EXPERIENCE IN THE OPERATION OF HYDRO DEVELOPMENTS AND HYDRAULIC TURBINES

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In the USSR electrohydraulic governors of turbines began to be used instead of hydromechanical governors at the end of the 1950s. At present six modifications of electrohydraulic governors (EHGs) differing not only in basic design but also in the block diagram are presently operating at Soviet and foreign hydroelectric stations along with hydromechanical governors. Despite these differences, a large part of the functional components of all EHG modifications are of the same type. The characteristics of the operation of two of them — the floating control component and automation scheme — are examined below for the example of governors of type ÉGRK-2M and ÉGRK-1T.

One of the differences of the floating control device in an EHG from the dashpot in hydromechanical governors is the absence in it of limitation of the action of the RC output signal. This leads to the need to supplement the EHG scheme with automatic devices intended for eliminating the consequences of this characteristic. However, the uncoordinated or untimely action of these automatic devices in a number of cases control leads to the incorrect action of the system.

According to the specifications of the State Standard (GOST) 12405-81 governors should provide "stable automatic control of the unit during operation under no load, under an isolated load, and in the power system, during load drops and surges," i.e., the correct action both in steady and transient operating regimes of the unit. In modern power systems the units operate, as a rule, in a no-load, idling regime during synchronization and in a power regulating regime (with frequency offset behavior), usually in a group active power control (GAPC) system. At the same time, a large number of units, along with these regimes, can operate also in a frequency control regime in a region isolated from large power systems.

To adapt the control system in these operating regimes of the unit, special measures are provided for in the EHG which are realized automatically during the transient. Thus, for example, during drops of the load automatic switching occurs by disconnection of the generator switch from the load floating control component to the idling floating control component, the set values of which were chosen beforehand from the condition of providing stability of the control system during idling operation of the unit and providing a minimum time of synchronization. Upon disconnection of the generator switch conversion of the mechanism changing the opening (MCO or MCP) to a position at which the signal from it is compensated by the signal of the sensor of the opening of the gate apparatus (to the "idling" position) is also accomplished automatically.

As a rule, the set values of the idling floating control component \((B_t \text{ and } T_d)\) are small, and therefore the slowing action of the floating control component is small, and if the mechanism changing the frequency (MCF) is not in the extreme position "to increase" and conversion of the MCP acts, control is realized despite the absence of limitation of the action of the floating control component in the presence of large disturbances.

Different results are obtained in the case of a drop or surge of the load, when the unit operates in a network and the generator switch is not disconnected. Such a situation is created when the units are separated from a large power system with conversion to operation under an isolated load. Since the generator switch remains connected, information about a change in the operating regime of the unit arrives in the control system only in the form of a considerable deviation of the network frequency from the rated. In this case, the floating control component, the set values of which should be chosen from the condition of providing stability of the control system during idling operation of the unit and providing a minimum time of synchronization, is not switched and there is no conversion of the MCP. As a consequence of the fact that the action of the floating control component is not limited and the speed of response of the governor is small, the dynamic changes in the frequency (increase in the case of a drop and decrease in the case of a surge of the load) are considerable.

Upon a drop of the load the increase of the rotational speed reaches the value of the set value of operating the 110% protective relay, bringing into action the programmed closing device (PCD) of the gate apparatus in the governor for adjustable-blade turbines. Under the action of the PCD the gate apparatus rapidly closes to the idling opening, and the blades...
turn through the starting angle. The frequency in the isolated power region is restored to the rated and the 110% relay returns the governor to a frequency control state. However, if the power of the consumers is greater than the power of the units being developed with small openings of the gate apparatus, then in the case of large set values of the floating control components a decrease of the frequency below the rated occurs as a consequence of the small response speed of the governor and inertia of the unit. Then under the effect of a signal from the MCP (MCO), which was left in a position corresponding to operation in a large power system, and signal from the frequency meter the gate apparatus opens. The dynamic increase of the frequency as a consequence of the causes indicated above again reaches the value of operating the PCD and the process is repeated. Thus self-excited oscillations of the frequency and power leading to cancellation of consumers occur in an isolated power system.

In the case of a load surge as a result of slow opening of the gate apparatus due to the disconnecting action of the floating control component, a deep decrease of the frequency and voltage occurs, which is perceived by the auxiliary equipment as a loss of voltage of own needs with all ensuant consequences.

During adjustment and operation of the type ÉGRK-1T and ÉGRK-2M electrohydraulic governors by the operating personnel of electrical engineering laboratories of a number of hydrostations, specialists of the Leningrad Metals Plant, and specialists of the Industrial Association for the Adjustment, Improvement of Technology, and Operation of Electropower Stations and Networks (Soyuztekhenergo) introduced a number of measures substantially improving the operation of these governors. We will examine some of these measures.

1. For improving the dynamic characteristics of the control system in the transient process, in the type ÉGR-1T governors is provided switching of the load floating control component to smaller set values of the idling floating control component for the time of action of the 110% protective relay (R23). The contact of this relay opens the circuit of relays R15 and R16, disconnecting them, which enables switching from the load floating control component to the idling floating control component. Upon disconnection of this relay (at the rated rotational speed) the contact again closes and connects the load floating control component (if the generator switch is on and the contact of relay R4 is closed). To improve the dynamic characteristics of the governor also in the case of a load surge with a decrease of frequency, in the circuit of the relay of the floating control component (R15, R16) is connected a normally closed contact of the frequency decrease relay RF-1 or its followers. Where relay RF-1 is not installed or any reason, for this purpose it is possible to use the circumstance that the circuit of relays R15, R16 is supplied from the voltage of a tachometer generator, the value of which is proportional to the rotational speed of the unit. For this purpose, contacts of relay R16 and additionally installed tuned resistors RN1 and RN2 are connected instead of the contact of RF-1 into the circuit of relays R15, R16 on the printed board of subblock SB17 according to the scheme in Fig. 1. By means of these resistors is tuned the voltage operating R15, R16, close to the voltage of the tachometer generator at a nominal speed, and the dropout voltage corresponding to a speed below the rated, at which the relay drops out, switching the floating control component with closed contacts of R23 and R4.

2. In the type ÉGR-1T governors conversion of the MCP is accomplished for eliminating incorrect action when changing to an isolated load with dropping it; for this purpose relay R14 is reconnected according to the scheme in Fig. 1. In this case, with the generator switch connected the process of converting the MCP lasts during the time of action of relay R23. Despite the fact that the position of the MCP after converting may not exactly correspond to the load on the generator, nevertheless its action during the transient substantially improves the dynamic properties of the control system.

Realization of these measures in the type ÉGR-2M regulators is difficult, and therefore examples are not given here, especially as their realization is not necessary also in the ÉGR-1T when the scheme of limiting the output signal of the floating control component is fulfilled.

3. Since the primary cause of incorrect action of the control system in the presence of large disturbances is the absence of limitations of the action of the floating control component, the introduction of this limitation should be carried out primarily on electrohydraulic governors.

With consideration of the relationship of the parameters of the electrical circuits of the output of the floating control component, output of the frequency meter, and input of the magnetic amplifier, limitation of the action of the floating control component in the ÉGR-2M is most simply accomplished on its capacitor on the output side by stabilitrons D1 and D2 connected in opposition (Fig. 2).

For the ÉGR-2M governors the voltage \( U_{\text{stab}} \) is about 15 V and is limited by type D815E stabilitrons. A limitation is placed on the load floating control component (it can be of equal value) and on the idling floating control component.