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Tests on Fuel Cell by Innovative Small Size Prototype Plant

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Abstract

The company noted that hospitals need continuous energy throughout the year, also using cogenerates powered by fossil energy sources (methane, diesel, LPG, etc.). The Company, evaluating the possible alternative energy solutions to the traditional, highly polluting ones, has carried out a careful technical-scientific analysis, also thanks to the internal staff, on technologies that are partially mature but which, to date, find applications difficult for high costs. and / or due to lack of technical-scientific knowledge. From here, the Company evaluated the application of Fuel Cells in the healthcare sector with the possibility of converting current cogenerates powered by fossil sources with hydrogen-powered fuel cells. This would also make it possible to guarantee alternative sources of supply, allowing, in the event of emergencies, to have energy sources capable of making the health structures autonomous.

Keywords: MCFC, Fuel Cells, prototype small-size, tests, dissemination

1. Introduction

The fuel cell is an electrochemical system capable of converting the chemical energy of a fuel directly into electrical energy, without the intermediate intervention of a thermal cycle, thus obtaining higher conversion efficiency than those of thermal machines conventional. The birth of fuel cells dates back to 1839, the year in which the English William Grove reported the results of an experiment in which he was able to generate electricity in a cell containing sulfuric acid, where two electrodes, consisting of thin sheets of platinum, on which hydrogen and oxygen respectively arrived. A fuel cell works in a similar way to a battery, as it produces electrical energy through an electrochemical process; however, unlike the latter, it consumes substances from the outside and is therefore able to function without interruption, as long as the system is supplied with fuel (hydrogen) and oxidizer (oxygen or air).

The cell is composed of two electrodes in porous material, separated by an electrolyte. The electrodes act as catalytic sites for cell reactions that basically consume hydrogen and oxygen, producing water and passing electric current in the external circuit. The electrolyte has the function of conducting the ions produced by one reaction and consumed by the other, closing the electrical circuit inside the cell, and at the same time preventing mixing between anode and cathode gases. The final reaction that takes place inside the cell is exergonic, that is, it occurs by releasing energy; this manifests itself in the form of heat and electricity.

2. Materials and Methods

Prototype developed.

The prototype system is made up of a fuel processing unit and a power unit characterized by two MCFC fuel cell stacks. The hydrogen produced is developed by a hydrolyzer that separates H_2 and O_2 from distilled water (Figure 1).

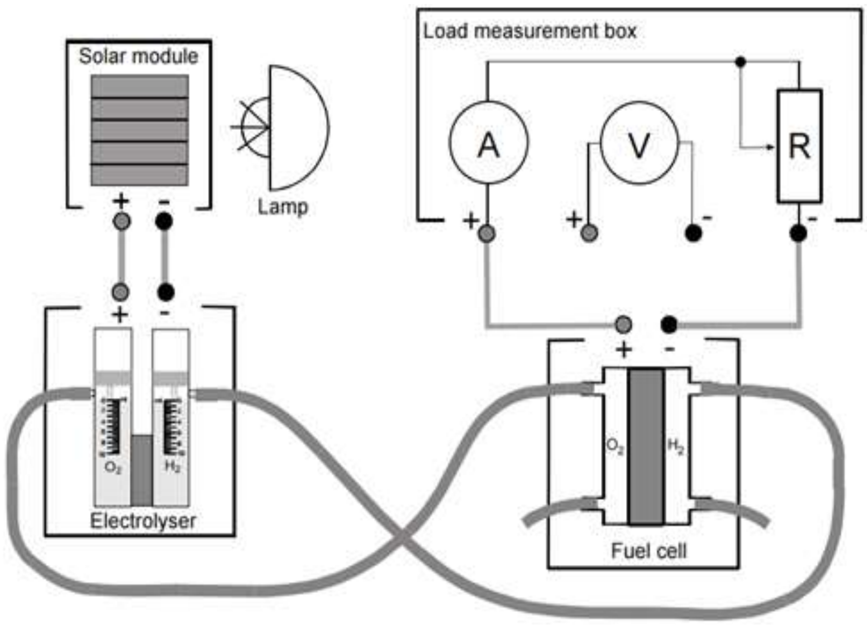


Fig. 1. Scheme of the prototype developed.

