THE COMBUSTION CELLS WITH HYDROGEN

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Rezumat
Căutarea unor mijloace de propulsie nepoluante pentru autovehicule a impus atenției și hidrogenul ca posibilă alternativă. Sistemul pilă de combustie cu hidrogen – motor electric s-a dovedit cel mai potrivit. Pilele de combustie au randament ridicat, putere mare pe unitatea de masă și siguranță în funcționare. fiind utilizate de mulți ani în tehnica spațială.

Abstract
The searching for new non-pollution propulsions for motor vehicle imposed in attention the hydrogen as a possible alternative. The system combustion cell with hydrogen – electric engine seems to be the suitable. The combustion cells have a great efficiency, a great power per mass unit and safety in use, and there are used since a lot of years in the space technique.

Résumé
La recherche des moyens de propulsion *qui* ne polluent pas, pur les véhicules a imposé á l'attention l'hydrogène comme possible alternative. Le système pile de combustion avec hydrogène – moteur électrique s'est prouvé le meilleur. Les piles de combustion ont un rendement élevé une grande puissance sur l'unité de masse et assurance dans le fonctionnement, étant utilisés beaucoup d'années dans la technique spatiale.

Introduction

The development of regenerable sources of energy as an important and non-pollution resource of energy it is a priority in the politics of energy in the world., which in the context of continues development have a purpose in the grow of safety energy feeding, the protection of the environment and the development on the commercial scale of the viable energy technologies.

Since 1997 when was adopted the Kyoto Protocol of United Nations Convention about the climatic changes (1992), the industry of regenerable sources was pointed to capitalized on a global market of regenerable energies, target which can be touched only with an international project pointed to the diminution of emissions of the gasses with green house effect.. By this project, the developed countries established as a target the reduction until 2012 of the gasses with green house effect with 5,2% compare with 1990 level. The Kyoto Protocol was signed in December 1997 in Japan by 84 nations, but was ratify by only 37, the great majority of these being countries in the way of development. After this protocol there were follow many international agreements, at the world or European level, as the Haga Agreement (November 2000) or Bonn (July 2001).

The hydrogen – the combustible of the future

T.N. Veziroglu (1), editor of the review specialized in the problems of hydrogen energy "International Journal of Hydrogen Energy" shows some proprieties which recommend the hydrogen as a product made with non-conventional technologies:

- the hydrogen concentrates sources of primary energy that can be presented to the costumer in a convenient form;
- low cost due to the modern technologies;
- the possibility of conversion in different energy form using procediments with high efficiency;
- it is an inexhaustible source, because it can be obtain by water and after use it transforms in water.

The production and use of the hydrogen represents a closed cycle which preserve the source of production, the water, and is a classical cycle of recirculation of the prime matter;

- it is the light and clean combustible. The burning of the hydrogen is almost completed lacking by pollution emissions, excepting Nox, which can be eliminate with a proper adjust of the burning conditions. It has an energetic density superior compare with any other combustible;
- the hydrogen can be stored in many ways: gas at normal or high pressure, as liquid hydrogen or like solid hydride;
- can be transported on high distances;
- can be a way to store the electricity, using the electrolysis of water.

The systems based on hydrogen represent one of the most attractive direction of the energy of the future. Producing hydrogen from convenient material such as water, is a project of the future.

Using hydrogen to obtain thermic and mechanical energy is not a new idea.

The burning of hydrogen is a strong exothermic process because the hydrogen has high caloric capacity, such as 119,872 MJ/Kg.

The superiority of hydrogen compared to the other combustible result from the next table.

Table 1. Caloric capacity of the most used combustible

Combustible	*Caloric capacity (MJ/Kg)*
gasoline	43,738
Diesel oil	41,855 - 46,04
Kerosene	43,0952
GPL	116,357
hydrogen	119,87272

Note: GPL – petrol liquefied gas

That why the hydrogen is now considered as a possible alternative of storing the energy. The solar energy can be stored only if it is transform in hydrogen using any kind of procedure such as the electrolyse.

On high interest are the actual research in the field of fotoelectrolyse, that means electrolyse under the action of solar energy.

$$2H_2O \xrightarrow{fotoni} 2H_2 + O_2 \qquad (1)$$

The first problem is to find the catalyser that can facilitate the reaction. It seams that the most appropriate are the enzymatic type.

One of the most used procedures to obtain the hydrogen is the chemical reaction between coal and water steams on 900-1000°C.

$$C + H_2O \xrightarrow{900-1000^0C} CO + H_2\uparrow \qquad (2)$$

and after then under the action of a catalyser of iron oxide.

$$H_2O + CO \rightarrow CO_2 + H_2\uparrow \qquad (3)$$

The dioxide of carbon obtained it is dissolved in water under pressure and so it is possible to be obtained hydrogen with 99% purity.

Most of the energy used now in our society it is obtain by burning fossil combustible such as oil, coal, natural gases. Another part it comes from nuclear reaction of fission and a small part it is obtained from as known unconventional energies (solar, eolian, etc).

