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Study on Vibration Detection System of Wind-driven Generator based on Virtual Instrument

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Abstract: This study analyzes the structural characteristics of wind-driven generator, concludes its comment malfunctions and proposes effective methods by general fault analysis methods, so as to design online detection and fault diagnosis system of wind-driven generator in virtual instrument. This work will realize real-time detection, help engineers to proceed remote fault diagnosis, reduce maintenance time and increase production efficiency. This study is meaningful and practical to develop a fault diagnosis system for wind-driven generators, which shows professionalization of fault diagnosis system.

Keywords: wind-driven generator; virtual instrument; vibration detection; fault diagnosis system

1 Introduction

With the development of economy, energy demand is becomes larger. Meanwhile, it's inevitable to avoid traditional non-renewable resources being exhausted. Therefore, the demand for clean energy increases. Because of the explosion at the Fukushima nuclear power plant, people stop develop nuclear plant quickly but safely. This drives the fast development of wind-driven generator. But the production of wind-driven meets more and more challenges. Maintainers and operators needs to find stronger and stable detection devices to ensure the normal operation of wind-driven generators.

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The study analyzes the structural characteristics of wind-driven generator, concludes its comment malfunctions and proposes effective methods by general fault analysis methods, so as to design online detection and fault diagnosis system of wind-driven generator in virtual instrument. This can realize real-time detection, help engineers to proceed remote fault diagnosis, reduce maintenance time and increase production efficiency. This study is meaningful and practical to develop a fault diagnosis system for wind-driven generators, which shows professionalization of fault diagnosis system.

2 Technical requirements

Wind-driven generator is the device that converts wind power into electricity. It has very difficult operational conditions. For example, wind power plants at coastal areas encounters typhoons every summer and those in inner Mogolia and Xinjiang suffer the weather of wind and sand all year. Such difficult conditions have harmful effects on the safety and stability of generator's operation. It's very important for inspectors to grasp advanced detection technology and professional experience. With larger and larger investment, the maintenance of wind-driven generator has become a new industry and detection for the generator has become top priority. Therefore, It's helpful for inspectors to solve the problems when they inspect the generator. Currently, the inspection of wind-driven generators meets problems below:

1) Generator's large size and difficult environment brings challenges to both devices and inspectors.

With larger capacity, the size of the generator becomes larger and larger. As the company of “New Power System” just announced, they are building the world's largest wind-driven generator. The rotor's diameter is about 126 m long which is the same as two football fields. In China, Sinovel Group began to produce China's first 6 MW generator at Yancheng of Jiangsu on 18 May, 2011. It has the biggest capacity among China's generators.

In 2018, the company successfully applied for the project of “Study and Development of 10MW Coastal Wind-driven Generator” which is invested by National Energy Office. In order to support bigger generator, the scaffolds have to be tall. But it's impossible for maintainers to climb each tower. Thus, detection devices should run stably, collect and transfer data and correctly analyze the generator.

2) It's difficult to collect vibration data due to the slow rotating speed and big torque

As we all know, the rotating speed of wind-driven generator's vane is generally between 10 r/min to 20 r/min. At such slow speed, the input axis can't produce enough speed for support shaft to make oil film, which causes dry friction among axis and affects the normal operation of generator. Generally, low frequency sensors are used to inspect low or super low frequency. For engineering test, UHF and ULF detection is a very difficult question and the devices are very expensive.

3) Generators suffer variable load force and strong wind

As the speed is unstable, generator's load force and rotating speed are also unstable even though it has pitch system and brake gears. The vibration or noise signal is non-stable signal which requires ore complex analysis and professional mathematical tools.

3 The situation and prospect

Our country has reached achievements in generator's fault diagnosis, not only we made breakthroughs in theories but also many companies produced fault diagnosis platforms for wind-driven generators, such as ADAPT. Wind detection system from Bentley Company and SCADA data collection and analysis system from Rock Well[1-3]. We also have gathered rich empirical and practical experience, such as Wigner distribution, Short Time Fourier Transform, Wavelet Transform, Hilbert-Huang Transform and so on. The reasons for the slow development of wind-driven generators these years are:

1) Domestic investment and construction of wind-driven generator mainly relies on policy. Due to technical reasons, generator's production effects is lower than its cost. Thus, wind power plant needs the support from the country' policies to a large extent.

2) The technology of connecting wind power with electricity net restricts the construction and development of wind-driven generator. Wind power plants are usually in remote areas. Limited by technology, the electricity from wind power plants can't be connected with the main electricity net.

Generators run for no use at some areas which seriously affects the development of wind power electricity.

3) Currently, our country is lack of long-term study on wind-driven generator′s vibration. Most of diagnosis system can meet the needs of fault diagnosis for wind-driven generators. But the lack of long-term data is harmful for future development.

