Industrial Water Pump Condition Monitoring by Using Time Signal Analysis and Fault Probability Distribution Function

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ABSTRACT: *As many mechanical problems are initially recognized by a change in machinery vibration amplitudes, we can constantly monitor the condition of a machine by using vibration analysis and make more detailed analyses to determine the health of a machine. Exponential distribution function was used for calculating a process water pump fault probability. This paper focuses on investigating the correlation between vibration analyses, time signal, fault diagnosis and Fault Probability Distribution Function (FPDF) of a process water pump. We were analysed measured time signal of a process water pump before and after repair situations. The FPDF of unhealthy situation was calculated. We can more understand on the dependent roles of vibration analysis in predicting and diagnosing machine faults and the results showed that by using the fault probability distribution function, we can find the specific frequency and the exact value of fault probability as soon as possible.*

Keywords: Probability Distribution Function, Fault probability, Process Water Pump, FPDF, Time signal

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1. Introduction

The fault analysis problem of particular parts of industrial machineries is very important because of the fault could cause serious problems such as production losses, expensive repair procedures or even the personnel injures[1].Condition monitoring systems have become more popular in recent years due to lower financial barriers to entry[2].Vibration based condition monitoring refers to the use of non-destructive sensing and analysis of system characteristics for the purpose of detecting changes, which may indicate damage or degradation [3].As many mechanical problems are initially recognized by a change in machinery vibration amplitudes, we can constantly monitor the condition of a machine by using vibration analysis and make more detailed analyses to determine the health of a machine [4].By analyzing the frequency spectra and using signal processing techniques, both the defect and natural frequencies of the various structural components can be identified (Barron, 1996; Eisenmann, 1998)[5, 6].Commonly used technique is to examine the individual frequencies present in the signal. These frequencies correspond to certain mechanical component or certain malfunction. By examining these frequencies and their harmonics, the analyst can identify the location, type of problem and the root cause as well (Cempel, 1988).The vibration signal analysis was often based on the Fast Fourier Transform (FFT) [7, 8].This paper focuses on investigating the correlation between vibration analyses, time signal, fault diagnosis and Fault Probability Distribution Function (FPDF) of a process water pump. In this research; density data produced by vibration analysis. We were analysed measured time signal of a process water pump before and after repair situations. The FPDF of unhealthy situation was calculated. We can more understand on the dependent roles of vibration analysis in predicting and diagnosing machine faults and by using FPDF we can determine the amount of fault probability before repair.

2. Materials and Method

The experimental procedure for the vibration analysis consisted of taking vibration readings at Driven End (DE) in vertical direct of the process water pump before and after repair. Details of the pump were given in table 1.

pump	Description
Type of pump	M2BA 315SMC 4
Power (kW)	160
Revolution Per Minute(RPM)	1500
Voltage(V)	400

Table1. Detail of the process water pump

The Vibration data were collected on a regular basis after the run in period.Vibration measurements were taken on the input shaft casing of the process water pump using an Easy-Viber (VMI was the manufacturer). Spectra Pro4 software was used for acquisition the vibration spectrum based on the Fast Fourier Transform (FFT) at frequency domain between 0 to 875.3 Hz.

2.1 Probability Distribution Function (PDF)

A mathematical function can be used to model the frequencies and probabilities of occurrences over time. A discrete probability distribution function associates a list of probabilities with each possible value of a discrete random variable. The probability distribution function is thus used to model the probabilities of a discrete random variable and is also known as a probability mass function. The probabilities of a continuous random variable are modelled using continuous distribution functions, also known as probability density functions (PDF's) [9, 10].

2.2 Probability density function

The probability density function (PDF) f of a random variable X gives a natural description of the distribution of X and allows probabilities associated with X to be computed [11]:

$$P(a < X < b) = \{\int_a^b f(x)d(x)\} \tag{1}$$

The probability density function (PDF) of an exponential distribution has the form

$$f(x,\lambda) = \begin{cases} \lambda e^{-\lambda x}, & x \geq 0 \\ 0, & x < 0 \end{cases} \tag{2}$$

Where $\lambda > 0$ is a parameter of the distribution, often called the rate parameter. The distribution is supported on the interval $[0, \infty)$. If a variable has this distribution, we write X ~ Exponential (λ) [12].

