Optimization of Frequency Modulation Control of Supercritical Reheating Unit

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Abstract. Through the research on the optimization of FM power plant, main disturbance of the power grid in a side of turbine, the boiler side mainly response delay and inertia and coal quality and for coal and furnace dust, aimed at the problems existing in the traditional PID in the unit control, based on the two degree of freedom PID control unit optimization scheme is put forward. The simulation is carried out before and after optimization, and the stability and economy of power grid frequency have been greatly improved.

Preface

With the new energy, increasingly in the proportion of new technology in the smart grid, the grid on the conventional thermal power units of the peaking FM capacity put forward higher requirements. Power grid regulations, the frequency of the grid beyond the primary frequency control dead zone within 3 seconds of its crew to respond in a timely manner. In the cycle of within 10s,the frequency fluctuations can be self-absorbed by the load; in the cycle of relatively long frequency fluctuations, because the primary frequency can not meet the requirements, must conduct the second adjustment of the frequency that is AGC control.

To ensure that the overall stability of the grid, the AGC and the primary frequency control unit must be fast and accurate response. The domestic units are basically running in the predominantly boiler follow under coordinated control mode (BF - CCS), that is, steam turbine side of the regulation of power, the boiler side to adjust the pressure. When the unit load command changes, rely on the steam turbine side for rapid power adjustment, the boiler side according to the load and pressure changes simultaneously adjust the wind, coal, water, so that the unit to maintain energy balance. .Because of the effect of primary frequency control and the accuracy is closely related with the economic benefit of power plant, so a frequency has been more and more attention, by increasing the primary frequency compensation and reduce the dead zone of primary frequency to ensure the qualified rate of a frequency modulation, but these methods produce very big disturbance to the coordinated control of the unit, a frequent movement of frequency modulation, not only affect the unit AGC regulation quality, but also affect the unit's economic operation level.

The Problem of Coordinate Control

China's unit coordination and control effect will be affected by all aspects of factors, the main side of the turbine side of the power grid disturbance, the boiler side of the main response to the delay and inertia and coal interference and coal consumption and furnace fouling and other interference, and this interference belongs to a kind of uncertain disturbance, difficult to measure and expect during operation, so that the design of the control system is more complex, and the control effect is not satisfactory.

At present, the power grid unit coordination control system commonly used traditional PID

control as shown in Figure 1, because it can only set a control parameter, call it a degree of freedom PID control. The external disturbance suppression characteristic and the target value following characteristic are the two characteristics of PID control. As the traditional PID control can not meet these two characteristics at the same time, it can not achieve the best control characteristics.

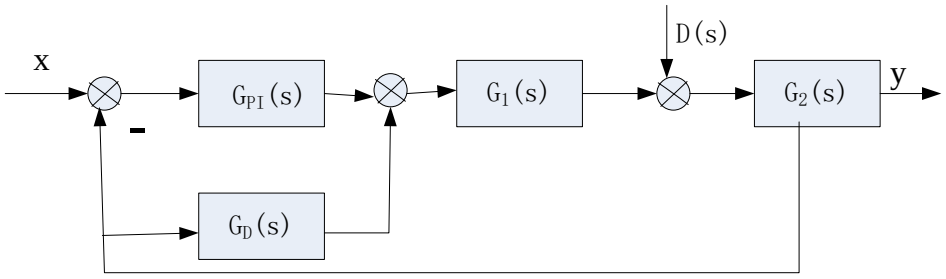

Fig. 1 block diagram of tradition

Based on Two-Degree-of-Freedom PID Control and Coordination Optimization Scheme

The traditional coordination system in the boiler main controller generally uses the PID controller, the steam turbine main controller generally uses the PI controller. And for the coordinated control system need to control the target value. Based on the two-degree-of-freedom PID control optimization scheme is based on the traditional PID control scheme to increase the corresponding compensation link and adjustment coefficient, as shown in Figure 2:

