Politechnika Śląska
Instytut Maszyn i Urządzeń Energetycznych

Rozprawa doktorska

# Analiza możliwości zwiększenia efektywności elektrowni gazowo-parowej bez i z instalacją wychwytu i sprężania $CO_2$

Mgr inż. Mateusz Brzęczek

Promotor: Prof. dr hab. inż. Janusz Kotowicz

Gliwice 2016

**ABSTRACT**

The main aim of this work was analysis the possibility of increasing the thermodynamic efficiency of the modern triple-pressure combined cycle power plant with steam reheat in the case without and with the carbon capture and compression installation. The state of the gas market in Poland and in the world was characterized. The overview of the combined cycle technology and carbon capture and storage technology for power plants was made. A common feature of the analyzed variants was gas turbine, characterized by a constant electrical power of 200 MW and a constant temperature of the exhaust gas of 630°C. Additionally, each power plant had the same structure of the subcritical triple-pressure heat recovery steam generator with steam reheat and steam cycle, which after optimization (genetic algorithm) has the parameters of live steam 600°C/ 18 MPa and reheat steam 600°C/ 4 MPa. The methodology for modeling of the gas turbine in a wide range of compression ratio ($\beta$ = 10 - 100) was developed. Computational algorithm of the isentropic efficiency for the compressor and expander from the following polytropic characteristics as a function of the compression ratio was developed. Methodology for determining the flow of coolant needed to cool the blades of the expander was described. Combined cycle power plants were analyzed in variants of application: open-loop air cooling (convection, film and transpiration) with and without cooling of the cooling air, closed-loop air cooling, closed-loop steam cooling and the use of sequential combustion. Additional heat recovery steam generator was used in case of using the heat of the gas turbine cooling air. The combined cycle power plant with closed-loop steam cooling and sequentional combustion was integrated with the carbon capture and compression installation. The analysis of influence of the absorbent energy intensity on the net electrical efficiency of the unit was conducted. The Organic Rankine Cycle (ORC) modules were used in order to manage a low-temperature waste heat from this power plant. All these activities led to an increase in net electrical efficiency of the combined cycle power plant to 67% for unit with applied closed-loop steam cooling and sequentional combustion and 60% for the same power plant integrated with the carbon capture and compression installation.