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OPTIMIZATION OF THE PROTECTION INTERLOCKING FUNCTION OF A 56 MW UNIT STEAM TURBINE

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Abstract

There are 2 x 56MW units in Kendari power plant, each unit is equipped with two 100% capacity electric feed pumps, one running and another one backup. During the operation of the unit, two defects, such as large vibration of the BFWP and high temperature of the thrust pad on the working face, were found to affect the operation. The large vibration of the BFWP is mainly due to the falling off of the positioning pin of the bearing bracket of the non-drive end, which causes the center to sink, and the balance drum and the balance sleeve are rubbed dynamically and statically. The main reason for the high temperature of the thrust pad of the BFWP is that the diameter of the balance drum is small, which leads to an increase in the axial thrust borne by the thrust pad of the working face, and the high temperature of the tile. This study aims to diagnose the root causes of these defects, implement corrective measures, and optimize pump performance to enhance operational safety. A combination of on-site inspections, data analysis, and engineering interventions was conducted. Findings indicate that structural realignment and reengineering of the balance drum significantly mitigated vibration and temperature issues. The study concludes that proactive maintenance and design optimization are essential for the reliable operation of power plant equipment, with implications for enhancing long-term efficiency and safety.

Keywords: feed water pump, vibration, thrust pad

Introduction

Datang Indonesia Kendari Power Generation Company has 2*56MW units and was put into operation in October 2019. The main engine is a high-temperature and high-pressure steam turbine with a rated power of 56MW produced by Dongfang Electric Corporation. The lubricating oil system uses 2 AC oil pumps and 1 DC lubricating oil pump, with one AC oil pump in use and one in reserve. After Datang Group took over the power plant, it organized personnel to investigate the hidden dangers that affect the safety of the main engine. The main hidden dangers investigated are that the temperature of the turbine bearing and the temperature of the thrust bearing are both single-point protection, and there is no rate judgment. The turbine vibration protection is a single-point protection, and the turbine is not reasonably configured to prevent oil outage and burning of bearings (Karikari-Boateng, 2016). The power plant uses the opportunity of unit maintenance to optimize them one by one (Basu & Debnath, 2014; Sarkar, 2015; Yunus & Michael, 2002).

Following the takeover by Datang Group, the company conducted extensive investigations into potential operational hazards affecting the main engine's safety. Key concerns included turbine bearing temperatures, thrust bearing temperatures, and

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inadequate multi-point protection mechanisms for vibration monitoring and oil supply failures (Kotzalas & Doll, 2010; Liu & Zhang, 2020; Ma et al., n.d.; Ryu & San Andrés, 2013). The lack of comprehensive protection posed a significant risk of bearing damage and turbine failure (Cotton et al., 2001; Hart et al., 2020; Singh & Sundaram, 2022).

To address these vulnerabilities, Datang Group leveraged unit maintenance periods to systematically optimize and enhance the power plant's reliability and safety. A critical focus was placed on the operational stability of the feed water pump (BFWP), essential for maintaining boiler efficiency and preventing overheating (Javed, 2022a; Sabia et al., 2019; Yang & Tang, 2011). Two primary issues emerged: excessive vibration in the BFWP and abnormal heating of the thrust pad. This study explores the root causes, corrective measures, and performance optimization strategies to address these challenges.

Research Methods

The research method was conducted through a series of approaches that included operational data collection from the generating unit, field inspection of the feedwater pump (BFWP) (Javed, 2022b), and in-depth analysis using Root Cause Analysis (RCA) techniques. Direct observations were made on operational parameters such as vibration levels and thrust bearing temperatures, along with historical data collection from operational logs to identify anomalous patterns. Fishbone diagram and fault tree analysis techniques were applied to determine the main causes of excessive vibration and high temperature. In addition, technical interventions were carried out through component alignment correction, replacement of loose positioning pins, and re-engineering of the balance drum to reduce the axial thrust force. Effectiveness evaluation was conducted after solution implementation through retesting and continuous monitoring to ensure long-term pump operation stability and reliability.

