

OVATION System Based Superheat Temperature Control of Power Plant

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Abstract

Ovation is a distributed control system (DCS) produced by Shanghai Emerson Process Control Co., Ltd., which is mainly used for thermal automation control of power plants and is a very critical system. Digital power plants are a major development direction of the modern power industry. Data integration, comprehensive optimization applications, and decision support are new demands on the control system due to modern management. This paper aims at the characteristics of large delays in superheated steam, large inertia, non-linearity, and many influencing factors. It uses a cascade control system to control the superheated air temperature, sets up configuration diagrams on the OVATION system, and draws out the display interface and operation interface. The opening of the spray cooler for the last superheated air temperature is controlled.

Keywords

DCS, power plants, modern management, Shanghai Emerson.

1. System Identification

Give a +5% disturbance to the valve opening, collect the values of the pre-lead temperature and inert air temperature, and in MATLAB, make the valve opening—lead air temperature and valve opening—inert air temperature, and use the Particle Swarm Optimization[1]. System identification, as shown in Figure 1.

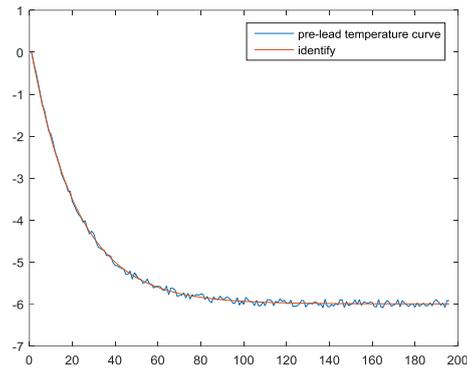
From the image, we can see that the recognition object is very close to the real object. The transfer function that identifies the leading temperature is:

$$\frac{\theta_2(s)}{\mu(s)} = \frac{-1.2}{21.35s + 1}$$

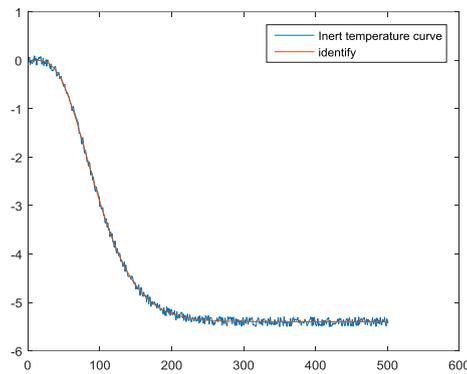
Similarly, the transfer function of the inert air temperature can be:

$$\frac{\theta_1(s)}{\mu(s)} = \frac{-1.08}{(19.96s + 1)^5}$$

To do a pre-lead air temperature-inertia air temperature fitting, we need to obtain $\frac{\theta_1(s)}{\theta_2(s)}$, although we have obtained the sub-object transfer function $\frac{\theta_2(s)}{\mu(s)}$ and The total transfer function $\frac{\theta_1(s)}{\mu(s)}$, but cannot simply use $\frac{\theta_1(s)}{\mu(s)} / \frac{\theta_2(s)}{\mu(s)}$ get $\frac{\theta_1(s)}{\theta_2(s)}$. It is necessary to assume that $\frac{\theta_1(s)}{\theta_2(s)}$ is a fourth-order inertial system and the gain can be determined as: $k_3 = \frac{k_1}{k_2} = \frac{-1.08}{-1.2} = 0.9$. To obtain further time Constants, try out in simulink in MATLAB, as shown in Figure 3



a. pre-lead temperature identification



b. Inert temperature identification

Figure 1

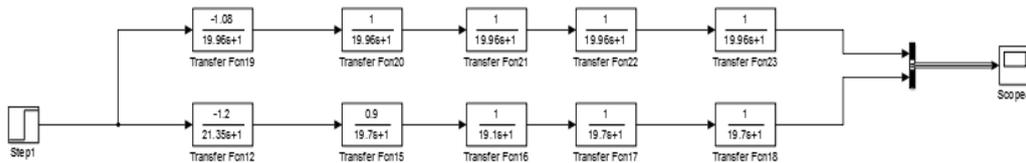


Figure 2. Try to master the main object parameter

After step disturbance, two curves of the actual object output and the output of the fitting object can be obtained. As shown in Fig. 3, it can be found that when the time constant is 19.7, the two curves basically overlap, so it can be said that the fitting object meets the requirements and can be used in later control algorithms.

