Formation of combustion wave in a hydrocarbon-air mixture in near high-voltage electrode of surface dielectric barrier discharge

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The study of nanosecond discharges for ignition purposes is presented in many works. The discharge influence in this case is reduced to the creation of chemically active particles by electron impact and fast gas heating. For example, in a number of works it is proposed to use SDBD – surface dielectric barrier discharge as a combustion initiator in the internal combustion engine. This type of discharge can create a diffuse plasma region at high pressures with a high reduced electric field in which chemically active particles are produced. It was noted that near a high-voltage electrode where the maximum energy is released, flame propagation in different directions may occur under certain discharge parameters.

In work [1] the ignition and propagation of the combustion wave in the stoichiometric mixture of air and C_2H_2, initiated by one nanosecond pulse were experimentally observed at P=1 bar, T_0=300 K. Also, based on the 2-D modelling of discharge and 0-D estimations of the ignition, the conclusion was made about possibility of ignition of the combustible mixture near high-voltage electrodes (including cathode layer) SDBD by one nanosecond pulse [1].

In given work, ignition conditions and the formation of a combustion wave in C_2H_2-air mixture near a high-voltage electrode of SDBD were investigated. A 1D numerical simulation based on the Navier-Stokes equations jointly with the equations of mass conservation for each component and the equations of chemical kinetics was carried out. Calculations show that only the heating of the gas in the cathode layer does not lead to ignition and further formation of the combustion wave. Since the discharge is a source of heating and O atoms, it is necessary to take into account the formation of O atoms as a result of dissociation. Only the corresponding combination of heating and O atoms concentration can lead to the formation of a combustion wave. As a result, a range of specific deposited energies and O atoms concentrations was found, at which a combustion wave was formed during t<45 μs - characteristic time of the formation of the combustion wave in [1]. It is shown that to simulate the initiation of a flame in discharge systems with high energy release it is important to take into account the gas-dynamic expansion of the hot area and its cooling by heat transfer on the surface of the metal electrode. Calculations in the 0-D approximation can lead to inaccurate results. During the discharge stage (40 ns), the fuel conversion is initiated, resulting in the formation of CO and H_2, which then burn, and CO_2 and H_2O are formed. The concentration of NO behind the front of the combustion wave was 0.1-0.2%.

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[1] E.M. Anokhin, D.N. Kuzmenko et al. Plasma Sources Sci. Technol. **24** (2015) 045014.