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Mechanical Equipment Vibration Condition Monitoring of Holographic Spectrum Technology and Shafting Space Vibration Mode Based on the Microsoft Visual Studio.NET Environment

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To understand mechanical equipment vibration condition monitoring technology of holographic spectrum technology and shafting space vibration mode based on the Microsoft Visual Studio.NET environment. Building mechanical equipment vibration condition monitoring technology system of holographic spectrum technology and shafting space vibration mode based on the Microsoft Visual Studio.NET environment; Introducing machinery vibration faults, monitoring passed can confirm whether the technical system is effective. The effectiveness of technical system is proved by simulation study in the research of this paper. The technical system of this paper has higher application value.

1. Introduction

In modern society, the application of network technology has penetrated into all levels, including mechanical equipment vibration condition monitoring. Holographic spectrum technology is main monitoring technology for mechanical equipment vibration condition monitoring at present. It can be effectively determined whether the mechanical vibration is reasonable through data feedback of holographic spectrum technology. However, with the continuous improvement of science and technology, traditional holographic spectrum technology still has the problem of insufficient precision. Modern related research fields have proposed a kind of new technology which called mechanical equipment vibration condition monitoring of holographic spectrum technology and shafting space vibration mode based on the Microsoft Visual Studio.NET environment. It abandons the disadvantages of traditional holographic spectrum technology and effectively improves the accuracy and comprehensiveness of the monitoring results. This paper studies this technology to understand it.
Based on common vibration faults of some mechanical equipment and aimed at its types and characteristics, a set of mechanical equipment vibration condition monitoring technology system of holographic spectrum technology and shafting space vibration mode based on the Microsoft Visual Studio.NET environment is established in this paper. This technology system is used to detect experimental mechanical equipment for determining whether it can effectively monitor the faults of mechanical equipment. Finally we can know the practicability of mechanical equipment vibration condition monitoring technology of holographic spectrum technology and shafting space vibration mode based on the Microsoft Visual Studio.NET environment.

2. Literature review

There are five aspects of the research status of hologram spectrum technology and axis space vibration mode, mainly in axis locus, two-dimensional hologram spectrum, three-dimensional hologram spectrum, holographic waterfall chart, axis space vibration mode. Endo and others pointed out that, for the axis trajectory, the displacement sensors for the rotor system in the horizontal (X) and the vertical (Y) direction rotors were only one direction of the vibration of the rotor system, which cannot fully represent the vibration state of the rotor

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(Endo et al., 2015). The axis locus refers to the trajectory of the rotor axis point relative to the bearing seat. The axis locus carries rich diagnosis information. The shape of the axis track and the direction of the precession and its stability are important parameter in the state fault diagnosis of the rotating machinery. It is an important auxiliary approach of the state monitoring and diagnosis of the rotating machinery equipment. The axis trajectory obtained in the direct test is rather complex in general, which is not conducive to the identification of the axis trajectory. Filtering the noise in the axis trajectory, the filter axis trajectory is obtained. On the basis of the spectral analysis, the multiple frequency components of the horizontal (X) and vertical (Y) direction signals are extracted and reorganized in the time domain, and the track of the axis must be synthesized. The fault characteristics of the equipment rotor system are not in the "banana type" axis trajectory in the wrong way, while the typical axis track of the axis crack is shown as "inner 8". The axis trajectory of the original signal is not easy to recognize because of the noise interference, and the axis trajectory of the filter axle center can clearly determine the cusp and mutation of axis locus caused by the rubbing fault.

Alloul and others stated that in the aspect of two-dimensional holography, the axis locus was combined with the spectrum analysis method; the horizontal and vertical signals obtained by the displacement sensor were processed and filtered through the FFT transform, and then the spectrum components, amplitude and phase were extracted after the transformation. Subsequently, the integration of signals of two directions under each frequency component was carried out and then two-dimensional holographic spectrum could be obtained; the trajectories of each frequency component were a series of circles, ellipses, lines, and oblique lines because only a single frequency component was contained (Alloul et al., 2015). Belhadj and so on described in detail the development of two-dimensional hologram and its application in monitoring and diagnosis of mechanical equipment (Belhadj et al., 2017).

In the aspect of three-dimensional holography, Thomas and others conducted Fourier transformation of the signals in the horizontal (X) and vertical (Y) directions, respectively, to extract a certain frequency component to fuse respectively, and arrange the elliptical trajectories of each section according to the relative position of the space. The transverse coordinates represent each supporting section, and the three-dimensional holography of the phase can be obtained from the point of phase (Thomas et al., 2017).

