SIMULATION OF A HYDROGEN FLAME INSTABILITIES AND TRANSITION TO TURBULENT BURNING

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In the lean combustion mixtures the flame surface is formed as a result of joint action of various instabilities. In the field of gravity the light combustion products are situated under the heavier reactants. As a result the Rayleigh-Taylor instability develops. Without reference to gravity the density jump through the combustion front initiates the front wrinkling. So the Landau-Darrieus hydrodynamic instability connected with thermal expansion of combustion products is shown. Due to hydrogen high diffusion capacity the burning of the gas mixtures containing hydrogen are subjected to diffusive and thermal-diffusive instabilities development. Research of the instability separate action is possible in the microgravity experiments [1–2].

In smooth tubes or in channels with obstacles the flame moving through the barrirers located along the path of the extending flame, leads to rapid increase of the flame surface and flame speed. In addition to the geometrical increase of the surface, Richmeyer-Meshkov and Kelvin-Helmholtz instabilities lead to additional flame surface increasing. At a later stage of the flame propagation, a significant randomization of the flow ahead of the flame occurs. This results in the development of intense turbulence in the flow.

Simulation of the flame propagation in the lean hydrogen-air mixture in laminar and turbulent regimes is performed. In the case of microgravity the two-dimensional flame shapes are identical to experimental ones in dynamics, morphology and concentration limits. Possibility of the three-dimensional analogues calculation is shown. In the case of burning in the channel the run-up distance to supersonic flames is calculated for hydrogen-air mixture of 10% hydrogen volume fraction.

References

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