

Effect of polarization molecules reagents of the burning reaction on the efficiency of equipment for thermogeneration

B. Kovalyshyn

National University of Life and Environmental Sciences of Ukraine, Kyiv, Department of Electric and Electro Technology, Educational and Research Institute of Energy and Automation,
e-mail: mailxx@xx.xx

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Abstract. The aspects of physical and chemical nature of oxidizing-reduction processes of burning were investigated. The communication of efficiency of fuel equipments with polarizing and activating of molecules-reagents was exposed. Application of molecules electro-activation for optimization of the chemical reactions at burning passed at incineration of gaseous hydrocarbon fuels in the oxidizing air environment was grounded experimentally.

Key words: energy efficiency, burning, electric field, high voltage, activation, polarization.

INTRODUCTION

The efficiency of fuel and energy resources use determines the development level of economies and population welfare in the world. Also, the time of resources exhaustion of the traditional fossil fuels (both found out, and prognosis) are measured by a few tens years [6,12,17]. Lengthening of the term of using of these fuels is important both from the point of view of time for researches on new methods and equipment for the obtainment of energy, and from the point of view of an increase of period of their use in the chemical and food industries and reduction of negative influence on the environment. A rise of efficiency of energy generating equipments in that direction of development of incineration technologies [15] which will prolong the period of using of the fossil hydrocarbon fuels is of current and timely interest.

Because of the basic quantity of thermal and other energy types we get at incineration of traditional and nontraditional fuels, it follows to focus attention at the burning process. A burning process is an exothermic oxidizing-reduction chemical reaction. For the rise of efficiency of heat generation at the use of hydrocarbon fuels it is necessary to achieve optimization of chemical reactions of burning and promote plenitude of the fuel burning.

Purpose of researches - to learn physical and chemical nature of oxidizing-reduction burning processes and to

correlate the fuel options efficiency with the structure and activity levels of molecules-reagents for the optimization of burning chemical reactions at incineration of gaseous hydrocarbon fuels in the oxidizing air environment.

THEORETICAL GROUNDING

The rise of energy efficiency of fuel equipments is based on the use of the basic aspect of chemical kinetics theory - Arrhenius law [4,9,16]. These law characterizes possibility and speed of chemical reactions between molecules-reagents. The theoretical and experimental researches showed the possibility of rise of incineration efficiency of gaseous hydrocarbon fuels in air by electro-activating of molecules-reagents of burning reaction. In theory [3,14,19], energy efficiency of fuel equipment at incineration of hydrocarbon fuel in air can be promoted across the acting on the components of burning reaction by the high-voltage pulsating uneven electric field of high voltage (HVPUEF).

The experimental researches of electro-activation of molecules-reagents by the burning reaction of propane and natural gas in air showed the possibility of practical realization of the offered method in the fuel equipments of different types for the gaseous hydrocarbon fuels [13].

The basic descriptions of molecules gaseous alkanes are shown in [18]. From this source it is evident that an increase of molecular mass of gaseous hydrocarbons is straight proportionally related to their basic descriptions - density, heat productivity and the specific expenditure of air (oxygen) for incineration. At the same time there is an inversely proportional dependence between the molecular mass and temperature of burning. This dependence, in our opinion, can be explained by the hydrocarbonic molecules structure and their polarization.

The molecules polarization consists in the distribution of general electronic cloud in space. If s-connection in

diatomic molecule with the identical atoms takes place, an electronic cloud is distributed symmetrically in relation to the kernels of both atoms [1,11]. By the connections between the atoms of different elements, a charge of electronic cloud is distributed between atoms asymmetrically (heteropolar connection).

Under act of external electromagnetic field or field of neighbouring atoms, the displacement of electronic cloud density process takes place [2,8,10,20]. This process is named polarization of molecules. The polarized molecules have electronic clouds with different spatial density of charge. Polarity of molecular connections relies on their length and difference of atom electro-negativities, which form connections. The larger this difference, the greater polarity of molecules. Polar molecules contain the two opposite signs charges, that are located on the definite distance and are named dipol. Dipol is characterization of the dipole moment. The dipole moment of molecule is a vectorial value and equals a vectorial sum of all dipole moments of separate connections and unshared electronic pair in molecule. The dipole moment is calculated as product of charge and distance between the centers of opposite charges. A dipole moment is measured in debay (D); $1D = 3,33 \cdot 10^{-30} \text{ C}\cdot\text{m}$ (Coulombs x metr). For the most molecules with the simple covalent connections the size of dipole moment is within the range 2...4 D.

