IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

CONDITION MONITORING STUDY OF SPINDLE BEARING OF A LATHE USING ACOUSTIC EMISSION SIGNALS

K.M. Sathish Kumar

Professor, Department of Mechanical Engineering, BMS Institute of Technology and Management, Bengaluru, India

Abstract: Bearing condition monitoring has received considerable attention in rotating machines. The Acoustic Emission (AE) monitoring is proved to be an important method in order to monitor the bearings. The advantage of AE monitoring over vibration monitoring is that the AE monitoring can detect the growth of subsurface cracks whereas the vibration monitoring can detect defects only when they appear on the surface. The present work involves studying the variation of AE signals obtained from spindle bearing housing of a lathe for various cutting conditions. AE signal was acquired during turning of S. G. Cast iron using multi-layer coated carbide tool. From the AE signals obtained, it was observed that the AE parameters varied in accordance with variation in the load on the bearing. Also, it was observed that as the cutting conditions increases there is an increase in the signal level of AE parameters. This is due to the increase in load acting on the bearing at higher cutting conditions.

***Index Terms* – Spindle bearing, Acoustic Emission, Lathe.**

I. INTRODUCTION

In modern manufacturing environments, machinery failures are predictable. Research directed at this goal has attempted to develop robust and accurate in-process machine condition monitoring systems with good defect prevention capabilities. Condition-based predictive maintenance can be implemented by manufacturing industries to detect faults, troubleshooting and anticipating equipment failure. Successfully implementing a condition monitoring programme allows the machine to operate to its full capacity without having to halt the machine at fixed periods for inspection. (Ranganath Kothamasu, Samuel H. Huang and William H. VerDuin, 2006).

Rolling element bearing condition monitoring has received considerable attention for many years because the majority of problems in rotating machines are caused by faulty bearings. The classical failure mode of rolling element bearings is localized defects, in which a sizable piece of the contact surface is dislodged during operation, mostly by fatigue cracking in the bearing metal under cyclic contact stressing. Thus, failure alarms for a rolling element bearing are often based on the detection of localized defects. (N. Tandon, G.S. Yadava and K.M. Ramakrishna, 2007).

There are many condition monitoring methods used for detection and diagnosis of rolling element bearing defects. Among them, Acoustic Emission monitoring is a better method for the early detection of failure. Acoustic emissions (AE) is the phenomenon of transient elastic wave generation due to a rapid release of strain energy caused by a structural alteration in a solid material under mechanical or thermal stresses (D. Dornfeld, 1992, E. Govekar, J Gradisek and I. Grabec, 2000). Some of the AE parameters are as shown in the Fig.1.

Counts involve number of times the signal amplitude exceeds a preset threshold value and gives a simple number characteristic of the signal. Threshold is a preset voltage level that has to be exceeded by the response so that it could be detected as an AE signal and processed. An event consists of a group of counts and signifies a transient wave. RMS is an electrical engineering power term defined as the rectified, time averaged AE signal. It is a measure of signal intensity expressed in milli-volts. Energy is derived from the integral of the rectified voltage signal over the duration of the AE hit. The unit of measured energy parameter is 10μ volt-sec/count. Signal strength is defined as the integral of the rectified voltage signal over the duration of the AE waveform packet. The unit of measured signal strength parameter is 3.05 Picovolt-sec.

