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1 Introduction

The modular fuel cell system is a newly developed concept for self-sustaining energy supply of small consumers in the range up to 300 W.

The main goal of the implementation was to design and provide effective and low-cost PEM fuel cell stacks which are hydrogen supplied and its balance-of-plant (BoP) components.

The system is scalable, built in 30 W increments, in order to cover all power categories up to 300 Watts.

Great importance was attached to the construction of an insensitive and robust system, because the portable system should be able to operate under a variety of environmental conditions.

The modular fuel cell system consists of a modular fuel cell stack, a modular designed electronic circuit board and a customizable BoP according to the total power/ overall performance.

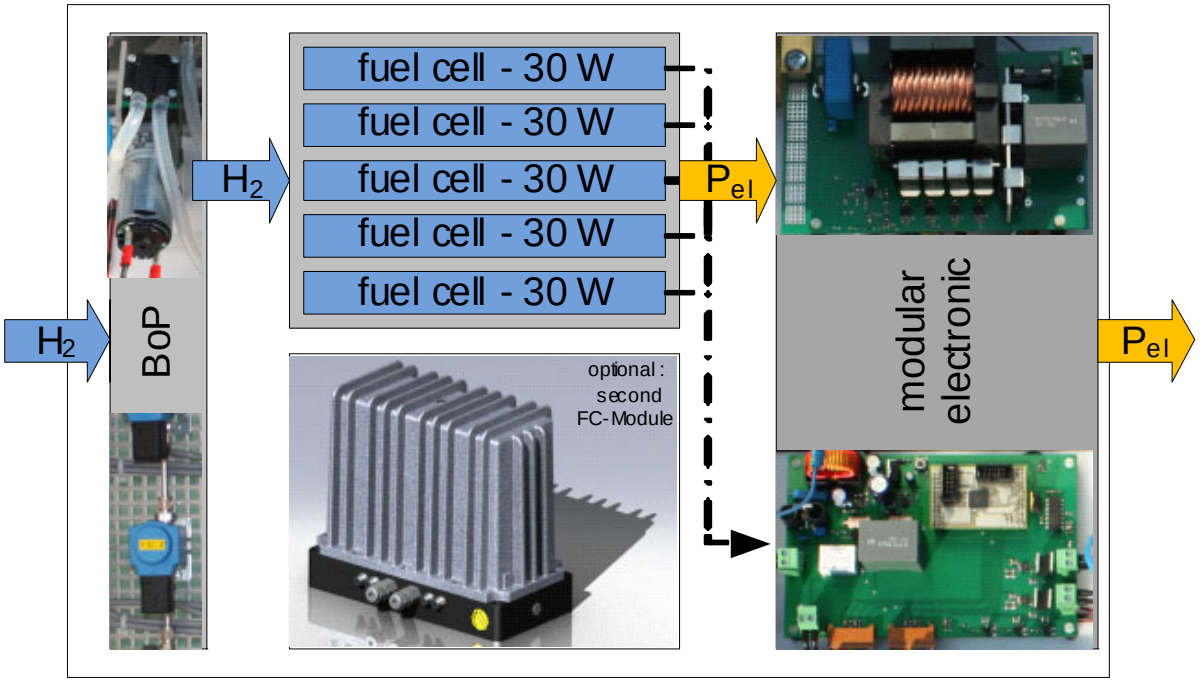

Figure 1: The modular fuel cell system.

2 The Modular Fuel Cell Stack

The modular fuel cell stack distinguishes itself from a standard fuel cell stack in two important features:

1. the design of the fuel cells based on metal pole plates and
2. the hydraulic compression of the fuel cell.

The advantages of point 1 are obvious, metal pole plates are more robust than graphitic pole plates. In addition, the pole plates can be quickly molded by a molding press, which leads to a low cost fabrication.

Figure 2: Section through a mono-cell.

Figure 2 shows the smallest unit of the modular fuel cell stacks, the mono-cell (the fuel cell itself) consisting of two metal pole plates with integrated membrane-electrode assembly.

This stack structure with parallel gas supply route and hydraulic compression has the advantage of been able to remove a damaged fuel cell quickly from the stack with minimal effort and without damaging the other units.

