SPP: Portable Power Technologies for the Dismounted Soldier

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Abstract

The project aims at the development of a portable power system as standard equipment for defence use, and is being developed by a Portuguese consortium leaded by SRE, a fuel cell developer, LNEG (Portuguese National Laboratory for Energy and Geology) and EID (Electronics and Telecommunications for Army) through a SRE/ Ministry of Defence contract. The system uses a SRE H2 PEM Fuel Cell and a Li battery buffer (30Wh). The fuel is provided by an on board H_2 generator based on chemical hydrides, aiming to provide 72h autonomy to the dismounted soldier. Main project constraints and challenges are the power density (both gravimetric and volumetric) and the operation under severe atmospheric conditions. A field test pre-series shall take place by the end of 2010 with probable commercialization foreseen by early 2012.

Keywords: *fuel cells, battery substitution, portable power, military applications*

1 Introduction

The supply of energy to a modern army is one of the main logistic challenges that any military operation faces. The needs of ground force's energy are being considered at several levels: portable power, mobile systems, telecommunications, and stationary requests. Conventional solutions present limitations and draw backs. Batteries have small power density and provide limited autonomy. Set generators are easily detected. Isolated areas request specific logistics to supply energy. Hydrogen is an emerging technology that can help to overcome some of the present limitations and difficulties. Hydrogen is a powerful fuel that can easily be produced at any place using a renewable energy source (Photovoltaic, for instance) and water. Fuel cells (FCs) are devices that supply electric energy using hydrogen as a fuel, through an electrochemical process. They can work at low temperatures, do not have significant metal parts, and produce a low level of noise. That means they are not easily traced by current detection systems. Hydrogen technologies ought to be seriously considered as an alternative energy power source for modern armies, at different levels of applications.

SPP project intends to develop a new solution regarding the energy requests of the modern dismounted soldier who is using more and more sophisticated equipment that needs energy to work. It shall be emphasized that a big effort is being made by equipment manufacturers in order to improve energy efficiency of all these systems. But, on the other side, the number of devices requiring being energetically supplied is increasing. The balance is that a dismounting soldier, namely in an isolated area, is obliged to carry a significant weight (and volume) in batteries if a standard operation autonomy (48h to 72h) is required. Better solutions regarding volumetric and gravimetric power density are being demanded. Fuel cells can be a new solution to this issue. These systems present better performances than batteries, either in volume or weight, when extended autonomy is required. The advantages for FCs choice are:

- Weight reduction
- Instant refuelling
- Silent operation
- Lower heat signature
- Greater fuel efficiency
- Longer run-times

The more widespread approach is based on Direct Methanol Fuel Cells (DMFC). These FCs take advantage on the energy content of methanol. One litre of methanol can provide about 1kWh. On the other hand, power density of DMFC is relatively low. If significant powers are required, the size and weight of the Fuel Cell will become a handicap.

That is the case of the specifications considered in the SPP project: an average power of 30W, with peak powers of 50W, 10% of the duty cycle.

The approach we followed considers using a PEM fuel cell, which has a better power density than the DMFC (300 mW/cm^2 versus 80 mW/cm^2). The main innovative solution of the system we present regards the use of a sodium borohydride, $NaBH_4$, in an on- board hydrogen generator. The challenge and the innovative approach of the SPP project is to integrate the whole power system, fulfilling the operational requirements defined by the Communications and Information System Directorate (Portuguese Army).

2 Operational Specifications

The operational specifications considered for the project took under consideration the work being done at NATO regarding the energy requirements of the dismounting soldier:

- Autonomy- *72h;*
- Average power- *30W*
- Peak power (10% of the time) *50W;*
- Temperature range: between *-30ºC and +60º;,*
- Volume [including power system + fuel(72h)] *< 5 dm3;*
- Weight [including power system + fuel(72h)] *< 3,2 Kg;*
- Other requirements: *to keep working during1 hour when dived;*

3 The Proposed Portable Energy System

Figure 1 presents a schematic diagram of the system being developed:

3.1 The Fuel Cell

The fuel cell, a PEM technology low power FC developed by SRE with support of LNEG, has the following main characteristics:

- Passive management of water and heat for reliable performance (external humidification and system for temperature control are not required);
- Reduced system complexity;
- Minimised power consumption of auxiliary components;
- Optimised cell geometry and materials;
- Low maintenance needs;

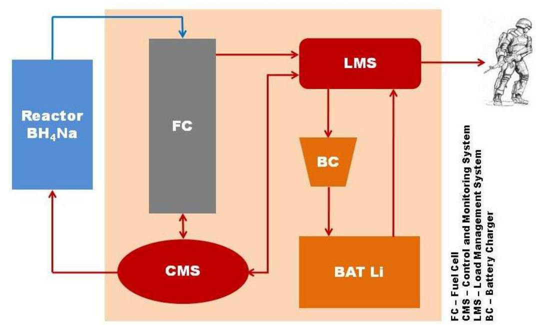

Fig 1.- Schematic diagram of the proposed power system using PEM fuel cell technology and on-demand hydrogen from sodium borohydride.

