FUEL ELEMENTS OF HYDROGEN POWER INDUSTRY AS A SOURCE OF EFFECTIVE ENERGY

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In recent years the public discusses a question of energy resources. According to expert opinions, stocks of oil have to suffice approximately for 50 years. Further oil production will be conducted from unattractive sources, the cost of its production and cost of the final petrochemical products will increase [4].

Certainly, some countries can not worry about a century, and then it will be possible to use gas and coal, however it won't be enough and it will be necessary to look for new energy sources.

The countries with rather small stocks of natural resources deal with these problems. For example, in Kazakhstan following the results of 2012 electricity generation from wind, hydro and solar energy made 1 trillion kWh [5].

Such examples make us think about the subject of alternative power engineering which at present totals more than 5 points:

-solar energy
-geothermal energy
-wind energy
-tidal energy
-biofuel

The solar power stations use energy of the sun for receiving current from photo cells, or warm a copper which spin the turbine with the generator. The geothermal power uses transformation of internal heat of the earth into electricity. Thewind power – wind is used for spinning of a rotor of the electricity generator. The tidal power engineering uses energy of waves of the seas and oceans as an electricity source. Besides, the types of electric engineering based on a difference of temperatures and biofuel is developed[2].

The great attention is drawn by fuel elements – the devices turning chemical energy of reaction into electric current. Some of them are very small and use alcohol for the work, but some of them are capable of working on technical hydrogen and air under certain conditions and there are a lot of such resources on the Earth. Besides, such elements can produce heat. It can be used to increase efficiency of resources use.

Before learning positive and negative aspects of fuel elements we should understand common processes in fuel elements and some definitions.

Fuel element (FE) is device in which the energy of fuel and oxidizer turns into electricity. In fact, it is a galvanic cell because of the presence of reacting substances and electrolyte. But the common difference is that the fuel element demands a continuous supply of active components.Galvanic cell has a stock of energy. If it exhausts the energy allocation will stop.

General view of current producing reaction, common for all elements is the following:

$mB+nOk=B_mOk_n$.

Wheremandk – integers, B – fuel, Ok – oxidizer

Such reaction is common for fuel elements and thermal electric generators. In thermal electric generators frequent collision of active components is necessary. In fuel elements there is a directed movement of electrons from a reducer to an oxidizer.It can be described by several formulas:

Fuel oxidation:

$mB \rightarrow mB^{n+}+(m*n)e$

Oxidizer restoration:

$nOk+(m*n)e \rightarrow nOk^{m-}$

$nOk^{m-}+ mB^{n+} \rightarrow B_mOk_n$

We can see that in both cases the results are the same but in the second case there is a production of current.

Fuel elements with alkaline electrolyte

In fuel elements with alkaline electrolyte KOH solution is mainly used. We can write current making reaction:

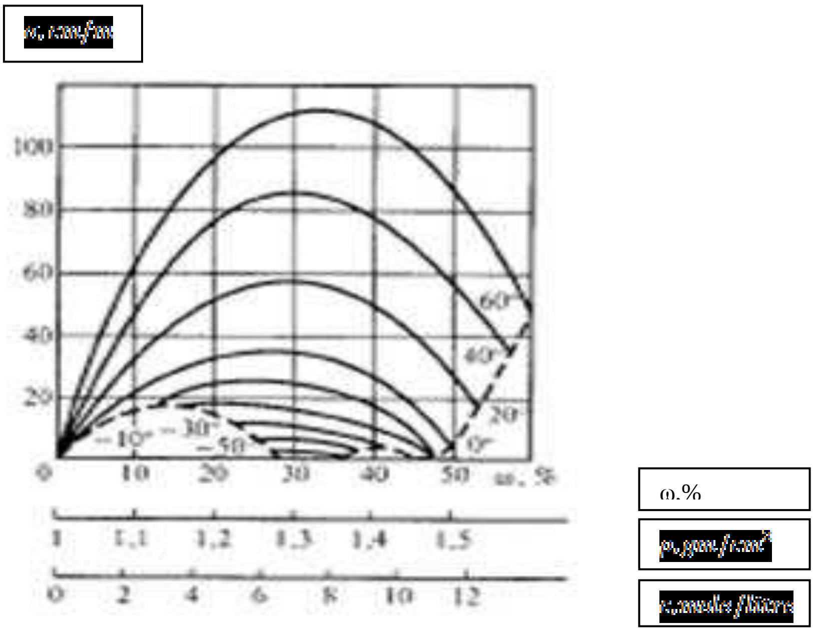
$2H_2+4OH^{-}4e \rightarrow 4H_2O$

$O_2+2H_2O+4e \rightarrow 4OH^{-}$

These fuel elements work on pure hydrogen and oxygen that is expensive. However, the mass of installation and cost of energy can be reduced, using air instead of oxygen. But air needs to be cleared of carbon so that electrolyte didn't react, bringing to decrease in conductivity:

$2KOH+CO_2 \rightarrow K_2CO_3+H_2O$

Potassium hydroxide was chosen in view of high electric conductivity that it is possible to see in figure 1.



The dependence of the electrical conductivity of potassium hydroxide solutions on concentration and temperature. Concentration is expressed as a percentage of mass fractions and moles per litre. Also listed density solutions.

