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Pressurized SOFC System Simulation for Hybrid Power Plant Operation

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Abstract

Hybrid power plants as a combination of a solid oxide fuel cell (SOFC) with a gas turbine (GT) are promising due to their high electrical efficiencies even at small installed powers. The goal of the activities at the German Aerospace Centre (DLR) is the realization of a 50 kW class hybrid power plant. In a first step, the main components of the power plant system, namely the fuel cell subsystem as well as the gas turbine subsystem are simulated. The second step will be to utilize the models to design and test a control strategy for the plant. At the same time, detailed experimental analysis of the electrochemistry of pressurized SOFCs is being performed.

When considering hybrid power plants for residential or industrial applications, the load-following capability is of utmost importance. Classic control strategies tend to keep the SOFC at a constant operating point, while the gas turbine is responsible for following the load of the system. This has several disadvantages. Firstly, the pressure delivered by the GT compressor is directly related to the GT shaft speed which will alternate during load transients of the GT generator, thus influencing the pressure on the cathode side of the fuel cell and with it the SOFC power. Secondly, at an expected power ratio of 1:4 (GT:SOFC), the system would only be able to perform load changes between 80 and 100% of maximum power while a typical load profile of a residential system alternates between 20 and 100%. In order to improve load-following characteristics, it is important to exploit the transient capabilities of the SOFC system.

In this work, we focus on the load cycling capability of the SOFC module in the hybrid power plant. The simulation is based on the models presented previously [1, 2]. We give a close insight to step responses of the system, evaluating its transient capabilities. Furthermore we investigate the behaviour of the SOFC system during a 24h load cycle for a typical residential area.