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Improving the efficiency of fuel plants at photoactivation molecules reagents

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Summary. Energy efficiency fuel gas installations possible when activating molecules reagents combustion reaction by ultraviolet light emission. Grounded basic parameters of ultraviolet light emission for transfer reagent molecules in the excited state. The results of the experiment show search efficiency of photoactivation reagent molecules of the combustion of vacuum ultraviolet radiation to improve the efficiency of the combustion of natural gas in the air.

Key words. The molecules, reactant, efficiency, combustion, activation, energy, radiation, level of excitement.

INTRODUCTION

Stocks and efficiency of use of energy resources determine the level of economic development in most countries. Terms exhaustion of conventional hydrocarbons measured several decades [10, 17]. Extending the duration of their use would conduct research to obtain new energy and energy technologies for energy production processes and needs. The increase in terms of hydrocarbon energy by increasing the energy efficiency of their use will allow to reduce the negative environmental impact, optimize the cost of hydrocarbon fuels in the chemical and food industries.

PROBLEM

It is known [7] that in the world, according to statistics in 2012, the basic amount of heat and other energy (about 80%) are using traditional energy sources. Therefore, the study of the processes of combustion should be given more attention. The process of combustion, in fact, is exothermic redox chemical reaction. Therefore, research should be directed at optimizing the combustion of chemical reactions that ultimately should lead to increased fuel efficiency thermal generating plants on hydrocarbons.

Activation molecules reagents combustion reaction is, in our opinion, one of the most promising ways to improve fuel efficiency units [11, 15], which will increase the use of non-renewable fossil terms of hydrocarbons, and demonstrates the relevance and timeliness of solving this problem.

The purpose of this work – the rationale mode power generating plants efficiency through the use of optical radiation to activate the molecules of the combustion of gaseous reactants hydrocarbon fuel in the air.

The theoretical justification. Activation of molecules involved in chemical reactions can be carried out in various ways. These methods include: thermoactivation, photoactivation, ultrasound activation, activation by magnetic field, an electric field activation, the activation of fast electrons, activation of radioactive particles and other methods.

Improving the efficiency of redox reactions is the main issue of chemical kinetics [16, 18]. The efficiency of combustion reactions depends on the concentration of reactants and properties: composition, structure, internal energy molecules and external factors.

The basic law of chemical kinetics find Arrhenius law [16]. The main condition of chemical reactions this law is activation of molecules reagents. Arrhenius law describes the possibility of chemical reactions between molecules of reactant and linking chemical reaction rate constant with the activation energy (E_A):

$$k = k_0 \cdot e^{-\frac{E_A}{RT}} ; \qquad (1)$$

where: k_0 - before exponential constant; R - Gas constant, equal to 1.987 kcal / mol • deg; T - The temperature in degrees Kelvin; e - The base of natural logarithms.

After the logarithm of the left and right sides of equations (1) and the replacement of natural logarithms to decimal obtain the formula:

$$\lg k = \lg k_0 - \frac{E_A}{4{,}575T} , \qquad (2)$$

where: the 1 / 4.575 - conversion factor of natural logarithms in decimal, multiplied by the value.

The activation energy of the molecules is given by:

$$E_A = (\lg k_0 - \lg k)4{,}575T . \qquad (3)$$

As can be seen from equation (3) the activation energy of molecules at thermoactivation directly proportional to the temperature.

Our working hypothesis is the assertion that the activation of molecules reagents, except heat (E_{AT}), you can use energy from other external factors (E_{AE}). In carrying out the external energy source feeding pulsating energy with a frequency corresponding to the resonant frequency molecules - reagents can achieve the effect of transferring these molecules in the active state with much lower energy costs. Supplementing the formula (3) by expression that describes the effect on the molecule reagents other factors we obtain an expression that describes the value obtained additional heat:

$$\Delta E_A = E_{AT} - E_{AE} = \\ = [(\lg k_0 - \lg k)4{,}575T] - Wb , \qquad (4)$$

where: W - energy obtained from external sources, b - utilization coefficient of reactant molecules external energy.

From formula (4) shows that the thermal activation energy is reduced through the use of external sources of activation molecules, and offset the heat to be used for useful purposes, thereby increasing the efficiency of thermal generating plants.

Activation of molecules and atoms in optical radiation (photon) is called photoactivation. Photoactivation takes place when the ultraviolet part of the spectrum and is inelastic collisions molecule and photon [4, 5, 9, 19]. To go from stationary electron energy levels at excitation energy of the incident quantum (E_c) should be sufficient to activate the molecule [13, 14].

Since $$E_c = h_o \nu \ , \qquad (5)$$

where: h_o - Planck's constant ($6{,}626 \cdot 10^{-34}$ J · s); ν - frequency electromagnetic waves (Hz) .

The frequency and wavelength of optical radiation to activate molecular oxygen and a major constituent of gaseous energy carriers are given in Table 1 [12].

