Field Dynamic Balancing System Based on Labview in AMB-Flexible Rotor System

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Abstract
The 10MW high temperature gas-cooled test module reactor (HTR-10GT) with the core made of spherical fuel elements was designed and constructed by the Institute of Nuclear and New Energy Technology of Tsinghua University in China. In the HTR-10GT,turbo-compressor and generator rotors are connected by a flexible coupling and a decelerator. The AMB is the important technology for the helium blower. AMB rotor commonly has high working speed, although on the theory base, you can raise winding rigidity at discretion through feedback control, in fact, because of the limit of AMB power, if dynamic balancing is not good, it will easily cause electric current saturated phenomenon and make the base of bearings cause fierceness vibration. SO it is quite essential to make precision dynamic balancing for high speed AMB rotor. In this paper significance of dynamic balance for the AMB system is discussed and as well vibration monitoring and field dynamic balance system for the AMB system is constructed. The feasibility of the dynamic balance system is tested through experiments in the paper.

Keywords : AMB, Vibration , Field Dynamic Balancing, Influence Coefficient Method, LABVIEW

1. Introduction

The 10MW high temperature gas-cooled test module reactor (HTR-10GT) with the core made of spherical fuel elements was designed and constructed by the Institute of Nuclear and New Energy Technology of Tsinghua University in China. In the HTR-10GT,turbo-compressor and generator rotors are connected by a flexible coupling and a decelerator. The rotors, restricted by actual instruments and working environment, must be supported without any contact and lubrication. Active magnetic bearing (AMB), is the best way to suspend and stabilize the position of rotors of HTR-10GT.Active magnetic bearing (AMB) is replacing ordinary mechanical bearings as the perfect sustaining assembly for the helium blower because they have several advantages: they are free of contact, do not require lubrication, are not subject to the contamination of wear, have endurance, and control performance very well. The AMB is the important technology for the helium blower.

AMB rotor commonly has high working speed, although on the theory base, you can raise winding rigidity at discretion through feedback control, in fact, because of the limit of AMB power, if dynamic balancing is not good, it will easily cause electric current saturated phenomenon and make the base of bearings cause fierceness vibration. So it is quite essential to make precision dynamic balancing for high speed AMB rotor.

In this paper significance of dynamic balance for the AMB system is discussed and as well vibration monitoring and field dynamic balance system for the AMB system is constructed. The feasibility of the dynamic balance system is tested through experiments in the paper.

2. Field Dynamic Balancing

Rotor imbalance results from materials or manufacture errors are inevitable. For a rotating system, the imbalance may generate a centrifugal force which would cause undesirable noise, rotor run-out and housing vibration. More specially, the centrifugal force is proportional to the square of rotating speed. Therefore, when the rotor operates at high speed, the synchronous vibration caused by rotor imbalance is obvious and even has an effect on the stability of the system.The dynamic balance study can effectively reduce the engine imbalance vibration, improving the whole engine vibration condition and working performance and prolong the life of the engine and its vital components.

2.1 THE MODEL OF INFLUENCE COEFFICIENT METHOD (ICM)

In this paper the ICM is used in the system such that the number of measuring positions is N and the adjustment face is M, then, the system has M input and N output. α is the Counterweight vector, each element represents quality and phase of each surface; β is the vibration response, each element represents the amplitude and phase of each measuring point ; β_0 is the initial vibration value; i is the number of the trial weight.

When the adjustment amount of the adjustment face is 0, measure the initial vibration on the balance revolving speed and the imbalance vibration signals, vibration matrix equation assuming as:

$$A\alpha_0 + \beta_0 = \beta_1 \tag{1}$$

Test Weight 1, measure the vibration on the balance revolving speed and the imbalance vibration signal, vibration matrix equation assuming as:

$$A\alpha_1 + \beta_0 = \beta_1 \tag{2}$$

Test Weight 2, vibration matrix equation assuming as:

$$A\alpha_2 + \beta_0 = \beta_3 \tag{3}$$

Test weight i , vibration matrix equation assuming as:

$$A\alpha_i + \beta_0 = \beta_{i+1} \tag{4}$$

So:

$$[A\ \beta_0]\begin{bmatrix}\alpha_0 & \alpha_1 & \alpha_2 \cdots \alpha_i \\ 1 & 1 & 1 \cdots 1\end{bmatrix} = [\beta_0 \quad \beta_1 \quad \beta_2 \cdots \beta_{i+1}] \tag{5}$$

