Politechnika Śląska
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Rozprawa doktorska

Wyznaczenie charakterystyk alkalicznego generatora wodoru

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Abstract

The work presents technologies that are enable to energy storage in energy systems, including technologies that use hydrogen as an energy carrier. An overview of selected types of electrolyzers responsible for hydrogen production in the water electrolysis process is also presented. The main aim of the dissertation was to determine the characteristics of a hydrogen generator operating in an alkaline environment equipped with two AEM electrolyzers and determine the possibility of the tested device cooperation with power sources characterized by variable in time amount of electricity produced. A distinctive feature of the work is the determination of tested system characteristics as a function of electrolyzers and hydrogen generator relative power. Basing on the measurements the electrolyzers efficiency η_{EC} was determined. Electrolyzers achieved highest efficiency of 79% for 0.51 of their relative power. The current-voltage characteristics of both electrolyzers were determined and their energy consumption was calculated. The efficiency characteristics of AC/DC converters were determined. AC/DC converters are responsible for the converting process of alternating current into direct current. Taking into account the power of auxiliary devices, the hydrogen generator's auxiliary power index and its efficiency η_{G} were calculated. Hydrogen generator the highest efficiency of about 60% was obtained for nominal power (for maximum device performance). Hydrogen generator was tested in various operating states and also in terms of its response to sudden changes of the currents supplied to the electrolyzers. The tests have shown that a fast response to rapid changes of the supply current is possible only in the case of continuous hydrogen generator work, because stable operation of the installation begins after 450 seconds from the "cold start" and after about 400 seconds from the "warm start" of the device. As part of the work, measurement uncertainties for particular quantities measured within the hydrogen generator installation were also determined. The calculations included standard uncertainties of type A and B, total uncertainty, composite uncertainty as well as expanded uncertainty (expansion factor k = 3). Using the *NPV* indicator,

a simplified economic analysis of the hydrogen generator installations were performed. As reference system the installation with parameters was assumed: unit investment cost k_G = 630 €/kW (~ 2620 PLN/kW), installation work time τ_G = 2920 hours per year (8 hours a day), installation power P_G = 10 MW, efficiency of hydrogen generator installations η_G = 80% and lifetime 100,000 h.

The purpose of the economic analysis was to determine the limit sale price of hydrogen produced in the water electrolysis process. The economic calculations were made for three different cases: assuming operating costs K_{OP} = 0 and free electricity supplied to the hydrogen generators installation, assuming operating costs K_{OP} = 0 and the third option was calculated taking into account the operational costs K_{OP} including the purchase cost of demineralised water, salary of employees and costs of periodic inspections and installations repairs.