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Analysis of vibration signal using Wavelet transformation

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Abstract– A monitoring system is capable of providing warning and predicting the faults about early stages. The monitoring system obtains information about the primary data and by using of modern signal processing techniques; it is possible to give vital information to operator before it malfunctioning. The suitable of a signal processing technique to be used depends upon the nature of the signal and the required accuracy of the obtained information. In the field of vibration signal analysis, one of the conventional methods is fast Fourier transform. The wavelet transform (WT) is more used to analyze vibration signals to overcome the disadvantages of the conventional methods.

In this work, vibration signals obtained from monitoring system have been processed with Algorithms to extract detailed information for fault diagnosis. The results of this investigation depict that the application of Wavelet Transform for processing and analysis of the vibration signal to improve the extraction of the information to enhance diagnosis.

Keywords -Vibration analysis, fault diagnosis, rotating machinery, spectral analysis, wavelet transform vibration signal.

I. INTRODUCTION

Unfortunately these techniques have several disadvantages. First of all, the Fourier transform is unable to accurately analyze and represent a signal that are non periodic, such as a transient signal. It is possible to detect a fault of any machine at an early stage before the fault develops to an eventual failure and interrupts the production process. Its application saves a large amount of time for machine maintenance and reduces the production losses greatly. The vibration diagnosis is normally carried out in the following main steps: signal measurement, signal analysis, diagnosis and strategic decision, where the signal analysis plays a key role and has the task of extracting useful information. Conventionally spectral analysis techniques, based on the Fourier transform provide a good description of stationary and pseudo ulses) as shown in Fig.1; This is due to that assumption of the signal to be transformed by fourier transform is periodic in nature and of infinite length.

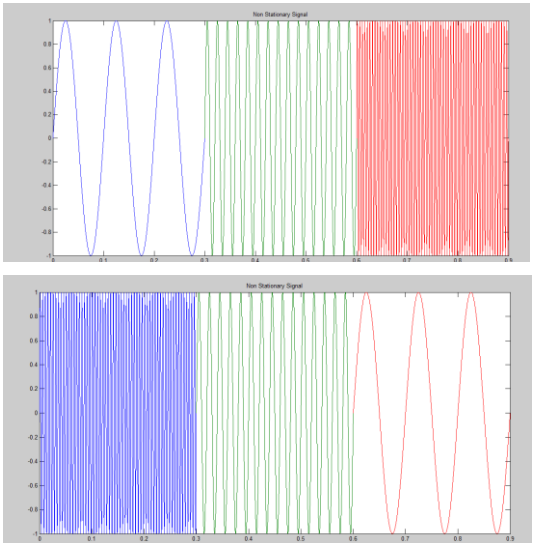

Fig1: Non stationary Signal (Frequency content changes with time)

Another deficiency of the traditional spectral analysis is, it does not provide any information about the time dependency of the frequency contents. This becomes a problem when the signals to be analyzed are highly non stationary means frequency content changes with time. In practice there are many cases for fault diagnosis, where the duration of a vibration signal is very short and the frequency information changes with time. Therefore in recent years there has been an increasing interest in the research of signal analysis concerning the time- frequency domain. The development of the time-frequency analyses is motivated by the desire to overcome the drawbacks of the conventional Fourier transform.

II. LITERATURE REVIEW

Condition monitoring is used for increasing machinery availability and machinery performance, reducing consequential damage, increasing machine life, reducing

spare parts inventories, and reducing breakdown maintenance. An efficient condition monitoring scheme is capable of providing warning and predicting the faults at early stages. The monitoring system obtains information about the machine in the form of primary data and through the use of modern signal processing techniques; it is possible to give vital information to equipment operator before it catastrophically fails. The suitability of a signal processing technique to be used depends upon the nature of the signal and the required accuracy of the obtained information. Therefore, in this paper, signals obtained from monitoring system have been processed using wavelet transform (WT) with suitably modified algorithms to extract detailed information for induction machine fault diagnosis. The results of this investigation depict that the application of WT for processing and analysis of the vibration signal to different frequency regions in time domain improves the extraction of the information that can enhance the ability of the system for diagnosis.

