DETONATION WAVE STRUCTURE IN A TWO-PHASE SYSTEM CONTAINING GASEOUS OXIDIZER AND LIQUID FUEL DROPLETS

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Abstract: The results of three-dimensional simulation of the propagation of detonation waves in suspensions of liquid isooctane droplets in air are presented. The calculation technique is based on solving mass, momentum, and energy conservation equations for the two-phase compressible turbulent reacting flow taking into account the movement, aerodynamic breakup, heating and evaporation of droplets, the finite-rate mixing of fuel components, and chemical transformations. The reliability of the method is verified by comparing the calculated and measured propagation velocities of two-phase detonations in a vertical channel of square cross section. The influence of the prehistory of the formation of a two-phase combustible mixture on the propagation velocity and structure of detonation waves in the channel is considered. New data have been obtained on the structure of the detonation waves in two-phase systems.

Keywords: heterogeneous detonation; *iso*-octane droplets; three-dimensional mathematical simulation; detonation structure; detonation velocity

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Figure Captions

Figure 1 Calculated distributions of the gas velocity (*1*) and the mass fraction of fuel vapor (*2*) when filling the channel with a gas suspension of *iso*-octane droplets with an initial diameter (before the start of filling the channel) of 400 μm

Figure 2 Calculated dependences of the detonation wave propagation velocity along a vertical channel filled with a gas suspension of *iso*-octane droplets with an initial diameter (before the start of filling the channel) of 400 μm at a fuel-to-air equivalence ratio of $\Phi = 0.7$ (*1*), 1.0 (*2*), and 1.8 (*3*). Horizontal dotted lines correspond to the Chapman–Jouguet detonation velocity for homogeneous *iso*-octane–air mixtures of the same compositions. The vertical dash-and-dotted line corresponds to the cross section of the channel (monitoring location) in which the structure of the self-sustained detonation wave is studied

Figure 3 Comparison of the calculated profiles of pressure (*a*) and temperature (*b*) along the center line of the vertical channel for self-sustained detonation waves traveling through a stoichiometric gas suspension of *iso*-octane droplets with an initial diameter (before the start of filling the channel) of 150 (*1*) and 400 μm (*2*); cross section $X = 0$ corresponds to the leading front of the detonation wave upon its arrival at the monitoring location (3.37 m)

Figure 4 Calculated profiles of pressure (*a*) and temperature (*b*) along the center line of the vertical channel for self-sustained detonation waves traveling through gas suspensions of *iso*-octane droplets with an initial diameter (before the start of filling the channel) of 400 μm at different values of the fuel-to-air equivalence ratio: *1* — $\Phi = 0.7$, *2* — 1.0, and *3* — $\Phi = 1.8$; cross section $X = 0$ corresponds to the leading front of the detonation wave upon its arrival at the monitoring location (3.37 m)

Figure 5 Calculated instantaneous distributions of *iso*-octane droplet sizes and energy release zones with (upper frames) and without (lower frames) superposition of the corresponding fields behind the leading front of detonation waves traveling through droplet suspensions with fuel-to-air equivalence ratio $\Phi = 0.7$ (*a*), 1.0 (*b*), and 1.8 (*c*) at an initial droplet diameter (before the start of filling the channel) of 400 μm. Energy release zones are shown by grey dots corresponding to spontaneously ignited Monte-Carlo particles

Figure 6 Calculated instantaneous distributions of the mass fraction of fuel vapor (upper frames) and temperature (lower frames) in a detonation wave traveling through a gas suspension of iso-octane droplets with an initial diameter (before the start of filling the channel) of 400 μm at $\Phi = 0.7$ (*a*), 1.0 (*b*), and 1.8 (*c*)

Table Caption

Parameters of reactions (1)–(5)

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