Analysis and Improvement of Screw Compressed Air Exhaust Gas Temperature

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Analysis and Improvement of Screw Compressed Air Exhaust Gas Temperature

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Abstract. Screw compressed air is an important part of thermal power plant unit, and its normal operation is the key to ensure normal operation of the unit. For high temperature in summer, the compressed air exhaust temperature is too high, which directly affects the operation of the unit. Example for Iraq Huashide Power Plant, the three main influencing factors of excessive compressed air exhaust temperature are obtained by experimenting, then the improvement proposals are proposed for the main influencing factors. The proposals are effective and can be promoted and used by actual verification.

1. Introduction
The oil-injected screw compressed air has become the new mainstream of compressed air development, and has been favored and applied by many enterprises. It has superior and reliable performance, such as low vibration, low noise, high efficiency and no wearing parts. Screw compressed air is an important part of thermal power plant unit, and its normal operation is the key to ensure the normal operation of the unit. The temperature in Iraq is very high in summer, which makes the temperature of the Huashide workshop higher. The high temperature of the compressed air workshop makes the operation of the air compressor face a huge test. If the compressed air exhaust temperature is too high, it will cause high temperature carbonization of the lubricating oil and the oil deterioration easily. It is easy to form oil coke, damage oil core, and cause frequent maintenance and economic loss of equipment, which is also very unfavorable for production. Therefore, compressed air is a device with multiple accidents, and it is urgent to reform and solve the problem of high temperature of compressed air effectively.

2. Working principle of compressed air
2.1. Structure of compressed air
The oil-injected screw compressed air is a kind of two-shaft volumetric rotary compressed air. The air inlet is located at the top of the fuselage, and the exhaust port is located at the bottom of the fuselage. It is equipped main and auxiliary rotors with high-precision [1]. It is mounted horizontally inside the fuselage. The main rotor has 5 teeth and the auxiliary rotor has 6 teeth. The diameter of main rotor is larger than the auxiliary rotor slightly. The tooth shape is spiral, and the tooth shapes of the two match with each other. Both ends of the main and auxiliary rotors are supported respectively by bearings.
The transmission mode of the motor and the main machine is driven directly by a flexible coupling. The flexible coupling is a set of couplings, the active end, the driven end and the transmission power surface of which is separated by an elastic body, and the motor and the main machine are combined. The speed of the main rotor is increased by a set of high-precision speed increasing gears to reach the designed speed [2]. The structure of compressed air is shown in figure 1.

Iraqi Huashide Power Plant uses the SA185W type oil-injected screw compressed air produced by Fusheng industrial CO., LTD. The cooling method is water-cooled. The main parameters of the compressed air equipment are shown in table 1.

![Figure 1. Structure of compressed air.](image)

| Parameter         | Value            |
|-------------------|------------------|
| type              | SA185W           |
| exhaust pressure  | 0.85MPa          |
| main motor power  | 185KW            |
| volume flow       | 27.4 m³ / min    |

2.2. Principle of exhaust

The compression and exhaust process of screw compressed air is divided into three steps: inhale, closed compression and exhaust. The specifics are as follows:

Firstly, inhale process. When the rotor rotates and the groove space of the main and auxiliary rotors is turned to communicate with the intake port, the outside air begins to inflate the groove space of the main and auxiliary rotors, and as the rotor rotates, the volume between the two teeth is continuously expanded. When it is closed, it is the critical time point, and the space reaches the maximum. In this process, the groove space of the rotor communicates with the outer space of the air inlet, and the outside air enters the groove of the female and male rotors [3]. When the air fills the full tooth groove, the air intake side end surface and the outer diameter spiral of the two rotors are turned to the sealing area of the casing, and the air between the tooth grooves is closed, and the intake air is stopped.

Secondly, compressed process. The outer edges of the main and auxiliary rotor teeth are closed after inhalation. Then, the air is closed in the groove and no longer flows out [4]. The two rotors continue to rotate, and the closed volume between the teeth of the male and female rotors decreased gradually. The gas in the groove is compressed gradually to increase the pressure, and the compressed liquid is also injected into the compressed chamber to mix with the air due to the pressure difference [5].

Thirdly, exhaust process. When the closed volume of the male and female rotors is turned to the exhaust port of the casing, the pressure of the compressed gas is the highest, and the compressed gas
begins to discharge until the volume between the teeth of the two rotors is zero [6]. As the rotor continues to rotate, the process above is repeated, starting inhaling, therefrom starting a new compressed cycle.

