Analysis and Treatment of Abnormal Vibration of Unit 2 in a Power Plant

Fei Chen¹,², Hao Cao¹, Bolin Zhang¹,², Jilong Wei¹,²

¹State Grid Hunan Electric Power Corporation Limited Research Institute, Changsha 410007, China
²Hunan Province Key Laboratory of High Efficient & Clean Thermal Power Technology, Changsha, 410007, China

*Corresponding author: chenf14@hn.sgcc.com.cn

Abstract. The Unit 2 in a power plant was first started in 2016 after the flow through transformation, the vibration basically reached the excellent standard in the single valve state with the load running. In the sequence valve state, the high and intermediate pressure rotor occurred obvious steam induced vibration fault at high load. By reducing the main steam pressure properly, the No. 2 regulating valve is in full open state as soon as possible, thus reducing the steam exciting force of the high and intermediate pressure rotor, the vibration fluctuation value of the unit is obviously reduced at high load, and the phenomenon of steam induced vibration is effectively suppressed, and the unit can be safely carried out for a long time.

1. Introduction

Unit 2 of a power plant is the N600-24.2/566/566 supercritical condensing steam turbine generator set produced by Dongfang turbine works. The bearings 1 and 2 of high and intermediate pressure rotor are floor-standing bearings, and the bearings 3 and 4 of low-pressure rotors are seated on the exhaust cylinders. The unit was refurbished in 2016, mainly to replace all the steam seals, replace some of the end steam seals and all balance piston seals with brush seals, and re-adjust the gap. The Unit 2 is equipped with the Philips TSI system. The Φ8mm eddy current displacement sensor is installed in the x and y directions of the 1st to 6th watts to measure the relative vibration of the shaft and the bearing. The velocity sensor installed in the vertical direction of 1st to 6th watts measures the bearing vibration. The Φ8mm eddy current sensor installed in the steam turbine front box is matched with the groove on the short shaft to measure the speed and phase of the unit.

2. Unit overview and vibration characteristics

2.1. Vibration characteristics of unit under load in single valve operation

Through this flow path retrofit, the steam seal of Unit 2 was replaced by a brush seal. According to the first running of other units in the province that replaced the same type of steam seal, the brush seal is easy to cause the rubbing faults of the unit. On August 13, 2016, the Unit 2 was cold-runned for the first time after the flow path retrofit. During the speed-up process, the high and intermediate pressure rotor were actually subjected to rubbing faults. After the sufficient friction at low speed, the high and
intermediate pressure rotor rubbing phenomenon disappeared, and finally the unit smoothly rose to 3000r/min. At 06:58 on August 14, the unit was connected to the grid, with load of 50MW at 07:40, 300MW at 11:32, and 600MW at 19:20. The vibration data of the unit under load are shown in Table 1. The vibration curve under load is shown in Fig. 1. With the passage of time and the increase of load, the vibration of the unit is basically stable, the shaft vibration and the tile vibration of high and intermediate pressure rotor of the unit have reached an excellent level.

![Fig. 1. Vibration characteristics of the high and intermediate pressure rotor of Unit 2 under load](image)

| Load   | Vibration measuring point | No.1 | No.2 |
|--------|---------------------------|------|------|
| 50MW   | X(μm)                     | 49   | 55   |
|        | Y(μm)                     | 56   | 69   |
|        | V(μm)                     | 10   | 2    |
| 300MW  | X(μm)                     | 47   | 34   |
|        | Y(μm)                     | 51   | 46   |
|        | V(μm)                     | 10   | 3    |
| 600MW  | X(μm)                     | 65   | 47   |
|        | Y(μm)                     | 58   | 73   |
|        | V(μm)                     | 15   | 5    |

**TABLE 1. Unit vibration under load**
2.2. Vibration characteristics of unit under load after single valve switching sequence valve

After the stable operation of Unit 2 with load, the single valve of the unit was switched to the sequence valve. It was found that the original relatively stable shaft vibration of 1X and 1Y fluctuated greatly at high load, and the maximum fluctuation could be from 50μm to 91μm. Through spectrum analysis, it was found that under the condition of sequence valve, the shaft vibration 1X and 1Y had a frequency component of 20-26Hz, which was exactly half of the working frequency of 50Hz, and the amplitude of the half frequency component fluctuated between 5μm and 25μm. When the load was between 450MW and 550MW, the half-frequency amplitude was large, and the shaft vibration 1X and 1Y fluctuated greatly at the same time, when the load was lower than 400MW or the load was 600MW, the half-frequency amplitude was small, the shaft vibration 1X and 1Y fluctuation was also small at the same time. The Unit 2 has six high pressure control valves, looking from the turbine head to the generator, the arrangement of the six high pressure control valves is shown in Fig. 2, at this time, the valve sequence is 4-5-6-3-2-1. By observing the opening degree of the control valve, it was found that when the load was high or low, the No.2 control valve was fully open or fully closed, and the shaft vibration of 1X and 1Y fluctuation was small, while when the load was 450MW to 550MW, the No. 2 control valve had partial opening, and the shaft vibration of 1X and 1Y fluctuated greatly. In this valve sequence, the waterfall diagram of the high and intermediate pressure rotor shaft vibration with load changes is shown in Fig. 3. It can be seen from the figure that there are obvious half frequency components in the shaft vibration of bearings 1 and 2 at high load.

