Rafał Bernat et al., Expert Opin Environ Biol 2017, 6:4
DOI: 10.4172/2325-9655-C1-018

Using cryogenic separation of anode off gases for high temperature fuel cell applications

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Environmental concerns regarding greenhouse gas emissions and depletion of fossil fuel deposits have driven significant research and development into alternative, clean energy sources. Fuel cells present very promising technologies mainly due to the fact that their electricity generation is not based on a heat engine which requires a working agent. Additional benefits could be obtained through combining fuel cells with gas turbines which could theoretically achieve very high efficiency over 70% though not proven to date. Thus, improving the performance of a hybrid solid oxide fuel cell gas turbine system is still under investigation. This can have done by estimating the geometric parameters of the turbomachinery components which shows a clear efficiency advantage for the whole operating range. This review work presents a comprehensive survey of the literature on cryogenic separation of anode off gas for fuel cells. First, the current status of anode off gas separation is assessed. Second, possible techniques are discussed in detail. These include the thermodynamics and heat transfer aspects of the solution. Thermodynamic relations are given for pure hydrogen as the fuel and then gas mixture as the fuel. CO_2 capture by chemical or physical sorption and membrane separation have been the dominant fields of research within post- and pre-combustion CO_2 capture from power cycles and industrial processes. For a selected range of conditions, potential applications for anode off gas cryogenic separation have been evaluated with respect to energy consumption and profits obtained. For all applications of anode off gas cryogenic separation, specific power consumption and obtainable fuel savings are sensitive to flue-gas or synthesis-gas. However, for certain applications anode off gas cryogenic separation shows promising potential and highly competitive energy figures compared to baseline technology giving an increase in efficiency of 29.58% relative to base values.

Biography

Rafał Bernat is a PhD candidate of Warsaw University of Technology. He has his expertise in contamination of fuel cells with solid particles, carbon dioxide capture from conventional power plants, fuel cell testing, energy systems modeling and economic analyses of energy systems. He has developed with his group a novel model for mathematical description of fuel cells in large system models. Part of his research methodology is on molten carbonate fuel cell contamination was adopted by the Institute of Power Engineering and similar research is ongoing on other types of fuel cells. He also works as a Sales Engineer for a company selling emergency power systems and acts as an expert consulting another company on their business development. His goal is to consolidate many aspects including research, engineering, economics and sales to obtain broader view on the whole energy business.

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