The Analysis and Simulation for the Guidance Differential Control System and Significance for Automatic Control

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Abstract. This paper mainly discusses the guidance differential control system via two aspects. On the one hand, it states what guidance differential control system is in detail and gives the comparison for the guidance differential control with single loop control according to their control methods and characteristics. Then we can draw a conclusion that the guidance differential control system is better than the single loop control system, and it runs faster than single loop control system. What's more, the guidance differential control makes dynamic errors smaller. On the other hand, the application of the guidance differential control system is illustrated to explain the benefit of the guidance control system for current automatic control system, especially for some other automatic control field which doesn't have enough cost.

Introduction

In terms of temperature controlling system, there are three destabilization factors which can influent the steam temperature, they are quantity of desuperheating water, steam quantity and capacity of flue gas heat transmission. Steam temperature has inertia and delay because of them, especially influenced heavily by the quantity of desuperheating water. In order to decrease the impact of them, we could adapt guidance differential control, single loop control or cascade control. For the three kinds of control methods, guidance differential control and cascade control has better control effect than single loop control, furthermore, guidance differential control cost smaller than cascade control.

The Guidance Differential Control

In order to improve the dynamic characteristic of the control system, we can take deputy signal to constitute a cascade control system. In addition, we can apply differential control effect to the system, and then it must be able to reflect the output variable quantity to improve the system performance. Their system block diagrams are as follows.



Fig. 1 The system block diagram of single loop control



Fig. 2 The system block diagram of guidance differential control



Fig.3 The system block diagram of guidance differential control (equivalent figure)

As shown in the above figures, it is clear that guidance differential control adds another feedback signal I'_2 , it will reflect the system response faster and timelier. Moreover, the differential controller conduces to decrease dynamic error when the valve opening changed or the temperature of desuperheating water. That is to say, guidance differential control has the ability of anti-interference.

The boiler superheated steam temperature control system

In the past, because of the lack of fund and technology, we could not afford the large coast of another set of PID-controller, so guidance differential control was adopted to replace another PID-controller. And the fact proved that guidance differential control has the same function for the boiler superheated steam temperature control system.



Fig.4 The model of guidance differential control



Fig.5 The model of cascade control

In fact, boiler superheated steam temperature is a typical object with large delay, inertia, time-varying and nonlinearity. Thereinto, valve is a kind of intractable control target in the boiler superheated steam temperature control system with large delay, inertia. In allusion to this kind of problem, guidance differential control and cascade control can help accelerate system response by differential effect.

The Results of system block diagram Analysis and Simulation and Image Analysis

Step1.The guidance differential control

For the convenience of analysis, we can make some deformation for the system block diagram of guidance differential control, as fig.6 shown.

According to fig.1 and fig.3, we can get their transfer function expressions.

$$\begin{aligned} \theta(s) &= \mu(s) \cdot W_{D2}(s) \cdot W_{D1}(s); \\ \theta^*(s) &= \theta_1 + \theta_2' = [W_{D1}(s) + W_d(s)] \cdot \mu(s) \cdot W_{D2}(s); \\ W_D^*(s) &= \frac{\theta^*(s)}{\mu(s)} = [W_{D1}(s) + W_d(s)] \cdot W_{D2}(s); \\ W_d(s) &= \frac{K_d \cdot T_d \cdot s}{1 + T_d \cdot s}; \\ \text{Suppose } W_{D_2}(s) &= \frac{K_2}{(1 + T_2 s)^{n_2}}, W_D(s) = W_{D_1}(s) + W_{D_2}(s) = \frac{K}{(1 + T_s)^{n_1}} \\ \text{So we can get } W_d(s) &= \frac{K_d \cdot T_d \cdot s}{1 + T_d \cdot s} = \frac{K}{K_2} - W_{D_1}(s); \\ \text{Then we can work out } W_D^*(s) &= \frac{K}{(1 + T_2 s)^{n_2}}; \end{aligned}$$

Compare $W_D(s)$ with $W_D^*(s)$, apparently, they both have the same value of K, so we can deduce that $T_2 < T$, $n_2 < n$. It also means that using differential signal can reduce the transitional time of system on the premise that they have the same controllers' parameters.

Step2. The boiler superheated steam temperature control system

Set the valve opening of a given value $\mu = 5\%$, making other disturbance quantity is constant, then put the system simulated.

The simulation results are as follows:



Fig. 6 The system response of the boiler superheated steam temperature control system

Conclusion

Can see from transfer function expressions, in the single loop control system, primary signal is θ , and the variation tendency of I_1 is on behalf of θ , its delay time const is τ , its inertia time const is T_c . While in the guidance differential control system, the variation tendency of θ^* reflects controlled object's dynamic characteristic, and its delay time const τ^* is smaller than τ , its inertia time const T_c^* is smaller than T_c . It means the system is getting easier and better to be controlled.

From figure 6 as you can see, guidance differential control can play the same role in the boiler superheated steam temperature control system. When the valve opening is changed, both guidance differential control and cascade control can control the boiler superheated steam temperature control system steady and make system running well.

There are various kinds of systems which need being controlled in the automatic control, although power plant has enough fund to use two sets of PID controller for the boiler superheated steam temperature control system, it is significant for some other small system, for instance, we can take the same ideology into the speed control of intelligent car.

References

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