MODELING OF CELLULAR DETONATION WAVE STRUCTURE IN STOICHIOMETRIC DUAL-FUEL MIXTURE OF SYNTHESIS-GAS WITH OXIDIZER

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Abstract: A generalized two-step chemical kinetic model of detonation of dual-fuel stoichiometric mixture of synthesis-gas with oxidizer is presented. It allows calculation of heat release in the course of chemical reaction and variation of molar mass, internal energy, and specific heat ratio of the mixture without computation of its detailed chemical composition. An algorithm for calculating the induction period of chemical reaction in the mixture under consideration according to known formulae for calculating the induction period in single-fuel mixtures of carbon monoxide and hydrogen with an oxidizer has been developed. Two-dimensional numerical calculation of the multifront detonation wave structure in the mixture under consideration at different relations between fuels is performed. Chemical transformations are described by the proposed kinetic model. Detonation cell size and qualitative wave structure (including the transformation of the cellular structure from irregular to regular with the increase in hydrogen concentration) are shown to correspond well to experimental data.

Keywords: two-fuels mixture; synthesis gas; kinetic model; detonation; cell

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Figure Captions

Figure 1 Detonation cell size in a stoichiometric mixture of syngas with air $(1-\alpha)\mathrm{CO} + \alpha\mathrm{H}_2 + 0.5(\mathrm{O}_2 + 3.76\mathrm{N}_2)$: *1–3* and *4* — experimental data of [2] and [13], respectively; *1* — no self-sustained detonation; and *2* — detonation limit (in terms of carbon monoxide concentration) above which no self-sustaining detonation is realized

Figure 2 Calculated (*1*) and measured [2] detonation cell size in a stoichiometric mixture of syngas with air $(1-\alpha)\mathrm{CO}$ $+\,\alpha\mathrm{H}_2 + 0.5(\mathrm{O}_2 + 3.76\mathrm{N}_2)$: *2* — detonation; *3* — no detonation; and *4* — detonation limit

Figure 3 Detonation wave structure in a stoichiometric mixture of hydrogen with air ($\alpha = 1$): (*a*) flow field of normalized density; (*b*) numerical Schlieren-visualization; (*c*) temperature; and AA and BB — main transverse waves; $H = a = 1.4$ cm. Experiment [13]: $a = 1.5$ cm

Figure 4 Detonation structure in a stoichiometric mixture of syngas with air, $0.7\mathrm{CO} + 0.3\mathrm{H}_2 + 0.5(\mathrm{O}_2 + 3.76\mathrm{N}_2)$: (*a*) flow field of normalized density; (*b*) numerical Schlieren-visualization; (*c*) temperature; AA and BB — main transverse waves; and aa, bb, and cc — secondary transverse waves; P_1 and P_2 indicate the pockets of unburned gas; $H = a = 1.5$ cm. Experiment [2]: $a = 1.1$–2.0 cm

Figure 5 Detonation wave structure in a stoichiometric mixture of syngas with air, $0.9\mathrm{CO} + 0.1\mathrm{H}_2 + 0.5(\mathrm{O}_2 + 3.76\mathrm{N}_2)$: (*a*) flow field of normalized density; (*b*) numerical Schlieren-visualization; (*c*) temperature; AA and BB — main transverse waves; and aa, bb, and cc — secondary transverse waves; P_1 and P_2 indicate the pockets of unburned gas; $H = a = 2.5$ cm. Experiment [2]: $a = 2.0$–4.0 cm

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