Power Spectral Density of Hydraulic Pumps

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ABSTRACT: *Vibration analysis is the main conditions monitoring techniques for machinery maintenance and fault diagnosis. Practical experience has shown that this technique in a machine condition monitoring program provides useful reliable information, bringing significant cost benefits to industry. Many vibration environments are not related to a specific driving frequency and may have input from multiple sources which may not be harmonically related. With these types of vibration, it may be more accurate, or of more interest to analyze and test using random vibration. In this research we were calculated grms(Root-Mean-Square Acceleration) and Power Spectral Density (PSD) of Naji crane hydraulic pump in different faults situations. The results showed that different faults were showed different PSD vs. frequency. The results showed that with calculating PSD we could find some fault and diagnosis of hydraulic pump as soon as possible.*

Keywords: Power Spectral Density, PSD, Hydraulic Pump, Condition Monitoring

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1. Introduction

Vibration analysis in particular has for some time been used as a predictive maintenance procedure and as a support for machinery maintenance decisions [1, 2 and 3]. Many mechanical problems are initially recognized by a change in machinery vibration amplitudes. In addition, the frequency of vibration, plus the location and direction of the vibratory motion are indicators of problem type and severity. Vibration characteristics can be distinctively divided into two types: forced vibration and free vibration. Typical forced vibration relates to problems such as mass unbalance, misalignment, and excitation of electrical or mechanical nature. Free vibration is a self-excited phenomenon that is dependent on the geometry, mass, and damping of the system, and typically caused by structural, acoustic resonance, and by aerodynamic or hydrodynamic excitation. Byrne and his co-worker showed that condition monitoring had a good application in industrials [4] .Machine condition monitoring has long been accepted as one of the most effective and cost-efficient approaches to avoid catastrophic failures of machines [5]. Vibration signals carry information about exciting forces and the structural path through which they propagate to vibration transducers. A machine generates vibrations of specific 'color' when in a healthy state and the degradation of a component within it my result in a change in the character of the vibration signals [6]. In this research, density data produced by vibration analysis was compared with previous data. Numerical data produced by power spectral density (PSD) were compared with power spectral density in healthy hydraulic pump, in order to quantify the effectiveness of the power spectral density technique [5, 6 and 7]. We were calculated grms(Root-Mean-Square Acceleration) and PSD of a hydraulic pump in different situation and different faults. The result showed that different faults were showed different PSD carves vs. frequency [7, 8]. The results showed that with calculating PSD, we could diagnosis hydraulic pump fault very fast. It was shown that PSD provides a good and rapid method to show faults of hydraulic pump. The results of this paper were given more understanding on the dependent roles of vibration analysis and PSD carve in predicting and diagnosing of a hydraulic pump faults. The objective of this research was to investigate the correlation between vibration analysis, PSD and fault diagnosis.

1.1 Calculating G_{rms}, (Root-Mean-Square Acceleration)

It is very easy to describe the G_{rms} (root-mean-square acceleration, sometimes written as GRMS or G_{rms} or grms or g_{rms} value as just the square root of the area under the ASD vs. frequency curve, which it is. But to physically interpret this value we need to look at G_{rms} a different way. The easiest way to think of the Grms is to first look at the mean square acceleration. Mean-square acceleration is the average of the square of the acceleration over time. Those is, if you were to look at a time history of an accelerometer trace and were to square this time history and then determine the average value for this squared acceleration over the length of the time history, that would be the mean square acceleration. Using the mean square value keeps everything positive.

1.2 Power Spectral Density (PSD)

Most random vibration testing is conducted using Gaussian random suppositions for both measurement and specification purposes. With Gaussian assumptions, there is no definable maximum amplitude, and the amplitude levels are measured in RMS (root-mean-squared) values [7, 8]. Random vibration can be thought of as containing excitation at all frequencies within the specified frequency band but no excitation at any specific single frequency [7, 8]. An acceleration spectrum is normally specified in terms of its' acceleration density using the units of g^2 per Hz. Acceleration density is defined as [7, 8]:

$$g_d = \lim a^2 / \triangle f \qquad \triangle f \geq 0 \qquad (1)$$

Where: g_d= acceleration density, a = rms acceleration, • f = bandwidth

2. Experimentation and Testing

The test rig used for the experimentation was a hydraulic pump. The rig design incorporated an unbalance, a coupling disk system to impose shaft misalignment, and looseness. Hydraulic pump was running under different faults. The coupling discs system was used to create an angular misalignment. Vibration data were collected on a regular basis after the run in period. The experimental procedure for the vibration analysis consisted of taking vibration readings at one select location over the hydraulic pump on input shaft casing. Datum was taken on the input shaft casing of hydraulic pump. Vibration measurements were taken on the input shaft casing of hydraulic pump using an Easy -Viber (VMI was the manufacturer). A coupling disc system was designed to impose shaft misalignment. The coupling system consisted of two discs: one attached to a short driven shaft and the other one attached to a longer shaft. This system was enabling us to considerable angular misalignment on the support bearing by moving the discs apart. The disks were moved relative to each other by tightening or loosening a grub screw, which pushes onto a key. It is very easy to describe the g_{rms} value as just the square root of the area under the PSD vs. frequency curve, which it is. But to physically interpret this value we need to look at g_{rms} a different way. The easiest way to think of the g_{rms} is to first look at the mean square acceleration. Mean-square acceleration is the average of the square of the acceleration over time. Using the mean square value keeps everything positive. We were calculated the root-mean-square acceleration grms response from a random vibration PSD curve. We were fixed our hydraulic pump on different faults and measured the overall vibration of hydraulic pump on that situation and calculated g_{rms} and PSD of hydraulic pump in different situation and different faults. The results showed that different faults were showed different power spectral density carves vs. frequency [7, 8].

3. Results and Discussion

Figures 1 until 3 showed frequency spectrum result of input shaft casing of hydraulic pump in healthy, misalign and looseness, respectively. The frequency spectrum of each fault was different and overall vibration values also were different at the same frequency.

The results showed that area under PSD carves were indicated a problem. The more area below PSD curve showed the faults were deeper. Figures 4 until 6 show PSD of DE of hydraulic pump in different situation. There was big different between PSD of

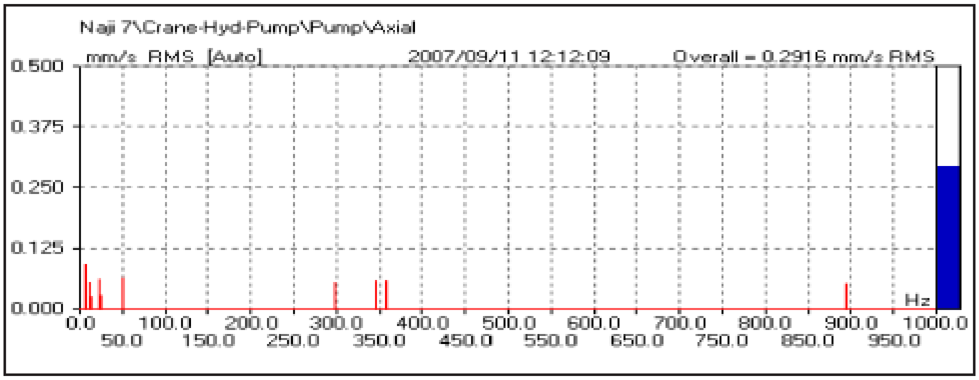

Figure 1. Frequency spectrum result of input shaft casing of hydraulic pump on healthy situation

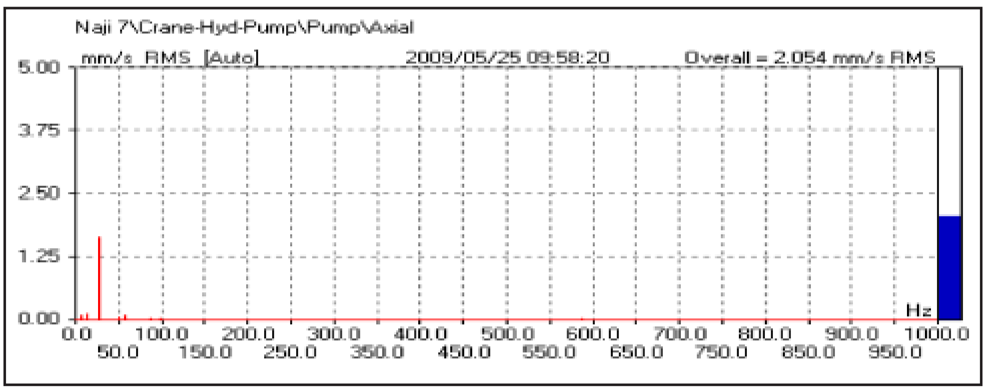

Figure 2. Frequency spectrum result of input shaft casing of hydraulic pump on misalign situation

