TRANSITION TO DETONATION IN FREELY PROPAGATING FLAMES

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Abstract: The paper presents results of theoretical and numerical analysis of the deflagration-to-detonation transition when combustion proceeds in unconfined volume. It is shown that in highly active mixtures, the gasdynamic mechanisms responsible for flame instability development and its acceleration can provide the conditions for detonation onset. Thus, in the process of flame front development, the short-wavelength perturbations born and grow on the flame surface. At this, the diverging pressure waves are formed on the stage of linear growth of these perturbations and at a certain stage of flame development, the intensification of combustion at the flame front and pressure waves takes place that can be related to the mechanism of thermoacoustic instability. As a result, the conditions arise for detonation onset.

Keywords: freely propagating flame; flame acceleration; deflagration-to-detonation transition

DOI: 10.30826/CE20130105

Figure Captions

Figure 1 Histories of the flame velocities and maximal overpressure in the process of combustion development in equimolar hydrogen–oxygen mixture at elevated pressure: *1* and *2* — ignition modes I and II, respectively (black curves — flame velocities calculated for average diameter of the flame front; and grey curves — for the leading point); *3* — overpressure for mode II; and *4* — calculation according to Eq. (1)

Figure 2 Wave pattern in the vicinity of the flame front at sequential time instants: (*a*) 37 μs; (*b*) 40; (*c*) 41.5; and (*d*) 43.5 μs. The absolute value of density gradient is shown, white color corresponds to the zero density gradient, and the black one to the maximal value. Ignition mode II

Figure 3 Pressure (solid curves) and temperature (dashed curves) profiles in the vicinity of the leading point of the flame front along the radius at sequential time instants: 40.2, 40.6, 41, 41.4, 41.8, and 42.2 μs. Ignition mode II

Acknowledgments

The research was carried out using the equipment of the shared research facilities of HPC computing resources at Lomonosov Moscow State University and using supercomputers at Joint Supercomputer Center of the Russian Academy of Sciences (JSCC RAS).

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Received November 25, 2019

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