The system was modified, changing the polymer fuel cell with a molten carbonate one, as the goal was to evaluate the performance of this cell for study purposes and for a potential application in the reference sector. In Figure 2, we can see how the replacement took place.

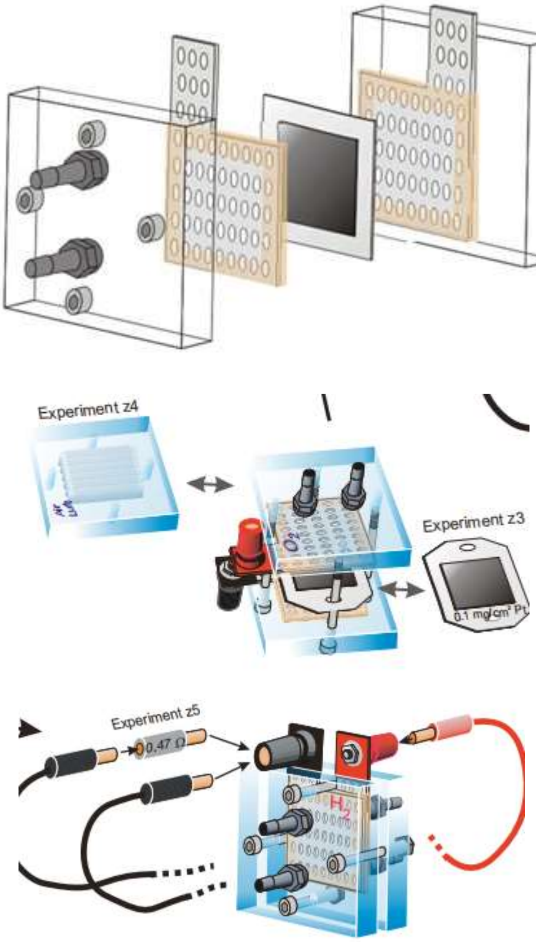


Fig. 2. Scheme of the prototype with the modified

Once the system was defined, several tests were carried out with different loads, evaluating the efficiency of the molten carbonate fuel cell on a scale. The first test is shown in the diagram below in table 1:

R Ω	t (s)	Vol1 cm^3	Volts (V)	I = mA	$H_{2consumato}$ cm^3	η (%)
3	180	6,5	0,74	233	5,2	93
5	200	5,5	0,65	220	5,5	85
10	250	4,5	0,55	215	6,7	75
50	300	3,5	0,45	200	7,5	70
100	350	2,5	0,30	150	6,5	65
200	400	2,0	0,25	100	5,0	55

Table 1. Test in lab on the prototype

3. Results and Discussion

Faraday efficiency is the ratio of the theoretical volume of hydrogen consumed by the load aa certain current flow and the experimentally determined consumption of hydrogen.

- $\eta = Vol\ H_2$ - Faraday efficiency should be 1 (100%).
- $H_2 \rightarrow 2H^+ + 2e^–$, so 1 mole of hydrogen gas gives 2 moles of electrons.
- A mole of electrons has a charge equal to 96,500 C.
- So 24,000 cm^3 H_2 gives (2 • 96,500 C) = 193,000 C.