Results and Discussion

Turbine protection optimization content

1) Turbine tile temperature protection

The steam turbine of Kendari Power Generation Company has 4 bearings, each bearing has a thermal resistor for measuring bearing temperature. There are 8 bearing temperature elements for the working face thrust bearing and 2 bearing temperature elements for the non-working face bearing. All of the above temperatures are tripping steam turbines when any point is higher than 100 degrees, single point protection and no rate judgment.

Because the feasibility of adding temperature measurement points is very low, in order to eliminate refusal to operate and reduce false operation, the temperature protection increases the rate and delay. According to relevant regulations and the practical experience of Datang Group's brother power plants, the rate of the thermal resistance of the turbine bearing is set to greater than 5 degrees Celsius/second to shield the protection output, and the delay is set to 2 seconds. Therefore, the final protection setting is: when the temperature of the turbine support bearing is higher than 100 degrees Celsius and the rate of change is less than 5 degrees Celsius/second, the delay is 2 seconds to adjust the trip; when the temperature of the support bearing is higher than 100 degrees Celsius and the rate of change is less than 5 degrees Celsius/second, the delay is 2 seconds to trip, both of which are single-point protection.

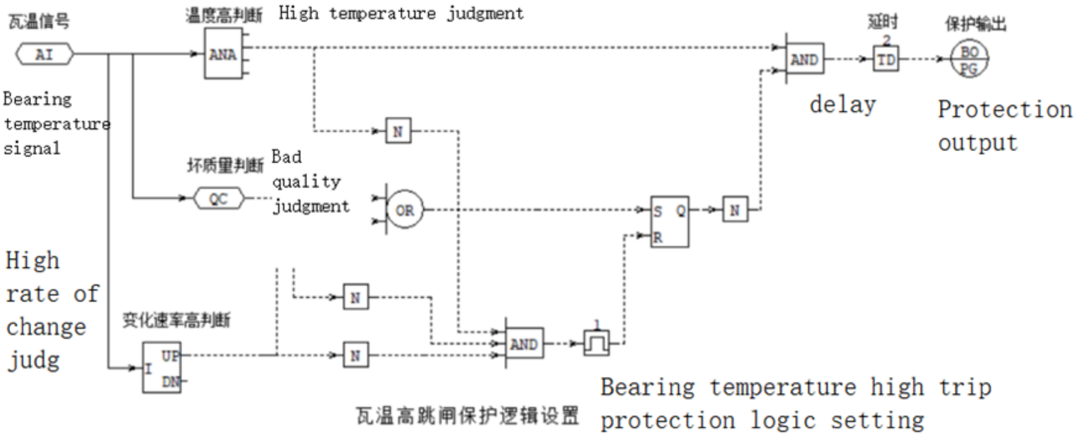


Figure 1. Logic Diagram Turbine Generator Bearing High Temperature Trip

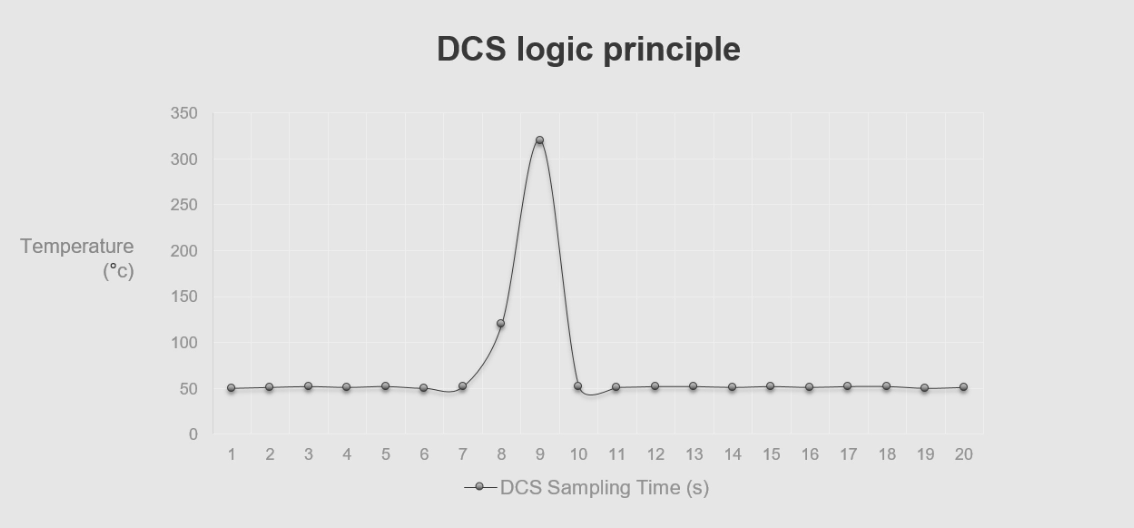


Figure 2. Bearing Temperature False Alarm Trend

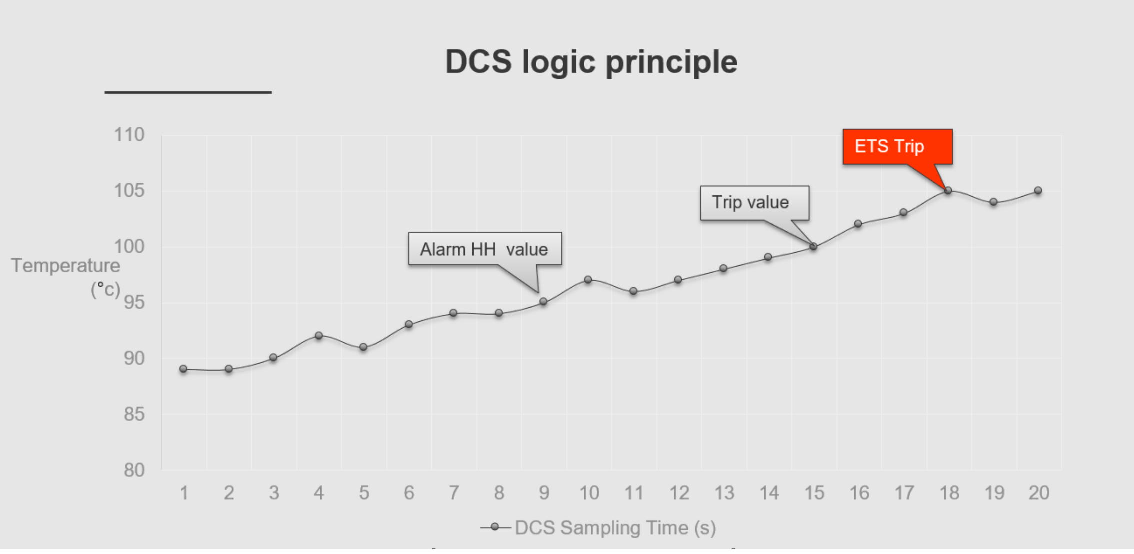


Figure 3. Bearing Temperature Real Alarm

2) Steam turbine vibration protection

The steam turbine of Kendari Power Generation Company has a total of 4 bearings, each of which has 2 shaft vibration measurement points. The original protection method was to trip the steam turbine if any vibration signal reached the tripping value, which did not meet the group company's configuration requirements for vibration protection.

Kendari Power Generation Company has made the following optimization: any vibration higher than the second value (trip value) and any other vibration higher than the first value (alarm value) will trip the turbine.

