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INFLUENCE OF SOME FACTORS ON THE GAS FLOW PRODUCED BY HHO GENERATOR

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Abstract

Natural resources are an energy source, the restoration of which becomes extremely slow. In Global terms, there is an energy crisis with distinct peaks and lows, which compels all sides to seek lasting solutions in terms of energy balance. To meet their energy needs, many countries are planning a more rational use of energy and the development of renewed energy sources (RES) to replace part of the fossil fuels.
As a variant of a renewable energy source, the Brown's gas can also be considered. The efficiency of Brown's generator is justified by the clear decomposition of the hydroxyl group and the amount of gas produced.
This article examines the influence of two factors on the flow rate of receiving Brown's gas. Two different electrolytes are used with different concentration and different current force from the power source. Conducted experiment is planned for B2 plan. It is decided the optimization task with a global maximum and it is found the meanings of the factors that give the maximum value of the gas flow rate.

Key words: *HHO gas, gas flow rate, planned experiment, RES, optimization.*

INTRODUCTION

In recent years, there has been strong interest in creating and using different types of alternative fuels. One of these fuels is HHO gas (Brown's gas). A number of authors have demonstrated that the addition of HHO gas to traditional fuels (diesel or gasoline) leads to improved operational and environmental performance of the internal combustion engines (Yilmaz A. et al., 2010; Levente B. et al., 2015; Chakrapani K., Neelamegam P., 2011; De Silva T. et al., 2015; https://www.doc-developpement-durable.org/).
Advantages of HHO gas are: a compact and easy-to-use device for receiving it, perfect blend of fuel flammability based on air and hydrogen, allowing easy engine start at any ambient temperature, the calorific value (140 MJ/kg) his exceed more than 3 times this item on natural methane gas, absolute ecological safety-exhaust gases are converted into water, 4-7 times greater burning rate compared to the petrol mixture without detonation with a high degree of compression; the ability to synchronize the work of some stunt in combined generator, allows to increase the performance of your device several times (Shalbaev K. et al., 2017; Malinowska M., 2015).
Its drawbacks are: the high cost of components for gas storage and transportation, the amount of hydrogen fuel tank is comparable with the parameters of the vehicle, the high explosive atmosphere of gas should exclude the possibility for the leakage; retrofitting of gas stations and the production of hydrogen fuel is now 4 times more expensive than the production of gasoline; the ability to burn when hydrogen comes into contact with the hot exhaust manifold. Therefore, it is proposed to use the engines and combustion systems with the remote location of the intake manifold from the exhaust pipe, hydrogen engines emit significantly more nitrogen oxides from gasoline engines.
As a source of HHO gas is used a low volume electrolytic cell. The electrolyte fluid is KOH or NaOH with different concentration (De Silva T. et al., 2015; https://www.doc-developpement-durable.org/).
Electrolysis runs under a constant, at low voltage of 10-14 V. An important element is the use of a suitable power supply control module for the generator (Yilmaz A. et al., 2010; Balawender K. et al., 2016).

Water was split by electricity to form its various elements, oxygen and hydrogen. When HHO mixture was ignited, both explosion and implosion occurred to form water, releasing the energy that was found in the bonds of the two elements in the form of heat (Yilmaz A. et al., 2010).
On the basis of the literature, it was found that there is insufficient data of characteristics for the HHO gas production.
The purpose of this study is to determine the optimal values of current power and electrolyte concentration used to achieve maximum flow of HHO gas.

MATERIALS AND METHODS

Applying the cybernetic method of the "black box", a model of the experiment presented in Figure 1.

Figure 1. Model of experiment:
W_D-process of obtaining HHO gas; C-concentration of electrolyte; I- force current power; D-gas flow

A two-factor B2 experiment is planned. The independent variables of this experiment are: electrolyte concentration (C) and current strength (I). Sodium (NaOH) and potassium (KOH) bases, each with three different concentrations, are used as the electrolyte. The power of the current also changes to three levels. Table 1 presents the factors and their variation levels.

Table 1. Factors and variation levels

Factors	Variation levels		
X - Electrolyte concentration, %	10	15	20
Y - Power of current, A	10	12.5	15

Attempts to determining the flow of generated HHO gas are carried out at the Department of Agricultural Mechanization in Agricultural University - Plovdiv on a research test stand (Figure 2).

The power supply is fulfilled with an adjustable DC source with a capacity of 12 V and 20 A. The HHO gas generator (1) used in the circuit is made up of two cells connected in electrical parallel connection with one pipeline. The generator's electrolyte container is connected to the atmosphere to reduce hydraulic losses. The gas produced by the HHO generator on the pipelines (4) passes through the water filter (3) and from there is directed to the flowmeter (5) for direct flow measurement.

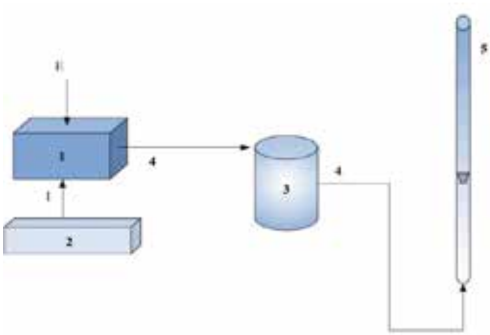

Figure 2. Scheme of test stand:
1-generator of HHO; 2-power source; 3-water filter; 4-pipes; 5-rotameter

The used rotameter is manufactured by the company "SKC", model "CHROMSERVIS" with a range of (0-5) l/min. The rotameter's protective case is removed and it is levelled to avoid errors at reading the values. With the obtained results in the experiments carried out a regression analysis using the software Statistica v.7 and the regression models for each of the electrolytes were constructed. The obtained models are illustrated with regression graphs and surfaces.

