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Fuel Cell / electrolyser, Solar Photovoltaic Powered

The paper presents experimental obtained results in the operation of electrolyzer powered by solar photovoltaic modules, for the water electrolysis and with the obtained hydrogen and oxygen proceeds to the operation in fuel cell mode, type PEM. The main operating parameters and conditions to optimize the energy conversion on the solar-hydrogen-electricity cycle are highlighted, so that those are comparable or superior to conventional cycles.

Keywords: *solar photovoltaic module, electrolyser, fuel cell*

1. Introduction

The functioning in reverse mode of the fuel cell / electrolyser is a variant in which fuel, hydrogen, is produced and consumed almost in the same functional unit. Hydrogen production and consumption is a closed cycle, which maintains constant the power production source, water, representing a classic cycle of recycling raw materials [1].

2. Experimental installation and obtained results

Figure 1 shows the experimental installation, representing hybrid photovoltaic-electrochemical system for producing electricity, using more clean energy sources. The solar energy is converted into electricity by photovoltaic solar modules, then through the electrolysis process, hydrogen and oxygen is obtained, used then in the fuel cell, to obtain electricity [2].

The hybrid system components themselves are [3]: 1. Solar panel (U = 2V); 2. PEM electrolyser; 3. Flexible tube for water circulation; 4. Water tank / hydrogen with a capacity of 30 cm; 5. Flexible tube for the water / hydrogen circuit; 6. PEM fuel cell power of 500mW; 7. Support; 8. Fan - ele; 9. Tube circuit flexible water oxygen; 10. Water tank / oxygen capacity of 30 cm; 11. Diode shunt.

The fuel cell receives hydrogen and oxygen released from the electrolysis of PEM electrolyser [4]. The reactions in the PEM fuel cell are:

Reaction at the anode: $2H_2 \rightarrow 4H^+ + 4e^-$

Reaction at the cathode: $4H^+ + 4e^- + O_2 \rightarrow 2H_2 0$

Global reaction: $2H_2 + O_2 \rightarrow 2H_2O$

Resulting from the reaction, the water is reclaimed by two reservoirs.

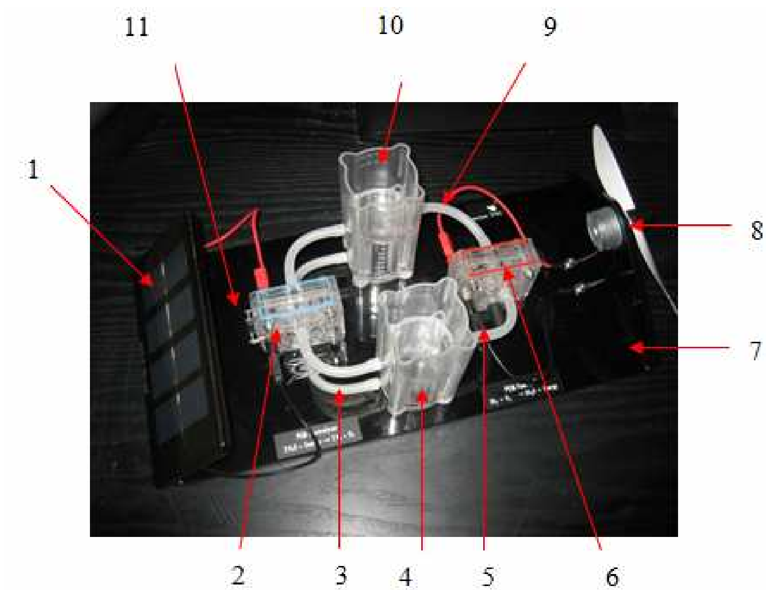

Figure 1. The experimental hybrid installation: electrolyser, fuel cell, photovoltaic module.

The PEM fuel cell (figure 2) consists of [7]: 1. cell body, 2. removable cap, 3. pressure tank, 4. connecting pipes, 5. flexible tube, 6. Negative terminal, 7. positive terminal, 8. tank nozzle, 9. fan connectors.

