Introduction

Ball and roller bearings are among the most common and important elements in rotating machinery. Every rolling element or anti-friction bearing has a limited life which is strongly influenced by installation, operating condition and the maintenance it receives. Machine reliability, efficiency and safety depend on bearings functioning properly. Eventually, metal fatigue causes every bearing to wear out and fail. Bearings fail prematurely due to operating condition, lubrication and usage problems. When a bearing does fail, the secondary damage to associated machine parts and the loss of production greatly exceeds the cost of replacing the bearing. Replacing bearings after a set number of hours is also risky since good bearings are thrown out needlessly and unscheduled failure can still result. The best solution then is to systematically monitor bearing condition and schedule replacement at times least influencing production efficiency.

The Shock Pulse Method: A Superior Alternative to Vibration Analysis

Several methods are currently used to monitor bearing condition. The most common is vibration analysis. This can be as simple as “listening” to or “feeling” for roughness using human senses or using sophisticated spectrum analysis. Temperature, sonic and ultrasonic noise and acoustic emission measurement techniques, among others, are also used. All of these methods can be influenced by outside factors other than bearing condition. Since vibration analysis is widely used, it deserves comment.

A change of speed, mass or alignment of any machine part will cause some changes in it vibration spectrum. Detecting and measuring that a change has occurred is quite straightforward using reliable vibration analyzers; interpreting and predicting the reasons for this change are not so easy. In many cases, failure detection is performed in the 20Hz to 20KHz frequency range. However, quite often the bearing can reach an advanced stage of damage before the vibration signature at the frequencies related to the speed of rotation increase above that of the background noise level. By the time the bearing vibration signal is large enough to be reliably detected, in many case the bearing is close to failure, providing very little warning time.

A method based on monitoring the mechanical impacts caused by bearing damage and operating condition problems is now available and widely used. This technique allows a bearing’s condition to be tested over its entire life. It is not influenced by design, size, or background vibration of the machine. this technique, the Shock Pulse Method (SPM), originated in Sweden, is patented in most countries and is now widely used in many industries.

The SPM Method — Basic Theory

In simple terms, the SPM Method detects development of a mechanical shock wave caused by the impact between two masses. At the instantaneous moment of impact, molecular contact occurs and a compression (shock) wave develops in each mass. The SPM Method is based on the events occurring in the mass during the extremely short time period after the first particles of the colliding bodies come in contact. This time period is so short that no detectable deformation of the material has yet occurred. The molecular contact produces vastly increased particle acceleration at the impact point.

Specifically, let’s examine what happens during a mechanical impact. Refer to Figure 1A where a ball is dropped onto a bar. Before the impact, the bar is at rest and the ball has a certain velocity (v). At the very instant of impact, the bar surface and ball surface will meet with a velocity equal to the ball velocity.

At the impact point, a large acceleration of the material is initiated. During this initial phase of contact, the magnitude of this acceleration is solely dependent upon the impact velocity and is not influenced by the relative sizes of the ball and bar or by an mechanical vibration. The acceleration of the material at the impact point sets up a compression wave which propagates ultrasonically in all directions through the bar. Another wave also travels through the ball. The magnitude of the wavefront is an indirect measurement of the impact velocity (v).
During the second phase of the impact (Figure 1B), the ball and bar surfaces will deform and the energy of motion will deflect the bar and cause vibrations in it. This is the vibration normally detected by vibration analysis. The SPM Method detects and measures the magnitude of a mechanical impact by detecting and measuring the resultant compression wavefront (shock pulses).

SPM Instrument uses a piezo-electric accelerometer to measure the mechanical impact or shock pulse, without being influenced by other factors such as background vibration and noise. This transducer is tuned mechanically and electrically to a resonant frequency of 32KHz. The compression wavefront (shock pulse) caused by a mechanical impact sets up a dampened oscillation in the transducer at its resonant frequency. This is shown in Figure 1 as a dampened transient electrical output caused by the impact. The peak amplitude of this oscillation (A) is therefore directly proportional to the impact velocity (v).

Because the dampened transient is well defined and of a constant decay rate, it is possible to electronically filter out all other signals, i.e. the vibration signals. The measurement and analysis of the maximum value of the dampened transient (A) is the principle behind the SPM Method for monitoring the condition of anti-friction bearings. See Figure 2.

Using the SPM Method to Monitor Anti-Friction Bearings

Bearing surfaces always have a degree of roughness. When the bearing rotates, this surface roughness or a surface defect will cause mechanical impacts. These mechanical impacts produce shock pulses causing the bearing to act as a “shock pulse generator”. The magnitude of these pulses are dependent upon the surface condition and the peripheral velocity of the bearing (r.p.m. and size). See Figure 3.

Shock pulses generated by a bearing increase up to 1000 times from when the bearing is in good condition to when it needs replacement. Only the SPM Method accurately interprets these shock pulses through the bearing’s life: from initial installation to final replacement. Unlike vibration analysis, SPM bearing analyzers have the unique ability to analyze and display lubrication and bearing condition without needing to develop base line data for trending.

The SPM Method’s ability to detect and quantify bearing damage makes it possible to prepare and schedule the bearing’s replacement for the most convenient time, without running the risk of failure and costly additional damage to the machine.

SPM Instrument manufactures a complete line of instruments, systems, and accessories incorporating the Shock Pulse Method. They offer a practical approach to increase productivity, reduce downtime, and provide the maximum in overall efficiency for industrial plant environments.