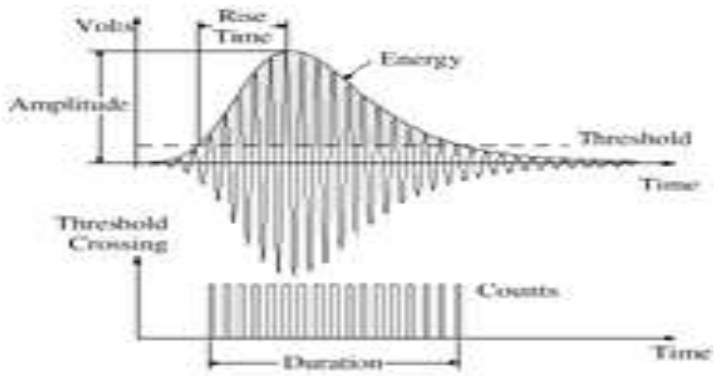

Fig. 1 AE signal parameters

In an attempt to understand how the defect size influenced AE waveform the investigation was centered on the application of the AE technology for characterising the defect sizes on a radially loaded bearing. The aim of this investigation was to ascertain the relationship between the duration of AE transient bursts associated with seeded defects to the actual geometric size of the defect. It is concluded that the geometric defect size can be determined from the AE waveform (Saad Al-Dossary, R.I. Raja Hamzah and D. Mba, 2006).

For automatic diagnosis of localized defects in bearings, the utility of advanced signal processing was established for investigating Acoustic Emissions (AE) of bearings. A bearing condition monitoring technique based on processing the acoustic emissions of the monitored bearing was investigated. It is observed that AE provides a better alternative to the traditional vibration bearing condition monitoring and also it allows the diagnosis of the locations of localized defects on bearings (C. James Li. and S. Y. Li, 1999).

The advantage of Acoustic emission monitoring over vibration monitoring is that the AE monitoring can detect the growth of subsurface cracks whereas the vibration monitoring can detect defects only when they appear on the surface (N. Tandon and A. Choudhury, 1999). The one of the earliest documented applications of AE technology to rotating machinery monitoring shows that there has been an extensive research- and application- based studies covering bearings, pumps, gearboxes, engines, and rotating structures. They have presented a comprehensive and critical review of the application of acoustic emission technology to condition monitoring and diagnostics of bearings where it was shown that the AE technology offered earlier fault identification than vibration analysis (D. Mba and Raj B. K. N. Rao, 2006).

Lathes are among the oldest and most important machine tools. The quality of the finished products depends mainly on the stability and rigidity of various machine components of lathe. It is required to collect more information about the condition of the lathe in terms of various sensor signals. Since lathe is a complex system, it is not possible to monitor all the machine elements. Since the entire load is concentrated on the spindle in particular on spindle bearings, monitoring is concentrated on spindle bearings.

II. EXPERIMENTAL SETUP

Machining tests were carried out on an automatic lathe to study the variation of AE signals obtained from spindle bearing housing of a lathe for various cutting conditions. Multilayer coated HK 15 carbide tool inserts were used to turn S. G. Cast iron. The machining was carried by varying the spindle speed and depth of cut and by keeping the feed constant. Vibration readings were recorded using Machine Condition Tester T 30 by placing the sensor on both the front and rear spindle bearing housings to study the critical bearing. The AE signal is acquired from placing the sensor at front spindle bearing housing.

The experimental work involves measuring AE parameters viz., RMS, Energy, Signal strength, Counts, etc., by using AE measuring system. The AE measurement system consists of an AE sensor with operating frequency range of 100 kHz – 1000 kHz. The output from the sensor was amplified by using 2/4/6 pre amplifier. Various filters were used to isolate the AE signals from the noise. The filtered signals were acquired to computer through PCI-2 AE System. A basic requirement during acoustic emission is to fix the threshold level which is required to avoid the presence of an external noise within the measured AE signal. Experimental trials were conducted in non-cutting condition and the threshold level was fixed to 40 dB. Later on AE signals were acquired during machining. The experimental analysis was made to study the condition of the bearing.

III. RESULTS AND DISCUSSION

Experimental results are presented in this section, so that a clear insight can be obtained about the signals involved. Functional relationship between the parameters obtained have been plotted to derive a basis for more detailed analysis. Fig. 2 shows the measured vibration in horizontal direction at cutting speed of 157.079 m/min, and depth of cut 0.5 mm with the constant feed of 0.208 mm/rev. From the figure it is observed that vibration in front bearing housing is more when compared to rear bearing housing. The same trend was observed at other cutting conditions. This is because front bearing is nearer to the source of vibration. Hence, further studies are concentrated on front spindle bearing housing.

