EXPERIMENTAL-DEMONSTRATIVE SYSTEM FOR ENERGY CONVERSION USING HYDROGEN FUEL CELL – PRELIMINARY RESULTS

D. STOENESCU, I. STEFANESCU, L. PATULARU, M. CULCER,
R. E. LAZAR, E. CARCADEA, D. MIRICA
National R&D Institute for Cryogenics and Isotopic Technologies – ICSI
Rm. Valcea, Romania, daniela@icsi.ro

ABSTRACT

It is well known that hydrogen is the most promising solution of future energy, both for long and medium term strategies. Hydrogen can be produced using many primary sources (natural gas, methane, biomass, etc.), it can be burned or chemically react having a high yield of energy conversion, being a non-polluted fuel. This paper presents the preliminary results obtained by ICSI Rm. Valcea in an experimental-demonstrative conversion energy system made by a sequence of hydrogen purification units and a CO removing reactors until a CO level lower than 10ppm, that finally feeds a hydrogen fuel stack.

Key words: (hydrogen, PEM fuel cell, reformation)

Introduction

A special attention is paid now to the non-polluted and inexpensively solutions for renewable energy to replace the available energy resources (petroleum, coal or nuclear energy), one of the most promising solution being the hydrogen.

In this context, the National R&D Institute for Cryogenics and Isotopic Technologies – ICSI Rm. Valcea has started a research project financed by the National Research-Development Program with the main purpose to develop an experimental-demonstrative pilot plant for energy conversion using hydrogen PEM fuel cells.

This paper presents a transition from theory to practice, proposing to lead the preliminary experimental results obtained by the research team of ICSI Rm. Valcea in the experimental pilot plant for energy conversion using PEM fuel cells, generically called the „Blue Room” (Figure 1).

Fig. 1. *Views from the reformer construction afferent to the experimental pilot for energy conversion using PEM fuel cells – „Blue Room"*

The research activity has been directed on two main fields, which are:

- Development of a fuel processor adequate to supply a fuel cell stack; the fuel processor consists in a unit for hydrogen production based on methane catalytic steam reforming process and a series of hydrogen purification units. The level of CO in the output hydrogen has to be lower than 10 ppm;

- Design and development of a hydrogen fuel cell stack.

The hydrogen processor

The methane catalytic steam reforming ($CH_4 + H_2O \leftrightarrow CO + 3H_2$; endothermic reaction $\Delta H = +206$ $kJmol^{-1}$) is the basic principle of hydrogen production, the plant having three main stages: the steam reforming, the water-gas shift reaction and the hydrogen purification.

The reactor designed in our institute woks at 700º C and 3 atm, the steam reforming process being produced on a Ni based catalyst disposed in ten columns, circle distributed.

After the reforming the output gas is drawn into the HTS (*high-temperature shift*) and LTS (*low-temperature shift*) reactors ($CO + H_2O \leftrightarrow CO + H_2$; exothermic reaction $\Delta H = -41.15$ $kJmol^{-1}$).

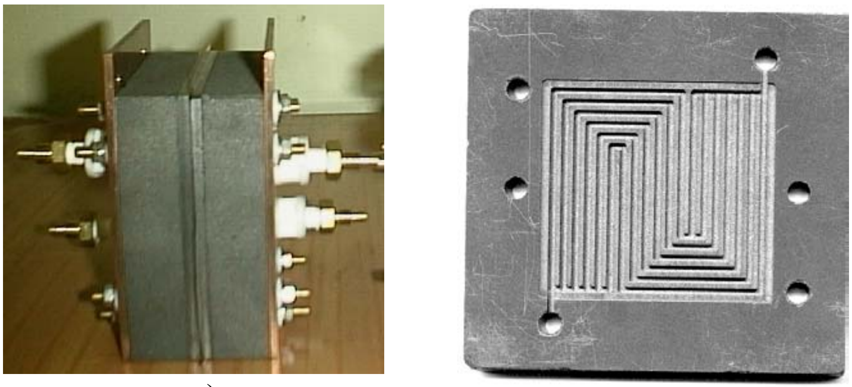
In the first purification unit, HTS, the water-gas shift reaction is produced at 500º C, the reaction being produced on a Fe_2O_3/Cr_2O_3 catalyst, disposed in three columns, circle distributed.