The total polarized of molecule has three components [7]: atomic, electronic and orientating:

$$P = P_{at} + P_{el} + P_{or} \quad (1)$$

In formula (1), P_{at} characterizes displacement of atomic kernels toward the negative end of dipol, P_{el} - displacement of electrons to positive pole of dipol, and P_{or} characterizes the orientation of molecules in the electric field. An electronic constituent of polarized P_{el} makes an insignificant part of the general polarized. An orientation constituent P_{or} considerably diminishes with the rise of temperature.

A magnitude of polarized can be defined after the definition of dielectric permeability of matter (ϵ) on formula Claouzius-Mosotti:

$$P = \frac{\epsilon - 1}{\epsilon + 2} \cdot \frac{M}{\rho} = \frac{4}{3} \pi N_A \alpha, \quad (2)$$

where:

M – molecular mass of matter ($\text{g}\cdot\text{mol}^{-1}$),

ρ – density of matter ($\text{g}\cdot\text{sm}^{-3}$),

N_A – Avogadro number ($6,02 \cdot 10^{23} \text{ mol}^{-1}$),

α – molecules polarization (sm^3).

If a matter is complex, that is it consists of a any components with polarizations α_i and by volume concentrations N_i , a formula Claouzius-Mosotti will have a kind:

$$\frac{\epsilon - 1}{\epsilon + 2} = \frac{4}{3} \pi [N_1 \alpha_1 + N_2 \alpha_2 + \dots + N_k \alpha_k]. \quad (3)$$

Polarized P is determined by formula:

$$P = \frac{4M}{3\rho} \pi [N_1 \alpha_1 + N_2 \alpha_2 + \dots + N_k \alpha_k]. \quad (4)$$

Sometimes the polarized names dynamic polarization, because it arises up under action of external field and relies on the structure of molecule and from size and direction of external field.

Polarized, as a measure of polarizing power of molecule, relies on mobility of electrons. So, p-electrons are more mobile than s-electrons. Therefore, molecules with π -connections are easier to polarize than molecules with σ -connections.

In our opinion, the larger degree of polarity of molecules, the more they are added to influencing of external electric field, acquired in this field of the proper kinetic energy and they are easier added to activating. The more the structure is similar in molecule to unipolar one, the heavier it is activated by the external factors.

The experimental researches of efficiency of the fuel burning under electro-activating influence by the high-voltage uneven electric field on molecules of gaseous hydrocarbons (propane and natural gas) and of air oxygen was conducted.

Spatial structures of molecules of methane CH_4 and propane C_3H_8 can also be presented as models [7,11]. Figure 1 presents a model of methane molecule. The form of molecule methane is tetraedr with the valency corners H-C-H even $109^\circ 28'$. A molecule of methane is symmetric, and unipolar (nonpolarized).

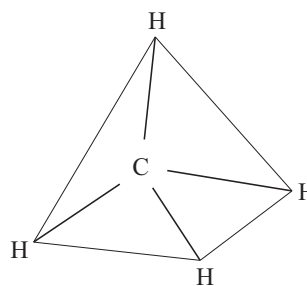


Fig. 1. Spatial structure of methane molecule

From our viewpoint, symmetry of methane molecule does not respond to transition of its electrons on the energy excitations levels.

The spatial structure of propane molecule – C_3H_8 has a crank form (Fig.2).

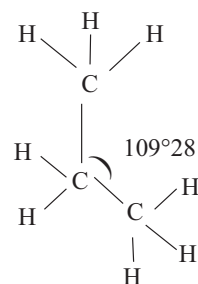


Fig. 2. Spatial structure of propane molecule

A molecule of propane has the asymmetrical distributing of electronic orbitals, that is it is heteropolar. This, in our opinion, allows with the less energetic expenditures to polarize the molecules of propane and translate them on excitation levels.

Atoms of carbon in molecules with the ramified chains differ by the type of having with other carbon atoms. With the increase of carbon atoms number in molecules the probability is multiplied and the fork of hydrocarbon chains is increased. A quantity of hydrocarbons isomers grows with the increase of quantity of atoms of carbon in the molecule.

The influence of polarity on the activating molecules can be their temperature of inflammation. The gas methane has autoignition temperature even 545, ethane - 530, propane - 504, and butane - 430 °C. In obedience to these data, evidently, the greater alkane polarization, the lower autoignition temperatures are.

MATERIALS AND METHODS OF RESEARCH

The experimental research on the efficiency of electro-activating of burning reaction molecules-reagents is presented by three series of experiments.

In the first series the research is conducted on the influence of HVPUEF separately on air and propane, and simultaneously on both components.

The first series of experiments included the following variants:

- incineration without electro-activation (control) ;
- incineration with electro-activation of air;
- incineration with electro-activation of propane;
- incineration with electro-activation of air and propane simultaneously.

