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Condition Monitoring of Spur Gear Box based on Acoustic Emission Signal Analysis

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***Abstract:** Monitoring the condition of rotating machinery, such as gearbox is an important task in order to enhance its performance. Acoustic Emission (AE) and vibration analyses are some of the most accomplished techniques used for this purpose. Acoustic emission technique has the ability to detect the initial phase of component degradation. This paper presents the experimental investigation of gearbox condition using acoustic emission techniques. AE signals of gearbox under different conditions are acquired. AE signal parameters such as RMS, amplitude and rise time have provided information about the condition of the gearbox. Hence, AE technique can also be used for monitoring the gearbox.*
***Keywords:** Condition monitoring, Acoustic emission, Spur Gearbox*

I. INTRODUCTION

Before the 21st century, there was a limited amount of research on monitoring the condition of rotating machines. Although, a number of industrial applications use low-speed rotating machines including steel mills, paper mills, water sewage plants and wind turbines. Most of the failures in these applications occur due to stoppages or failures related to the condition of gearbox which is one of the vital components. Gears are the key components of modern power transmission systems in different industrial applications. Particularly in case of high power density and different operating conditions, different damage modes such as micro-pitting, pitting, or scuffing are observed on the tooth surface of gears[1]. Condition monitoring of gear box using AE technique is a powerful non destructive method to characterize progressive damage and deformation processes[2]. Micro-pitting is common gear failure mode, which is determined by experimentally, followed by visual inspection and photographing of tooth surface of the gear, which is time consuming and gives limited information about the damage mode. So, the pitting fault was detected with online particle monitoring from lubricating oil[3]. AE technique is capable to diagnosis the fault in the gear tooth at different load conditions. Hence, AE technique has significant potential in the condition monitoring of the gear box[4].

A single damage on the surface of the gear wheel create an unusual signal in the gear box which is acquired by the AE sensor that is mounted on the gear box casing[5]. In addition to that, a great deal of research on spur gear has been done for understanding the possible gear faults by considering their acoustic characteristics[6]. Condition based maintenance has been developed as a maintenance policy, which contributes to the improvement of reliability and availability of technical systems through maintenance decisions based on real time information regarding the current health state of a system[7]. AE technology, an established technology in various applications, has been investigated for its suitability for material flow characterization of bulk material. High-frequency waves generated during impact processes are recorded as acoustic emission signals to be used as a suitable measurement technology. By analyzing the acoustic emission signals of known material flow compositions, suitable parameters and algorithms can be developed[8]. This paper is focused on monitoring techniques used to oversee the mechanical integrity of these vital components. Monitoring methodologies include the collection of data related to conventional measurements, as well as newer forms of sensing incipient degradation such as acoustic emission. The results of experimental investigations carried out in spur gear of back to back gearbox under different loading conditions. The studies considered the estimation of AE parameters and their effects on the gear tooth surface. The results provide a variation of AE parameters on different loading conditions.

II. EXPERIMENTAL SET UP

The operations were performed on a standard FZG gear box test rig is shown in figure 1. The test rig contains two gear stages, namely test gears and slave gears in a back to back arrangement. The slave gears are driven by an electric drive. Static torque loading of the gears is achieved via torque clutch. Defined loads, which are specified in terms of load stages, can be applied by means of calibrated weights and a lever arm.