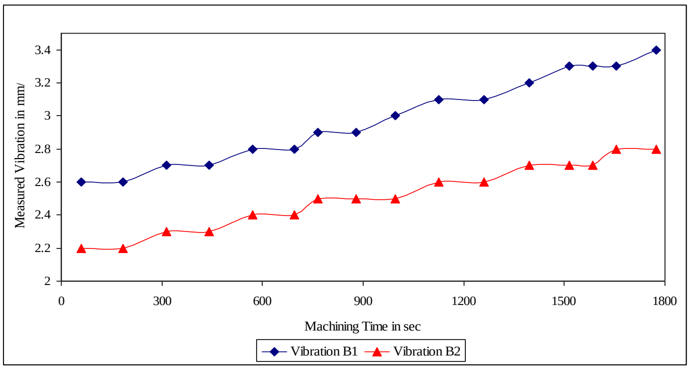

Fig. 2 Measured vibrations from spindle bearing housing

The results of the acoustic emission measurements on the front bearing housing are presented in this section. Functional relationship between the various parameters of AE with the variations in cutting conditions were plotted to derive a basis for more detailed analysis. Fig. 3 gives measured AE RMS with machining time at cutting speed of 70.371 m/min for various depth of cut of 0.1, 0.3 and 0.5 mm. Fig. 4 gives measured AE energy with machining time at cutting speed of 377.142 m/min for various depths of cut. Fig 5 gives measured AE signal strength with machining time at cutting speed of 157.079 m/min for various depths of cut.

AE parameters viz., RMS, energy and signal strength in the above graphs can be divided into three stages. In the first stage i.e., at the initial period of machining the signal increases sharply. This is because at the initial stage there will be run-in wear of the cutting tool and produce more load, which is finally transmitted to spindle bearing. The signal reduces and becomes constant during the second stage. At this stage, there will be constant load on the bearing as the cutting tool experiences steady wear. With further machining, increase in the signal values takes place in the third stage. This is because of more load acting on the bearing which is due to rapid wear of the cutting tool. It can also be observed that as the depth of cut increases there is an increase in the signal level of AE parameters. This is due to increase in load acting on the bearing at higher depth of cut.

Fig 6 shows the measured AE counts with machining time at cutting speed of 157.079 m/min for various depths of cut. From this figure it is observed that during initial period of machining the count reduces. As we know in the first stage their will be more load on the bearing, there will be liberation of high strength AE signal. Thus, there will be high amplitude resulting in less number of counts. i.e., it can be observed that most of the AE signal does not cross threshold level. During second stage, counts increases and becomes constant. Here the load on the bearing will be constant which gives rise to more number of counts due to less energy. Again more load will be acting on the bearing in the third stage, which results in higher strength of AE signal. Hence, AE Counts reduces. The graphs were also drawn for various cutting speeds by keeping depth of cut constant. Here also we observe the same trend as observed in various depth of cut at a particular cutting speed. As the cutting speed increases, there is an increase in the signal level. This is because as the cutting speed increases, more load will act on the spindle bearing. Hence it can be stated that the AE signal level increases with the increase in cutting speed and depth of cut during turning operation.