RESULTS AND DISCUSSIONS

The results of the experiments are reflected in Table 2.
For both electrolytes the change in the flow rate of the generated gas is not one-way. With an increase in the concentration of 10% to 15% there is an increase in the flow, then from 15% to 20% decreases.
As the current increases in both electrolytes, the amount of gas generated increases one-sided.

The general observation is that, within the range of the observed factors change, KOH electrolyte determines a gas flow higher than when NaOH is used.

Table 2. Results of the experiments

№ of experience	X, %	Y, A	D_{NaOH}, l/h	D_{KOH}, l/h
1	20	15	80	100
2	20	12.5	60	27.5
3	20	10	50	15
4	15	15	140	190
5	15	12.5	115	140
6	15	10	20	110
7	10	15	50	190
8	10	12.5	35	32.5
9	10	10	10	22.5

After the regression analysis by B2 plan, the following results were obtained:

- For electrolyte NaOH, the results of experiments are shown on Table 3.

For this electrolyte, the amount of gas generated is mainly influenced by the power of the current.

The regression model has the form (1):

$$D = 0.398.Y^2 \quad (1)$$

The flow of HHO for using NaOH electrolyte is graphically shown in Figure 3.

The debit is linear increase only with increase of current.

Table 3. Regression analysis for flow using NaOH electrolyte

Regression Summary for Dependent Variable: D_{NaOH} : R= 0.90332014; R^2= 0.81598728; Adjusted R^2= 0.79298569; F(1,8)=35.475; p=0.00034						
	Beta	**Std. Err.**	**B**	**Std. Err.**	**t (8)**	**p-level**
Y^2	0.903320	0.151663	0.398101	0.066839	5.956111	0.000340

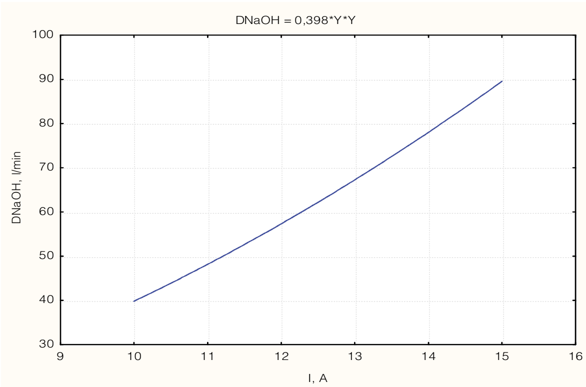

Figure 3. HHO gas flow for using NaOH electrolyte

Table 4. Regression analysis for flow for using KOH electrolyte

Regression Summary for Dependent Variable: D_{KOH} : R= 0.98457257; R^2= 0.96938316; Adjusted R^2= 0.94488968; F(4,5)=39.577; p<0.00056						
	Beta	**Std. Err.**	**B**	**Std. Err.**	**t (5)**	**p-level**
X	12.9552	2.940868	95.643	21.71127	4.40524	0.006988
X2	-7.7727	1.705232	-3.289	0.72166	-4.55813	0.006067
Y2	8.0441	1.551205	5.483	1.05740	5.18574	0.003508
Y	-12.5926	2.809162	-114.106	25.45482	-4.48269	0.006503

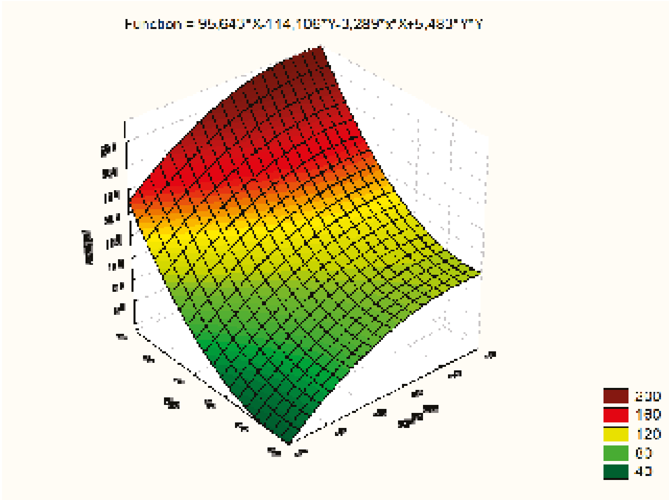

Figure 4. HHO gas flow for using KOH electrolyte

- For using electrolyte KOH, the results of experiments are shown on Table 4.

The amount of gas generated is affected to the equal extent by the current and electrolyte concentration

The regression model has the form (2):

$$D=95,643*X-114,106*Y-3,289*X^2+5,483*Y^2 \quad (2)$$

The flow of HHO for using KOH electrolyte is graphically shown in Figure 4.

The figure shows that the highest flow rate is obtained at the maximum values of the electrolyte concentration and the current strength.

CONCLUSIONS

On the basis of the experiments and analysis carried out, the following conclusions can be drawn:

The flow of the generated HHO gas is higher for using KOH electrolyte.

For both electrolytes (NaOH and KOH), the flow increases as the current increases.

Maximum debit for both electrolytes is obtained at 15 A current.

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