A FAST RESPONSE MAIN STEAM TEMPERATURE CONTROL SYSTEM BASED ON HEAT TRANSFER MODEL AND DCS

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ABSTRACT

The main steam temperature is an important parameter in boiler operation and the temperature instability will affect the boiler normal operation. However, due to the bidirectional delay between the operator and the feedback result of the control system in the actual operation of the plant, a rapid response of the main steam control system is urgently needed.

Since the DCS (Distributed Control System) introduced, it has been widely used in various industrial fields also in thermal power plants for the high performance of reliability, openness, and flexibility. In DCS, various control strategies can be combined to improve the system. A feedforward-feedback PID control system with fast response is proposed to solve the large lag in the boiler main steam temperature control system. In this paper, the thermodynamic data of the boiler main steam system under variable working conditions are calculated based on the heat transfer calculation model. At the same time, the feedforward PID control system is used to improve the boiler original PID control system, which is coupled with DCS (Distributed Control System), and the feedforward PID control system is applied to a supercritical boiler. Through the test of a 350 MW supercritical boiler, system response time is shortened by about 30 s, high-temperature superheater outlet temperature and inlet temperature is stable around the set value of 566 ℃ and 458 ℃, respectively, and secondary spray desuperheater valve opening fluctuates from 15% and is stable around 38% eventually. It shows that the system with a fast response has a good control effect, reliability and stability. The study in this paper has a positive effect on the power plant boiler main steam temperature control system.

1. METHDOLOGY

Feedforward control adjusts the controlled quantity according to the interference quantity of the controlled object. When the disturbance occurs, the regulator compensates the controlled object to make the controlled object value equal to the set value according to the interference quantity. Compared with the delay regulation in the feedback control, when the controlled quantity has not changed obviously, the disturbance has occurred. At this time, the feedforward regulator has begun to adjust the controlled quantity, so the feedforward control also can be called disturbance compensation control.

For boiler main steam temperature, there is a large delay and hysteresis in controlling its temperature and the control system is easy to be interfered with by the main steam flow. Therefore, the feedforward system and the original cascade control system with feedback are combined to form a feedforward feedback cascade PID control system. To minimize deviation, feedback control is needed to adjust.

In this paper, the control main steam temperature control system circuit is a feedforward PID control system, as shown in Figure 1. As the boiler has the strongest stability under full load, the cascade-feedforward PID control effect is selected to be studied under 100% boiler load.

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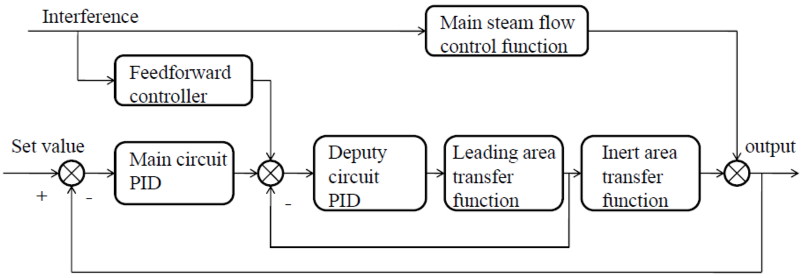

Figure 1: Main steam cascade- feedforward PID control system

The DCS control system has multiple system tools, among which the control configuration tool is an important part to realize control configuration function. As shown in Figure 2, it is the SAMA diagram of DCS control configuration with the feedforward PID control system adopted in this paper.

