

Research Article

Acoustic Emission Output Parameters Prediction for Rotary Device MonitoringAhmad Doudani^{a*}^aDepartment of Mechanical Engineering, Science and Research Branch, Islamic Azad University, Kermanshah, Iran.

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Abstract

Rotating mechanical fault detection mechanisms, particularly in hydro dynamic bearings of the utmost importance in determining the defect to prevent unplanned outages is high. In this paper, empirical studies to investigate the effects of different operations, and there is a flaw in the audio release of hydro dynamic bearing in mind. Mechanism of lubrication and lubrication behavior recognition in real operating conditions of bearings used in rotating equipment and different working conditions in terms of number of rounds, etc. The load was investigated.

Keywords: Rotary Device, Acoustic Emission, Hydro Dynamic Bearing, Lubrication.

1. Introduction

Condition Monitoring of rotary machine can be defined as the periodic or continuous measurement and interpretation of data in order to indicate the condition of rotary device which is needed to maintenance. It is widely used in detecting defects in rotary machine due to prevent suddenly failures. In this way Acoustic Emission technique, famous for its sensitivity in high frequency domain of micro-damage evolution, which has been found in monitoring of rotary machine such as: Hydro dynamic bearing.

The traditional definition of Acoustic Emission (AE) is an elastic wave produced as a result of swift discharge of energy from a source within a material that is compelled by an externally applied stimulus [T. Henderson., 2003; V.T. Henderson., 2003]. The source of this emission in metals is associated closely with the movement of dislocation supplemented by plastic deformation and with the starting and expansion of cracks in a structure affected by stress [T. F. Drouillard., 1996]. The first comprehensive investigation into the phenomenon of AE was undertaken by Kaiser in 1950 [Mba, D. and Rao, R.B.K.N., 2006]. Kaiser was the first to digitally acquire AE signals produced in the crystal structure of materials during stress tests. Leahy [S. Prieto., 2006] undertook the most realistic controlled verification of applicability of AE to shaft seal rubbing where it was noted that a simulated rub on the shaft of an operating steam turbine could be detected with AE sensors mounted on the bearing pedestal. Al-Shaikh Mubarak [M. Leahy, D. Mba., P. Cooper., A. Montgomery., D. Owen., 2006] attempted to apply the technology for monitoring blade rubbing. The AE technology is continually developing into a complimentary technology for condition monitoring of machines [Al.

Shaikh Mubarak., M. Mba., D. Cooper., 2003] where most investigators applications have utilized the frictional phenomenon associated with AE. Acoustic Emission technology has advantages in comparison to other diagnostic methods [A. Morhain., D. Mba., 2003]. Its main advantage when compared with vibration analysis is that it offers early defect detection. However it is difficult in doling out, interpreting and classifying the acquired information [D.C. Baillie., J. Mathew., 1996]. In the recent years, new techniques such as; artificial neural networks and fuzzy inference systems were employed for developing of the predictive models to estimate the needed parameters. The traditional methods for fault diagnosis are categorized as pattern classification, knowledge-based inference, and numerical modeling. Pattern classification and knowledge-based inference techniques are used in the industry. For both of the mentioned methods, a human expert looks for particular patterns in the vibration signature that might indicate the presence of a fault in the bearing. Alternatively, statistical analysis and ANNs are utilized for the automated fault detection systems. ANNs are capable of learning the behavior of nonlinear systems. In a fuzzy inference system, a set of logical rules is extracted from an expert knowledge database, independent of the system's configuration. ANNs are adopted for machinery fault diagnosis and condition monitoring. One of the first applications of ANNs for bearing fault diagnosis has been proposed by Baillie and Mathew [A. Esposito., C. E. Eugene., A. R-G. Carlos., 2000] .

2. Experimental Program**2.1 Hydrodynamic Bearing**

The hydrodynamic bearing test rig employed for this study has an operational speed range between 30rpm to 5000rpm with a maximum load capability of 20kN (Figure 1) [M.

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Esmaeili., A.Refahi Oskuei., 2012]. The hydrodynamic bearing material was Bronze. The test bearing had a radius of 17mm, length of 63mm, a surface roughness of approximately 3µm and a measured radial clearance of 0.17mm.



Fig.1 Test Rig Layout.

2.2 Oil

To understand the influence of viscosity on generating AE, three different oil types were employed. This included:

Table1. Oil type and Viscosity

Temp & Oil	μ_d Kinematic Viscosity (Cst)	
	SAE 40	SAE 68
40	6.75	9
100	46	72

2.3 Acoustic Emission Sensor

Two Physical Acoustics Pico type sensors with a frequency bandwidth of between 100 kHz to 750 kHz were employed. Both sensors were placed directly onto the test bearing housing (see Figure 2) and connected to a pre-amplifier at 40dB gain.