The conductivity peak occurs apparently at about 60 degrees Celsius is the share of concentration of 6-8 mol per litre. The first such battery was presented by the English scientist F. Bacon in the 1950th, it worked at 200 degrees Celsius; hydrogen and oxygen pressure was 2-4MPas. The element had a good density of current up to 4 kA/sq. m at a voltage of 0.9 V, the battery power was near 5 kW. However, the resource of this device sufficed to work 100 hours and because of high pressures it was necessary to increase installation weight. Similar elements were applied in meteorological stations, television stations, buses and even in the submarine where the power of the battery was 100kW [3].

Comparison of alkaline fuel elements is presented in table 1.

Company	Temperature℃	Anode catalyst	Cathode catalyst	Current density, kA/m^2	Voltage, V	Power density, kW/m^2	Durability, th.hrs.
Varta and ISET	60	Ni	Ag	1	0,8	0,8	>4
Siemens	80	Ni	Ag	0,8-2	0,9-0,8	0,7-1,6	8,5
Union Carbide	65	Pt	Spindle	1	0,85	0,85	8
ELENKO	70	Pt	Pt	1	0,7	0,7	20
Allins Chalmers	90	Pt-Pd	Ag	2,5	0,85	2,25	5
UTC (Apollo)	200-260	Pt	Pt	0,25-2	1-0,8	0,25-1,6	2,5
UTC (Shuttle)	92	Pt-Pd	Au-Pt	2,7	0,86	2,2	5

Ural Electrochemical Integrated Plant	98	Pt	Pt	2,2	0,92	2,1	5

So, the main advantages of alkaline fuel elements are: availability and high electric conductivity of electrolyte, the inexpensive production technology, ability to work at a temperature up to-30 degrees Celsius, reliability and environmental friendliness.

Shortcomings: need for pure hydrogen and use of expensive platinum catalysts.

Methanol fuel elements

Practical experiments showed that methanol is oxidized on platinum electrolyte in acid solutions:

$CH_3OH+H_2O^+ \rightarrow CO_2+6H+6e$

Because of rather weak parameters methanol fuel elements can't compete with alkaline and firm polymeric, however, found the application. Storage of pure hydrogen and oxygen is expensively and ineffectively. From this point of view methanol is much more favorable as at the room temperature it is liquid. Therefore it is simple to store it.These advantages are used in portable equipment, for example, for power supply of laptops, as theoretical energy which can be received from methanol kilogram is above, than at lithium.

Advantages: ease of storage of methanol, low pressure, easy replacement of sources of methanol.

Shortcomings: toxicity of methanol, by-products of reaction worse properties of the catalyst.

Fuel elements with solid oxide electrolyte

Strong substances are used as electrolyte. For example, the dioxide of zirconium stabilized by teroxide of yttrium,$(ZrO_2)_{0.92}(Y_2O_3)_{0.08}$.

Because of features of such electrolyte acceptable conductivity is reached at a temperature about 1100K. This feature allows using such fuel element as heat source. The part of energy of fuel passes into heat which is simple to use at such temperatures for heating and for receiving additional electricity using a gas turbine (hybrid installation).

Main reactions of a solid oxide fuel element:

$H_2+O^{2-} \rightarrow H_2O$

$CO+O^{2-} \rightarrow CO_2$

$O_2+4e=2O^{2-}$

Working pressure of such fuel elements is 300-400 kPas. The Siemens-Westinghouse firm achieved power near 200 W on fuel kilogram. Density of power made to 3kW per sq. m, a resource about 60000 hours.

Parameters of environmental friendliness of hybrid electrical units are presented in table 2 given below.

Options	Power HybEU	
	300	100

Efficiency, %	More 55	More 55
Power of electricity	244	805
Power of gas turbine	65	220
Summary power	300	1014
CO_2, kg/MWhr	Less 350	Less 350
NO_N, ppm	Less 0.5	Less 0.5
CO_2, ppm	0	0
SO, ppm	0	Less 0.1
Particles, pp,	0	0
Noise, 5 metredb	<75	<75

Advantages: ecological safety, high efficiency, possibility of use in a heat supply, use as fuel Advantages: ecological safety, high efficiency, possibility of use in a heat supply, use as fuel not only hydrogen, but also various biogases.

Shortcomings: high working temperature because of which it is necessary to buy the qualitative materials compatible at thermal expansion is necessary.

Fuel elements with firm polymeric electrolyte

In such fuel elements the ionic conductor is the membrane, capable to carry out hydrogen ions. For example, using electrodes made of platinum grids the element gave out tension 0,6 V at the current density 1,25 kA per sq. m at a temperature about 60 degrees Celsius.

Main reactions:

$H_2\text{-}2e^+ \rightarrow 2H^+$

$1/2O_2 + 2H^{++} \rightarrow H_2O$

Such fuel element was applied in Geminy spaceships and the power was 1.8 kW, a stock of 90 kg of oxygen and hydrogen was enough for two-week flight. Modern samples are capable to give out 3 kA per sq. m at a voltage of 0.8 V.

Increasing the temperature with 50 to 90 degrees Celsius tension of each element rises by 30-50 mV, but the resource considerably decreases. Therefore the used temperature is about 70 degrees. At pressure increase from 100 kPas to 500 kPas there is an increase in density of current on 50 mA per sq. cm, but power consumed by the compressor. Therefore gas pressure usually isn't higher than 200 kPas.

Advantages: use as fuel of technical hydrogen or air, high specific power, firm electrolyte.

Shortcomings: high cost of a membrane because of the content of platinum in it in large numbers, small service life because of accumulation of impurity in a membrane [1].

Conclution

This review gives a clear understanding that fuel elements can provide with electricity and heat in the future. However, mankind shouldn't be focused only on this problem, there are many options of alternative power engineering and it is better to use them together.

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