International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.06, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

VIBRATIONAL MEASUREMENT ANALYSIS OF FAULT LATENT ON A GEAR TOOTH

J.Sharmila Devi [1], Assistant Professor, Dr.P.Balasubramanian [2], Professor

[1] *Department of Instrumentation and Control Engineering,* [2]*Department of Mechanical Engineering,*
[1,2]*A.V.C. College of Engineering, Mayiladuthurai, Tamil Nadu, India*

ABSTRACT

Mechanical equipment fault diagnosis technology uses the measurements of the monitored machinery in operation and stationary to analyze and extract important characteristics to calibrate the states of the key components. The current conditions of the key components quantitatively, predicts the impending abnormalities and faults, and prognoses their future condition trends. The contents of mechanical fault diagnosis contain four aspects, including fault mechanism research, signal processing and feature extraction, fault reasoning research and equipment development for condition monitoring and fault diagnosis. As a result, the development of the fault diagnosis technique still faces great difficulties. To achieve a dynamic system condition monitoring and fault diagnosis, primary task is the need to get enough reliable characteristic information from the system. Due to the fluctuation of the system itself and the environment disturbance, reliable signal collection is seriously affected. It is therefore very urgent for advanced signal processing technology to eliminate noise to get true signal. A gear in the gearbox rotate at a fixed speed the vibration data are generated and analyzed. Time-synchronous averaging is used to isolate vibration components associated with a specific gear and average out all other components.

Index Terms: **Gear, *Vibration signal, Condition Monitoring, MATLAB***

I. INTRODUCTION

Vibration measurements are critical in predictive maintenance and diagnostic fault testing applications for quality assurance. Most of the fault mechanism research is on the qualitative and numerical simulation stage, the engineering practice is difficult to implement. In addition, the fault information often presents strong nonlinear, non stationary and non Gaussian characteristics with simulation tests can not reflect these characteristics very accurately. By this way, the optimized maintenance strategies can be settled, and as a result the industrials can benefit from the condition maintenance significantly. In the past decades, there has been considerable work done in this general area by many researchers. The fault diagnosis results and the application possibility may be influenced significantly. Rotating mechanical vibration is usually of strong harmonic and its fault is also usually registered as changes in some harmonic components. In reality, the signals measured from mechanical equipment are ever-changing, non-stationary, non-Gaussian distribution and nonlinear random.

II. DIAGNOSTIC PROCESS

Pattern recognition conducts cluster description for a series of process or events. It is mainly divided into statistical method and language structure method. The fault diagnosis of equipments could be recognized as the pattern recognition process, that is to say, it recognizes the fault based on the extraction of fault characteristics. There are many common recognition methods, including bayes category, distance function category, fuzzy diagnosis, fault tree analysis, grey theory diagnosis etc.

The fault diagnosis of rotary machines, such as the combination of fuzzy set and neural network, the dynamic pattern recognition based on hidden markov model, etc. at present research and development of fault diagnosis devices is in the following two directions: (1) Portable vibration monitoring and diagnosis (including data collector system), and (2) On-line condition monitoring and fault diagnosis system. Portable instrument is mainly adopted single-chip microcomputers to complete data acquisition, which has certain ability for signal analysis and fault diagnosis. On-line monitoring and diagnosis system is usually equipped with sensors, data acquisition, alarm and interlock protection, condition monitoring subsystem, etc. And it is also fitted with rich signal analysis and diagnosis software [1].

III. ROTATING MACHINERY BEHAVIOR

Antifriction bearing is the most important components of rotating machinery. With the characteristics of high efficiency, convenience of assembling and lubrication, and low frictional resistance, it is widely used in rotating mechanical equipment. However, the harsh and complex work environment of rotating machinery always results in the damage, corrosion and flaking of antifriction bearings, which can leads to the improper operation of mechanical equipment or even severe industrial accidents.

IV. VIBRATION BASED ON CONDITION MONITORING IN ROTARY MACHINERIES

It is very important to display the measured signal in convenient form so as to be useful for the interpretation of the condition of rotating machinery.

Every fault has a specific signature in the measured signal and it is most convenient and cheapest way to identify possible fault in machinery. Now very advanced signal processing techniques like Wavelet transform, Genetic algorithms, Neural network, fuzzy logic and machine support vectors are being applied in laboratory test set ups to detect, locate and quantify the faults and based on this even the life of the machinery is also being predicted [7].

