Bifurcations of stretched premixed flame stabilized by a hot wall

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Abstract

Characteristics of stretched methane-air flames stabilized in a forward stagnation region in front of an inert hot wall with constant temperatures were examined computationally and experimentally. Attention was paid to the bifurcations of stretched flames. To minimize potential experimental errors caused by natural convection, all the experiments were conducted under 10-second microgravity conditions at the JAMIC drop tower in Hokkaido, Japan.

Computations for methane-air flames were performed with detailed chemistry and variable properties. Optically thin radiation model was employed using the Planck mean absorption coefficients for CO_2, H_2O, CO and CH_4. Statistical narrow-band model was also used. Flame bifurcations, that is, the coexistence of multi-temperature flames at the identical conditions of the stretch rate, equivalence ratio and wall temperature were observed. Combustion was completed in the high-temperature flames which stand far from the hot wall, however, incomplete combustion was found in the low-temperature flames which locates close to the hot wall. Hence, levels of the CO concentration in the low-temperature flames were relatively high at the wall and those in high-temperature flames were negligibly low. Flame locations were experimentally measured at the conditions of the equivalence ratio around 0.6 and the wall temperature of 973 K by changing the stretch rate from 6 to 10 s^{-1}. Two flame locations were successfully confirmed in the identical conditions of the stretch rate, equivalence ratio and wall temperature. Computational and experimental results were compared with each other and discussed in terms of the flame bifurcations.

Keywords

Bifurcation, Stretched flame, Premixed flame, Wall effect, Microgravity experiment