A standard polarization curve of SRE cells is presented in figure 2.

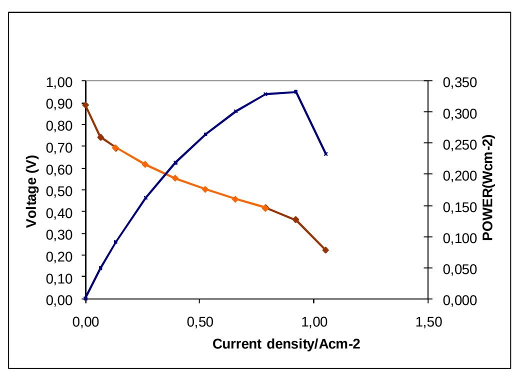

Fig.2 Typical Polarization and Power curve of cell of the SRE stack, indicating power densities better than 0,3Wcm^{-2}

The global evaluation is that the SRE stack can fulfil the stringent requirements concerning temperature, with some reduction on the power availability.

3.2 Hydrogen Production

Sodium borohydride ($NaBH_4$) is currently being studied as a promising hydrogen storage option due to its high gravimetric capacity (10.73 wt%), well within DOE targets for 2015. The use of sodium borohydride has the following advantages in portable applications:

- Supplies hydrogen without the need for compression or liquefaction;
- Hydrogen is stored at environmental conditions in liquid stabilised fuel which is water-based;
- catalysed hydrolysis produces pure humidified hydrogen;
- Easily couple to a fuel cell system;
- Allows variable output rates and delivery pressure;
- Reaction is exothermic, allows heating of the gas and also the fuel cell;
- By-products are water soluble and recyclable;
- Fuel is stabilised, safe for transportation, non-flammable and non-explosive

In this particular case, the proposed solution allows for fuel replenishment in batch on-demand production taking the system to a total volume of only 2 L and a weight less than 1 kg. The system will provide 72h autonomy to the dismounted soldier.

c) The system

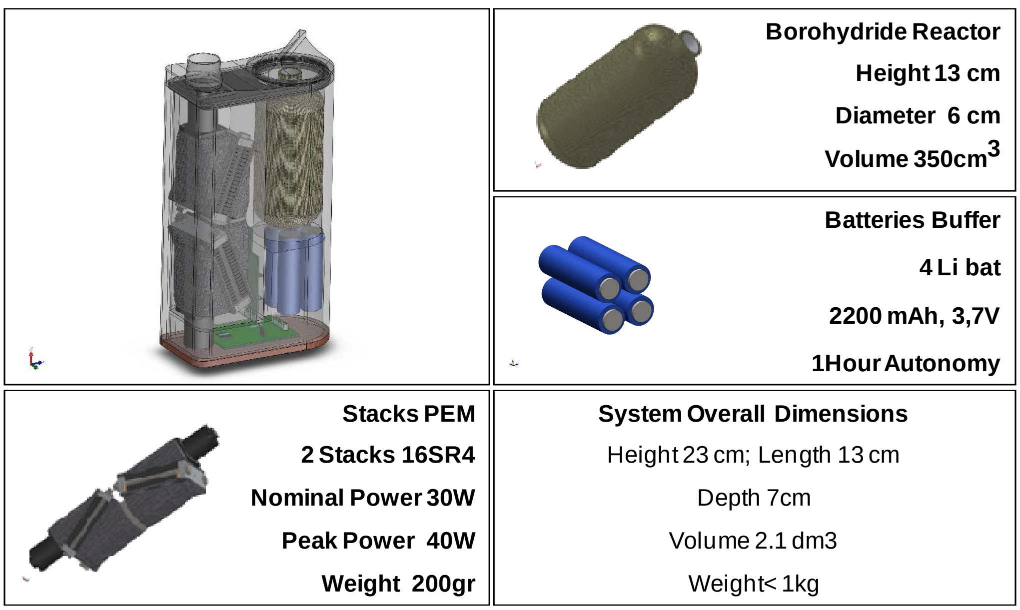

Fig. 3 The proposed power source and main characteristics of the overall system and components

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