DETERMINATION OF ALLOWABLE CHANGES IN THE TURBOGENERATORS LOAD WITH DIFFERENT COOLING SYSTEMS

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In transient operating modes of a turbogenerator (TG), significant changes in the thermal state of their windings and structural components occur. Such modes include periods of peaks and troughs in energy consumption, the impact of automatic excitation control systems, etc. During operation, frequent starts and stops of the TG (up to 30-40 times a year) lead to a change in the temperature of its active parts by 50-70 ºC even when operating only in nominal modes. Even an uneven daily schedule of TG operation leads to a change in the temperature of its active parts by 25-35 ºC. As the load increases, thermal elongation of the winding rods occurs, deformation (stretching) of the insulation occurs, and mechanical stresses arise, the magnitude of which depends on the rate of temperature rise. Friction and adhesive forces bind the copper and insulation so they elongate equally. Consequently, the state of insulation under variable load conditions is determined by the rate of the winding rod deformation when the current changes.

The rotor winding bars cannot freely extend in the rotor slots when the load suddenly increases. This is prevented by friction forces that arise when the rotor rotates due to centrifugal forces. Therefore, movement of the rotor winding in the grooves in the rotating rotor is not observed, and thermal elongation of the copper rods turns into compression deformation. If the yield strength of copper is exceeded, the deformation will be irreversible (the yield strength for permanent deformation of soft copper at +20°C is 90-150 MPa) [1]. Despite significant residual temperature deformations of the rotor winding copper rods, cases of emergency limitation of TG with indirect cooling of the rotor are very rare. In a TG with direct cooling of the rotor, when the turns in the ventilation channels of the rods are shortened, a narrowing of the flow area occurs and the cooling conditions sharply deteriorate. This causes significant local overheating of the rotor winding. Particularly dangerous are sudden increases in load immediately after the TG reaches the synchronous speed at start-up. For example, the need to significantly increase the current in the field winding and therefore its temperature, when the load increases sharply after self-synchronization of the TG with the network.

Due to the large difference in the thermal constants of copper and steel, the difference in their heating temperatures can reach large values. In this case, temperature stresses in copper can exceed the yield strength, which will inevitably lead to residual deformations. Therefore, for TG with direct cooling of the rotor winding, additional calculations are performed and an analysis is carried out of modes in which significant heating is possible and which can cause residual thermal deformation of copper.

Reference:

1. Shevchenko V.V., Minko A.N., Dimov M. Improvement of Turbogenerators as a Technical Basis for Ensuring the Energy Independence of Ukraine // Kharkiv: NTU "KhPI". – Electrical Engineering & Electromechanics, 2021, no. 4, pp. 19-30. doi: 10.20998/2074-272X.2021.4.03