

THEORETICAL GROUND OF INFLUENCE OF OZONIZATION ON WORKING PROCESS OF DIESEL

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Keywords: diesel, ozonization of fuel, heat generation, expense of fuel, toxicness.

Abstract: theoretical pre-conditions of high-quality influence of ozonization on physical and chemical properties of fuel and energy and ecology indexes of work of diesel are validated. The results of theoretical and experimental researches of influence of the ozonized fuel on the working process of diesel are resulted.

Technical paper

On a transport there is providing of necessary quality of fuel, lubricating materials and technical liquids the inalienable making economy of fuel and energy resources [1, 2]. It is known that structural perfection of internal combustion engine practically exhausted itself and in a great deal potential of improvement of combustion of fuel depends on its quality and physical and chemical properties. In addition, during the deficit of oil fuels and increasing of world ecological crisis the task of increase of efficiency of working process of diesel acquires all of greater value.

An idea to use of alternative types of fuels [3 - 5], deputizing partly or fully oil fuel got lately enormous dissemination. However for the successful use of such fuel the structural retooling of internal-combustion engine is required. Thus technology of production of such fuel it is not enough rational and economic weakness. Therefore during the passing to the renewable energy sources, the researches, directed on perfection of organization of working process, are actual. The improvement of unevenness of distributing of air-gas is needed on cylinders, diminishing of mechanical losses, improvement of mixture formation by treatment of aerofuel mixture by different ways (treatment the electric field, plasmatron, magnetic field, ionization, ultrasound), application of multi-stage injection of fuel, change of form of combustion chamber, the special niche among which is occupied by application of additives or change of fuels properties.

Good results on upgrading combustion of fuel are attained at the use of additives for cetane ratio raising [6]. Works, directed on the change of physical and chemical properties of fuel in the exploitation process of internal combustion engine, so-called physical and chemical adjusting, deserve attention [7]. A basic problem at the similar adjusting is a search of catalyst of burning or additive, allowing to react on the change of terms of work of diesel. As a similar matter the use of ozone is possible for subsequent ozonization of fuel [8].

However similar sort of research braked because of absence of general fundamental theory of burning, taking into account high-quality influence of additions on flowing of process in whole. Mainly researchers for a similar describing of physical properties of fuel is a closeness, viscosity, surface-tension, that allows adequately to describe the processes of injection, fineness of pulverization, fumes and mixture formation of fuel in a combustion [9 - 11]chamber, however much works, taking into account the change of chemical structure of fuel, absent practically, its hydrocarbon composition which influences on the period of delay of self-ignition and flowing of process of combustion in whole.

In the fundamental theory of similar sort hydrocarbons burning research conducted both in our country and abroad, more than 1500 stages of elementary chemical reactions are described at oxidization of hydrocarbons [12, 13], however to complete description of process of burning of hydrocarbons yet far. It should be noted that conformities to the law of influence of catalysts on speed of flowing reaction are known a long ago [14, 15], but because of substantial difference of terms of flowing reaction in a combustion chamber application of these conformities to the law is laboured at description of influence of additives or catalysts of burning.

There are many researchers mark that, coming from the existent theory of self-ignition of the nebulized fuel, high-quality description of this process is a period of delay of self-ignition [16, 17]. Thus, as proved in the article [18], total energy of process activating E is accepted permanent, temperature-independent, proper two phase oxidization. Therefore in kinetic equalization of self-ignition

$$(\tau_1)_{chem} \cdot P^n \cdot e^{-\frac{E}{RT}} = const \quad (1)$$

sizes E , n and $const$ are permanent for every type of fuel and their kinetic descriptions. Consequently, chemical constituent of period of delay of self-ignition $(\tau_1)_{chem}$ depends only on pressure in the chamber P_0 and veritable temperature of self-ignition in the torch T_v :