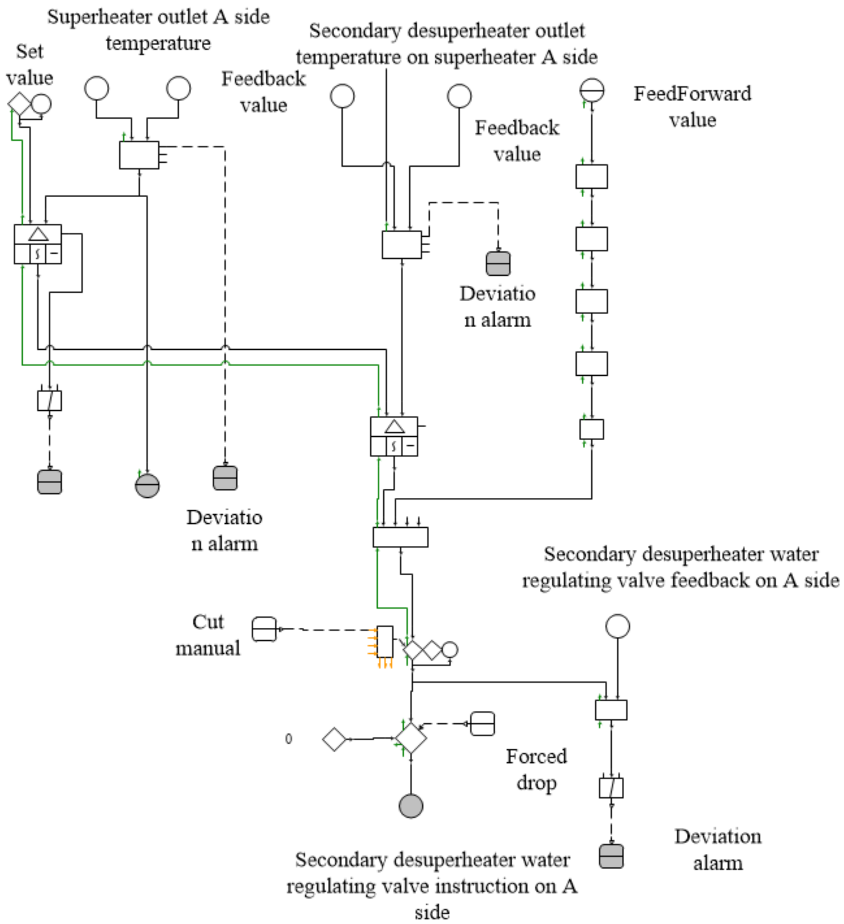

Figure 2: Boiler DCS control system feedforward-feedback system SAMA diagram

Figure 2 is the SAMA diagram of the main steam temperature control system on the superheater side A, which is built according to the control strategy proposed in this paper. It is a double-circuit PID control system with the main steam flow as feedforward quantity, and the two feedback inputs in the control main and auxiliary circuit are the superheater outlet steam temperature and the secondary desuperheater outlet temperature. On the figure right side is the feedforward circuit, which is composed of feedforward input, inertia link and relation function module (f (x)) between feedforward and controlled quantity, and is connected with the main circuit by accumulation module (Σ). The system can effectively realize the main steam temperature control with the main steam flow as feedforward.

The relationship between desuperheating water flow and main steam flow calculated by the program calculation model is brought into the main steam flow feedforward control function (f (x)), which is the feedforward feedback control system shown in the figure. In order to verify the control effect of the DCS control program on the boiler main steam temperature system, the system is applied to a supercritical boiler in the Shanxi Shuonan power plant. By comparing with the operating state when the system is not applied, the control effect is verified to be improved. In this paper, the main steam-water DCS control master diagram in actual operation combined with the control strategy is shown in Figure 3.

