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OPTIMAL METHOD FOR INFLUENCING POWER-CONSUMING PROCESSES BY THE PULSE-PERIODIC NANOSECOND DISCHARGE *)

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Stable ignition and stable combustion of fuel-air mixtures is an important technological requirement for power plants that use fuel energy. As a rule, in the thermodynamic cycle there must be an element of initial mixture activation to predetermine the transition of the mixture from the initial state to an equilibrium high-temperature state in which the working substance can perform useful work. In addition, the time interval of the activation stage is also important. The activation efficiency requirement implies an assessment of the required energy costs.

In the field of plasma-assisted combustion, it is believed that pulsed-periodic (including corona) nanosecond discharges are well suited for ignition of weakly reactive lean fuel mixtures, as has been demonstrated in many works. It seems that these types of discharges can solve the problem of ignition of any lean mixture under appropriate conditions, and then it is possible to control the final stage of the system operation by changing parameters of the system during the discharge stage.

To understand how effective an electric discharge is for igniting a methane-air mixture at atmospheric conditions, a calculation was made of the composition evolution for three types of activation: 1) discharge treatment - the creation of chemically active particles and heating of the mixture, 2) the creation of partial super-equilibrium dissociation of oxygen and/or nitrogen, 3) preheating. The calculation was carried out in a zero-dimensional formulation, in an adiabatic cell, in order to exclude the influence of spatial processes. Impact by the discharge was the best in terms of the time to achieve ignition (several milliseconds), but the energy input should be too large - several MJ/m^3. However if a significant fraction of this energy in the system is deposited due to external heat supply (like compression by a piston in an engine), a discharge with a noticeably lower specific energy can be successfully used for ignition and control of combustion processes in the combustion chamber.

From the point of view of combustion completeness, not only the concentration of chemically active particles and heating are important, but also the stabilization of combustion and the development of self-ignition. In this work, in order to determine the mechanism of the discharge influence on various stages of combustion: ignition of the zone activated by the discharge, advancement of the combustion wave front, self-ignition of the gas ahead of the front, a study was carried out on the development of combustion of a propane-air mixture in the combustion chamber, varying the discharge parameters [1].

A relationship was established between the ignition of the discharge-activated zone and the self-ignition of the gas ahead of the combustion wave front. On basis of that relationship, a new method has been proposed to control the combustion of a lean fuel-air mixture in the combustion chamber of a compression engine with homogenous charge using a high-frequency corona discharge. By changing the discharge parameters over a wide range, it is possible to ensure self-ignition in a narrow range of crankshaft rotation angles near top dead center. The influence of the discharge decreases with increasing level of mixture leanness.

Thus, to achieve the desired combustion scenario of the fuel-air mixture, an optimal combination of external energy supply (for example, piston compression) and control electric discharge impact is required.

References

[1]. Dobrovolskaya A.S., Filimonova E.A., Bocharov A.N. Fuel, 2023, 354, 129349.

*) abstracts of this report in Russian