![Fig 2. Layout of high-pressure control valves of Unit 2](image)
3. Vibration fault analysis

It can be seen from the above that the shaft vibration of bearing 1 of Unit 2 fluctuates greatly at high load, and there is a large half frequency component at the same time, and the amplitude of vibration fluctuation is related to the opening degree of No. 2 control valve. Therefore, it can be judged that the steam induced vibration fault has occurred in high and intermediate pressure rotor of Unit 2. The so-called steam induced vibration fault is that the uneven steam exciting force acts on the high and intermediate pressure rotor of steam turbines, at the same time, if the bearing stability of the high and intermediate pressure rotor is poor, the high and intermediate pressure rotor will produce large low-frequency vibration (mainly half frequency vibration). The shaft vibration of high and intermediate pressure rotor increases while the fluctuation phenomenon exists [1, 2]. There are three kinds of steam exciting forces acting on the high and intermediate pressure rotor of steam turbine [3, 4]: (1) exciting force due to different tip clearance in circumferential direction; (2) exciting force produced by uneven axial and circumferential flow in steam seal; (3) exciting force caused by asymmetry of inlet steam of nozzle. When the resultant force of the above three steam exciting forces is greater than the damping force of the oil film of the high and intermediate pressure rotor bearings, the vibration will be excited. The mass of high and intermediate pressure rotor of steam turbine is small, and the blades are short, therefore, under the action of small steam exciting force, the high and intermediate pressure rotor will produce obvious steam induced vibration fault. The main measures to eliminate and reduce the steam induced vibration fault of high and intermediate pressure rotor of large steam turbines are as follows: reducing steam exciting force; improving bearing stability.

4. Vibration characteristics of unit after valve sequence change

The main way to improve the stability of bearing during running is to increase the temperature of lubricating oil. After increasing the temperature of lubricating oil of Unit 2, it was found that there was...
little effect on the vibration. Therefore, it was decided to control the opening degree of No. 2 control valve by changing the valve sequence, so as to reduce the steam exciting force on the high and intermediate pressure rotor, so as to reduce the vibration amplitude and fluctuation range of the high and intermediate pressure rotor. At 15:30 on September 6, 2016, the valve sequence of the unit was changed to 4-5-6-3-1-2. Under this valve sequence, the waterfall diagram of shaft vibration of high and intermediate pressure rotor with load changes is shown in Fig. 4. It can be seen from the figure that the vibration has not been significantly improved.

Through analysis, it is found that after changing the valve sequence, when the load is between 450MW and 550MW, the No.2 control valve is fully closed, but the No.1 control valve is only partially open at this time, so there is still obvious steam induced vibration phenomenon. When the load reaches 600MW, the No.1 control valve is fully open, but No.2 control valve is only partially open. Therefore, at full load, the unit still has obvious steam induced vibration phenomenon due to the influence of No.2 control valve.

Then, the valve sequence of the unit was restored. When the load is between 450MW and 550MW, the main steam pressure can be appropriately reduced to make the No.2 control valve fully open as soon as possible, so as to ensure the vibration stability of high and intermediate pressure rotor of the unit at high load. The Unit 2 was shut down at the end of September 2016. During the process of shutdown and load reduction, it was found that the vibration fluctuation value of the unit was significantly reduced at high load, ranging from 50μm to 75μm, and the unit could run stably for a long time.

5. Conclusions
The Unit 2 was started for the first time after the flow path retrofit. When the unit was running with load under the condition of single valve, the vibration of unit basically reached the excellent standard. Under the condition of sequence valve, the shaft vibration of bearing 1 fluctuated greatly at high load, and there

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**Fig 4.** Waterfall diagram of high and intermediate pressure rotor with valve sequence of 4-5-6-3-1-2

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was a large half frequency component. Moreover, the amplitude of vibration fluctuation was related to the opening degree of No. 2 control valve. Therefore, it can be judged that steam induced vibration fault occurred in the high and intermediate pressure rotor of Unit 2. By properly reducing the main steam pressure, the No.2 control valve is fully opened as soon as possible. The vibration fluctuation value of the unit at high load is significantly reduced, and the steam induced vibration phenomenon is effectively suppressed, and the unit can run safely for a long time.

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