Analysis on Abnormal Problems of Steam Turbine of Shandong Power Plant in 2019

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Abstract. The completion of steam turbine main operation indexes of Shandong power plant in 2019 is analyzed. The technical transformation of steam turbine energy saving and the problems found in the technical supervision and inspection are also introduced. Then the main problems in the safety and economy of the steam turbine profession are pointed out, and the next key work for these problems is proposed.

1. Introduction

By the end of March 2020, the installed capacity of direct regulating units in Shandong Province is 69.825 million kW. In addition to two nuclear power units and four pumped storage units, the main units are thermal power units, including 10 million kW units. The health status of steam turbine and its auxiliary equipment is related to the stable, safe and economic operation of the unit. Through the professional technical supervision and inspection of steam turbine and the supervision, inspection and exchange during the summer peak period, the main operation data of each unit are counted and analyzed, and the technical supervision report of steam turbine of each power plant is summarized and sorted out. The main problems of steam turbine and auxiliary equipment in 2019 are summarized and analyzed for the convenience of electricity supply the plant shall formulate preventive measures in advance to avoid the recurrence of similar events in the plant and improve the operation stability of the unit.

2. Completion of Main Operating Index of Steam Turbine

According to the requirements of supervision regulations, each power plant shall submit the monthly report of turbine technical supervision to Shandong electric power technical supervision office every month, including main operation data, maintenance, abnormal analysis and treatment, regular test, technical transformation, etc. The steam turbine specialist of Shandong Electric Power Technical Supervision Office sorted out, counted and analyzed the main operating statistics of steam turbines and their auxiliary equipment within the scope of supervision of the province. The completion of main operating indicators in 2019 and the changes in the last three years are shown in Table 1.
Table 1. Main Technical Index In 2017 ~ 2019.

| Name                                      | Target value | 2017   | 2018   | 2019   |
|-------------------------------------------|--------------|--------|--------|--------|
| Rate of rubber ball cleaning device (%)   | ≥95          | 99.91  | 99.90  | 99.93  |
| Recovery rate of rubber ball (%)          | ≥95          | 96.56  | 96.47  | 96.52  |
| Input rate of high pressure heater (%)    | ≥98          | 99.85  | 99.91  | 99.95  |
| Condenser vacuum (kPa)                    | ≥93          | 94.41  | 94.36  | 94.45  |
| Vacuum tightness (kPa/min)                | ≤0.27        | 0.149  | 0.143  | 0.143  |
| Condenser terminal difference (%)         | ≤8           | 4.08   | 4.12   | 4.09   |

It can be seen from Table 1 that the completion of various statistical indicators in 2019 is good, the overall level is the same as that in 2018, and the target value has been achieved. The vacuum of the condenser is 94.45kPa, which is an increase of 0.09kPa from 2018. In recent years, more and more units have been retrofitted with high back pressure. During heating in winter, high back pressure operation has a great impact on the statistical value of condenser vacuum. In order to eliminate the influence of high back pressure operation on vacuum statistics during this period, no statistics on vacuum of this part of units is conducted during heating period, so the statistical data is higher than that in 2018 as a whole.

3. Main problems of steam turbine specialty

3.1. Periodic tests were not conducted

The "Twenty five key requirements for the prevention of power production accidents" (Guoneng safety [2014] No. 161) clearly stipulates that the main steam valve and control valve of steam turbine shall be subject to valve activity test and valve tightness test on a regular basis. In case of any abnormality, it shall be handled in time to prevent the steam turbine from running with fault and hidden danger of overspeed. However, the supervision and inspection found that there are still some power plants that do not regularly carry out valve activity test or valve tightness test according to the specified requirements, or some units have carried out corresponding tests but the test results are not qualified, there are problems such as valve jamming, valve tightness unqualified, etc., and the unit running with fault has serious hidden danger of turbine overspeed.

It was found that there were no full stroke activity test records of main steam valve and control valve for several units. According to "technical supervision guide for steam turbine and turbine of power plant" (DL/T 1055-2007) and "Technical supervision of steam turbine operation regulation system"(DL/T 338-2010), the full stroke activity test shall be conducted regularly for the main steam valve and control valve of steam turbine.

