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EXPERIMENTAL STUDY OF A HYDROGEN GENERATOR WITH APPLICATION MODULES OF ULTRASONIC CAVITATION AND VIBRATION OSCILLATIONS

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ABSTRACT

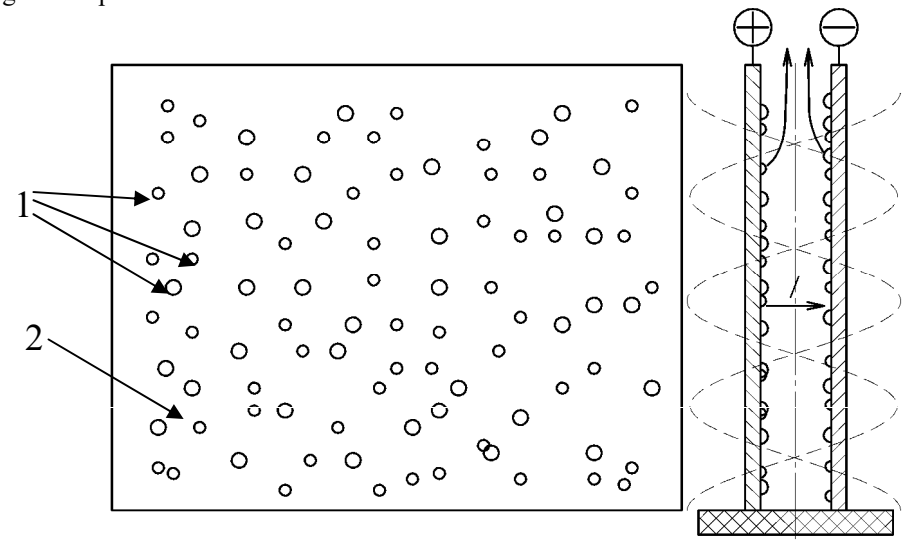
In the article the increase in the efficiency of HHO gas generation is considered due to the application of the phenomenon of ultrasonic cavitation and the module of vibration oscillations, the intensity of which exceeds the threshold of cavitation occurrence. A bench was developed for studying the efficiency of the hydrogen generator with an ultrasonic cavitation block to accelerate the separation of gas bubbles from the surface of electrodes. The efficiency of this method is confirmed. An increase in the amount of isolated gas during the application of the phenomenon of ultrasonic cavitation and vibrational influence is obtained.

INTRODUCTION

In our time, coal, oil or gas are often used as fuel. As a result of the combustion of these products, many harmful gases are emitted into the atmosphere. In addition, these natural resources are also quite rapidly expiring. Therefore, hydrogen energetics is promising, because the reserves of hydrogen are very large and as a result - the work of power systems on hydrogen gives no pollutants.

In industry, hydrogen is often produced by chemical reactions in which the final product is carbon monoxide or carbon dioxide [1-3]. In addition, the electrochemical method is widely used, in which hydrogen and oxygen are obtained by passing an electric current through an electrolyte based on water.

The main disadvantage of electrochemical hydrogen production is its high energy consumption. Therefore, for hydrogen energy, a promising and urgent task is the development of electrochemical hydrogen generation technologies using recyclable processes or alternative energy sources. Alternative sources such as wind, solar or water can fully provide operation of this device. Today, Brown's gas generators are actively used in the market of



a) *b)*

Fig. 1. Scheme of electrolyzer plates with "adhered" gas bubbles (a - the chaotic distribution of gas bubbles on the working surface of the electrodes, 1 - the bubbles of gas, 2 - the effective area of the plate, and b - the effect of oscillations on the plate to accelerate the separation of bubbles)

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motorists. Therefore, this technology is now actively implemented as a catalyst for combustion or alternative fuel in modern vehicles with the use of direct transformation in fuel cells.

The aim of the work is to increase the efficiency and performance of the electrolyzer - a generator of the hydrogen-oxygen mixture.

Setting objectives:

- conducting of experimental researches and estimation of efficiency of work of electrolysis;
- identification of the main factors that influence the performance of the electrolyzer;
- development of methods and constructive solutions for increasing the efficiency of hydrogen generation.

As a result of experiments it was discovered that during the operation of the electrolyzer, bubbles of hydrogen and oxygen were delayed for some time on the surface of the electrodes, which leads to a decrease in the effective area of the electrodes and, accordingly, to slow down the rate of separation of the combustible gas (Fig. 1).