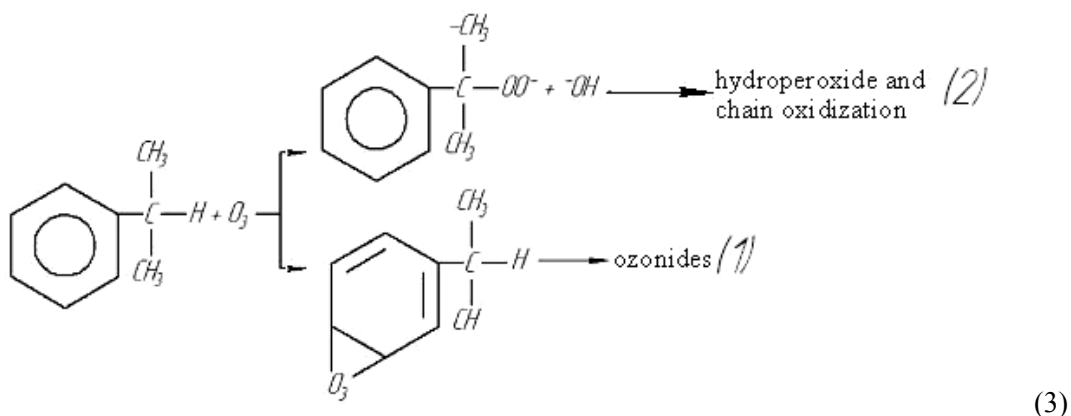
$$(\tau_1)_{chem} = f(P_0, T_v). \quad (2)$$

The expounded pre-conditions of theory of self-ignition of fuel allow to assert that for the high-quality account of change of chemical structure of fuel, because of input of catalysts of burning, that is an affecting structure of fuel at molecular level, the use of kinetic descriptions of fuel is possible, namely to total energy of activating of mixture E , that in addition is confirmed the laws of chemical kinetics (equalization of Arrhenius, law of Van-Goff) [15].

In addition, from the general adduction of the initial stage of self-ignition, determining character of flowing burning process of fuel hydrocarbons, basic influence is an amount of well-educated «active centers» of burning, i.e. free radicals and ionized atoms.

One of perspective, in our view, affecting methods period of spontaneous combustion there is affecting physical and chemical properties fuels, among which it is necessary to select ozonization of fuel, as new and insufficiently known possibility of influence on the process of combustion of fuel. There are many articles of research of influence of fuel, exposed to ozonization on descriptions of working process of diesel are devoted this question [8, 19].

As marked in [8], ozonning will undergo, mainly, most reactive aromatic hydrocarbons, the percentage of alkyl benzenes in a fuel-oil makes near 13,5 % [20]. Concordantly [21] the reaction of ozone with alkyl benzenes can flow in two ways:



Thus prevailing is direction 2 reactions (3), the amount of appearing ozonides (direction 1 in reaction (3)) on researches [21] makes order of 1- 4% from the general amount of products of reaction. Besides, at the reaction of ozone with aromatizers the ramified chain (reaction 3, second direction) is possible - two radicals appear, it diminishes probability of precipice of chains in the period of delay of spontaneous combustion and abbreviates its duration, that positively tells on engineering-and-economical performance and ecological indexes of diesels. At the same time, in [22] it is marked that ozonides can grow into organic acid radical groups.

Consequently, as a result of ozonizing of fuel-oil ozone enters into a reaction with alkyl benzenes connections, as a result their chain oxidization prevails with formation of peroxidates. During the test operation on the exposure of influence of ozone on physical and chemical properties of fuel-oil [23] this supposition is confirmed the presence of sediment of sour character at the protracted ozonization of fuel, that talks about the receipt of connections, formed at the attack of alkyl substituter on a radical mechanism (cetones, alcohols, peroxides and acids).

As a result of the mechanisms of possible reactions of ozone described higher with a fuel-oil, pre-flaming reactions pass a few by other appearance, namely, on the first stage of chain oxidization of hydrocarbons in the volume of mixture already there are hydrogen peroxide connections and, together with education, goes simultaneously and their decomposition. As a result of it, there is more intensive and «early» warming-up of mixture and acceleration of flowings reactions, formation of greater amount of active particles. A process results in diminishing of duration of flowing of pre-flaming reactions and, consequently, period of delay of spontaneous combustion of mixture.

With the purpose of estimation of period of delay of self-ignition the existent method of determination of temperature of flash was regenerate in closed crucible [24] in accordance with pre-conditions, described in [25]. Approximation dependence of activating energy of fuel-oil E is got on the concentration of ozone k , given in a fuel, taking into account its senescence t :

$$E = 16,234kt^2 + 0,268t^3 - 20,605t^2 + 401,726t - 286,963kt - 165,657k^2t + E_m - 23100k + 5530k^2 - 29680k^3, \quad (4)$$

where E_m – energy of activating of fuel-oil to it ozonization.