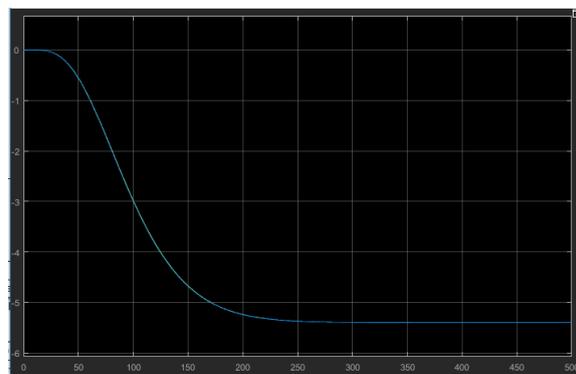


Figure 3. Main object fitting effect chart

So, the resulting primary object transfer function is:

$$\frac{\theta_1(s)}{\theta_2(s)} = \frac{1}{(19.75s + 1)^4}$$

2. Simple Cascade Control System Configuration

In the OVATION configuration interface to build a simple cascade control configuration, the need for two PID controllers, an M / A station, set the set value tracking the control amount. In addition, an inertia link is added before the control amount to prevent the valve from moving violently and destroy the valve, as shown in Fig.4 .

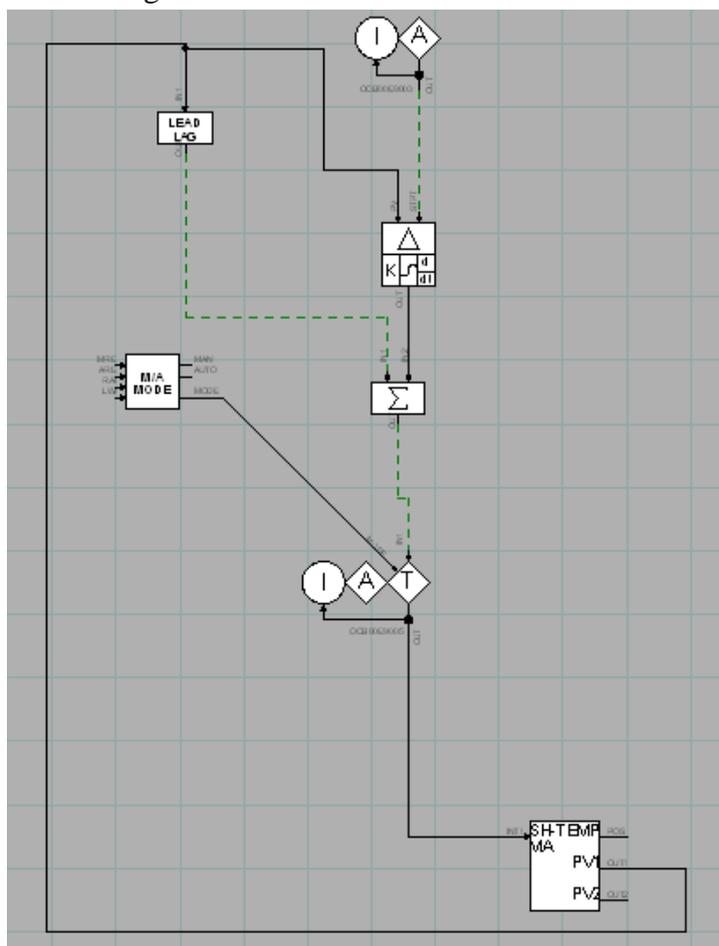


Figure 4. Simple cascade control system configuration diagram

The corresponding control system block diagram of this configuration diagram is shown in Fig.5.

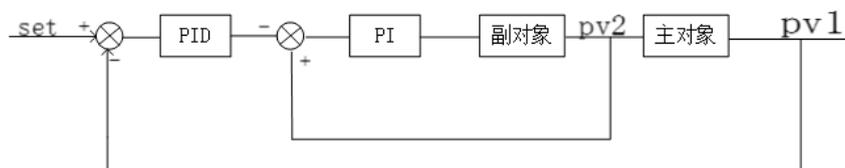


Figure 5. Cascade control system block diagram

The secondary loop consists of a secondary object and a secondary loop PID controller. The primary loop is composed of a primary object and an external loop PID controller, and the two loops are formed. The value entering the outer loop is the set value minus the measured main air temperature value (set-pv1), and the value entering the inner loop is the measured temperature before the lead minus the control amount of the main loop PID. That is, the external loop PID is a reaction and the internal loop PID is a positive action. The inner loop PID adopts proportional adjustment or proportional integral adjustment, and the outer loop PID adopts proportional integral differential adjustment [2].

3. Display Interface and Operation Interface Production

Operators in the power plant need to watch the screen to adjust the superheated air temperature, so they need to draw the display interface and operation interface, and display important parameters (leading air temperature, inert air temperature, valve opening) on the operation interface, as shown in FIG. 6 .

