On the structure and stability of ultra-lean flames

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The hazards related to gaseous explosions demand the accurate estimations of the stable combustion limits. Moreover, it is of paramount importance to obtain a detailed pattern of all the possible combustion regimes developing in near-limit combustible mixtures. Present work studies the peculiarities of combustion in ultra-lean hydrogen-air mixtures. On the basis of numerical analysis, it is shown that the ultra-lean flame can exist in the form of stable flameball in terrestrial gravity conditions. Herewith, the buoyancy force affects greatly the flameball structure via the heat and mass transfer driven by the formed convective flows. At the final stages of its evolution, the flameball propagates upwardly with almost constant terminal speed, while a set of independent satellite flame kernels detached from the main flame core propagates in the thermal wake behind the flameball determining the effective growth of the flame. It should be also noted that due to the peculiarities of flameball structure the temperature of combustion products is superadiabatic. Therefore such a flameball could easily induce ignition in the upper layers of the stratified hydrogen-air atmosphere where more reactive gas containing a larger amount of hydrogen is located due to natural convection.