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A new stack design for closed loop fuel cell applications

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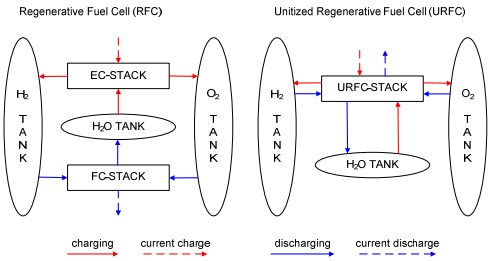

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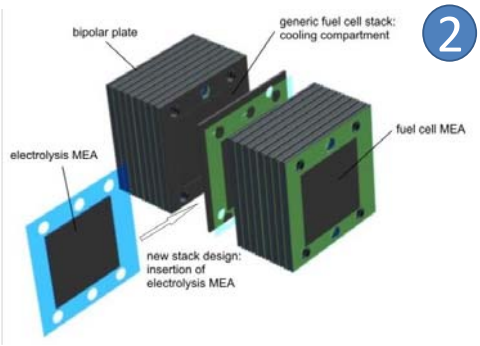

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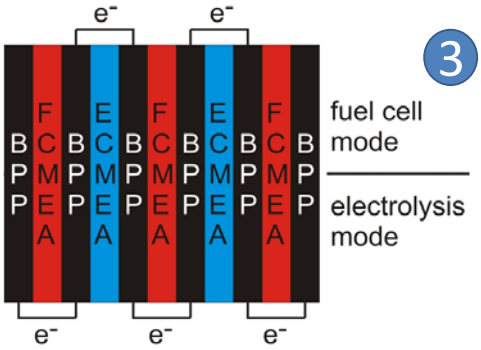

BPP – bipolar plate
FCMEA – fuel cell membrane electrode assembly
ECMEA – electrolysis membrane electrode assembly

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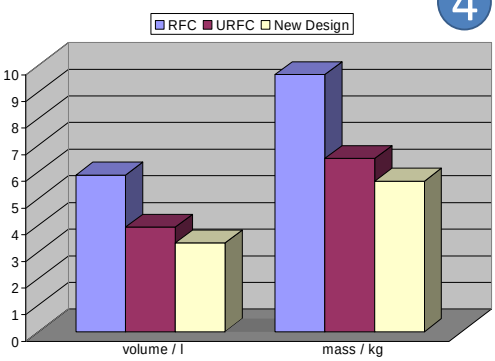

Introduction

In mobile and portable applications electrical energy is normally supplied by secondary batteries since the grid connection is required for use of electricity from stationary power plants. Unfortunately the specific energy and the energy density of those energy storage systems are rather low. Therefore fuel cells are an interesting option to overcome the limitation of energy density. However, fuel cells need a continuous supply with fuel and oxidant. For some special applications, like space crafts, autonomous long distance aircrafts or stand-alone power supplies, an external refuelling is not possible or feasible. In that case the reactants must be regenerated by water electrolysis and thus a reversible fuel cell system is needed.

Description

Two different designs of reversible fuel cell systems are known, see Figure 1. First a reversible fuel cell system which has two separate stacks for both electrolysis and fuel cell mode. The second type is the unitized reversible fuel cell using only one stack for both. While the first system is characterized by high masses and volumes, the second one shows lower performance because of the reduced activity of the catalyst mixture and the compromises required to accommodate two functions in one reactor.
The new stack design, Figure 2, uses features of both systems with a simplified set-up. Only one stack is used, but the electrolysis cells and fuel cells are galvanically separated.
Generic high power fuel cell stacks are cooled by water in between two bipolar plates. Those cooling compartments can be equipped with electrolysis membrane electrode assembles (MEA). In fuel cell mode the water cools down the stack and in electrolysis mode the water will be split into hydrogen and oxygen, which can be stored afterwards.
When inserting a non-conducting material (e.g. Nafion®) between the bipolar plates an external electrical connection is necessary. Figure 3 shows the electrical circuit in fuel cell and electrolysis mode. By switching the connections between the bipolar plates with changing the operating mode the simultaneous use of electrolysis and fuel cell MEA's isn't possible.
Compared to the state-of-the-art system the presented stack shows many advantages. Mass as well as volume of the new stack design are significantly smaller, see Figure 4, and also the production costs are reduced because of less material used.

Summary

A combination of the two reversible fuel cell designs shows an improvement in specific energy and energy density and offers therefore an alternative to secondary batteries in stand-alone applications.
The new design has been patented (DE 10 2007 027 005 A1).