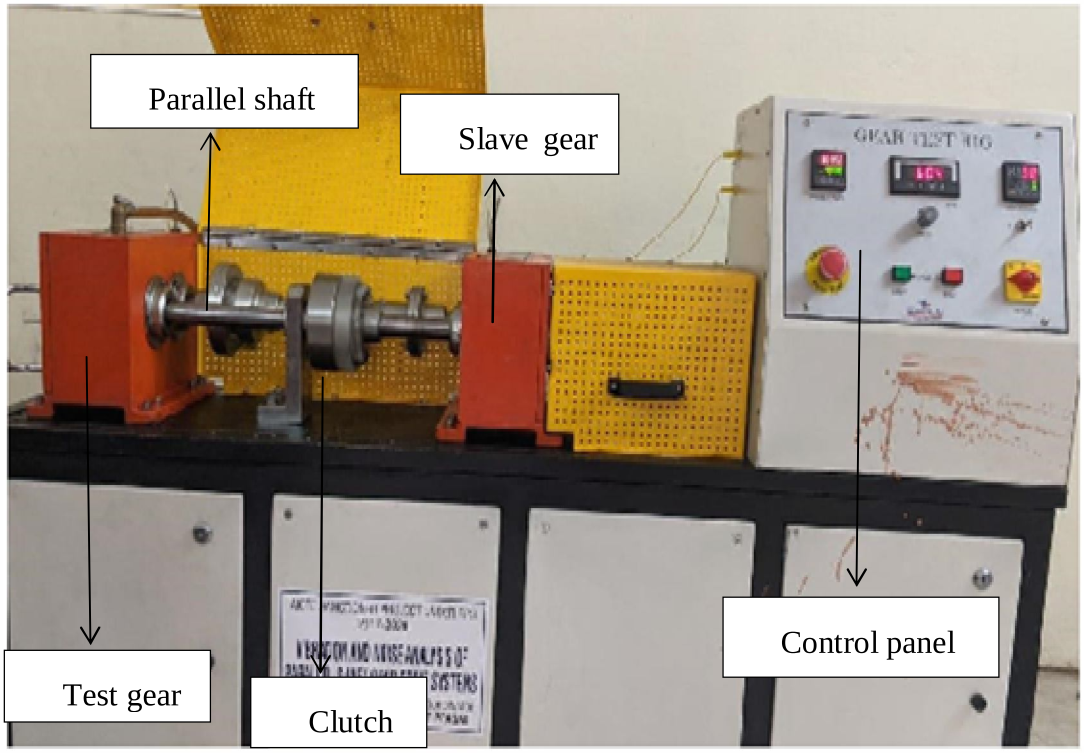


Figure 1:- Illustration of FZG standard test rig

In this study, AE signals were acquired using WS α SN AF79 AE sensor, which is mounted on the outside casing surface of the test gearbox. Simultaneously 2 analog input channels, 24 bit DAQ system was used for signal conditioning and processing of AE signals. The experiment was conducted at a speed of 600 RPM and AE signals were acquired in three operating conditions such as 0N, 50N and 100N. These AE signals were acquired and analyzed to correlate the condition of the gearbox. The AE signal parameters are shown in fig 2.

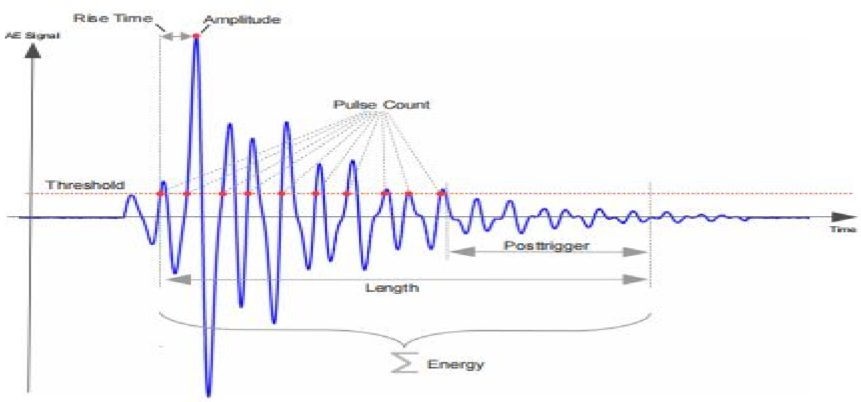


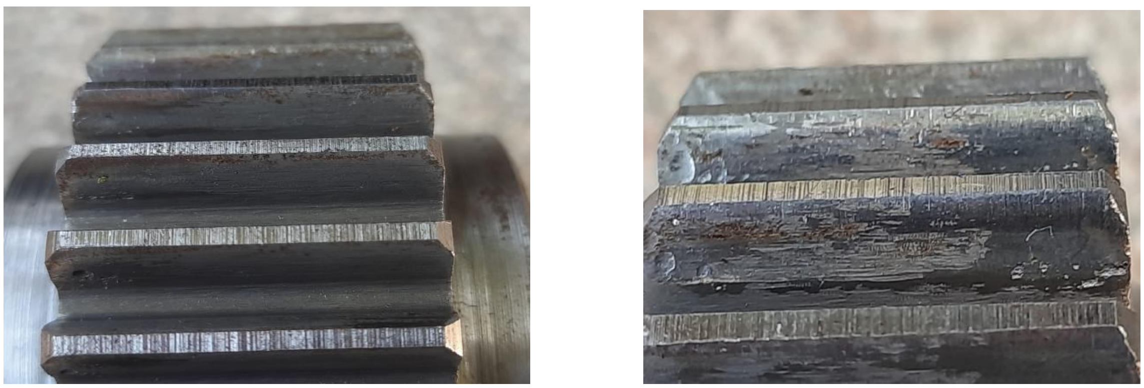
Figure 2:- Illustration of AE parameters, Josua Hunziker et al,(2012)[2].

