EFFECTS OF RADIATIVE HEAT LOSS ON THE UNSTABLE BEHAVIOR OF HIGH-TEMPERATURE PREMIXED FLAMES AT LOW LEWIS NUMBERS: NUMERICAL SIMULATION BASED ON THE DIFFUSIVE-THERMAL MODEL EQUATION

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Premixed flames with high-temperature combustible mixtures, so-called high-temperature premixed flames [1], are recognized as the effective method for the reduction of irreversibility in combustion, i.e. the reduction of exergy loss. In view of the energy saving, we need to adopt high-temperature premixed flames in industrial furnaces and obtain the knowledge on combustion phenomena to control them smart. The flame instability occupies a significant position in the characteristics of high-temperature premixed flames and affects the unstable behavior of flame fronts. Heat loss has a great influence on the intrinsic instability of premixed flames [2-3]. Thus, we should elucidate the heat-loss effects on the unstable behavior of high-temperature premixed flames.

The effects of radiative heat loss on the unstable behavior of high-temperature premixed flames at low Lewis numbers are studied by two-dimensional unsteady calculations of reactive flows. In the present numerical simulation, we adopt the diffusive-thermal model equation, where constant-density approximation is used and thermal expansion is disregarded. Thus, we treat only diffusive-thermal instability in the present study.

Under the adiabatic conditions, the burning velocity of a planar flame increases as the unburned-gas temperature becomes higher. The dispersion relations are almost unchanged, because of the constant-enthalpy conditions. In addition, cellular flame fronts form at low Lewis numbers, which is due to diffusive-thermal instability. When radiative heat loss is taken into account, the growth rate becomes larger at small wave-number range. In addition, the behavior of cellular flame fronts becomes more unstable. The obtained results indicate that the radiation promotes the unstable behavior of high-temperature premixed flames at low Lewis numbers.

References

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