Form the formula (5) we can see:

$$[\overline{A} \quad \overline{\beta_0}] = [\beta_1 \quad \beta_2 \cdots \quad \beta_{i+1}][\begin{matrix}\alpha_0 & \alpha_1 & \cdots \alpha_i \\ 1 & 1 & \cdots 1\end{matrix}]^{-1} \tag{6}$$

So optimal Balance is $-\overline{A^{-1}\beta_0}$

2.2 Field Dynamic Balancing process

The experiment is done in several steps:

1) Starting the engine, measure the initial vibration signals and calculate the fundamental frequency vibration signals.
2) Top the engine after the first experiment, add test weight α_1 at the adjustment face, increasing the rotor speed to balance speed, measure the vibration signals and calculate the fundamental frequency vibration signals of each test points.
3) Stop the engine after the second experiment, add test weight α_2 at the adjustment face, increasing the rotor speed to balance speed, measure the vibration signals and calculate the fundamental frequency vibration signals of each test point.
4) According to the experiment results in the first and second steps, calculate the system influence coefficient and the required adjustment amount to counteract the initial imbalance vibration balance. Then adjust the weight to meet the requirements for the adjustment amount. Restart the engine and measure the rotor vibration signals, and then test the effect of dynamic balance.

The process of dynamic balancing is seen in Fig. 1.

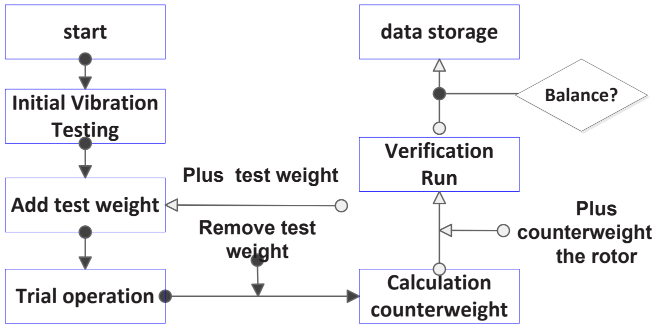

Fig 1. Dynamic Balancing process

3. Field Dynamic Balancing system based on labview

Under Microsoft's Windows operating system platform, the field dynamic balancing system based on LabVIEW2013in this paper. Virtual balancing instrument features shown in Figure 2, including: system parameter setting, speed test and vibration signal acquisition, vibration data analysis, balancing calculations, as well as balancing the results reporting. Block diagram of dynamic balancing system is seen in Fig.3.

