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DOCTORAL THESIS ABSTRACT

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Mathematical modeling of a gas turbine combined cycle power plant for thermal diagnostic systems

The doctoral dissertation presents the mathematical model of a gas turbine combined cycle power plant for thermal diagnostic systems based on example of CHP plant Zielona Góra. The model has a modular design and encompasses following partial models: the simulation model of PG 9171E gas turbine unit by *General Electric*; the simulation model of the OU-192 double-pressure heat recovery steam generator by *Rafako* as well as the simulation model of steam-water cycle with 7CK65 steam turbine by *Alstom*. These models, have been elaborated by the use of mass and energy balances as well as empirical functions describing phenomena taking place in analyzed machines and installations. In order to estimate unknown values of empirical coefficients, measurements results were used. Due to measurement errors, in order to obtain the most reliable results, measurement results were reconciled by the use of data reconciliation algorithm. The main advantage of the presented model is short computing time. As a result the model allows to conduct multicriteria calculations.

The partial model of PG9171E gas turbine unit encompasses partial models of the axial compressor, low-emission combustion chambers and the axial expander. The model of the compressor has been developed with the use of the generalized compressor map and empirical relationships describing the compressor internal efficiency and the pressure drop in the air filter. The expander model includes mass and energy balances and a theoretical-empirical model of flue gas expansion line.

The mathematical model of the OU-192 double-pressure heat recovery steam generator contains the model of HP (high pressure) and LP (low pressure) economizers, HP and LP evaporators as well as HP and LP superheaters. It encompasses mass and energy balance equations and empirical functions describing the heat exchange process and pressure drop in each heat exchanger. The heat transfer process have been described with relationship approximating the product the overall heat transfer coefficient and the surface area $k \cdot A$. The unknown values of empirical coefficients were estimated with the least-squares method.

The simulation model of steam-water cycle contains the model of 7CK 65 steam turbine, the model of the heating system as well as the model of a feed water tank and a cooler condensate. This model includes mass and energy balance equations and a theoretical-empirical model of steam expansion line. The formulated mass balance equations take into account leaks from valve stems and glands. The steam expansion line model contains the turbine steam flow capacity equation and the equation of the turbine internal efficiency.

The mathematical model of steam-water cycle with the model of gas turbine unit and heat recovery steam generator form the simulation model of the gas turbine combined cycle power plant. The conducted validation of the model has confirmed the high prediction quality. The difference between calculation and measure result in the case of gas turbine electrical power do not exceed 1% of nominal power. In case of steam turbine electrical power the difference do not exceed 0,5 % of nominal power. The developed model allows to calculate energy assessment indicators as well as investigate the impact of deviations between reference and operational parameters on energy assessment indicators. An important benefit of the developed model is that it has the capability of adapting to the changing technical

conditions. The short calculation time allows to conduct multicriteria calculations in the current optimization layer. As a result such model is an efficient tool in thermal diagnostic systems.

The developed model of the gas turbine combined cycle power plant is continuation of researches conducted during many years in Institute of Thermal Technology in Gliwice. This model has been developed for specific CHP plant Zielona Góra. Both, during developing assumptions as well as during modelling, many problems were consulted with engineering-technical staff of CHP plant Zielona Góra. The obtained results may be also used during mathematical modelling of others gas turbine combined cycle power plants.