4 study on vibration detection system of wind-driven generator

From domestic and foreign studies, the diagnosis analysis of wind-driven generator studies testing methods and testing system. Hardware is the first condition of testing system. Hardware includes sensors and collection card, which requires high collection precision. For example, the study of sensors concentrates on find dynamic characteristics, sensitivity, stability, anti-interference. Software includes signal processing, signal analyzing, signal filtering and calculating. It has turned to the development of digital technology from traditional statistics analysis, which contributes to higher precision and procession. In term of the study of signal analysis, in addition to traditional statistics analysis, time domain analysis, frequency domain analysis, more mature analysis methods such as zoom technique, Wigner-Ville allocation analysis, wavelet conversion analysis have been used in the analysis of vibration signal[4]. Recently, signal analysis technology based on AI has been adapted into engineering testing, including neural network and professional system.

As the development of electronic technology and virtual instrument, domestic and foreign vibration signal collection system is composed of collection module and computer or microcomputer and test circuit, which has come micro and intelligent. Moreover, with the development of technology, vibration fault diagnosis has higher applicability. Developing a specific vibration fault diagnosis system is the developing trend of modern online devices.

Time domain signal analysis is the most common method to analyze time signal. It includes statistic analysis for time series, calculation based on time signal (integration) and the analysis of some tracks[5-7]. Common statistic includes maximum, minimum, root-mean-square value, peak value, peak-to-peak value, variance, mean value, kurtosis value, crest factor, crooked degree index, impulse factor and so on.

The use of different time domain statistics is different. For example, signal's root-mean-square value can describe the size of signal's energy. Devices with larger vibration have larger root-mean-square value. But for some temporary impulse, the energy caused by temporary impulse will be averaged by root-mean-square value. At this time, steepness index shows a good description of the impulse's power. Thus, root-mean-square value is used to describe the size of vibration and steepness index the size of impulse.

Statistic is directly related to the size of device vibration. But individual time domain statistic can only show the size of signal and power of impulse, which can't be the direct basis of fault diagnosis. Otherwise, a lot of samples need to be gathered, and normal and fault samples need to be classified. The statistical value is taken as the abscissa, and the sample number within the statistical value interval is taken as the ordinate, and the distribution curves are drawn respectively. Generally speaking, the distribution curve of a certain statistic is normally distributed. In this way, the distribution curve of normal samples and fault samples are drawn in the same coordinate axis, and the abscissor value of the intersection point can be used as the judgment threshold to see whether the equipment has a fault. The misjudgment rate of this threshold is related to the number of samples. The more the number of samples, the better the convergence of statistical results and the smaller the probability of misjudgment.

Frequency domain analysis mainly refers to the frequency spectrum analysis, which is based on Fourier transform spectrum analysis. Spectrum analysis, whch includes spectrum, phase spectrum, power spectrum and so on, can only be used for steady periodic signal and is the basis of fault diagnosis technology. For steady periodic signal, its spectrum stands for the components of the signal. However, general spectrum analysis methods can't deal with non-stationary signals from wind-driven generator, because the Fourier transform is built on the premise of constant signal frequency. Thus, for non-stationary signals, we need to use other frequency domain analysis methods.

5 Relevant tests

1) The application of time domain statistic in the fault diagnosis of wind-driven generator Figure

1 respectively shows the vibration data of normal engagement, the engagement of scratched gears and the engagement of broken gears.

