Rotating Shaft Crack Detection by Acoustic Emission

Novitha L. T. Thenu
Marine Engineering Department
Pattimura University
Ambon, Indonesia
novithathenu@gmail.com

Dhany Arifianto
Department of Engineering Physics
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
dhany@ep.its.ac.id

***Abstract*— Acoustic emission measurement techniques have become part of the field of condition monitoring of rotating machinery. This article shows that the measurement of the acoustic technique can provide good potential to evaluate the level of cracked rotating shaft. Through a simple signal processing methods for the measurement showed that the amplitude of the uncrack shaft increased along with the increase of shaft rotation. As well shaft crack 0.25 and 0.5 of the diameter of the shaft. The amplitude will shift to the right if the rotation axis is increased. Measurements were taken when the shaft rotates with the load symmetry. Torsional and bending load impact significantly on the level of cracked shaft.**

Keywords—Acoustic Emission; Crack Propagation; Amplitude Spectrum; torsional

I. INTRODUCTION

Generally, ship propulsion system consists of three main parts motor drive, transmission and propulsor system. Shaft as a component of the transmission system serves to transmit power to the propeller. At the time of the power transmission, shaft bending load gets combined with continuous torque load. Shaft with continuous torque load is difficult to access when maintenance and prone to cracking and growth [1]. The combination of loads bending, longitudinal and torsional vibrations in rotating shafts have been studied by Darpe at al [2], wherein when the frequency of torsional excitation force equal to the natural frequency of the bending load on the rotation axis of the crack showed significant changes in crack depth. Sinou and Lees [3] also investigated the influence of a transverse crack in a rotating shaft. To conduct this study, the dynamic response of a rotor with cracks were evaluated with the frequency domain using alternative approaches / time. This shows that this method can evaluate the crack propagation behavior of nonlinear rotor system quickly and efficiently with the truncated model of crack. Through the method of vibration analysis Mohamed et al [4] also conducted a study to monitor the level of cracked shaft rotating, the identification of the difference between the depth of the pre-cracked three different and distinct five shafts shows the crack growth shifted in frequency spectrum and peak amplitude modification. The results of tests and analyzis clearly demonstrate the feasibility of using vibration to detect the frequency changes due to changes in shaft stiffness such as that associated with the cracked shaft. In addition to the vibration analysis methods are used to evaluate the crack propagation, many researchers have developed various methods for monitoring condition of rotating machinery that experienced fatigue cracking, one of which is the method of acoustic emission [5-8]. This article displays the method of acoustic emission signal processing approach to evaluate the effect of a crack on rotating shaft. In this study, shaft speed variation with load symmetry will show the changes in amplitude on each shaft with different cracks.

II. EXPERIMENT PROCEDURE

A. Specimen and Material

Testing machine consists of a shaft that are supported by bearings equipped with roller bearings. Shaft is connected to the coupling to elektromotor and equipped with radial mass load at the other end of the shaft. Shaft is used as a test specimen made of ST 41 DIN 17135A. Shaft diameter of 28 mm and length of 800 mm. Shafts made 3 pieces. Respectively uncrack shaft, crack shaft with depth of 0.25D and 0.5D. Crack is made transverse cross section and is located closer to spi groove.

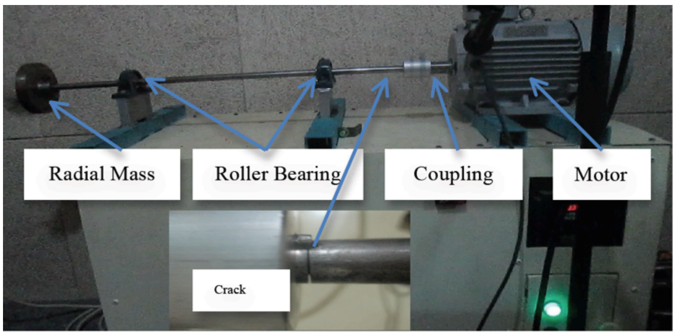

Figure 1. Setup Experiment

B. Acoustic Emisson Measurement

Acoustic emission is measured when testing machine is operated with some shaft speed of 500 - 1000 rpm at 100 rpm intervals. AE sensor used is a microphone Behringer. Distance sensor with motor 2 cm. The sensor is connected to the device from the PCI soundcard breakout box (M-Audio). Sampling frequency in the recording process is 11250 Hz, mono and 32 bits. The sampling frequency is taken by noting that the maximum frequency is 5000 Hz motors, to meet the Nyquist criterion then the sampling frequency must be greater equal to twice the maximum frequency [8]. Microphones are used in this study to be able to capture a cardioid-type sound from five sources. The microphone is connected to the breakout box on the PCI soundcard (M-Audio Delta) that has six inputs and six outputs. Load used is the load symmetry.