III. THE SIMULATION METHOD

FFT and STFT TRANSFORM

Fast Fourier Transform (FFT) is an important algorithm in the field of digital signal processing (DSP) to compute the discrete Fourier transform (DFT Fourier analysis involves representing a signal as the summation of its constituent sine waves at various frequencies. If a signal contains a transient of a finite time interval, its Fourier transform includes the contribution from the transient pulse, but the information about the transient is lost on the time axis. However, only wavelet analysis can adequately handle signals with transients that have both high and low- frequency components. Wavelet analysis accomplishes this by dividing a signal into shifted and scaled versions of a fixed function, the original (or mother) wavelet. Thus, wavelet analysis eliminates the restrictions of Fourier techniques by considering a signal locally i.e., in time and frequency by ‘‘windowing in’’ only on a small portion of the signal.

A valid signal model is necessary for accurate Vibration detection. Normally, a vibration waveform is represented as a sinusoid and normal distribution white noise (Gaussian noise) as follows:

$$v(t)=s(t)+\sigma(n) \qquad \text{-----(1)}$$

Where $v(t)$ is the vibration signal that consists of $s(t)$ the signal of interest, and σ is the scaling factor of the additive white noise n, in which the signal is lost. To better approximate the actual vibration environment for machine, the vibration model will be given as:

$$v(t)=\sin(2\pi f_1 t)+\sin(2\pi f_2 t)+randn(t) \qquad \text{-----(2)}$$

Where f_1 and f_2 are the frequencies that provide information about the mechanical malfunction of the machine. For this model the vibration signal is totally corrupted by additive white noise, represented by randn(t)

IV. EXPERIMENT RESULT

In this section, the vibration model is expressed as:

$$v(t)=\sin(2\pi f_1 t)+\sin(2\pi f_2 t)+randn(t) \qquad \text{-----(3)}$$

Simulation is based on a short pulse (over a 2sec period) to better approximate real vibration signals.

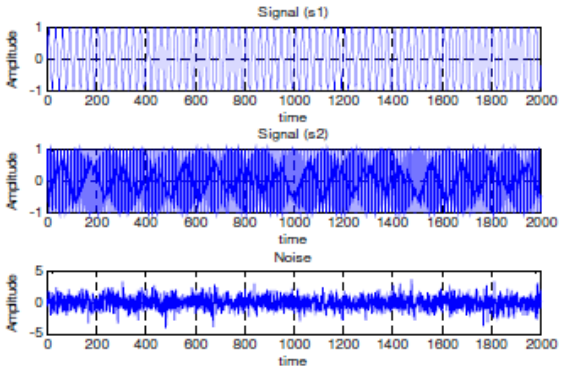

Fig.2 Components of the vibration signal and noise) that are analyzed using FFT & STFT.

Tool Used for analysis is Matlab 7.5

Simulation of the proposed system has been done in Matlab software. Simulation results are shown in figure 4 to 6

