FAULT DIAGNOSIS OF ROTATING MACHINERY USING FEM ANALYSIS

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Abstract: This paper presents a technique to find the different conditions of rotating machinery through data obtained by vibration analyses. The various earlier researchers work is also elaborated in this paper. The major focus of the proposed work is to analyses all obtained data from the milling machines vibrations using wavelet transform. The vibration data is obtained by experiment done on milling machine. The faulty signals give the condition of that Milling machine component. The results will be also going to test by FEM analysis. It is general thinking at this stage that comparisons of FEM analysis and experiment result give better solution for faults occur in rotating machinery.

Keywords: Failure criteria, FEM, Milling machine, Pro-E model, Rotating machinery.

Introduction: Rotating machinery is the important machines in Industrial field. Any fault occurs in rotating machineries gives the breakdown in machines and decrease the production. For that Study of fault diagnosis is very important to reduce the downtime of production machinery and increase the performance of machine. Modern rotating machines are susceptible to equipment malfunction and ambient disturbances because of their complexity and high speed. The complexity hampers the operator's ability to diagnose and eliminate equipment failures before their occurrence. Fault diagnosis of rotating machinery has been done by analyses the external condition with the help of vibration signals to determine the internal fault in machines. For a rotating machine, the rotational speed of the machine is not a constant, especially not during the start-up and shutdown stages of the machine. Even if the machine is running in the steady state the rotational speed would vary around a steady-state mean value, and such a variation depends on load and other factors. Since the sound and vibration signals are directly obtained from a rotating machine which is strongly related to its rotational speed, it can be said that they are time-variant signals in nature.

This paper presents a robust fault detection method in rotating machinery. The proposed method allows an experimental fault diagnosis using other techniques, such as FEM analysis, it works under different operational conditions, a different angular speed and torque transmitted. So, there is different forms of deformation and stresses has been used to assess the condition of the machine. Here an approach for cutter and Arbor of milling machine fault detection, combining FEM map is proposed.

Litrature review: Various techniques are used to fault diagnosis in artificial intelligent like expert system and artificial neural network (ANN). Changzheng Chen and Changtao describe the method of back propagation neural network and wavelet neural network with experiment done on turbine generator unit. In this method, the output layer and hidden layer are optimized so that the whole learning process is simplified by optimizing weights in every layer. They uses 9 inputs corresponding to the 9 different ranges of the frequency spectrum of a fault signal. Vibration fault determines due to friction between rotor and cylinder, misalignment, looseness and unbalance etc. The test is performed on bearing and speed of turbine using different spectrum. [1]. The techniques of fault diagnosis rely on expert experience, modeling using classical techniques in the time or frequency domain, and statistical analysis. Fault diagnosis that uses artificial intelligence is a better method than those mentioned above. The artificial intelligence technique includes an expert system and artificial neural networks (ANNs). Rusen , Levent , and Karen gives the ideas about Wavelet Packet transform in comparison with dyadic wavelet transform to show the better result obtained through Wavelet packet transform. In dyadic wavelet low frequency band is used whereas in Wavelet packet transform all frequency band is used for each level. The final decomposition structure will be a subset of the full tree, chosen by the best basis selection algorithm as shown below [2]

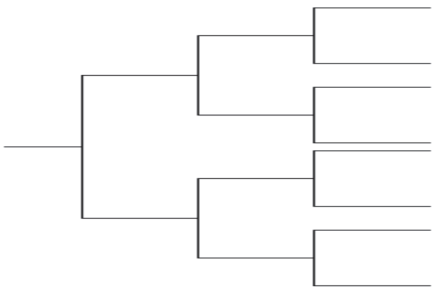

Figure 1. A wavelet packet decomposition tree.

Xiaochuang Tao issue paper on fault detection and fault diagnosis using combination of Fisher

discriminant analysis (FDA) and Mahalanobis distance (MD) samples with tested rigs were collected and difference between them give perfect picture of fault in hydraulic pump and roller bearing. [3].

B A Paya and I.Esat shown result of Wavelet analysis and artificial nueral network through experimental setup of drive line.[4].

Meng Hee Lim and M. S. Leong studied an experimental was conducted in order to evaluate the effectiveness of the proposed wavelet analysis method to detect early changes in rotor dynamics caused by two different machinery faults, namely, rotor unbalance and blade rubbing. Here the experimental results showed that method is more effective than vibration spectrum analysis to detect early changes of rotor dynamics caused by minor rotor unbalance and minor blade rubbing conditions [5].