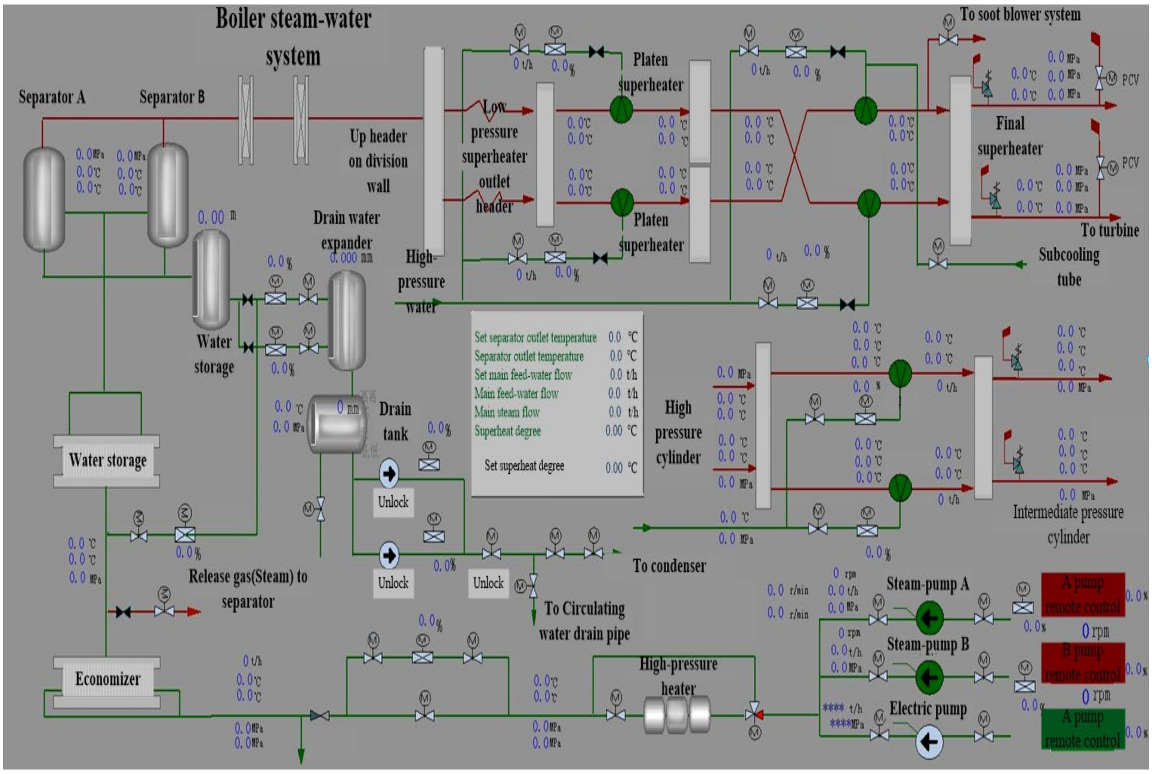

Figure 3: DCS control main diagram of boiler steam water system

2. RESULTS

High-temperature superheater temperature is the main parameter of the main steam temperature, monitor the temperature change of high-temperature superheater before and after the control system with the main steam flow as feedforward. The secondary spray desuperheater is located between the cold section and the hot section of the high-temperature superheater, and the valve opening needs to be adjusted continuously with the steam temperature change. At the same time, the valve changes of the secondary spray desuperheater and the outlet temperature of the high-temperature superheater are monitored to verify the superiority of the control system.

The high-temperature superheater outlet temperature is set at 560 ℃, a step interference is given at a certain time point, which increased the set value to 566 ℃. Then, monitor the variation of main steam system parameters. Figure 4 and Figure 5 show the variation of the main steam temperature before and after the application of the feedforward-feedback PID control system. Figure 6 and Figure 7 show the variation of secondary spray desuperheater before and after the application of the feedforward-feedback PID control system.

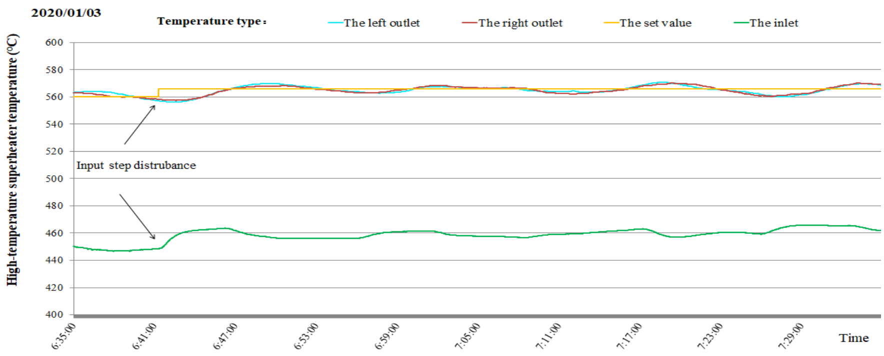

Figure 4: Variation diagram of high-temperature superheater temperature of non-feedforward cascade PID control system

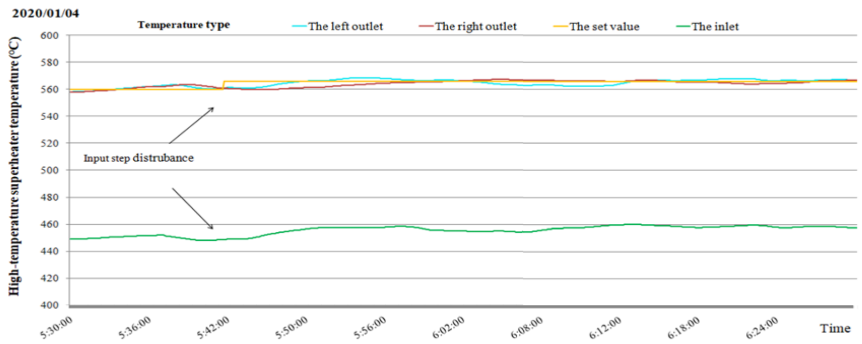

Figure 5: Variation diagram of high-temperature superheater temperature of feedforward-feedback cascade PID control system

In Figure 4, the set value curve is given as the reference, and the main steam temperature fluctuates up and down at the set value, and the floating range is around 556 ℃-570 ℃. At the last moment, its temperature value still tends to fluctuate up and down and is still around 560 ℃-570 ℃. However, in Figure 5, after a given step response interference, the main steam temperature fluctuates slightly up and down, ranging from 560 °C to 566.5 °C and the changing axis of the temperature curve rapidly rises to the set value. At the last moment, the change tends to be stable, always around the set value of 566 °C. As can be seen from the figure, the control system can respond quickly and make corresponding control adjustment, from input interference to adjustment, which is shortened from the original 1.5 min to 1 min.

The change law of high-temperature superheater inlet temperature is similar to that of outlet temperature, high-temperature superheater inlet temperature fluctuates from about 5 ℃ to be stable around 458 ℃.

