Internal Model Control of Overheating Temperature Based on OVATION System

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Abstract

In the thermal power plant, the main task of the overheating temperature control is to ensure that the temperature of the main steam entering the high-pressure cylinder of the steam turbine works within the allowable range. For this purpose, the superheated steam must be controlled by spray water temperature reduction. For the characteristics of large delays in superheated steam temperature, large inertia, nonlinearity, and many influencing factors, internal model control is used to improve the followability and robustness of the system. Based on the Emerson Ovation system, this paper builds flow charts and logic configuration diagrams based on the characteristics of the water spray desuperheating process, realizes internal model control of superheated air temperature, improves the dynamic characteristics of objects, improves the quality of control, and ensures the safety and economy of the control system

Keywords

Environmental Management, Social Responsibilities.

1. Internal model control（IMC）

1.1 The basic structure of internal model control [1]

The basic structure of the internal model control system is shown in Fig. 1. The internal model control system has the characteristics of simple structure, strong followability, and good robustness

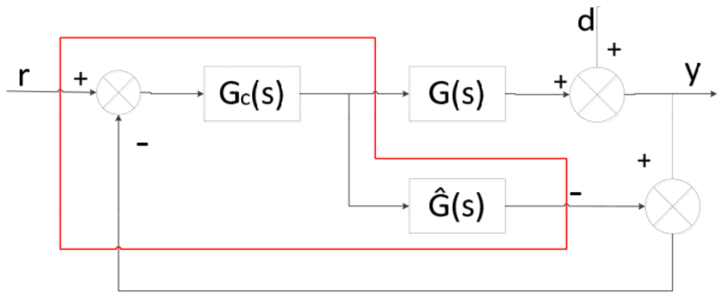


Figure 1 Internal Model Control System Structure

$G(s)$——Object transfer function (controlled production process)

$\widehat{G}(s)$——The internal model of the object

R,y,d——The system set value, output value and unmeasured interference

$G_c(s)$——Internal Model Controller

Internal model control has the following three basic properties:

Property 1 Stability: If $G = \widehat{G}$， a sufficient condition for the closed-loop stability of the internal model control system is that both G and G_c are stable.

Property 2 No static difference: If the G_c static gain is equal to the reciprocal of the static gain of the model $\widehat{\mathrm{G}}$,and the closed-loop system is stable, the steady-state error (r−y) is zero.

1.2 Internal Model Control Design

In practical applications, considering the influence of the mismatch between the model and the object, a low-pass filter is usually added in front of the controller to improve the robustness of the system. The design method can be briefly described as follows:

Divide the internal model of the object $\widehat{\mathrm{G}}$ into two parts:

$$\widehat{\mathrm{G}} = \widehat{\mathrm{G}}_{+}\,\widehat{\mathrm{G}}_{-}$$

Where: $\widehat{\mathrm{G}}_{+}$ is the stable part of the object, $\widehat{\mathrm{G}}_{-}$ contains the time-delay and the unstable part of the object

Robust design of model error

Define the internal model controller as:$\mathrm{G}_c = \widehat{\mathrm{G}} + \mathrm{f}$

Where: f is a low-pass filter, usually it's in the form of: $\mathrm{f} = 1/(\mathrm{Ls} + 1)$。

2. Set up the internal model control system configuration diagram

Based on the actual superheated steam temperature control system, the superheated steam temperature internal model control system built in MATLAB's simulink is used to initially determine the parameters for simulation[2]. The circuit is shown in Figure 2:

