Simulation of plasma initiation of ignition of methane-air mixtures under atmospheric pressure

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The idea of using plasma methods of ignition of fuel-air mixtures is based on nonequilibrium production of chemically active particles in an electric discharge to accelerate combustion. Detailed reviews of the current state of this problem are presented in [1-3]. Theoretical and experimental aspects of the plasma initiation of combustion in hypersonic ramjet air-jet engines are discussed in [4-5]. In [6] studies were carried out to improve stability of combustion by electric discharge in gas turbines operating on a lean mixture with natural gas. An experimental study of plasma initiation of combustion of methane and ethylene air mixtures in a gas stream at a pressure of about a hundred Torr was performed in [7-8].

In this paper the results of calculations of the plasma initiation of ignition in the flow of a stoichiometric methane-air mixture at atmospheric pressure at various initial temperatures (300, 500 and 700 K) and various excitation powers of 20-100 kW/g are presented. To verify the model, a comparison was made with the data on plasma initiation of ignition given in [7-8], where a subsonic flow of methane and ethylene-air mixtures passed through a barrier discharge excited by nanosecond pulses with a repetition rate of 10-50 kHz is used. The lengths (times) of ignition and the specific energies of the discharge necessary to ignite the methane-air mixture were found. The energy values depended on the initial temperature of the gas and were in the range 170-380 J/g. The results of calculations of temporal evolution of the number densities of various plasma components are presented: in particular, for different electron-excited states – $O(^1D)$, $O_2(a^1\Delta_g)$, $O_2(b^1\Sigma^+{}_g)$ and $N_2(A^3\Sigma^+{}_u)$.

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