DEVELOPMENT OF HYDROGEN–AIR FLAME INSTABILITY IN AN OPEN CHANNEL

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Abstract: The paper deals with the analysis of the development of flame front instability in lean hydrogen–air mixtures of various compositions during combustion in an open channel. Numerical analysis of the various stages of front development is carried out. In particular, characteristics of the linear stage of instability growth are determined, dispersion curves are plotted, and the dependence of the critical wavelength on mixture composition is obtained. Specific features of nonlinear development of the process following the linear stage are demonstrated. Based on the obtained results, the dependence of the flame propagation velocity on the combustion front perimeter for mixtures of various compositions is derived. It is shown that for lean hydrogen–air mixtures, the dependence of the propagation velocity on the front area has a nonlinear behavior for small values of the combustion front area.

Keywords: hydrogen combustion; numerical modeling; flame front instability; flame propagation velocity

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Figure Captions

Figure 1 Problem setup

Figure 2 Dispersion curves for the lean hydrogen–air mixtures with hydrogen content 10% (*1*), 12% (*2*), 15% (*3*), and 20% (*4*). Solid lines denote approximations by second-order polynomials. Vertical dashed lines are drawn through the maxima of the approximating curves

Figure 3 Critical wavelength vs. mixture equivalence ratio

Figure 4 Flame front development in the mixture of 15% hydrogen in air; curves denote temperature isolines $T = 1000$ K: (*a*) nonlinear stage, time interval 5–25 μs, interval between lines $\Delta t = 5$ μs; and (*b*) stabilization stage, time interval 25–75 μs, interval between lines $\Delta t = 25$ μs

Figure 5 Dependence of flame velocity in channel $S_L/S_{1,1\mathrm{D}}$ on the flame front perimeter normalized by the channel width P_f/H for different hydrogen content in the mixture: *1* — 12%; *2* — 15%; *3* — 20%; and *4* — 25%. Thin solid lines indicate linear approximation for high values of the perimeter. Dashed curves connect the points obtained in the channels of the same width

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