Advantage of Vibration Condition Monitoring For the Estimation of Performance of the Machine Tool

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Abstract

A manufacturing company's output rates will be impacted if a piece of machinery breaks down unexpectedly. An imbalance in the machine system can lead to problems like wear or misalignment because of vibrations that are generated during operation. Wear and tear on the machine tool and foundation joints, distortions that develop over time and a host of other variables all contribute to vibrations. The study explains how the assembly of the machine may be assessed to have degraded. With this technique, vibrations are continually measured and the trend of those vibrations over time is obtained. As part of this monitoring, we look at the overall levels of vibration as well as variations in the frequency spectrum. Each spectral component can be linked to a specific system error. When vibration and spectral component changes are monitored, the pace at which a machine tool degrades may be determined. This type of research can provide early indications for machine tool repair.

Keywords: *Vibration analysis, Spectrum, Monitoring system, Shaft, Machine tool.*

I. INTRODUCTION

In today's world, machines are essential to the running of a production. The machinery must be closely monitored, and the corporation would suffer enormous losses if they break down without warning. An imbalance, wear, misalignment, damaged bearing, friction whirl and cracked teeth in gearing can all cause a machine to malfunction. Diagnostic approaches that have been used in the past include oil analysis and vibration signal analysis, as well as particle analysis, corrosion monitoring and acoustic signal analysis. Acoustic and vibration signal analysis is two of the most common methods for identifying machine defects without stopping or dismantling the unit. The fluctuations in these signals are sometimes an indicator of a malfunction. An acoustic analysis method provides the advantages of a fast analysis, a high level of identification, and non-destructive testing. As a result, it is extremely difficult to capture the acoustic signals accurately due to a variety of factors including ambient circumstances and the varying parameters of recording software. Analyzing vibration signals also offers certain benefits and drawbacks. Vibration analysis may be used to monitor machines in real time, and a variety of signal processing methods are available. Due to noise and sensor positioning, vibration analysis has its limits.

A machine's status can be determined by analyzing its vibrations. Vibration analysis is used in more than 80% of Saucedo-Dorantes' fault identification methods, he claims. Vibration analysis may be used to determine whether or not a machine should be shut down and serviced based on the amount of unwanted vibration it produces. It is possible to identify the status of a machine by its vibration amplitude and frequency, both of which show the severity and cause of the machine's issue. In the beginning, machine faults may still be assessed using the human brain and the senses of touch and hearing, which function as a vibration analyzer without the use of vibration equipment. In addition, the human senses of touch and hearing are restricted, and it is impossible to identify abnormalities that are beyond the capabilities of the human senses of sight and sound. A real-time spectrum analyzer was used for vibration analysis, which can now be divided into time, frequency, and time-frequency categories.

II. VIBRATION MONITORING SYSTEM

Some foundations of vibration analysis can help grasp the reasoning behind the monitoring system.

Machine vibrations can be caused by mechanical, electrical, or a combination of mechanical and electrical disturbance forces. These pulsing forces have the potential to produce fatigue failures of the components over a long period of time. In cases when the frequency (ies) of the perturbation force(s) matches or is near to the natural frequency, failures are considerably hastened. High-level tensions caused by resonance/near resonance are to blame. Thus, the failure may be due to high cycle fatigue or low cycle fatigue, depending on the degree of stress and the duSration of the operation. Scientific observation of machine tool vibration behavior can reveal the perturbation forces operating on the tool, as we'll see in a later section. As a result, a specialized vibration system is not only intended to diagnose and rectify the vibration problem on the machine tool (which the system can do, of course), but also to generate data on the pace at which the machine tool deteriorates.

- **Vibration sensing and transducers for condition monitoring system**

Body motion that repeats after a predetermined interval is referred to as vibration. Simplest vibrations are shown in Figure 1. (Simple harmonic wave form). The graphic depicts the waveform's different key parameters.

Figure 1 shows a simplified vibration waveform, although this is rarely the case in actuality. Figure 2 When analyzing these types of waveforms, it is easy to determine their frequencies and amplitudes using simple tools such as wave factors and crest factors, but these do not shed any light on the underlying forces.

Identifying the perturbation forces that generate a machine's vibration behavior is the primary goal o f condition monitoring. Figure 3 shows how this can only be done by doing a vibration spectrum study.

