VIBRATION ANALYSIS FOR ROTATING MACHINES

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The most commonly used method of identification failures for rotating machines is called vibration analysis. Measurements can be taken on machine bearing casings with seismic or piezo-electric transducers to measure the casing vibrations, and on the vast majority of critical machines, with eddy-current transducers that directly observe the rotating shafts to measure the radial (and axial) vibration of the shaft. The level of vibration can be compared with historical baseline values such as former startups and shutdowns, and in some cases established standards such as load changes, to assess the severity.

Interpreting the vibration signal obtained is a complex process that requires specialized training and experience. Exceptions are state-of-the-art technologies that provide the vast majority of data analysis automatically and provide information instead of data. One commonly employed technique is to examine the individual frequencies present in the signal. These frequencies correspond to certain mechanical components (for example, the various pieces that make up a rolling-element bearing) or certain malfunctions (such as shaft unbalance or misalignment). By examining these frequencies and their harmonics, the analyst can often identify the location and type of problem, and sometimes the root cause as well. For example, high vibration at the frequency corresponding to the speed of rotation is most often due to residual imbalance and is corrected by balancing the machine. As another example, a degrading rolling-element bearing will usually exhibit increasing vibration signals at specific frequencies as it wears. Special analysis instruments can detect this wear weeks or even months before failure, giving ample warning to schedule replacement before a failure which could cause a much longer down-time. Beside all sensors and data analysis it is important to keep in mind that more than 80% of all complex mechanical equipment fail accidentally and without any relation to their life-cycle period.

Most vibration analysis instruments today utilize a Fast Fourier Transform (FFT) which is a special case of the generalized Discrete Fourier Transform and converts the vibration signal from its time domain representation to its equivalent frequency domain representation. However, frequency analysis (sometimes called Spectral Analysis or Vibration Signature Analysis) is only one aspect of interpreting the information contained in a vibration signal. Frequency analysis tends to be most useful on machines that employ rolling element bearings and whose main failure modes tend to be the degradation of those bearings, which typically exhibit an increase in characteristic frequencies associated with the bearing geometries and constructions. In contrast, depending on the type of machine, its typical malfunctions, the bearing types employed, rotational speeds, and other factors, the skilled analyst will often need to utilize additional diagnostic tools, such as examining the time domain signal, the phase relationship between vibration components and a timing mark on the machine shaft, historical trends of vibration levels, the shape of vibration, and numerous other aspects of the signal along with other information from the process such as load, bearing temperatures, flow rates, valve positions and pressures to provide an accurate diagnosis. This is particularly true of machines that use fluid bearings rather than rolling-element bearings. To enable them to look at this data in a more simplified form vibration analysts or machinery diagnostic engineers have adopted a number of mathematical plots to show machine problems and running characteristics.

Handheld data collectors and analyzers are now commonplace on non-critical or balance of plant machines on which permanent on-line vibration instrumentation cannot be economically justified. The technician can collect data samples from a number of machines, then download the data into a computer where the analyst or artificial intelligence can examine the data for changes indicative of malfunctions and impending failures. For larger, more critical machines where safety implications, production interruptions, replacement parts, and other costs of failure can be appreciable, a permanent monitoring system is typically employed rather than relying on periodic handheld data collection. However, the diagnostic methods and tools available from either approach are generally the same.

Performance monitoring is a less well-known condition monitoring technique. It can be applied to rotating machinery such as pumps and turbines, as well as stationary items such as boilers and heat exchangers. Measurements are required of physical quantities: temperature, pressure, flow, speed, displacement, according to the plant item. Absolute accuracy is rarely necessary, but repeatable data is needed. Performance analysis is often closely related to energy efficiency, and therefore has long been applied in steam power generation plants.

To draw the conclusion, one can say that vibration analysis is the most widespread and versatile method of diagnostics for rotating equipment. Therefore it has a big field for further investigation.

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