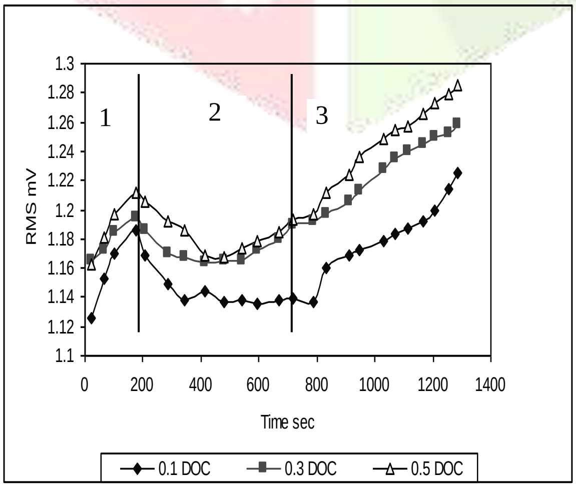

Fig. 3 AE RMS with machining time at cutting speed of 70.371 m/min

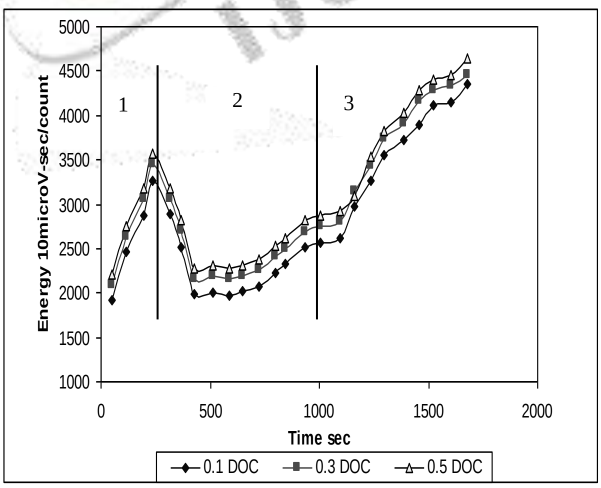

Fig. 4 AE Energy with machining time at cutting speed 377.142 m/min

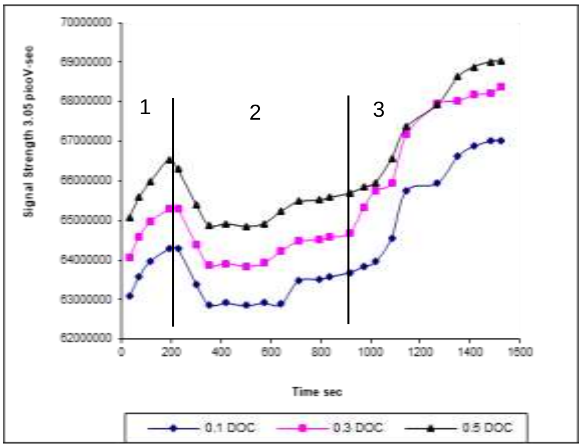

Fig. 5 AE Signal Strength with machining time
at cutting speed 157.079 m/min

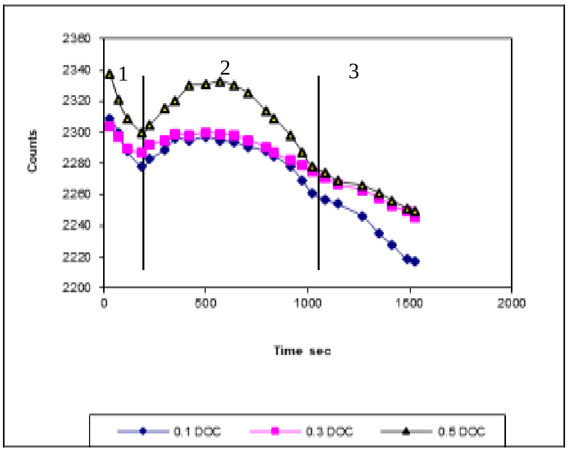

Fig. 6 AE Counts with machining time
at cutting speed 157.079m/min

Fig. 7 & Fig. 8 show Power Spectral Density (PSD) plots of AE signal from the spindle bearing location for sharp state and worn-out state of the cutting tool respectively. From the figures, it was observed that voltage level of the AE signal from the spindle bearing location increases from sharp state to worn-out state of the cutting tool. This is because as the tool wears out, the load acting on the bearing increases. This is also evident from the power spectral density plot as more number of frequency components dominates at the later stage of machining. The relatively slower decay of PSD with worn-out tool indicates continuous/increased acoustic activity.

