

Research on Fault Analysis Technology of Hydraulic Generator Set

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Abstract: The thrust of the hydropower plant and the temperature measurement resistance of each guide bearing tile are important sensors in the hydropower plant, and the operation of the temperature measurement resistance directly affects the safe operation of the generator set. In this paper, aiming at the problems of wire breaking and the measured value reaching the maximum in the operation of the temperature measuring resistance in Liujiaxia Hydropower Plant, the faults are solved by improving the temperature measuring resistance, standardizing the installation and wiring of the temperature measuring resistance, improving the outlet device of the oil tank, and adopting redundant configuration at the important monitoring points, which provides experience for dealing with similar faults.

1. Introduction

Unit 1-4 of Liujiaxia Hydropower Plant is a suspended hydrogenerator set. The axial force and radial force of thrust, upper guide and water guide bearings support the operation of the unit. The bearing temperature is an important means to monitor the running status of the unit. If the temperature is connected to the unit protection, if the temperature is too high, it will alarm or stop, the importance is self-evident. However, during the operation of the unit, especially during the period operation of the leader of the large generator in the flood season, the temperature measurement resistance of each bearing bush has some problems, such as false alarm, jump and no reading. It is difficult to judge whether it is the problem of the unit itself or the temperature measurement resistance, which brings hidden trouble to the safe operation of the unit.

2. Brief introduction of temperature Measurement system of Water Turbine Unit

In industrial applications, there are two principles of temperature measurement: thermocouple and thermal resistance. The thermal resistance is based on the thermal effect of the resistance for temperature measurement, that is, the resistance value of the resistance varies with the temperature. Therefore, as long as the change of the resistance value of the temperature-sensing thermal resistance is measured, the temperature can be measured. At present, the most widely used metal thermal resistance materials are platinum and copper, and the commonly used indexing numbers are Pt100 and Cu50 [1]. Pt100 temperature measuring resistance is used in the bearing part of Liujiaxia Hydropower Plant.

The temperature measurement resistance is installed in the production site, and there is a certain distance between the temperature measurement resistance and the control cabinet. The resistance signal is transmitted to the computer acquisition module through the lead wire. The commonly used signal connection methods are two-wire system, three-wire system and four-wire system. Because the bearing bush temperature of Liujiaxia Hydropower Station directly acts on signaling and tripping after exceeding the fixed value, there are higher requirements for temperature measurement accuracy, in order to minimize the influence of cable resistance imbalance on the measurement results, therefore, the bearing bush temperature measurement adopts three-wire connection mode [2].

3. Existing problems

After the statistical data (see Table 1), it is found that there are some main problems in the operation of temperature measurement resistance, such as frequent jump of measured value, short circuit of temperature measuring element, resistance value of 0Ω , open circuit of temperature measuring element, resistance value of ∞ , big deviation between display value and actual measured value, and so on.

Table 1. Statistical table of defects in temperature measurement system from April to November

| Defective project | Frequency / times | | | | | | | | Cumulative frequency / times | Cumulative rate /% |
|-------------------------|-------------------|-----|------|------|--------|-----------|---------|----------|------------------------------|--------------------|
| | April | May | June | July | August | September | October | November | | |
| Measured value jump | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 5 | 55.6 |
| Component short circuit | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 11.1 |
| Component open circuit | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 22.2 |
| Display deviation | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 11.1 |
| Total | 1 | 0 | 1 | 4 | 1 | 1 | 1 | 0 | 9 | 100 |

4. An empirical Analysis of the causes of failure

4.1 It takes a long time to run and is not easy to maintain.

The thrust and temperature measuring resistors of each guide bearing tile are installed in a place where the space is narrow and unsuitable for maintenance and replacement. during the operation of the unit, the sensors and some wires are soaked in the turbine oil with higher temperature for a long time, and bear the impact of oil flow and the vibration of the unit at all times. therefore, the mechanical damage is more serious. Because the bearing position temperature measuring element usually has the opportunity to check and maintain when the unit is decomposed at the level An overhaul. In peacetime, if you need to deal with the faulty components, you need to apply for unplanned shutdown of the unit, and carry out a series of work, such as oil discharge, removal of spring fuel tank, tile pulling and so on, which is long and difficult. Therefore, when the temperature measurement resistance jumps or breaks in the normal operation, it is usually unable to deal with it in time, and the fault point needs to be temporarily withdrawn from operation. The bearing temperature is an important parameter of the unit operation, the long-term lack of bearing part of the measuring point temperature, will make the operator can not timely and accurately judge the operation of the unit, and directly endanger the safe and stable operation of the equipment.

4.2 The problem of temperature measuring resistance itself

As the temperature measuring element installed on the bearing bush has been subjected to continuous vibration during operation, there is no spring in the fixed part to cushion the impact of vibration on the element.



Figure 1. The root of the sensor is disconnected.



Figure 2. The root of the sensor is disconnected.

The oil resistance, corrosion resistance and heat resistance of the temperature wire are relatively poor; in the oil-immersed environment for a long time, it is easy to harden, brittle, skin cracking and other phenomena, shortening its service life; long-term vibration will cause the wire to be disconnected at the root of the sensor (see figure 1, figure 2). After on-site inspection, it is found that the fault of root broken line accounts for almost 50% of the total number of temperature measurement resistance faults.