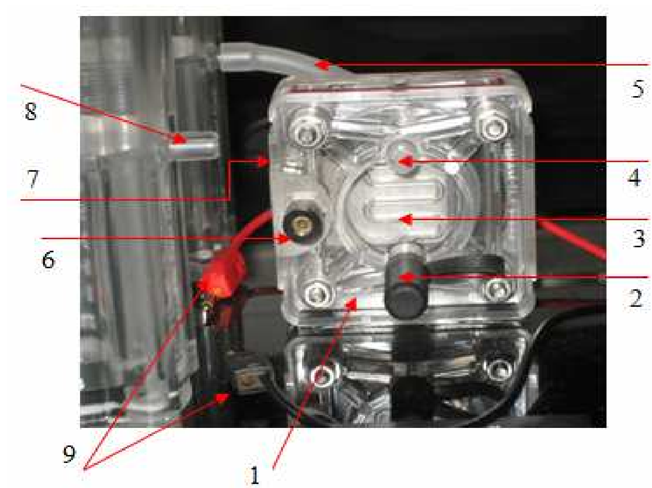

Figure 2. PEM fuel cell

Attempts made to the electrolyser and fuel cell, have led to the rise the voltage - current characteristic, illustrated in figure 3 and 4, and power curve, figure 5, which shows that the maximum power point is related to MPP.

