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CONDITION MONITORING OF MACHINES USING VIBRATION ANALYSIS: A REVIEW

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Abstract: Condition monitoring is applied as a technique for improving productivity, efficiency and reliability of the machine components with significant benefits to firm. Condition Monitoring of rotating machinery are used to monitor the status of critical operating major components such as the shafts, bearing, gearbox, generator, misalignment of parts. Faults can thus be detected while components are operational and appropriate actions can be planned in time to prevent failure of components. This work contains study of various monitoring techniques which are used to monitor the machine with the objective of improving the reliability of given system and also the techniques are categorized with system application. Among the various methods for condition monitoring, this study focuses on condition monitoring of machines using vibration analysis technique. Future work is based on the identifying functional requirement of machine and the monitoring technique can be analyzed to maintain good health of the machine and safety of machine.

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INTRODUCTION

Machine condition monitoring (MCM) involves the continuous analysis of operational equipment and the identification of problems before component breakage or machine failure.

It involves monitoring the health of the machinery through measurement by using parameters such as vibration, shock pulse, speed, temperature, pressure etc. Condition monitoring systems are becoming increasingly necessary in improving the efficiency of the manufacturing system. With the proper skills and equipment, plant maintenance technicians not only detect problems before they result in a major machine malfunction or breakdown, but they also perform root cause failure analysis to prevent problems from recurring. Condition Monitoring is most frequently used as a Predictive or Condition-Based Maintenance technique. One of the main challenging problems of present day machine tools is the development of machine tools with high vibration proof qualities. Vibration influences the operation, performance and life expectancy of the machine tools. Deterioration in the machine running conditions always produces a corresponding increase in the vibration level. By monitoring vibration level it is possible to obtain information about the machine condition. Excessive vibration in the rotating machineries is the major cause of premature failure and can lead to disastrous machinery breakdown. Vibration can be caused by a variety of factors. This includes unbalance-rotating elements, misalignment of bearings, looseness of parts and resonance from machineries.

Condition Monitoring involves the measurement or checking of all vital primary and secondary parameters or signals given out by the machine during its operation. Pressure, temperature flow rate etc. are primary parameters whereas vibration, noise, corrosion, wear etc. are secondary parameters.

1.1 Techniques of Condition Monitoring:

There are many techniques available to monitor the health of the machinery. In spite of the large amount of techniques available, there are few techniques of condition monitoring and these are explained below:

1.1.1 Vibration Monitoring: Vibration analysis can give useful quantitative idea about the condition of the equipment. This essentially uses vibration pick-up and frequency analysers. The existence of a problem can be detected from overall vibration levels. Problems can also be diagnosed from frequency content, wave shape, and direction of major component and phase analysis of the vibration signals.

1.1.2 Wear Debris Monitoring: This method works on the principle that the working surfaces of a machine are washed by means of lubricating oil, and any damage to them should be detectable from particles of wear debris in the oil. The amount of wear particles in the lubricating oil gives information about the problem existence.

Analysis of the size, shape, density and material composition of wear particles helps to pin point the problem.

1.1.3 Performance Trend Monitoring: It involves checking the performance of a machine or component to see whether it is behaving correctly. By monitoring the trend in the performance characteristics such as temperature, pressure, efficiency etc., we will be able to assess the condition of the equipment. This may for example involves the monitoring the performance of a bearing by measuring its temperature to see whether it is carrying out its function of transmitting load.

1.1.4 Corrosion Monitoring: Some of methods used for CM are i) Corrosion Coupons ii) Measurement of polarization resistance, which is inversely proportional to rate of corrosion, iii) Electrical resistance method, which makes use of the fact that change in area due to material loss changes resistance

1.1.5 Acoustic Emission Monitoring: This involves detection and location of cracks in bearings, structures, pressure vessels and pipelines. Acoustic emissions (AE) are defined as transient elastic waves generated from a rapid release of strain energy caused by a deformation or damage within or on the surface of a material.

1.1.6 Non-Destructive Testing: This involves Radiography, ultrasonic flaw detection, acoustic emission technique, Dye-penetrant tests, magnetic particle test etc. Suitable technique is to be selected depending upon the type of defect and nature of data to be obtained.

