Optimization and application of coordination control system based on the site fast model

Zhang Fang and Zhang Li
Huadian Electric Power Research Institute Co., LTD., Hangzhou, China
E-mail: 815433165@qq.com

Abstract. According to the introduction of modern power system competition mechanism, the power grid frequency regulations and peak regulations requirements are getting higher and higher, so more and more units have participated in Automatic Generation Control (AGC) scheduling. The premise to realize AGC is that the control system of unit must have the function of coordinated control between steam turbine and boiler (CCS), and the quality of coordinated control between machine and furnace has a great influence on the use effect of AGC. In order to meet the needs of power grid and the economy of power plant, we propose an optimization method of coordinated control system based on field rapid modeling, which is implemented on distributed control system (DCS). This method reduces the difficulty of engineers' optimization, improves the control quality of CCS, and achieves the goal of energy saving and consumption reduction.

1. Introduction

With the development of economy, the proportion of large capacity units is more and more. For thermal power units are required to participate in power grid frequency control, load capacity, with the development of power grid technology and smart grid technology, grid dispatching center to the regulation of large and medium-sized thermal power plant unit is becoming more and more high quality requirements, these requirements include: a wide range of load change, static, dynamic tracking performance, stability, good load performance, etc.

Therefore, the CCS control logic and parameters need to be optimized regularly to ensure the parameter stability of the unit coordination control system when the unit meets the requirements of power system load change. Now An optimization method of coordination control system based on field rapid modeling is proposed in this paper.

2. Method

At present, modeling and experience optimization are the main optimization methods for the coordination control system of thermal power units at home and abroad. Most of the modeling are based on mechanism model and big data, but expensive, time-consuming and dangerous.

According to experience optimization, engineers have higher technical requirements, and the optimization process is uncertain. This paper mainly USES field data for rapid modeling, which can not only meet the precision requirements of the model, but also improve the controllability of optimization, with less cost and short cycle, and can quickly and effectively solve the actual production problems.

A fast modeling method based on unit disturbance test is introduced. The unit safe operation within the scope of change control, is accused of quantity after stability, the pure delay time for reading
response process, tau, time constant of the process of Tc, manipulated variable change measure ΔMV, modulated ΔPV, are shown in figure 1.

![Figure 1. Schematic diagram of response curve.](image)

Suppose the transfer function of the controlled object is shown in equation (1)

\[ G(s) = \frac{K}{(1+Ts)^n} \]  

According to equation (1), the transfer function of the controlled object can be obtained, and n, T and K need to be solved.

\[ \frac{\tau}{Tc} \] value is calculated, and according to table 1, the value of n is calculated.

| \( \frac{\tau}{Tc} \) | 0 | (0, 0.1) | (0.1, 0.22) | (0.22, 0.32) | (0.32, 0.41) | (0.41, 0.5) |
|---|---|---|---|---|---|---|
| n | 1 | 2 | 3 | 4 | 5 | 6 |

The calculation of T in the transfer function is shown in equation (2),

\[ T = \frac{Tc+\tau}{n} \]  

The calculation of K in the transfer function is shown in equation (3),

\[ K = \frac{\Delta PV}{\Delta MV} \]

3. Optimization

Test optimization on the 1000 mw ultra supercritical unit, CCS for supercritical unit, the main steam pressure and load response significantly faster than the drum boiler generating set, the optimization on the basis of the original DCS control logic, through the determination of control object model, determination of feed-forward channel model, control system simulation, the set value perturbation and the test of increasing or decreasing the load of unit step completion (whether you need to list each subsystem model). The control object model and feedforward channel model are measured by the method of field rapid modeling. Based on the model, the control system simulation and parameter adjustment are carried out to optimize the existing control logic.

In order to make the unit coordinated control system adapt to the changes of coal quality, a fuel calorific value correction loop based on unit load is designed.

