Developing a Generic Fuel Cell Stack

One for all

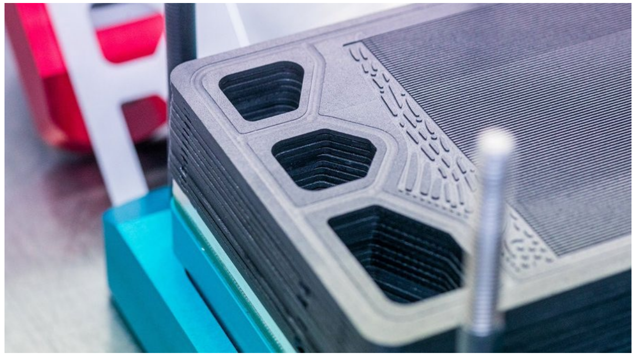
Research on fuel cells has made giant leaps over the last few years and the first commercial applications are now available. To reduce costs further, the entire system must now be even more in tune. One of the development tools required for this is currently being created in a research project at the ZSW in Ulm, sponsored by FVV.

Text: Johannes Winterhagen | Fotografie: Dirk Lässig

“The stack has to be this small.” Joachim Scholta spreads his thumb and index finger apart. Then he spreads his arms. “Or this big.” The physicist has been conducting research at the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) in Ulm for around 30 years. When he talks about his current project, he becomes more animated. His goal is to develop a “generic fuel cell stack”, a type of universal machine for the subsequent research and development of fuel cell drives.

To explain just why this is important, Scholta takes a step back and begins to talk about the enormous progress made over the past decades, which has resulted in some automotive manufacturers constructing pilot series of fuel cell vehicles. But despite his enthusiasm for hydrogen as an energy source and its use in fuel cells, the expert is aware that the big breakthrough can only come when costs sink significantly – or the performance output per cell, i.e. the energy density, can be further increased. This is not just an issue regarding the cells themselves, says Scholta, but requires the entire system to be optimised. In a similar way, combustion engines achieve their high power density not just from optimised combustion in the cylinder, but also through carburation which has been refined over decades, especially regarding turbocharging and injection.

A fuel cell engine comprises similarly complex subsystems, for example to compress or humidify the feed air. Although the often-used collective term of “peripheral systems” makes them sound marginal, they have a decisive impact not only on the performance of the cells, but also on their life cycles. As such, unequal hydrogen distribution across the cell membranes can result in premature ageing. The problem when developing these components is that testing has previously generally only been performed on commercially available fuel cell systems. Understandably, the manufacturers of these systems often do not provide details on the system specifications, for example the materials used in the cells. As a result, individual test results are often not applicable for further research. This is exactly the problem the “Generic Fuel Cell Stack” research project, sponsored by FVV, aims to solve. Within the project, which will run until mid-2020, all requirements of a stack will be defined. In a potential follow-up project, they could then be implemented and tested using a physical prototype.



Fuel cell components – bipolar plate.

Scholta will not decide alone how the stack “for all” will be designed, but is working together with a group of experts to develop a questionnaire which will be available to all FVV members. There are several fundamental questions which require answers. Arguably the most important: Should the generic stack be constructed using bipolar plates made from graphite or metal? The bipolar plates are vital components, as they not only act as cathodes, thereby enabling electricity to flow, but also ensure that hydrogen is split using a catalyst on the anode side. One of the benefits of graphite, a crystalline structure of carbon, is

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that the shape, including the fine channels to conduct the gas, can be precisely milled. However, this is a long-winded process, even when high-performance tool systems are used. Reshaping production processes can be used for the metallic bipolar plates, thereby enabling high production numbers with short cycle times – however, achieving the necessary precision across repeated production runs is a challenge, as the walls are only one tenth of a millimetre thick.

> »We are providing SMEs with the opportunity to test their components with high-tech tools.«

Once the question of the materials has been answered and the remaining requirements have been defined, the concept development can begin. As the ZSW has already constructed its own development platform for graphite bipolar plates, the current project could even result in a specific prototype. Should the FVV experts select a metal solution, an initial cell and stack concept is available. Either way, a hardware solution requires a subsequent project to be conducted, which would result in the development of a universal stack by 2023 at the latest, and a product which all FVV members could use. Scholta views this as a fantastic opportunity for smaller automotive suppliers in particular. "We are providing SMEs with the opportunity to test their components with high-tech tools." Furthermore, the generic stack would be useful for further research projects in which an entire simulation world could be constructed for the fuel cell. When it comes to the design of a fuel cell vehicle drive, there are still several unanswered research questions, for example regarding the high-voltage battery on board the vehicle.

Robot-assisted fuel cell stack assembly.

After a tour of the workshops, Scholta says goodbye to the visitors at the hydrogen filling station in front of the building. "It's been working perfectly for years", he says, adding with a smile: "Only the card reader breaks from time to time, but then you can fill up for free." Filling up with enough energy to get home takes just minutes.

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About | Dr. Joachim Scholta (ZSW Ulm)

Since 2009, Head of Department Fuel Cell Stacks (ECB). 1989 to 2008, Scientist at ZSW in Ulm in the field of low- and middle-temperature fuel cells. Until 1993, PhD at Technische Universität Darmstadt in the field of phosphoric acid fuel cells (PAFC).

Research priorities: Polymer Membrane Fuel Cells (PEMFC) - fuel cell components and systems. Further topics: Direct-methanol fuel cells (DMFC) & PAFC - characterisation of full cells and components, also through x-ray and neutron radiation.

Dr Joachim Scholta, Head of Department – Fuel Cell Stacks (ZSW), presenting a fuel cell stack for automotive applications.

Solar energy and hydrogen technologies are currently maturing on an industrial scale and will be major components in the sustainable energy supply of the 21st century. As early as 1988, the German state of Baden-Württemberg, together with universities, research institutions and companies, established the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) as a non-profit foundation under civil law. Today the ZSW has approximately 280 employees and 100 student and scientific assistants and is one of the leading energy research institutes in Europe. Joint ventures and the growing proportion of industry commissions demonstrate the consistent relevance for applied research.

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