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ANALYSIS OF MULTIPLE PITTING DEFECTS ON SPUR GEAR USING ACOUSTIC SIGNALS

Mr. Vijay Kumar Karma*, Shveta Nargawe
[1]Assistant Professor, Department of Mechanical Engineering, Institute of Engineering & Technology, DAVV University, Indore, Madhya Pradesh, India
[2]M.E. Student, Department of Mechanical Engineering (Design & Thermal Engineering), Institute of Engineering& Technology, DAVV University, Indore, Madhya Pradesh, India

ABSTRACT
Gears are very important mechanical elements in industrial applications and it is generally made for high performance, efficiency and reliability. Any defect/fault in gear will reduce its operations/performance etc. Acoustic signal is the tool to detect fault and it is widely used for gear fault diagnostics in moving element like gear box, machine etc. The Acoustic signals can be captured from the machine with the help of acoustic sensors. The aim of this paper is to analyze the acoustic signals to capture from single stage spur gear. Here the faults consider is pitting on single and multiple teeth. The fault is created artificially. The Acoustic signal data is collected from the experimental setup at different pitting defects and then the energy dissipated is found out. The Wavelet technique is used for analysis through MATLAB software.

KEYWORDS: Spur Gears, MATLAB, Acoustic signal, pitting defect, Wavelet Analysis, Energy dissipated.

INTRODUCTION
Gear is one of the moving elements which is used to transmits to motion from one shaft to another shaft. To transmit the power it is necessary that the gear should be free from any type of defect or fault. Hence condition monitoring is a necessary condition.
Condition monitoring is defined as the detection and collection of information that indicate the state of machine. Condition monitoring provides information, which helps to maximize machine life. [1]
In this paper, Acoustic signal is used for analyzing the pitting defect. It is highly sensitive and offers opportunities to detect the defects in moving elements. Acoustic signal mainly detect high frequency sound and it is not affected by mechanical background noise. [2]

LITRATURE SURVEY
Vincent obghonndh [3] done his research to find out the trends in the pitting progression of a gear tooth over time using MATLAB. He used wavelet techniques for the analysis of data and concluded that wavelet is easier to analyse and also it was very useful in determining the rate at which the pitting process progressed. K.H Pedersen [4] carried out condition monitoring of gear failures with acoustic Emission. He utilized data taken from earlier experiments to investigate the use of acoustic emission for tool conditions monitoring of gears. He concluded that the results obtained from test confirm that the acoustic emission method for condition monitoring best suited to gear also. Singh A et al [5] compared the effectiveness of different diagnostic methods to detect gear teeth cracks from experimentally measured data, it was concluded that the application of the wavelet transform to the raw measured signals is sensitive to the presence of gear defects. Hongyu Yang et al [6] explained various vibration feature extraction techniques for fault diagnosis of rotating machinery in time domain, frequency domain. He concluded that the Frequency domain features are generally more consistent in the detection of damage than the time domain parameters.

EXPERIMENTATAL SETUP
In the present work, the single stage gear box has been used for the experimentation. Here gearbox is derived at different rpm by 0.5 HP electric DC motor which is connected through Oldham's coupling. Dimmer is used to control the speed of DC motor The gearbox consists of two gears for experimental purpose, one gear (driven gear) has 32 teeth, mounted on driven shaft coupled with 50 Hz DC motor and second gear (driver gear) has 35 teeth. Both the driven and driver shaft is supported between two ball

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bearings. Other end of the driver shaft has provisions to apply load. The setup is shown in the figure 1.

METHODOLOGY

Acoustic signal data are processed in MATLAB software. Wavelet techniques were used in order to evaluate the acoustic signals which is collected from gear box and obtained energy dissipation information out of them.

The artificial pitting defect is introduced on driver gear and the Acoustic signal readings are taken using microphone. Small pits were produced manually on the tooth flank using a chisel.

Figure 1 Gear box

Microphone was placed 0.5m above the experimental setup and the data is analyzed by wavelet analysis techniques using MATLAB software. For this analysis gearbox is rotated at different rpm. The gearbox is having two types of faults, which were artificially created on spur gear. Defects are

- Defect (1) single pit on multiple teeth
- Defect (2) multi pits on multiple teeth

The Acoustic signals were recorded in time domain and frequency domain for healthy gear, which are depicted in figure 2 and 3 respectively. The energy dissipated by the healthy gear at different rpm is shown in the figure 4 to 13. The time domain signal is converted into frequency domain with the help of FFT of the signal. The energy dissipated by the healthy gear at different rpm is depicted in figure 14.

