Examination Parameters of SomeBasic Construction of the Brown Gas Generators

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Abstract – **Increasing fossil fuel consumption, enforce much more need of developing and using construction, which generate so called renewable sources of energy. One of these sources is water. There is an opportunity to use energy saved in it. Dissociation of the water with the help of electric current, create mixture of oxyhydrogen gas (brown gas), which can be used like alternative fuel.**

In this article are represented a few brown gas generator's constructions and some of its main parameters are examined. The experiments are conducted with generators working on DC current. The main parameters, observed in the experiments are: voltage, current, oxyhydrogen gas production and efficiency of the construction.

Keywords– **Brown gas, Generators, electrolyser.**

I. Introduction

One method to produce hydrogen is electrolysis. In this way applying electrical dc current in the solution or melt, on the electrodes the elements are dissociated into different components. This process represents breaking down of the chemical compounds. Anions (negative ions) are separated on the positive electrode anode, and cations (positive ions) on the negative – cathode. Electrolysis of water produces on the both electrodes two gases – hydrogen and oxygen. The hydrogen is separated on the cathode and oxygen – on the anode. They are in molecular state and saturate the solution with small bubbles in proximity to electrodes. After dissociation of the water molecule, generated gases mixes each other (if construction allows that) into combustible compound consist of two part hydrogen and one part oxygen. This is so called brown gas.

In the electrolyser begins to flow the follow processes:

On the cathode:

$$2e^{-} + 2H_2O \rightarrow H_2 + 2OH^{-} \quad (1)$$

On the anode:

$$2H_2O \rightarrow O_2 + 4H^{+} + 4e^{-} \quad (2)$$

This means that the cathode release two electrons and two hydroxyl ions and one molecule of hydrogen are produced from two molecules of water. In the other side anode accept four electrons and create four hydroxyl ions and one molecule of oxygen.

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The equation of that process can be expressed like that:

$$2H_2O \rightarrow O_2 + 2H_2; E = +1,229V, \quad (3)$$

what means, that for dissociation of the water is needed applying external electrical field equivalent to +1,23V. Practically for starting the process of the electrolysis and acceleration the brown gas generation, is necessary catalyser in the solution (KaOH, NaOH, NaSO4). For realization of a reliable electrolyser, is necessary not only good catalyser, but electrodes from durable

material resistible on the aggressive effect of the base and solution. In other case corrosion will destroy the electrodes.

II. Statement

There exist a big variety of constructions of different electrolysers. They has equal principal of operation, but different number and shape of the electrodes, and its localization. Common type of the system for brown gas generation is shown on the Figure 1. It was made different types of electrolysers constructions in order to estimate their efficiency and reliability.

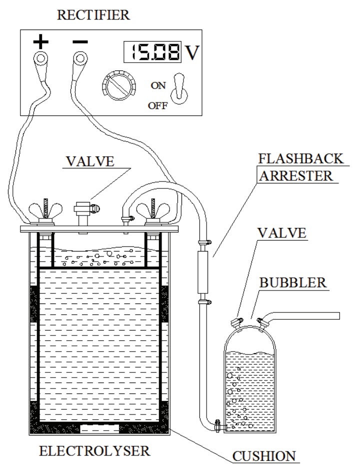

Fig. 1. Common type of the system for brown gas generation

The efficiency was evaluated using both Faraday's lows for electrolysis, which can be expressed with the equation:

$$m = \frac{Q}{F} \cdot \frac{M}{z}, \quad (4)$$

where:

m is mass of the materials released over the electrodes.

Q – quantity of the electrical charge, used in the electrolysis,

M – molar mass of the elements,

z – valency,

F – Faraday's constant (F=96 485 C/mol), and free Gibbs energy which is equal to:

$$G = -nFE \, , \tag{5}$$

where:

N is number of the molls of electrons, participated in the reaction.

F - Faraday’s constant,

E – electrical potential between anode and cathode.