Some units have valve jam problems and still run sick. For example, in a factory #9 machine #2 high pressure main valve has the phenomenon of jam, in the valve activity test, its opening to 93% jam, after a few hours or 1~2 days after the full opening. The plant has cooperated with the manufacturer to conduct a preliminary analysis of the reasons for the jamming of the main valve and formulate operational measures. The next step will be to use the maintenance opportunity for disassembly treatment to eliminate potential safety hazards. There is a jam problem in the #8 unit of a certain plant. Preliminary analysis shows that there is scaling phenomenon in the middle gate, resulting in the change of clearance, which is the main reason leading to the jam of the valve. It is planned to eliminate oxide scale and adjust the clearance between valve stem and disc to the standard range.

Some units did not perform the valve tightness test or failed the valve tightness test. For example, a factory #6 unit #2 high-profile door was dismantled and repaired in the first half of 2019, but the tightness test was not carried out. The main steam valve tightness test of No.1 unit in a factory was not qualified, and the tightness test of control valve was not conducted. According to the shutdown process records, the idling time was 169 minutes, which was significantly longer than that of the main steam valve, which was closely related to the unqualified tightness of the main steam valve. The a tightness test of #1 unit of a certain plant is not qualified. The main reason is that the joint surface of individual
control valve is unqualified during repair a, and there are foreign matters in the joint surface of individual control valve and valve seat during the test [1].

3.2. Abnormal vibration of steam turbine
The vibration of most units is good, but there are still many units whose vibration is too large or even exceed the alarm value. Some units have already affected the normal load adjustment of the units. The power plant analyzes and handles as soon as possible to prevent major accidents.

For example, the vibration of No.1 shaft of No.6 machine in a factory is unstable, the high value of 1x can reach 160 μm, the high value of 1y can reach 180 μm, and the alarm value exceeds 127 μm. It is suggested to strengthen the operation monitoring and reduce the load to suppress the vibration when the vibration trend is obvious. In order to increase the stability, it is suggested to raise the elevation of #1 tile by 100 μm-150 μm during maintenance, and enlarge the oil baffle gap by 150 μm-200 μm on the existing basis. If the vibration fluctuation still exists, the shaft seal clearance should be further enlarged in the next overhaul. When the sequence valve of #1 unit of a power plant is running, the vibration of #1 shaft is too large, the maximum value is 130 μm, exceeding the alarm value of 125 μm. It is suggested to optimize the valve sequence of steam turbine to reduce the influence of steam flow disturbance on vibration by changing the opening sequence of high pressure governing valve.

3.3. Non-standard installation position of accident discharge valve
The installation of the emergency relief valve of the turbine lubricating oil system of several units was not standardized. It was found that the installation position of the emergency relief valve of the main engine lubricating oil system basically met the requirements of 5 meters away from the main oil tank. However, some emergency relief valves were installed in the pit outside the plant and covered with a cover plate, so the relevant marks of the valve could not be seen, and the operation was not convenient, which did not meet the requirements of countermeasures. There are also some units installed in a small space, which does not meet the requirements of "there are more than two channels"; there is no obvious signboard hanging and other problems are more common. In addition, there are some problems, such as the vertical installation of the emergency oil drain valve and the small diameter of the accident oil discharge pipeline. For example, the emergency relief valve of turbine lubricating oil in a power plant is placed in the fence of main transformer field, and the entrance of fence is locked, which is not easy to operate in case of accident. It is also found that the emergency relief valve of turbine lubricating oil of a unit is located in the fence of the accident oil pool and has been locked, the channel is blocked, and the oil drain valve of main oil tank is located below the ground, which is not easy to operate.

The "Twenty five key requirements for the prevention of power production accidents" (Guoneng safety [2014] No. 161) clearly stipulates that the emergency oil drain valve shall be equipped with two steel stop valves in series. The operation hand wheel shall be set at a place 5 m away from the oil tank with more than two channels. The operation hand wheel is not allowed to be locked and shall be hung with an obvious "no operation" sign. Rectification shall be carried out according to the above provisions.

3.4. No overspeed test
Some units did not carry out the mechanical overspeed test according to the specified requirements after the overhaul, for example, the mechanical overspeed test was not conducted for unit 1 and unit 2 of a certain plant; the specified cycle of valve activity test was once a week, and the actual test cycle was half a month. Some units have been tested for overspeed, but the operating speed of the emergency protector is not within the range of 109% - 111% of the rated speed.

