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Effect of Spalling and Pitting 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 spalling and pitting on vibration signature of single stage spur gear box. To perform this work, an experimental set-up is fabricated. The vibration signatures are captured using MATLAB software from the experiments and the change in amplitude and peaks of signature patterns is analysed. A number of defects i.e. pitting and spalling are created on driver gear and signature is captured of healthy and defected gear. 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

A machine in standard condition has a certain vibration signature and is changed when fault developed. Many such vibrations are directly linked to periodic events in the machine's operation, such as rotating shafts, meshing gear teeth, rotating electric fields, and so on [1]. The frequency of 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 occurred on gear tooth, a short duration impulsive signal will be generated. The impact will produce additional amplitude and phase modulation 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 of 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]. The vibration signature analysis is used to detect the fault in any system with applying Time domain analysis. In this paper vibration signature analysis method such as Time domain is used for signature analysis. Waveform analysis can also be useful in identify vibrations that are non synchronous with shaft speed. 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.

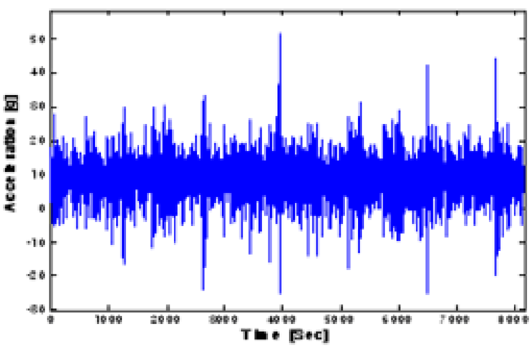

Figure 1 Vibration signature in time domain

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 casing 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.

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 pitting and spalling. The vibration signature is captured and a sample data of five second duration carried out.

Figure 2 Experimental test -rig

4. Data Acquisition

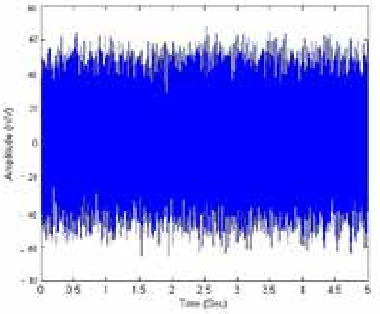

Figure 3 Vibration signature in time domain of Healthy gear at 900 rpm

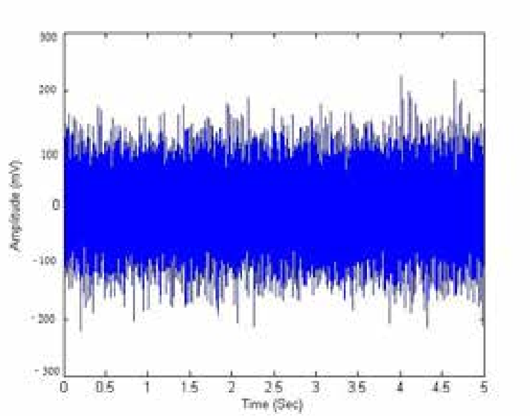

Figure 4 Vibration signatures in time domain of Healthy gear at 1800 rpm

5. Analysis of Defect1 (Pitting)

Figure 5 Pitting defect

In the second phase, the driver gear was replaced with gear of defect1 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 shown in figure 5. The vibration signal in time domain are shown in figure 6 and 7

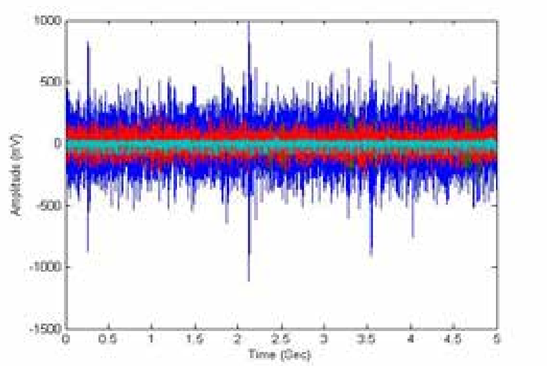

Figure 6 Vibration signature in time domain of gear of pitting defect at 900 RPM

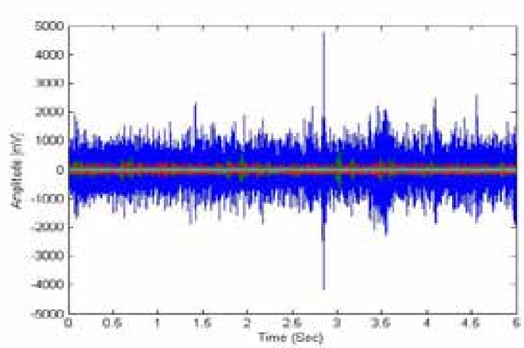

Figure 7 Vibration signature in time domain of gear of pitting defect at 1800 RPM

6. Analysis of Defect2 (Spalling)

Figure 8 Spalling defect

In the second phase, the driver gear was replaced with gear of 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 shown in figure 8. The vibration signals in time domains are shown in figure 9 and 10.

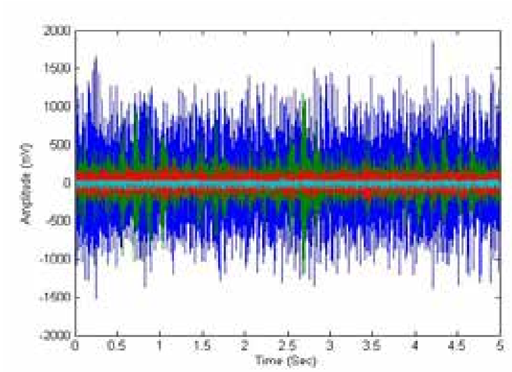

Figure 9 Vibration signature in time domain of gear of spalling defect at 900 RPM

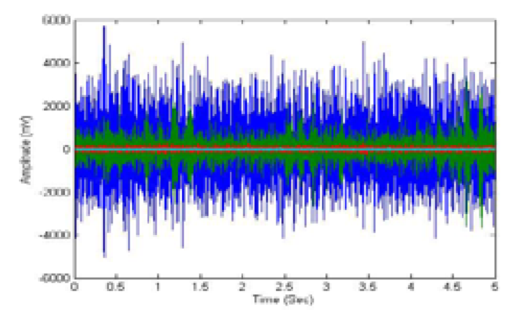

Figure 10 Vibration signature in time domain of gear of spalling defect at 1800 RPM

7. RESULTS

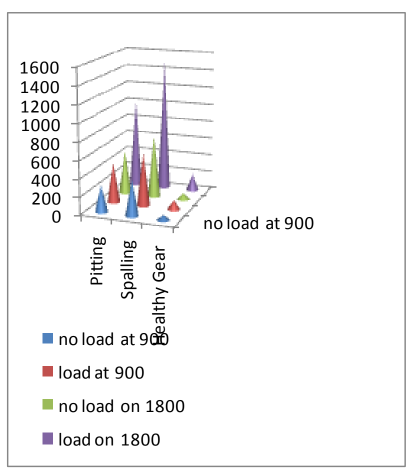

Figure 11 Comparisons of the Defects

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 Spalling (1800 mv) defect and lowest in case of pitting (300 mv) respectively.

8. Conclusions

- It is observed that it is difficult to identify the differences in between pattern of pitting and spalling 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 spalling defect rather than the pitting defect.

Acknowledgement

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