The basic condition that determines the balance of gas bubbles on the vertical surface of the electrode is the condition of the balance of the pushing and holding forces. With the increase of the force of pushing, the processes of displacement or slipping of gas bubbles on the surface of the electrode are manifested. The beginning of this process depends on many parameters of the electrolysis cell and it is difficult to precisely determine it. In addition, the mechanism of formation and separation of bubbles of gas from the electrodes is complicated by additional forces that arise when fluid moves along the surface of the electrode through natural convection or with the turbulent nature of the motion of the fluid [4].

To increase the performance of the hydrogen generator, it is necessary to accelerate the separation of gas bubbles, that is, to "shake" them, for example, by means of low-frequency oscillations or ultrasonic cavitation. Were proposed options for shaking these bubbles from the surface of the electrodes:

- with the help of a vibration block of low-frequency oscillations;
- with ultrasound cavitation;
- due to the application of pulse-width mode of excitation of ultrasonic emitters;
- combination of all three previous variants.

When applying low-frequency high-amplitude oscillations of the electrolyzer cell, electrodes are carried out by high-amplitude forced oscillations. In this case, gas bubbles on their surface as a result of the forces of liquid friction experiencing the damping effect of the electrolyte and do not make it to the fluctuations of the plates of the electrodes, which leads to their separation from the surface of the electrodes. Bubbles are actively raised up, and the surfaces of the electrodes are cleared, which leads to the activization of electrolysis.

The presented experimental booth includes an electrolyzer with the ability to feed the plates directly from the power supply unit (PS) and through the Pulse Modulation (PWM) module. The pulse frequency of the module is 100 Hz, the duty cycle is 50%. The amplitude of the pulses is 60 V. There is the vibration module (VM) connected to the bottom of the electrolyzer case.It oscillates with a frequency of 50 Hz, an amplitude of ± 0.5 mm and consume power of 47 W.The temperature was measured by temperature sensor, which is connected to side wall of the case of hydrogen generator.

EXPOSITION

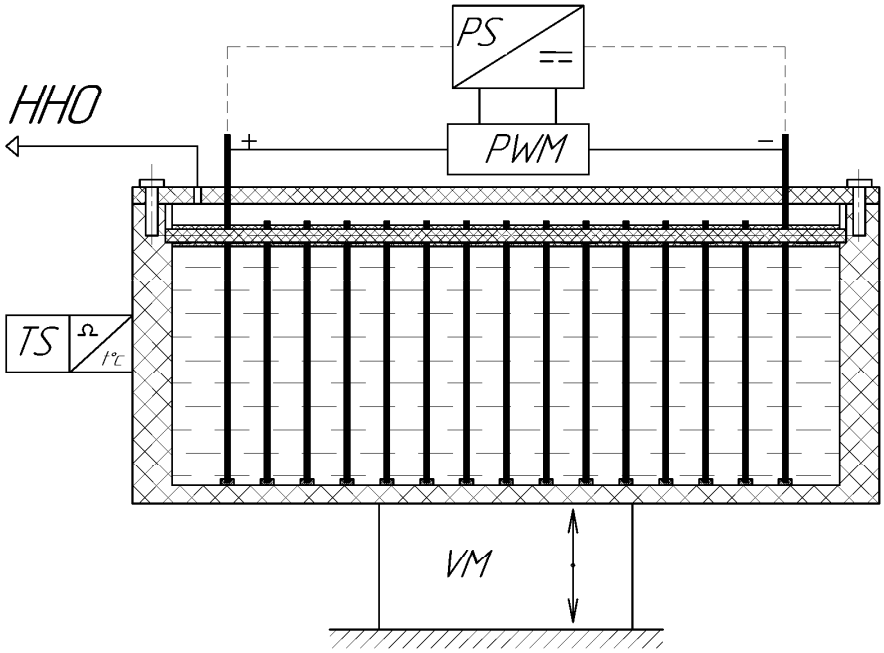

Fig. 2. Scheme of experimental electrolyzer with ultrasound module:
PS - power supply, PWM - pulse width modulator, TS - temperature sensor, VM – vibration module

General view of the test stand of hydrogen generator is shown in fig. 3.According to the results of the experiment on the stand (Fig. 3), it is achieved to improve the performance of the generator of hydrogen by 17%.

