Vibration fault diagnosis and dynamic balance processing analysis of blower in thermal power plant

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Abstract. The fan vibration of the forced draft fan in a power plant is too large during normal operation, which seriously affects the normal operation of the unit. Through the vibration detection, on the basis of comprehensive analysis of the fan vibration failure mechanism, the means of adjusting the balance of the fan is adopted to reduce the excessive vibration to an excellent level. This paper introduces an excessive vibration fault caused by a device imbalance problem that is treated by vibration detection and dynamic balance test. The article elaborates the diagnosis method, diagnosis process and treatment suggestions, and deeply analyses and summarizes the characteristics of rotor imbalance, and provides reference for the diagnosis and analysis of the same type of fault.

1. Introduction

At present, the power plant has given sufficient attention to the vibration monitoring and fault diagnosis of the main steam turbine, but the research work on the vibration fault analysis and diagnosis of the auxiliary machines such as pumps, fans and motors is still less, and many auxiliary machines in power plants have vibration defects for a long time. There are vibration defects in the machine for a long time, which seriously affects the service life of the equipment and buries safety hazards for the normal and stable operation of the unit.

The blower is a power device that feeds the air required for fuel combustion into the boiler, and a centrifugal fan is often used [1]. In balanced ventilation, the blower overcomes all resistance from the inlet of the duct to the furnace, including the resistance of the air preheater, air duct, grate and fuel layer. In positive pressure ventilation, the blower overcomes all smoke and duct resistance from the inlet of the duct to the exit of the chimney. The wind sent by the blower is the heated hot air from the outlet of the air preheater, and is also sent to the furnace twice, so it is also called the secondary fan. This paper introduces a diagnosis and treatment method for the cause of excessive vibration of the blower in a thermal power plant, and introduces its vibration characteristics, data analysis and dynamic balance processing steps.

2. Equipment introduction

The blower is a cantilever centrifugal fan driven by a horizontal asynchronous motor with a rated speed of 992 r/min. Due to the unstable load of the unit, there are fewer full-load operating conditions. In order to improve economic efficiency, reasonably control the power consumption rate of the plant and reduce the waste of electric energy, the fan was transformed into a frequency conversion during a certain overhaul. Its structural diagram is shown in Figure 1.
Since the last overhaul, the fan has been in operation for nearly 4 years. During the period, there are problems such as excessive vibration of unknown reason and excessive temperature at the drive end of the motor bearing. In summer, it is necessary to add temporary fan cooling at the drive end of the motor bearing. Affect the safe and stable operation of the unit.

3. Fault diagnosis and cause analysis

3.1. Vibration test results
In order to solve the faults such as large vibration of the fan and excessive temperature of the bearing at the motor drive end, the fan is subjected to precise diagnostic vibration detection. The horizontal vibration value and frequency spectrum of the forced draft fan are shown in Figure 2-5. At the rated speed, the vibration of the bearing box fan end was measured: 149μm in the horizontal direction, 37μm in the vertical direction, and 29μm in the axial direction; vibration of the motor drive end: 104μm in the horizontal direction, 30μm in the vertical direction, and 25μm in the axial direction. It can be seen that the horizontal vibration of the equipment is prominent.

![Figure 2. Vibration frequency value of the horizontal direction of the blower.](image-url)

| Measuring point                                      | Rotating speed | Amplitude | 1X         | 2X         |
|------------------------------------------------------|----------------|-----------|------------|------------|
| Horizontal Direction of Free End of Motor, μm, p-p   | 997            | 59.7      | 36.6∠18    | 13.0∠297   |
| Horizontal Direction of Motor Driving End, μm, p-p   | 997            | 104       | 79.8∠6     | 9.00∠289   |
| Horizontal Direction of Motor End of Bearing Box, μm, p-p | 997            | 73.4      | 39.9∠350   | 7.37∠74    |
| Horizontal Direction of Fan End of Bearing Box, μm, p-p | 997            | 149       | 93.3∠341   | 13.4∠72    |
3.2. Causes and mechanism analysis of faults

The function of the blower system is to transport a large amount of hot primary air. The fan is a cantilever centrifugal fan. During long-term operation of the fan, the impeller, the front cover and the rear cover have different degrees of wear due to a large amount of hot air friction. As a result, the rotor impeller rotor is of uneven quality, its dynamic balance is destroyed, vibration is generated, and the support stiffness of the cantilever fan is relatively small compared to the support type, which expands the unbalance [2].