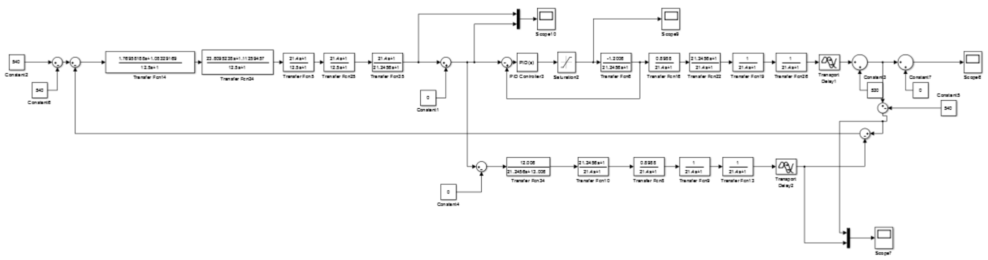
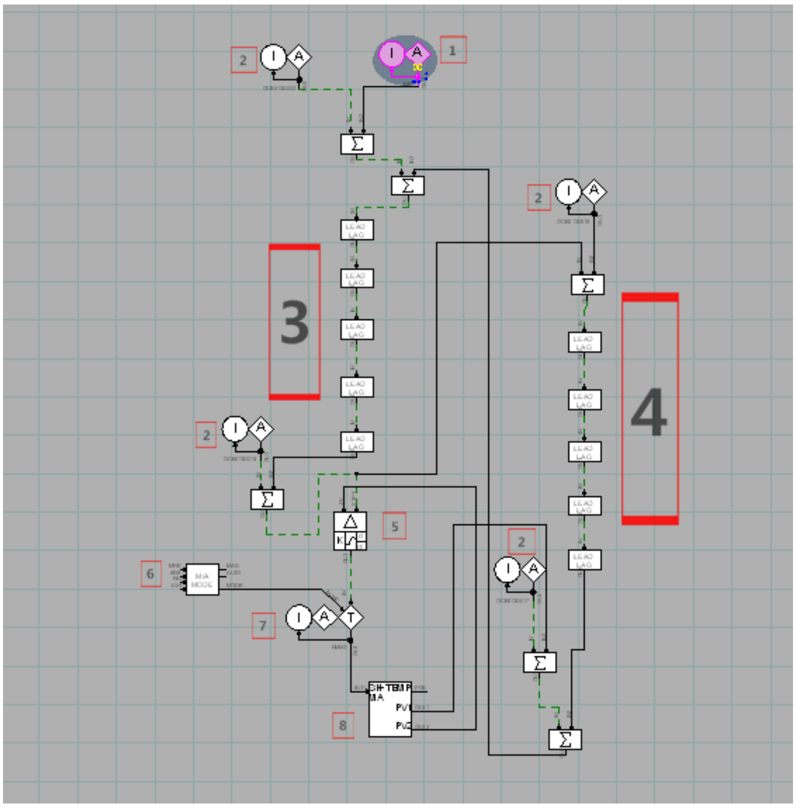


Figure 2 superheated steam temperature internal model control system

Figure 3 Superheated steam temperature internal model control system configuration diagram

Superheated steam temperature internal model control system configuration diagram shown in Figure 3. Module No. 1 is the setpoint Module No. 2 is the 510 and 540 fixed value module, Module No. 3 is the inner film module, Module No. 4 is the main module, Module No. 5 is the inner loop series PID controller module, Module No. 6 is a manual/automatic operation module, Module No. 7 is a manual/automatic switching module, and Module No. 8 is a superheated steam temperature virtual object module.

The No. 1 setpoint module sets the superheated steam temperature in the automatic state, minus the static operating point 540 as the input value of the No. 3 intima module, and the No. 3 intima module output adds 510 as the No. 5 inside. The input SP of the loop cascade PID controller module is output through the No. 8 superheated steam temperature virtual object module, on the other hand 510 is subtracted from the No. 4 master module output, and then No. 8 superheated steam temperature dummy object module temperature output OUT1 Subtracting the value of 540 sums the other input value as the number 3 internal module. The No. 8 superheated steam temperature dummy object module temperature output OUT2 is used as the PV value of the No. 5 inner loop cascade PID controller module.



Then set up the configuration diagram in the OVATION system, as shown in Figure 3.

3. Display interface and operation interface design

The operator in the power plant needs to view the screen to adjust the superheated air temperature, so it is necessary to draw the display interface and operation interface[3], and display important parameters (leading air temperature, inert air temperature, valve opening) on the operation interface, as shown in FIG. 4 .

