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Vibration Analysis for Machinery Monitoring: A Past Review

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Abstract

The present paper is a review of the past work done in the field of Vibration Analysis for the condition monitoring of machines. The state of art of condition monitoring includes various techniques like vibration measurement, use of some kind of diagnostic tool like ANN, Fuzzy, etc. based on these comparisons, future challenges in condition monitoring are summarized.

Keywords: condition monitoring, dignostic tools, vibration analysis

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INTRODUCTION

To acquire the best viability in the operation of complex machines and mechanical framework, condition maintenance techniques are being broadly utilized to minimize working and overall expenses without unfavorably influencing the dependability and accessibility. Condition monitoring is the process used to determine the operational state and health of a machine for the purpose of detecting potential failures, before they turn into functional failures. The condition monitoring process consists of a periodical or continuous data collection, data analysis, interpretation and diagnosis and even in now-a-days some kind of diagnostic tools should require.

REVIEW OF PAST WORK

Tirpude et al. [1] paper titled Vibration Based Condition Monitoring of Rolling Mill. Presents the maintenance of rolling mill by using vibration analysis. Primarily the paper has focused on the approach for a new maintenance strategy for rolling mill. The rolling mill which is considered in this paper is older therefore it has many problems like worn out components, parts misalignment, looseness of components were observed. So rather than breakdown maintenance, vibration based condition monitoring found suitable.

In this paper relation of load with vibration response is studied i.e. when the load torque is increased on each component of rolling mill, it creates additional bearing reactions. This bearing reaction produces more vibration amplitude at that frequency. While collecting field data intermittently failure components have been considered for condition monitoring and for that the affected components were placed in between bearings. At these bearings vibrations are created because of reactions and poor conditions of components.

So, to measure vibration amplitude, multiple readings of vibration signature has been taken by using FFT Analyzer and it is observed that load variation affects the life of component, the components which are near to bearings are failed frequently. They have chosen gear as an element to find out the cause of failure because in rolling operation load torque is transferred to motor which transmits power to gears and other elements. As load increases it

produce torque at the tip of tooth and this is invariant. Hence because of the variant loading condition, the chances of gear tooth failure are more. So on available readings, different loading conditions, time data, frequency data, etc. a phase wise discussion for various bearings has been made. And also fault diagnosis for each bearing has been done. And it is checked that the amplitude of vibration exceeds the standard or not. If yes then there is a problem in bearing has been identified.

Kiran Kumar et al. [2] the paper Unbalance in Rotating Machine Using Vibration Signature Analysis is concerned with the unbalance in rotor. In this paper, Experimental studies were performed on a rotor to predict the unbalance in rotor. Here, again implementation of vibration based condition monitoring has been done which is also termed as "predictive maintenance".

In this paper experimentation is done on set up which consists of 0.5 hp A.C. Induction motor having 1440 rpm speed, a steady type flange coupling and single disk rotor and is reinforced by bearing. It has some bearing span, some rotor shaft diameter. The speed of motor is controlled by variable frequency drive. With the help of FFT analyzer vibration signatures has been taken at motor non drive end, motor drive end, and at bearing also.

In experiment, set-up has been run for few minutes so that minor vibrations are settled down. First shaft has been check for misalignments and distortion. And the by creating some distortion by keeping some mass in the rotor then acquire vibration signature by using FFT analyzer and different readings of amplitude has been taken for different speeds. And the same procedure is adopted for balanced rotor, rotor has been balanced by adding the same amount of mass in opposite of rotor and then taken the vibration readings for the same speeds as earlier.

In observations it is observed that vibration readings are maximum at bearing rather than machine non-drive end and machine drive end. And it is observed that vibrations in radial direction are higher than axial. And hence high radial vibrations are due to unbalance, misalignment and bending of shaft, etc. And for this vibration analysis and phase analysis has been carried out. Then it is observed that as speed increases amplitude also increases, it proves unbalance force. Phase analysis and spectrum analysis represents their presence of unbalance in rotor. And the reading after balancing shows reduction in amplitude of vibration drastically. This is the nondestructive testing method and also reduces the cost of maintenance.