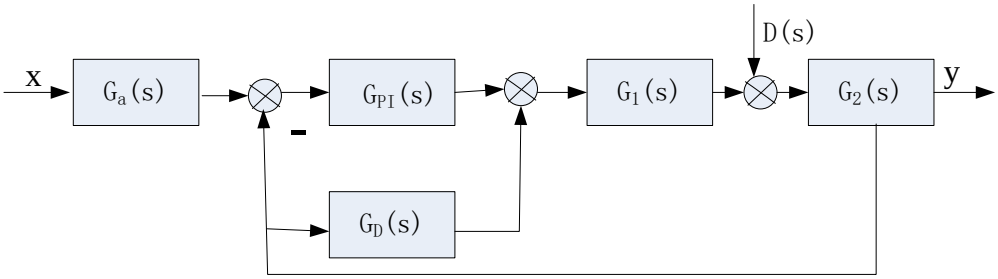

Fig. 2 block diagram of two-degree-of-freedom PID control algorithm

Based on the two-degree-of-freedom PID control optimization scheme, the block diagram is given the following formula:

$$G_a(s)=\frac{1+(1-\lambda)T_{iS}}{1+T_{iS}} \tag{1}$$

$$G_{PI}(s)=K_P+\frac{K_P}{T_{iS}} \tag{2}$$

$$G_D(s)=\frac{K_P T_{dS}}{1+\lambda T_{dS}} \tag{3}$$

When using the two-degree-of-freedom PID control algorithm, the system outputs a given response as shown in equation (4), the response of the traditional PID is as follows(5):

$$\frac{Y(s)}{X(s)}=\frac{G_a(s)G_{PI}(s)G_1(s)G_2(s)}{1+G_1(s)G_2(s)\left(G_{PI}(s)+G_D(s)\right)} \tag{4}$$

$$\frac{Y(s)}{X(s)}=\frac{\left(G_{PI}(s)+G_D(s)\right)G_1(s)G_2(s)}{1+G_1(s)G_2(s)\left(G_{PI}(s)+G_D(s)\right)} \tag{5}$$

(1)From the above equation (4), it is known that the differential link adopts differential first with incomplete differential. When the unit is in the rapid adjustment stage of load, that is, a frequency modulation preload instruction set value change rate is large, the boiler master must be quickly

adjusted to make the wind, coal, water and other fast action, at this time in order to ensure its needs, can take two degrees of freedom PID to the boiler main control loop, increase the module of one-order inertial system and the auxiliary judgment logic this optimization scheme.

