carpet level. These irregular peaks (the 'maximum value'), which stand out clearly from the background level, are ideal indicators of bearing damage.

Shock pulse diagrams

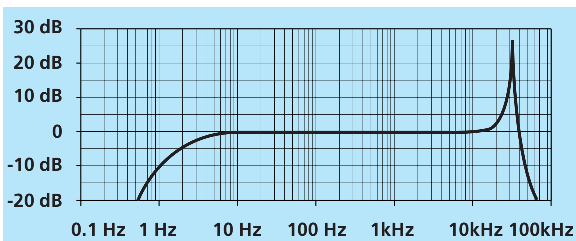


Signal strength shown in logarithmic decibels (dB) for clarity: 60 dB represents a change of 1000x.

Measurement

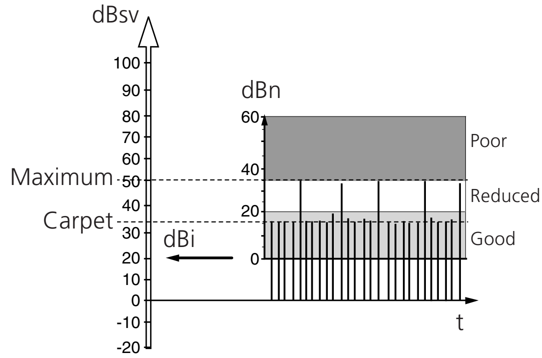
Shock pulses propogate within a much higher frequency range than that of ordinary machine vibration, and their energy content is much weaker. Therefore, the accelerometer used for shock pulse measurement has a resonance frequency (approx. 36 kHz) that lies precisely within this range. This means that in this high frequency range of particular interest for bearing condition evaluation, the transducer is especially sensitive to the shock pulse signal - even when far more energetic machine vibration occurs at lower frequencies (for example, due to unbalance or shaft misalignment) or from adjacent machines. And since high-frequency signals tend to dissipate rapidly, very little interference is encountered from adjacent bearings.

Accelerometer frequency response



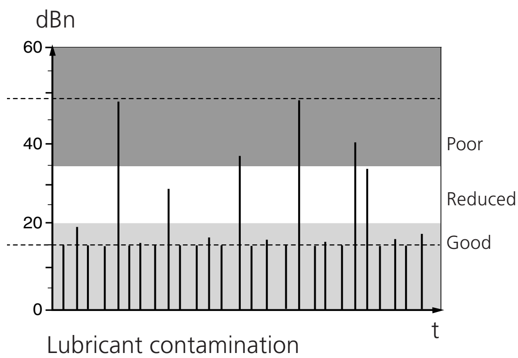
Evaluating bearing condition

Just as with other condition evaluation methods, the shock pulse technique reaches its conclusions via certain defined parameters. These are influenced by factors such as bearing size, RPM, signal damping and lubrication, and so shock pulse readings generally should be compared with 'signature' readings (taken when condition is known to be good) or normalized to take these factors into account.
Over the years, reliable normalization methods have been developed, based upon extensive measurements, to calculate the effect of bearing size and RPM on shock pulse readings of new, perfect bearings. The normalized signal level (dBn) calculated for an actual bearing allows its condition to be rated directly as 'good', 'satisfactory' or 'poor'.
The validity of this statistical method is confirmed by a practical success rate of up to 90%.



Quantitative analysis

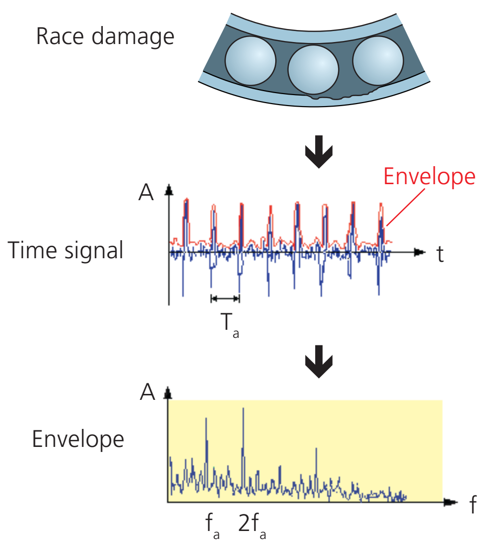
Two normalized parameters are used to determine bearing condition: the carpet value previously mentioned indicates deterioring or poor operating condition (e.g. caused by insufficient lubrication, shaft misalignment or improper installation).
Damaged bearing elements, in contrast, generate individual shock pulses of greater intensity. The resulting maximum value is a direct indication of bearing operating condition. Specific types of damage can be recognized not only from the absolute signal amplitude, but also from the difference to the carpet level and the pattern of pulses. Comparison with typical shock pulse diagrams often shows clearly where the problem lies (e.g. 'lubricant contamination').



Lubricant contamination

Qualitative analysis

Analysis of the signal 'envelope' offers a detailed depiction of the source and extent of bearing damage. Here the outline of the bearing time signal is transformed into a spectrum. Shock pulses that occur at regular intervals in the time signal can then be clearly seen as peaks which occur at the corresponding damage frequencies. The frequencies characteristic of bearing damage can be calculated from the geometric information of the particular bearing.
This process allows highly accurate diagnosis of bearing damage – even when external signal interference (such as that from gear tooth meshing) would otherwise tend to cover up the bearing signal. In contrast to the shock pulse method, which is based upon measurement and evaluation



Damage frequency $f_a = 1/T_a$

of single-value parameters, the envelope technique requires experience on the part of the user as well as extensive computing power and memory capacity of the FFT analyzer instrument.

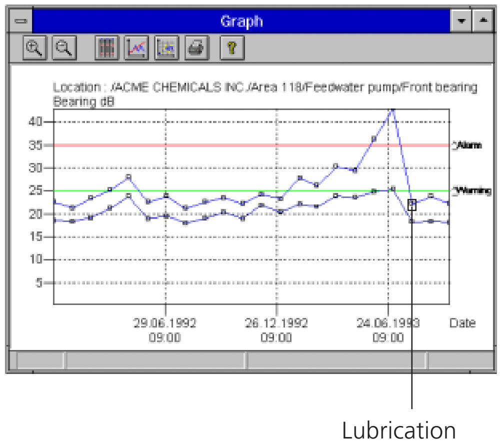
Applications and advantages

The shock pulse method is suitable for use with all types of anti-friction bearings installed on rotating equipment (such as motors, pumps, turbines and compressors).

When parameters are recorded at regular intervals, any deterioration in bearing condition can be recognized immediately. The required maintenance procedures can then be planned and carried out with maximum efficiency, long before the bearing fails, bringing production to a halt along with it.

Bearing trends plotted over longer periods of time offer additional information on premature wear, improper installation and lubrication problems – or even improper machine operation (such as overloading) or defective machine parts.

Trend diagram of carpet and maximum values



Summary

Just as with any other method, the shock pulse technique cannot guarantee infallible bearing evaluation, but can only deliver measurement values for comparison with known types of bearing damage. Twenty-five years of practical experience has shown, however, that its evaluation criteria have proven their reliability in practical use.

Future development

Even after twenty-five years, the shock pulse phenomenon still holds considerable potential for practical development. PRÜFTECHNIK AG is therefore continuing its commitment of research resources toward further refinement of signal measurement and evaluation in order to achieve even higher accuracy of diagnostic results.