In the presence of high-frequency low-amplitude oscillations, which are introduced into the electrolyzer by an ultrasonic emitter, under conditions when their intensity exceeds the threshold of cavitation, ultrasonic cavitation occurs in the volume of the electrolyte. Effects that

accompany the phenomenon of ultrasonic cavitation - intense microcurrents, shock destructive spherical waves and high-energy cumulative jets lead to intense oscillations and separation, bubbles adhering to the electrodes, active degassing of the electrolyte due to gluing gas microbubbles in a turbulent medium and cleaning the surface of the electrodes from adhering gas bubbles, oxides and pollution [3].

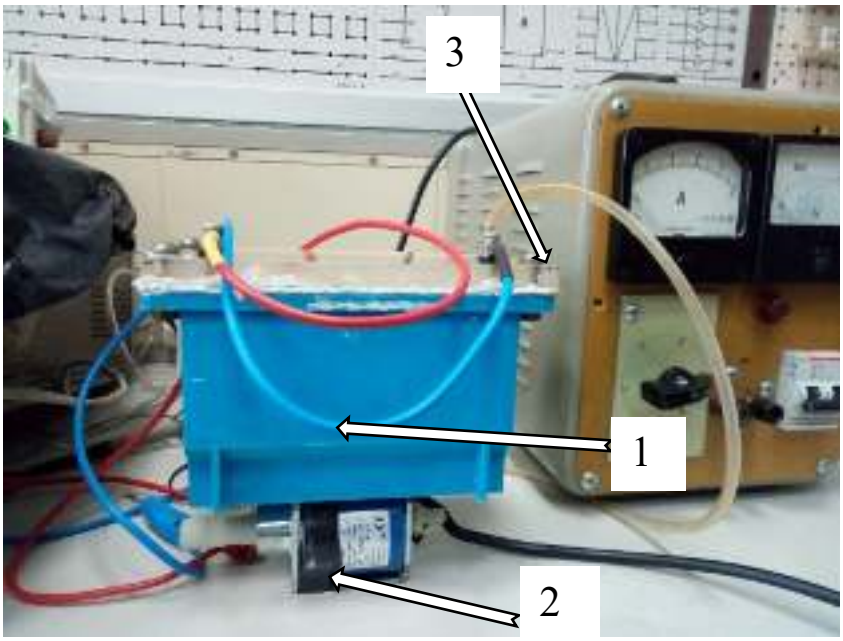

Fig. 3. General view of experimental hydrogen generator with vibration block (1-electrolyzer, 2-vibration module, 3-power supply unit)

By means of an experimental booth it was proved that the use of ultrasound cavitation in the volume of the electrolyte allowed to increase the efficiency of the electrolyzer by 30% (Fig. 4).

The most effective is the operation of the electrolyzer at a temperature of 50-55°C, that is, the efficiency depends directly on the temperature regimes. In order to prolong the period of stable operation of the electrolyzer, it is necessary to cool the electrolyte. It has been experimentally established that with an increase in the temperature of the electrolyzer over 55-60°C, instability of the technological process is observed.

The ability of operation and efficiency of the electrolyzer with small dimensions is experimentally confirmed.

