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Hydrogen based uninterruptible power supply

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An uninterruptible power supply system based on hydrogen technologies will be presented. The system consists of a Proton Exchange Membrane Fuel Cell (PEMFC) running on hydrogen and oxygen, a gas storage section and a water electrolyser for hydrogen and oxygen production. A prototype with an output power of 5 kW for a maximum of 5 hours has been designed, manufactured and tested.

This hydrogen energy system has been realized in the frame of the HELPS project, co-funded by the EC under the 5th Framework Programme. A small battery is continuously maintained charged in order to assure the uninterruptible power supply. It is dimensioned to assure the first 15 minutes of operation at full load but it takes less than 5 minutes for the cold fuel cell to deliver full power. The uninterruptible power supply is completely silent and very reliable, thanks to the complete absence of moving parts.

An alkaline electrolyser produces 0.5 Nm^3/h of deoxidized and dried hydrogen at 99.98%vol. purity, and 0.25 Nm^3/h oxygen at 99.6% vol. purity under controlled pressure. The produced gases are delivered to the storage section at 15 bar pressure for hydrogen and 13 bar for oxygen. The unit is of fail-safe design and completely automatic.

The hydrogen storage unit consists of a small conventional tank and three metal hydride storage tanks, with a total hydrogen capacity of 21 Nm^3. The hydrogen storage material is an AB_5-based alloy with the composition $LaMm_{1-x}Ce_xNi_5$. The metal hydride storage can supply hydrogen to the fuel cell at the desired rate of 360 g/h (4 Nm^3/h) and 3 bar pressure, even at freezing temperatures, thanks to the high charging pressure. The delivery rate is maintained with the help of low temperature heat recovered from the cooling water of the fuel cell. The specific storage capacity of the metal hydride tank is circa 1% weight.

The fuel cell has been designed for an output voltage of 40 V to 56 V, at 125 A and 150 A respectively. In order to reduce the gas consumption, the fuel cell operates in a dead end mode, and an adequate water and gas separation device at the outlet of the stack facilitates the periodic bleedings. The stack efficiency is optimized by finely tuning the operating temperature, thanks to a closed cooling water circuit. So, only the cooling water coming out of the fuel cell cooler is used to heat up the metal hydride tank.

With respect to the Low Heating Value of hydrogen, the efficiency of the water electrolyser is approximately 60% and the efficiency of the fuel cell 40%, resulting in an overall energy efficiency of circa 25%. There are no hydrogen losses associated with the operation of the metal hydride tanks.

The results of the operation of this prototype will be presented and discussed, showing the efficiency of the system and the rapid response of the fuel cell to load variations as a function of the initial conditions. The safety issues related to the implementation of such uninterruptible power supply systems will be detailed. The results of the Life Cycle Analysis performed for this system will also be commented.

The water electrolyser for hydrogen generation and the proton exchange membrane fuel cell operating on hydrogen / oxygen are shown in Picture 1.

Picture 1. A picture of the PEMFC (in front) and the water electrolyser (in the back) of the uninterruptible power supply.