So the hydrogen it is obtained using the fossils combustible, oil, coal and natural gases. It is less efficiently to transform oil in hydrogen comparing to the direct used of oil (by burning).

The studies about the using of the hydrogen has been developed in the last time because of another reason: the necessity to reduce the pollution in the big towns of Europe, towns with higher agglomeration and traffic (using the administrative measure, such as closing the traffic, does not solve the problem).

The hydrogen engine produce only water so does not create pollution and does not increase the "green house" effect because does not produce CO_2.

The hydrogen has a small density (89,22 g/m^3) and reacts easy with the oxygen in the air being explosive.

At the internal combustion engine (specially the engine with spark) it can be utilized instead of gasoline, GPL, without important modification: but the hydrogen can not be used because of the problems with the tight of the installation and so because of the danger of explosion.

Another solution can be "borrowed" from the field of space technology and we are talking about the ***combustion cells with hydrogen***. This kind of cells gives electric energy of the spaceships. The procedure is known from a long time ago but because the technical difficulties can not be used on high scale.

We are talking about minimize the ecological impact in the field of transports. There are two future ways of action:

- combustion cells with hydrogen,
- mixed engine(with internal combustion and electric).

The combustion cells with hydrogen for the engines

The combustion cell is a galvanic cell inside of which the free energy of a chemical reaction it is transformed in electric energy.

All the combustion cells are having a similar structure: they contains 2 electrode devised from an electrolyte and connected to an external circuit. The anode is supply with gas fuel (here take place their direct oxidation) and the cathode supply with an oxidant (ex. the oxygen from the air). The electrode must have been permeable so they are having a sponge structure. The electrolyte must have a lowest permeability.

The general reaction can be write:

$$2H_2 + O_2 \rightarrow 2H_2O$$

such as in the case of commune burning. But the reactions from the cathode and the anode are those that produce energy. The electrolyte is the key and there is the most vast field of research. The reactions from those two electrodes can be write:

the anode (-): $2H_2 \rightarrow 4H^+ + 4e^-$

the cathode (+): $O_2 + 4e^- \rightarrow 2O^{2-}$

on the electrolyte: $4H^+ + 2O^{2-} \rightarrow 2H_2O$

Energetically we can write:

$$H_2 \rightarrow 2H^+ + 2e^-$$
$$26768 \text{ Ah kg}^{-1}$$

$$O_2 + 4e^- \rightarrow 2O^{2-}$$

3346 Ah kg^{-1}

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

1 Kg of moisture has the stoechiometric ratio 111,11 g H_2 and 888,88 g O_2, so from the total reaction results 2974,22 Ah kg^{-1}.

The law of working of that kind of cell it is pointed in figure no. 1.

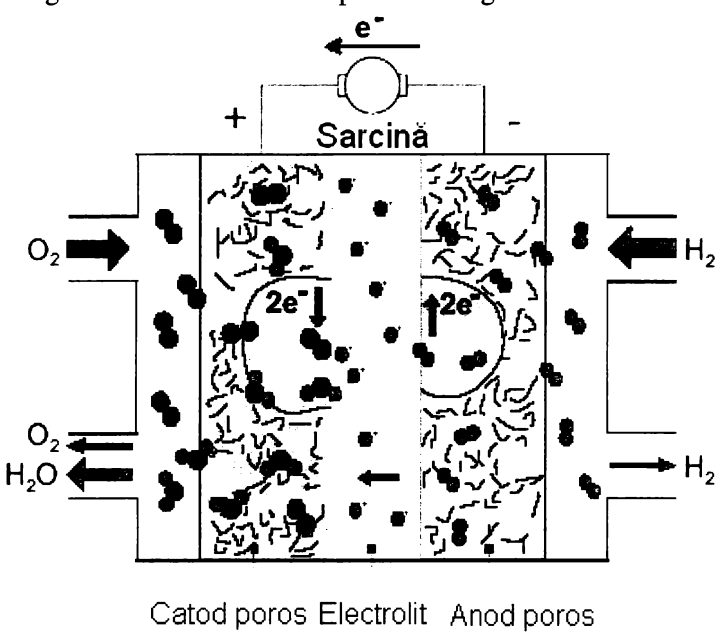


Fig. 1.

If we compare the classic accumulator of a car ($Pb/H_2SO_4/PbO_2$) that produce 81 Ah kg^{-1}, the superiority of the combustion cell is clear.

We can also notice that a combustion cell it is not so heavy. With all its components it has 1100 Wh/kg, instead of 60 - 150 Wh/kg of an ordinary one.

There were realised prototypes with a power of 5 MW, but on a car it could obtain only 275 W/kg because it must considerate the mass of the tank with hydrogen.

The global efficiency of electric conversion it is also superior to those of systems with thermic engine this comparation can be seen in the figure 2.