In the holographic waterfall chart, the waterfall chart is an effective tool to analyze the starting or stopping process of the rotating equipment. It is essentially the superposition of the amplitude spectrum of the change of the rotational speed during the starting or stopping process. The holographic waterfall diagram is the superposition of two-dimensional holographic spectra at various speeds during the starting or stopping process. Because it combines the amplitude and phase of the horizontal and vertical vibration in two directions, it more effectively indicates the vibration characteristics of the rotating equipment during the shutdown process than the traditional waterfall map. This phenomenon can be explained by different thermal effects in the process of starting or stopping. Renson and other scholars, in the study, pointed out that when the timing seat of the unit rose gradually, the bearing stiffness was higher than the square direction of the two direction expansions, when the heat inertia affected the rotor and bearing characteristics in the vertical and horizontal direction of the cemetery in the vertical and horizontal direction, and the bearing stiffness was higher than the square direction of the two direction expansion. At that time, the heart rate of fundamental frequency ellipse was greatly increased (Renson et al., 2014).

For the vibration mode of the shafting, large rotating equipment is a multi-rotor supporting system. The shafting usually consists of several rotors, which are connected by coupling. The vibration characteristics of shafting in large rotating equipment are an important index, which is directly related to availability and safety. The vibration mode representation of the shafting is the relative relationship between the synthetic trajectory curves of a first order signal component on several sections and the relative relationship between them. First of all, the signal of a certain direction, after Fourier transformation, extracts the order frequency circle of a certain frequency component, and each section circle is arranged according to the relative position of the space. The transverse coordinates are used to express the various supporting sections, and the points of the initial phase on each circle are connected in order. Jin and others pointed out that in the horizontal vibration curve of a turbo generator axle bush, after the rotational speed was stable, the generator and steam turbine were analyzed as an axis system, and the vibration of the shaft system was two-order distribution. The vibration of the bearing was probably caused by the vibration of the generator, and the two-order imbalance of the generator rotor caused the vibration of the tile to be larger (Jin et al., 2015).

The research status of rotating machinery vibration condition monitoring system is reviewed. The research on the state monitoring system of rotating machinery is relatively early in foreign countries. In the study, Rao and Lakshmi described the NI (National Instruments) company's data acquisition instrument and supporting software (Rao and Lakshmi, 2015). However, Jung and so on pointed out that the foreign software had the following shortcomings: the function of the online monitoring system is single, and it is difficult to meet the requirements of the growing variety of monitoring conditions; the off-line analysis system contains a relatively simple signal processing method, and there are not many alternative analysis methods in practical engineering applications; the whole system does not contain the database system, but it is not easy to handle and manage the data in the form of data file and the system containing the database is often difficult to meet the requirements of different users for data retrieval and data management; the whole system is bound to sell abroad, and the price is high, which is not conducive to reducing the cost of on-line monitoring and maintenance of rotating machinery and other equipment; the domestic system is relatively lagged in the whole system development, and the integrated signal processing methods of the system are relatively simple; and most of them are based on Labview and Matlab software, and have many inconveniences in practical engineering applications (Jung et al., 2016). At present, more and more attention has been paid to the state monitoring and fault diagnosis of rotating machinery, so there are more and more requirements for the diversity, convenience and economy of the rotating machinery state monitoring system.

3. Method

The experimental verification is performed on a GE Bently rotor test bed. The test bed type is Bently RK 4. The rotor of test bed is driven by an infinitely variable speed motor. A disk is installed on the rotor and six eddy current sensors are installed respectively on the test bed, which corresponding to one rotation speed measuring point, one key measuring point and four vibration measuring points. These four vibration measuring points are divided into two groups, two for each group, installed at 90 degrees angle and formed a channel pair. The test bed has two front and rear copper bearings to provide support for rotor and disk. The test uses a 16-channel synchronous data acquisition card called type 9200 from USA NI Company and single slot crate with IEEE 802.11 Wi-Fi function for vibration and key phase data acquisition. Data which passes through a wireless gateway is collected by wireless network card of laptop. Use self-developed multi-channel vibration acquisition analysis software for data analysis. Real-time calculation order tracking algorithm is adopted on this software.

The common crack forms of rotor are opening, closing, transverse and transverse crack. It is known that transverse crack of rotor is the most common form and more likely to occur at the root of rotating shaft assembly part tightly fitted with rotor. When rotor crack continuously change, the frequency-divided resonance phenomenon will obviously come out during startup and shutdown of the unit, obviously the amplitude of rotor increases at 1/2 or 1/3 critical speed. There has been some wrong confusion of calculation of balance weight on the cracked rotor in the process of rotor factory or field dynamic balancing, for example, single plane influence coefficient of the rotor is abnormal, and the balance effect is too far from calculated value. At the same time, the cracks of rotating shaft make rigidity no longer the same directionality, with cracks expanding the rigidity of rotor will reduce further. When the rotor has cracks, it extends slowly in the early but faster and faster in the later period, this means a great damage.

