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Effect of Full Tooth Breakage and Improper Chamfer Defect on Vibration Signature of Single Stage Spur Gear Box

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ABSTRACT

The aim of this paper is to identify and find out the effect of full tooth breakage and improper chamfer of spur gear on vibration signature of single stage spur gear box. This is done with the help of experimental set-up. The vibration signatures are captured from the experiments using MATLAB software and the change in amplitude and peaks of signature patterns is analysed. On comparing the signature of healthy and defected gear at initial stage defect is identified. Finally, with the help of signature pattern technique the amplitude range of all the faulty gears is determined

Keywords: Spur Gear, Condition Monitoring, Vibration Signature Analysis, Matlab.

1. Introduction

The machines used in industries contains certain vibration signature machine in standard condition. Development of fault changes that signature in a way that can be related to the fault. This has given rise to the term 'mechanical signature analysis. Even in good condition, machines generate vibrations. Many such vibrations are directly linked to periodic events in the machine's operation, such as rotating shafts, gear teeth in mesh, rotating electric fields, and so on [1]. The frequency with which such events repeat often gives a direct indication of the source and thus many powerful diagnostic techniques are based on frequency analysis [2-4]. Due to the rotating nature, the signature of localized faults of the gear teeth, such as deformation, breakage, and fracture, generally represents as periodic transient impulses. The fault frequency can be identified by Vibration signature analysis.

2. Vibration Signature Analysis.

While a local defect such as crack etc occurred on gear tooth, a short duration impulsive signal will be generated. The impact will produce additional amplitude and phase modulation effects to the gear meshing components. As a consequence, a few of sidebands of the tooth-meshing frequency and its harmonics will spread over a wide range frequency. It is difficult to detect the spacing and evolution of sideband families in the frequency spectrum due to noise and vibration from other mechanical components [5–7]. In this paper vibration signature analysis method such as Time domain is used for signature analysis. Time-plot analysis is used simply to analyze the signals in time domain, and can be interpreted as the most straight forward way to analyze a signal.

The time domain methods try to analyze the amplitude and phase information of the vibration time signal to detect the fault of gear-rotor-bearing system. A typical vibration waveform is shown in figure-1 for a gearbox. This waveform shows the anomalous behavior of the gear after certain intervals with large magnitude. The peak level, RMS, level, and the crest factor are often used to quantify the time signal.
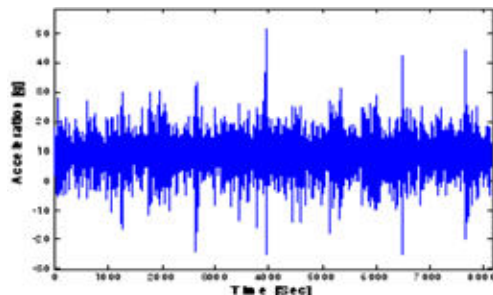

Figure 1 Vibration signature in time domain

3. Experimental Set-up

In the present work, the experiments are conducted on a gear mesh assembly fabricated for the purpose as shown in Figure 2. The gearbox used in the setup is an automotive gearbox of Maruti 800 car. The driver gear is having 32 teeth, mounted on driver shaft coupled with a single phase 50 Hz DC motor (make: Crompton_, power rating 0.5 HP). The driver shaft is supported on two ball bearings 6303z. The gear on the driven shaft is having 29 teeth and also supported between two ball bearings 6204z. Other end of the driven shaft has provisions to apply load. A Piezoelectric type accelerometer is mounted on the case closer to matting gears. The vibration signal is captured with the help of a PC using Matlab software. The operating speed was set at 900 and 1800 RPM and verified with an optical tachometer.


Figure 2 Experimental test -rig

The experiment is carried out in two phases with and without loading. In the first phase, the healthy gears are mounted and the corresponding vibration signal is captured. A sample data of five second duration and its Vibration Signature Analysis are shown in Figure 3 and 4, respectively. In the second phase, the driven gear was replaced with a gear with different common defects, full tooth breakage and improper chamfer.

4. Data Acquisition
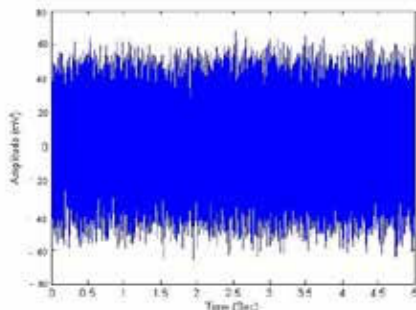
Figure 3 Vibration signature in time domain of Healthy gear at 900 rpm
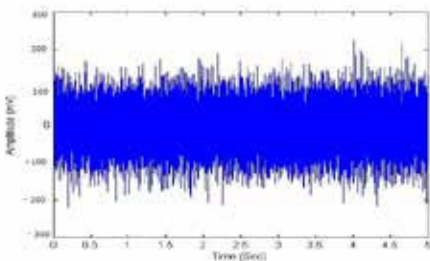
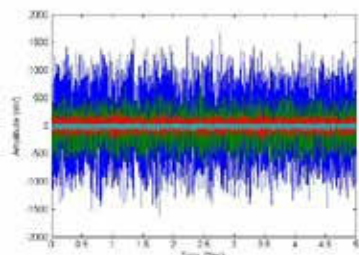**Figure 4 Vibration signature in time domain of Healthy gear at 1800 rpm**