Table 1. Parameters activating molecules of hydrocarbon fuel gas and air main components of optical radiation

Molecules	Energy level type	Activation energy			Light freaquency, Hz	The length of electromagnetic wave, nm
		eV	J/molecules	J/mol		
Methane	Singlet	11,00	$17{,}62\cdot10^{-19}$	$10{,}60\cdot10^{5}$	$2{,}65\cdot10^{15}$	113
	Triplet	9,00	$14{,}42\cdot10^{-19}$	$8{,}68\cdot10^{5}$	$2{,}17\cdot10^{15}$	138
Propane	Singlet	10,00	$16{,}02\cdot10^{-19}$	$9{,}64\cdot10^{5}$	$2{,}41\cdot10^{15}$	124
	Triplet	7,70	$12{,}34\cdot10^{-19}$	$7{,}42\cdot10^{5}$	$1{,}86\cdot10^{15}$	161
Butane	Singlet	9,70	$15{,}54\cdot10^{-19}$	$9{,}36\cdot10^{5}$	$2{,}34\cdot10^{15}$	128
	Triplet	8,03	$12{,}87\cdot10^{-19}$	$7{,}74\cdot10^{5}$	$1{,}94\cdot10^{15}$	155
Oxygen	Singlet	9,30	$15{,}90\cdot10^{-19}$	$9{,}57\cdot10^{5}$	$2{,}24\cdot10^{15}$	134
	Triplet	4,50	$7{,}21\cdot10^{-19}$	$4{,}34\cdot10^{5}$	$1{,}08\cdot10^{15}$	278

Table 1 shows that the transfer of these molecules in the singlet energy levels is exposed to UV, the so-called vacuum UV (VUV) with a wavelength less than 200 nm. Conversion of propane and butane molecules in triplet energy levels possible using VUV wavelengths in the range 155 – 161 nm, and oxygen – in the field C with a wavelength of 278 nm. To transfer to triplet excitation level most energy radiation with a wavelength of 138 nm, for reduced molecules require methane molecule.

Ultraviolet light rays with energies close to the energy sufficient to transfer hydrocarbon molecules of gaseous fuel and oxygen to the triplet level can be obtained using the spark and arc discharges in open sources, enclosed burners pressure discharge lamps and by other sources.

Fig. 1 shows the spectral characteristics of open source VUV performed in a bit matrix [3].

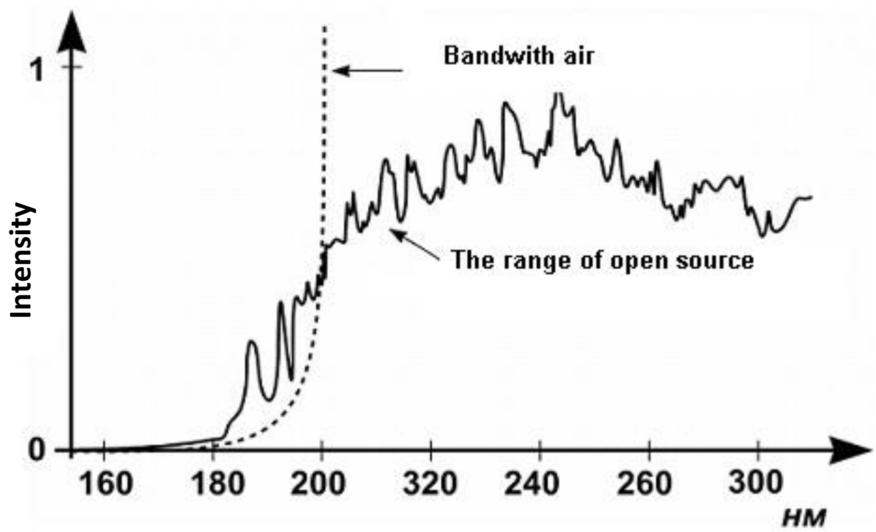

Fig. 1. A typical emission spectrum of the plasma electric discharge source UV atmospheric ambient air

Fig. 1, in addition to the spectral characteristics also shows the bandwidth air, showing that under normal conditions of radiation with a wavelength less than 180 nm in the air almost does not apply.

Use as a source of VUV radiation enclosed burner pressure discharge lamps closely associated with the generation of radiation in the environment inside the gas discharge burner and burner type bulb, which determines the spectral transmission characteristics of ultraviolet rays. Inside airtight flask burner electric discharge takes place in the rarefied gas environment one or two inert gases and mercury. It molecule of mercury is the main source of hard UV radiation inside the burner.

With mercury obtain the following spectral lines used in HID lamps and have the following wavelengths: 184.95 nm, 253.65 nm, 365.02 nm, 404.66 nm, 435.83 nm, 546.07 nm 578.2 nm. The most intense line is 184.95 nm, 253.65 nm and 435.83 nm. The intensity of the other lines vary depending on the category of [8, 20].

To produce bulb burner gas discharge lamps used as quartz glass and special svitlopronyknu ceramics. To produce burners using quartz glass KU-1 type. The spectral transmittance characteristics of quartz glass KU-1 type shown in Fig. 2 [6].

