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PECULIARITIES OF TPS UNITS PARTICIPATION IN THE SECONDARY FREQUENCY CONTROL IN THE ITEGRATED ENERGY SYSTEM OF UKRAINE

The paper analyses the problems of participation of TPS power units in the secondary frequency control. Consideration of the non-linear element in the flexible feedback of the control system and refining the models of the power units will improve maneuverability characteristics of TPS and provide meeting the requirements for participation in the secondary frequency control and active power in IES of Ukraine.

Keywords: *secondary control of frequency and active power, energy system operating modes, modeling, thermal power station.*

Introduction

Automatic control of frequency and active power plays an extremely important role in ensuring power system reliability and its safe operation. In IPS of Ukraine there is a problem of providing secondary resources for satisfying the requirements as to the secondary control of frequency and active power. The use of TPS units in the secondary frequency control will make it possible to increase maneuverability of the energy system of Ukraine and the efficiency of frequency control.

The research aims at studying the problems of participation of TPS units in the secondary frequency control in IPS of Ukraine.

Problem set-up

At present the Integrated Energy System of Ukraine operates in parallel with the Integrated Energy System of Russia. Frequency control in IPS of Ukraine is conducted in the automatic mode of the active power control with frequency correction.

Rapid development of renewable energy sources and their application in IPS of Ukraine, observed in recent years, puts forward new requirements to the systems for automatic control of frequency and active power (SARFP) as the main part of the turbines of the wind and solar plants are connected to the network through the inverter converters that have low inertia. Therefore, in case of the growing share of renewable energy sector in the generating powers as well as partial replacement of the units of traditional energy sources, inertia reduction will be observed in IES of Ukraine, which will negatively influence frequency control in the energy system as a whole. To solve this problem, it is necessary to take measures as to increasing the power of the primary and secondary control reserves.

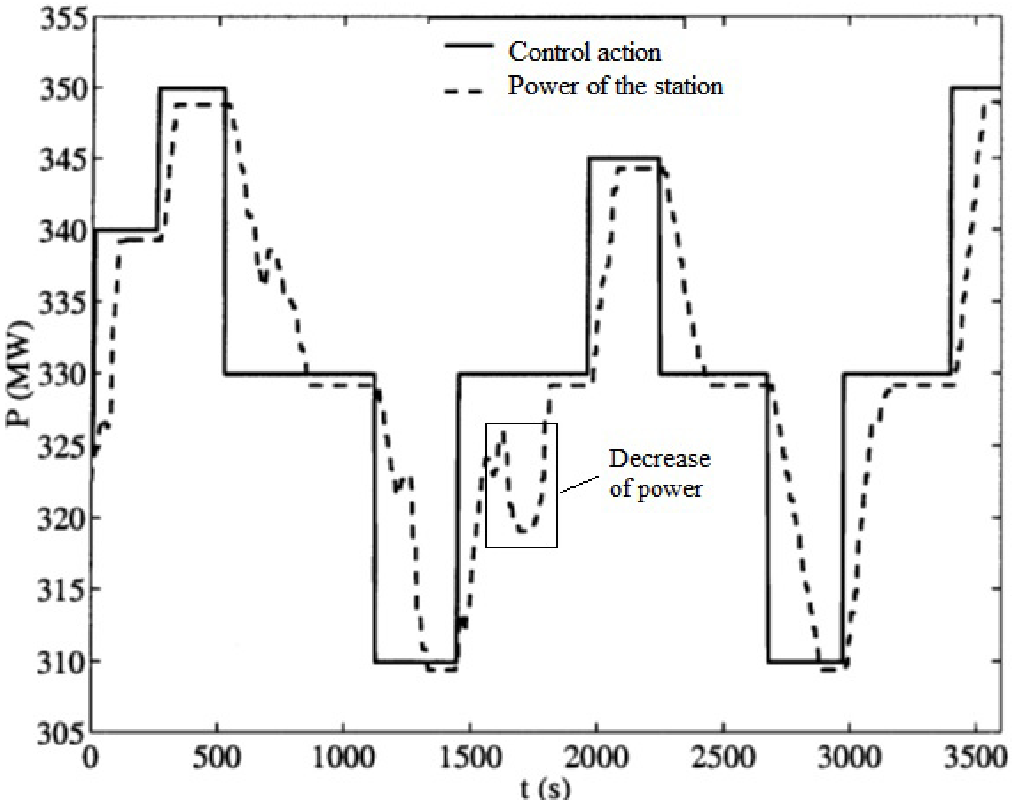
At present, only Dniepro TPS-1 with the total power of 432 MW, connected to SARFR of Ukraine, participates in the secondary frequency control. It should be noted that Kremenchug, Dnieprodzerhzinsk, Kakhovka and Kyiv hydro-electric power stations with the total power of 797.4 MW could be involved in the secondary frequency control [2]. To satisfy the requirements [3], this control secondary capacity will not be sufficient.