Many rotating machines, such as power station turbo generators, may be considered as consisting of three major parts; they are the rotor, the bearings and the foundations. In many modern systems, the foundation structures

IJARSE
ISSN: 2319-8354

are flexible and have a substantial influence on the dynamic behavior of the complete machine. These rotating machines have a high capital cost and hence the development of condition monitoring techniques is very important. Vibration based identification of faults, such as rotor unbalance, rotor bends, cracks, rubs, and misalignment, fluid induced instability, based on the qualitative understanding of measured data, is well developed and widely used in practice. However the quantitative part, the estimation of the extent of faults and their locations, has been an active area of research for many years.

Over the past three to four decades, theoretical models have played an increasing role in the rapid resolution of problems in rotating machinery the process of the roller bearing fault diagnosis consists of three steps: (1) the collection of the roller bearing fault vibration signals; (2) the extraction of the fault features; (3) condition identification and fault diagnosis. How to extract the fault features and identify the condition from the roller bearing vibration signals are the key steps in the fault diagnosis of roller bearings. As the fault vibration signals of roller bearings are non-stationary, it is a crux how to obtain feature vectors from them for the fault diagnosis.

VI. TRADITIONAL DIAGNOSIS

These techniques perform this from the waveforms of the fault vibration signals in the time or frequency domain, and then construct the criterion functions to identify the working condition of roller bearings. However, because the nonlinear factors such as loads, clearance, friction, stiffness etc., have distinct influence on the vibration signals due to the complexity of the construct and working condition of roller bearings, it is very difficult to make an accurate evaluation on the working condition of roller bearings only through the analysis in time or frequency domain [4].

The main purpose of this paper is to propose a new fault feature extraction method for roller bearing fault diagnosis. Features are those parameters derived from the measured data that robustly indicate the presence of the roller bearing faults. The main feature extraction methods include: time-domain methods, frequency-

domain methods, and time–frequency methods. Time domain methods such as peak amplitude, root-mean square amplitude, crest factor, kurtosis and shock pulse counting have been successfully applied to roller bearings [5]. Frequency domain methods applied to roller bearing fault diagnosis include Fourier spectra time waveform, cepstrum analysis, sum and difference frequencies analysis and the envelope spectra technique.

As the roller bearing vibration signals possess non-stationary characteristic, time–frequency methods is effective to extract the feature of the original data. The wavelet transform has been applied to feature extraction for roller bearing vibration signals and efficient results have been obtained.

VII. VIBRATION ANALYSIS

Envelope spectra are especially useful in identifying localized bearing faults that cause high-frequency impacts consider an idealized gearbox that consists of a 13-tooth pinion meshing with a 35-tooth gear. The pinion is coupled to an input shaft connected to a prime mover. The gear is connected to an output shaft. The shafts are supported by roller bearings on the gearbox housing. Two accelerometers, A1and A2, are placed on the bearing and gearbox housings, respectively [2]. The accelerometers operate at a sample rate of 20 kHz.

The pinion rotates at a rate fpinion = 22.5 Hz or 1350 rpm. The rotating speed of the gear and output shaft is

$$\text{fGear} = \text{fpinion} \times \frac{\text{Number of pinion teeth (Np)}}{\text{Number of gear teeth (Ng)}}$$

The tooth-mesh frequency, also called gear-mesh frequency, is the rate at which gear and pinion teeth periodically engage:

$$\text{fMesh} = \text{fpinion} \times \ (\text{Np}) = \text{fGear} \times \text{Ng}$$

VIII. HIGH-FREQUENCY IMPACTS USING A LOCAL FAULT ON A GEAR TOOTH

Assume that one of the teeth of the gear is suffering from a local fault such as a spall. This results in a high frequency impact occurring once per rotation of the gear. The local fault causes an impact that has duration shorter than the duration of tooth mesh. A dent on the tooth surface of the gear generates high-frequency oscillations over the duration of the impact. The frequency of impact is dependent on gearbox component properties and its natural frequencies. In this example, it is arbitrarily assumed that the impact causes a 2 kHz vibration signal and occurs over duration of about 8% of 1/fMesh, or 0.25 milliseconds. The impact repeats once per rotation of the gear [3].

IX. TIME-SYNCHRONOUS AVERAGING TO THE OUTPUT VIBRATION SIGNAL

Time-synchronous averaging averages out zero- mean random noise and any waveforms not associated with frequencies of the particular shaft. This makes the process of fault detection easier. Use the function TSA to generate time-synchronized waveforms for both the pinion and the gear. Specify time-synchronized pulses for the pinion. The time-synchronous averages for 10 rotations of the pinion are calculated.

