EFFECT OF THE PLAZMAZER PLASMA IGNITION SYSTEM ON THE FUEL COMBUSTION REGIMES IN COMBUSTION CHAMBERS OF ENGINES

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An economically efficient method of combatting toxic products of incomplete fuel combustion in engines and other movable and stationary power installations by means of pulsed automatic control of the ignition and combustion processes carried out by the PLAZMAZER system is proposed. A new concept of the occurrence of motor knock in internal combustion engines with external carburetion, the stiff operating mode of diesel engines, erosion of turbine blades, burn-out of combustion-chamber and exhaust-line elements, and jet engine compression stalling are presented.

Introduction. Modern engines are designed and built as applied to the classical ignition system with single ignition of the fuel load in combustion chambers, usually by an electric spark between the electrodes of the spark plugs [1]. In tending to achieve the maximum energy output, designers:

a) improve the combustion-chamber shape and material;
b) increase the compression ratio;
c) use fuel diffusers and ion-exchange filters in the supply line, working-mixture turbulizers, direct fuel injection with homogeneous and layered charges (das Einspirtzsystem) or direct injection of the fuel-air mixture (the Orbital Engine), individualization of the angle of advance of ignition (the SAAB Direct Ignition), turbosupercharging, and multichannel supply and exhaust systems that improve filling and emptying of the combustion chamber;
d) vary the number of cylinders as a function of the load, and vary the homogeneity of the fuel charge over the combustion-chamber volume;
e) use various fuel additives, including water, alcohols, ozone, hydrogen, and polycyclic aromatic hydrocarbons (PAH), in order to increase the octane rating of gasolines.

However, the conventional method of combustion of hydrocarbon and synthetic fuels does not ensure complete oxidation of carbon and hydrogen in the combustion chamber to yield carbon dioxide and water. The exhaust gases contain a wide range of highly toxic components [2].

It should be noted that incomplete fuel combustion is a forced measure included in the design due to instable operation of carburetor internal combustion engines at air excess coefficients exceeding unity. This problem induced invention of costly, low-efficiency, and short-lived catalytic neutralizers of exhaust gases, which, due to the additional gas-dynamic resistance in the exhaust line, increase fuel consumption by 20–25%, thus increasing the exhaust of toxic substances into the atmosphere, and are easily poisoned by oxygen, water, lead, manganese, mercury, and other compounds, including soot and analogs of warfare gases invariably present in exhaust gases.

In addition, PAH and azaarenes cannot be completely neutralized on platinum, rhodium, and palladium (with alumosilicate admixtures) catalyzers, and regeneration of neutralizers is not a less costly process than production of these expensive metals [3].
In recent years, the attention of numerous scientists has turned to investigation of the microphysical and chemical processes taking place in spark and barrier discharges in the combustion chamber and outside it with various energy-liberation dynamics [4].

1. Hydrodynamics and Chemical Physics of Combustion. In Zel’dovich’s opinion [5], investigation of the detonation wave itself cannot provide information on the chemical-reaction kinetics in the combustion chamber, unless its mechanism is revealed by some independent method. In investigating the explosion conditions in the combustion chamber, Semenov, the founder of the theory of chain reactions, derived the dynamic constant of the action on the process, which characterizes the ability of the reactants to transform in the course of the reaction into unstable chemical compounds that liberate the energy stored to provide a new act of transformation of the reactants [6, p. 28].

Earlier, the hypothesis of excitation of general-detonation noise by conversion of acetylenelike compounds (EGNCAC) was developed [7]. By now, extensive data directly or indirectly substantiating this the hypothesis are available [2; 6, p. 312; 8-12].

The modern hydrodynamic model of combustion (of not just hydrocarbon fuels) in the combustion chamber of an engine (e.g., internal combustion engine, jet engine, etc.) developed by Landau and Lifshits [13] on the basis of Zel’dovich’s theory [5] makes it possible to describe, along with the detonation and deflagration regimes, condensation jumps (collapses) of pressure in the combustion chamber that are formally similar to detonation, deflagration, and other high- and low-frequency combustion waves. These collapses result from polycondensation of gases and vapors that are intermediates of the oxidative fuel pyrolysis, and it should be noted that the polycondensation process takes place at a very high rate within a very narrow zone that can be regarded as a discontinuity surface separating the original gas, vapor, or a mixture of both from "smoke" or "fog" that is a gas with suspended solid matter or condensed vapor (e.g., coke, soot, PAHs with their heterogeneous modifications, water, etc.) present in exhaust gases.

The condensation collapses (jumps) are an independent physicochemical phenomenon rather than a result of gas compression in conventional shock waves, where the effect of condensation due to an increase in the pressure is overcompensated by the effect of an increase in the temperature [13].

Manifestations of pressure collapses due to polycondensation, polymerization, copolymerization, etc., such as 1) reddish-green flames ejected from exhaust nozzles, 2) rumble, rattle, howl, knock, and other acoustic effects, 3) decrease of power and overheating of internal combustion engines, 4) ejection of black smoke (coke and soot) from the exhaust system, 5) sharp peaks and collapses in indicator diagrams, 6) vibration and disintegration of parts of the piston group of internal combustion engines, 7) erosion of turbine blades and the walls of the combustion chamber of jet engines, 8) chipping of pistons and burning-through of their bottoms in internal combustion engines, and 9) burning-through of gaskets and exhaust valves, are normally ascribed to detonation, and it should be noted that in the pressure diagram these periodic collapses are described as "ejections" or "peaks" of shock waves [14-17]. The above reasoning makes it possible to state that the "peaks" correspond to the pressure in the combustion chamber that would be observed in the absence of collapses.

Following Landau and Lifshits [13], we carry out an approximate calculation of the forbidden range of condensation jump (collapse) rates in the combustion chamber:

$$\sqrt{c^2 + \frac{k^2 - 1}{2} q} - \sqrt{\left(\frac{k^2 - 1}{2} q\right)} < v < \sqrt{c^2 + \frac{k^2 - 1}{2} q} + \sqrt{\left(\frac{k^2 - 1}{2} q\right)},$$  \hspace{1cm} (1)

By substituting into (1) the parameter values $c^2 = k(k - 1)C_vT = 1.4 \left((1.4-1) \cdot 32 \cdot 2500 \approx 40,000 \text{ m}^2/\text{sec}^2\right)$, $k = 1.4 \rightarrow k^2 = 2$, $T = 2500 \text{ K}$, $C_v = 32 \text{ kJ/(k mole \cdot deg)}$ [1], $q = 3[C_2H_2]-[C_6H_6] \approx (3 \cdot 227 - 40) \cdot 10^3 \approx 64 \cdot 10^4 \text{ kJ/mole}$ [18], we obtain

$$\sqrt{4 \cdot 10^4 + \frac{2 - 1}{2} 64 \cdot 10^4} - \sqrt{\left(\frac{2 - 1}{2} 64 \cdot 10^4\right)} < v < \sqrt{4 \cdot 10^4 + \frac{2 - 1}{2} 64 \cdot 10^4} +$$