2D modeling of V-shaped turbulent methane-air flame

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A methodology for simulating of turbulent combustion in a two-dimensional formulation is presented in the work. A distinctive feature of this methodology, based on the URANS approach, is the assignment of the non-stationary profiles of velocity components at the input to the computational domain. These profiles are determined wiyh the use of the algorithm of artificial turbulence [1] that specifies the necessary values of both the intensity of pulsations and the integral scale of turbulence in the incoming flow. In technical terms, the User Defined Function (UDF), provided in the Fluent program, is used for this purpose. Quasilaminar combustion model, k-ε realizable turbulence model and the kinetic mechanism DRM-19, describing combustion of methane in air and including 84 reactions for 21 species, are used for calculations. The results of modeling has shown that this methodology describes with good accuracy the angle of inclination of the V-shaped flame front observed in the experiment [2] and its broadening depending on the distance from the flame stabilization point.

Based on the developed methodology, the influence of various parameters of the incoming flow on the characteristics of the V-shaped flame was analyzed.

— With an increase in the intensity of the velocity pulsations, the turbulent burning velocity and the angle of inclination of the flame front increase (with an increase in the intensity of the velocity pulsations from 6.25 to 14%, the turbulent combustion rate increases by 36% and the angle of the flame front grows by 30%).

— The integral scale of turbulence significantly affects the change in the angle of flame front broadening and weakly affects the turbulent burning rate (with an increase in the integral scale of turbulence by 2.5 times, the angle of front broadening increases by a factor of 1.8 and the turbulent burning rate decreases no more than than by 2%).

— The completeness of mixing of methane with air (the intensity of pulsations of the fuel mole fraction in the range 0–6% and the integral scale of pulsations of the fuel mole fraction in the range 0–5 mm) has small effect on the characteristics of turbulent combustion.

— The introduction into the flow of a separating plate oriented along the incoming stream leads to a decrease in both the turbulent burning rate (by 12%) and the angle of front broadening (by a factor of 3).

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1. Kozlov V.E. Computer study of the effect of the turbulence of an oncoming flow on the V-shaped combustion of a homogeneous methane-air mixture // High Temperature 2012. V.50. No.4. P.501-505.

2. Bell J.B., Day M.S., Shepherd I.G., et al. Numerical simulation of a laboratory-scale turbulent V-flame // Lawrence Berkeley National Laboratory Report. LBNL–54198–J.