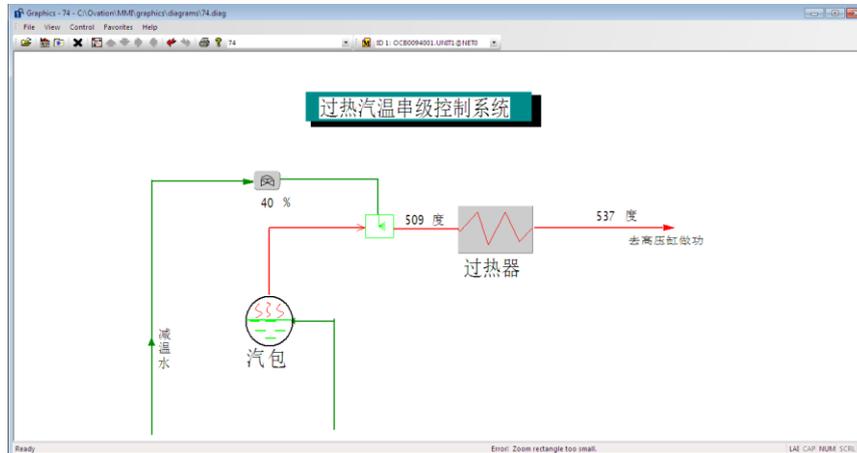


Figure 6. Overheat temperature single loop control system

Figure 6 shows the superheated air temperature cascade control system we built. The superheated steam from the steam drum is further heated by the superheater. The main steam temperature of the subcritical unit needs to be controlled at about 540°C. During the operation of the unit, the main steam temperature will increase or decrease. In order to ensure the normal operation of the unit, the temperature of the main steam is generally adjusted by using a spray water desuperheating method. From the spray desuperheater to the superheater outlet pipe is very long, spray water adjustment has a large delay, large inertia characteristics, so also after the water spray desuperheater, before the superheater to increase the temperature measurement point used to guide Estimate the change in main steam temperature.

When it is found that the overheat temperature abnormality is manually adjusted or the overheat temperature setting value is changed, click the valve of the water injection desuperheating valve to pop up the operation screen. As shown in FIG. 7

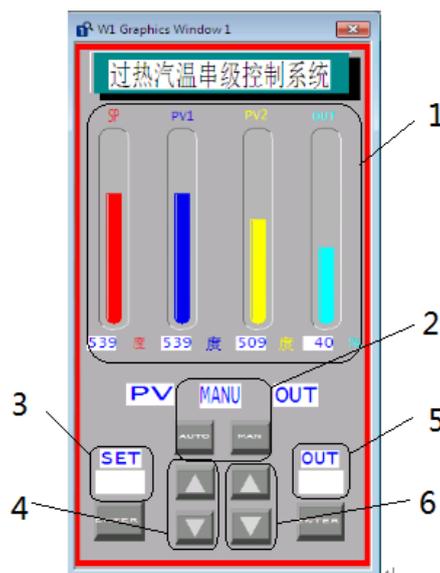


Figure 7 Overheat temperature cascade control interface

The four bar graphs for Area 1 from left to right are: main steam temperature set point (SP), actual main steam temperature value (PV1), actual pilot temperature value (PV2), and the valve opening of water spray desuperheater (OUT).

Area 2 is the hand automatic switching button "AUTO", "MANU" and hand automatic state display.

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Area 4 can complete the "+1" and "-1" settings in the automatic state.

Area 5 is manually entered through the input box input water desuperheater valve opening value, direct control of the valve opening.

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4. Commissioning Parameters and Observing Curves

The cascade control system uses a step-by-step approximation method for tuning. The specific steps are as follows:

(1) First set the secondary ring. Disconnect the main ring at this time, according to the single-loop setting method, find the sub-regulator tuning parameters, get the first set value, recorded as $[G_{c2}]_1$.

(2) Set the main ring. Take the newly-demarcated sub-ring as a link of the main ring, and still follow the single-loop setting method to obtain the setting parameter of the main regulator $[G_{c1}]_1$.

(3) Set the secondary ring again. At this time, the secondary loop and the primary loop are closed, and the parameters of the master regulator remain unchanged, and the secondary regulator parameters $[G_{c2}]_2$ are set by trial and error.

(4) Re-adjust the main ring. Similarly, the secondary loop and the primary loop are closed. When the secondary regulator's parameter is $[G_{c2}]_2$ the primary regulator is reset to obtain $[G_{c1}]_2$.

(5) If the adjustment process still fails to meet the quality requirements, proceed in steps (3) and (4) above until the control effect is satisfactory [3].

The adjustment curve of the cascade control algorithm is shown in Figure 8. The red line is the set value, the light blue line is the measured value, and the green line is the valve opening.



Figure 8. Cascade control curve

According to the results shown in the figure, it can be seen that the system overshoot is about 5%, the attenuation rate is about 1, and the regulation time is about 110s. In addition, the single-loop regulation curve for the superheated air temperature is shown in Figure 9.



Figure 9. Single loop control curve

According to the results shown in the figure, it can be seen that the system overshoot is about 9%, the attenuation rate is about 1, and the adjustment time is about 120s.

Comparing the cascade control with the single-loop control curve, it can be found that the cascade control and adjustment time is faster, the overshoot is smaller, and the stability of the system is enhanced.

References

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