The above diagram shows the features of AE parameters such as rise time, amplitude, RMS, energy, duration, peak count and count. These parameters are acquired by an AE sensor and analyzed through an AE win software. The specifications of spur gear is given in table 1.

Table 1 :- Specification of spur gear

SL No.	Parameters	unit	Gear	Pinion
1	Number of Teeth		45	28
2	Module	mm	2.5	
3	Pressure angle	degree	20	
4	Face width	mm	25	
5	Centre distance	mm	91.25	
6	Pitch circle diameter	mm	112.5	70
7	Max. Allowable stress	MPa	448	

During operation of gears, cyclically repeated rolling and sliding contact of gear teeth lead to damage of tooth flank surface. The gears are subjected to surface fatigue failures like micro pitting and pitting faults. Recently, AE technique gained attention in the context of gear transmission monitoring for detection of different damages. In this regard, contact of gears was identified as major source of AE meshing. Fig 3 shows the faults occurred in the current research work.



(a) (b)

Figure 3:- a) Micro-pitting b) Pitting faults

Signal processing of AE involves the extraction of time domain features i.e., amplitude, count, rise time, Root mean square, duration, peak count, Average signal level[ASL], AE hit. However, all these parameters are not provide the information about condition of gearbox. Hence, the few features of AE wave forms such as amplitude, RMS and rise time is used in context of gears to provide the information about condition of gearbox.

III. RESULTS AND DISCUSSION

In the sequence, results of AE measurements from a FZG gearbox test rig are presented. The experiment was conducted on different loading conditions in generating AE signal during meshing of spur gear. Firstly, the AE signals are acquired from the experiment. Here, different AE parameters are obtained and tabulated with the different operating conditions as shown in table 2.

Table 2 :- The values of AE parameters by experimental study.

Type of test gear	Load condition	Amplitude(db)	RMS(v)	Rise time(µs)
Spur gear	0N	76.12	0.0884	3166.6
	50N	93.77	0.2643	3336.09
	100N	85.36	0.2532	3156.43

The above table 2 shows the values of AE parameters by experimental study. These values are plotted on a graph with variation of load as shown in below figures.

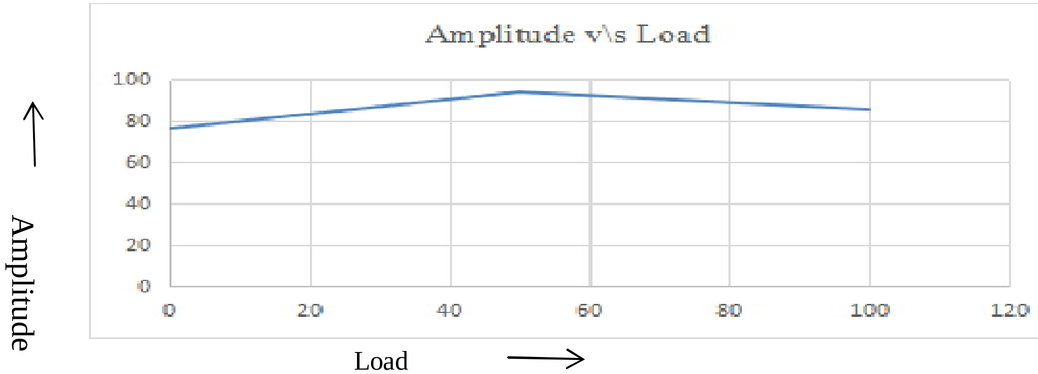


Figure 4:- Amplitude versus Load

Fig. 4 presents the variation of amplitude with respect to load on the gear box test rig, initially the value of the amplitude at without loading condition was measured about 76.12db. For 50N and 100N the value of the amplitude are 93.77db and 85.36 db respectively. It can be seen that value of the amplitude at maximum load condition is high compared to no load condition. The effect of load variation on RMS value as shown in fig 5.