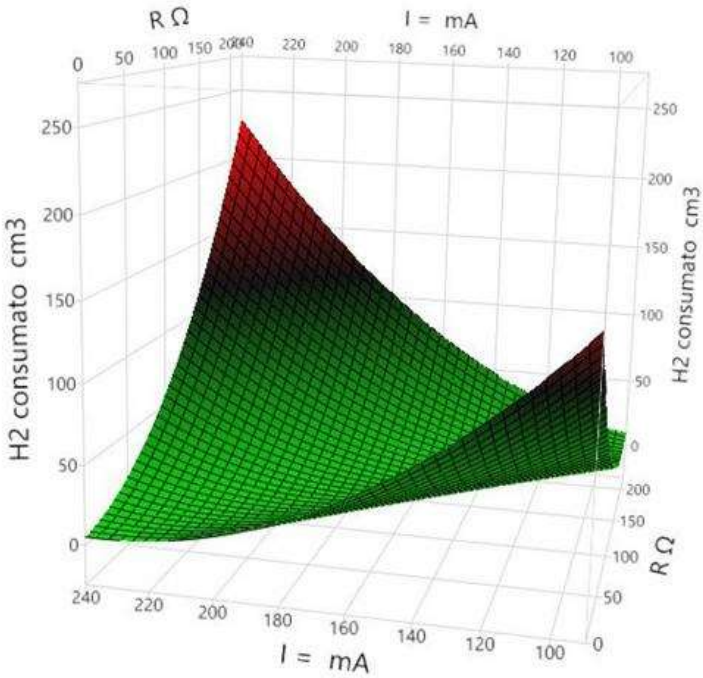
In this experiment, the fuel cell supplies 233 mA (= 0.233 A) for 180 s. Therefore the theoretical volume of the hydrogen consumption is:

- $Vol\ H_2 = (0.233A * 180s * 24.000\ cm^3) / (193.000\ C)$
- $Vol\ H_2 = 5.2\ cm^3$

Therefore the efficiency is:

$\eta = Vol\ H_2\ (th.) / VolH_2$
$\eta = 5.2\ cm^3 / 5.6\ cm^3$
$\eta = 0.93$ (93%).

The cell efficiency trend as a function of the load variation and indirectly of the variables listed above, of the tests carried out, are correlated in the following graphs.



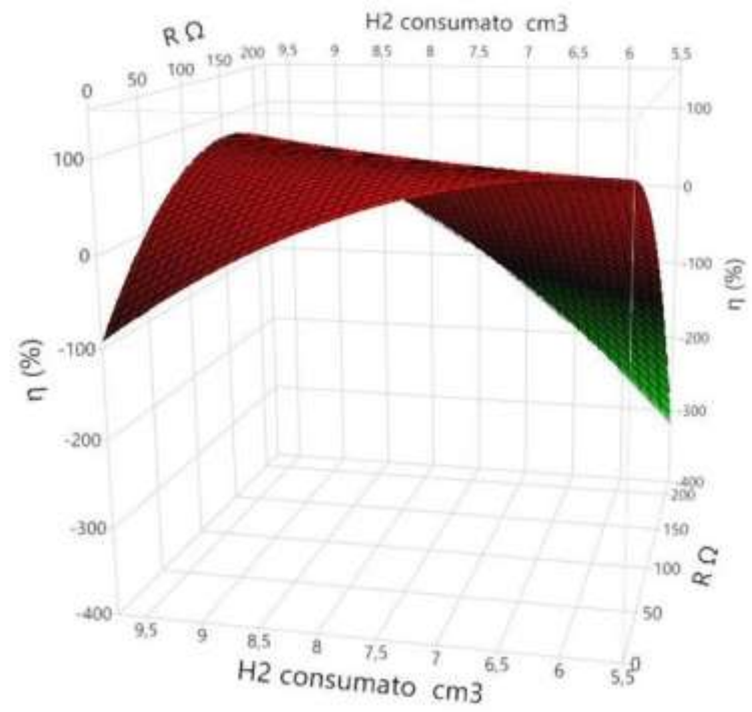


Fig. 3. Correlation between cell operating parameters and efficiency

4. Conclusion

The purpose of the work carried out was precisely to investigate a sector that presents a very high possibility of expansion, in fact the characteristics of great flexibility in the use of fuels and high yields, independent of the nominal power of the modules used and the size of the plant, make it possible to install fuel cells even in small plants

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