European Fuel Cell Car Workshop | March, 1st - 3rd 2017, Orléans, France

Reliable optimization of the PEMFC stack efficiency for automotive application

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Keywords: stack efficiency, performance optimization, stack test procedures

The operating conditions essentially determine the performance and the efficiency of a polymer electrolyte membrane fuel cell (PEMFC) stack in an automotive system. Due to space and weight limitations in such systems, an optimization is mandatory to assure high power output and fuel utilization. Typically, the operating conditions are defined in a system by look-up tables and are not adapted over stack lifetime. But the best operating conditions can vary over the lifetime due to the presence of different degradation phenomena, e.g. resulting in changes of the electrode structure, the electrode hydrophobicity, and the catalyst activity. Predefined tables cannot cover this behavior and the use of optimization algorithms is highly favorable to facilitate optimal stack operation during entire lifetime.

In the presented work, η^*_{stack} is defined to represent the stack efficiency in a system because the commonly used stack electrical- and fuel efficiencies do not consider the operating conditions [1]. This new efficiency covers all power losses based on the applied conditions including theoretical losses for stack feed stream conditioning. An example is given which power losses are relevant and dominant for automotive application. The performance and efficiency determining conditions are characterized by the stack temperature as well as the stoichiometric values, the relative humidity, and the pressures of the reactants. Their effect is non-linear and synergistic. A separate optimization of the parameters is not meaningful. Therefore, a direct-search algorithm, the Nelder-Mead simplex, was used for the simultaneous optimization of all parameters [2]. The algorithm was realized using harmonized test procedures elaborated in the Stack-Test project to assure reliable and reproducible parameter optimization [3]. The optimization process and the used test procedures are explained in detail and presented results demonstrate that the efficiency can be improved in a running PEMFC stack by up to 4 % only by optimizing the operating conditions in an automotive system (Figure 1).

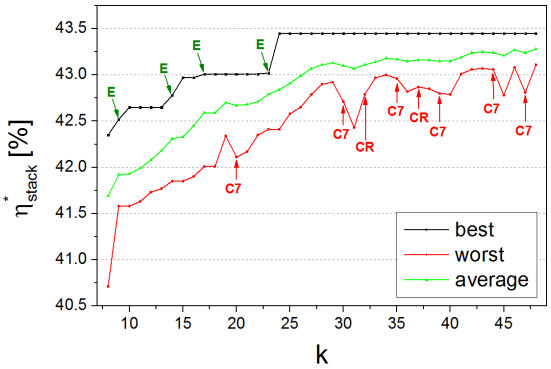

Figure 1: efficiency optimization process for a PEMFC stack operating at 0.75 A/cm².

Acknowledgements
The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) for the Fuel Cells and Hydrogen Joint Technology Initiative under grant n° 303445 (Stack-Test).

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