Study of Gearbox Failure Identification using Vibration Analysis

M. Maniraj, Department of Mechanical Engineering,
Galgotias University, Greater Noida, Uttar Pradesh
Email ID: m.maniraj@galgotiasuniversity.edu.in

ABSTRACT: The gearbox is a central component of spinning machinery and has been commonly used in various industrial equipment. Unexpected failure of the gearbox may result in severe economic losses. It is also very important to detect early signs of fault from gearboxes. There are many ways to find defects in the gearbox. The primary method for tracking the condition and finding faults in the gearbox is vibration signal analysis. Vibration analysis was used as a predictive maintenance technique and as a support for system maintenance decisions. Using effective signal processing techniques, shifts in vibration signals induced by faults may be observed to help determine the health condition of the gearbox. Through calculating and evaluating the vibration of the machine, it is possible to assess the extent and magnitude of the defect and thereby anticipate the malfunction of the machine. The vibration signal of the gearbox bears the signature of the failure in the gearbox, and early identification of the gearbox is possible by examining the vibration signal using various signal processing techniques. This paper provides a short overview of the different methods used to analyze gearbox faults based on the vibration analysis process, with some insight into the modern approach used to diagnose gearboxes, such as the Artificial Neural Network, fuzzy sets and some emerging technologies in gear fault analysis.

KEYWORDS: Fault diagnosis, Vibration, Gearbox, Vibration measurement techniques, Vibration signature.

INTRODUCTION

Both devices with moving parts produce sound and vibration. Each machine has a particular vibration signature related to the structure and condition of the machine. If the state of the system shifts the signature of the vibration [1]. A difference in the vibration signature can be used to detect incipient defects until they become critical. These are the fundamentals of many types of condition control. Condition tracking can save money by increasing maintenance productivity and reducing the risk of serious injuries by avoiding breakdowns. The use of vibration analysis as one of the key methods for condition control has been widely developed over a period of approximately 35 years [2]. With parallel advances in electrical devices, transducers, computers and applications, system supervision is now almost fully automated. In the present work, the authors present a study of a number of diagnostic strategies for the detection of gearbox faults with special regard to vibration analysis. Vibration methods have been developed for two primary purposes.

The first goal is to isolate the signal associated with the gearbox from other components and to minimize the noise that may mask the signal of the gearbox, particularly in the early stages of the fault. The second goal is to classify the condition of the gearbox, to differentiate between the good and the defective gear, and to specify the damaged elements. Examples of commonly used gearbox techniques include Waveform Analysis [3], Time-Frequency Analysis, Quicker Fourier Transform (FFT), Spectral Analysis, Order Analysis, Time Synchronous Average, and moments of probability density.

These vibration-based diagnostic techniques have become the most common monitoring methodology due to the simplicity of calculation. Former vibration analysis was primarily used to locate defects and critical working conditions. Nowadays, demands for condition control and vibration analysis are no longer limited to attempting to mitigate the effects of system faults, but to allow more productive use of available tools [4].

The measurement signal produced from the computer in the operating area will also include results from a variety of various noise components. One of the key problems of condition monitoring is to locate and pick the aspect of the signal that may be connected to the condition of the monitored portion. The most advanced techniques for gear diagnostics are recognized in the study of vibration signals obtained from the gearbox housing [5]. The key goal is to identify and track the occurrence and form of fault at the start of production, in order to determine the residual life of the system and to select an acceptable maintenance schedule.

LITERATURE REVIEW

Time-frequency domain average technique (TSA) effectively reduces signal noise and captures the characteristics of one signal cycle. Wavelet Transform shows an accurate outcome in the identification and localization of gear fractures with varying degrees of injury [6]. Time domain strategies for vibration signal analysis such as waveform generation, indices (RMS value, peak value and crest factor) and full vibration level do not provide any diagnostic evidence under differing load conditions. In the frequency domain, FFT was able to display whims at fault-characteristic frequencies and several frequencies, but other peaks are also present due to the signal modulation effect [7].

RESULT AND CONCLUSION

It is well established that the most important components in the vibration of the gear are the meshing frequency and the harmonics generated with the sidebands due to modulation. Increases in the number and amplitude of the sidebands can suggest a defect in the gearbox. In Gears, vibration analysis may diagnose broken teeth, misalignment, damaged and/or worn teeth, excentric gear etc. Both the flaws. Vibration analysis can diagnose imbalance, bent shaft, misalignment, excentric papers, loose bits, rubs, crucible rpm, broken shaft, etc., rotor and shaft faults. Race and ball/roller pitting, spalling, etc. defects in roller bearings can be found successfully using vibration analysis techniques. Time-frequency domain average technique (TSA) effectively reduces signal noise and captures the characteristics of one signal cycle. Wavelet Transform shows an accurate outcome in the identification and localization of gear fractures with varying degrees of injury. Time domain strategies for vibration signal analysis such as waveform generation, indices (RMS value, peak value and crest factor) and full vibration level do not provide any diagnostic evidence under differing load conditions. In the frequency domain, FFT was able to display whims at fault-characteristic frequencies and several frequencies, but other peaks are also present due to the signal modulation effect. The detection of fault groups is difficult by this strategy. Help Vector Machine has a greater classification ability to detect different faults in the gearbox and can be used for automated fault diagnosis. The network will reduce maintenance costs and maintain a consistent production system, and it can even be used for online process diagnostics.

REFERENCES

[1] D. G. Lewicki, K. E. LaBerge, R. T. Ehinger, and J. Fetty, “Planetary gearbox fault detection using vibration separation techniques,” 2011.

[2] A. Aherwar and S. Khalid, “Vibration analysis techniques for gearbox diagnostic: A review,” *Int. J. Adv. Eng. Technol.*, 2012.

[3] E. B. Halim, M. A. A. Shoukat Choudhury, S. L. Shah, and M. J. Zuo, “Time domain averaging across all scales: A novel method for detection of gearbox faults,” *Mech. Syst. Signal Process.*, 2008, doi: 10.1016/j.ymssp.2007.08.006.

[4] S. J. Loutridis, “Damage detection in gear systems using empirical mode decomposition,” *Eng. Struct.*, 2004, doi: 10.1016/j.engstruct.2004.07.007.

[5] L. Hong and J. S. Dhupia, “A time domain approach to diagnose gearbox fault based on measured vibration signals,” *J. Sound Vib.*, 2014, doi: 10.1016/j.jsv.2013.11.033.

[6] J. Antoni and R. B. Randall, “Differential diagnosis of gear and bearing faults,” *J. Vib. Acoust. Trans. ASME*, 2002, doi: 10.1115/1.1456906.

[7] F. Herzberg, “Two-Factor Theory of Motivation.,” in *Motivation theory.*, 1959.