Dependence (4) allows in theory to estimate the size of period of delay of self-ignition in accordance with (1) and to model flowing of process of combustion in the diesel cylinder.

Modeling was conducted on the method of N.F. Razleyceva [19] for the diesel of D49 on positions of comptroller of machinist (tab. 1) in connection with suggestion about a recovery and use of ozone on a diesel engine, which is described in [26].

Table 1: Basic data for the design of work of diesel-generator of 18-9DG (D49) by diesel engine characteristic

Position of comptroller of machinist	Frequency of rotation, rotations per minute	Middle diameter of fuel drop, mm	Duration of injection, degree of crankshaft rotation	Coefficient of surplus of air	Temperature of cylinder walls, K
0	350	100	9	10	490
4	450	86	11	1,72	510
7	550	72	13	1,9	550
11	650	60	16	2,0	650
15	1000	50	19	2,1	750

The got results of modeling (fig. 1 – 2) are explained pre-conditions of influence of ozonization on the period of delay of self-ignition. As follows from (4) at ozonization of fuel specific effective energy of activating diminishes, that, in turn, results in reduction of period of delay of self-ignition (1). And, properly, from the results of design of description of тепловыделения, for example on the nominal mode (fig. 3), its first maximum is moved aside top dead point, that in turn results in the increase of maximal pressure of combustion, as be obvious from a fig. 1, and, consequently, to reduction of specific effective expense of fuel (fig. 2).

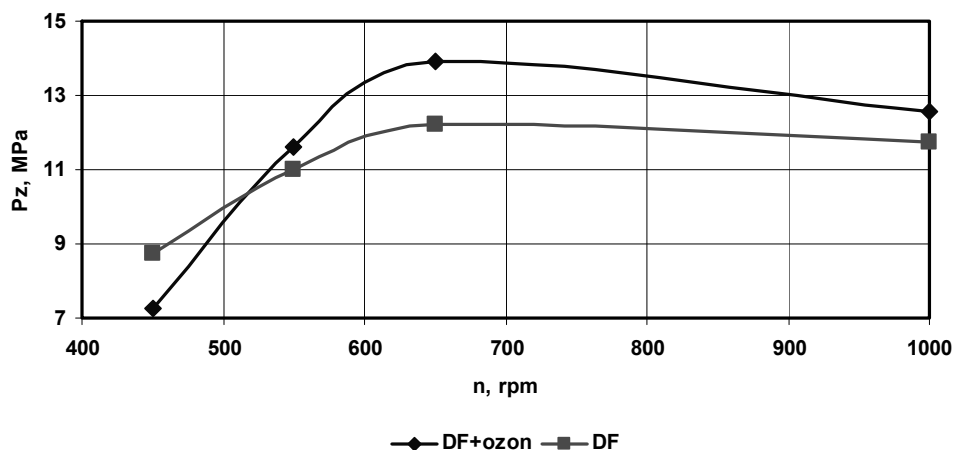


Figure 1: Change of maximal pressure of combustion of Pz on positions of comptrroller of machinist of diesel D49 diesel engine 2TE116

