NUMERICAL STUDY OF THE TRANSITION OF A SPORADIC COMBUSTION WAVE TO A BALL-LIKE FLAME

E.V. SERESHCHENKO[1], *V.V. GUBERNOV*[1], *S.S. MINAEV*[1]

[1]*P.N. Lebedev Physical Institute RAS, Moscow, Russia*

The present study is devoted to a numerical study of the propagation dynamics of sporadic combustion waves consisting of a set of individual flame spots in straight channels within the framework of a three-dimensional reaction-diffusion model. As a result of numerical modeling, the dependences of the propagation velocity of a sporadic combustion wave, residual fuel concentration, and the number of flame spots on the channel size, mass flow rate, and radiative heat losses h are obtained.

It was found that when a sporadic combustion wave propagates in a sufficiently narrow adiabatic channel, modes arise when, as a result of chaotic splitting of the reaction front into several combustion spots, only one of them "survives". In this case, the shape of the "surviving" combustion spot becomes almost spherical, in contrast to the cup-like flame in a sporadic combustion wave, i.e., it becomes similar to a drifting flame ball. In this case, the chemical reaction proceeds along the entire perimeter of the sphere, somewhat intensifying in the direction of the ball-like flame movement, since the fuel concentration in this region is higher. As a result of numerical modeling, it was found that when the mode of propagation of the combustion wave changes from sporadic to single ball-like flame, the combustion wave propagation velocity drops from close to adiabatic ($\sim U_b$) to 0.1 - 0.2 U_b, i.e. 5-10 times.

All this indicates that in this regime the dynamics of flame propagation is determined mainly by diffusion, similar to the way it is realized in flame balls. The study of the influence of radiation heat losses on the dynamics of the ball-like flame has shown that, unlike a sporadic combustion wave, a single drifting ball-like flame can exist in a wider range of changes in the radiation heat loss parameter, which is also predicted by theory. At the same time, the radius of the ball-like flame slightly decreases as the radiative heat loss increases.

Considering ball-like flame separately, by increasing the channel size, the asymptotic behavior of the fuel concentration distribution and its temperature along the symmetry axis is numerically investigated to determine whether this mode of combustion wave propagation is a classical representation of a flame ball.