JOURNAL OF CURRENT RESEARCH IN SCIENCE (ISSN 2322-5009)
CODEN (USA): JCRSDJ
2013, Vol. 1, No. 4, pp:177-179
Available at www.jcrs010.com

ORIGINAL ARTICLE

FAULT DIAGNOSIS OF ALTERNATOR USING POWER SPECTRAL DENSITY

Mohammad Jafarpour Jalali[1], Saeid Farokhzad[2], Mohamad Reza Asadi Asad Abad[2]
1- Department of Electrical Engineering, Buinzahra branch, Islamic Azad University, Buinzahra, Iran
2- Department of Mechanical Engineering, Buinzahra branch, Islamic Azad University, Buinzahra, Iran

ABSTRACT: Alternators are used in modern automobiles to provide the electrical power. The electrical power requirements in automobiles have been rising rapidly for many years and are expected to continue to rise. Thus the alternator is one of the critical components of an automobile, so it health monitoring has a great impact in provide the electrical power. Many vibration environments are not related to a specific driving frequency and may have input from multiple sources which may not be harmoniously related. In this research we have calculated RMS and PSD of alternator in different faults situations. We have calculated Grms and PSD for different faults. The results showed that with calculating PSD we could find some fault and diagnosis of alternator as soon as possible.
KEYWORDS: Alternator, Power Spectral Density, Vibration Signals.

INTRODUCTION

Fault detection and diagnosis have an effective role for the safe operation and long life of systems. Condition monitoring is an appropriate way of the maintenance technique that is applicable in the fault diagnosis of rotating machinery faults (Farokhzad *et al*., 2013). One of the most common applications of condition monitoring is fault diagnosis of electrical machines (Mohamadi Monavar *et al*., 2008; Ahmadi and Mollazade, 2009a; Ahmadi and Mollazade, 2009b). Vibration monitoring of electrical machines has become an attractive field for many researchers and has also gained industrial acceptance, since it is related to almost all machinery failures and it does not require modification of the machine or access to the supply lines (Undacheck and Dodd, 1976; Sing and Ahmed, 2004; Chindurza *et al*., 2004).

Alternators are used in modern automobiles to provide the electrical power. The electrical power requirements in automobiles have been rising rapidly for many years and are expected to continue to rise. This trend is driven by the replacement of engine-driven loads with electrically powered versions, and by the introduction of a wide range of new functionality in vehicles. The continuous increase in power requirements is pushing the limits of conventional automotive power generation and control technology, and is motivating the development of both higher-power and higher-voltage electrical systems and components (Perreault and Caliskan, 2000) Now the alternator is one of the critical components of a automobile. If the alternator does not work properly, the automobile cannot operate. Hence, in this research, density data produced by vibration analysis was compared with previous data. Numerical data produced by power spectral density were compared with power spectral density in healthy alternator, in order to quantify the effectiveness of the power spectral density technique (Wowk, 1991). We calculated Grms and Power Spectral Density (PSD) of an alternator in different situation and different faults (Peng and Kessissoglou, 2003). The objective of this research is to investigate the correlation between vibration analysis, PSD and fault diagnosis. In this research, the alternator of Pride vehicle, that is one of high production vehicles in Iran, was used as case study.

MATERIALS AND METHODS

Experiments were carried out on the Pride alternator. The main objective of the study is to find whether the alternator is in good condition or in faulty condition. If the alternator is in faulty condition then the aim is to segregate the faults into wear in bearing and unbalancing in driven shaft. An unbalancing effect was created by gluing three nuts to the outer body of the driven shaft

---

Corresponding Author: Mohammad Jafarpour Jalali, Department of Electrical Engineering, Buinzahra branch, Islamic Azad University, Buinzahra, Iran. **E-mail:** mp.jalal@yahoo.com

ring. The alternator with sensor and data acquisition has been shown in Figure 1. A piezoelectric accelerometer, type VMI 102 (VMI Ltd, Sweden), was mounted on the alternator body in the vertical direction. The sensor was connected to the signal-conditioning unit (Easy-Viber FFT analyzer). The software SpectraPro-4 that accompanies the signal-conditioning unit was used for recording the signals directly in the computer. The speed of alternator was provided by electromotor in 3000 RPM. Three commonly conditions of the alternator were studied in this research; i) healthy ii) wear in bearing iii) unbalancing in driven shaft. These classes have been shown in Figure 2.