1. VIBRATION MONITORING:

There are different techniques used for condition monitoring and fault diagnosis of machines. In this section vibration monitoring technique is discussed in details. Whole machine or overall vibration occurring in the 10Hz-10KHz band is considered the best parameter for monitoring structural problems like deterioration or defective bearings, mechanical looseness, worn or broken gears, misalignment and unbalance of rotor etc. and many such problems will cause excessive machine vibration. Vibration generated from a machine contains vital information on the health of the machine and can be used to identify developing problems. Measurements can either be trended to produce an ongoing evaluation of condition or the values obtained compared to the machine's 'normal' value (ISO 2372). The latter is commonly accepted as a one-shot indication of the machine's 'health'. While internal transmission of vibration is a characteristic of the machine it is important that we monitor at the same point(s) in a consistent way. It is standard practice to mark the measurement point(s) on machines utilising studs or mounts to allow consistent contact of the pick-up transducers. In all cases it is important that –

- Readings are always taken from the same point(s) on the machine.
- Whole machine vibration readings are collected under consistent machine conditions. (Speed, loading etc.)
- The machine speed (in RPM) is noted.

Table 1.Vibration Parameters

Displacement (m)	Velocity (m/s)	Acceleration (m/s^2)
Frequency (Hz)	Bandwidth (Hz)	Spike energy (gSE)
Power spectral density	Peak value	Root mean square (RMS)
Crest factor (CF)	Arithmetic mean (AM)	Geometric mean (GM)
Standard deviation (SD)	Kurtosis (K)	Skewness
Phase (deg)		

Depending upon these parameters the range of techniques available that utilize vibration and associated techniques to determine condition is extensive. The introduction of more and more sophisticated hardware and software continues to see more techniques becoming applicable by and available to maintenance personnel. This will certainly continue and means that techniques that once required trained and experienced vibration specialists are now within the capability of technicians – with the right equipment and a minimum of training. The various techniques fall into this category although specialist help may be needed in initial set up.

2.1 Enveloping Techniques

A variety of analysis techniques are available within commercial software packages to refine the detection of potential failures. Enveloping is such a technique, whereby a shape is created around the spectrum plot that equates to alarm profile values set for each monitored component of the machine. These individual alarms are triggered even though the component signal may not be the highest amplitude signal within the spectrum (i.e. not of sufficient value to affect the whole machine or overall value).

2.1.1 Octave Band Analysis

Despite its name (which comes from the type of filters it uses) this is a vibration technique which has to be set up (usually by an expert) to determined measurement parameters relating to the frequency bands of interest on the machine being monitored (based on RPM frequency relationships). Once set up it is fairly simple to use for overall measurements, but has a limited diagnostic ability.

2.1.2 Shock Pulse

This is a derivative of acoustic techniques. Shock pulses are generated within a machine by the impacting of surfaces, and the extent of this shock depends on the extent of damage, the RPM and the size of the components. The peak value of the amplitude picked up by the transducer is directly proportional to the impact velocity and, as deterioration occurs, shock pulse measurements increase significantly (up to 1000 times). It is a relatively quick and easy technique to use, but needs information on bearing size and speeds and the transducer to be 'tuned'.

2.1.3 Energy Spiking

Works on the principle that some faults excite the natural frequencies of components and structures within a machine. Repetitive impacts generate intense energy which can be sensed by a transducer (accelerometer) as periodic spikes of high frequency in a spectrum. Electronically processed and enhanced, the fault frequency shows clearly. Diagnosis usually needs the services of an expert although the latest software developments help. The above discussed different vibration analysis techniques are listed in table below:

Table 2. Vibration analysis techniques.

Analysis technique	Applications	What it detects
Broadband Vibration (overall values only)	Belt drives, Compressors turbines, engines, electric motors, gearboxes, pumps, roller & journal bearings, shafts	Changes in vibration characteristics due to fatigue wear. Imbalance, looseness, misalignment.
Shock Pulse Monitoring	Rolling element and anti-friction bearings, impact tools, (usually pneumatic) valve on combustion engines	Relatively advanced mechanical deterioration and poor lubrication that is causing mechanical shocks

Enveloping Techniques	Rolling element bearings and low speed machines (with care & relevant expertise)	Bearing faults
Energy Spiking	Pumps (particularly sealless) gearboxes, roller element bearings	Dry running & cavitating pumps, valve noise, bearing lubrication Problems loose bearings, metal to metal wear, surface flows
Octave Band	Shafts, gearboxes, compressors, engines, bearings (journal and roller) mechanical looseness and wear - primarily noise measurements	Changes in machine characteristics, caused by fatigue, wear imbalance etc.
Frequency Analysis	Shafts, gearboxes, belt drives, compressors, journal bearings, motors, pumps and similar	Changes in vibration caused by fatigue, imbalance / alignment, turbulence etc.

