Analysis of the advanced oxygenate water level control scheme of the engineering supercritical unit

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Abstract. The oxygenate water level is an important adjustment parameter in the operation of the fire generator set, and the water level may result in the safety of the water pump. The high water level will not only affect the oxygen effect, but it is also possible to cause the water shot to the steam turbine to cause a water shot or give the water tank full water, oxygenate vibration, drain and vapor with water. When the load is low (generally 35% rated load), the oxygenate water level is controlled by large and small valve, condensate pump variable frequency control condensed water drum pressure. When the unit load is high (greater than 35 rated load), the oxygenate water level is controlled by the condensed water pump, the large valve and small valve controls condensed water drum pressure.

1. Introduction
The water tank of the oxygenator is to give water to oxygen, heating and hydrophobic flow, ensuring that the boiler has a certain water supply reserve. Due to the use of DC boilers, the sectors are high-loaded in the unit, the soda separator is in a purely direct current, and there is no function of the water supply, and the type unit has not set a large water reserves, then the deaerator becomes the only feedwater storage container of the unit, and its capacity should generally be less than the water supply amount required for 15-20 minutes under the boiler rating [1].

The oxygenate water level is an important adjustment parameter operation in the fire generator set, and low water level may lead to cavitation of feed pump and affect the safety of feed pump. The high water level will not only affect the oxygen effect, but it is also possible to cause the water shot to the steam turbine to cause a water shot or give the water tank full water, oxygenate vibration, drain and vapor with water. Deaerator water level control is related to the safe and stable operation of the power plant. There are many cases of unit tripping due to deaerator water level imbalance.

2. Introduction of commonly used condensate system
In the traditional power plant design, the power frequency condensate pump is used in the condensate system. The water level of deaerator is mainly controlled by the water level regulating valve of deaerator. The power consumption of the condensate pump is large, and the closure loss of the condensate system is serious due to the closure of the water level regulating valve of the deaerator, resulting in poor economy. At present, most projects use variable frequency condensate pumps. The normal operation of the unit depends on the variable frequency control of the condensate pump, and the main valve and auxiliary valve of the deaerator control the pressure of the condensate header.

As shown in Figure 1, the supercritical thermocomputer group is usually equipped with two frequency conversion condensate pumps. A condensate pump is running, and another condensate pump...
is in a substitute state. The exhaust steam of the steam turbine becomes condensate through the condenser. After the condensed water is pressurized by condensed water pump, condensation is sequentially treated with a condensed water sensing device, a shackler heater, a hydrophobic cooler, an oxygenate water level main sub-valve, a low pressure heater, then reaches the oxygenator.

![Figure 1. Concentration water system diagram.](image1)

Usually two condensate pumps use one-to-drag in such a way, as shown in Figure 2. The power supply is taken from the plant electricity 6kv a and 6kv b. Each condensate pump can carry 100% load, and both condensate pumps can operate at constant frequency or variable frequency. However, only one condensate pump can operate with frequency conversion at any time.

![Figure 2. Condensate pump electrical wiring diagram.](image2)

3. oxygenate water level control scheme

If the condensed water pump does not have a variable frequency function, the oxygenate water level can only controlled by the large and small valve control. In order to control the oxygenate water level under different loads on the expected value, big valve and small valve can't fully open. In order to reserve a certain regulation margin for the regulating valve, some units need to appropriately increase the condensate pipe's pressure, which seriously reduces the economy of the unit. In order to improve the economy of the unit and reduce the auxiliary power consumption, many units carry out frequency conversion transformation of the condensate pump. The water level of deaerator is controlled by frequency conversion of condensate pump, and the regulating valve shall be in the fully open position as far as possible on the premise of ensuring the pressure of condensate header. Although it is economical to control the water level of deaerator by frequency conversion of condensate pump, this method can not be used in the full load section of supercritical unit.

3.1 Control mode

The boiler is warmed, boostable to the turbine to transfer the grid stage, the oxygenator begins by the
condensed water pump, the vapor flow is not very large, the system requires less water. At this time, if it is completely modulated by the pump, the rotational regulation speed is given to oxygen Introducer, the speed of the pump is very low, and the pump inlet pressure is low, which may result in the cement of the pump. At the same time, if the speed is low, the pump speed may reach the critical area of the first speed, resulting in large vibration and damage to the pump body.

In addition to providing condensate to the boiler, the condensate pump also provides desuperheating water for many users, of which each user has a minimum requirement for condensate pressure. The outlet pressure of condensate pump must meet the minimum pressure requirements of condensate users (such as mechanical seal water of feed pump, spray water of low-pressure cylinder, water for bypass desuperheater, etc.). If the flow of condensate pump is too low, the water level of deaerator may not be low and the outlet header pressure of condensate pump is too low, which will eventually fail to meet the minimum pressure requirements of important users of condensate. For example, it cannot meet the requirements of low-voltage bypass, resulting in low-voltage bypass protection action [2]. Therefore, when the unit is started or the load is low, the water level of deaerator still needs to be controlled by main and auxiliary regulating valves, and the condensate pump frequency conversion controls the pressure of condensate main pipe.