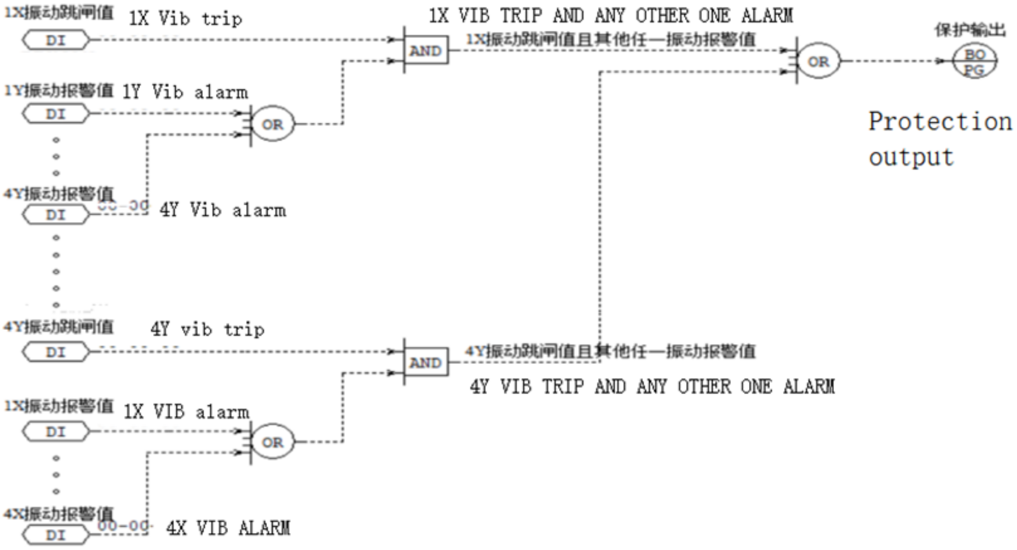


Figure 4. Logic Diagram Vibration Alarm & Trip

3) Optimization of steam turbine to prevent oil shortage and tile burning

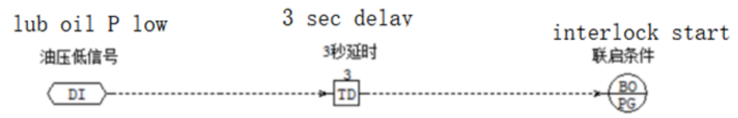
The steam turbine lubricating oil system of Kendari Power Generation Company is equipped with one AC oil pump in operation and one in reserve, and the DC oil pump is used as an emergency standby pump.

a. The original logic of joint start of AC oil pump of turbine A (B) is as follows:

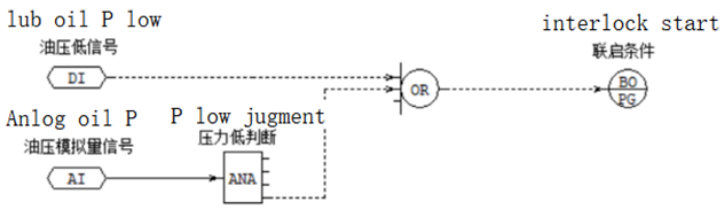
1) When the lubricating oil pressure is low (pressure switch), the oil pump will be started after a delay of 3 seconds.

The following optimizations are performed:

1) Cancel the delay condition of 3 seconds to start the oil pump when the lubricating oil pressure is low (pressure switch), and change it to a delay-free start;
2) Increase the low lubricating oil pressure (analog value) and start the oil pump.



A（B）交流油泵原联启条件
A (B) AC oil pump original interlock start condition

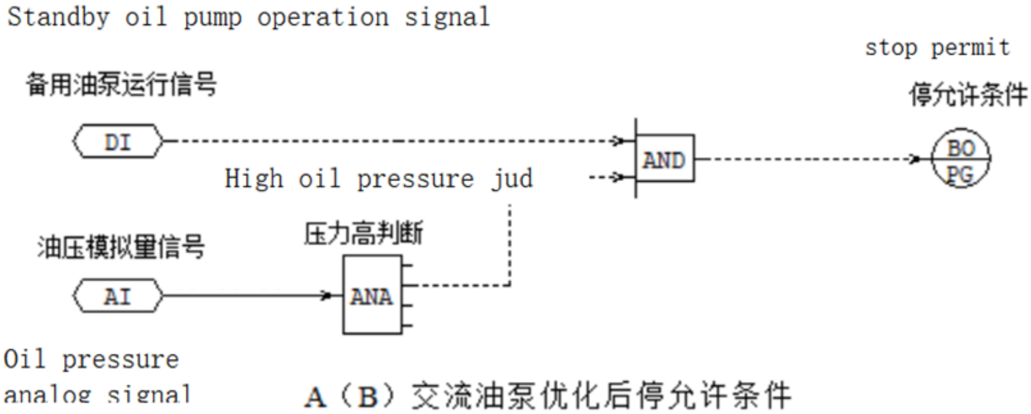


A（B）交流油泵优化后联启条件
A(B)AC oil pump new interlock start condition

Figure 5. Modification Logic Diagram for Interlocking AC Oil Pump

b. The original logic of the AC oil pump stop permission of turbine A (B) has no locking conditions:

The stop permission condition adds the condition that the standby AC oil pump has been started and the oil pressure is normal.



A（B）交流油泵优化后停允许条件
The AC pump is optimized to allow stop conditions

Figure 6. Logic Diagram AC Lube Pump Stop Permission

c. The original logic of turbine DC oil pump joint start is as follows:

1) When the lubricating oil pressure is low (pressure switch), the oil pump will be started after a delay of 3 seconds;
2) Stop both AC oil pumps and restart them after a delay of 3 seconds.

The following optimizations are performed:

1) Cancel the 3-second delay of the oil pump when the lubricating oil pressure is low (pressure switch) and change it to a delay-free start;
2) Increase the lubricating oil pressure (analog value) and start the oil pump;
3) Both AC oil pumps are stopped, the 3-second delay condition is cancelled, and they are started directly in conjunction with each other.

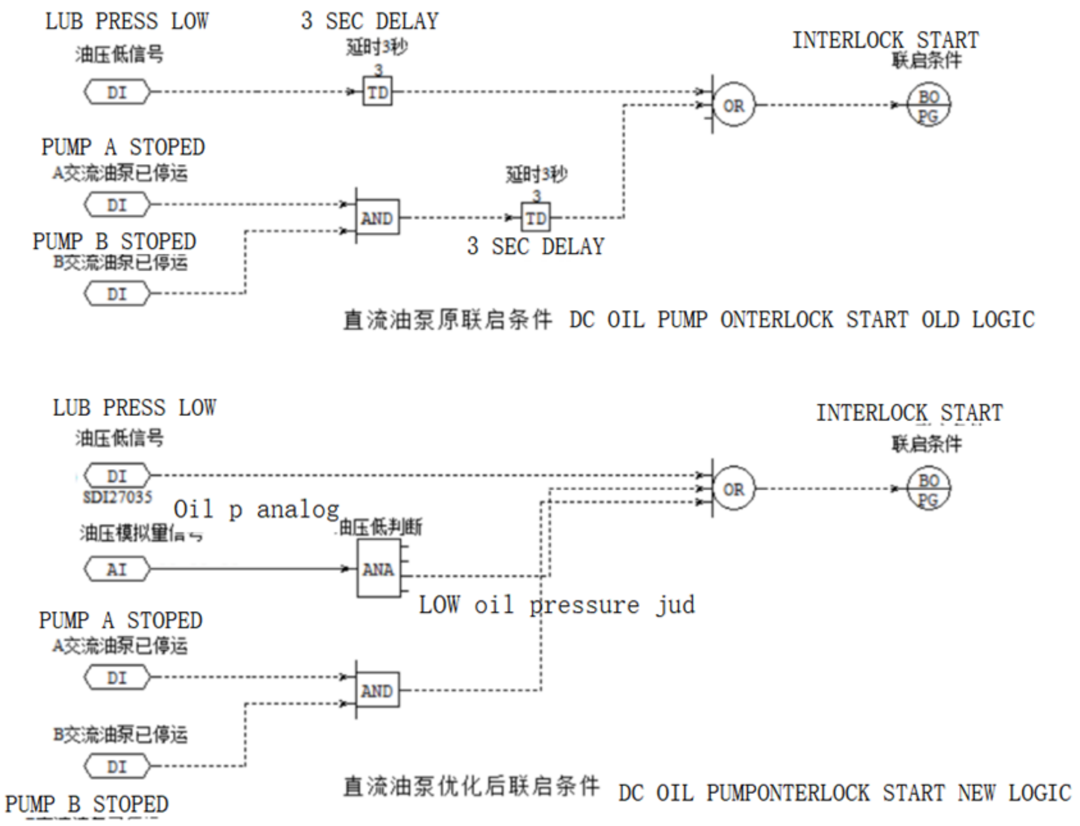


Figure 7. Diagram Logic Modification DC Lube Oil Pump

d. Adding joint start conditions to the DC lubricating oil pump hard wiring :