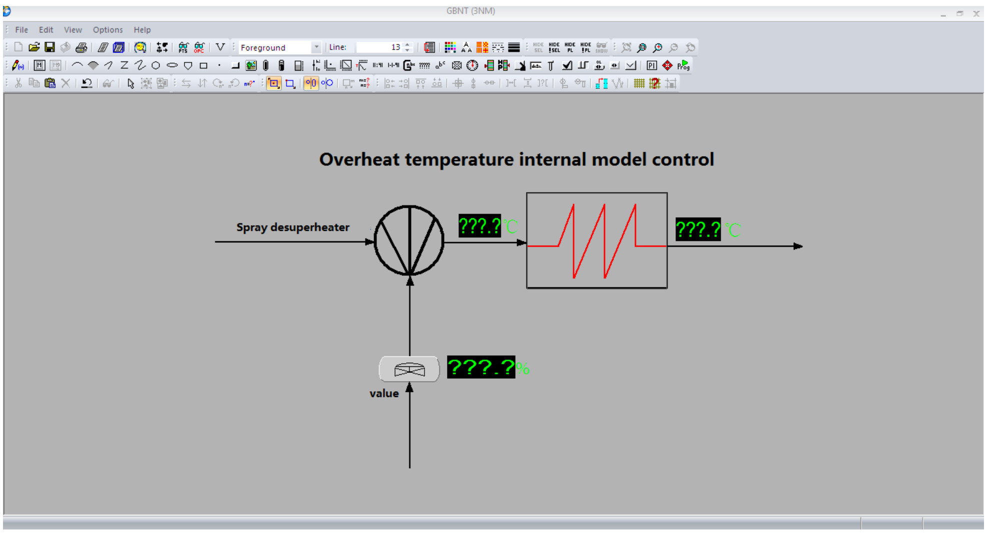


Figure 4 Internal Model Control Display Interface

Figure 4 shows the superheated air 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 desuperheater, before the superheater to increase the temperature measurement point before the lead 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. 5 . The user interface can complete the following operations

(1)Shows leading air temperature, inert air temperature, valve opening, manual/automatic status, etc.

(2)The manual/automatic bumpless switching of the system is achieved via the buttons "AUTO", "MANU".

(3)Change the main steam temperature setting value in the automatic state, can directly input the setting value, also can realize the setting value "+1" and "-1" through the setting value "+1" and "-1" button, then inside Internal model control logic controls the main steam temperature to the set value.

(4)Directly given a valve opening in the manual state, or through the control volume "+1%" and "-1%" buttons to achieve the valve opening "+1%" and "-1%"

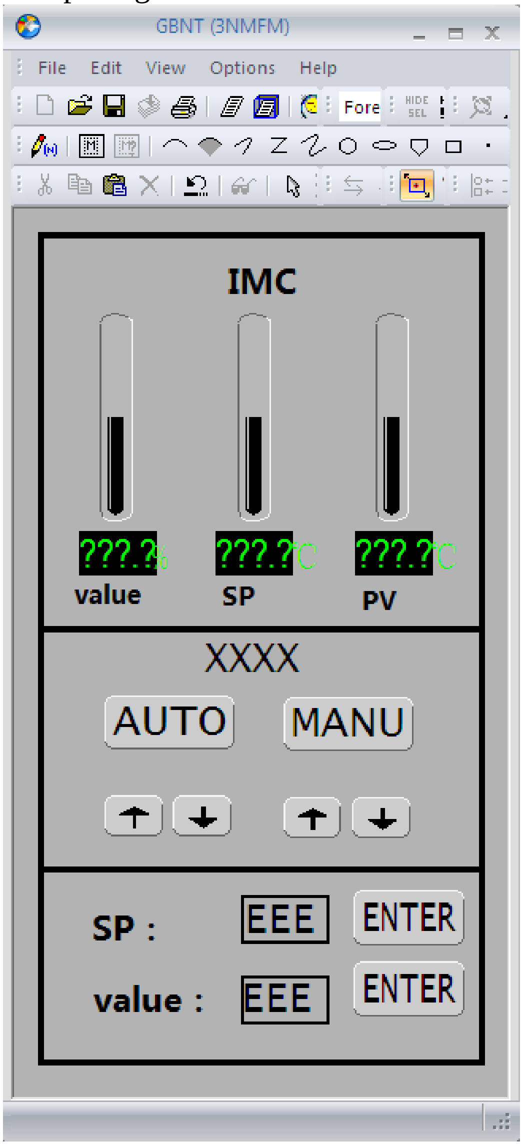


Figure 5 Internal Model Control System Adjustment Interface

4. Simulation Implementation of Internal Model Control in Ovation System

After the internal model control system has been built, the parameters that need to be adjusted are the inertia time constant λ of the inertia section in the controlle $G_C(s)$. So we performed parameter tuning directly in the Ovation system.

