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A dynamic simulator for a 250 kW class ER-MCFC system

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Abstract

A dynamic simulator has been built for a 250 kW ER-molten carbonate fuel cell (MCFC) system in order to study the controllability of this system. The tool has a modular set-up and will be used for designing the control system of more advanced MCFC systems, such as the SMARTER system, or can be adapted for systems based on other types of fuel cell, such as phosphoric acid fuel cell (PAFC), solid polymer fuel cell (SPFC) or solid oxide fuel cell (SOFC). © 1998 Elsevier Science S.A.

Keywords: Dynamic simulator; MCFC; System controllability

1. Introduction

Simulation of the dynamic behaviour of a fuel cell system is considered indispensable in the design process and may help avoiding costly mistakes in early fuel cell demonstrators. Therefore, a dynamic simulation platform has been developed jointly by BCN, KEMA, ECN, and Stork Product Engineering as a tool for fuel cell system design and to enable future operator training. The simulator is based on physical–mathematical (first principle) process models.

2. Simulated system

A first generation 250 kW natural gas (NG) ER-MCFC system has been selected for simulation. This system was designed by BCN in the framework of its 1992–1996 'Proof of Concept' programme. The control scheme is classical, based on a distributed set of local proportional, integral and derivative (PID) controllers. A simplified process flow diagram is shown in Fig. 1.

3. Simulator features

PC-TRAX (under OS.2) has been selected as a suitable software toolbox for the platform. The simulator has a modular set-up and has been built by integrating three types of modules:

- standard TRAX modules for water pump and control equipment;
- modified TRAX modules for other system components, e.g. rotating equipment, heaters, valves, etc.;
- dedicated modules for stack, reformer, burner and condenser.

Thermodynamic syngas properties are calculated using a dedicated property package.

During simulation, easy interaction with the model remains possible: all component and control parameters are accessible in run-time, enabling parameter studies. Results can be viewed in user-configurable graphs and tables.

4. Results

Several runs were conducted with the simulator, showing the responses of the system to changes in the power demand

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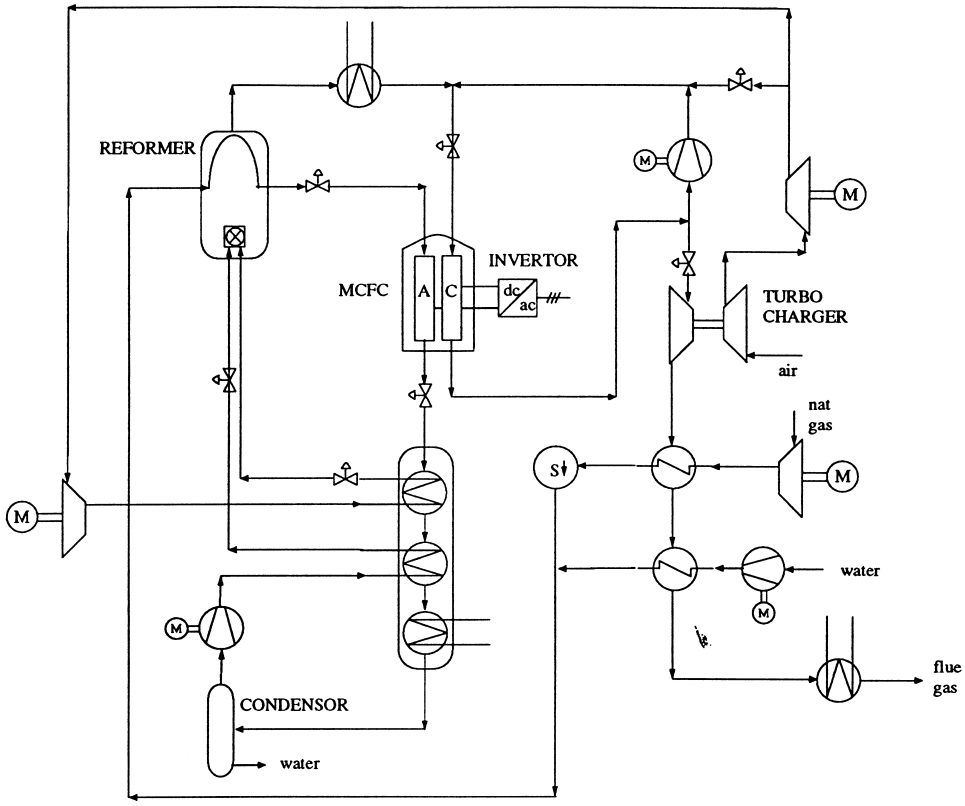

Fig. 1. Process flow diagram of 250 kW ER-MCFC plant.

and other important system parameters. As an illustration, Figs. 2 and 3 show the response of the system to a step-wise 10% decrease in power demand.

5. Conclusions

- Simulation of the dynamic behaviour of even a complex first-generation MCFC system proved to be well possible.
- PC-TRAX is a suitable tool, although for many system components either modifications of standard TRAX modules or dedicated developed modules are required.
- Due to the simulations, the controllability of the system could be improved.

6. Plans for continuation

The tool will be used for:

- studying and optimising the controllability of advanced MCFC systems, such as the SMARTER

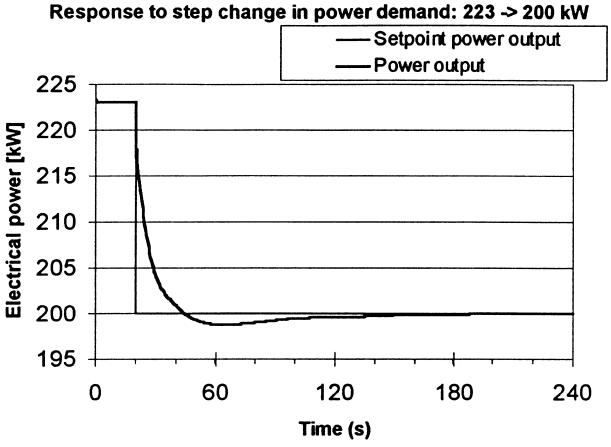

Fig. 2. Response to a step change in power demand.

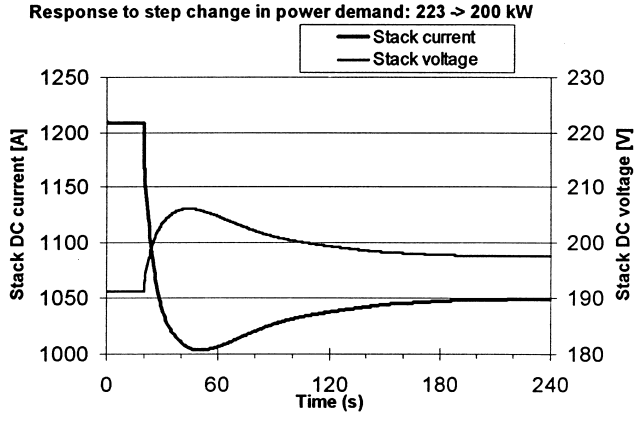

Fig. 3. Corresponding responses of MCFC stack outputs.

system, developed in the ‘Advanced DIR-MCFC Development’ project;
- simulation of systems based on other types of fuel cell such as PAFC, SPFC or SOFC (after adaption of the stack module).

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