3. Thermocouples

One LM35-type thermocouple was fixed on the bearing housing in Figure 2 and 3 [M. Esmaeili., A.Refahi Oskuei., 2012]. The thermocouple had an operating range of -55 to +150°C with an accuracy of ±1.0°C. Measurements of temperature were taken throughout all test conditions at a sampling rate of 50 Hz.

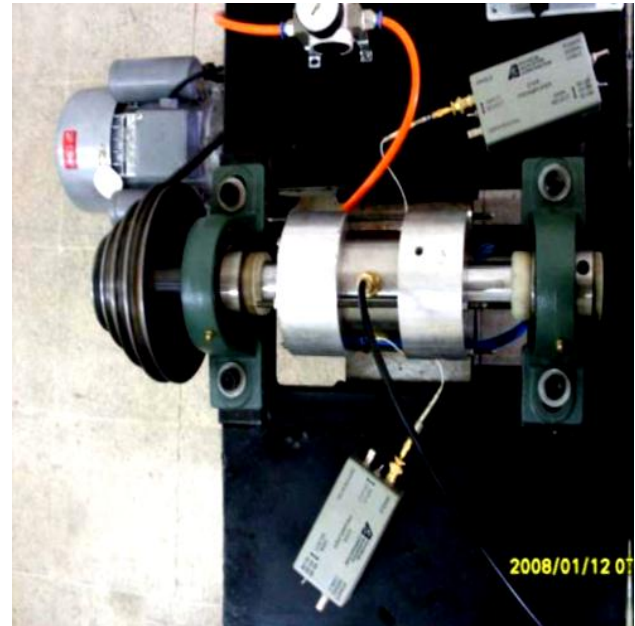


Fig 2. Location of AE and Thermocouple Sensors on Test Bearing

4. Experimental Procedure

This investigation involved varying the bearing rotational speed for fixed loads and also investigating the influence of different viscosities whilst recording the AE r.m.s levels. Prior to performing the tests, the temperature of the test bearing was raised to approximately 60°C. As soon as the desired temperature was reached, the test sequence began. In developing and understanding of the relationship between Acoustic Emission and the operational variables an experimental design was developed which involved testing at a speed range of 1600, 2000 and 2300 rpm and a load range of between 75, 150, 225N carried out by pneumatic cylinder. Also the effect of three oil types (SAE 40, SAE 68) in this work was investigated.

In addition, the drive motor (1.5 Hp) was connected to the drive shaft via a belt drive thus eliminating AE noise generated from the electric motor. For all tests undertaken in this investigation the AE features were recorded over a sampling rate of 2 MHz.

Also a coupling was employed between the drive shaft and the shaft from the motor within the test bearing, further eliminating reducing any AE’s from outside the test bearing. Acquisition of AE and temperatures values were acquired continuously over duration of 5 sec. for every speed, viscosity and load condition tested.

5. Result & Discussion

In the statistical analysis of output data from the experiments and obtain the correlation coefficient between the acoustical parameters of the covariance and The correlation between the different parameters analyzed in terms of correlation parameters has been studied is most associated.



Fig 3. Nylon 6/6 Applied to Attenuate AE from the Rolling Element.

5.1 Covariance, Correlation and Regression:

In most statistical studies to understand whether the relationship between a given feature in a series of equipment or not, is considered.

How can we determine which variables are interdependent and it calculates the correlation between the index and -1, +1. Varies and depends on the relationship between the two varies. If there is no relationship between the two variables (two variables are independent) correlation coefficient would be zero. If there is a perfect correlation between the two characteristic properties with an increase proportional to the increase of the sole is another feature coefficient equal to +1. If a property has increased in proportion to the reduction in the coefficient equal to -1 another property will be shown in figure 4.

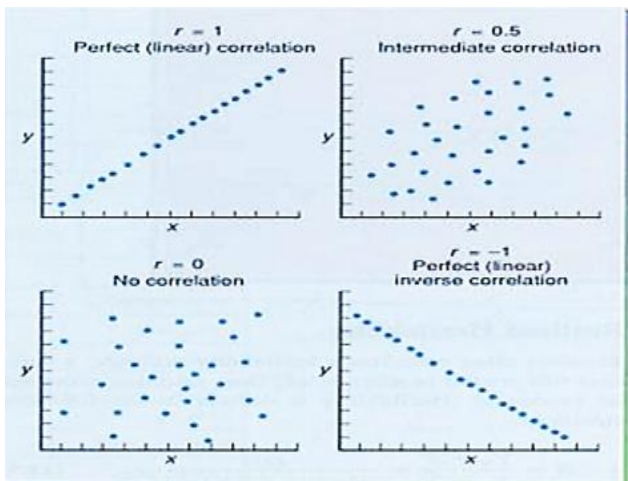


Fig 4. Graph of Correlation

Based on the mentioned parameters i.e. load, speed and oil type, at different levels, a large number of AE waveforms (Events) are recorded for each test set-up under steady state condition. Waveform features were extracted by the AEWin software. It is also found that Energy and RMS values, as an AE waveforms features, are varied by changing rotation condition.

$$r = \frac{\text{covariance all x and y}}{s_y s_x} \tag{1}$$

The similarity between the covariance and the variance can be seen by comparing equations 1 and 2.