For estimation efficiency is introduced a quantity MMW – ml/W/min, which in fact is volume of created brown gas (in milliliters) divided on amount of energy needed for its production (in wattminutes):

1MMW=1ml/1Wmin.

According Faraday’s lows is obtained that 100% efficiency will be reached when MMW is equal to 9,282.

For electrolysis cells were used electrodes made from stainless steel 316L type. That type consist molybdenum which support better redox reaction. For electrical measurements was used digital multimeter type MY-64 and current clamps type MS- 3302. It was tested constructions with anode, cathode and different numbers of neutral plates between them Figure 2.

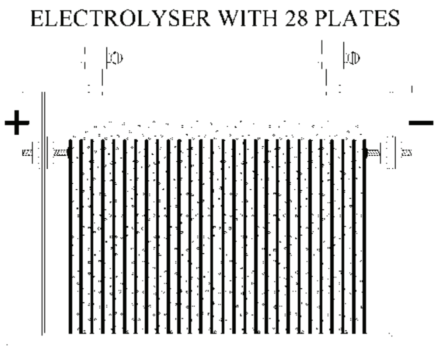

Fig. 2. Electrolyser with 28 plates

In this way from n number of electrodes are obtained n-1 numbers of cells. When voltage U is applied between anode and cathode, every internal cell gets Un/n-1 volts. One important parameter of an electrolyser is optimum drop of the voltage over each one cell which ensures maximum efficiency. The graph below (Figure.3) shows V-A characteristics of the constructions with different number of plates.

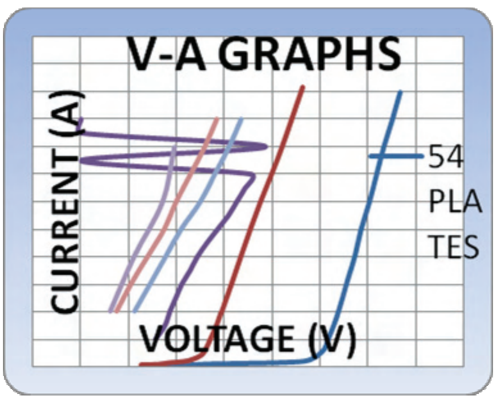

Fig. 3. V-A characteristics of the constructions with different number of plates

Dependencies at low voltage to the start of electrolysis are nonlinear, then increase release of gas and curves becomes almost linear as the steepness is maintained with increasing voltage. During the measurements it was found that the highest efficiency is obtained when on each cell of the electrolyser, a voltage drop is in the range (2V ÷ 2,2 V).

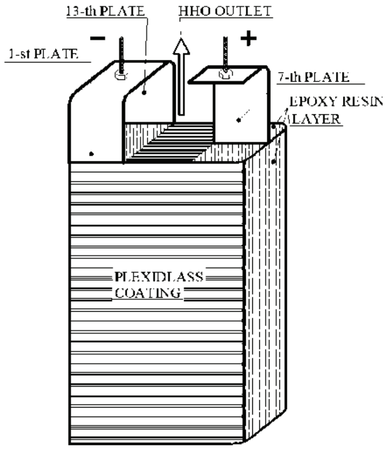

Fig. 4. The design of the work cell consisting of 13 plates

In electrolysis, a huge influence affects currents whose contours are closed in more distant electrodes. These currents represent a loss of efficiency, since their energy by polarizing electrolyte rather than producing gas. To avoid such losses, was designed electrolyser under which was minimized adverse currents, and in fact there are only losses in the cells themselves between adjacent electrodes. Thus, currents flowing around cells of the electrolyser are minimal and achieve less energy input per unit volume of produced gas. The design of the work cell consisting of 13 plates is shown in Figure 4, and the resulting performance data for design are in Table 1.