Kim et al. [3] The paper Condition Monitoring of Low Speed Bearings: A Comparative Study of The Ultrasound Technique Versus Vibration Measurements presents experimental investigation of ultrasound method contrasting with vibration estimation for low speed bearings. In this paper, Ultrasound method has been clarified in point of interest furthermore as well as compared it and Acoustic Emission technique as both the methods are utilized to characterize sound waves, however the distinction is only in frequency range. That means, ultrasound technique is characterized as sound waves that have frequency levels in the range of 20 kHz to 100 kHz; higher than what the unaided human ear can normally hear. And, Acoustic Emission technique mostly operates in the 100 kHz to 1MHz. Signal processing techniques for bearing condition monitoring has been clarified. In this firstly time space measurable strategy has been clarified. The most straightforward technique is utilized i.e. root-mean-square and crest factor i.e. the ratio of peak value to RMS. This strategy is not widely used and it is been utilized with a limited success in the detection of

defects. This study subjects to the investigation of vibration and ultrasound technique statistically. Also frequency domain method has been explained. It is nothing but the treatment of signals expressed as a function of frequency using the time domain signal. It is been suggested that rather than going for vibration spectrum analysis which is widely used for finding out bearing defects, envelop detection signal processing technique can be used and it involves high pass filters and low pass filters. The processed signal is then displayed in the frequency spectrum showing bearing defect frequencies. One experimental study has been carried out by the test rig with the help of some equipment such as, accelerometer, an ultrasound detector, a signal conditioner, an analog filter, DAQ card, laptop, etc.

The signals measured were vibration and ultrasound for normal bearing and defective bearing under low speed and high speed condition. It is observed that time wave forms of acceleration for both normal and defective bearing at low speed and high speed i.e. 150 and 1200 rpm, there is no significant change in characteristics of signals and amplitude also. But in case of time wave forms of ultrasound signals for both cases i.e. normal and defective and at low and high speed, there is a change in characteristics and amplitude for low speed bearings. So, it is been found that ultrasound technique is more suitable for low speed bearing fault detection.

Similarly comparisons were made between statistical parameters of ultrasound signals and from this it is found that RMS value is a good indicator for condition monitoring of low speed bearings. Also in frequency domain analysis, a modified peak ratio can be calculated and modified peak ratio from ultrasound signals was compared with those from vibration signals and they found that ultrasound technique is more suitable Tervo et al. [4] paper titled Intelligent Techniques for Condition Monitoring of Rolling Mill presents condition monitoring of rolling mill by using hybrid intelligent technique. According to this paper any single intelligent technique is not that much effective tool so to overcome this, an approach to the development of a hybrid expert system has been made. Hybrid expert system uses multiple intelligent techniques in regard with the problem.

In this paper condition monitoring and diagnosis of steel rolling mill is considered. Hydraulic system of rolling mill has been taken into account. Process automation is included for this hydraulic system, but this is not enough for complex machinery. Therefore, methods such as vibration measurement, acoustic emission and hydraulic oil analysis need to be applied. The data acquisition system includes sensors, instruments, and accessories are selected depending on the measured variables. Necessary signal processing methods like amplification, modulation, isolation and filtering have been specified and attached. Data acquisition and mathematical pre-processing has been taken care by measurement software. Data type dependent analysis software performs signal analysis procedure such as FFT and wavelet transformation.

Finally expert system analyses the pre-processed data from databases and draws conclusion. In this paper expert system is a hybrid because rule based reasoning methods and neural network are being applied. A hybrid system can be built by joining expert systems with neural networks (Lemmen, Svaricek, 1994). The expert system can be used as a means to select significant inputs for the neural

network, as well as to check the validity of the neural network output. The expert system can also be used as an off-line tool in a qualitative way. The user selects the observed symptoms and the expert system offers the logic and the mechanics for the problem solving. Expert systems can be used to interpret symptoms in situations where learning requires numerous measurements from faulty machinery. An existing problem with expert systems is that they need to be application specific. Each machine is an individual. Therefore generating and maintaining a list of symptoms and their causes requires a lot of work and machinery specific expertise. So, hybrid expert systems are powerful tools in condition monitoring and diagnosis of machinery as it is a combination of intelligent techniques. Mohanta and Pati, [5] The paper titled Monitoring and Analysis of Vibration Signal Based on Virtual Instrumentation In this paper data acquisition system, signal analysis and lab view are used to find out various faults or defects in machine. In this paper various maintenance techniques, component of the proposed system, algorithm for vibration signal monitoring system and the simulation result along with discussion is described. There are various maintenance techniques and it includes mainly vibration monitoring technique as fault detection is very easy. In this technique there are two processes explain one is time domain and other one is frequency domain by using FFT analyzer. Vibration monitoring system consists of following components like sensor system, vibration signal acquisition, vibration signal analysis, vibration signal processing, vibration signal display and recording. The structure of the vibration monitor system is shown in Figure 1.