The experiments were raised from 540 degrees Celsius to 550 degrees Celsius. The following are experimental data that meet the requirements of the experiment:

Group No	λ	σ/(%)	ts/(s)
1	5	31.87	105
2	7	26.96	110
3	9	13.80	115
4	10	4.43	120
5	11	4.00	160
6	15	3.32	220

According to these groups of data, it can be found that the smaller λ is, the better the system tracking ability is, but the worse the robustness is; the larger λ is, the better the robustness is and the worse the tracking is. So comprehensively comparing the above data, we got a set of the best experimental data. Figure 6 below shows the optimal curve in the Ovation system. At this time, λ=10, the overshoot amount is 4.43%, and the settling time is 120 seconds.

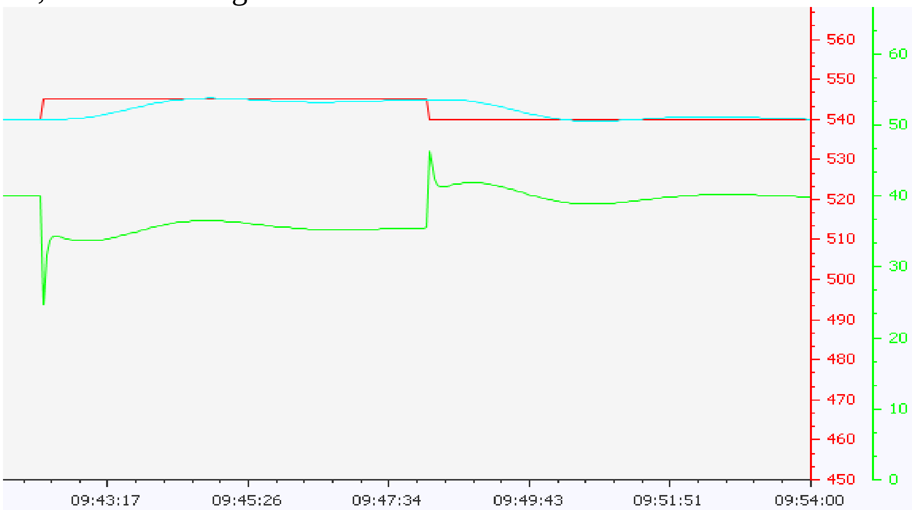


Figure 6 Internal model control adjustment curve

In addition, the single-loop regulation curve for superheated air temperature is shown in Figure 7.

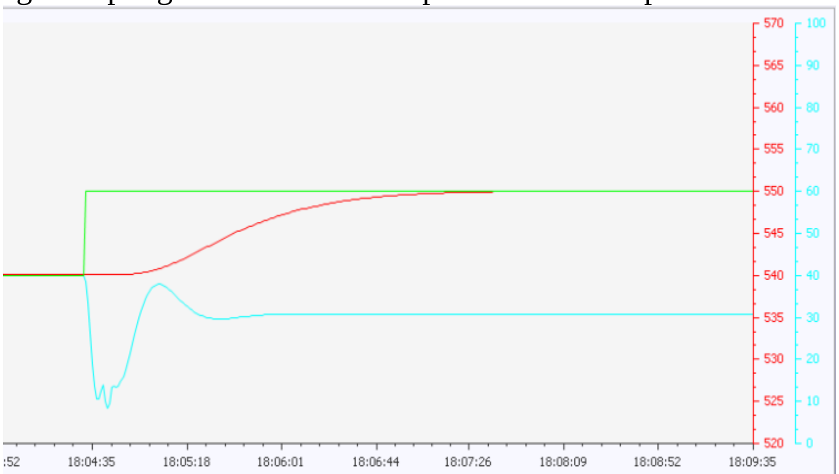


Figure 7 Single loop control curve

Using single-loop control, if you do not want too much overshoot, then the adjustment time is very long, according to the results shown in the figure can be seen that the system tuning time is about 120s. Comparing the internal model control with the single-loop control curve, it can be found that the internal model control adjusts the time faster, the robustness is better, and the stability of the system is enhanced.

References

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