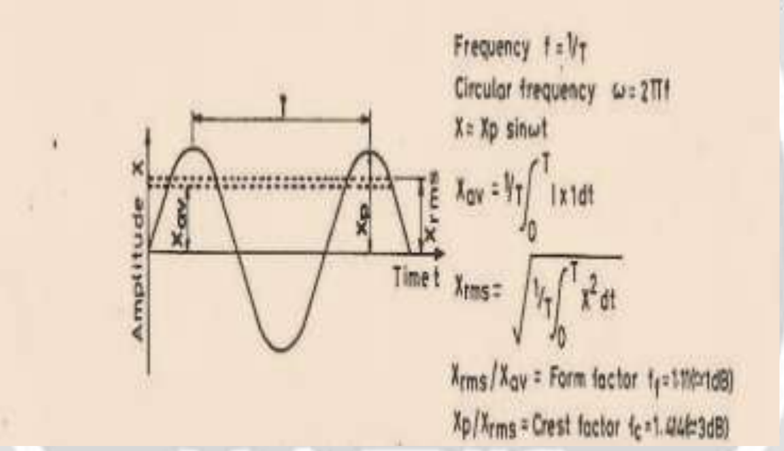

Figure 1: The simplest kind of vibration

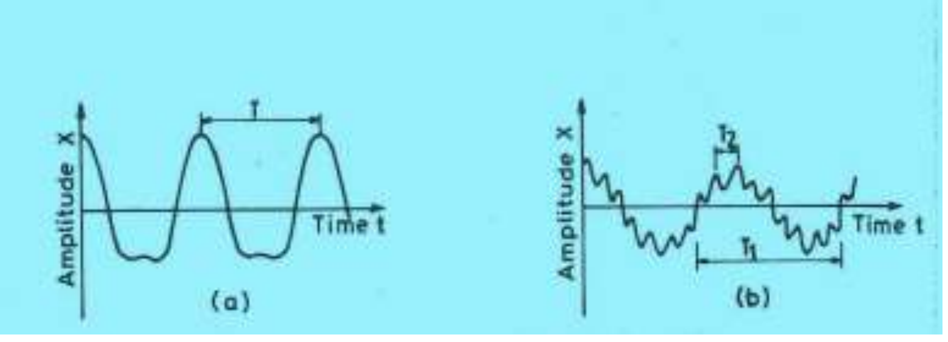

Figure 2: Typical waveforms

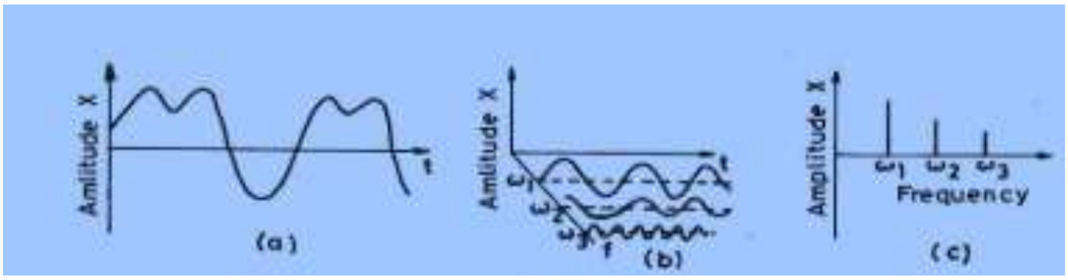

Figure 3: Spectrum of periodic vibrations

For determining the perturbation forces, the spectrum analysis is one of the most powerful tools available since each peak in the spectrum corresponds to a recognized problem in the system, such as an imbalance or misalignment or an erroneous gear meshing.

The choice of the vibration parameter is another crucial consideration. Peak to peak in microns, peak to peak in mm/sec, or peak to peak m/sec2 acceleration can all be used to measure the vibration.

Displacement = acceleration / $(2\pi.f)^2$ and velocity = acceleration / $2\pi f$ are linked, as is the vibration frequency f. Displacement may be too tiny to be recorded when a perturbation force has high frequency. As an illustration, examine the effects of an external force of 10g at a frequency of 2500 hertz. Most vibration analyzers will miss displacement = $10.9.81.10^6$ / $(2\pi.2500)^2$ ~0.4 micron if we try to measure it at this frequency. It is usually preferable to utilize acceleration as the vibration measuring parameter since many perturbation forces in machine tools occur at high frequency.

Component deterioration caused by prolonged exposure to high frequency forces causes machine tools' displacement mode vibrations (microns, peak to peak) to reach abnormally high levels. Low-frequency vibration phenomena can emerge when deterioration levels, such as imbalance development and disrupted alignment/leveling, reach a specific magnitude. Vibration spikes and substantial machining errors are common occurrences. Gear meshing frequencies, rolling element defect frequencies, etc. are examples of typical high frequency forces.

Unbalanced rotating components, misalignment of connected rotating parts, looseness in the assembly are all typical causes of vibration. Frequency analysis of the vibration signal may be used to identify these issues. It is therefore possible to evaluate both current and future vibration issues by using an accelerometer as a fundamental transducer in the condition monitoring system, which will allow us to analyses the vibration spectrum at higher frequencies. The position of the journal center and the frequency of shaft vibration are two more critical machine tool health indicators.