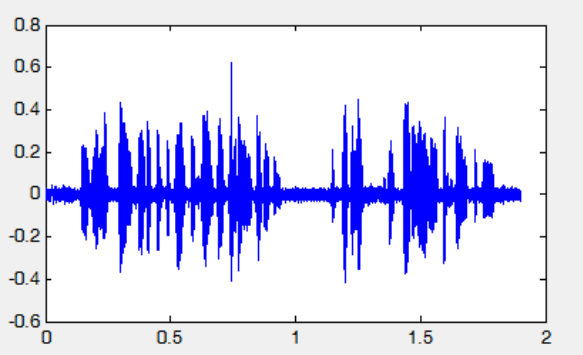

Fig:3 Input Vibration signal

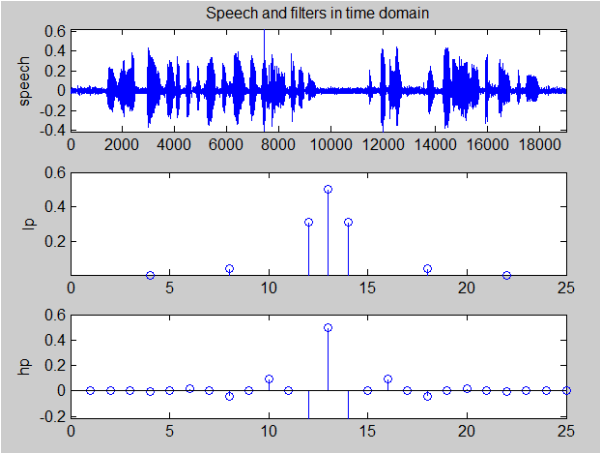

Fig4: Fourier transform

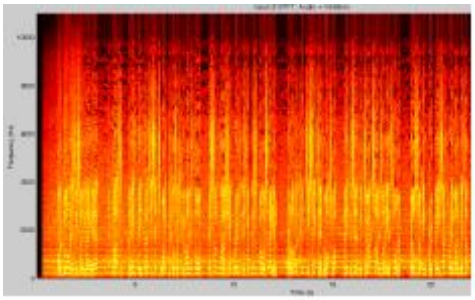

Fig5: Output: signal + vibration

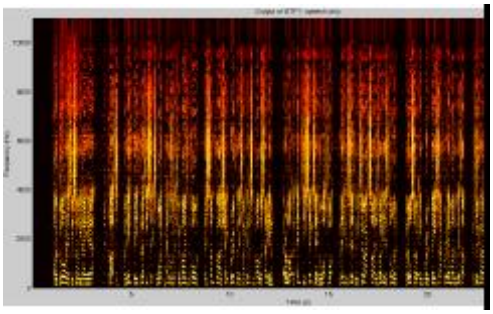

Fig6: Output: STFT speech

V.PROPOSED ANALYSIS BY WAVELET TRANSFORM

Vibration signal of healthy machine wavelet decompositions (Daubechies) Daubechies Wavelets The Daubechies wavelet transform is named after its inventor, the mathematician Ingrid Daubechies , one of the brightest stars in the world of wavelet research. As one of a number of wavelet families, the Daubechies family of wavelets, so called compactly supported orthonormal wavelets—thus making discrete wavelet analysis practicable–is widely applied in engineering.

In this simulation, the wavelets are also used to make wavelet analysis. Here, we first introduce Daubechies wavelets in detail. Remarkably, the Daubechies wavelet function (mother wavelet) is orthogonal to all functions

WT is a time-frequency analysis technique. Due to its strong capability in time and frequency domain, it is applied recently by many researchers in rotating machinery. It decomposes a signal in both time and frequency in terms of a wavelet, called mother wavelet. The WT includes Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT).

VI. MERITS OF THE SYSTEM

Fault diagnosis method based on the WT. DWT and CWT have been tested on real measurement signals collected from a vibration system containing machine unbalance rotating fault. Better results are obtained by identifying the type of fault. Such method is useful for improving the conditions monitoring and faults diagnosis of rotating machines. It remains to test its application on a signal containing two or more types of faults.

VII. CONCLUSION

Analysis of vibration signal and the results of the investigation demonstrate the components of signal the FFT STFT. In proposed investigating Different families of WTs will be implemented with vibration signals covering the proposed machine conditions.

The results of testing various popular types of the WT show different degrees of success in relating the decomposed band with machine condition. signal analysis

techniques play a key role for fault diagnosis of Machine. Traditional spectral analysis techniques provide a good description of stationary signals. However they cannot give any information about the time dependency of the frequency contents of a signal.

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