Figure 2 is the basic technical route for CCS optimization.
4. **Control effect**

After optimization, the unit load response speed is accelerated and the main steam pressure deviation is reduced. Under the stable working condition of the unit, the deviation between the main steam pressure and the set value is less than 0.3 Mpa, and the deviation between the unit load and the set value is less than 5 MW. When the pressure deviation of the main steam is reduced, the fluctuation range of fuel volume, air volume and feed water flow of the unit is also greatly reduced compared with that before optimization, and the performance indexes of main steam temperature and reheat steam temperature are also improved. The load reduction curve response of unit 3, 620 MW-592 MW-522 MW-402 MW, is shown in figure 3. The maximum pressure deviation is 0.44 Mpa. The load response curve of unit 4 is shown in figure 4, figure 5 and figure 6. Figure 4 is the transition curve from 681 MW to 543 MW, figure 5 is the transition curve from 515 MW to 630 MW, and figure 6 is the CCS loop curve of 1000 MW stable load segment.
Through the display of the above four figures, the field rapid modeling method is used to carry out control system simulation and parameter adjustment based on the model. Optimizing the existing control logic is one of the more effective means. It can be seen that the pressure deviation during the variable load is small (generally no more than 0.5mpa), and the unit load response is timely (forward to the target according to the instruction). When the load is stable, the CCS loop is even more stable.

5. Saving energy effect
Another gain of this optimization is the energy saving effect of coordinated optimization. Thermal engineering major is not good at unit energy consumption calculation. I have seen some energy saving effects in the implementation of some optimization projects and saved data, but I did not analyse these
data systematically. In view of the outstanding steady-state effect of this optimization, the optimization team will make a comparative analysis of the data of the month before and the month after the optimization, and the data and curves are shown in Table 2, Figure 7 and Figure 8.

It can be seen that from Figure 7, the auxiliary power unit rate before and after optimization in various load all have varying degrees of decline, low load drop more, average of 0.24%, the image of the expert control when compared to the steady state is just like driving on the highway, even splits, and steady-state periodic load fluctuation is like driving in the city, often should speed up - the brakes - speed, energy consumption or scale than before and after.

The reduction in coal consumption from reduced utility rates alone is 0.68g/kWh, which is significant. Before and after the unit optimization, the coal consumption of power supply also decreased to varying degrees, with the mean value reaching 1.36g/kWh. Unexpected gains were achieved. On the basis of no additional equipment transformation, the thermal control specialty made outstanding contributions to the energy conservation of thermal power plants through its own efforts.

**Table 2.** Comparative analysis data of unit 3 before and after optimization.

| Unit load (MW) | Optimize coal consumption before power supply (g/kWh) | Optimized coal supply coal consumption (g/kWh) | difference value (g/kWh) | Optimize pre-plant auxiliary power unit rate (%) | Optimized auxiliary power unit rate (%) | difference value (%) |
|---------------|------------------------------------------------------|-----------------------------------------------|-------------------------|-----------------------------------------------|---------------------------------------|---------------------|
| 500           | 295.11                                               | 292.54                                        | 2.57                    | 5.18                                          | 4.84                                  | 0.34                |
| 600           | 287.49                                               | 286.07                                        | 1.41                    | 4.66                                          | 4.42                                  | 0.23                |
| 700           | 285.09                                               | 284.00                                        | 1.09                    | 4.40                                          | 4.18                                  | 0.22                |
| 800           | 285.88                                               | 283.59                                        | 2.29                    | 4.32                                          | 4.13                                  | 0.19                |
| 900           | 285.73                                               | 283.00                                        | 2.73                    | 4.43                                          | 4.31                                  | 0.12                |
| 1000          | 283.34                                               | 283.05                                        | 0.28                    | 4.59                                          | 4.39                                  | 0.19                |
| Average value | 1.36                                                  | Average value                                  | 0.24                    |                                               |                                       |                     |

**Figure 7.** Comparison curves of before and after optimization of unit 3
Figure 8. Comparison curves of power consumption before and after optimization of unit 3

6. Conclusion

Although the method of rapid modeling in the field is relatively poor in accuracy, it is faster, easier to start, and has good effect in practical application.

Based on the simulation optimization of the modeling method, the existing DCS logic optimization and adjustment, control quality has been greatly improved, to meet the grid AGC assessment, meet the DL/T655 standard, meet the requirements of power production. After optimization, the fluctuation amount and amplitude of coal feeding to the unit are small, so as to achieve the effect of energy saving.

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