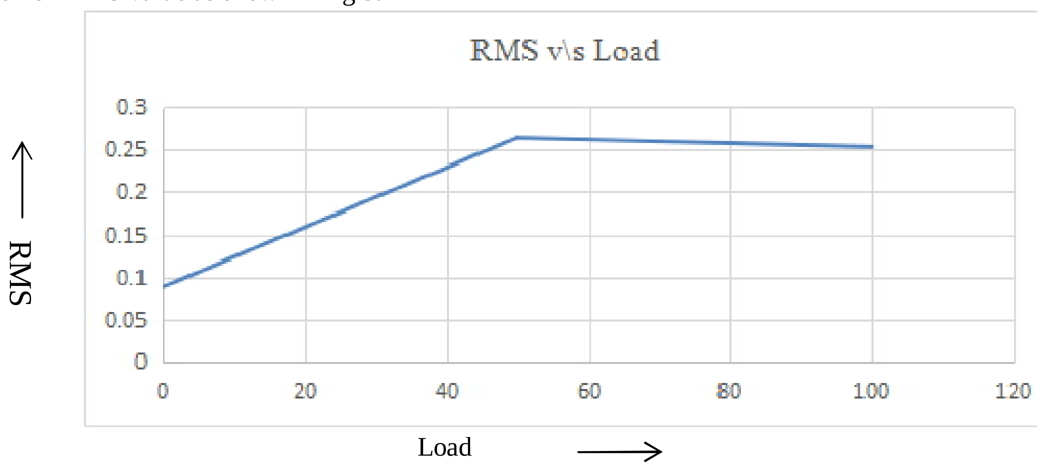


Figure 5:-RMS versus Load

In the above diagram shows that the effects of load deviation on RMS value. The RMS value is increased up to 0.2643v at loading condition compared to the RMS value about 0.0884v at initial(no load) condition. This variation in value of AE rms clearly shows the change in condition of gear. The variation of rise time with respect to load as shown in figure 6.