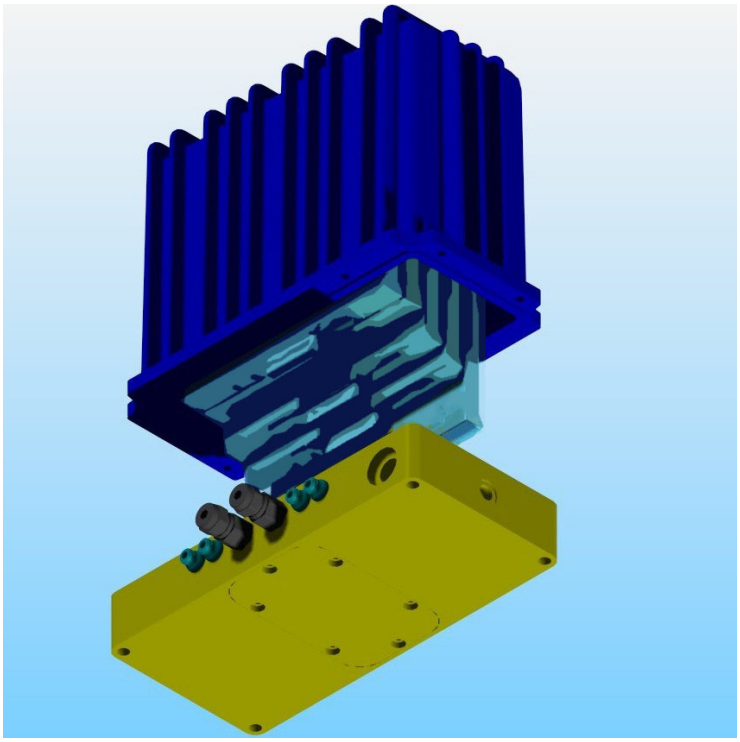

Figure 3: Schematic representation of the modular fuel cell stacks.

In conventional fuel cell stacks an exchange of the fuel cell is often not possible because the plates are pressed or bonded with each other what leads to damage while disassembling.

In the case of the modular fuel cell system the replacement of one cell is quite simply.

For the structure of the modular stacks, see Figure 3.

In order to perform a cell switch, the housing has to be relieve, which is easily done via a simple screw mechanism.

Subsequently, the cover can be removed and the cell can be easily replaced. Evan a non-specialist is able to replace a faulty fuel cell within minutes. The information regarding which cell has to be changed is displayed by the electronic circuit board!

3 The BoP

There are a variety of components such as valves, pumps etc. offered at the market, suitable for operation with hydrogen. However, the selection and integration of corresponding components are still a challenge.

Great deal of importance was attached to the high availability of the BoP, which are applied in modular fuel cell systems and the system efficiency optimization.

Since the fuel cell stack is scalable, BoP of the system has to be adapted depending on the system output power.

The appropriate platform for an individual adjustment is realized by standardized housing and mounting fixtures.

4 The Modular Electronic Circuit Board

In order to supply a load with electrical energy efficiently, an electronic circuit board is required in addition to the fuel cell BoP, which has to provide a stable output voltage by an optimized efficiency.

Especially for this purpose, a two-stage DC / DC converter was designed. It is possible to operate a second fuel cell stack in addition to the main stack at the entrance of the DC / DC converter. The second-stage of the switched power amplifier offers an efficient increase of the DC voltage to output voltage level, as well as electrical galvanic separation.

The output voltage of the DC / DC Converter is, by the way, adjustable to the needs of the load.

In addition, the galvanic separation allows switching the output of a further modular fuel cell system in series, thus doubling the output voltage is possible.

It is also apparent that great value was attached to a high degree of modularity and flexibility while designing the system.

Another essential element is the control board, which constitutes the controlling “heart” of the whole system. Especially for this purpose a microcontroller board was developed. This board has high power outputs for the BoP, such as the pumps and the magnetic valves. All the control and automation interventions are initiated by the microcontroller.

In addition, the control unit supervises the fuel cell stack, for example, individual cell voltages are continuously read. Thus, the real functions of the fuel cell are monitored and if

necessary, a message will be displayed. Finally, on this board the monitoring as well as the communication with the external monitoring point are possible. In this way an online monitoring is possible for a given network connection or GSM.

References

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