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Pressurized SOFC systems for stationary applications

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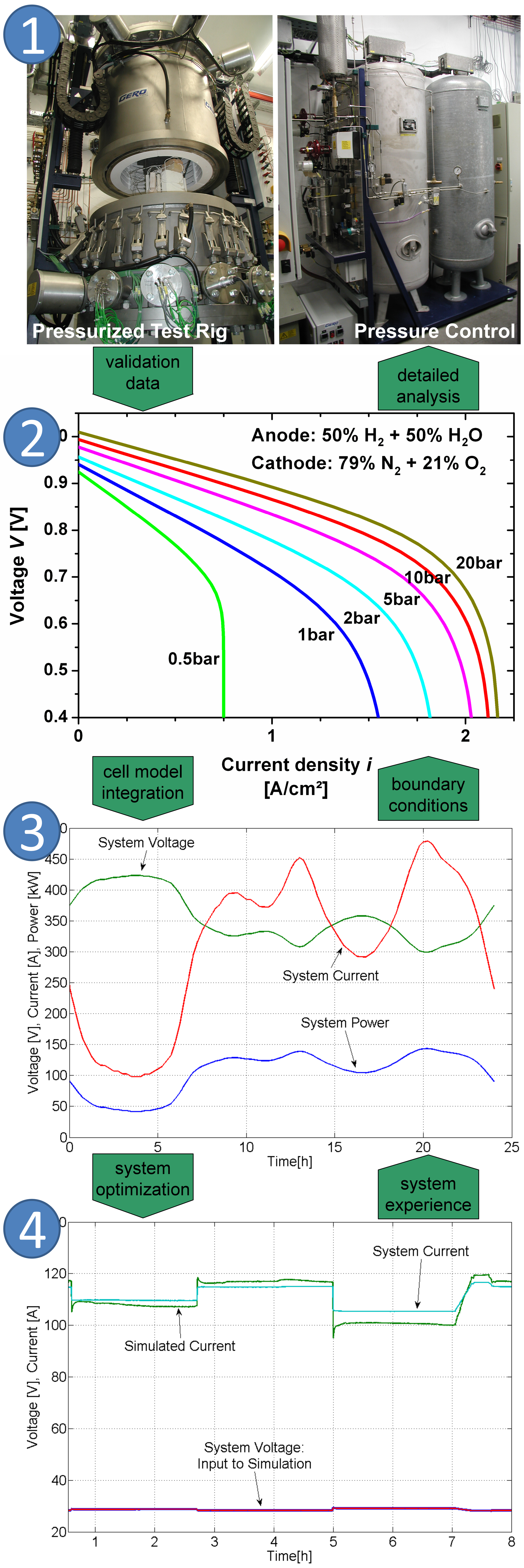

Introduction

Solid oxide fuel cell (SOFC) systems show very high electrical efficiencies even at small sizes. DLR applies a multidisciplinary and multiscale approach to designing and optimizing pressurized SOFC systems for hybrid power plants.
A large Simulink model library was developed featuring balance-of-plant components as well as fuel cell models. Recently a pressurized cell test rig was taken into operation.

Pressurized Cell testing

A new test facility for pressurized SOFC has been built (Fig. 1):

- Pressurized operation (1 - 8 bar)
- Precise pressure control
- Pressure difference between anode/cathode/surroundings controllable from 10 to 500 mbar
- U-i-characteristics
- Impedance spectra
- Gas analysis

Work focus:

- Electrochemistry and performance at elevated pressures
- Operation of pressurized SOFC at system-relevant conditions

Cell Modeling

An in-house simulation code was developed and validated [1,2]:

- Elementary kinetics and transport
- Easy adaptation to new cells
- U-i-characteristics simulation
- Impedance spectra simulation
- Detailed analysis of pressurized electrochemistry
- Deep insight into surface electrochemistry

Fig. 2 shows simulation results for a 2D model at 800°C.

System Modeling

System modeled in Matlab/Simulink.
Model library contents:

- Desulphurization
- Humidification (POX, steamer)
- Reformer
- Ejector for anode recirculation
- Fuel cells (tubular concept) [3]
- Planar fuel cell models to be integrated via in-house code [1,4]
- Control concept (fuel, air, voltage with regard to nickel oxidation)

Fig. 3 shows the dynamic system behavior of a 100 kW (atm) system at 4 bar.

System experience

Siemens SFC-5 alpha system installed and operated on site.
Major gains:

- System experience
- Validation data for system model

Fig. 4 compares experimental and simulated behavior:

- Control approaches in system and model differ
- Transient load changes reproduced well

Industrial benefit

Our partners are able to deliver their input at any stage. Short stacks can be characterized within the pressurized test facility.
Results of the experiments can be further investigated via the in-house cell model that allows a physically-based description of electrochemistry and transport processes.
Utilizing the model library, system designs can be optimized. The operational experience on cell and on system level are a major benefit.
With this framework we are ready to head towards more efficient energy supply – are you?

[1] Bessler, W.G. et al., 'A new framework for detailed electrochemical modeling of solid oxide fuel cells.' Electrochim.Acta 53, 1782-1800 (2007)
[2] Bessler, W. G., et al., 'Spatial distribution of electrochemical performance in a segmented SOFC'. Fuel Cells, submitted (2009)
[3] Leucht, F., 'Modelling of Tubular SOFC in Hybrid Power Plant Systems – Cell and Stack Modelling.' In European Fuel Cell Forum (2008)
[4] Eschenbach, M., et al., 'Multi-scale modelling of fuel cells: From the cell to the system', Solid State Ionics, submitted (2009)

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