Interval Methods for the Implementation of Real-Time Capable Robust Controllers for Solid Oxide Fuel Cell Systems

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Abstract

The development of control strategies for solid oxide fuel cell systems (SOFC systems) represents a complex engineering task. This design task is impeded by important nonlinearities of dynamic models for SOFCs with a large number of parameters which are only known within certain interval bounds. Moreover, measurement uncertainty and approximation errors resulting from finite-dimensional approximations of the underlying distributed parameter systems governed by partial differential equations are further issues that a reliable controller has to cope with.

For these reasons, control-oriented system models have been derived in previous work on the basis of physical system properties. Such properties are related to heat transfer according to the first law of thermodynamics and to exothermic electro-chemical reaction processes between the fuel gas (typically hydrogen or mixtures with natural gas and methane) and oxygen. To account for the above-mentioned sources of uncertainty, the identification of the system parameters (in this case parameters of a finite volume model) was performed by a global optimization technique [1].

After that, dynamic models containing intervals to represent parameters and external disturbances in both transient and stationary operating conditions have to be stabilized in a guaranteed way by means of suitable control strategies. To solve this task, novel extensions of sliding mode and predictive control procedures, in the latter case making use of an underlying sensitivity analysis of the dynamic system model, are presented in this contribution.

Both types of controllers have to be evaluated in real time by means of suitable interval algorithms in order to account for all uncertain variables and to perform the robust stabilization of the system dynamics [2, 3]. In this talk, representative simulation results and experimental data are presented for a SOFC test rig that is available at the Chair of Mechatronics at the University of Rostock. Details about the real-time capable implementation of the interval-based control procedures on a commercial rapid control prototyping hardware by means of the C++ toolbox C-XSC conclude this presentation for the control of stationary and transient operating conditions and for a disturbance attenuation [4].

References

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