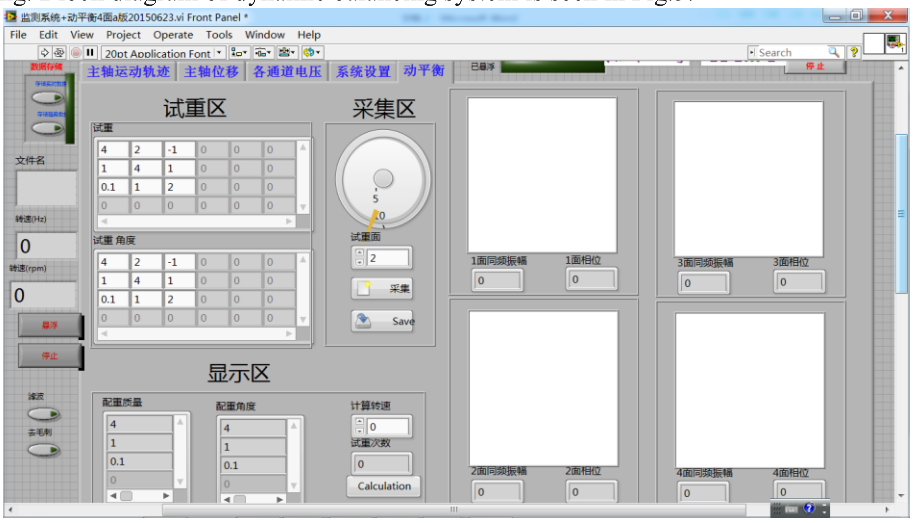

Fig 2. Dynamic Balancing system based on Labview

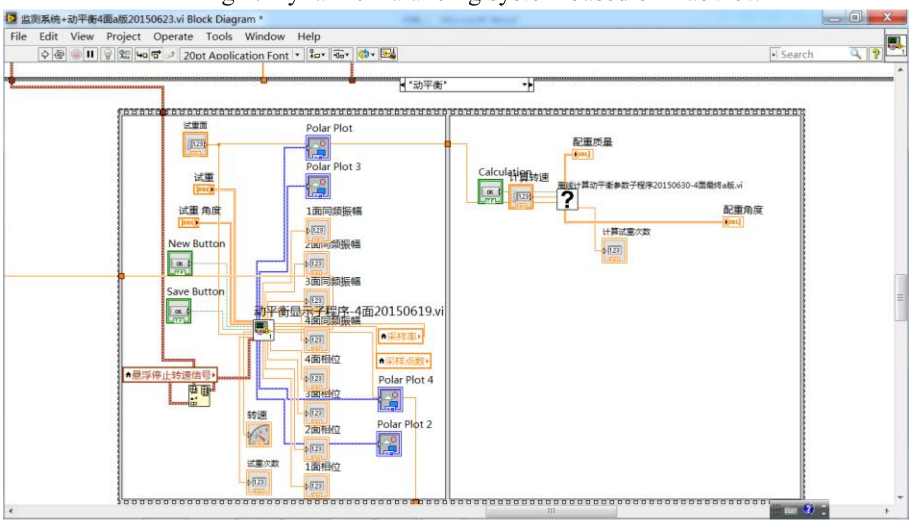

Fig 3. Block diagram of dynamic balancing system

4. Experiment and Conclusion

This experiment system is characterized by an about 3.5m long and 630kg heavy rotor. Four radial electromagnetic bearings and an axial one are mounted to suspend the rotor. Relationship between the vibration amplitude equal to the rotor speed and rotor speed is shown in Figure 4.The red curve is before dynamic balancing, the black curve is after dynamic balancing.

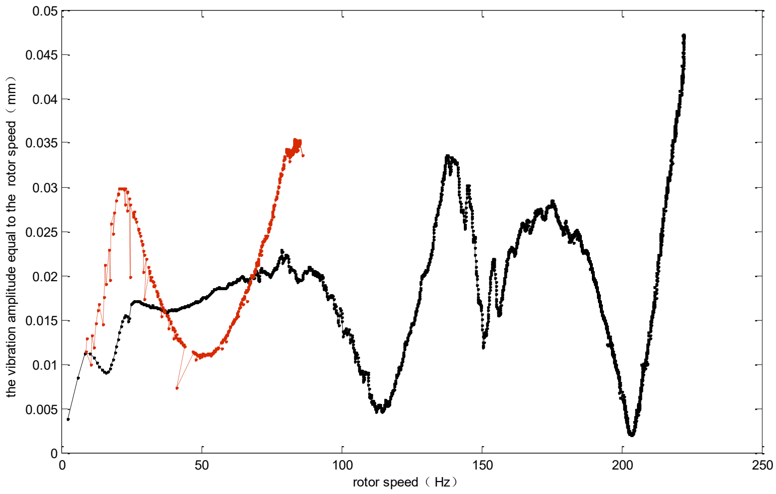

Fig.4. Before and after dynamic balancing

In this paper the ICM is used in the system such that the number of measuring positions is N and the number of correction planes is M. The hardware circuit can effectively reduce interferences, such as white noise and temperature change. The software system testing responds with rapid speed and an excellent human-computer interaction interface.

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