Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2018.22881

128 (2018) 330–340
October

The analysis of possibilities to increase the efficiency of the zero-emission combined cycle power plant with the membrane reactor

Marcin Job, Janusz Kotowicz*

Institute of Power Engineering and Turbomachinery, Silesian University of Technology, Konarskiego 18, 44-100 Gliwice, Poland, Tel. +48 32 2371745; email: janusz.kotowicz@polsl.pl

Received 27 May 2018; Accepted 17 July 2018

ABSTRACT

Oxy-combustion is one of the promising carbon capture technologies in fossil fuel power plants. Currently, the greatest challenge is to find ways to reduce the energy consumption of the process of oxygen separation from the air. The use of oxygen ion transport membranes (ITM), intensively developed in recent years, especially in terms of use in zero-emission energy units, may be a solution of this problem. Due to high ITM operating temperatures, they are thermally integrated with a gas turbine, placed within the structure of a membrane reactor, which replaces the combustor in the gas turbine installation, performing three functions: separation of oxygen from the air in the ITM, heating the oxygen-depleted air and fuel combustion. The paper presents a model of the zero-emission combined cycle power plant with the membrane reactor and results of thermodynamic analysis for the basic model with assumptions corresponding to currently available technologies and membrane materials. The analyzes of the influence of the most important membrane parameters, taking into account the possibilities of improving materials used for ITM as a result of technological progress, on the parameters of AZEP plant are made. The basic model of the analyzed power plant obtained the electricity generation efficiency of 51.2%, which is a competitive result compared with other units equipped with carbon capture. However, the analysis for improved ITM materials showed that at the case of assumed technological progress it is possible to increase net electric efficiency of AZEP plant by 0.5%–0.8% point, achieving up to almost 52%. The higher efficiency was achieved for the lower compression ratio of gas turbine than for the basic model, which could also lead to lower capital costs. Therefore, the presented results confirmed that the further development of the ITM for the power plants with membrane reactors would contribute to both higher efficiency of electricity production and lower investment costs of these power plants.

Keywords: Oxy-combustion; Membrane reactor; Ion transport membrane ITM; Zero-emission combined cycle power plant; AZEP

* Corresponding author.

Presented at the XII Scientific Conference "Membranes and Membrane Processes in Environmental Protection" – MEMPEP 2018 13–16 June 2018, Zakopane, Poland