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The influence of the membrane-cryogenic technology of the oxygen separation from the air and CCS installation on the efficiency of the supercritical coal unit with the pulverized bed boiler

Abstract Ph.D.

In the doctoral dissertation a 600 MW coal unit with live steam parameters at 30 MPa/650 ° C and reheated steam parameters at 6 MPa/670 ° C with pulverized oxy type bed boiler was analyzed. For this unit an oxygen separation with the use of hybrid membrane-cryogenic system and carbon dioxide separation and compression installation were proposed.

Oxygen separator consists of two modules: the membrane installation where polymer membrane is used and two cryogenic distillation columns where the product is obtained with a final purity of 95% O₂. In this paper the results of four types of the analyzed membrane with a different selectivity and permeability coefficients of nitrogen and oxygen were presented. The membrane which allowed to obtain product with a best parameter of oxygen purity with a low energy intensity was selected. The energy intensity of membrane-cryogenic oxygen separation unit was calculated. The several ways of energy intensity reduction i.a. through the use of two sections vacuum pump, reducing the temperature of cooling between sections of the devices in the considered system to the 20°C and the assumption of the lower flow resistance in the membrane module were proposed. The potential of reducing the energy intensity of the hybrid system in the dependence on the selectivity parameter of the membrane was presented. The auxiliary power rate of the each system of a coal unit was calculated. The improvement of efficiency of the electricity generation through the thermal integration turbine steam cycle with the oxygen production unit and CCS installation was proposed.

In this work the economic analysis was performed and break-even price of electricity for oxy-type and reference coal power plant was calculated. The sensitivity analysis on the cost of 1 MWh electricity generation for parameters such as: unit investment costs, fuel price, the price of CO₂ emission allowances, unit availability and membrane price were performed.