2. FAULT DETECTION:

Fault detection is subfield of control engineering which concern itself with a monitoring a system, identifying when fault has occurred, and pinpoint the type of fault and location. Two approaches can be distinguished: A direct pattern recognition of sensor reading that indicate a fault and an analysis of that discrepancy between the sensor reading and expected values derived from some model. In the latter case, It is typical that a fault is said to be detected if the discrepancy or the residual goes above a certain threshold it is then the task of fault isolation to categorized the type of fault and its location in the machinery.

3.1 Machinery Fault Detection by Using Vibration Analysis Technique:

Consider a typical example of machine system is shown in Fig.1. It consists of a driver, such as electric motor, diesel engines, gas engines, steam turbines and gas turbines. The driven equipment could be pumps, compressors, mixers, agitators, fans, blowers and others. The driven equipment is connected to the prime mover via a gearbox, belt drive, coupling and other connectors. Each of these rotating parts is further comprised of components such as: Stator (volutes, diaphragms, diffuser, stator poles etc.), Rotors (impellers, rotors, lobes, screws, vanes, fan blades etc.), Seals, Bearings, Couplings, Gears, Belts and pulleys etc.

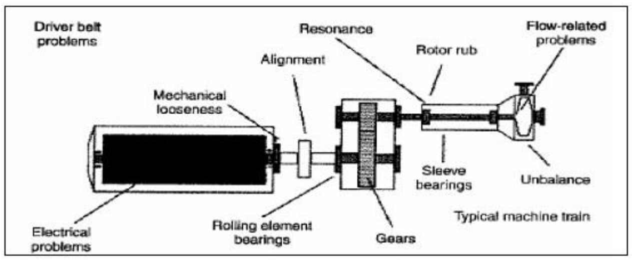

Fig 1. Different faults in machine.

All rotating and moving parts are prone to wear and failure after a period of service and when mechanical defects occur, they generate high vibration levels. Some of the common faults are listed in Table.

Table 3. Faults in different machines.

Machine components	Faults
Roller bearings	Cage fault or cage loading, Ball or Roller fault, Race defect, Inadequate lubrication, Installation fault, Bearing loose in housing, Bearing turning on shaft
Journal bearings	Excessive clearance (and looseness), Oil whirl, Oil whip
Coupling	Misalignment
Pump/fan	Hydraulic related pumping problem
Spur gears	Input & output gear looseness, Input & output gear, eccentricity, Misalignment, Bent shaft (input & output) Backlash or oscillating gears, Broken, cracked chipped or pitted teeth (input & output gear), Gear or pinion fault (due to manufacture or mishandling), Preferential wear
Belt	Worn, loose or mismatched belts, Belt/sheave misalignment, Eccentric sheaves, Belt resonance

General	Imbalance, Bent drive shaft, Looseness

3. CONCLUSIONS:

The study finally concludes that Vibration analysis is the most effective techniques for monitoring the health of machinery. They offer complementary strengths in root cause analysis of machine failure, and are natural allies in diagnosing machine condition as compared to others.

4. REFERENCES:

1. Downham, E., and Woods: “The Rationale of Monitoring Vibration in Rotating Machinery in Continuously Operating Process Plant,” ASME paper no. 71-Vibr-96, 1971.

2. Andrew D. Dimarogonas. Vibration of cracked structures: A state of the art review. Engineering Fracture Mechanics, 55(5):831-857, 1996.

3. O. S. Jun and H. J. Eun. Modelling and vibration analysis of a simple rotor with a breathing crack. J. Sound and Vibration 155(2):273-290, 1992

4. Amit Aherwar, Md. Saifullah Khalid, Vibration analysis techniques for gearbox diagnostic: A review, IJAET Vol 3.

5. Eshleman, R. L., “Machinery Vibration Analysis II Notes,” Vibration Institute, Willowbrook, Ill., 2000.

6. J. Antoni, R.B. Randall, The spectral kurtosis: application to the vibratory surveillance and diagnostics of rotating machines, European Journal of Mechanics A/Solids 20 (2006)308–331.