MECHANISMS OF COMPRESSION WAVE GENERATION AND AMPLIFICATION IN FREELY PROPAGATING FLAMES

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Abstract: The paper is devoted to the numerical and theoretical analysis of the mechanisms of generation and amplification of shock waves in the process of unconfined flame propagation. Two basic mechanisms of shock wave generation corresponding to the linear and nonlinear stages of hydrodynamic instability development are distinguished. The role of thermoacoustic instability in shock wave amplification and the establishment of the conditions for deflagration-to-detonation transition is demonstrated on the example of a highly chemically active mixture.

Keywords: freely propagating flame; flame instability; shock waves; thermoacoustic instability; deflagration-to-detonation transition

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Figure Captions

Figure 1 Problem setup

Figure 2 Dispersion curves demonstrating the dependence of the flame-instability growth rate on the perturbation wavelength. Calculated dispersion curves are presented for different computational meshes: *1* — $\delta x = 50.0\ \mu$m; *2* — 25.0; *3* — 12.5; and *4* — $\delta x = 6.25\ \mu$m

Figure 3 Convergence test for critical wavelength Λ_C (δx is the numerical cell size). The error in the values of the critical wavelength relative to the exact solution is presented in percent

Figure 4 Convergence tests for length (L_{DDT}) and time (τ_{DDT}) of transition to detonation (δx is the numerical cell size)

Figure 5 Flow structure in the vicinity of the flame front at the linear stage of instability development (SW stands for the generated shock wave) (*a*); flow pattern in the flame front zone at the nonlinear stage of instability development (*b*); and generation of the shock wave due to intense burnout of fresh mixture inside the surface of the developed flame (*c*). Dashed line highlights the front of the shock wave. Gray scale in frames (*b*) and (*c*) indicates the absolute value of the density gradient normalized by its maximal value. Gray scale variation from white to black corresponds to the increase in the density gradient

Figure 6 Flow pattern during deflagration-to-detonation transition at two subsequent time instants within 5-microsecond interval. Dashed line highlights the front of the shock wave in the process of interaction with the flame front. Gray scale indicates the absolute value of the density gradient normalized by its maximal value. Gray scale variation from white to black corresponds to the increase in the density gradient

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