In the second reactor, LTS, the reaction takes place at 200º C, before the LTS the gas being cold. The LTS reaction is based on a CuO/ZnO alumina supported catalyst disposed in three columns, circle distributed. The LTS product will be a mixture of hydrogen (70-80%), CO_2 and small amounts of H_2O and CO.

The hydrogen will be finally purified so that the CO concentration to be lower than 10 ppm, the CO easily poisoning the exchange protons membrane used for fuel cells construction.

The PEM fuel cell

As we showed before the second step was the design and construction of a fuel cell stack. First we developed a single fuel cell (figure 2) constituted by 2 Cu plates (6 mm) – anode and cathode - and two graphite plates. The channels developed in the graphite plates for hydrogen and oxygen/air transport from anode to cathode has a specific geometry so that the surface between gases and protons exchange membrane to be bigger.



a) b)

Fig. 2. *PEM fuel cell developed in ICSI Rm. Valcea*
a) fuel cell ensemble; b) gases supply channels in graphite plates

The third element of the fuel cell is the Nafion polymeric membrane with a 25 cm^2 useful surface.

The preliminary results on this fuel cell are presented in Figure 3 (to a maximum current of 10.7 A results a maximum voltage of 0.44V). After the tests we can say that the fuel cell is operational to 0.6 V and 5 A, the power being 3 W/cell.

The next step was to develop a fuel cell stack, to improve the fuel cell performances, knowing that the max temperature supported by the cell is 80º C. This new configuration was designed and constructed, now being tested.

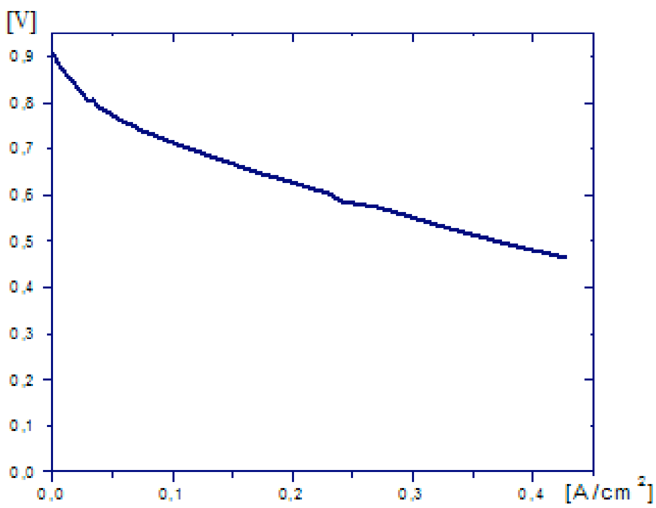


Fig. 3. *Voltage – current density variation*

Conclusions

The paper tried to concentrate the main results of ICSI Rm. Valcea in the field of energy conversion using hydrogen fuel cells. In this moment we designed and developed an experimental pilot for hydrogen production by methane steam reforming process and we have under construction a fuel cell stack from 4 cells as intermediary step to the final stack formed by 21 fuel cells. The research purpose is to optimise the stack configuration (geometric and thermodynamic) and to increase the power production for the future applications.

References

[1] Ioan Stefanescu Mihai Varlam, Eugen Vitan, *Cercetari si dezvoltari privind realizarea primului sistem integrat demonstrativ bazat pe celule de combustibil cu hidrogen – solutie tehnologica in secolul hidrogenului*, Stiinta Moderna si Energia – Producerea Transportul si Utilizarea Energiei, Cluj, mai 2003

[2] Arthur D. Little, *Multi-Fuel Reformers for Fuel Cells used in transportation,* May 1994;

[3] J.S. Chang, H.S. Roh, M.S. Park, S.E. Park, *Bull. Korean Chem, Soc*, **2002**, Vol. 23, 5.