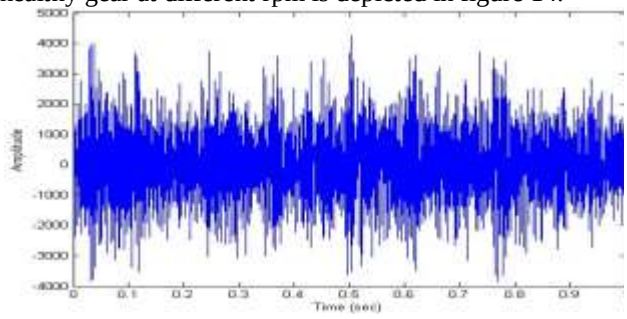

Figure 2 Acoustic signal in time domain of Healthy gear

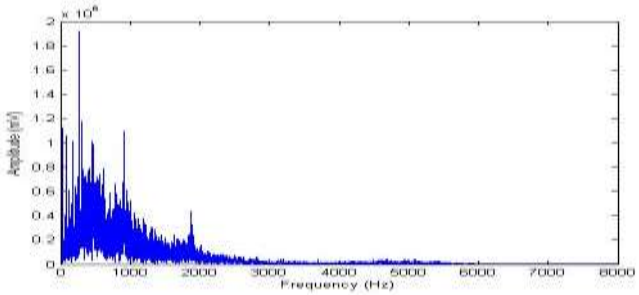

Figure 3 Acoustic signal in frequency domain of Healthy gear

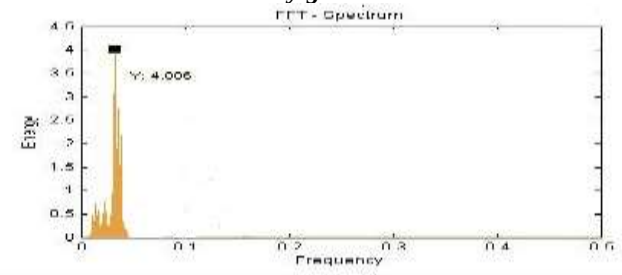

Figure 4 Energy dissipated by Healthy gear at 150 rpm

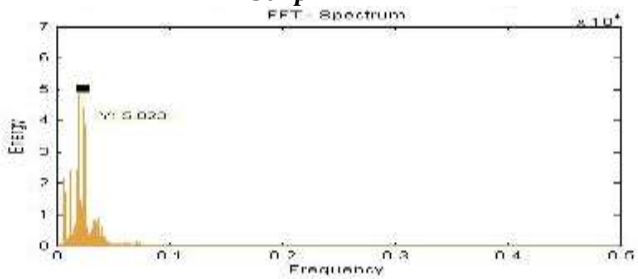

Figure 5 Energy dissipated by Healthy gear at 300 rpm

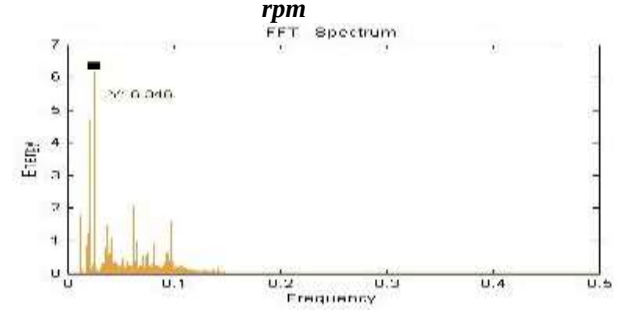

Figure 6 Energy dissipated by Healthy gear at 450 rpm

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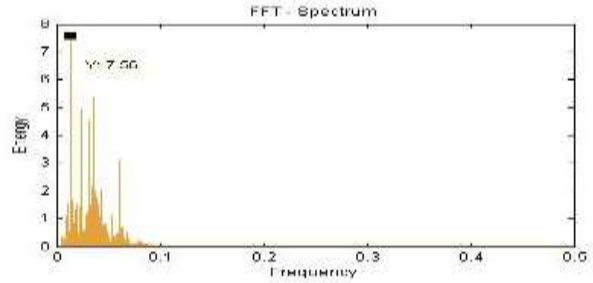

