Experimental and numerical investigations of flame pattern formations in a radial microchannel

Abstract

Flame pattern formations in a heated radial microchannel with a gap width of 1.75 mm were investigated experimentally and numerically. A premixed methane-air mixture was introduced at the center of microchannel formed by two parallel quartz discs which were heated with an external porous burner to create a positive temperature gradient condition in the direction of flow. In addition to conventional stable flames, some non-stationary flame patterns termed single- and double-pelton-like flames and the traveling flame were also observed. The double- and single-pelton-like flames occurred at a random possibility under certain conditions, which rotated around the center of the radial microchannel at a frequency of ~25-55 Hz. Regime diagram of all those flame patterns was drawn based on the experimental findings in the mixture equivalence ratio range of 0.65-1.30 and inlet mixture velocity range of 1.5-5.0 m/s. Meanwhile, the experimental results also qualitatively verify our previous theoretical prediction that is the S-shaped dependency of flame radial location on inlet velocity for stoichiometric mixture. Finally, numerical simulations using a global one-step Arrhenius reaction model successfully captured some rotating flame structures that may be associated with single- and double-pelton-like flames observed in the experiments.

Keywords: micro-combustion; radial microchannel; pattern formation; flame instability; rotating flame