MOTOR VIBRATION: SYMPTOM OR DISEASE ?

Let us begin by defining what vibration is. It is the oscillation of any object about some reference point. It is caused by an alternating force which is present in a structure either because of an external influence or excitation within the structure itself.

Vibration in a rotating machine, troublesome itself, may serve as an indicator of more serious trouble. Low frequency vibrations or those which cause parts to contact each other, often emit audible sounds. The vibrations most associated with machinery problems are seldom in the audible range; therefore, we cannot "hear trouble coming."

A nationwide study of commercial and industrial motor failures indicated that the predominant "initiator," 33% of the total, was mechanical breakage. The largest single contributor to failure was high vibration resulting from inadequate maintenance. Obviously, this makes a strong case for the critical importance of having a vibration monitoring program.

Often there is a tendency to think of vibration as being unbalance. While it is true that unbalance causes vibration, even a well-balanced machine may exhibit destructive vibration. These vibrations may be caused by such things as shaft misalignment, load torque pulsation, foundation resonance, or forces coming from other machines.

Vibrations cause damage due to the alternating force producing both impact and stress reversal. This is analagous to bending a wire coat hanger until it breaks. Impact force varies directly as the square of the speed of the moving object. For this reason, measuring vibration in displacement is not the best indicator of possible vibration damage.

Universal experience has indicated that vibration velocity is the best measure of vibration severity over a wide frequency range. Velocity is directly related to the amount of vibration energy being dissipated. This amount of energy, and the damage associated with it, is independent of frequency.

Vibration metering ranges from things as simple as a dial indicator (for low frequencies) to computerized analyzers with a tremendous scope of measuring capabilities. The simpler vibration meters indicate vibration levels only and can be used to detect whether or not a problem exists. Identification of a vibration source requires at least the ability to "tune" to different frequencies, and measure amplitudes over a frequency range. Periodically checking the pattern of frequencies present in machine vibration is called "signature analysis." A continuing record of frequency versus magnitude will show a consistent pattern for a machine in good, stable condition. Conversely, a changing signature pattern indicates trouble, and the frequencies which change can be interpreted to identify probable causes.

Modern analyzers for this type of repetitive readings are spectrum analyzers. These are compact, portable, and equipped with a computer memory to store the spectra of frequency vs. magnitude. Today these instruments are supported by software programs to store an unlimited amount of data, print it out, or display various combinations of data on a computer screen. They can also "zoom" in on narrow frequency ranges. For example, it is only recently that this type of relatively affordable equipment could distinguish between two times running speed of a 2-pole motor, and electrical frequency. Typically this means being able to look at vibration at 7140 cycles/min (2 x 3570 rpm) and 7200 cycles/min (2 x 60 Hertz). Incidentally, line frequency must be multiplied by 2 to account for the positive and negative peaks in the sine wave which occurs in each cycle.

Vibration monitoring, with today's equipment, can be used on low speed, say 10 rpm, equipment as well as high speed machines. Bearing condition detection techniques and instruments are available that do not depend on bearing speed.

The more frequently readings are taken, the better the ability to assess conditions, and make predictive judgements. Twice a year may be suitable for low speed machines, weekly for high speed machines in severe environments or critical applications, and most common for typical machines is quarterly testing. Frequency of testing depends on many factors, such as: economics, management philosophy, insurance requirements, importance to production, etc.

Just as there is a wealth of equipment available to test for vibration, there is no shortage of vibration standards. NEMA sets only factory test values, not limits for installed use. Other prevalent standards are military, American Petroleum Institute, Hydraulic Institute (pumps), and the International Standards Organization. Each takes a different approach, thus leaving the user with having to select a standard which appears to "best fit" their situation. For face-value judgements, based on a number of recognized sources and standards, we use:

up to .10 in/sec	Good operating conditions.
.10 to .20	Satisfactory
.20 to .35	Correct to extend life
.35 to .50	Unsatisfactory - mechanical wear
over .50	Severe wear - correct ASAP

Equally important is to compare readings from time to time. These comparisons, or trend values, are the heart of predictive maintenance. They allow for planned, instead of unscheduled, repairs.

Complicating the significance of vibration measurements is the simple fact that system stiffness and vibration level will usually be different in different directions. Readings should be taken at bearing housing, and in line with the shaft, to detect the vibration in the rotating parts. When harmful vibration is found, there are three ways to reduce it. These are structural changes to reduce resonance, damping to absorb vibration energy, or balancing to reduce inertial forces in rotating parts. Any of these three usually involves special equipment and training, not a place for trial-and-error appearances.

Adjustable speed drives are becoming more and more popular today and may be in the majority of motor applications a decade from now. Since many resonant frequencies may be excited in the operating speed range, it is important to perform vibration analysis, and effect reduction if needed, at the time of drive installations. This is especially important on retrofits for what had been fixed speed drives.

To answer our original question, motor vibration is both a symptom and a disease. As a symptom, it is the precursor of trouble. As a disease, it is more widespread than most people are aware of. The best solution is prevention by way of a predictive maintenance program.