III. RESULTS AND DISCUSSIONS

A. Data Analysis

The method of analysis in this experiment is based on the frequency with the highest amplitude in the form of a Fast Fourier Transform (FFT) through acoustic emission measurement. In this study, acoustic emission measurement was first performed on uncrack shaft. It is intended to obtain the reference data. The first phase of testing is the measurement of acoustic emission on uncrack shaft at shaft speed varied. From Figure 2.a. show that the peak amplitude of 500 rpm rotation of 0.0004927 is at 8392 Hz frequency. In part b, the highest amplitude at a frequency of 0.0005711 Hz 10.07. Shaft speed of 700 rpm, the highest amplitude of 0.0006719 at frequency 11.6 Hz. From Figure 2 a - f, we see that if the shaft speed increased the frequency shift to the right or up. Likewise seen that the higher rotation amplitude also increased. From this incident explained that the higher the round, the energy released by the motor higher. The energy released can be represented by a higher amplitude scale.

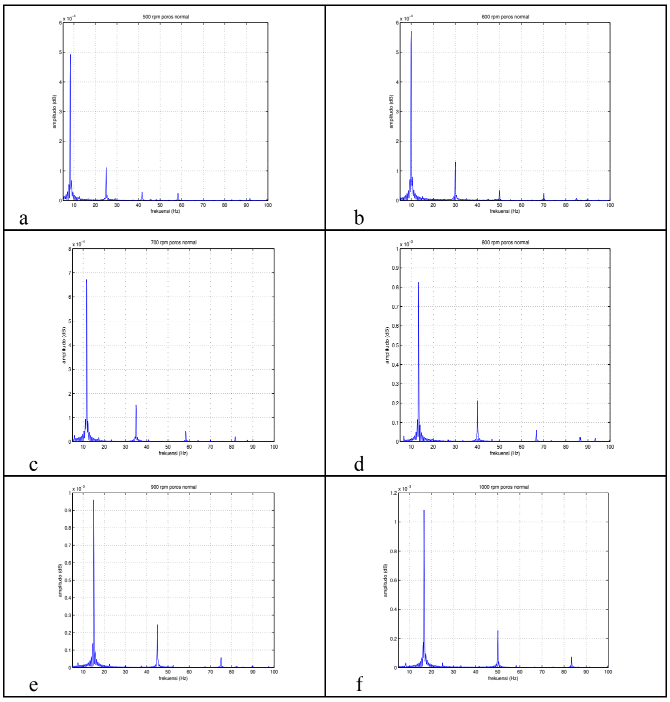

Figure 2. Acoustic emission measurement un-crack shaft at shaft speed variation: a. 500 rpm, b. 600 rpm, c. 700 rpm, d. 800 rpm, e. 900 rpm f. 1000 rpm

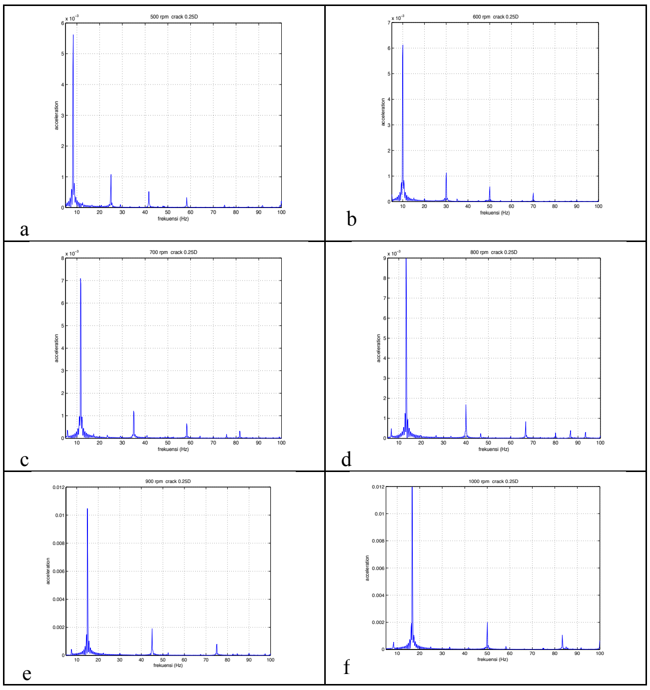

Figure 3. FFT of acoustic emission on crack shaft 0.25 D at shaft speed variations : a. 500 rpm, b. 600 rpm, c. 700 rpm, d. 800 rpm, e. 900 rpm f. 1000 rpm

