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METALS AND STRENGTH ANALYSIS

Analyzing the State of Steam Turbine Metal Based on Safety and Reliability Factors

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Abstract—An approach for estimating the technical state of the metal of turbines with a capacity higher than 200 MW installed at thermal power stations is described. Different methods for estimating the lifetime of turbine elements are compared with one another. A procedure for monitoring the current state and residual life of turbine main elements is proposed. A turbine decomposition procedure is carried out, and a set of parameters and technical state criteria for groups of critical elements in a turbine corresponding to these parameters are developed. Stages of estimating the current technical state of equipment are suggested. The possibility of estimating the technical state of each individual element and the turbine as a whole is revealed.

Keywords: turbine, rotor, technical state, state parameter, criterion, point, monitoring

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Unbiased assessment of the technical state of equipment operating for a long period of time has to be carried out if we wish to evaluate the prospects of its further operation. At present, the normative service life (the fleet life) of high-pressure turbines designed for operation at steam parameters of 13.0–24.0 MPa and 535–560°C is no more than 220 000 h [1]. In the course of operation, significant changes occur in the metal of rotors and cast casing parts, causing their reliability to degrade.

In this paper we present a new approach for estimating the technical state of equipment and prospects of its long-term operation. We also analyze approaches for estimating the state of metal based on the results of its examination carried out according to the existing regulatory documents and propose new solutions for this problem proceeding from a comprehensive analysis of reliability and safety factors.

The *STO (Industry Standard) 17230282.27.100.005-2008: Main Components of Boilers, Turbines, and Pipelines for Thermal Power Stations. Metal State Examination. Regulations and Requirements* is one of regulatory documents establishing the norms and requirements for methods and means of examination, organization and procedure for carrying out examination, and for the procedure of extending the service life of the main elements of heat-generating and mechanical equipment [boilers, turbines, and pipelines of thermal power stations (TPSs)]. This regulatory document incorporates all requirements that were contained in the previously issued guidelines, enterprise standards, and other documents prescribing the procedure of carrying out examination, estimating the technical state, and extending the service life of TPS turbines. These documents are based on a common approach for estimating the lifetime of turbine metal.

The following information is used in analyzing the state of turbine metal [2, 3]:

—information on the operating mode, damages, replacements of individual equipment elements, restorative repair, and results of metal examination throughout the entire service life;

—data of nondestructive tests;

—results from investigation of metal structure and properties; and

—results from an analysis of a calculated assessment of stressed state and residual life taking into account actual data on the properties of metal and operating conditions.

For turbines with a capacity of higher than 200 MW, their high-pressure rotors, intermediate-pressure rotors, and cast casing parts operating at temperatures and stresses under which damage accumulation processes governed by creep and low-cycle fatigue mechanisms occur in metal are the critical elements determining the equipment lifetime. In addition, the fasteners of flanged joints operating at a temperature of 450°C or higher relate to the category of critical elements.

Different approaches are applied for estimating the technical state of large steam turbines. Thus, examination of the high- and intermediate-pressure parts involving full disassembling and withdrawal of the rotors is carried out only during an overhaul or intermediate repair. The metal of the low-pressure parts can be examined also during a current repair. The service life of the most critical turbine elements, such as high-and intermediate-pressure rotors and turbine