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Basic concepts of vibrations in electric motors and generators

Introduction

Various factors are involved in the vibrations of rotating equipment, among which the most common are mass unbalance, misalignment, failure of rolling components in bearings, failure of gearbox gears, leakage, and so on. One of the most effective methods of maintenance and repair is CM or condition monitoring, which has been considered more and more in all aspects of the industry today, and with the devices and hardware becoming more precise, the need to process delicate engineering matters is always in front of prominent engineers, which can play an important role in the effective and useful implementation of resources, reducing waste and costs, increasing efficiency and productivity. Homogeneity in the efficiency of the Sections of a production unit contributes to the production efficiency and, conversely, a defect in a piece of any equipment due to lack of monitoring of the situation will reduce efficiency. As we know, one of the main CM tools is vibration analysis. Vibration analysis and monitoring can be a simple and hassle-free task. You can save money by monitoring machine vibrations and utilizing related information.

What are vibrations

Most of us are familiar with vibrations. Vibration is the movement of an object back and forth. Vibration is an object's oscillation. We have experienced many examples of vibration in our daily lives. A simple pendulum is an example of vibration. The sound of the guitar is caused by the vibration of its strings. The movement of vehicles on rough and uneven ground causes vibrations, and geographical activities such as earthquakes also cause massive vibrations. There are different ways to notice vibration in objects. We can touch the object and feel these vibrations. We can also see forward and backward movements due to vibration. Sometimes vibrations create a sound that we can hear, or a warmth that we can feel. To understand how vibration creates sound and heat, you can drag your finger on the carpet. In industrial machinery, there is a type of vibration that we are concerned about and interested, which is machinery vibrations.

In simple terms, machine vibrations are the simple back and forth movement of the machine or machine components. Every forward or backward movement or oscillation is considered a vibration. Machinery vibration can be in many forms. A machine component can vibrate at high or low amplitudes, fast or slow with or without sound, and with noticeable heat. Machine vibrations are sometimes purposefully designed and useful, such as screens or surface polishers. In other cases, the vibrations of machines are unwanted and can cause damage to the device.

The cause of all electromotor vibrations is often one or more of the following problems:

Repetitive forces •

Imagine a boat anchored in the bay where the waves are hitting the sides of the boat, and as long as the waves hit the boat in the same way, we will naturally have the boat oscillating. The boat will shake as the force waves, which are repeated over and over again according to a pattern, hit the boat. Repetitive forces are also the cause of most vibrations in electric motors and generators. Repetitive forces similar to those mentioned occur in the electric motors and generator components and cause the machine to vibrate.

The repetitive forces in electromotors and generators are often caused by the rotation of the components of electromotors and generators, which are unbalanced, non-coaxial, and worn parts, or electromotors and generators that have improper actuators.

Mechanical looseness •

Mechanical looseness in the components and mounting bases of electric motors and generators causes the vibration of electric motors and generators. If the components or mounting bases of electric motors and generators are loose, normal vibrations that are within acceptable limits may be excessive and unrestrained.

Resonance •

Electric motors and generators often tend to oscillate at a certain rate. The oscillating frequency that every electric motor and generator tends to oscillate is called the natural oscillating frequency of that electromotor and generator.

The natural oscillation frequency of an electromotor and generator is the same as the natural vibration frequency with which the electromotor and generator prefer to vibrate. When the electric motor and generator are released to vibrate freely, they will tend to oscillate with the natural frequency.

Electric motors and generators fluctuate more than a normal frequency. An example of a device that has two components with different oscillating natural frequencies shows at least two different natural oscillating frequencies. In general, electric motors and generators with more combinations also have more natural oscillations.

What happens if repetitive forces push an electric motor or generator with a natural oscillating frequency? These conditions cause the electromotor or generator to vibrate more and more. This repetitive force encourages the electromotor or generator to vibrate at its normal frequency.

The electromotor or generator will vibrate excessively, not only because these forces encourage the electromotor or generator to vibrate at a rate that the electromotor or generator tends to do, but also because it receives external assistance or vibration. The generator that vibrates in this way experiences resonance.

The repetitive forces that cause resonance may be small and due to the movement of intact components of the electromotor or generator. Highly repetitive forces can not cause a problem unless they cause resonance. However, resonance must be avoided because it can cause rapid and severe damage.

Description of vibration

By observing, feeling, and hearing the machine vibrations, we can make general and approximate decisions about the intensity of the vibrations and figure its intensity. Some special forms of vibration may be intense and violent, some of which may be noticeable and some of which may be slight and minor. We can also touch the bearing and feel the heat from the vibration, or we can hear the noise and conclude that there is something wrong.

The description of the machine vibrations relying the general explanation is inaccurate and depends on the person. What is felt in this way may be intense to one person and acceptable to another. These inaccurate diagnoses are usually unreliable.