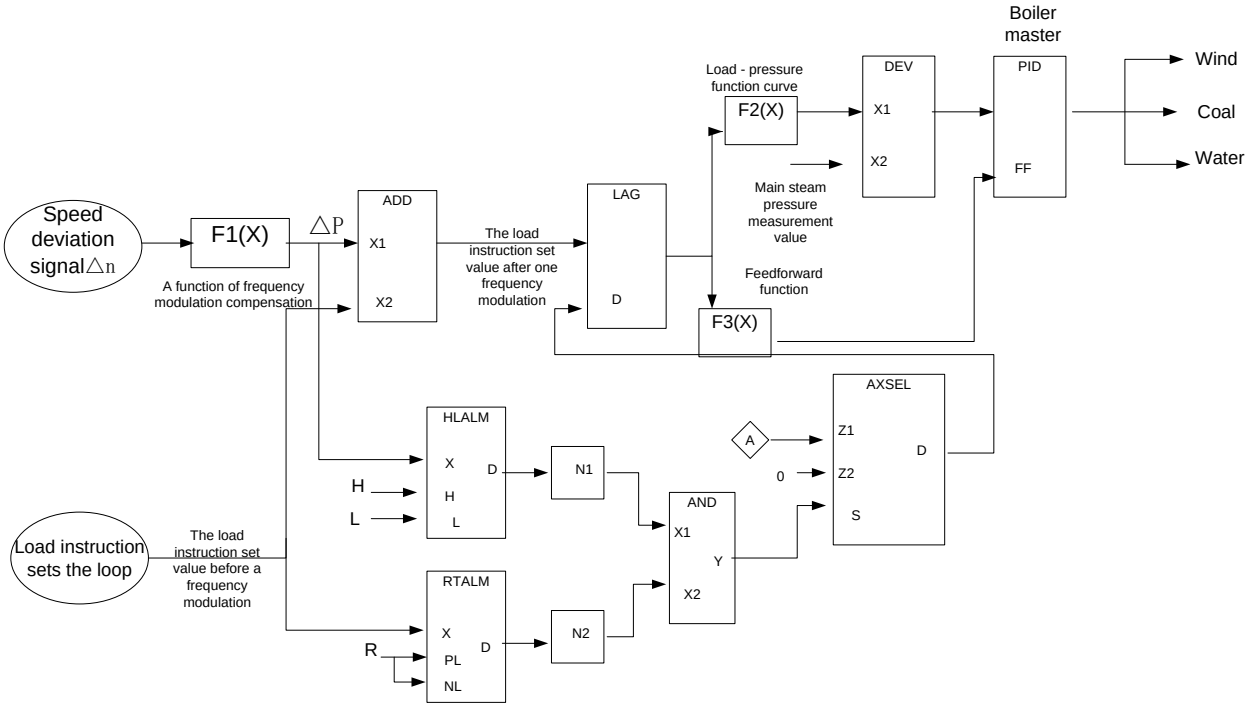

Fig. 3 schematic diagram of main control logic of boiler after optimization

The introduction of differential signal can improve the dynamic characteristics of the system, but also may introduce dynamic interference, adding a first-order inertia link can effectively suppress the high-frequency interference. Compared with the above 1 and 2, the molecules of the two degree of freedom PID algorithm control algorithm for G_{PI} (s), without differential effect, while control algorithm of the general PID algorithm is G_{PI} (s) + G_D (s).

The program can effectively improve the ability of the supercritical unit to cope with a frequency modulation, improve the stability of the unit in a small frequency fluctuation, effectively improve the dynamic response of the system to ensure the safe and stable operation of the unit itself.

(2)In the main control aspect of steam turbine, there is a Ga in the above formula 4, which is a variable parameter filter whose main function is low pass filtering and suppression overtone. In the CCS mode, the main control PID of the steam turbine is adjusted according to the deviation of the given load and the actual power value of the unit, and the feedforward and the main steam pressure correction circuit are added in the steam turbine master PID regulation. The control algorithm is a target filter plus proportional integration algorithm, which can effectively achieve the stable operation of the system.

By increasing the closed-loop and PD feedforward load control loop, can achieve the unit load closed-loop regulation, and through the PD feedforward loop to improve the unit load adjustment speed,to ensure that the grid AGC unit to meet the inspection requirements, at the same time improve the large disturbance test of primary frequency when the initial load response speed and amplitude, to ensure that a qualification rate of FM large disturbance test meet the requirements.

The Simulation Verification

The following waveforms are obtained by simulating the control optimization based on two degrees of freedom PID and traditional PID control. It can be seen from Figure 4 that the control algorithm of the two-degree-of-freedom PID can achieve the control optimization parameters more accurately than the traditional PID control algorithm. The target value is faster and more stable, and the adjustment time is shorter and the overshoot is more suitable.

It can be seen from Fig. 5 that the control algorithm of two-degree-of-freedom PID is superior to the traditional PID control algorithm, and can overcome the interference in the shortest time and reach the steady state.

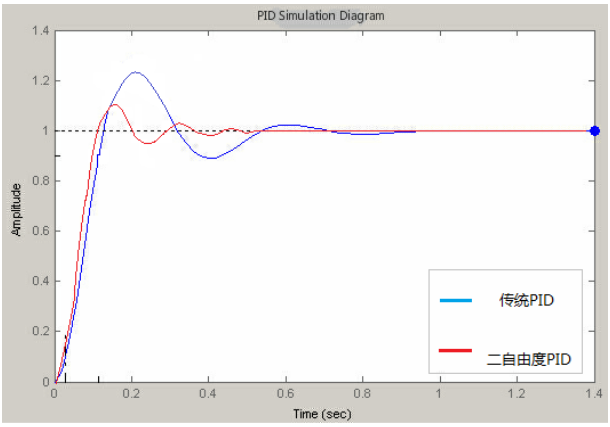

Fig. 4 PID optimization before and after simulation diagram

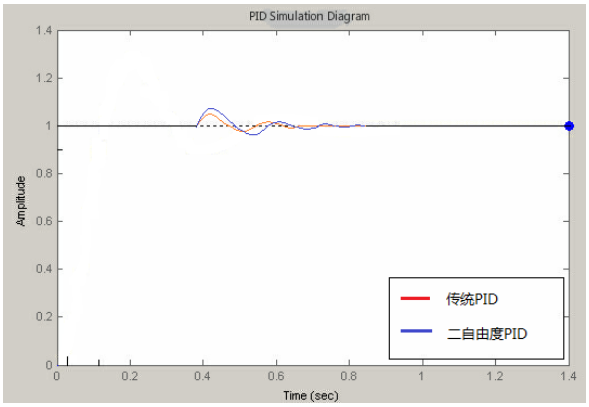

Fig. 5 PID anti-interference comparison simulation diagram

Conclusion

With the rapid development of power system, the existence of its disturbance factors are increasing, which makes the stability and reliability of the unit greatly reduced, so this paper put forward with regard to this phenomenon of ultra-supercritical once FM reheat unit control coordination under two degree of freedom PID control is optimized to ensure safe operation, also can optimize the unit in a certain disturbance range,to optimize the unit control within a certain disturbance range, and better economic performance.

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