Fighre 7 Energy dissipated by Healthy gear at 600 rpm

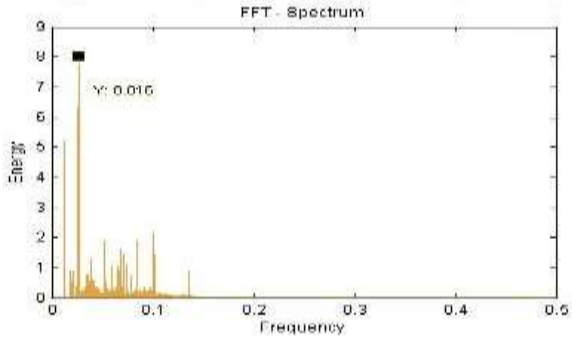

Figure 8 Energy dissipated by Healthy gear at 750 rpm

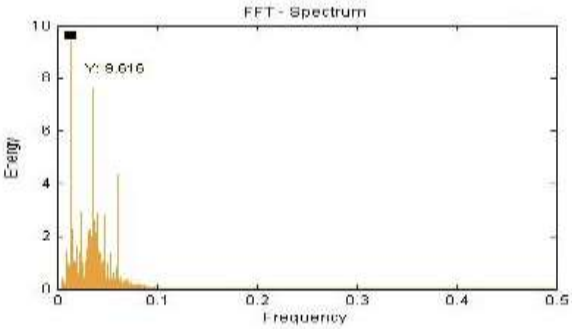

Figure 9 Energy dissipated by Healthy gear at 900 rpm

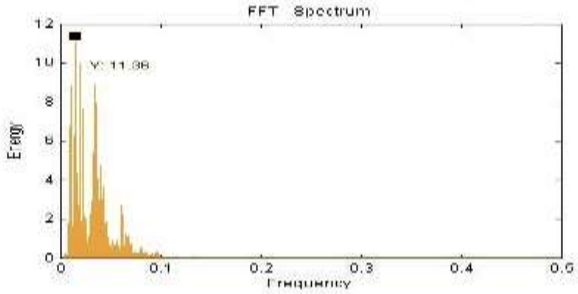

Figure 10 Energy dissipated by Healthy gear at 1050 rpm

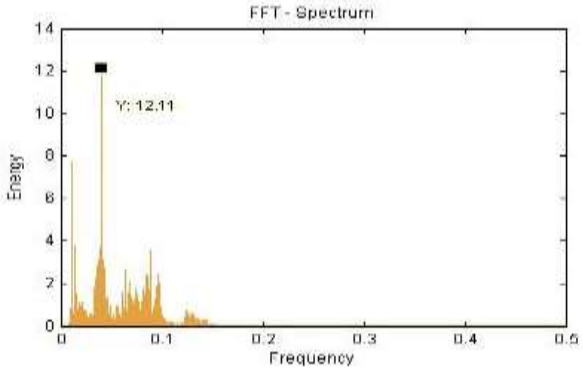

Figure 11 Energy dissipated by Healthy gear at 1200 rpm

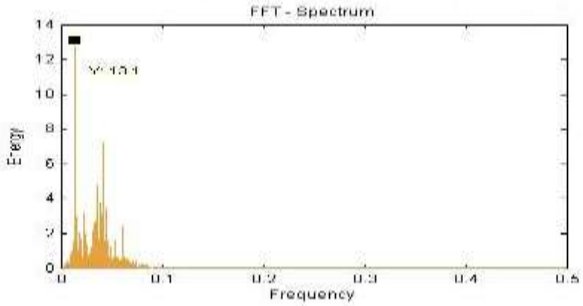

Figure 12 Energy dissipated by Healthy gear at 1350 rpm

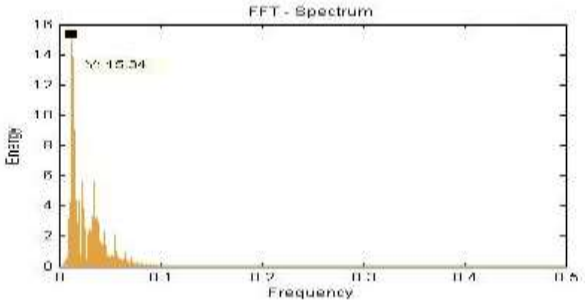

Figure 13 Energy dissipated by Healthy gear at 1500 rpm

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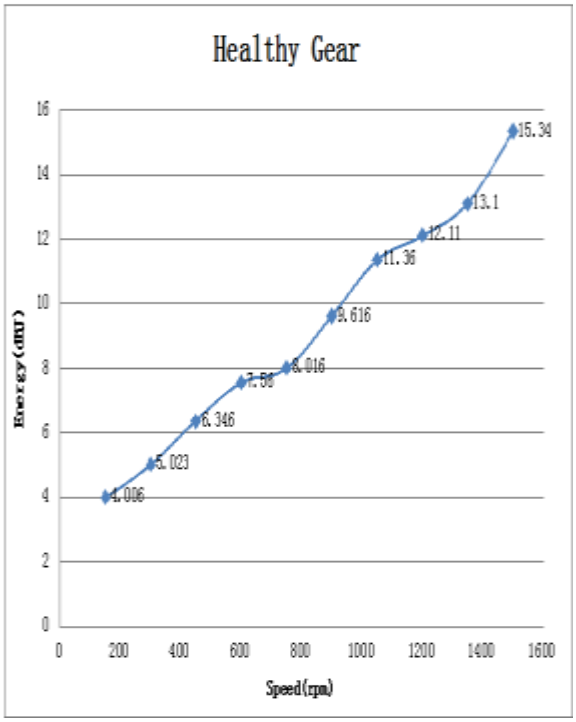

Figure 14 Energy dissipated by the Healthy gear at different rpm

After this, the driver gear was replaced with gear of defect1 and Acoustic signal is captured for duration of one second. Acoustic signal in time and frequency domain of defective gear of defect 1 is shown in figure 15 and 16 respectively. The energy dissipated by the gear of defect1 at different rpm is shown in figure 17. The same procedure is repeated for the defect2 gear. The figure 18 shows the energy dissipated by the gear of defect2 at different rpm. The figure 19 represents the comparative energy dissipated by health, defective gear of defect1 and defective gear of defect2.