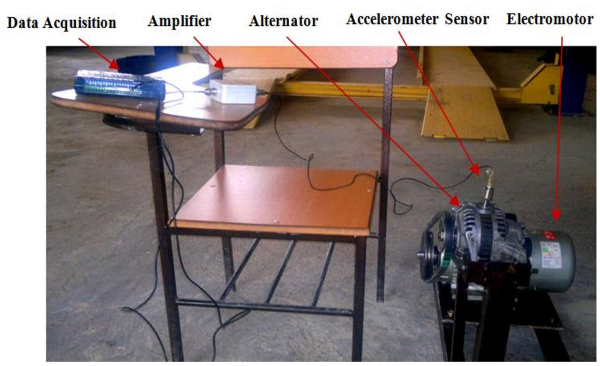

Figure 1: The experimental setup.

Figure 2: Alternator faults.

2.1. Power Spectral Density

Power Spectral Density (PSD) function indicates the vigor of the variations (energy) as a function of frequency. In other words, it shows at which frequencies variations are powerful and at which frequencies variations are weak. The PSD curve is the normal method used to describe random vibration specifications. Since the PSD curve is a plot of acceleration density, the overall RMS acceleration can be found by summation of the density over frequency. The complex spectrum of a vibration x(t) in the time range (t_1, t_2) for any frequency f in the two-sided frequency domain (-F, +F) can be expressed as:

$$X(f) = \int_{f_1}^{f_2} x(t)\, e^{-2\pi i f t}\, dt$$

(1)

Generally, if FFT of vibration signal be applied, PSD can be computed directly in the frequency domain by following formula:

$$PSD = \frac{g^2_{rms}}{f} \quad (2)$$

Where, Grms is the Root Mean Square of acceleration in a certain frequency f (Moosavian *et al.*, 2012).

RESULTS AND DISCUSSION

The frequency spectrum result of alternator in healthy, unbalancing in driven shaft and wear in bearing have shown in figures 3-5 respectively. According to this Figures it is obvious that the maximum value of FFT is increased by increasing the severity of alternator faults. The frequency spectrum of each fault was different and overall vibration values also were different at the same frequency. The results showed that the area under power spectral density curves indicated a problem. More area below power spectral density curve showed that the faults were deeper. Figure 6 showed the power spectral density of alternator in different situations. There was a big different among PSD of unbalancing in driven shaft fault and other faults. The results showed that with calculating PSD we could find some fault and the alternator diagnosis as soon as possible. Results showed that when we had deeper faults the area under PSD curves was grown.

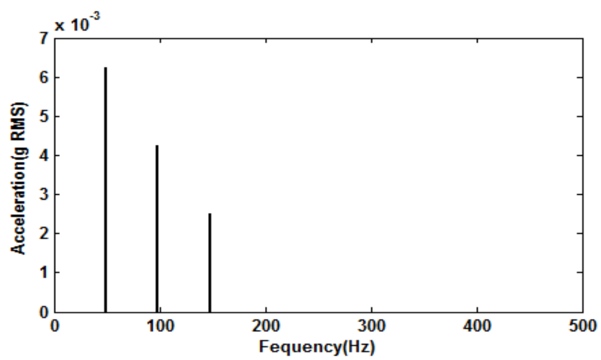

Figure 3: Frequency spectrum result of alternator on healthy situation.

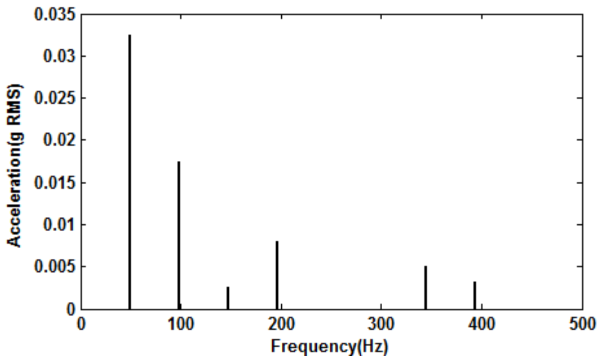

Figure 4: Frequency spectrum result of alternator on unbalancing in driven shaft situation.