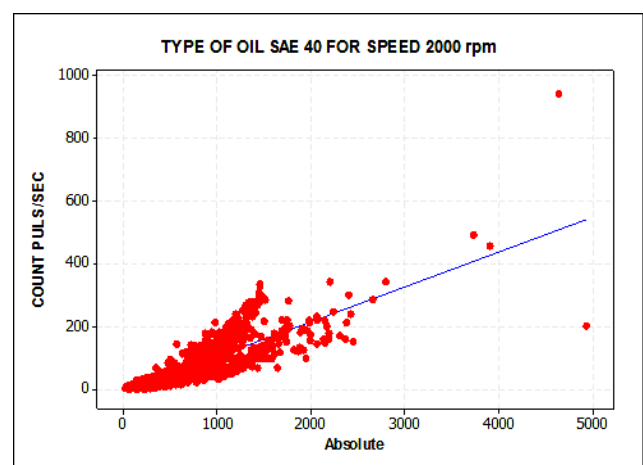
$$\text{COV}(x,y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{n-1} \tag{2}$$

Correlation or regression is computed on a set of data. Regression analysis assumes the existence of a causal connection can be used for correlation analysis, but this does not work.

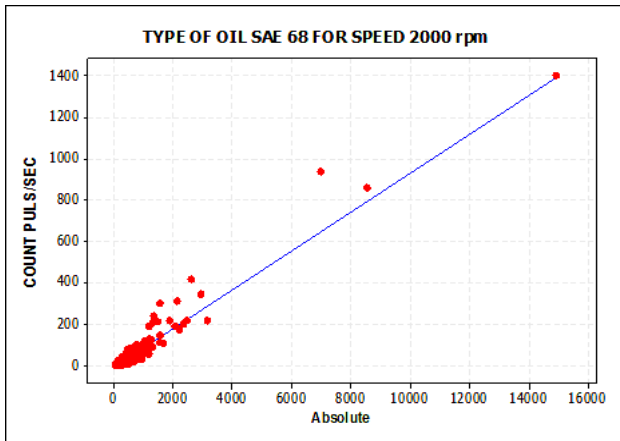
Table 2. Correlation between typical parameters AE

Correlations: COUNT,RISE,RMS,ABS-ENERGY				
	COUNT	RISE	AMP	AMS
RISE	0.598			
AMP	0.754	0.45		
RMS	0.247	0.119	0.132	
ABS-ENERGY	0.977	0.654	0.787	0.227

As outlined above, the static coefficient of correlation between different variables and counts among his highest pulse (count), ABS-ENERGY. Thus, the correlation between these two variables is high. In drawing scatter plat of the two is used. The curves for different oil types have been investigated at the constant changes in fault and no fault was found and changes made in the laboratory with the increase in pulse counting AE, Was associated with the absolute energy curves obtained in these experiments are indicated. In Figure 4, data are shown in graphical form, and it seems that there is a relationship between two variables. When a Axis X (Absolute energy), Can increase the rate of increase in pulse counting Axis Y Be seen. You can determine how much the two variables are interdependent, and this interdependence as Table 2, Is calculated and displayed, a claim that this dependence is shown in the following figure. The results of the graph is shown in Table 3.



(a)



(b)

Fig 4 (a,b) Scatter Plat for Same Speed.

Table 3. Result of Scatter Plat

Oil	SAE 40	SAE 68	Speed
Count	1000	1400	2000 rpm
ABS-ENERGY	5000	16000	2000 rpm

Conclusion

In this paper the results of different types of oils and loading during function were studied hydrodynamic bearings.

- 1- application of acoustic Emission technology for monitoring predict hydrodynamic conditions under different loads and speeds, as well as functional testing in the laboratory environment.
- 2- Strategy for interpreting the results of AE measurements by determining the effect of oil properties and determine by functional parameters bearing on the mental condition of hydrodynamic bearings in actual operation.
- 3-Correlation between changes in hydrodynamic bearings are oil lubricate and acoustic parameters.

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