For revolving shafts of possible cracks, generally monitoring from the following two aspects:

(1) For the amplitude and phase monitoring of basic frequency and double frequency at a certain speed, when the rotor is running steadily, the amplitude and phase of bearing of revolving shaft changes slowly at power frequency and double frequency. If there is no other factors such as bearing elevation changing, center hole oil leaking or shaft coupling center changing, it can be an important reference factor for shaft cracks. The beginning period is measured in weeks or months, and the changes of vibration are collected in several weeks or months. Initial changes of rotating shaft cracks can be knew by comparative analysis. With the deepening of cracks, the vibration period is by daily. Observation and judgment are made combining with polar charts and time trend charts. In the polar chart, the changing area is sector form.

For amplitude of double frequency and phase monitoring at variable speed during the unit start-up and shutdown, when high-medium pressure or low-pressure rotor occurs double frequency resonance at 1/2 critical speed, it is the key criterion for rotor cracks. The crack becomes bigger with resonance peak increasing. However, in fact, the fault feature of rotor coupling misalignment is exactly same as the crack in the above process. It is necessary to observe the phase and amplitude for judge their difference. When overhauling, eliminate the double frequency characteristic factor of coupling by eliminating the problem of coupling misalignment.

In order to control the watering problem caused by excessive clearance of bearing box, the clearance of bearing box should be as small as possible. But this preventive measure will create another problem: as the clearance between rotor and stator become smaller, the chance of frictional collisions increases greatly. When stator and rotor rub, the reaction force will produce a force supporting the rotor at rubbing points. At the moment of rotor and stator component touching, the rigidity of rotor system increases instantaneously, the stability of original revolving shaft system is disturbed, causing higher possibility of self-excited vibration. In addition, the heat generated by the friction cannot be taken away through heat exchanging in time, it will easily cause serious problems such as hot bending of rotor. According to rubbing direction and location, static and

dynamic rubbing can be divided into static and dynamic axial rubbing, radial rubbing or both. Axial rubbing is generally caused by axial unbalance force, and the rotor comes into axial movement. Radial rubbing is generally caused by small clearance and excessive vibration between rotor and stator. Radial rubbing includes full annular and partial rubbing.
High accuracy is required for the conclusion of rubbing faults. At present, the judgment of rubbing faults is based on amplitude, frequency spectrum and axial trajectory together. In addition, the force of collision point may change journal centre greatly, the change of journal static position can also be used as one judgment. Now the supercritical units mostly use double cylinder structures of high and medium pressure cylinders. Low pressure cylinders are also mainly double cylinder structures. Even if rubbing occurs in the flow passage, live sound is easily covered by noise, only the rubbing sound of shaft steam seal is easily heard. At low speed of the unit, we can determine whether there exists rubbing from the noise changes of on site monitoring. In the state of high speed, we only rely on frequency spectrum analysis function of eddy current sensor to judge the features and parameters.

4. Results and analysis

4.1 Order analysis

Order analysis application (revolution angle) samples in sequence, reflecting the relationship between signal and rotational speed and generate an order spectrum with order as horizontal axis and amplitude as vertical coordinate. It can measure the rotation of rotating parts. No matter how rotational speed changes, order can reflect the numbers of each rotation, so order method has a better effect on analyzing the equipment and vibration related to rotation. The most basic difference between order method and traditional spectrum method is the collection of signal. Traditional spectrum analysis is sampling on the signal at equal time intervals. If the original signal is stationary signal, then the sampled signal at equal time intervals is also stable, but if the original signal is unstable, the sampled signal is also unstable, as shown in Figure 1:

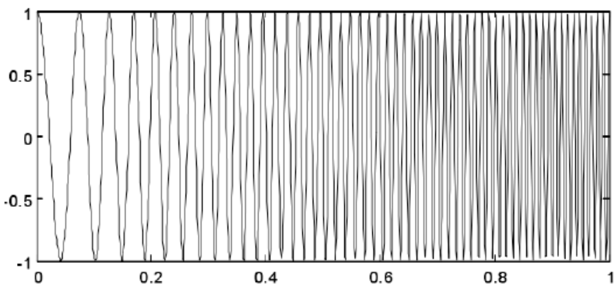

Figure 1: Time interval sampling for original signal

Order analysis samples at equal angle on original signal. In this way, no matter how the rotational speed of studied subject changes, the sampling points of each cycle are the same. That is to say the resulting signal is stable signal, as shown in Figure 2:

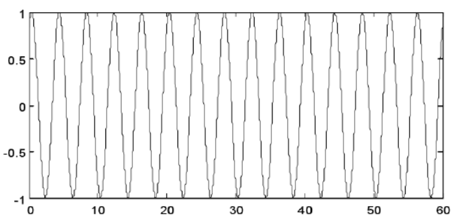

Figure 2: The angle interval sampling of the original signal

4.2 Simulation Signal Example Study

Taking a simulation vibration signal of the linear variation of fundamental frequency as an example, the signal fundamental frequency increases from 1Hz to 10Hz, the time of signal is 8 seconds. The above signals can be produced by MATLAB software. Vibration signals and key trust signals are shown in Figure 3 and 4:

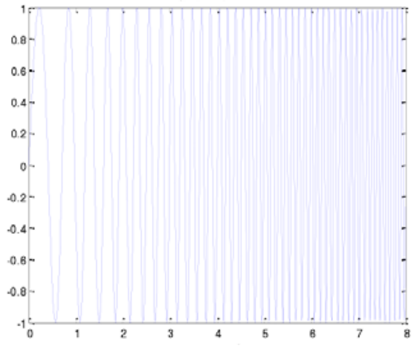

Figure 3: Simulation of vibration signals

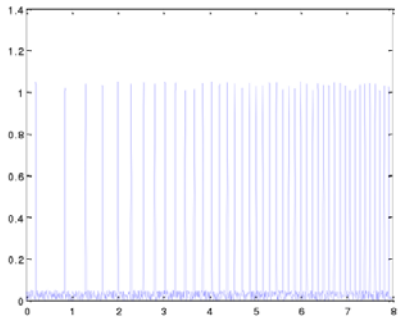

Figure 4: The key trust number of Simulation

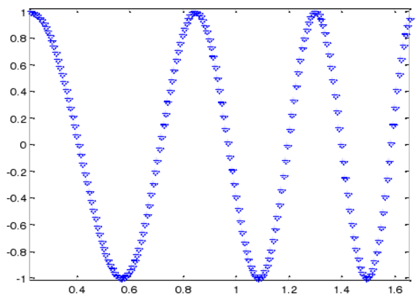

Figure 5: Local amplification of simulated vibration signals

From Figure 5, it can be seen the number of sampling points in the middle of each revolution becomes less and less with time increasing, that is, the rotational speed of each revolution becomes faster and faster and the fundamental frequency becomes higher and higher. Transform FFT directly on the vibration signal obtained from simulation, frequency spectrum figure of vibration signal is shown in Figure 6:

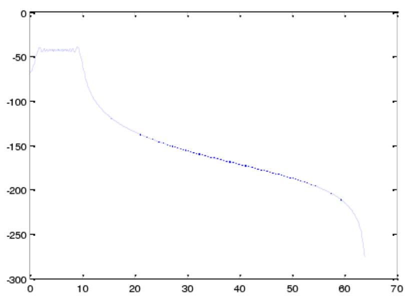

Figure 6: The frequency spectrum of the original vibration signal

The reason why signal frequency information cannot be seen from Fig. 6 is that frequency spectrum leakage occurred. For such a simulation signal, real-time calculation order tracking technique is adopted, and the result is shown in Figure 7:

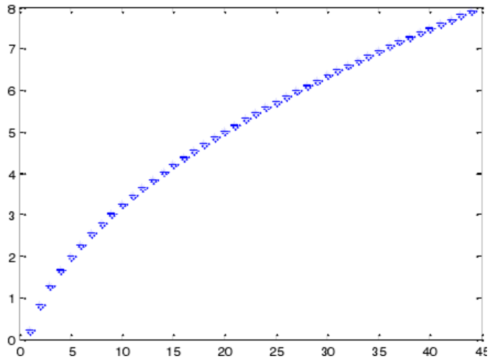

Figure 7: Position of rising edge pulse calculated by bonding phase.

5. Conclusion

The paper mainly builds Vibration state monitoring technology system of holographic spectrum technology and shafting space vibration mode for mechanical equipment under the Microsoft Visual Studio.NET environment. After that it introduces common faults of some common mechanical equipment, including cracked rotor vibration, static and dynamic rubbing and analysis their characteristics. Parameters are obtained by faults monitored separately through the platform of this paper, Finally, through the two steps order analysis and simulation signal examples, the actual function of technical system in this paper is verified. Compared the data in the figures, it is shown that holographic spectrum technology and shafting space vibration mode based on the Microsoft Visual Studio.NET environment in this paper are effective for mechanical equipment vibration state monitoring technology.

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