There are clear requirements in the "Twenty-Five Key Requirements for the Prevention of Power Accidents", and it is strongly recommended that units with the above-mentioned defects should take preventive measures as soon as possible, and shut down when necessary to prevent overspeed incidents.
3.5. Lack of depth load capacity
After the separation of power plant and power grid, it is more and more difficult to control the network related equipment and operation performance of power generation enterprises. Due to the joint influence of new energy, new external power and heating units, the grid has higher and higher requirements for flexibility adjustment of generating units. The grid related performance of units does not meet the requirements of safety standards, which seriously affects the security and stability of the system. Therefore, technical supervision units and power generation enterprises should increase the control of power generation units in order to meet the requirements of power grid, the research on the flexible regulation and monitoring technology of generator set is carried out.

3.6. Aging of unit equipment
At present, the units put into production in the 1990s have entered the aging stage. Although most units have undergone the transformation of the main engine and auxiliary equipment, the pipes, valves, pressure and temperature measurement points in the system have not been replaced or modified accordingly. If the metal supervision is not carried out strictly or daily supervision is not in place, there will be the following hidden dangers: EH oil pipe rupture, pipeline and valve crack, high temperature and high pressure pipeline temperature measurement spot welding joint cracking.

Supervision and inspection found that there are many units non-stop due to the above reasons, resulting in great losses, profound lessons need to be paid attention to, the life assessment of old units has been put on the agenda.

3.7. Unqualified vacuum tightness
The vacuum tightness of most units is basically within the qualified level, and the vacuum drop speed is less than 270Pa/min, but there are still many units that fail to reach the qualified level. The vacuum tightness has different influence on the condenser vacuum, condensate subcooling degree and condenser end difference, and increasing auxiliary power is one of the key work of energy saving management [2].

For the unit with better vacuum tightness, in the cool season, two units are combined with one vacuum extraction device, which has obvious power saving effect. For units with poor vacuum tightness, two or even three vacuum pumps need to be opened, which greatly increases the auxiliary power supply, and the condenser vacuum is not very ideal. At present, some power plants have added refrigeration devices to vacuum pumps, which can increase the output of vacuum pumps when the cooling water temperature is high in summer. However, for units with good vacuum tightness, the impact of vacuum tightness on condenser vacuum has been very small. It is suggested to consider other ways when carrying out energy-saving transformation [3].

3.8. Unit valve internal leakage
Although all power plants attach great importance to the valve internal leakage control work, the valve internal leakage problem is still relatively common, especially the unit high and low pressure bypass valve, high pressure heater emergency drainage control valve, feed pump minimum flow valve and other parts of the leakage phenomenon is serious, put forward rectification suggestions. For example, the shaft temperature rise of #1 and #3 units in a certain factory exceeds 7℃, which is much higher than the design value. The main reason is that the steam leakage of the shaft seal is too large, which leads to the high temperature rise of the shaft heater. It is suggested to check the steam leakage of the shaft seal and reduce the steam leakage of the shaft seal [4].

It is suggested that each factory should establish a special valve internal leakage management account, timely grasp the valve internal leakage situation, and carry out treatment in a planned and step-by-step manner. At the same time, it is necessary to strengthen the communication and exchange between the plants, especially in the aspects of valve selection, maintenance, operation and monitoring to learn from each other and improve together.
4. Conclusion
Do a solid job in the province's electric power technical supervision work, fully guarantee the safe and economic operation of power generation equipment, further analyze the problems affecting the safe and stable operation of electric power, improve the supervision professional system, guide and standardize the technical supervision work, and realize the dynamic and standardized technical supervision.

Deepen energy conservation supervision and improve the energy saving detection means and methods, enhance the level of energy conservation supervision and continue to conduct detailed test verification of renewable energy, and the new unit and reforming unit capacity verification work, completes the verification test of energy consumption and the related preparation work.

To strengthen the construction of scientific research ability, enhance the level of production, scientific research equipment to support and promote the optimal allocation of resources, open sharing. Retrofitting flexibility for thermal power units and depth of peak shaving capability evaluation of technical research, technical progress tracking peak shaving, for new energy sources to accept technical reserves.

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