Analysis and Treatment of 660 MW Ultra Supercritical Units Vibration

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Abstract. This paper analyses the excessive vibration of the bearing caused by the high-medium pressure rotor bending of the steam turbine, provides a basis for the weighted and balanced bending scheme of the high-medium pressure rotors of the 660MW ultra-supercritical unit and also provides reference for the same type of unit.

1 Introduction

It is often seen in domestic 600MW units that high- and medium-pressure rotors of the steam turbine generators are bent due to improper operation or other reasons, with the main performance of that the vibration is not large during load operation and the vibration exceeds the standard at the critical point even causes abnormal start up during the process of the units starting or stopping, which seriously affects the safe operation of the unit.

At present, there are two common treatment methods for rotor bending failure of large steam turbine generator sets: the first is straight-axis processing, which is to apply a direct-axis load to straighten the rotor; the second is to remove the unbalanced quality caused by bending deformation by cutting processing. These two treatment methods require a long construction period, high costs and have certain risks. Therefore, for a rotor with a small amount of bending deformation, it can be considered to perform on-site weighting to compensate for its unbalanced quality.

2 Unit overview

This unit in model CCLN600-25/600/600, is a super-supercritical, one-stage intermediate reheat, single-shaft, two-cylinder double-exhaust steam and condensing steam turbine jointly manufactured by Harbin Turbine Works Co., Ltd. and Mitsubishi Corporation. The radial bearings of rotor are supported by the tilting-pad bearings which have good alignment performance. The two bearings of the generator use end-cap bearings, and the bearing load is supported by the end caps. The bearings adopt two lower halves of the tilting-pad bearings, which can automatically adjust the load centre and has strong stability and strong ability to resist disturbance from oil film. The shafting structure is shown in Figure 1:

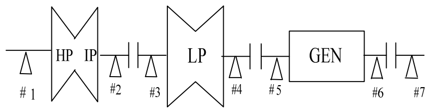

Fig 1 Shafting structure

3 Brief introduction of unit vibration

During the normal load operation of unit, except for the vibration of #1 and #2 bearings exceeding the standard, the vibration of other bearings is below 70μm. The vibration is too large when the unit is over-critical during the start up process. The vibration data is as shown in Table 1. During the maintenance, by measuring the high and medium pressure bending amount, it shows that the maximum bending position was at the second stage of the intermediate pressure cylinder, and the maximum bending amount was 130 μm. Due to the maintenance schedule, the rotor was not returned to the factory.

Table 1 Vibration value of unit start up and over-critical (μm)

Point	3000rpm	1397rpm
1X	101	321
1Y	101	305
2X	117	276
2Y	108	207

After the unit is repaired, the eccentricity of the front plate is 65μm, and the rotation starts at 23:30. According to the previous experience, the vibration protection value is set to 250μm. The unit's over-critical process is due to the 2X vibration exceeding the standard. The vibration value is shown in Table 2. After the speed is reduced to 600 rpm, the rotation is repeated at 23:56, the fixed speed is 1200 rpm, the stability is 25 minutes, the vibration climbs during the constant speed, and the second rush is

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started after the speed of 0:26 is reduced to 600 rpm for 10 minutes. The historical start vibration value adjusts the vibration protection value to 300 µm. When the rotation speed is 1300, the 2X vibration is 370, and the machine is again tripped. The vibration is as shown in Table 3.

When the start up speed drops to 120, the 2 watts temperature suddenly rises from 46 degrees to 76 degrees. After the shutdown, the No. 2 bearing was inspected, the bearing was in good condition. It was initially suspected that the sudden rise of the bearing temperature was related to the oil quality.

The sway is monitored in real time during the start up. When the speed is reduced to 500, the eccentricity is 61µm; the sway is 40µm at 40 rpm; the eccentricity is 40µm at 20 rpm, which is stable at this value. When the vehicle is thrown, after 40S, the eccentricity becomes 31µm. After the minute, the eccentricity was 30 µm, and after 12 s, the eccentricity became 43 µm, and the value remained unchanged at this value.

Table 2 Vibration value of the unit when it is first rushed over critical (µm /µm ∠ phase °)

Point	600rpm	1397rpm
1X	27/11∠337	222/216∠228
1Y	29/11∠69	112/99∠300
2X	21/9∠210	251/243∠209
2Y	22/10∠306	132/128∠296

Table 3 Vibration value of the unit when it is over-critical

(µm / µm ∠ phase °)

Point	600rpm	1397rpm
1X	36/21∠330	299/298∠195
1Y	39/22∠61	184/179∠299
2X	52/39∠143	386/377∠174
2Y	52/41∠241	263/253∠279

4. Vibration monitoring analysis and processing

Through the vibration process of the unit starting process, the unit first rushed through the critical process and then retraced after 600 rpm. When the speed reached 1200 rpm, the vibration climbed and the frequency spectrum was analyzed. The occurrence of rubbing occurred, and the monitoring of the local needle was consistent with the measurement conclusion. According to the conventional operation experience, the unit will be rubbed at low speed. It should be warmed up for a long time until the rubbing component is eliminated. The mill can continue to rush according to this experience. The vibration is climbed due to the impact. For rotors with original bending, the occurrence of rubbing below the critical speed will aggravate the original bending of the rotor, and thus will cause a large increase in vibration when the overshoot is again forced.