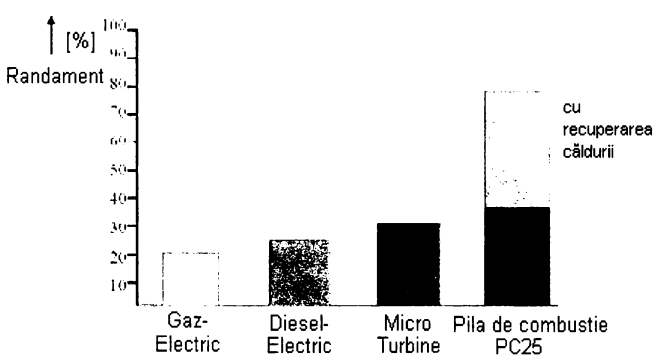


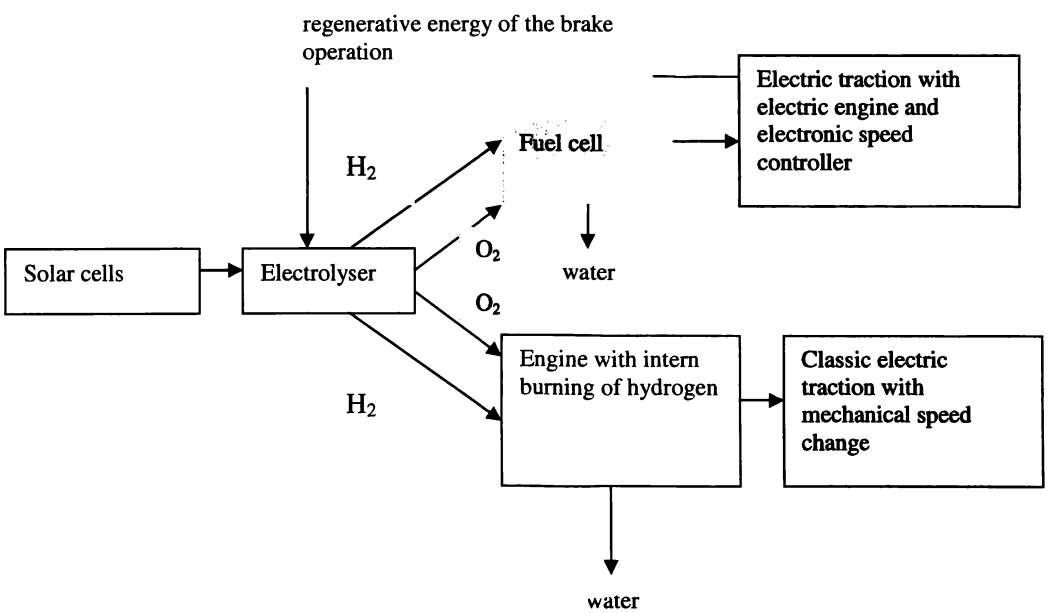
Fig. 2: Comparising between the efficiency of the electric conversion of an combustion cell and of the systems of energetic conversion.

The high efficiency of the combustion cells can be explain by the fact that the process are isothermal, so after the reach of the system temperature, the quantity of heat produced remains constant and does not exceed the quantity of electric energy produced. It can be utilized even the heat produced so the combustion cells are becoming sources of electric and thermic energy.

An thermic engine with spark does not have an efficiency higher than 30 -35% and a Diesel one 35 - 40%. Instead the electric one has an efficiency of 80 - 90%, so the system combustion cell - electric engine gives over 60% efficiency. That represent a higher ratio in using of energy without producing toxic gases and without increasing the "green house" effect.

The results are satisfactory and it could be seen in towns buses with electric engine that use combustion cells. In Italy (Torino) the Fiat Group experiments this kind of buses on regular courses and also in Germany (Stuttgart) are running the experimental buses of the Daimler-Chrysler.

In the perspective of the introduction of the CO_2 foreseen by the Kyoto agreement, the hydrogen is a perfect solution on a globally scale, in the situation when it would be produced leaving from other primary sources of energy (solar, atomic energy):



Conclusions

Taking into account the time of implementation of some new technologies and of replacement of the existent equipment, it is necessary that the rhythm of development of the new technologies to be more alert and also of those that suppose reduced consumption of energy. In the same time it is needed a deep evolution of the lifestyle and of the orientation towards a lasting development.

Unless our country enters the European Union at the beginning of 2007, we should assume the strategic objectives of this in the field of the regenerated resources.

The regenerated resources of energy are the solar energy, the wind energy, the geothermal energy, the biomass, the hydrogen's energy and others.

Bibliography

1. [Mu 89] Muscalu S, V. Platon, *Pile de combustie*, Editura Tehnica, 1989
2. [On 74] Oniciu L, *Chimie fizica*, Editura didactică și pedagogică , București, 1974
3. [On 82] Oniciu L, Constantinscu E., *Electrochimie și coroziune*, Editura Didactică și Pedagogică, București, 1982
4. [Ve 20] T. N. Veziroglu, *International Journal of Hydrogen Energy*, 2000, 1143
5. [Il 20] I. Iliescu, Prefață la STAREA LUMII 2000, *Probleme globale ale omenirii* (autori: L.R. Brown, C. Flavin, H. French), Editura Tehnică, București, 2000
6. Romanien Alliens Hydrogen and Fuel Cells Technology