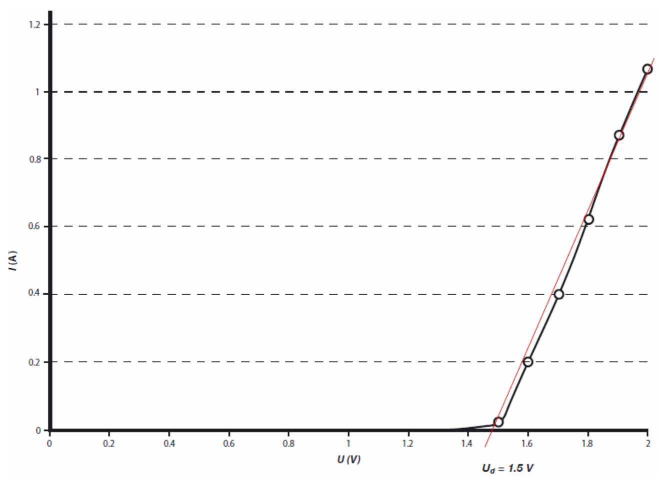

Figure 3. VA characteristic of the electrolyser

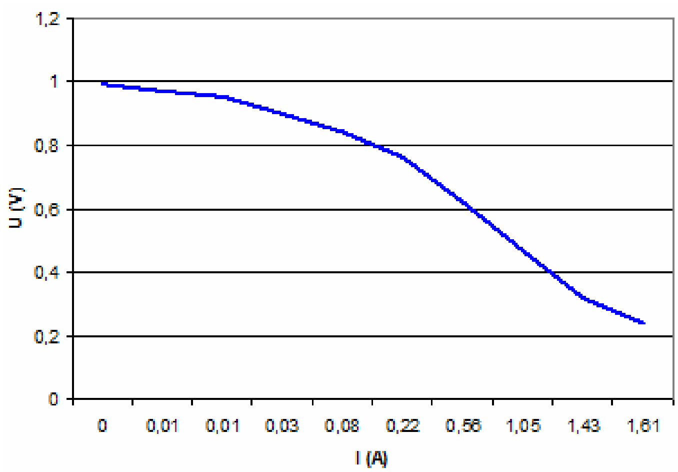

Figure 4. VA characteristic of the PEM cell

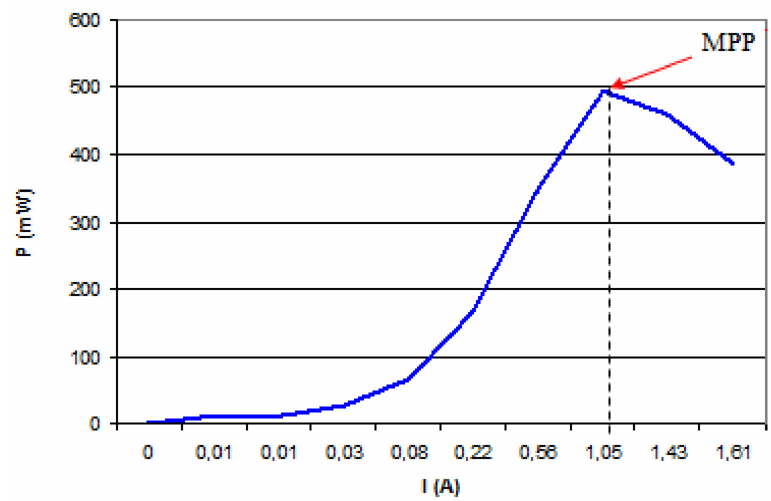

Figure 5. Power curve of the fuel cell

Ideal fuel cell efficiency, obtained in standard conditions of pressure and temperature is:

$$\eta_{id} = \frac{\Delta G}{\Delta H} = \frac{\Delta H - T \cdot \Delta S}{\Delta H} = 1 - \frac{T \cdot \Delta S}{\Delta H} = 1 - \frac{298K \cdot \left[-162.985 \frac{J}{K \cdot mol}\right]}{-285840 \frac{J}{mol}} = 0.83 \qquad (1)$$

(T = 298 K was introduced, ΔS = -162 985 and ΔH) where ΔG - the amount of energy converted into electrical energy, H - energy existing in the chemical reaction, S-entropy of the system.

Real energy efficiency has been calculated with:

$$\eta_{real} = \frac{E_{Electric}}{E_{Hidrogen}} = \frac{U \cdot I \cdot t}{V_{H_2} \cdot H_i} = \frac{0.72V \cdot 0.21A \cdot 712s}{20 \cdot 10^{-6} m^3 \cdot 10.8 \cdot 10^6 \frac{J}{m^3}} = 0.498 \approx 50\% \quad (2)$$

And Faraday efficiency:

$$\eta_{Faraday} = \frac{V_{H2}(computed)}{V_{H2}(used)}^{3} \quad (3)$$

The gas volume in an terminal, can be calculted as follows:

$$V = \frac{R \cdot I \cdot T \cdot t}{F \cdot p \cdot z} = \frac{8.314 \frac{J}{K \cdot mol} \cdot 0.21A \cdot 298K \cdot 712s}{96485 \frac{C}{mol} \cdot 1.013 \cdot 10^5 Pa \cdot 2} = 18.96 cm^3 \quad (4)$$

where: V - theoretical gas volume produced in m^3; R - universal gas constant 8.314 J/ K·mol; P - pressure in Pa (1Pa = 1N/m2); Z - number of free electrons (zH2 = 2); F - Faraday constant (96,485 C/mol).

$$\eta_{Faraday} = \frac{18.96 cm^3}{20 cm^3} = 95\% \quad (5)$$

3. Conclusion

The hybrid photovoltaic – electrochemically system, highlights the reversible functioning electrolyser - fuel cell, which requires an optimal load to function in the MPP. The electrolyser is capable to produce hydrogen, on optimal voltage, current, and therefore, maximum power. Fuel cell, among its, produce maximum electrical power, default corresponding voltage and current, only on an optimal load resistance. In these conditions, the fuel cell efficiency is much higher than the solar photovoltaic module [6].

The analyzed system represents a storage solution for the solar energy in form of hydrogen, obtained in the water electrolyser process. The obtained hydrogen can be used, depending on necessities, in producing electric energy with the fuel cell system.

References

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