X. POWER SPECTRA FOR THE TIME-SYNCHRONOUS OF THE AVERAGED SIGNALS

The power spectra of the time-synchronous averaged pinion signal in the same frequency range. The power spectrum of the original signal contains waveforms from two different shafts, as well as noise. It is difficult to distinguish the sideband harmonics. However, observe the prominent peaks at the sideband locations on the spectrum of the time-synchronous averaged gear signal. Also observe the no uniformity in sideband magnitudes, which are an indicator of localized faults on the gear. On the other hand, sideband peaks are absent from the spectrum of the time-synchronous averaged pinion signal. This helps us conclude that the pinion is potentially healthy [6].

By averaging out the waveforms that are not relevant, the tsa function helps identify the faulty gear by looking at sideband harmonics. This functionality is especially useful when it is desirable to extract a vibration signal corresponding to a single shaft, from a gearbox with multiple shafts and gears.

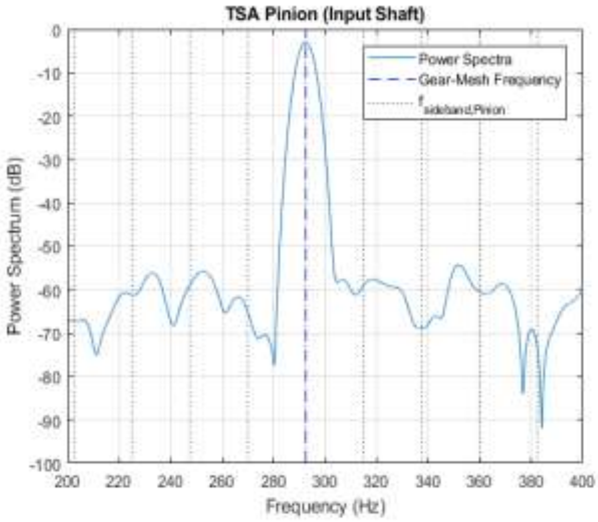

Figure 1: TSA Pinion for the input shaft.

XI. CONCLUSION

Vibration measurements taken at the bearings can also indicate the condition of the gearbox. A gear typically generates a complex, broad vibration spectrum beginning with frequencies well below the shaft rotational speeds and extending to several multiples of gear mesh frequency. The amplitude at mesh frequency may vary greatly from gear to gear, depending on number of teeth, gear ratio, tooth surface finish and load. When one gear becomes damaged the gear mesh

frequency component of vibration may increase substantially as compared to the base line vibration measurements, but this is not always the case.

Harmonics of gear mesh frequency may also become more apparent. Another frequency, which is often excited by gear defects, is the resonant frequency of geared shaft itself. This frequency can usually be measured by impulse testing. Both the natural frequency of the geared shaft and the gear mesh frequency may have accompanying side bands; sometimes side bands themselves may be the main indicator of a defective gearbox.

REFERENCES

[1] Al-Balushi KR and Samanta B, 2002, Gear fault diagnosis using energy-based features of acoustic emission signals, Proceedings of Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering 216, 249–263.

[2] Brandt, Anders. Noise and Vibration Analysis: Signal Analysis and Experimental Procedures. Chichester, UK: John Wiley and Sons, 2011.

[3] Fan X, and Zuo MJ, 2006, Mechanical Systems and Signal Processing 20, 966–982. Gearbox fault detection using Hilbert and wavelet packet transform.

[4] He, Y, Chen, Z, Guo, D, Chu, F, 2003, Key Engineering Materials. Vol. 245-246, 115-122 A genetic algorithm based inverse problem approach for pedestal looseness identification in rotor-bearing systems.

[5] Lacey, S. J. An Overview of Bearing Vibration Analysis.(From:http:// www.maintenanceonline.co.uk/maintenanceonline/content_images/p32-42%20Lacey%20paper%20M&AM.pdf)

[6] Owolabi GM, Swamidas ASJ, and Seshadri R, 2003, Crack detection in beams using changes in frequencies and amplitudes of frequency response functions, Journal of Sound and Vibration 265, 1-22.

[7] Randall, Robert Bond. Vibration Based Condition Monitoring: Industrial, Aerospace and Automotive Applications. Chichester, UK: John Wiley and Sons, 2011.

[8] Scheffer, Cornelius and Paresh Girdhar. Practical Machinery Vibration Analysis and Predictive Maintenance. Amsterdam: Elsevier, 2004.