Beata Walczak et al [12] studied the application of the wavelet packet transform (WPT) as a tool for improving pattern recognition based on near-infrared spectra. To position this tool in the pattern recognition process, it is useful to describe the process as consisting of different steps like

a. Construction of the pattern space: selection of representative training data.
b. Data pretreatment: reduction of measurement noise and other sources of error.
c. Dimension reduction: feature selection or reduction.
d. Classification: build a model to classify new samples.
e. Validation: check if the model is stable and not built on noise.

Javier Sanz et.al. [6] shown result of fault diagnosis of gearbox through experiment on rotor pump. This fault diagnosis occurs by combining artificial neural network and wavelet analysis vibration signals. They have also used ANN technique. They have used the term called as novelty index vector λ. For that ANN has been designed and trained; the training pattern vector yi is fed again into the network changing the output yo.

$$\lambda = |y_o - y_i|.$$

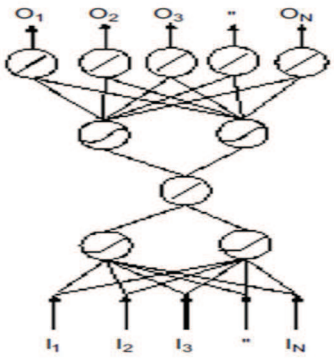

Figure 2 Nonlinear auto-associative neural networks.

Jian-Da Wu, Jian-Ji Chan employed fault of gearbox ,98% on experiment base using wavelet transform and artificial neural network [7].

Xiaoran Zhu employed the kernel method is combined with neighborhood rough sets to map the fault data to a high-dimension feature space via the Gaussian kernel function to fault diagnosis of rotating machinery [8].

S. Saravanan et.al. studied various machine tool and data shows the breakdown and downtime of various machine tool [9].Now advanced signal processing method are effectively employed to fault diagnosis of health and management of rotating machinery.[10].

Statistical feature are used like time domain., frequency domain and time - frequency domain to show the result of various signals in advanced signals processing analysis.[11].

Zeki Kiral, Hira Karagulle studied condition of rotating bearing with the help of model created and analysis done using Fem Technique on different loading condition.

3. Objective: This paper is proposed to find out fault occur on experimental setup of Milling

Figure: Horizontal Milling Machine used in company

Machine arbor and cutter using various changing parameter like different cutting speed and sizes of cutter.And after that create model of Milling machine Arbor and cutter to find the real situation of that machine component. The model is created by PRO-E and analysis by finite element method.

4. Methodology: In this paper we choose the company, name Friends Gear Engineering where horizontal milling machine is operated. In this company

various product are produced and repair. They use different cutting speed and tangential force required as per product.

Milling machine having spindle speed 40-1150 rpm , spindle motor are 3HP having cutter size 3' to 8'. We choose 8' cutter and following results are obtained using external load on Arbor at different speed .

Speed (rpm)	External load (T in N-m)	Tangential Force (F in N)	Resultant force (R in N)
40	534.76	5268.6	5606.7
120	178.25	1756.2	1868.8
300	71.30	702.4	747.5
500	42.78	421.5	448.5
1100	19.45	191.6	203.9

Using these values for static and dynamic FEM analysis to get result for component failed during operation.Compare those results to find failures in cutter.

FEM Result:

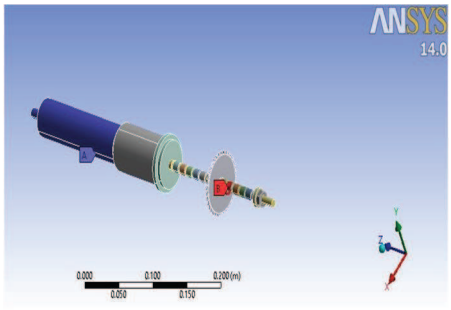

Figure:-Boundary condition and loading condition

In above figure shows the boundary condition and loading condition of different cutting speed and tangential force and gives following result

Sr no.	Tangential Force (F in N)	Speed (rpm)	Deflection (m)	Von misses stress(Pa)
1	5268.6	40	0.21044	8.6407e10
2	1756.2	120	0.070145	2.880e10
3	702.4	300	0.028055	1.152e10
4	421.5	500	0.016835	6.9128e9

The above result shows that at low speed and high tangential force, maximum deflection and maximum von mises stresses obtained at cutter and arbor .

Conclusion : In this paper, fault diagnosis are done by experimental setup of milling machine applying different speed and tangential force and using FEM analysis and PRO-E model. The result shows that maximum deflection and von mises stresses is obtained at low cutting speed and highest tangential force.

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