4.3 The problem of temperature measuring resistance itself

The short outlet of the temperature measuring resistance results in more transfer points in the oil tank, each transfer point has to be welded, the position in the oil tank is narrow, the welding operation is inconvenient, and it is easy to appear virtual welding, de-welding and other phenomena, which leads to the disconnection of the solder joint after the temperature measuring element is impacted by vibration and oil flow in operation. For example, taking the No. 4 unit of Liujiaxia Hydropower Plant as an example, the transfer of thrust and temperature measurement resistance wire in the upper guide tank adopts screw transfer, and the temperature measurement element lead wire and temperature measurement cable wire are fixed on the epoxy plate through nuts to achieve the purpose of transfer. However, during the overhaul and decomposition of the unit, it is found that the connecting terminal of the epoxy plate is easy to loosen and oxidize, resulting in poor contact and temperature jump.

The wire is fixed and tied with plastic bandage, which is easy to hurt the outer skin of the wire. The fixed wire card in the oil tank is made of thin iron sheet, and its edge is more sharp. If the outer skin of the wire is not wrapped in the protective layer, it is easy to be damaged by the sharp part and retain the hidden danger. Some wiring is not secure in the oil tank, and the temperature measurement line is broken at the joint caused by oil flow and surge during the operation of the unit, as shown in figure 3.

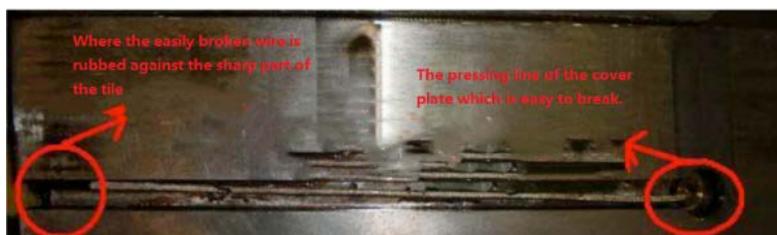


Figure 3. The temperature measurement lead is worn out.

5. Improvement measures

5.1 Improve the temperature measuring resistance

A special spring is installed in the fixed part of the element, to cushion the influence of the vibration of the unit on the temperature measuring element; to select the outer insulation material with excellent oil resistance, corrosion resistance and heat resistance for the temperature measurement lead to prolong the service life of the wire; use the temperature measuring wire with dense mesh shield to reduce the interference of strong magnetic field to the temperature measuring element.

5.2 Improve the temperature measuring resistance

During the normal operation of the unit, once the temperature measuring element is damaged, it is very difficult to replace. In order to improve the operation reliability, double-branch temperature measuring resistors should be used in important parts such as thrust and guide bearings as far as possible. That is, two thermal resistors with the same indexing number and the same precision are arranged in the same sheath to measure the temperature at the same point. The lead wire of the temperature measuring element should use a six-wire system to eliminate the influence of the imbalance of lead resistance on the measurement results. The use of double-branch temperature measuring resistance can lead to two measuring points in the same position, and the leads of the two measuring points are led to the terminal box on the outer wall of the oil basin. Under normal circumstances, one is in operation and the other is used as a backup. When the component fails, the external cable can only be connected to the spare component at the terminal box, which reduces the hidden danger that the equipment can not be replaced after a single resistance is damaged.

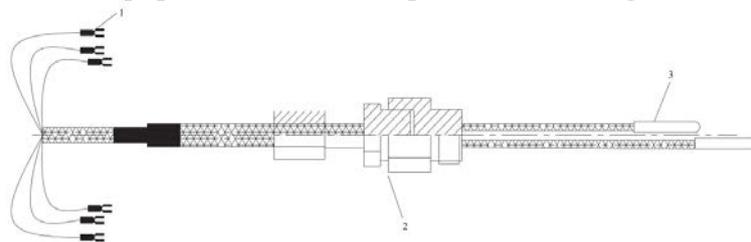


Figure 4. Schematic diagram of double-branch temperature measurement resistance structure

6. Conclusion

This paper analyzes the causes of the problems such as the broken wire and the instantaneous maximum of the measured value during the operation of the temperature measuring resistance in the hydropower plant, and puts forward the following improvement measures:

- (1) improve the temperature measurement resistance.
- (2) standardize the installation and wiring of temperature measuring resistors.
- (3) improve the outlet device of oil tank.
- (4) redundant configuration is adopted in important monitoring points.

According to the above method, the temperature measurement resistance of the bearing part of unit 1 to 4 of Liujiaxia Hydropower Plant has been gradually reformed. The operation shows that the improved temperature measurement resistance can operate safely, reliably and stably during the A-level maintenance period once every five years. It avoids the downtime and maintenance caused by false alarm and damage of components. The practice shows that the method is operable and can be well applied in the field. It can be used as a reference for the transformation of other temperature measuring resistors in Yun hydropower stations and the selection and installation of temperature measuring resistors in new hydropower stations.

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