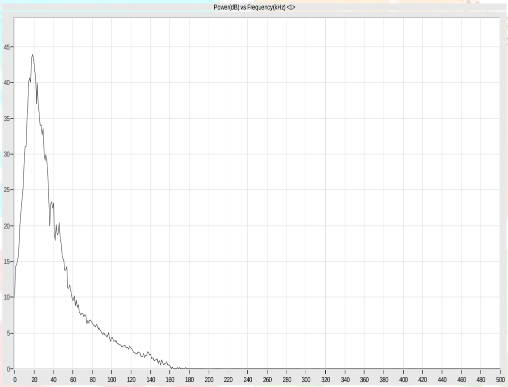

Fig. 7 Power Spectral Density plot
for sharp state of the cutting tool

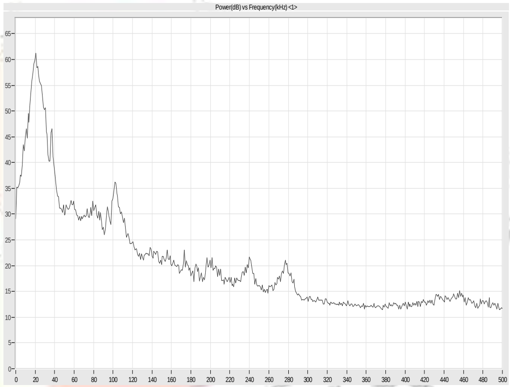

Fig. 8 Power Spectral Density plot
for worn-out state of the

IV. CONCLUSION

The present work was to study the variation of AE signals on the spindle bearing for various cutting conditions. Monitoring was concentrated on front spindle bearing which was critical in the lathe tool structure. Functional relationship between the various parameters of AE with the variations in cutting conditions were plotted to derive a basis for more detailed analysis. From the AE signals obtained, it was observed that the AE parameters viz., RMS, Energy, Signal Strength and Counts varied in accordance with variation in the load on the bearing. Also it was observed that, there is an increase in the signal level of AE parameters for increase in cutting conditions. This is due to increase in load acting on the bearing at higher cutting conditions.

REFERENCES

[1] Ranganath Kothamasu, Samuel H. Huang and William H. VerDuin, 2006, "System health monitoring and prognostics – a review of current paradigms and practices", International Journal of Advanced Manufacturing Technology, Vol. 28, pp. 1012–1024.

[2] N. Tandon, G. S. Yadava and K. M. Ramakrishna., 2007, "A Comparison of some condition monitoring techniques for the detection of defect in induction motor ball bearings", International Journal of Mechanical Systems and Signal Processing, Vol. 21, pp. 244-256.

[3] D. Dornfeld., 1992, "Application of acoustic emission techniques in manufacturing", *International Journal of NDT & E*, Vol. 25, No. 6, pp. 259-269.

[4] E. Govekar, J Gradisek and I. Grabec, 2000, "Analysis of acoustic emission signals and monitoring of machining processes", *International J*ournal of Ultrasonics, Vol. 38, pp. 598-603.

[5] N. Tandon and A. Choudhury, 1999, "A review of vibration and acoustic measurement methods for the detection of defects in rolling element bearings", Tribology International, Vol.32, Issue 8, pp. 469-480.

[6] D. Mba and Raj B. K. N. Rao, 2006, "Development of Acoustic Emission Technology for Condition Monitoring and Diagnosis of Rotating Machines: Bearing, Pumps, Gearboxes, Engines, And Rotating Structures", The Shock Vibration Digest, Vol 38, No.1, pp.3-16.

[7] C. James Li. and S. Y. Li., 1995, "Acoustic emission analysis for bearing condition monitoring", *International Journal of Wear*, Vol. 185, pp. 67-74.

[8] Saad Al-Dossary, R.I. Raja Hamzah and D. Mba, 2006, "Acoustic Emission Waveform Changes For Varying Seeded Defect Sizes", Advanced Materials Research, 13-14, pp 427-432.