In the first series of experimental researches 1,0 l of water was heated from 20 °C to 40 °C. In both experiments impulses of electric field were explored in the range of frequencies from 0 to 200 Hz. The impulses of electric field were explored in the range of frequencies from 0 to 140 Hz. The efficiency of electro-activation of components of burning reaction was estimated on the exceeding of time of heating of water without activating of burning reaction components above time under their activating. The first experiment was repeated three times. Results of the first experiment are shown in Fig. 3.

In the second and third series of experiments the influence HVPUEF was explored on the molecules-reagents of burning reaction at incineration of propane and natural gas in the air. In both experiments impulses of electric field were explored in the range of frequencies from 0 to 200 Hz. The efficiency of action of impulsive electric field with different frequency at incineration of propane and natural gas was estimated by time heating 0,7 l of water from 20 to 40 °C. The second and third experiments were repeated three times.

The variants of the second experiment of research were as follows:

1. Without high-voltage impulsive signal.

2. With activation - on the electrode system in the channel of air the impulsive mainly negative voltage is given, and on the electrode system in the channel of propane - impulsive mainly positive voltage (- - on air + - on propane).

3. With activation (+ - on air + - on propane).

4. With activation (+ - on air, - - on propane).

5. With activation (- - on air, - - on propane).

6. With activation (+ - on air), propane - without straightening.

Efficiency of influence HVPUEF on the components of burning reaction was estimated on differences at time between the experimental variants and control (without electro-activating of molecules). Results of the second experiment are presented in Fig. 4.

In the third experiment the estimation was conducted of electro-activating efficiency of molecules of natural gas and air. In the first variant of this experiment the research of activation was conducted only on air, in the second variant - general activating of air and natural gas.

Efficiency of electro-activating was estimated on contraction of heating time of water. Results of the third experiment are shown in Fig. 5.

RESULTS AND DISCUSSION

Experimental results obtained in the first series of experiments have shown that electro-activating of reaction components of burning of propane in the environment of air comparatively to controls variant substantially abbreviates time of heating of 1 litre water in all variants. Calculated $LSD_{0,05}=4,33$. The electro-activation of propane in the pulsating high voltage field with frequency 80 Hz allowed to warm water at the expenditure 11,3 % less fuel than in the control. The most positive effect (reduction of expenditure of fuel on 21,5÷22,0 %) is observed at action on both components of oxidizing-reduction exothermic reaction of burning by the high-voltage pulsating uneven electric field with frequency 100÷120 Hz. In the last variant of the first experimental series it is possible to mark realization of principle of superposition on the compatible influencing of activating of burning reaction of components.

Results obtained in the first experiment have proved the substantial abbreviation of time of heating of water during electro-activating of air and propane in the electric field of high tension practically in all variants. For all variants of research maximums of decline of time of heating of water were marked at the use of impulses with frequency 100÷120 Hz. The most positive effect (decline of time of heating on 22,1÷19,0 %) was found in the indicated range of frequencies for variant with the serve on the electrode systems of impulses of high tension without straightening. Calculated for the second experiment $LSD_{0,05}=3,31$ has given ground to consideration of substantial differences between the results of different variants.

Results of the first and second experiments are similar and show that most efficiency of incineration of propane in mid air is observed during electro-activation of both components of reaction of burning without straightening on frequency HVPUEF from 100 to 120 Hz.

From the result of the third experiment it is evident, that activating HVPUEF of natural gas and air abbreviates the water heating time in both variants of research. During activation of air for the high-voltage impulses with frequency 100 Hz the time of water heating was reduced by 11,1 %. During the general activation of natural gas and air the time of water heating was reduced by 12,0 %. Calculated for the third experiment $LSD_{0,05}=2,46$ testifies about unimportance of differences between both variants of experience practically for range of explored frequencies. This unimportant difference is explained, from our point of view, that in variant with the simultaneous activating both component of reaction of burning effective there was only activation of air. Payment in the general efficiency of reaction of burning of the activated natural gas was insignificant. It is possible also to make a conclusion about that in the second variant of

the third experiment the parameters of electric field did not allow the sufficient measure to conduct activation of molecules of natural gas. So, by the fact that maintenance in the natural gas of methane makes 89÷99 % [10], in our opinion, it is explained that the obtained result shows ineffective influence of HVPUEF on the gomeopolar molecules of methane. Therefore, the difference in the degree of electro-activation of molecules of propane and methane can be explained by the structure and polarization of molecules.

CONCLUSIONS

1. Theoretically and experimentally the possibility was proved of increasing fuel efficiency equipments on gaseous hydrocarbon fuel molecules in the activation of the combustion reactants under high-voltage pulsed uneven electric field.