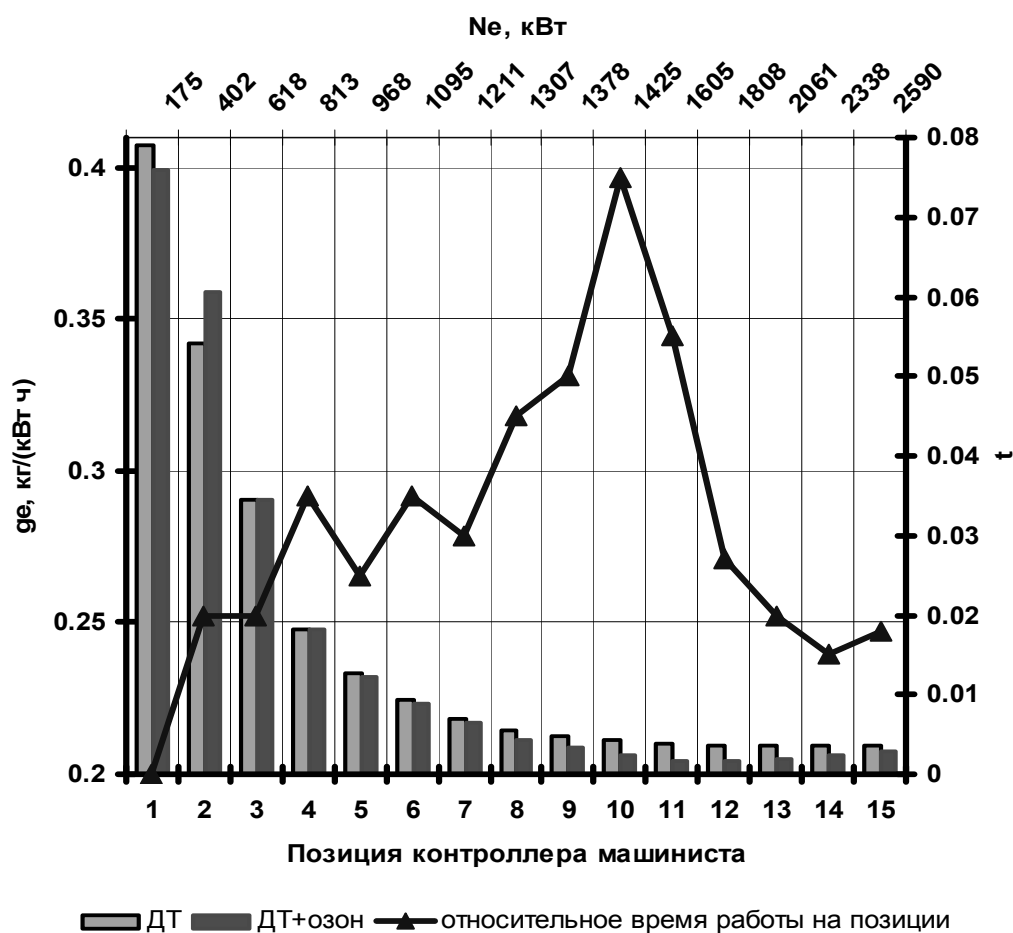


Figure 2: Specific effective expense of fuel on positions of comptrroller of machinist of diesel D49 diesel engine 2TE116

In addition, as follows from a fig. 3, at ozonization of fuel description of heat generation has more declivous character (position 2). At ozonization of heat generation takes a place longer, that talks about the increase of duration of combustion, plenitudes of combustion of fuel and decline of toxicness of workings gases.

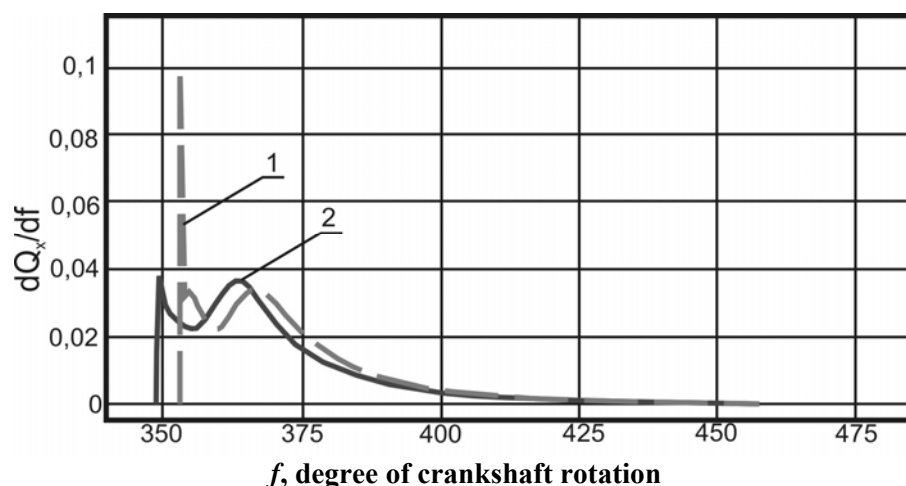


Figure 4: Description of heat generation of D49 diesel on the nominal mode during work:
1 – on DF; 2 – on DF+ozon

Conclusions

1. The use of methods of activating of fuel influence on his hydrocarbon structure by ozonization is the perspective method of perfection of working process of diesel.
2. Ozonization of fuel results in education in composition the fuel of peroxidates the increase of which reduces the size of conditional energy of activating. Dependence of size of energy of activating from the concentration of ozone and senescence of fuel is experimentally got, which talks about instability of properties of the ozonized fuel and necessity of leadthrough of process of ozonization right before a serve in an engine.
3. The design of working process of diesel of D29 was rotined by the decline of operating specific effective expense of fuel on 1,6%, exhaust opacity on 15%.

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