For acceptable and reliable analysis of vibration issues, it is necessary to analyze vibrations in a stable and reliable manner.

To analyze vibrations accurately and effectively, these analyzes should, in principle, be based on precise numerical criteria, not superficial descriptions.

Important numerical criteria indicate vibrations, amplitude and frequency. Vibration amplitude and frequency describe the rate of vibration fluctuations. Amplitude, frequency, waveform, and spectrum together provide a means by which the causes of vibration can be traced.

Amplitude •

The amplitude of a vibration indicates the magnitude of that vibration. An electric motor or generator with a high vibration amplitude is a machine that is tolerating a large, fast, or powerful vibrational motion.

A larger amplitude means that it can withstand more or more stressful motion, which makes this electromotor or generator more prone to failure.

: The vibration amplitude or magnitude is generally related to the following
The dimension of vibrational motion ✓
(Movement velocity (simply the velocity of movement measured in a certain direction ✓
The force caused by vibrational motion ✓
In most cases, it is the velocity or acceleration that gives us the most useful information about the
. condition of the electric motor or generator
The velocity amplitude can be measured by reading the amount of available peak or the root mean
. (square (RMS
Simply put, the peak point of the velocity amplitude in machine vibration is the maximum vibration
. velocity that the machine achieves in a given period of time
Compared to the peak, the RMS velocity range indicates the vibration energy of the machine. Higher RMS indicates more energy. It is important to know that the RMS amplitude is always less than the
. vibration peak amplitude

Frequency

The vibrating components of an electric motor or generator oscillate, a repetitive motion that is repeated in cycles. The components of an electric motor or generator may oscillate fast or slow, depending on the generating force. The rate of oscillation of each component is called the oscillation
. frequency of that component. A higher vibration frequency indicates faster oscillation
The vibrational frequency of machine components is defined by counting the number of complete
. oscillating cycles per second
Just as the heart rate or its frequency which indicates the excitement of the person or the general health state, the vibration frequency of the electromotor or generator components is often a good method to . indicate the condition of the machinery
Similar to amplitude, frequency is represented by a unit. The typical unit for cycle frequency is CPM(Cycle Per Minute) . Hertz is a unit equivalent to cycles per second, which ۱Hz is equal to ۱ CPS or ۶۰ CPM

Wave form •

Graphical representation of electrical signals taken from the human heart (electrocardiogram or ECG) is a practical tool for analyzing the condition of the human heart. In a similar way, a graphical
. representation of vibrational motion is a practical tool for analyzing the nature of vibration
. A graphic screen is generally used by a vibration analyzer to see the waveform

. The waveform is a graphical representation of the vibration changes over time
The amount of information that the waveform includes depends on the duration and resolution of the waveform. Waveform duration is the sum of the periods of time from which wave information may be obtained, equal to only a few seconds in most cases. Waveform resolution is the measurement of the amount of detail in a waveform, which is determined by the number of dots in the data or the samples
. described in the waveform. If there are more examples, more details are available about waveforms

Spectrum •

Another common tool that can be used to analyze vibrations is spectrum analysis. A spectrum is a graphical representation of the frequencies of a vibrating component of an electric motor or generator along with the amplitude of those frequencies on a graphical display .

But how can an electric motor or generator component vibrate at several different frequencies? The answer lies in the fact that, unlike the simple oscillation of a pendulum, in electric motors and generators, often the oscillating motion does not involve just a simple vibrating motion. Rather, it involves several vibrational movements occurring simultaneously .

For example, the velocity spectrum caused by the vibration of the bearing indicates that the bearing does not vibrate at only one frequency, but vibrates at several different frequencies. Vibration at certain frequencies may be due to the movement of the bearing elements, the interaction of the gear teeth, and due to the rotation of the motor rotor at other frequencies .

Since it shows the spectrum of vibration frequencies, it is one of the practical tools for vibration analysis. By studying the frequencies individually, where the components of the electromotor or generator are oscillating, as well as the amplitudes of those frequencies, much information can be obtained about the causes of the vibrations and the condition of the machine .

Conversely, the waveform does not clearly indicate the frequencies at which the vibrations occurred. Instead, the waveform shows the results as a whole. Thus, it is not easy to troubleshoot complex defects of an electric motor or generator by waveforms, except in certain special cases. Spectra (rather than waveforms) are usually a basic tool for analyzing machine vibration .

The information in the spectrum depends on the maximum frequency and spectral analysis. The maximum frequency of a spectrum is the high frequency range visible on the screen that contains information from the spectrum. The maximum frequency depends on the operating speed of the electric motor or generator. Higher operating speed means the need for a higher maximum frequency.

Spectral analysis is the measurement of the level of detail in a spectrum that is represented by the number of spectral lines that describe the shape of the spectrum. More spectral lines reveal more details of the spectrum .