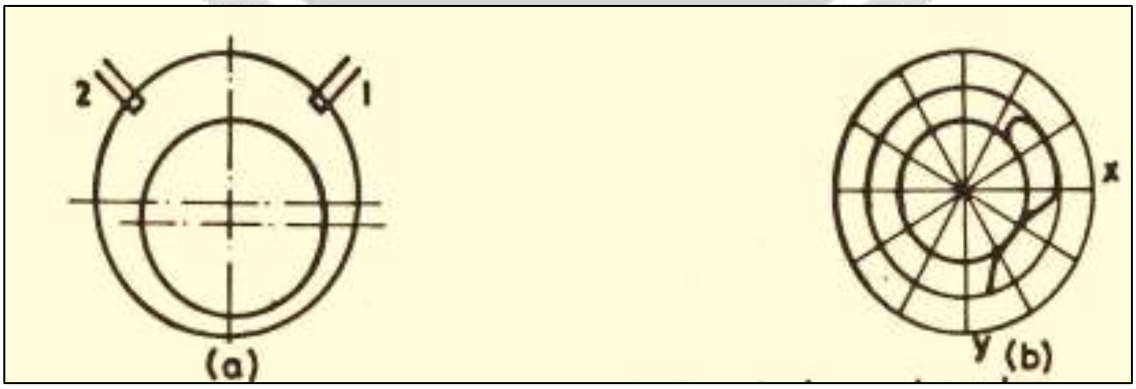

Figure 4: Two mutually perpendicular shaft probes

Probes can be installed in the bearings or on a suitable fixture on the machine tool as seen in the picture. The voltages generated by the pick-ups are proportional to the distance between the shaft and the mounting of the probe. DC gap voltage is proportional to the average gap between probes and shaft (and thus locates the shaft center position) whereas A.C. voltage is proportional to the shaft vibrations; these voltages make up the whole voltage range that may be used to determine the shaft center position. Stability of the shaft center is determined by the D.C. voltage, whereas vibrations of the shaft are determined by A.C. voltage. The stability of the machine tool's rotating mechanism may be determined with the data collected by shaft probes.

III. TYPICAL CONDITION MONITORING SYSTEM FOR LARGE MILLING MACHINE

We've shown a possible condition monitoring system for a typical machine, such as a Milling machine, here (figure 5). Using shaft and worktable vibrations, the system may determine the quality of assembly of the milling machine's components and hence its overall health. Probe 1 and Probe 2 are set at a 90-degree angle to each other to monitor the shaft's location relative to their installation. Probes that produce voltage in direct proportion to the distance between them and their mounting are known as non-contact sensors or proximity sensors, as was previously stated. Fixing the sensors to the bearing housing or shell is an option. It'll give you a sense of where vibrations in the journal center and shaft are coming from.

This table has been equipped with an accelerometer to measure high-frequency vibrations and slip-stick vibrations, as shown in Figure 5. The frequency range of an accelerometer, ranging from 0 to, say, 20 KHz, made it an ideal transducer option. The placement of the accelerometer is critical. Stud mounting is the only way to go if you want them to last.

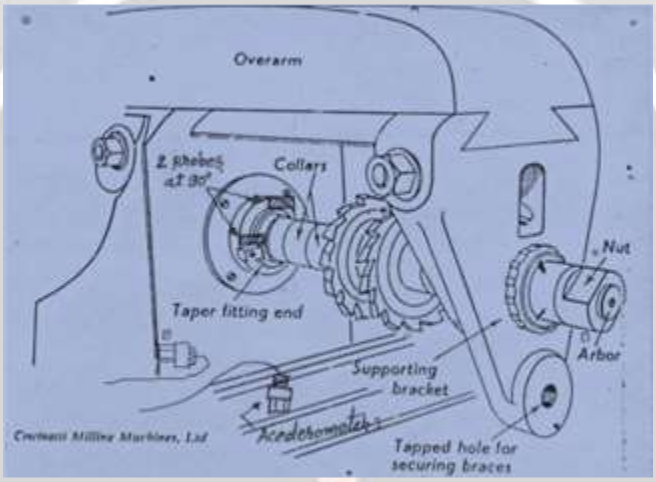

Figure 5: Milling machine

Journal center loci, shaft orbits/vibration spectra, water fall diagrams, vibration time wave forms, etc. should be recorded and shown by the analysis equipment. We believe the Bently-Nevada ADRE system is ideal for this application. Other manufacturers of vibration analyzers are also available.

Due to the bespoke nature of these machines, the condition monitoring system must also be tailored to each individual unit.

IV. CONCLUSIONS

Scientific vibration analysis of the machine tool can be used to determine if the tool's performance has deteriorated. The existence of perturbation forces, which cause damage to machine parts, may be detected using an appropriate condition monitoring system. It is possible to monitor the status of a machine tool by using an accelerometer and shaft vibration probes. Vibration spectrum analysis may therefore be used to identify known malfunctions, providing an early warning of machine tool degradation and preventing failures. To keep the precision machine tool in excellent working order, it is necessary to perform appropriate repairs and maintenance.

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