2. When activating molecules reagents chemical reactions, it is important to take into account their degree of polarity.

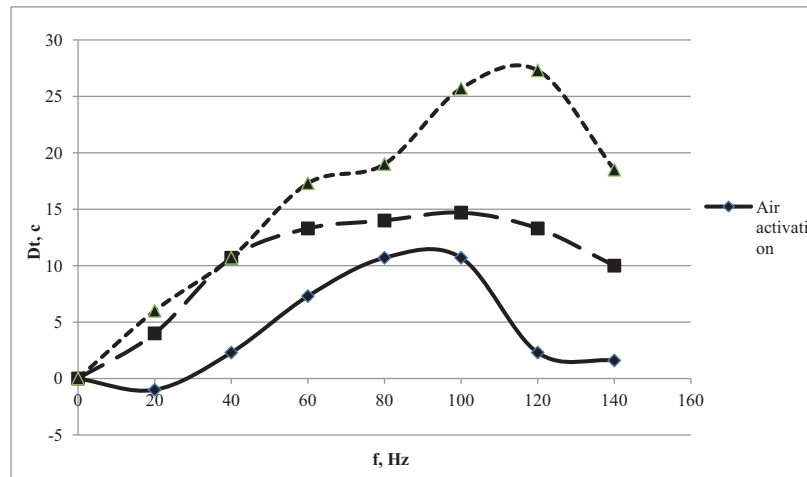


Fig. 3. Dependence of the reduction of water heating time on frequency impulses at electro-activation of propane and air (experiment 1)

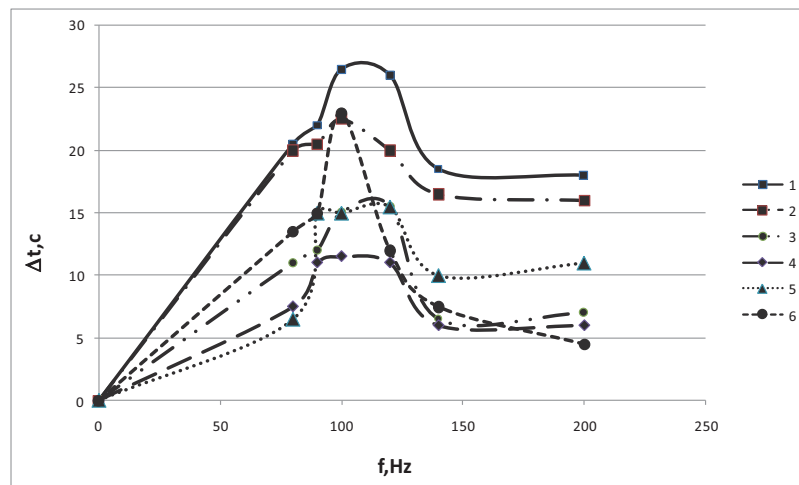


Fig. 4. Dependence of time reduction of water heating on frequency impulses for different variants of electro-activation of propane and air (experiment 2)

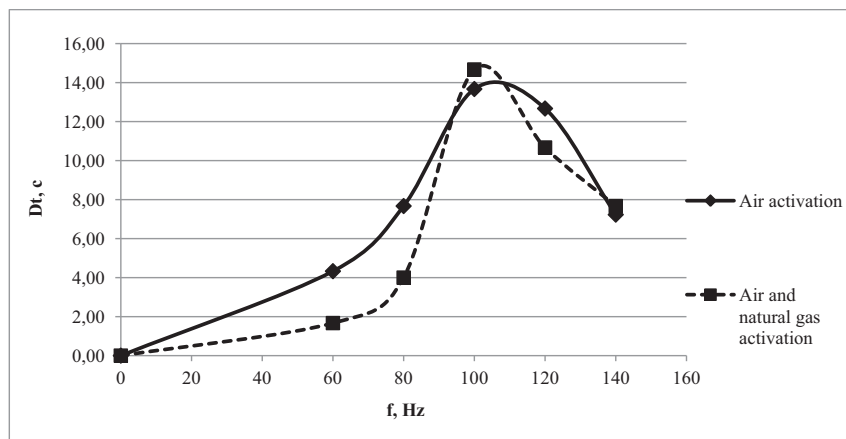


Fig. 5. Dependence of decline magnitude of water heating time on frequency impulses during electro-activation of natural gas and air (experiment 3)

3. The experimental results confirm the theoretical conclusions about the important role of polarization of molecules for their electroactivation.

4. Research should be continued on impact of high pulsed uneven electric field on molecule reagents at the combustion of natural gas (methane) in the air.

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