3. Analysis of the reason
The screw compressed air is designed to have an exhaust temperature between 80° and 90°. The temperature is above 90° by normal operation, which can reach 110° in summer. If compressed air exhaust temperature is above 95°, it is easy to cause high temperature carbonization of the lubricating oil and to form oil coke, damage oil core, cause frequent maintenance and cause the unit to trip. After a number of trips, the reasons for the on-site investigation are analyzed and the main reasons are obtained:

Firstly, the water inlet of the closed cooler industrial water is blocked by debris and aquatic creature, which affects the amount of cooling water, and the temperature of the closed water is high, which causing high exhaust gas temperature protection action. The compressed air cooling water uses closed circulating cooling water from the steam turbine system, and the incoming water is affected by the operation of the steam turbine system. If the temperature of the closed cooling water is high or the pressure is low, it is easy to cause a limited amount of cooling, so that the heat of the lubricating oil cannot be taken away in time, resulting in a high injection temperature, which leads to a high exhaust gas temperature. In the actual production, when the continuous high-load operation of the unit in summer and the shutdown of the unit have a great influence on the closed cooling water system, it is necessary to communicate with the operator in time to adjust the operation mode to avoid large fluctuations of the cooling water parameters. At the same time, during the inspection, the temperature of the cooling water is measured in the field. The normal incoming water temperature is below 30°C. If the incoming water temperature exceeds 35°C or even 40°C, it can be determined that the cooling water temperature is high.

Secondly, the water in the outlet pipe of the spare compressed air is not drained, and the overload protection action is caused when the joint is started. If the standby compressed air is in standby for a long time or is in a standby state, water may accumulate in the outlet pipe or the machine. Regular inspection shall be carried out to perform regular drainage operation. The standby compressed air shall be included in the regular work execution, and the standby shall be switched regularly. The operation of the compressed air is effective to avoid the overload protection action when the joint is started. Leaving the spare compressed air in a good standby state.

Thirdly, due to the weak Iraqi power grid and the large fluctuation of the grid voltage, when the power plant starts or switches the auxiliary machine, the voltage drop of the 6KV bus voltage in the plant is large relatively, which is likely to cause low voltage and high current of the closed cooling water pump and compressed air protection action. The sudden drop of the bus voltage will cause the closed cooling water pump and compressed air to operate due to low voltage protection. Eventually, the compressed air trips or the exhaust gas temperature rises due to the large fluctuation of the water pressure of the closed circulation pump.

4. Improvement proposal
According to the three main reasons for the high exhaust gas temperature of the compressed air, the improvement proposals are proposed after the analysis and verification.

Firstly, compressed air closed water system installed with backwash valve.
Considering that the air inlet and outlet water shut-off of the compressed air is not tight, there is an internal leakage, which increases the difficulty of cleaning each maintenance. The closing of the industrial water inlet and outlet of the cooler also affects the operation of other compressed air. It is a good choice to install a backwash valve in the industrial water outlet pipe of the closed cooler. No isolation operation is required, the backwash valve is opened, the water pressure is increased, and the cooler is flushed.
The project plan is shown in figure 2. A manual backwash valve is installed at the industrial water inlet of the closed cooler, and the foreign matter is quickly taken out of the system by industrial water backwashing.

![Figure 2. Improved compressed air closed water system.](image)

After the retrofitting of the backwashing valve, the temperature of the cooling water is reduced and controlled effectively, thereby reducing the exhaust temperature of compressed air, and the high temperature of the compressed air is no longer frequent. The temperature conditions before and after the installation of the backwash valve are shown in table 2. It can be seen from the table that after the backwashing valve is installed, the water temperature is reduced significantly, and compressed air exhaust temperature is also reduced significantly.

| Parameter                        | Before operation | After operation |
|----------------------------------|------------------|-----------------|
| Atmospheric temperature          | 43               | 43              |
| Industrial water pressure (MPa)  | 0.42             | 0.42            |
| Industrial water inlet temperature | 30              | 30              |
| Industrial water outlet temperature | 43              | 35              |
| Industrial water temperature rise | 13              | 5               |
| Closed water inlet temperature   | 33               | 33              |
| Closed water outlet temperature  | 46               | 38              |
| Compressed air exhaust temperature | 90              | 74              |

In the next three months of peaking summer in 2018, the backwashing operation was performed three times in July and four times in August. Through the backwashing operation of the industrial water side of the closed cooler, the closed water temperature is effectively reduced and controlled, thereby reducing the exhaust temperature of the compressed air, and compressed air trips no longer because of high exhaust temperature.

Secondly, open compressed air outlet pipe drain door to drain. Regular work is carried out to perform compressed air discharge drain operation every day to reduce the accumulation of water in the outlet pipe and compressed air. The standby compressed air is included in the regular work execution, and the standby compressed air is periodically switched to avoid the overload protection action when the joint is started, leaving the spare compressed air in a good standby state.
Thirdly, before starting the high-power auxiliary machine, it should be avoided as much as possible during the peak hours of operation, and should be adjusted as far as possible when the power is low. When the high-power auxiliary machine must be started, the high-loaded taps can be adjusted, and increase the 6KV bus voltage, then wait until the voltage is stable before performing the operation. During the peak hours of power consumption, the flow rate of the closed cooling water pump is increased appropriately, and the operation mode of the closed cooling water pump is changed to avoid the large fluctuation of the water pressure of the closed circulating water pump when the grid voltage is low, which affects the exhaust temperature of the compressed air.

5. Conclusion
The high exhaust temperature of the main engine is one of the most common defects of the screw compressed air, and its influencing factors are also various. Especially in the high temperature period in summer, high exhaust gas temperature defects occur more frequently, which causes great operational pressure on the production power plant system. The various influencing factors are analyzed, and the main influencing factors are obtained through repeated verification. The proposals are proposed for the main influencing factors. It is proven that the proposals are effective and can be promoted.

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