In view of the above situation, in order to measure the vibration value of the rotor over-critical, it is determined that the unit will re-run after a long time of cranking, and the vibration value of the previous over-critical is obtained, and the vibration protection of 1, 2 bearing is adjusted to 310 µm. The start-up set 2 sets of start-up plan: 1. After the constant speed of 600 rpm is checked, the vibration is observed at 1200 rpm, and the collision is eliminated by warming up for a long time;2. Due to the large adjustment of the steam seal gap during the overhaul At the same time, the spectral analysis of the last process of the process is small, and it is inferred that there will be no serious impact. Therefore, it is decided to perform a short inspection at a fixed speed of 600 rpm. After the inspection, it is directly rushed to 2000 to prevent the heat caused by the friction of the rotor. The impact of the bend on the original curved stacking, the starting scheme has certain risks, and all necessary precautions need to be taken. After discussion, it was decided to adopt the second scheme. The unit re-runs after nearly 8 hours of cranking. The critical speed is successfully passed, and the vibration data is shown in Table 4.

Table 4 Vibration value of the unit when it is over-critical

(µm /µm ∠ phase °)

Point	600rpm	1411rpm	3000rpm
1X	26/10∠336	220/216∠242	95/87∠338
1Y	28/11∠74	170/168∠323	82/77∠62
2X	24/8∠206	274/272∠230	114/103∠284
2Y	21/10∠295	210/207∠314	96/85∠26

The above collected data were analyzed to determine the high-intermediate-pressure rotor dynamic balance scheme. Due to the actual reason of the field, the rotor intermediate balance hole could not be aggravated. Therefore, only the two-end weighting method could be selected for balance treatment, and finally 870g was weighted at 1, 2 watts. Because the weighting time is longer and the two ends are symmetrically weighted, the weight is increased and then put into the car again. The eccentricity reaches 130µm. Therefore, it is decided to flip 180 for 1.5 hours based on the rotor weighting position, and put it into the car again. After 4 hours of eccentricity, the eccentricity is 47 µm. Then the unit rushed again.

After the unit is aggravated, the vibration is first maintained at 310 µm, and the rotor is over-critical. The vibration of 2 watts is 304 µm. With the speed increase of 3000, the vibration data is shown in Table 5. Based on past experience, it is initially suspected that the two-end weighting has less response to the first-order unbalanced component, and it is decided to adjust the weighting scheme. The unit was then tested for valve tightness. When the rotor deceleration is too critical, the critical amplitude is greatly reduced after the first reversal, and the vibration data is as shown in Table 6. After completing the analysis of the data: 1. The temporary bending of the rotor caused by the weighting period is not fully recovered; 2. The cranking time of the unit is insufficient.

Due to the load regulation requirements of the network, it is temporarily decided not to process the unit again to maintain the current operation. Since the phase has not changed significantly, it is only necessary to look for opportunities to adjust the weighting quality. The unit has no significant change in vibration after 1 and 2 watts. In view of the fact that the over-critical vibration value of the unit is still too large, the following opinions are put forward for the operation of the unit: 1. Maintain the vibration protection value of the unit 1 and 2 watts at 300 µm, and then look for opportunities to carry out the lifting speed over-critical test and observe the critical vibration value, such as Each vibration repeatability is better, the vibration protection value of 1, 2 is adjusted to the specified 250; 2, for the rotor is bent, the vibration of the cold state of the rotor and the thermal state of the hot state are very different, each comparison before the reversal The rotor is eccentric when it stops, ensuring that the eccentricity can be reversed before returning to start up.

Table 5 Vibration value after the unit is aggravated and over-critical (µm /µm ∠ phase °)

Point	1411rpm	3000rpm
1X	,267/261∠248	76/69∠353
1Y	167/165∠323	69/61∠85
2X	304/300∠232	112/109∠284
2Y	187/186∠314	103/96∠35

Table 6 Vibration value at critical time after unit valve tightness test (µm /µm ∠ phase °)

Point	Critical at speed reduction	Critical at speed increase	Speed 3000
1X	,197/189∠226	164/161∠238	76/72∠324
1Y	168/158∠347	136/132∠317	72/66∠57
2X	224/219∠225	206/204∠222	101/92∠302
2Y	179/172∠348	154/151∠314	89/81∠39

5 Conclusion

The bending of the high and medium pressure rotor of the unit leads to the need to increase the vibration protection value to overshoot the critical value every time the engine is over-critical. The rotor over-critical vibration value is adjusted to the specified protection value by dynamic balance. Due to the actual situation on the spot, the dynamic balance can only be selected by adding the weighted response to the smaller symmetrical weighting method, and the intermediate intermediate response can be compared in detail. At the same time, this paper expounds that the overview of the bending rotor before and after the reversal provides a reference for the on-site dynamic balance and unit operation of similar faults.

5 References

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