Experimental analysis of rub impact fault of rotor system

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Abstract: rub impact is one of the typical faults of rotor system, which brings many adverse effects to production and life, and even leads to major safety accidents, hinders the development and progress of society and economy, and also threatens the safety of people's lives and property. Therefore, it is important and urgent to study the rub impact of rotor system. This paper mainly uses the purchased three sets of rotor system simulation test-bed to test the rub impact of rotor system, obtain the rub impact characteristic signal, analyze the time domain, axis trajectory and frequency domain characteristics of rub impact, and draw some conclusions, so as to effectively prevent and timely detect the rub impact of rotor system, and better protect the normal operation of rotor system.

Firstly, this paper introduces the relevant equipment required for the rub impact test of rotor system, including the double rotor vibration characteristics test system, the intelligent vibration control test bench with single rotor and squirrel cage elastic support, and the flexible single rotor comprehensive vibration characteristics test bench; Then, aiming at the rub impact fault of rotor system, the rub impact experimental research is carried out by using the rotor system simulation test-bed, observing the rub impact characteristic signals obtained by the experimental equipment, analyzing the fault characteristics of normal, unidirectional and multidirectional rub impact in time domain, axis trajectory and frequency domain, and evaluating its safety, so as to provide a certain theoretical basis and experimental reference for the safety and protection of rotor system.

Key words: rotor system; Rubbing; Fault; Experimental analysis

Introduction

The early research on rub impact of rotor system can be traced back to the 1960s. Many foreign researchers have carried out a large number of theoretical, experimental research and practical applications in this field. In 1968, John sohre of the United States summarized the types and corresponding characteristics of rub impact with tables; Bently Nevada has carried out experimental research on the rubbing mechanism; Wambo hakki of Japan has done some theoretical research on the treatment of rub impact; Wolfson industrial maintenance company of the University of Manchester in the UK, SPM bearing monitoring in Sweden, Norwegian ship fault diagnosis system, etc. In the past three decades, the research on rub impact of rotor system in China has made rapid progress. Chu Fulei analyzed the rub impact stability of rotor system; Hu pengqing developed the aerospace fault detection system; Meng Guang studied the rub impact mechanism, and his scientific research in the field of squeeze film damper of aeroengine is in the forefront of the world; Xu Min established the relationship between rub impact type, vibration characteristics and sensitive parameters, and gave the corresponding treatment measures. The research on rub impact of rotor system is booming in China.

1 Introduction to experimental equipment

(1) The experimental platform is mainly composed of low-voltage rotor drive motor, high-voltage speed drive motor, three support bearing pedestal, high-voltage rotor, low-voltage rotor, rotor rub impact support and two sets of high-voltage and low-voltage rotor drive controllers.

(2) The controller operation interface is shown in Figure 1.1. This experimental platform mainly realizes the test and analysis of double rotor startup characteristics, the test and analysis of bearing pedestal vibration characteristics at support position, the test and analysis of rotor shaft vibration characteristics, the test and analysis of typical fault vibration of intermediate bearing, and the test and analysis of rotor misalignment fault vibration.

Figure 1.1 controller operation interface

(3) The intelligent vibration control test bench with single rotor and squirrel cage elastic support mainly completes the design of rotor vibration control experiment and the experimental exploration of bearing motion stability under typical load force. The experimental platform is mainly composed of high-speed rotor drive motor, squirrel cage vibration control device, rotor, rubbing screw and bracket, rotor drive controller, coupling and sensor.

(4) The experimental platform is mainly able to test the starting characteristics of single rotor, the vibration characteristics of bearing pedestal, the critical characteristics of shafting, the control effect of squirrel cage elastic support, the oil film oscillation fault test, the vibration test of rotor misalignment fault and the rub impact test.

(5) Figure 1.2 shows the flexible single rotor comprehensive vibration characteristics test bench, which is mainly composed of high-speed rotor drive motor, load force loading control device, support bearing seat, rotor, counterweight plate, rub impact screw and bracket, rotor drive controller, coupling and sensor. It can carry out single rotor startup characteristic test, bearing pedestal vibration characteristic test, shafting critical characteristic test, rolling bearing typical fault vibration test, rotor misalignment fault vibration test and rub impact test.