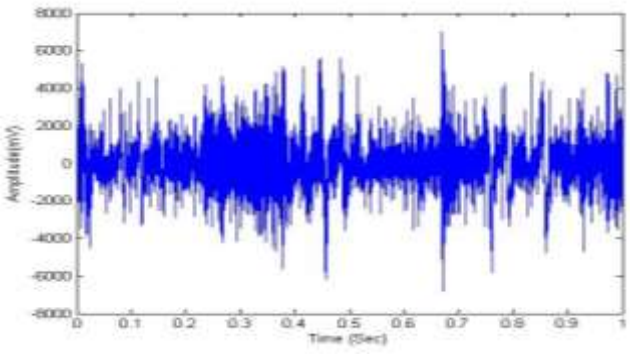

Figure 15 Acoustic signal in time domain of defective gear

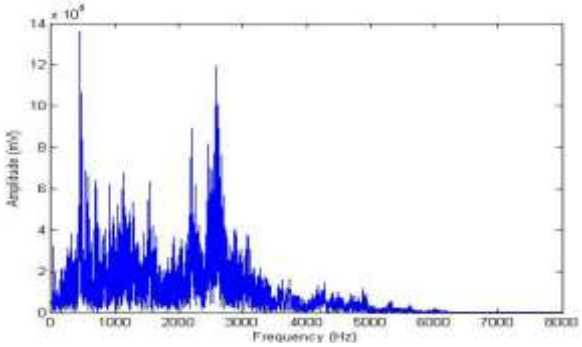

Figure 16 Acoustic signal in frequency domain of defective gear

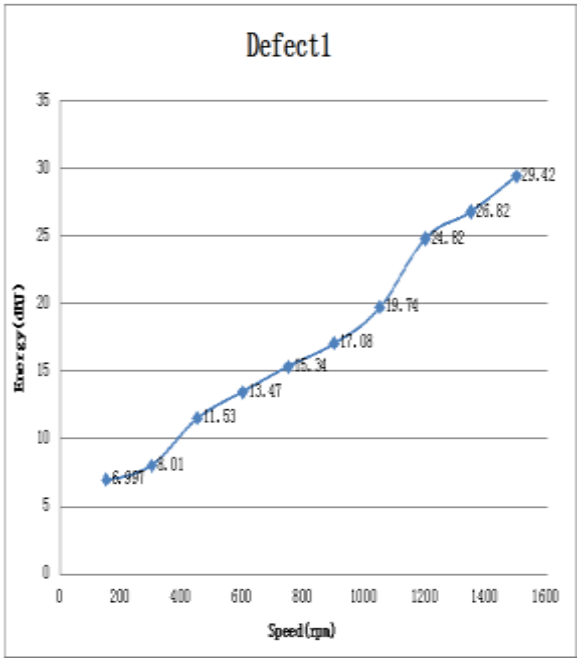

Figure 17 Energy dissipated by the gear of defect1 at different rpm

RESULT AND DISCUSSIONS

It is clearly seen from the figure 16 that the Energy dissipated is higher at the frequency nearly 5.1 kHz. The setup box contains two different kind of pitting defects and they produced different acoustic signals. The defective gears generate high frequency components (in the range of 4.5–5.5 kHz). Therefore Acoustic signal were filtered at high strips frequency range between 4.5 kHz to 5.5 kHz.

It was observed that when the severity level of the pitting defect is increased then the energy dissipation is also increased and It was also noted that the captured acoustic signal was not as good, if the position of the microphone was not correct.

It can be seen from the figure 19 that the energy