3. Results and Discussion

The warning and critical reference value of overall vibratory velocity level is 2.8 and 4.5 mm/s, respectively (ISO TC108, 1963 standard). The experimental result of the overall vibratory velocity level of DE of the pump in vertical direct has shown in figure 1. The overall vibratory velocity levels are warning status at several measurements .second and third measurement are higher than 4.5 mm/s. The secondary measurement was considered as unhealthy (before repair) situation.

Figures 2 and 3 show frequency spectrum result of DE of the process water pump before and after repair respectively.

Vibration signals carry information about exciting forces and the structural path through which they propagate to vibration transducers (Williams, 1994) [13].Time signal plots (Figure 2 and 3) recorded during the operation of the process water pump under unhealthy and healthy situations (before and after repair) respectively. By comprising of unhealthy and healthy situations, we can understand that the different between modulation of electromotor before and after repair. In unhealthy situation the

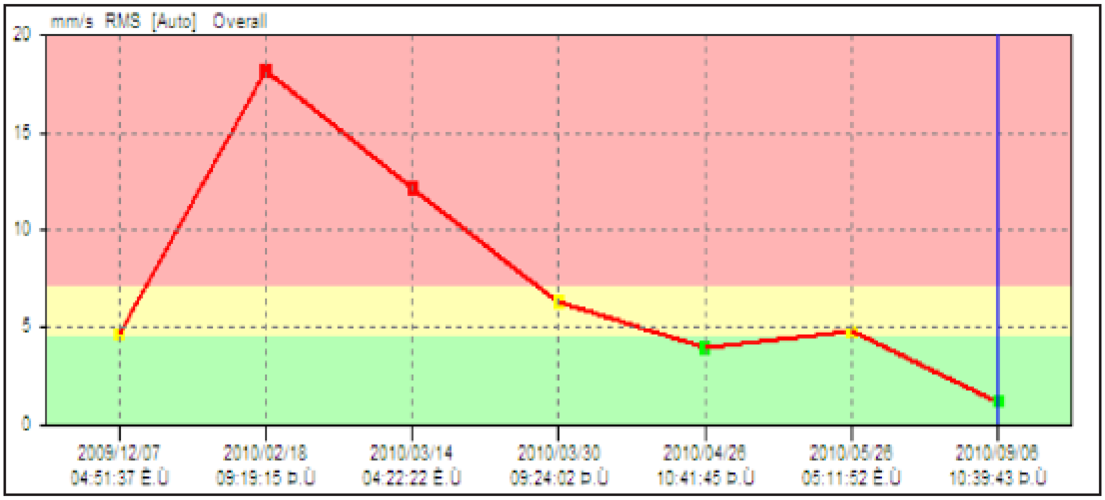

Figure 1. Overall vibrations of DE of the process water pump

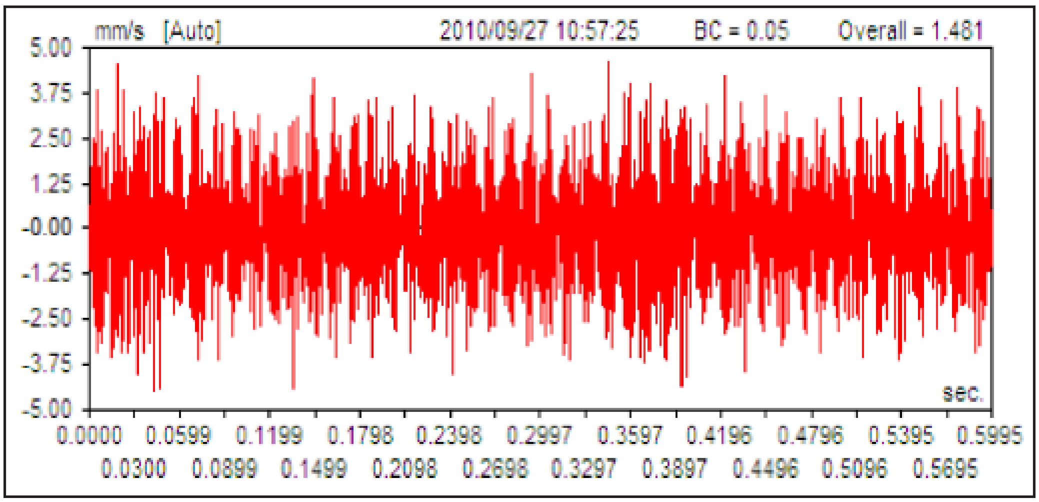

Figure 2. Time signal result of DE of the process water pump before repair

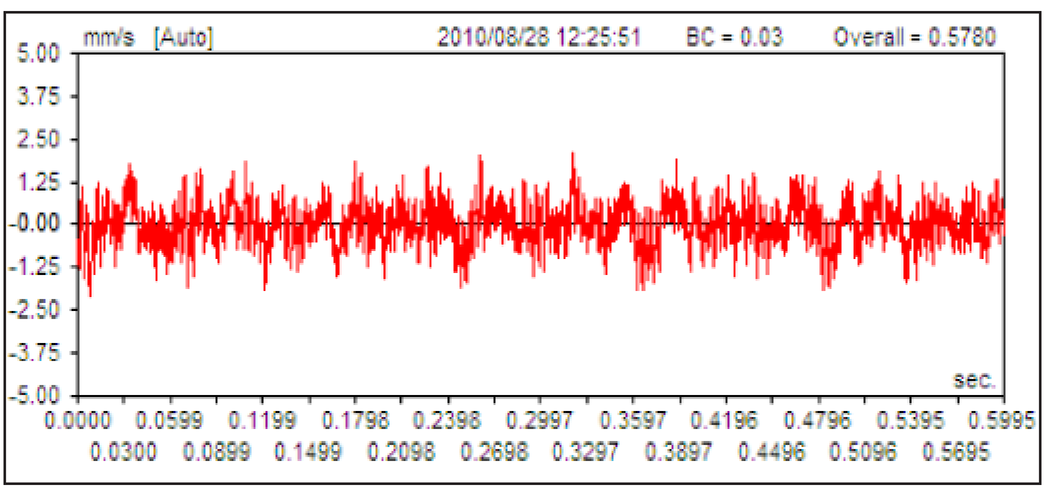

Figure 3. Time signal result of DE of the process water pump after repair

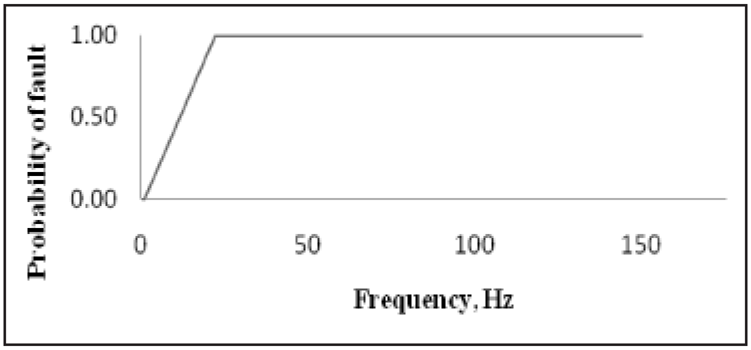

Figure 4. Fault probability result of DE of the process water pump before repair

results of time signal showed that we had more unshaped signal and also modulation and the overall of time signal in this situation was over than healthy situation. Fault probability distribution function of DE of the electromotor of process water pump was calculatedbefore repair that shows in figure 4. By using FPDF, we could determine the amount of fault probability before repair at each frequency.

The results of Fault probability distribution function showed that in rotary speed of electromotor and its harmonic we have 100 percent probability of fault. It was first time that we used this function to show that the faults. Compare to the results of this function about healthy electromotor the results showed that we had higher probability of faults in this situation.

4. Conclusions

We were analysed measured time signal of a process water pump before and after repair situations. The FPDF of unhealthy situation was calculated. We can more understand on the dependent roles of vibration analysis in predicting and diagnosing machine faults and the results showed that by using the fault probability distribution function, we can find the specific frequency and the exact value of fault probability as soon as possible. By comprising of unhealthy and healthy situations, we can understand that the different between modulation of electromotor before and after repair. In unhealthy situation the results of time signal showed that we had more unshaped signal and also modulation and the overall of time signal in this situation was over than healthy situation. The results of Fault probability distribution function showed that in rotary speed of electromotor and its harmonic we have 100 percent probability of fault. It was first time that we used this function to show that the faults. Compare to the results of this function about healthy electromotor the results showed that we had higher probability of faults in this situation. The results showed that by using the fault probability distribution function we can find the specific frequency and the exact value of fault probability as soon as possible.

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