CALCULATION OF THE CHEMICAL COMPOSITION AND GAS TEMPERATURE IN THE ACTIVATED REGION CREATED BY THE pulse-periodic streamer DISCHARGEs in COMPRESSION ENGINE

Filimonova E.A., Naidis G.V., Dobrovolskaya A.S.

Joint Institute for High Temperatures of RAS, Moscow, Russia,
helfil@mail.ru, gnaidis@mail.ru, dobrovolskaya.anastasia@gmail.com

Currently hybrid internal combustion engines are being created, where the initiator of combustion is not a conventional spark from the spark plug, but a non-equilibrium electrical discharge, for example, a corona discharge of megahertz frequency [1]. Such discharges make it possible to create stable conditions for the operation of a compression engine operating with lean mixtures or at low temperatures of the fuel-air mixture. The fraction of the volume of the activated region in relation to the volume of the combustion chamber depends on the pressure, temperature, energy input, etc. During the discharge action, because of the displacement of the streamer channels in space and diffusion due to turbulent mixing associated with the movement of the piston and the fuel supply to the combustion chamber (the estimates of the mixing time are given in [2]), an activated region is created, its degree of homogeneity on the chemical composition and temperature depends on different parameters. The task of given work was to determine the composition and temperature of the activated region for a lean propane-air mixture.

In the framework of the ideology set out in [3], it is assumed that the discharge has two stages: the 1st stage is a streamer stage, with a high reduced electric field, where there is a production of chemically active particles, but with a small heating of the gas; the 2nd stage is a stage of energy deposition in the streamer channel, but with a small production of particles. By varying the voltage and capacitance of the capacitor supplying the discharge, one can choose the desired gas heating. Thus, we have the separation of two important processes for the formation of the combustion wave: the formation of active particles and heating.

The dynamics of positive streamers in a mixture of N2:O2:C3H8 = 0.7671:0.2043:0.0286 was calculated using a two-dimensional axisymmetric hydrodynamic model. G-values determining the production of chemically active particles per 100 eV of deposited energy were found. Heating of the gas in the channel was obtained according to the method described in [2]. The average temperature of the activated region was estimated from the law of enthalpy conservation taking into account the volume fraction occupied by streamers. The gas composition in the activated region was calculated using the software RADICAL [4] accounting for the obtained G-values and the heating of the activated region. RADICAL allows one to take into account the multi-pulsed mode, the diffusion of streamer channels and the non-uniform of the streamers filling the area treated by the discharge. The composition of the mixture at the end of the discharge operation and the temperature of the activated region were used as initial conditions for the problem of formation of the combustion wave. As a result of 1D modelling, the dependences of the combustion wave velocity, ignition time and auto-ignition on the size of the activated region, its composition and energy contribution were obtained.

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References

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