Involvement of TPS units in the secondary control will make it possible to increase the necessary reserves of the secondary control capacities. However, in the recent decades unfavorable conditions have developed in Ukraine for the use of TPS units as a part of maneuverable capacities. The main reason for the low attractiveness of the TPS units involvement in the frequency control is low maneuverability and automation of the units. Moral and physical resources of the existing systems for power unit automation have been exhausted, which affects negatively the maneuverability characteristics of TPS. In order to increase maneuverability of the units and their involvement in the secondary control of frequency and active power, there is a need for studying the compliance of the mathematical models of the power units with the experimental data as well as for revealing the drawbacks of the existing automatic systems for controlling the output power of the power unit and to propose measures directed towards TPS maneuverability improvement.

Solution of these problems will make it possible to involve TPS power units in the secondary control of frequency and power, which will increase the secondary power control range, will have a positive influence on the efficiency of frequency control in IES of Ukraine and satisfy the requirements of the current normative documents [3].

Research results

While studying the efficiency of secondary control with the involvement of TPS units, simplified models are often used that, at best, take into account non-linearities such as dead zone of the station regulator, gain or decrease of the unit power [4]. Studies of the experimental data [5] have shown that when the regulator control signal arrives, the thermal station unit with the power of 355 MW starts to increase its output power. However, overtime the block power decrease is observed. Fig. 1 presents a graph of the unit active power change depending on the change in the control influence of the unit control system. Similar data were also obtained for other units of different powers.



(4)

Fig. 1. The graph of change in the active power of the station unit depending on the output control influence of the control system

Such characteristic reduction of the unit output power from 1600 to 1800 is explained by the influence of the boiler house equipment on the turbine, namely: when the control influence for the increase of the station active power arrives, the regulating valve opens to the set value relative to the initial position and larger amount of the energy carrier is supplied to the turbine. As a result, the station power starts to increase. However, after a certain time interval the vapor pressure starts to decrease and the boiler control system supplies a control signal for closing the regulating valve. The boiler furnace is unable to provide rapid growth of the energy carrier pressure. When TPS are involved in the secondary frequency control processes, the boiler equipment influence should be taken into account for the adjustment of the station regulators as well as for the adjustment of SARFP regulator of IES of Ukraine in order to provide more efficient regulation process in IES of Ukraine as under such reduction in the output power of TPS units, involved in the secondary control, SARFP system changes the output values of the control influences on the regulating stations. This causes worsening of the energy system maneuverability characteristics.

Another problem, arising when TPS is switched to the maneuverable operating mode, is a significant regulation error and rapid exhaustion of the actuation equipment, caused by the negative influence of the differentiator of the turbo-unit speed control system. For reducing the regulation time and damping vibrations in the rotor speed regulator, which is a component of the turbogenerator control systems, differential feedback is introduced. When mechanical-hydraulic systems were used, the rotor speed derivative measurement was conducted with significant error, which resulted in false triggering of the differentiator. Switching from mechanical-hydraulic to electrohydraulic systems enabled partial compensation of these drawbacks. However, in the process of the turbine rotor speed regulation there is a problem of determining the differentiator transfer coefficient in the flexible feedback of the turbine speed electromechanical control system. The research [6, 7] has shown that in the case of a non-linear system, represented by the mathematical model of the turbine, the feedback transfer coefficient value will change with the rotor acceleration value variations. If this coefficient is fixed at a single value, oil pressure variations will be observed in the actuation part of the control system, which will affect significantly the time constant values of the servomotors. This will cause significant static regulation error as well as rapid exhaustion of the actuation equipment resource. Therefore, there is a problem of determining the control system coefficients under the control object parametric uncertainty conditions. Its solution will make it possible to improve regulation characteristics of TPS units as well as to involve them in the secondary control of frequency and power.

Conclusions

1. The current state of TPS energy units does not allow their involvement in the secondary frequency control because their regulation equipment is morally and physically obsolete. Transition from mechanical-hydraulic to electrohydraulic control systems will enable application of more effective algorithms and laws for the control of TPS power units in frequency regulation in IES of Ukraine.

2. Taking into account the thermal part of TPS unit as well as the non-linear element in the flexible feedback in the mathematical model during the process of designing station regulators and SARFP regulator, will make it possible to improve regulation characteristics of TPS units.

3. The proposed measures will enable involvement of TPS power units in the secondary control, which will increase the secondary power resource and improve the efficiency of secondary frequency control in the energy system.

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