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dissipation of the single pits on multiple teeth and multi pits on multiple teeth was found to be 6.997 dBJ to 29.42 dBJ and 13.36 dBJ to 47.13 dBJ. It is observed that multi pits defect on multiple teeth is most severe as the energy of defect2 is highest i.e. 47.13dBJ.

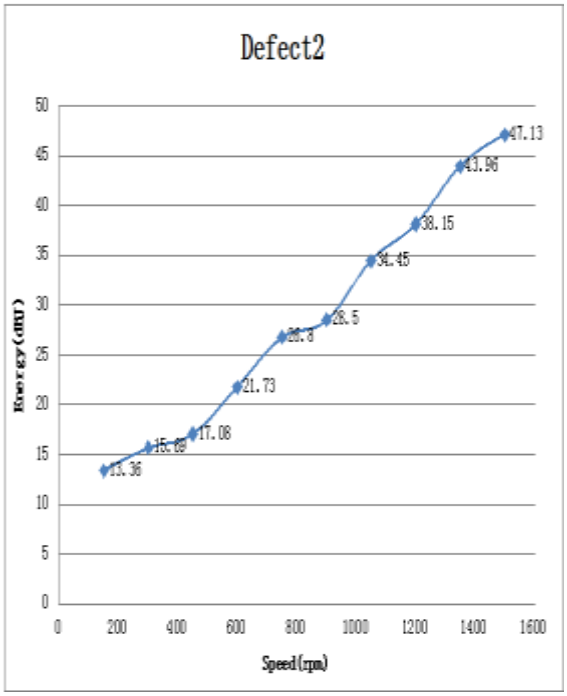

Figure 18 Energy dissipated by gear of defect2 at different rpm

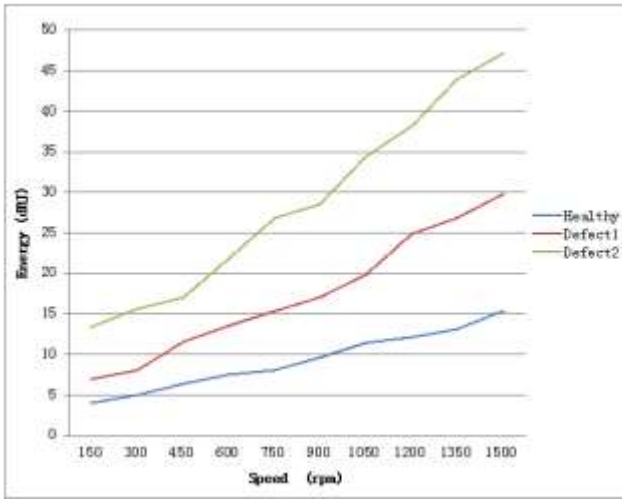

Figure 19 Comparison of Energy dissipated by the gears at different rpm.

CONCLUSION

Acoustic signal data which is collected during the experimentation provide useful information for condition monitoring. Experimental work was carried out with the intention to use Acoustic signal data which is analysed using wavelet technique and it show how the energy dissipation varies for different faults.

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	**Mr. Vijay Kumar Karma** Assistant Professor, Department of Mechanical Engineering, Institute of Engineering & Technology, DAVV University, Indore, Madhya Pradesh, India
	**Shveta Nargawe** Student, Department of Mechanical Engineering (Design & Thermal Engineering), Institute of Engineering & Technology, DAVV University, Indore, Madhya Pradesh, India