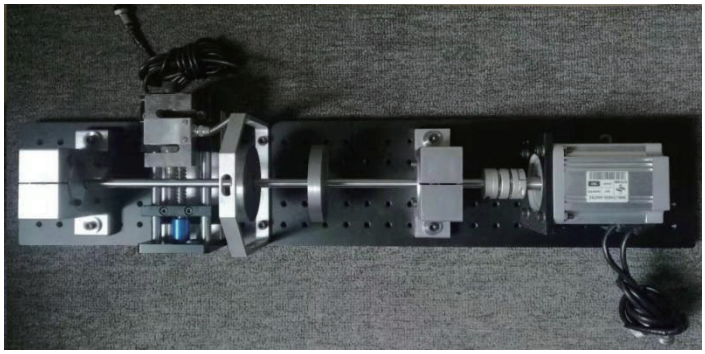

Figure 1.2 flexible single rotor comprehensive vibration characteristics test bench

2. Experimental study on rub impact fault

The experimental study of rub impact fault is mainly carried out on a flexible single rotor comprehensive vibration characteristics test-bed. By placing the eddy current sensor in the direction of 90 degrees, the vibration signals in the horizontal and vertical directions are collected, and the normal, one-way rubbing and multiple rubbing experiments are carried out respectively.

Fig. 2.1-fig. 2.9 show the time domain, axis orbit and frequency domain of the rotor system under normal conditions, one-way rubbing and multiple rubbing. According to figure 2.1-2.9, it can be concluded that:

Under the normal operation of the rotor system, the waveform in the time domain diagram is relatively stable. In the spectrum diagram, there is only the fundamental frequency, with a frequency of 30Hz. Its axis trajectory is a relatively regular circle, and the system operates stably.

In the case of one-way rub impact of the rotor system, the waveform in the time domain diagram has changed, the displacement is asymmetric, the axis trajectory has divergent phenomenon, and there is a certain concave. In the spectrum diagram, the fundamental frequency is mainly 30Hz, and the double frequency is 60Hz.

In the case of multiple rub impacts of the rotor system, the waveform in the time domain diagram has changed significantly, the amplitude has changed greatly, and the divergence of the axis trajectory has become more and more obvious. In the spectrum diagram, in addition to the fundamental frequency and the second harmonic frequency, the high octave frequency such as the third harmonic frequency has become prominent, and the proportion of the second harmonic frequency has increased.