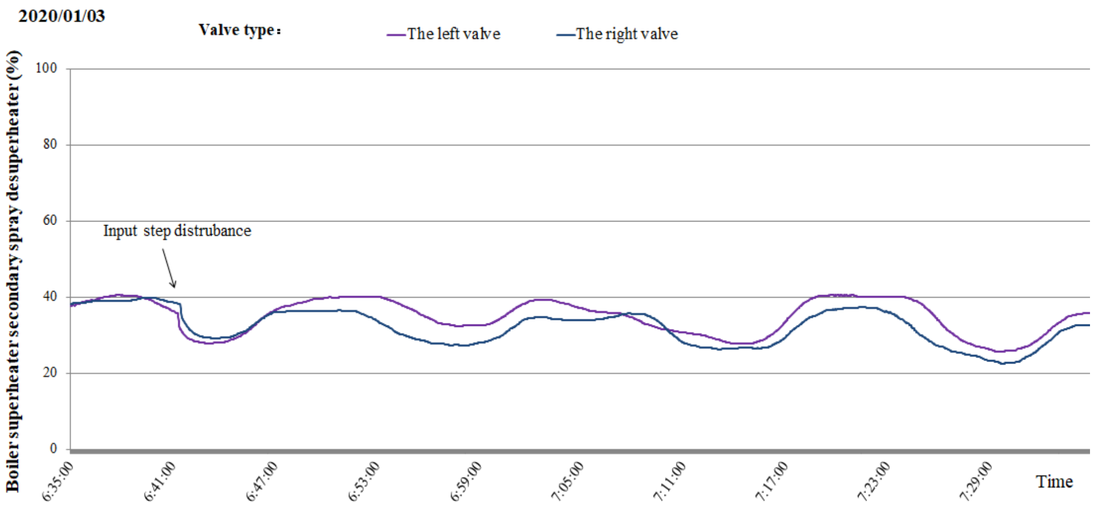

Figure 6: Variation diagram of boiler superheater secondary spray desuperheater opening of non-feedforward cascade PID control system

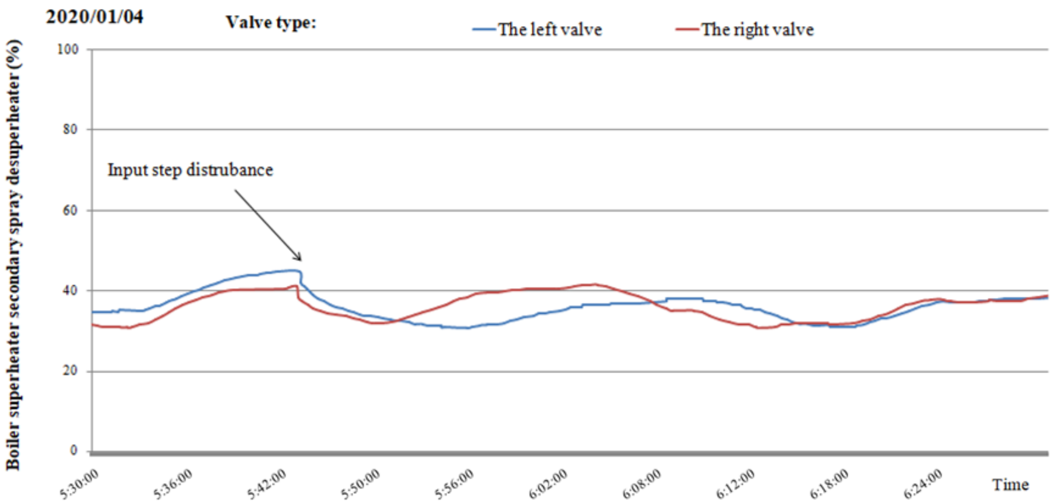

Figure 7: Variation diagram of boiler superheater secondary spray desuperheater opening of feedforward-feedback cascade PID control system

In Figure 6, the valve opening curve of the secondary desuperheater fluctuates greatly, ranging from 23% to 36% and does not tend to be stable. However, in Figure 7, the change of secondary desuperheater valve opening fluctuates greatly at the beginning of step interference, but the fluctuation becomes smaller and smaller over time, ranging from 29% to 37% and tends to be stable around 38% at the last moment.

Therefore, the main steam temperature change is more stable and the desuperheating water valve opening change is smaller after the feedforward control system is applied by the comparison between the two diagrams. This indicates that the system has a good control effect, which proves the feasibility of the control strategy and can improve the boiler's main steam temperature control system stability and reliability.

3. CONCLUSIONS

A feedforward-feedback PID control system is designed and applied in DCS. Through the test, system response time is shortened by about 30 s, high-temperature superheater outlet temperature and inlet temperature is stable around the set value of 566 ℃ and 458 ℃, respectively, and secondary spray desuperheater valve opening fluctuates from 15% and is stable around 38% eventually.

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