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Streszczenie w języku angielskim

Conventional power units currently operating in the national energy sector within an "energy mix" framework interact with rapidly fluctuating renewable energy sources. This situation, which entails multiple shutdowns and restarts of conventional units, adversely affects the service life of the equipment, particularly by causing damage to critical structural components. To counteract this and maintain the conventional units' operational lifespan at a standard level, it is necessary to control the critical areas of boiler, turbine, and condenser structures so as to prevent excessive wear resulting from accelerated and repeated thermal load changes.

The purpose of this doctoral dissertation is to develop a method for controlling a selected critical component of the turbine's structure, namely the radial blade in the control stage of the highpressure section. The control technique proposed herein should be considered "advanced" because it employs steam injection to mitigate the thermal state, while information regarding the injection method and technique is obtained via an advanced numerical simulation approach, commonly referred to in the literature as "thermal-FSI."

The dissertation demonstrates why this particular area of analysis constitutes a "critical component" of the power unit, prone to accelerated degradation. It also examines methods for controlling the thermal state during expedited startups and shutdowns and presents the technical feasibility of such control along with its economic rationale. The advanced control method for the critical component developed in this dissertation has the additional feature that, once the analytical constraints have been established according to the proposed algorithm, it can be readily implemented in the BOTT diagnostic and control system.

In the dissertation, the thermal-FSI computational tool—an interdisciplinary, advanced methodology combining solid-body thermomechanics (CSD) with working-fluid thermomechanics (CFD)—was expanded and validated. In the chapters addressing the selection of cooling/heating steam injection, based on the established and verified startup simulation method, a series of simulations was conducted to determine the range of possible thermal-state control. This control ensures that permissible states are not exceeded and that the overall service life of the equipment is not compromised.

In summary, the dissertation responds to the needs of the power sector, which is struggling with rapidly fluctuating and unpredictable changes stemming from renewable energy sources. It tackles a current issue in a practical manner, one that does not significantly increase operating costs and does not allow for a drastic reduction in the service life of power units. From the scientific standpoint adopted in the dissertation, the task cannot be solved using simplified methods; it requires interdisciplinary research tools. The problem in question is scientifically challenging because it must address a full set of realistic conditions and does not allow simplifications in either reasoning or calculations. Consequently, the greatest value of this dissertation lies in its utility and its applicability to facilities that are critical to the national power industry.