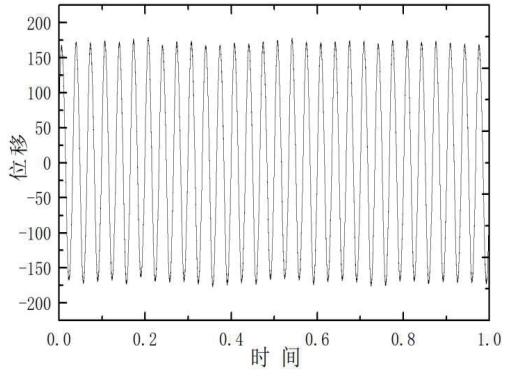

Figure 2.1 normal time domain

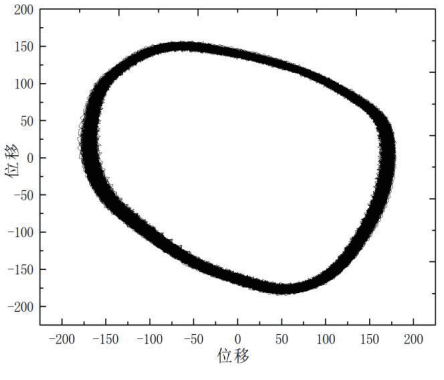

Figure 2.2 normal axis trajectory

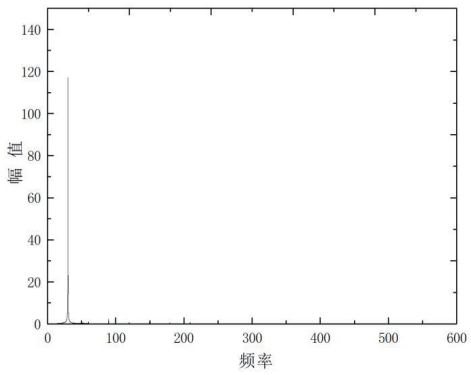

Figure 2.3 normal frequency domain

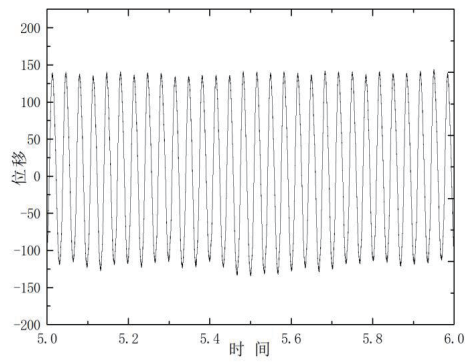

Figure 2.4 time domain of unidirectional rub impact

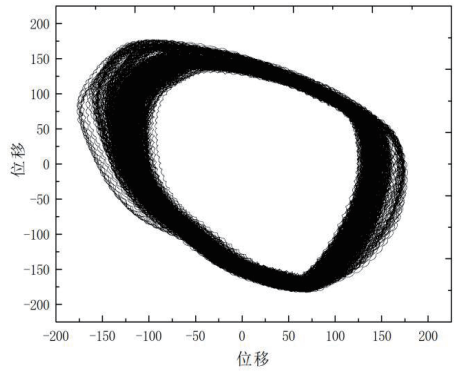

Fig. 2.5 axial trajectory of unidirectional rub impact

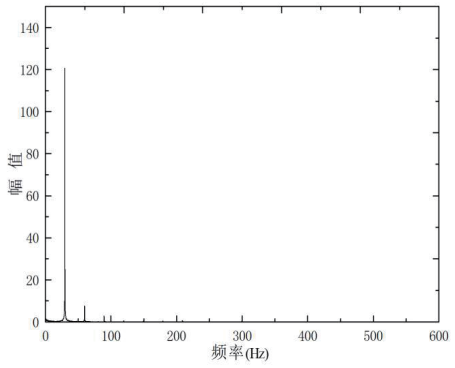

Fig. 2.6 frequency domain of unidirectional rub impact

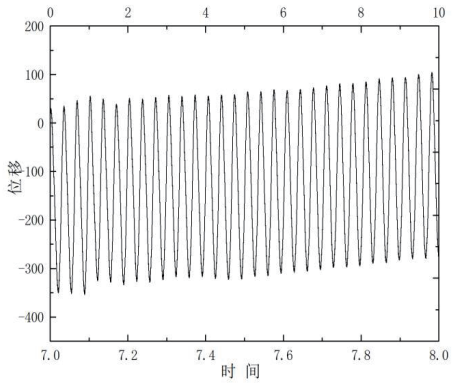

Figure 2.7 multiple rub impact time domain

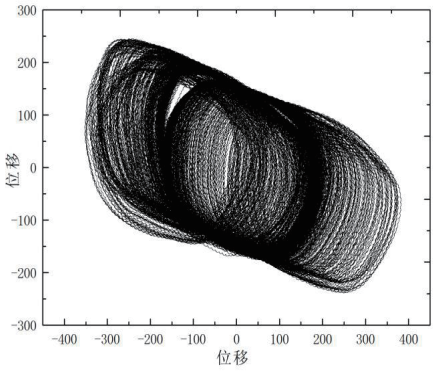

figure 2.8 multiple rub impact axis trajectory

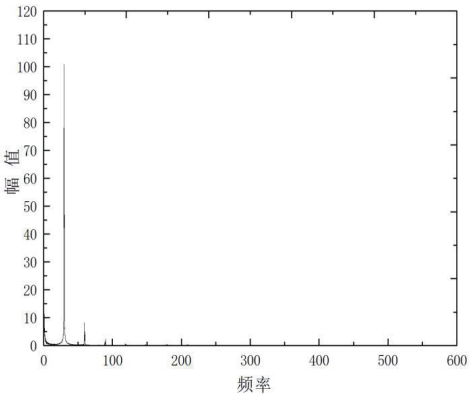

Figure 2.9 frequency domain of multiple rubbing

4 Summary

This paper mainly uses the rotor system simulation test-bed to carry out the experimental research on the rub impact fault of the rotor system, and obtains the characteristic signal of the rub impact fault of the rotor system. Through data analysis, it can be concluded that when the rub impact fault occurs, the axis trajectory will change significantly, and the displacement change will increase significantly, which may lead to a variety of faults. This experimental study can provide some theoretical and experimental basis for the safety of rotor system and the protection of rub impact fault, and also provide some basic data for the subsequent research of other single faults and multiple coupling faults.

References:

[1] Wang Qian, Wu Weiming, Zhang Fukai, Wang xin Early rub impact fault detection of rotor systems via deterministic learning[j] Control engineering practice, 2022124

[2] Shi Kunju, zhaorongzhen. Research on d-lle dimensionality reduction method of rotor system fault data set [j]. mechanical science and technology, 2014,33 (04): 516-521.doi:10.13433/j.cnki.1003-8728.2014.04.028

[3] Songliyuan, liangkuixi, taobenyong. Research on rub impact feature extraction technology of steam turbine generator units [j]. industrial control computer, 2022,35 (12): 123-124