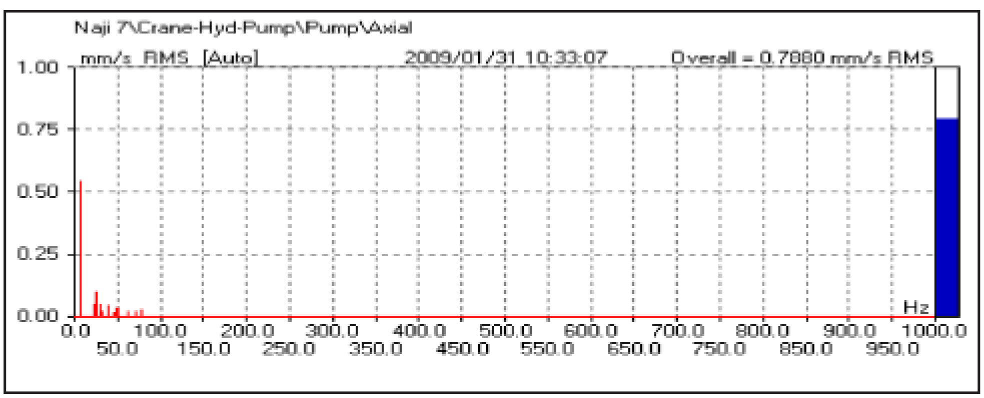

Figure 3. Frequency spectrum result of input shaft casing of hydraulic pump on looseness situation

looseness fault and other faults. The results showed that different faults were showed different PSD vs. frequency. The results showed that with calculating PSD we could find some fault and diagnosis of hydraulic pump as soon as possible. Results showed that when we had deeper faults such as looseness the area under PSD carves was grown.

4. Conclusions

Results showed that vibration condition monitoring and Power Spectral Density technique could detect fault diagnosis of hydraulic pump. Vibration analysis and Power Spectral Density could provide quick and reliable information on the condition of

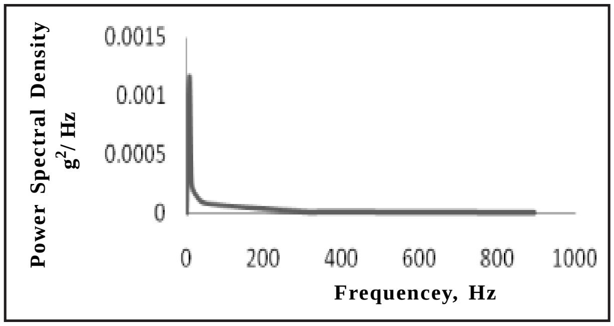

Figure 4. Power Spectral Density result of hydraulic pump on healthy situation

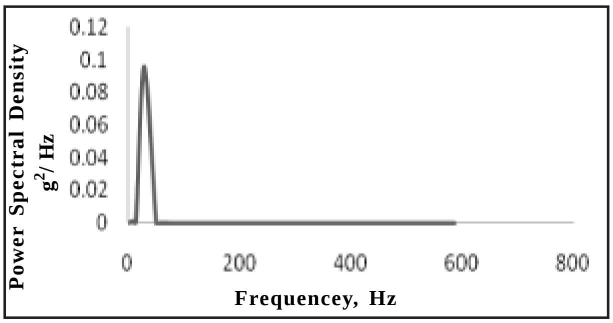

Figure 5. Power Spectral Density result of hydraulic pump on misalign situation

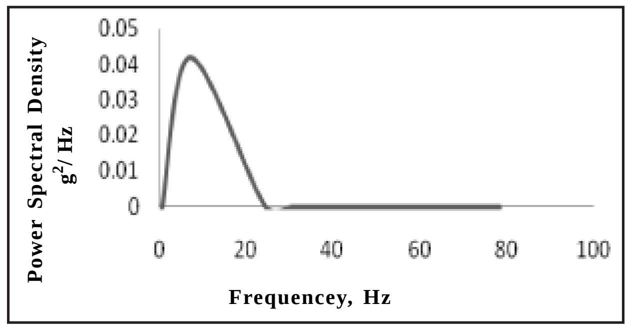

Figure 6. Power Spectral Density result of hydraulic pump on looseness situation

the hydraulic pump on different faults. Integration of vibration condition monitoring technique with Power Spectral Density analyze could indicate more understanding about diagnosis of hydraulic pump.

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