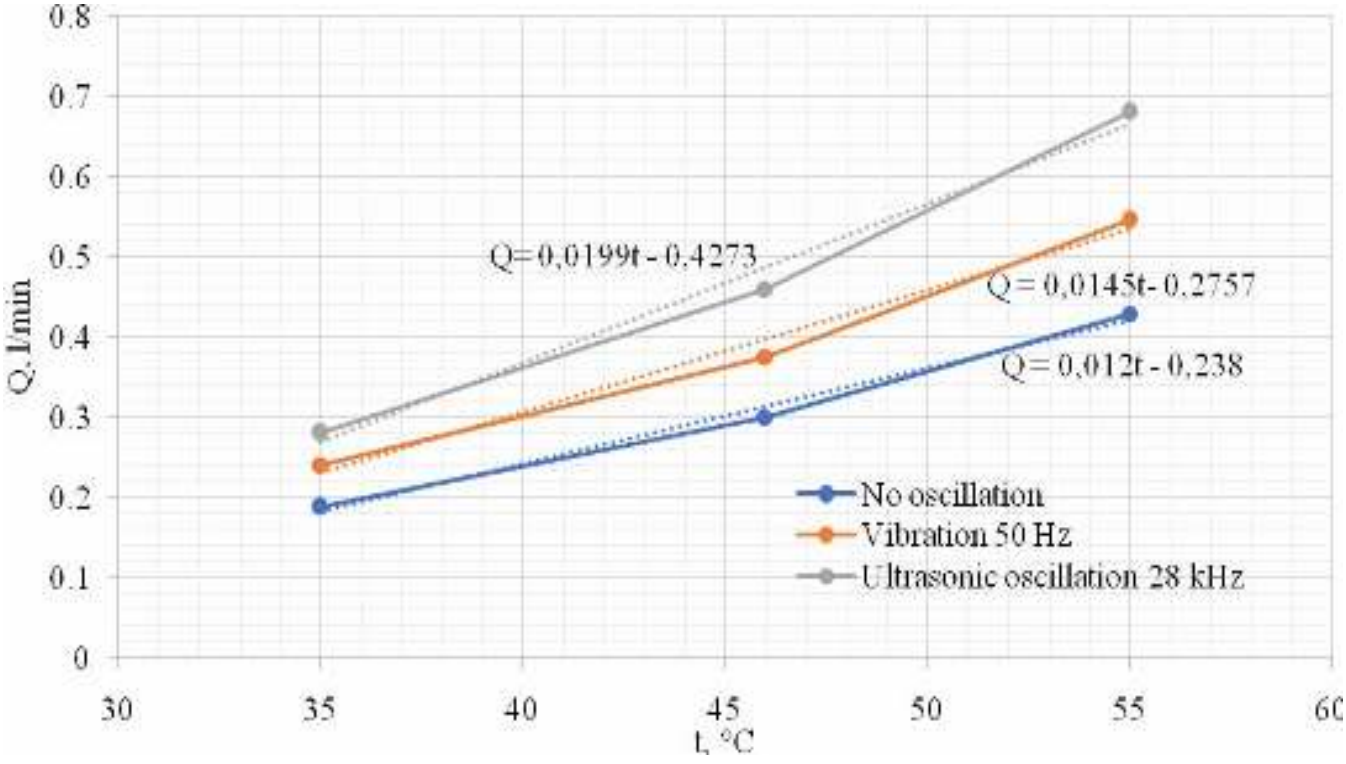

Fig. 4 Comparison of the performance of the electrolyzer without the effects of vibration, with vibration and with the use of ultrasonic cavitation

CONCLUSION

According to the results of studies, the dependence of the time of gas volume separation on the temperature at different initial valuesof current and temperature, as well as the rate of the course of a chemical reaction with the release of a stable volume of gas from temperature was obtained.

The problem of sticking bubbles of gases on the surface of electrodes during the operation of the electrolyzer was revealed. Proposed options for its solution.

A comparison of the work of the electrolyzer with the presence of external low-frequency vibrations and normal work is carried out. There was an increase in the productivity of the electrolyzer under the influence of low-frequency vibration oscillations up to 17%, and with ultrasonic cavitation - up to 30%. However, for the detailed determination of the efficiency of the electrolyzer, it is necessary to take into account the power consumed by the additional modules.

REFERENCE

[1] Jakimenko L.M., Modylevskaja I.D., Tkachek Z.A. Jelektrolizvodyizdatel'stvoHimija. Moskva. 1970. -264s.

[2] Nochnichenko I.V., Perspektyvyzastosuvannia HHO-elektro-lizeradliaheneratsiihazu Brauna yak domishky do ridko-hopalyva v avtomobilnomu transporti XXII Mizhnarod-nanaukovo-tekhnichnakonferentsiia «Hidroaeromekhanika v inzhenerniipraktytsi», m. Cherkasy 2017. -30-31 s.

[3] Luhovskyi O., Increase generation efficiency of hydrogen by the means of ultrasound field and the mechatronic control system of the operation mode / I. Nochnichenko, A. Zilinskyi, V. Mironchuk// International scientific conference “UNITECH 2018”. Vol. I. – Gabrovo, Bulgaria, 1-7, 2018

[4] Bahtaev Sh. A., Nusibalieva A. B., Bakirova N. S., Mehanizmy rosta i otryvapuzyr'kovgaza na poverhnostij elektrodov prij elektrolize. VestnikAUJeSNauchno-tehnicheskijzhurnal 6. 2014.