The supercritical unit of oxygenate water level control scheme is: when the load is low (generally 35% rated load), The large valve and small valve control the oxygenate water level, the condensate pump variable frequency control condensed the water drum pressure.

The logic of the water level regulating valve controlling the water level of the deaerator is shown in Figure 3. Under the single impulse control mode, the deviation between the actual water level of the deaerator and the set value of the water level of the deaerator is calculated by the PID controller to give the control command of the regulating valve. Under the three impulse control mode, the deviation between the actual water level of the deaerator and the set value of the water level of the deaerator is calculated by the main PID, the output value of the main PID plus the feed water flow is the set value of the auxiliary PID, the regulated quantity of the auxiliary PID is the condensate flow, and the deviation between the set value and the regulated quantity is calculated by the auxiliary PID to give the control command of the regulating valve.

![Figure 3. Valve Control Oxygen Water Level Logic.](image)

When the unit load is high (greater than 35 rated load), the condensed water pump variable frequency control of the oxygenator water level. The large valve and small valve control the condensed water pipe pressure, the condensed water pump variable frequency control oxygenator water level logic is shown in Fig. 4.
When the condensate pump trips during the variable frequency operation of the condensate pump, the standby condensate pump starts at power frequency, and the water level of the deaerator will drop rapidly and then rise rapidly. In order to reduce the fluctuation of water level, it is necessary to respond quickly to the disturbance, so a variable gain regulation loop can be designed. At this time, the water level regulating valve is put into automatic operation, and the total deviation of the water level at the inlet of the regulator is amplified by 1.5 times to respond to the disturbance. When the total deviation of the water level is less than the limit value, the regulator will automatically switch back to the normal regulating circuit[3].

3.2. Switching between single-element level control and three-element level control

Due to the large volume of the deaerator, the water level of the deaerator as the regulated quantity has great inertia. When the feed water flow changes greatly during the load increase and decrease, there may be a false water level phenomenon, which increases the imbalance between feed water flow and condensate flow and prolongs the regulation time. Single impulse control can not solve this problem [4].

Three-element level control has two regulators. The main PID regulator is also known as the water level regulator, and the water level deviation is added to the PID regulator to give the feed forward to generate a condensed water flow value. The condition of the regulator output is that the oxygenate water level is equal to the oxygenate water level setting value, so the water level is free of adjustment. The sub-PID regulator is a condensed flow regulator that controls the oxygenate water level tension according to the deviation of the condensed water flow. Three-element level control can both adjust the oxygenate water level, and eliminate condensate and perturbation of water.

Ingle-element level control and three-element level control are designed to be automatically switched. When the following conditions are met, ingle-element level control mode is switched to three-element level control method:

(1) The flow of water is> 25%;
(2) The oxygenate water level is in automatic control mode;
(3) Condensate the flow signal, the water flow signal is not bad

Some supercritical units have poor feedstock signals, and the load can be used as a switching signal between the ingle-element level control and three-element level control. When the unit load is near the switch point, it may be frequently switched, resulting in adjusting system disorders. In order to avoid the problem of the ingle-element level control and three-element level control frequently switched, a
segment switching dead zone is usually provided. When the amount of water supply is greater than 25%, the single-element level control is switched to a three-element level control. When the flow rate is less than 22%, the three stroke is switched to a single stroke amount.

3.3. Oxygenate water level adjustment large valve and small valve

Supercritical unit condensate system is typically equipped with an oxygenate water level large valve and an oxygenate water level small valve, usually a 30% small valve + 70% of large valves. Big valves and small valves can use independent control or common control. Under independent control mode, large valves and small valves have their own independent PID controllers.

The common control method is shown in Figure 5. The large valve and small valve share a valve general instruction, and the valve general instruction is calculated from Fig. 3, and the valve general instruction gives a small valve command and the large valve command through two different functions. In the figure, F1 (x) is a small valve command function, and F2 (X) is a large valve command function. The polyline function settings of F1 (x) and F2 (x) are shown in Table 1.

| Table 1. polyline function. |
|-----------------------------|
| x  | 0  | 30 | 100 |
| F1 (x) | 0 | 100 | 100 |
| F2 (X) | 0 | 0 | 100 |

When the total valve command is in the range of 0-30%, the large valve is in a closed state, and the oxygenate water level is adjusted by small valve. When the total valve command is greater than 30%, the small valve is fully opened, the oxygenate water level is adjusted by the large valve. When the unit is low-load operation, the condensed water is small, and if the oxygenate water level is adjusted with a large valve, it will increase the loss of the throttle and reduce the economics of the unit. The use of small valves and large valve segments into regulation, which can maintain the stability of the oxygenator and improve the economy of the unit.

4. Conclusion

This paper analyzes the advanced control scheme of the supercritical unit of oxygenate water level. When the unit load is low (typically 35% rated load), the oxygenate water level is controlled by large valves and small valve control, and the condensed water pump is controlled to condense the water drum pressure. When the unit load is high (greater than 35 rated load), the condensed water pump variable frequency control of the oxygenate water level, large valve and small valve control condensed the water drum pressure.

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