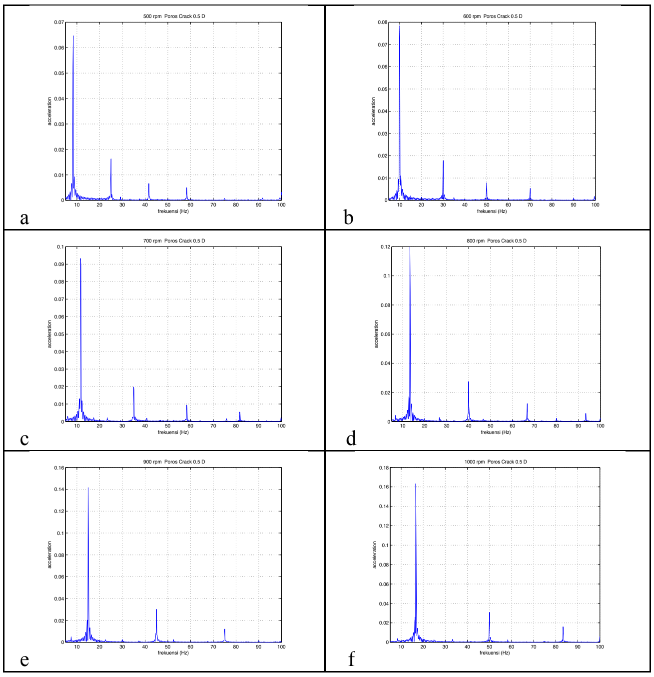

Figure 4. Measurement of acoustic emission on crack shaft 0.5D at shaft speed variation: a. 500 rpm, b. 600 rpm, c. 700 rpm, d. 800 rpm, e. 900 rpm f. 1000 rpm

Figure 3 shows the acoustic fft of crack shaft 0.25D with the shaft speed varies. In part a, the highest amplitude seen is 0.005616 Hz at 8.392 Hz. In part b on 600 rpm, the highest amplitude at a frequency of 0.006122 Hz 10.07. Shaft speed of 700 rpm, the highest amplitude is 0.007092 at 11.6 Hz. Shaft speed 1000 rpm, the highest amplitude is 16.63 at 0.01197

Hz. From Figure 3, the trend increases with increasing amplitude of motor speed.

While Figure 4 shows the acoustic fft crack shaft 0.5D with varying shaft speed. Section a, at 500 rpm, the highest amplitude of 0.06464 is at 8392 Hz frequency. Section c, rotation 700 rpm, the highest amplitude at a frequency of 6.11 0.09325 Hz. From Figure 2-4, it appears that if the shaft speed increased, the frequency and amplitude increased. Amplitude will increase even more in the shaft crack 0.25 D amplitude at a frequency of 8392 Hz increased by 10 times the uncrack shaft of the highest amplitude. Similarly, the shaft crack 0.5D, the amplitude at a frequency of 8392 Hz amplitude increased 10 times from the shaft crack 0.25D.

From the experiments conducted, it was explained that if the motor the higher the energy released by the motor higher. The energy released can be represented in magnitude higher amplitude. Shaft to a depth of 0.5D crack if given high rotation requires higher energy.

IV. Conclusion

1. The amplitude of the shaft without crack with shaft will increase if shaft speed is increased.
2. Ampitudo position will shift to the right with increasing shaft speed.
3. Obtained from the amplitude change of uncrack shaft and crack shaft (0.25D and 0.5D) provide good potential for detecting the effect of cracks on a rotating shaft using shaft speed changes.
4. With increasing amplitude of uncrack shaft and crack shaft showed that the motor requires high energy to drive shaft with a larger crack depth. In other words, the higher the rate of cracking of a shaft, the energy required is also higher.
5. Acoustic emission technique can be applied for monitoring the condition of rotating crack shaft.

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