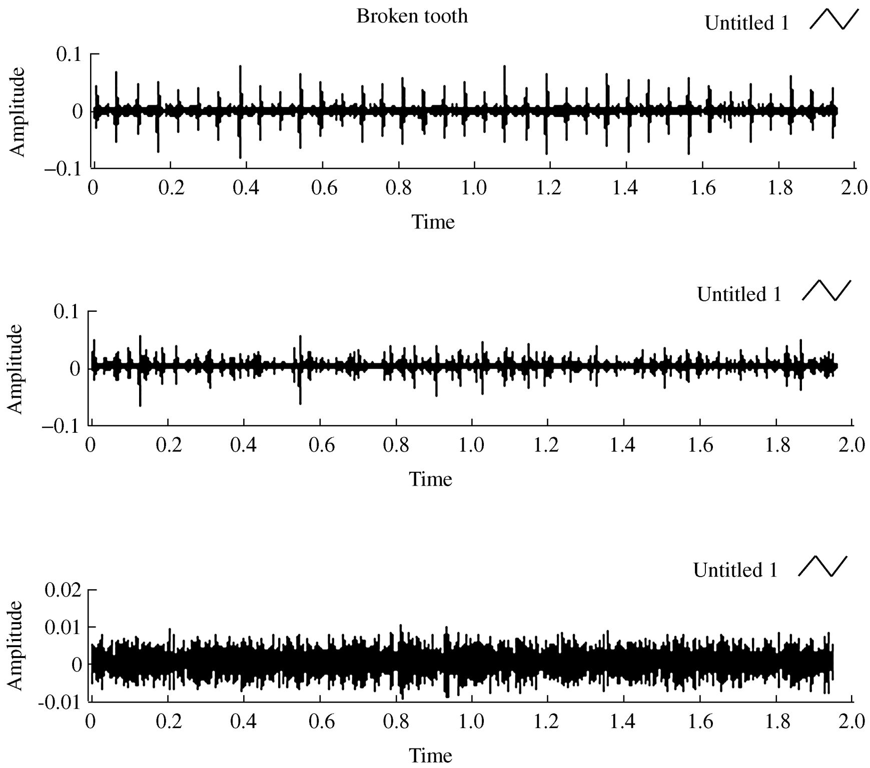

Figure 1 The vibration signals of gear engagement

Figure 1 obviously shows the impulse of the broken gears' vibration signal, scratched gears' vibration signal and the size of impulse, with obvious beat wave. But the vibration signal for normal gear is more stable. It's easy to find that the changes of statistic is obvious if the engagement of gears is fault. In terms of the vibration signal above, steepness index shows the most obvious changes. This because that fourth moment is used as the statistic index for steepness and impulse signal can be welled captured. Therefore, fault diagnosis can check if generator functions normally by international statistic or steepness index.

Figure 2 shows the bearing's different fault vibration signal, and shows their time domain statistic. The charts shows that the time domain statistic of fault bearing's vibration is bigger than normal ones.

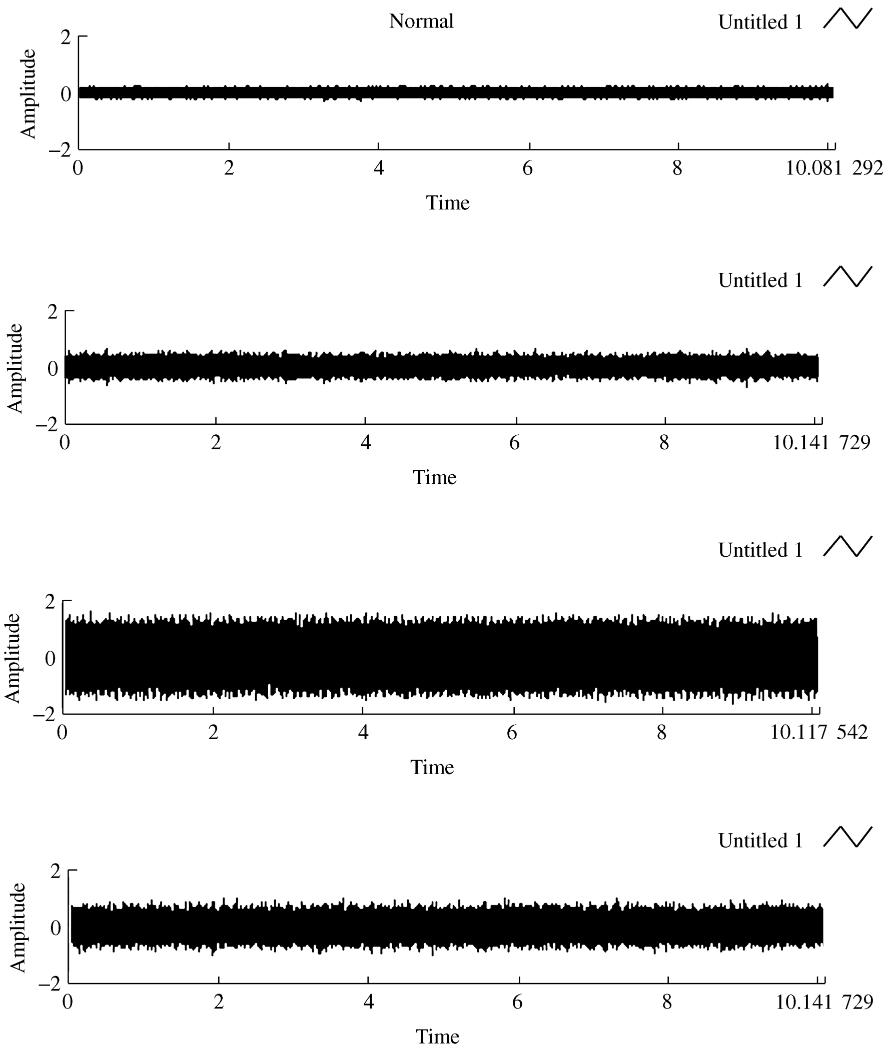

Figure 2 Bearing's vibration signal

Bearing supports mechanical equipment. Its vibration signal has the modulation phenomenon. Traditional analysis is resonance demodulation method. Hilbert transform is used to extract bearing signal, and then the power spectrum is calculated. this method is called resonance demodulation method. From the chart above, original vibration signal is the bearing vibration signal whose outer ring is fault, and its characteristic frequency is 104 Hz. If Fourier transform is directly used for the vibration signal, we can' t get the fault characteristics. However, we can see the vibration characteristics of outer ring's fault when we calculate the vibration signal's specturm after the Hilbert transform.

6 Conclusion

This study is meaningful and practical to develop a fault diagnosis system for wind-driven generators, which shows professionalization of fault diagnosis system.

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