Research on Primary Frequency Modulation of Coordinated Control System for Wind Power Generator and Thermal Power Unit

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Abstract. Combined with the practical problems in the development of power system, the paper introduces the technical scheme and characteristics of primary frequency modulation (PFM) for thermal power units. Aiming at the impact of the rapid development of wind power generation on the stable operation of the power grid, the PFM strategy on the coordinated control system for wind power generators and thermal power units is proposed to dynamically adjust the PFM capacity of thermal power units, which effectively make up for the adverse impact of the uncertainty of wind power generation, and improve the stable operation capacity of the power grid. It has certain reference significance on the flexible operation control optimization of the power grid in the wind power centralized area.

1. Introduction

Wind power generation has the technical characteristics of non-polluted and easy to use, so wind power generation has become an important part of the development of new energy power. With the development of wind power equipment and the support of power policy, wind power generation has developed rapidly. The installed capacity of new energy such as wind power is becoming larger and larger, and some regions account for 40% of the total installed capacity. The composition of power grid is becoming more and more complex. Due to the large randomness and poor predictability of wind power generation, the wind power load fluctuates greatly, which has a negative impact on the stable operation of power grid frequency [1]. The pressure of frequency modulation and peak regulation is also increasing, which increases the pressure of power grid dispatching, especially in the north and coastal areas of China where wind power generators are concentrated.

2. The Overview and Technology Status of PFM

2.1. The Overview of PFM

During the operation of the power grid, the frequency is mainly affected by the power grid input and consumption. When the power consumption does not match the input power, it can cause the small and short period change in grid frequency, which mainly relies on the regulating system of the steam turbine generator to directly and automatically adjust the steam admission control valve to change the load, that compensate the real-time load instruction of the power grid, and correct the fluctuation of
the power grid frequency[2]. It's the principle of primary frequency modulation(PFM). The PFM structure diagram is shown in Figure 1.

Figure 1. The typical structure diagram of PFM

2.2. The Optimization Technology of PFM

2.2.1. Correction of PFM Instruction. The instruction correction technology can modify the primary frequency modulation instruction according to the operation parameters, which can change the compensation load of the primary frequency modulation. The common methods include multiple amplification instruction or deviation correction of the instruction. In principle, this technology belongs to the modification of the speed unequal rate of the primary frequency modulation, and its implementation is relatively simple. It is also the most widely used[3].

2.2.2. Variable Parameters Control on Load Control Loop. To speed up the load response of the unit, the thermal power units usually used coordinated control. At the same time, the load control loop used PID control strategy, which added the feed-forward and differential of the load instruction. When the power grid frequency is fluctuating, the ability of load compensation response and primary frequency modulation can be improved by the instruction differential[4].

2.2.3. Data Transformation of The Same Source. The primary frequency control system consists of DCS and DEH. Real-time data of grid frequency participating in control system and sending to dispatching department for evaluation maybe from different data sources, which make the actual compensation capacity of the primary frequency modulation can't reach the design value. At present, in order to improve the primary frequency modulation capability, some units carry out a data transformation of the primary frequency modulation control system to ensure that the frequency data involving the primary frequency modulation system are the same source, and to improve the accuracy of the primary frequency modulation compensation.

3. The Problem of Power System Frequency Modulation

Because wind power and other new energy are limited by their own technical characteristics, their ability to participate in grid frequency modulation is poor. The decentralized new energy generation is less controllable, and their contribution to grid flexible regulation is small. The task of frequency regulation of some regional power grids which are lack of flexible regulation means, such as hydropower and gas generating units, mainly depends on thermal power generating units. Therefore, in the coordinated control system of wind power generation and thermal power generation, how to better ensure the frequency stability of power grid, especially in the wind power concentrated area, is an important problem for the safe and stable operation of power grid. This paper mainly introduces how to optimize the primary frequency modulation system of the thermal power unit, improve the frequency modulation ability of the unit and support the stable operation of the power grid in the coordinated control system of wind power generation and thermal power unit.
4. Coordinated Control Technical Scheme
The structure of the coordinated control system for thermal power unit and wind power generation is shown in Figure 2. The main components include wind turbines, wind power load forecasting devices, power grid monitoring units, RTU devices, thermal power unit control systems, thermal system equipment, generator output monitoring devices, and so on.

4.1. Task Rating of the thermal Power Unit's PFC
The load of wind turbines can be calculated through the measuring device, which was sent to the power grid monitoring unit. According to the power grid operation parameters such as wind power output, thermal power output, power flow. The power grid monitoring unit calculates and determines the PFM's task level of the thermal power units in the key PFM areas. the PFM's task level are generally divided into ordinary mode(OM), compensation mode(CM), and emergency mode(EM).

4.2. Thermal Power Unit's Load Optimal Dispatch
During the operation of the power grid, the load instructions of the frequency-modulated thermal power units in the PFM key areas are adjusted to the load range with better regulation performance(60%-90% Rated load).The thermal power unit Control System accepts load instructions and PFM's task level signals issued by RTU, then adjusts its operation modes.

4.2.1. Generator Set Adaptive Control
After the thermal power unit accepts PFM's task level signals issued by the grid dispatch, it automatically adjusts the unit speed unequal rate and variable load rate settings to improve PFM and AGC capabilities. For example, when the wind power generation output is large at night, the frequency regulation task of the power grid is more stressful. At this time, the thermal power unit Control System in the PFM key areas automatically converts PFM mode from OM to CM according to the operation of the grid. That is to reduce the unit speed unequal rate and increase the unit's variable load rate, which can increase the unit's frequency response speed, and stabilize the safe operation of the power grid. When the grid frequency deviation exceeds the grid frequency standard, the grid monitoring unit issues an instruction to transfer PFM mode to EM, and forces the unit's load to rise or fall. At the same time, wind power generator reduces power output through its own regulation. Coordinated control of wind power generators and thermal power units to maintain stable operation of the power grid.

![Figure 2. Structure schematic diagram of coordinated control system](image-url)
5. Application and Prospect
According to the operation parameters of power grid and wind power output, the PFM method of the coordinated control system for wind power generation and thermal power generation can automatic adjust of PFM parameter settings of thermal power unit, and improve the PFM ability of thermal power unit. At the same time, it can improve the rapid adjustment ability of power grid in the rapid development area of wind power, and improve the stable operation of the power grid.

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