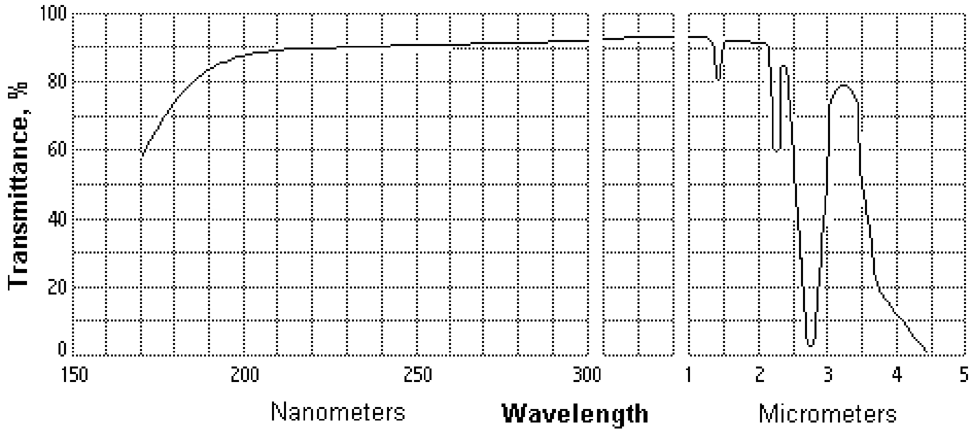

Fig. 2. The spectral transmittance characteristics of quartz glass КУ-1

From Fig. 2 shows that the bulb torches made of quartz glass type KU-1 pass ultraviolet radiation with wavelengths up to 170 nm. This enables the use of mercury burner filled with high pressure gas discharge lamp as the source of vacuum ultraviolet radiation.

MATERIALS AND METHODS

Investigation of photoactivation reagent molecules of the combustion of natural gas in the air was carried out by us previously described method [2, 15]. Activating effect on the methane molecule natural gas and oxygen provides ultraviolet radiation from the burner lights DRL-80.

Evaluation of the results of the search experiments confirm the working hypothesis was conducted by heating time of 0.7 liters of water from 20 to 40 ° C when exposed to molecules of the combustion reagents and ultraviolet radiation in the normal flow of process water heating. In carrying out the first experiment used artificial ventilation room. In the second experiment, ventilation facilities was conducted.

RESULTS AND DISCUSSION

Results of the first experiment are shown in Table 2, and the second - in Table 3.

Table 2. Time for water heating and the ordinary heating under the action of molecules reagents UV radiation and ventilation facilities

Incineration	Variant							t_{cp}
	1	2	3	4	5	6	7	
Without UV	67	68	65	70	65	68	66	67,00
With UV	64	63	61	62	58	64	60	61,71

Table 2 shows that by heating 1 liter of water from 20 to 40 ° C, using UV heating time, a decrease of 8.8%. The presence of a significant effect of ultraviolet radiation on improving the efficiency of natural gas combustion in air shows that the null hypothesis in the evaluation of the results is not supported. Since 5,29> 3,10 (d> LSD_{05}).

Table 3. Time for water heating and the ordinary heating under the action of molecules reagents UV radiation without ventilation facilities

Incineration	Variant					t_{cp}
	1	2	3	4	5	
Without UV	74	67	71	71	70	70,60
With UV	57	63	61	60	58	59,80

Table 3 shows the reducing of heating time of 0.7 liters of water from 20 to 40 ° C in experiments with UV irradiation and absence of active ventilation of premises amounted to 15.3%.

The null hypothesis when assessing the results obtained in this experiment is not confirmed, since d > LSD_{05} (10,80 > 4.0).

Comparison of the first and second experiments show that in the absence of ventilation of the room there is a significant reduction in heating time specified volume of water than in experiments with active ventilation of the room. This effect, in our opinion, can be explained by a significant impact on the process of burning ozone, formed by UV irradiation.

CONCLUSIONS

1. In theory, the opportunity of improving energy efficiency by photoactivation fuel installations molecules of gaseous reactants hydrocarbons and oxygen by ultraviolet radiation.

2. The results indicate a significant effect of ultraviolet radiation on improving the efficiency of the combustion of natural gas in the air.

3. Increased ultraviolet radiation influence on the efficiency of combustion is observed in the absence of active ventilation, which indicates a significant contribution of ozone in the course of the process of burning hydrocarbon fuels.

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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ СГОРАНИЯ ТОПЛИВА НА МОЛЕКУЛЫ РЕАГЕНТОВ ФОТОАКТИВАЦИИ

Л. Червинский, Б. Ковалышин

Аннотация. Энергоэффективность установки возможных топливного газа при активации молекул реагентов реакции горения ультрафиолетовым излучением света. Заземление основные параметры ультрафиолетового излучения света для молекул реагента переноса в возбужденном состоянии. Результаты эксперимента показывают эффективность поиска молекул фотоактивация реагентом сгорания вакуумного ультрафиолетового излучения для повышения эффективности сжигания природного газа в воздухе.

Ключевые слова: молекулы, реагент, эффективность, сжигание, активация, энергия, излучение, уровень волнения.