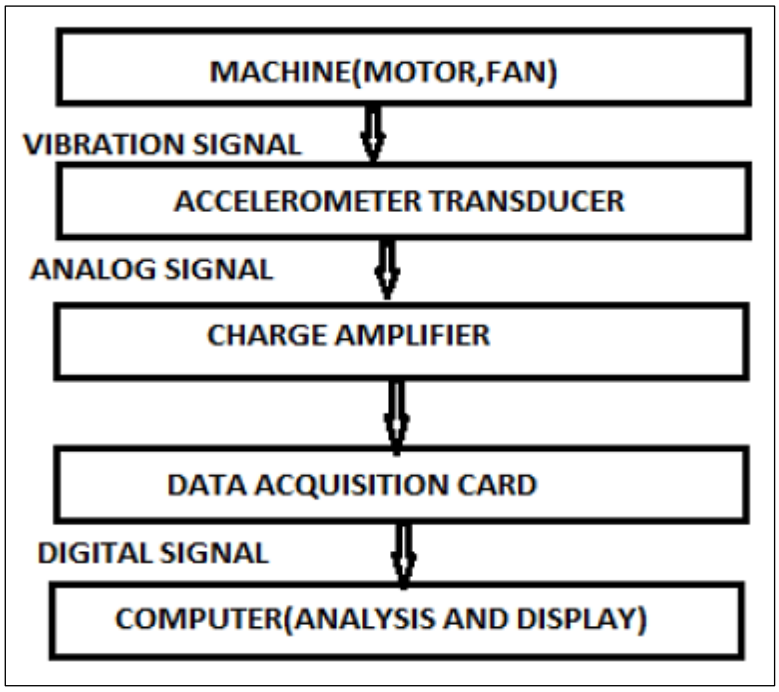

Fig. 1. *Component of Vibration Monitoring System.*

Also flow chart for vibration signal monitoring system is presented in Figure 2. Thereafter simulation has been done by using LABVIEW software. It is observed that from time domain one cannot get a clear result, so frequency domain is more efficient tool to find out fault and can easily obtained more information about the vibration signal, type of signal fault, fault region from the spectrum analysis. It helps in taking preventive control action immediately.

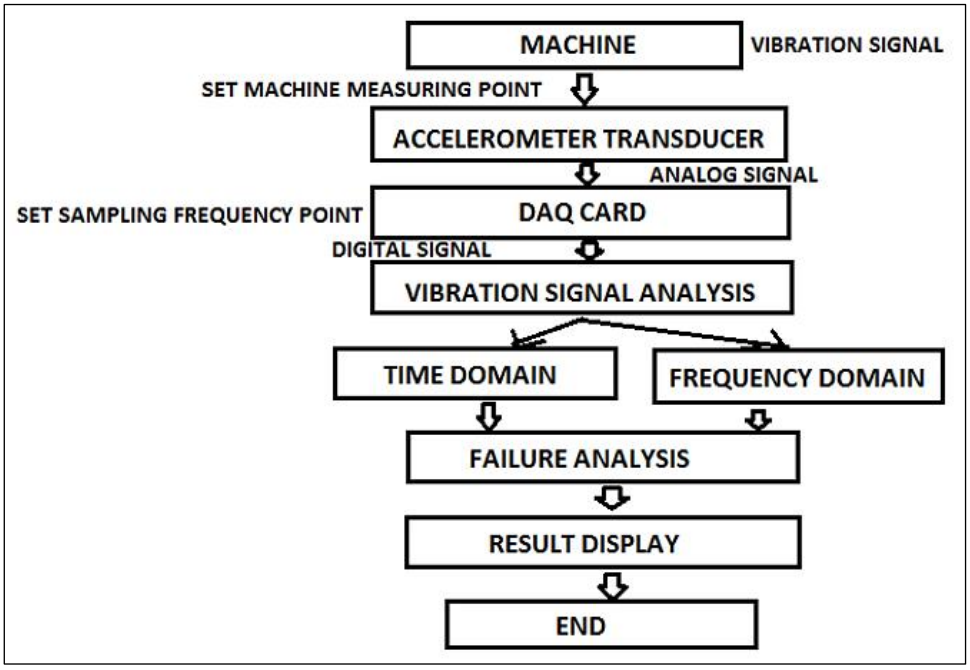

Fig. 2. *Flow Chart for Vibration Signal Analysis.*

CONCLUSION

The present research work involves detailed survey on progression in vibration measurement. In order to solve the purpose, various techniques of fault findings have been selected and examined such as ANN and fuzzy. The paper follows the analysis to make use of intelligent techniques along with the traditional methods of vibration measurement analysis.

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BIOGRAPHY

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