5. Analysis of Defect1 (Full tooth breakage)
Here the driver gear was replaced with gear of Full tooth breakage (defect1) and the
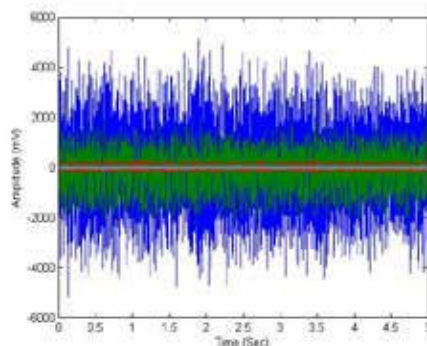

Figure 5 full tooth breakage defect

vibration signature is captured for five second. This step is done on two rpm i.e. 900 and 1800 on different defective gears. The gear with full tooth breakage is shown in figure 5 and the vibration signal in time domain is shown in figure 6 and 7.

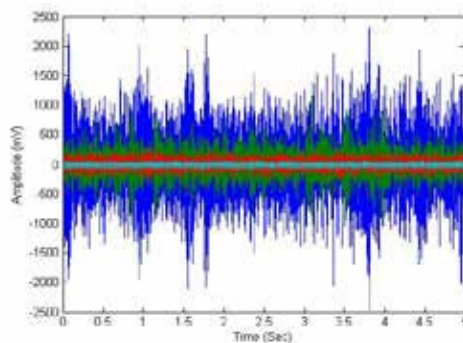**Figure 6 Vibration signature in time domain of gear of full tooth breakage defect at 900 RPM**

Figure 7 Vibration signature in time domain of gear of full tooth breakage defect at 1800 RPM

## 6. Analysis of Defect2 (Improper Chamfer)

Figure 8 Improper chamfer defect

Here the driver gear was replaced with gear having improper chamfer (defect2) and the vibration signature is captured for five second. This step is done on two rpm i.e. 900 and 1800 on different defective gears. The defected gear is shown in figure 8 and the vibration signal in time domain are shown in figure 9 and 10
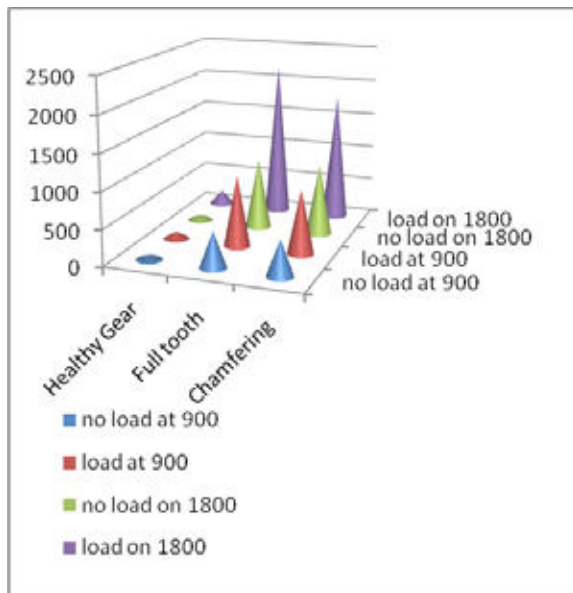

Figure 9 Vibration signature in time domain of gear of chamfer defect at 900 RPM
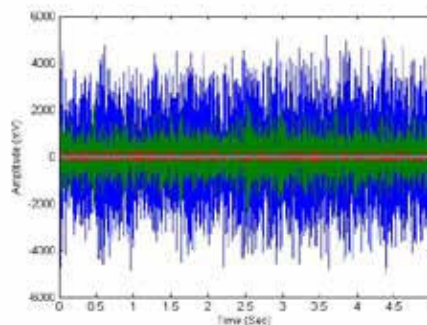
Figure 10 Vibration signature in time domain of gear of chamfer defect at 1800 RPM

7. RESULTS

Figure 11 Comparisons of the Defects

A graph is plotted between the amplitude of the defect signature pattern and working conditions. It is clear from the figure 11 that the amplitude range of defect is higher in case of. Full tooth breakage defect (2200 mv) and lowest in case of improper chamfer defect 500 mv) respectively.

8. Conclusions

➢ It is observed that it is difficult to identify the differences in between pattern of full tooth breakage and improper chamfer defect at low speed in without load condition, but in loading condition one can easily observe the vibration signature.

➢ It is observed that at high speed the vibration pattern with gear defect easily obtained when the condition is still on no load or without load and at loading condition we can easily observe difference in amplitude range of vibration signature pattern.

➢ It is clear from the result data the amplitude range is much higher in case of full tooth breakage defect rather than the improper chamfer defect.

Acknowledgement

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