The analysis of influence of cold condenser cooling water parameters on energetic efficiency of extraction-condensing steam turbine

Abstract

In this doctoral thesis it has been analysed how the operating conditions of steam condenser affect the performance of a turbine-generator unit operating in a district heating-condensing system. It has been investigated if the performance and cost-related parameters of the turbine-generator unit can be improved by adjusting the cooling water flow through the steam turbine condenser.

This work consist of eight chapters describing theoretical and experimental part of the thesis. In chapter one the current status of knowledge has been presented and the proposition as well as purpose and scope of the thesis are described. Chapter two presents the basic characteristic performance parameters of cold condenser operation as well as selected models of heat exchange in steam condenser. The next chapter presents numerical models which allow the analysis how the change of steam condenser cooling parameters affects the turbine-generator unit efficiency. An algorithm to determine the pressure in cold condenser for various turbine operating parameters as well as for varying cold condenser cooling parameters has been presented. The energy effect has been defined and the algorithm for calculating this parameter has been described. In chapter four the experimental part of the research has been presented, the tested plant has been described, the scope of test, turbine-generator unit operating parameters, test and calculation methodology have been discussed together with the results and the measuring instruments used have been described. In the next chapter the calculated pressures in cold condenser obtained based on the numerical model and experimental data have been compared and analysed. The steps taken in order to validate the numerical model have been presented as well as the results of numerical simulations. In chapter six the analysis of possible energy and environmental effects, obtained as a result of adjusting the cooling water flow to the respective operating parameters of the plant and cooling water temperature at the inlet to the cold condenser have been presented. For the analysis the actual plant parameters in a specific calendar year have been used. In chapter seven the results of this doctoral thesis have been summarised and conclusions of the discussion presented.

In the theoretical part of this doctoral thesis the selected numerical models of heat transfer in steam condenser have been described and a zero-dimensional numerical model has been presented, which makes it possible to determine the pressure in steam condenser in steady-state conditions for the defined parameters of the turbine-generator unit operation. The numerical model has been developed for Microsoft Excel environment, in Visual Basic language, and the calculation were carried out using iteration method. Based on the correction curves prepared by the turbine supplier describing turbine-generator unit power output vs. pressure change in cold condenser as well as cooling water pump power consumption curves, a numerical method has been presented, which makes it possible to determine the turbine-generator unit energy efficiency vs. cooling water flow, for varying cooling water temperature.

In the experimental part the field tests have been described, which were carried out on the 120 MW turbine-generator unit 1 installed in Combined Heat and Power Plant in Kraków, using high precision measuring instruments. Based on the measurement results the input data for the numerical model have been obtained.

The results of the numerical simulations of the turbine-generator unit energy effect for varying condenser cooling parameters have been shown as dimensionless charts.