The DC lubricating oil pump increases the hard-wired circuit of the lubricating oil pressure (pressure switch) to the local control cabinet to start the relay coil, ensuring that when the lubricating oil pressure is low and there is a problem with the DCS system, the DC lubricating oil pump can be interlocked and started in time to protect the safety of the equipment through the local control circuit.

Conclusion

Through the transformation, the reliability of turbine support bearing temperature and turbine vibration protection was improved, protection refusal to operate was eliminated, false operation was reduced, and the optimized protection measures for turbine to prevent oil outage and bearing burning were improved, providing reliable protection for the safety of turbine equipment.

BIBLIOGRAPHY

Basu, S., & Debnath, A. K. (2014). *Power plant instrumentation and control handbook: a guide to thermal power plants*. Academic Press.

Cotton, I., Jenkins, N., & Pandiaraj, K. (2001). Lightning protection for wind turbine blades and bearings. *Wind Energy: An International Journal for Progress and Applications in Wind Power Conversion Technology*, *4*(1), 23–37.

Hart, E., Clarke, B., Nicholas, G., Kazemi Amiri, A., Stirling, J., Carroll, J., Dwyer-Joyce, R., McDonald, A., & Long, H. (2020). A review of wind turbine main bearings: design, operation, modelling, damage mechanisms and fault detection. *Wind Energy Science*, *5*(1), 105–124.

Javed, K. (2022a). Boiler feed water pumps: techniques for improvement in design and balance of the drum. *Natural and Applied Sciences International Journal (NASIJ)*, *3*(2), 15–29.

Javed, K. (2022b). Boiler feed water pumps: techniques for improvement in design and balance of the drum. *Natural and Applied Sciences International Journal (NASIJ)*, *3*(2), 15–29.

Karikari-Boateng, K. A. (2016). *Accelerated testing of tidal turbine main bearing in a full scale nacelle test rig*.

Kotzalas, M. N., & Doll, G. L. (2010). Tribological advancements for reliable wind turbine performance. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *368*(1929), 4829–4850.

Liu, Z., & Zhang, L. (2020). A review of failure modes, condition monitoring and fault diagnosis methods for large-scale wind turbine bearings. *Measurement*, *149*, 107002.

Ma, C., Zhu, G., Chen, Z., & Guo, S. (n.d.). Study on the Influence of Key Structural Parameters of Turbine Heat Shields on the Thermal Load of Bearing Shell. *Available at SSRN 5031705*.

Ryu, K., & San Andrés, L. (2013). On the failure of a gas foil bearing: high temperature operation without cooling flow. *Journal of Engineering for Gas Turbines and Power*, *135*(11), 112506.

Sabia, G., Heinze, C., Alobaid, F., Martelli, E., & Epple, B. (2019). ASPEN dynamics simulation for combined cycle power plant–Validation with hot start-up measurement. *Energy*, *187*, 115897.

Sarkar, D. (2015). *Thermal power plant: design and operation*. Elsevier.

Singh, G., & Sundaram, K. (2022). Methods to improve wind turbine generator bearing temperature imbalance for onshore wind turbines. *Wind Engineering*, *46*(1), 150–159.

Yang, C., & Tang, S. (2011). Transient Analysis for Effect of TDFWP on the Operation of Main Equipments in Direct Air-Cooled Thermal Power Generating Unit. *ASME Power Conference*, *44601*, 299–305.

Yunus, A. C., & Michael, A. B. (2002). *Thermodynamics: An Engineering Approach.* Mcgraw-Hill.
