PRES17.0325

Thermal management of Solid Oxide Electrolysis Cell systems through air flow regulation

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Abstract

Due to the load fluctuations and the geographical dispersion of renewable energies, the large scale installation causes grid instability issues. The grid stability can be ensured through the development of smart grid management combined with energy storage. The conversion of electricity into another energy carrier, which can be stored and used directly as a fuel, is an attractive option. In this framework, the Power-to-Gas concept consists in converting electricity into hydrogen (H₂), which can be further converted into methane (CH₄). Power-to-Gas is a general concept for the production of gas from electricity and encompasses both power-to-hydrogen and power-to-methane. The objective of this work is to analyse the effect at the SOEC system level and to optimise this control strategy in order to maximise the system efficiency.

The conversion of electrical energy into hydrogen is done electrochemically within an electrolyser. High Temperature Electrolysers (HTEL) operates around 1073 K, the temperature varying with the applied power. Thus a restricted power range of 60-100% should be respected to avoid thermal gradients. The present paper aims to propose control strategies which lower the thermal gradients and thus extend to power range. Two strategies, based on the use of an air flow at the anode, are proposed and analysed in detail. The first strategy, consisting of a constant ratio between the inlet air and the produced oxygen molar flow rates, leads to an extended power range of up to 22-100% for an air ratio of 14. The need for heating up the inlet air to 1073 K has however an impact on the system efficiency, independently from the power applied. Thus a second control strategy, consisting of an air flow rate being adapted to the thermal needs of the reaction, is proposed. The regulated air flow enables to extend the power range to 1-100% and has an impact on the system efficiency only below 60% load.