TABLE I
THE RESULTING FOR DESIGN OF FIGURE 4

1	2	3	4
I(A)	U(V)	V/t(ml/min)	MMW
current	voltage	flow	efficiency
2,6	10,8	110,1	3,92
2,8	10,9	134,9	4,42
5,5	12	279,8	4,24
7,5	12,7	414,33	4,35
10,5	13,2	591,82	4,27
13,2	14	778	4,21
15,4	14,4	929,17	4,19

It was eliminated not only the currents of the long sides between the electrodes, but some of those at the short sides. In the middle of them was left only a small slit that maintains circulation of electrolyte and the evacuation of gas production (Figure4).

Another type of design is shown on Figure 5.

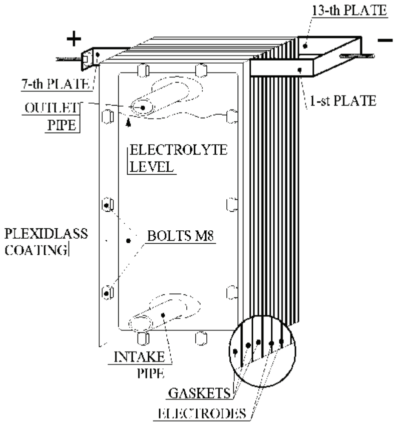

Fig. 5. The design of another type electrolyser

While previous types of electrodes are immersed in the electrolyte, this structure represents isolated cells with an electrolyte filled between them. These are the so-called dry electrolysers. Structures were tested with 4, 5 and 6 neutral plates i.e. 11, 13 and 15 plates. There were experiments with different distance between the plates - 2, 3 and 5mm.

TABLE II
THE RESULTING FOR DRY CELL-11 PLATES, 2MM GASKETS

1	2	3	4
I(A)	U(V)	V/t(ml/min)	MMW
current	voltage	flow	efficiency
3,4	10,25	185	5,29
6,35	11,55	356	4,85
15,8	14,25	808	3,59

TABLE III
THE RESULTING FOR DRY CELL-13 PLATES, 2MM GASKETS

1	2	3	4
I(A)	U(V)	V/t(ml/min)	MMW
current	voltage	flow	efficiency
2,5	11,85	170	5,71
7,4	12,75	525	5,56
10,2	13,3	750	5,28

It appears that reducing the distance between the plates is reduced and optimum voltage on each cell, yielding maximum efficiency. This leads to lower losses and hence to better performance of the electrolyser. On the other hand, the distance between the plates, cannot be too small (for example less than 2mm), as it hinders the conveyance of gas bubbles "adhered" on the plates, and thus slowing the process of electrolysis. Survey data are presented in Tables 2 ÷ 5. For better performance have to be ensured appropriate aperture on the plates for evacuation of the brown gas in order to prevent any undesired circumstances such like increasing of the pressure, leakage of electrolyte, slowdown the reaction.

TABLE IV
THE RESULTING FOR DRY CELL-15 PLATES, 2MM GASKETS

1	2	3	4
I(A)	U(V)	V/t(ml/min)	MMW
current	voltage	flow	efficiency
4,9	14,75	382	5,28
8,3	15,5	650	5,05
12,5	15,86	955	4,81

TABLE V
THE RESULTING FOR DRY CELL-13 PLATES, 5MM GASKETS

1	2	3	4
I(A)	U(V)	V/t(ml/min)	MMW
current	voltage	flow	efficiency
1,5	11,9	106	5,91
9	13,6	592	4,83
11,2	14,6	677	4,14

III. CONCLUSION

The effectiveness of an electrolyser improves when:

1. It works with smaller currents. This is explained by the smaller heat losses, which depend on the square of current, i.e. the lower the temperature of the electrolyte, the better is the effectiveness of the construction.
2. Reduces the distances between the plates, leading to lower ohmic losses, as well as those of polarization. The optimum distance is about 2mm. and depends on many parameters.
3. Reducing any adverse currents between distant plates, which do not participate in gas production.

In general, "dry" cell is more efficient, but their parameters are more unstable in terms of working currents and are less reliable because of the danger of leakage through gaskets. Immersion cell that was examined with more stable parameters throughout the operating range and better reliability, but inferior in efficiency by about 10%.

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