Through spectrum analysis, there is no obvious high-frequency or low-frequency component in the spectrum, and the vibration of the measuring point is dominated by one frequency. The phase is stable and the equipment has typical unbalanced characteristics. And the temperature at the drive end of the motor bearing is too high. In summary, the analysis of the device has the following problems: 1. The device has an unbalanced amount.2. The motor drive end bearing is worn.
4. Troubleshooting process and result tracking

4.1. Improvement plan
(1) Check the motor bearing for wear. After disassembly, the bearing was found to be severely worn and a new bearing needs to be replaced. After the bearing was replaced, the vibration value dropped to 117μm, the bearing temperature returned to normal, and the vibration condition improved, but it still exceeded the standard value.

(2) Check the dynamic balance of the fan rotor for the imbalance of the equipment. The balance accuracy satisfies the G6.3 standard specified in GB/t9239.1-2006/ISO1940-1:2003 "Mechanical vibration. Constant state (rigid) rotor balance quality requirements Part 1: Specification and balance tolerance test ".

4.2. Dynamic balancing process
On September 6, 2018, the blower was dynamically balanced.

(1) The initial vibration of the fan in the horizontal direction is measured: 117μm, at a phase of 341 degrees.

(2) Perform a dynamic balance test, pre-estimate the lag angle by 30 degrees according to experience, and add a test weight of 300g at the phase of 131 degrees to destroy the original unbalance [3]. The test obtained the test vibration: 85μm, the phase is 340 degrees. After calculation, the influence coefficient of the fan is 0.11, and the phase of the influence coefficient is 33 degrees. It is calculated that the weight of the weight is 795g and the phase is 127 degrees without removing the test weight.

(3) Keep the original test weight and add 795g at the phase of 127 degrees. After the equipment is operated, it vibrates in the horizontal direction by 55μm and the phase is 337 degrees. The vibration displacement value was reduced from 149μm before treatment to 55μm, and the standard value was 80μm or less. The vibration of the equipment was qualified and the dynamic balance treatment was completed.

4.3. Vibration test after dynamic balance treatment
The test horizontal direction is 55μm, vertical 17μm, axial 13μm, in line with equipment operating vibration regulations. After dynamic balance treatment, the horizontal spectrum of the fan end of the bearing box is as shown in Figure 5. Through the dynamic balance treatment, the vibration value is significantly reduced, and the dynamic balance effect is obvious.

![Horizontal spectrum of the bearing box fan end after dynamic balancing.](image)

5. Summary of imbalances
High-speed rotating machinery is greatly affected by materials. Impact, corrosion, wear and coking can cause unbalanced faults on the rotor system of the machine [4]. The rotor imbalance is the main
exciting force that causes the vibration of the rotating equipment to be abnormal [5]. This exciting force cannot be completely eliminated. Solving the vibration problem can start from the exciting force and response, and the on-site dynamic balance is the most direct way to eliminate the exciting force. The rotor dynamic balance processing can only eliminate the 1x frequency (power frequency) amplitude.

In general, an unbalanced rotor exhibits the following characteristics:

1. Unbalanced vibration always shows vibration of twice the frequency of the unbalanced component's rotational speed.
2. 1 Multiplier (power frequency) amplitude has the largest proportion in the spectrum pass frequency value, less accompanying other multipliers, and no other large peaks appear; the amplitude of the first frequency vibration is usually greater than or equal to 80% of the total vibration value [6].
3. When the imbalance is dominant, the 1x frequency axial vibration is lower than the radial vibration (except for the cantilever rotor).
4. 1 Multiplier vibration increases significantly with increasing speed. When the rotor speed is lower than the first critical speed of the rotor, the amplitude of the vibration varies proportionally with the square of the rotational speed [7-8].
5. Unbalanced rotors typically exhibit a stable, repeatable vibrational phase in the radial direction.
6. Resonance can sometimes be greatly affected by imbalance.
7. Unbalance has a great influence on the excessive vibration of rotor. However, in some bearing blocks with low stiffness, although the residual unbalance is very small, there will be a large unbalance vibration.

When the device has the above features, it can be considered that there is an imbalance problem. For example, in this example, through the spectrum analysis of the fan vibration test, there is no obvious high-frequency or low-frequency component in the spectrum. The vibration of the measuring point is dominated by a frequency, the phase is stable, and the vibration value increases rapidly with the increase of the rotational speed. Based on the above characteristics, on the basis of eliminating the vibration caused by other causes, determining the mass imbalance of the fan is the main cause of excessive vibration. After the dynamic balance is correctly implemented according to the test data, the vibration is obviously reduced, the dynamic balance effect is obvious, and the vibration of the fan is restored to an excellent level. During the operation of the power plant, while paying attention to the monitoring of the main engine operation, it should strengthen the monitoring of the auxiliary equipment of the unit, eliminate the hidden dangers of the equipment, avoid the further development of equipment defects, and ensure the safe and stable operation of the unit.

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