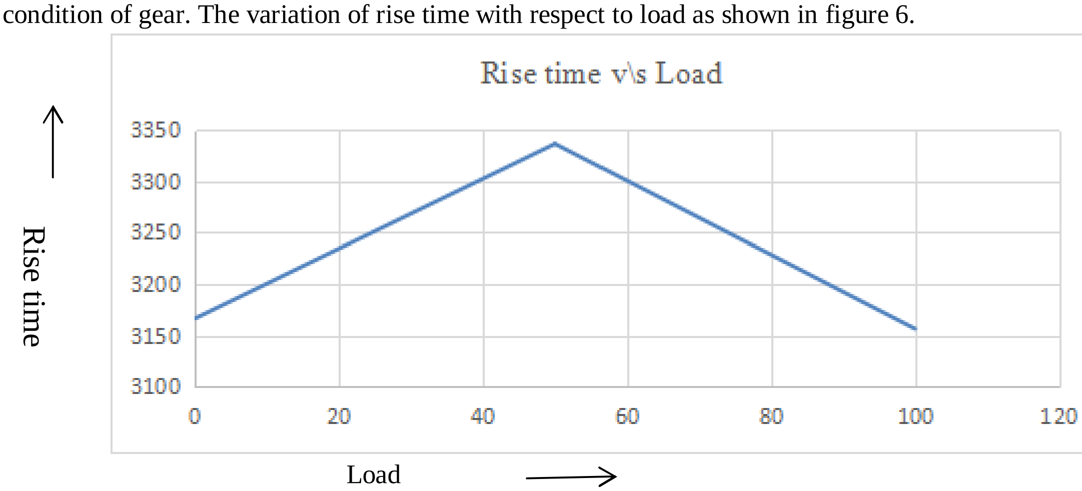


Figure 6:- Rise time versus load

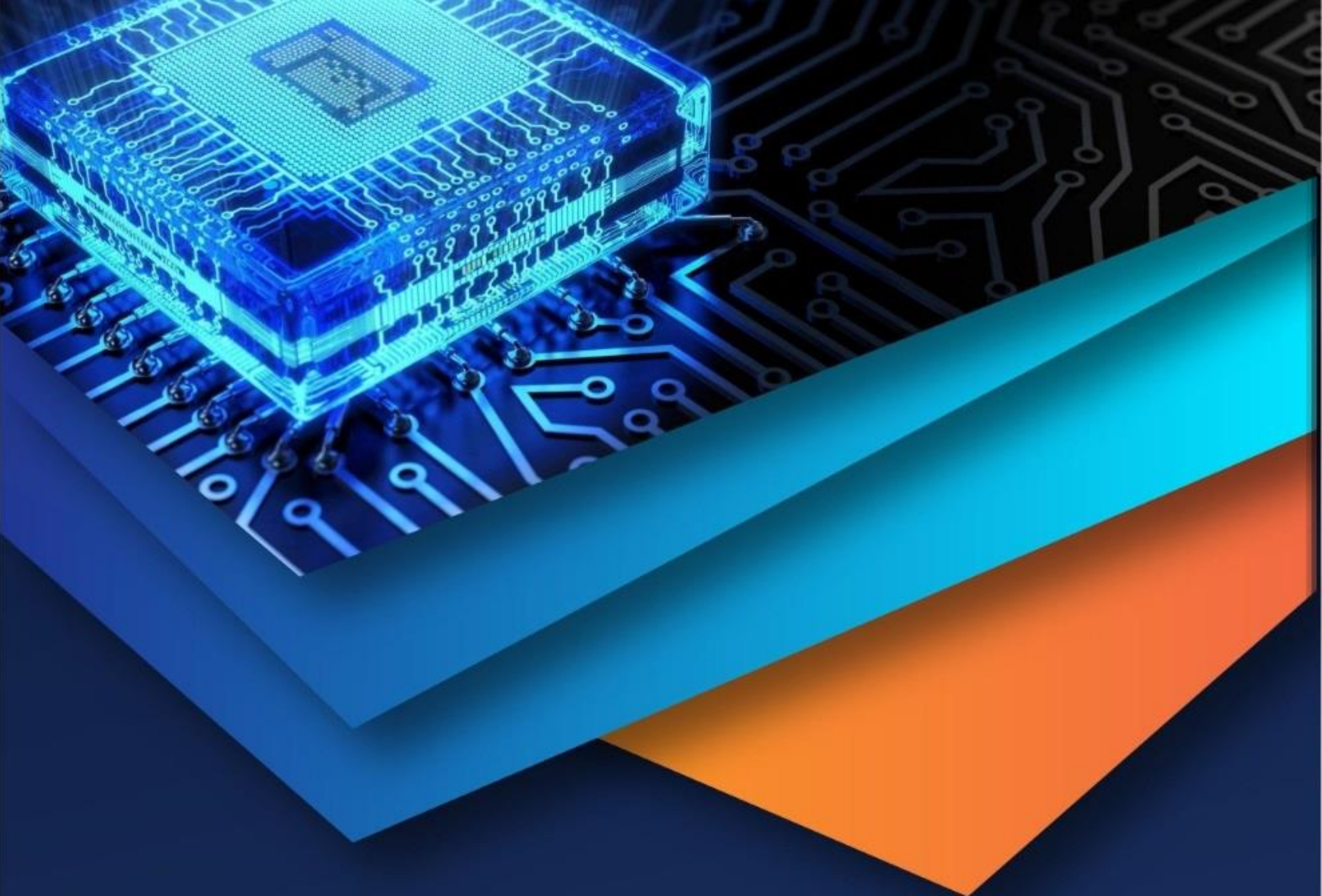
The AE signal with a load of 50N have higher rise time about 3336.09µs and initially 3166.6µs for unloading condition as shown figure 6. This higher rise time is an indication of change in gear condition.

IV. CONCLUSION

Acoustic emission is transient in nature occurring in discrete bursts, these bursts are seen as AE hits relating to amplitude and RMS analyzing the various aspects of the wave forms. The experimental results were obtained and analyzed under different loading conditions. From the results of this present work shown that all three AE parameters such as amplitude, RMS and rise time exhibit similar variations under different loading conditions. The current research work demonstrated the capability of the AE technique in diagnosis of gear and the effective condition monitoring of gear box.

REFERENCES

[1] Gürsel, D., Möllemann, G., Clausen, E., Nienhaus, K., & Wotruba, H. (2021). "Online measurements of material flow compositions using acoustic emission: Case of gypsum and anhydrite," Minerals Engineering, 172, 107131.
[2] Girard, J. Beutel, S. Gruber, J. Hunziker, R. Lim, S. Weber. (2012) "A custom acoustic emission monitoring system for harsh environments: application to freezing-induced damage in alpine rock walls," Geoscientific Instrumentation, Methods and Data Systems 1.2 : 155-167.
[3] J. Kattelus, J. Miettinen, A. Lehtovara. (2017). "Detection of gear pitting failure progression with on-line particle monitoring," Tribology International 118 : 458-464.
[4] Ram Bihari Sharma and Anand Parey. (2017). "Condition monitoring of gearbox using experimental investigation of acoustic emission technique," Procedia engineering 173: 1575-1579.
[5] Saban ulus, Selcuk Erkaya. (2016). "An Experimental Study on Gear Diagnosis by Using Acoustic Emission Technique," International Journal of Acoustics and vibration 21.1: 103-111.
[6] Sebastian Felix Wirtz, Nejra Beganovic. (2016). "Gear transmission monitoring 4.0," Chair of Dynamics and Control
[7] G. Dalpiaz, A. Rivola, R.Rubini. (2017). Available at http://dieml.ing.unibo.it/mechmach/rivola/pub13.pdf .



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