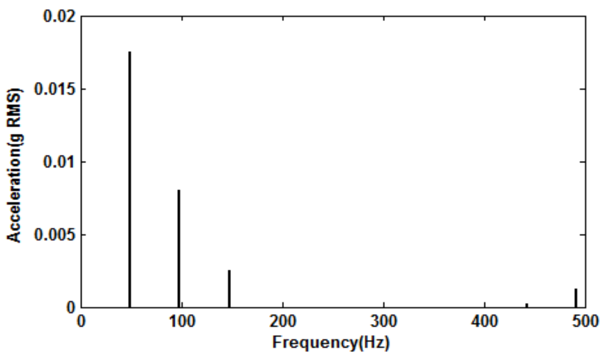

Figure 5: Frequency spectrum result of alternator on wear in bearing situation.

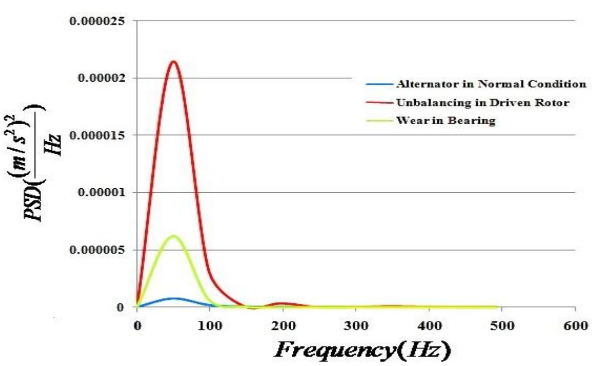

Figure 6: PSD- Frequency diagrams of alternator in three conditions: (i) normal (ii) unbalancing in driven rotor (iii) wear in bearing.

CONCLUSION

In this research, density data produced by vibration analysis was compared with previous data. Numerical data produced by power spectral density were compared with power spectral density in healthy alternator, in order to quantify the effectiveness of the power spectral density technique. We calculated Grms and PSD of an alternator in different situation and different faults. The results showed that with calculating PSD we could find some fault and diagnosis of alternator as soon as possible.

REFERENCES

Ahmadi H, Mollazade K. A practical approach to electromotor fault diagnosis of Imam Khomaynei silo by vibration condition monitoring. African Journal of Agricultural Research 2009a;4(4):383-388.

Ahmadi H, Mollazade K. Fault diagnosis of an electro-pump in a marine ship using vibration condition monitoring. Journal of Insight 2009b;51(8):431-438.

Chindurza I, Dorrell DG, Cossar C. Vibration analysis of a switched reluctance machine with eccentric rotor. Journal of Power Electronics Machines and Drives 2004;2(3):481-486.

Farokhzad S, Ahmadi H, Jafary A. Fault classification of centrifugal water pump based on decision tree and regression model. Journal of Science and Today's World 2013;2(2):170-1176.

Mohamadi Monavar H, Ahmadi H, Mohtasebi SS, Hasani S. Vibration condition monitoring techniques for fault diagnosis of electromotor with 1.5 kW power. Journal of Applied Sciences 2008;8(7):1268-1273.

Moosavian A, Ahmadi H, Tabatabaeefar A, Sakhaei B. An appropriate procedure for detection of journal-bearing fault using power spectral density, k-nearest neighbor and support vector machine. International Journal on Smart Sensing and Intelligent Systems 2012;5(3):50-55.

Peng Z, Kessissoglou NJ. An integrated approach to fault diagnosis of machinery using wear debris and vibration analysis. Wear 2003;255:1221–1232.

Perreault DJ, Caliskan V. A new design for automotive alternators. Massachusetts Institute of Technology 2000.

Sing GK, Ahmed SAKS. Vibration signal analysis using wavelet transform for isolation and identification of electrical faults in induction machine. Journal of Electrical Power Systems Research 2004;68(2):119-136.

Undacheck J, Dodd VR. Progress and way out of a machinery surveillance and diagnostic system. In Proceedings of the ASME Conference on Pressure Vessel and Piping, Mexico City, Mexico 1976.

Wowk V. Machinery Vibration: Measurement and Analysis. McGraw-Hill Inc, New York 1991.