Experimental and numerical investigation of microscale hydrogen diffusion flames

鄭藏勝,趙怡欽,吳志勇,李約亨,中村佑二,李國源,袁曉峰,呂宗行
Mechanical Engineering
Engineering
tscheng@chu.edu.tw

Abstract

Characteristics of microscale hydrogen diffusion flames produced from sub-millimeter diameter (d = 0.2 and
0.48 mm) tubes are investigated using non-intrusive UV Raman scattering coupled with LIPF technique.
Simultaneous, temporally and spatially resolved point measurements of temperature, major species
concentrations (O_2, N_2, H_2O, H_2), and absolute hydroxyl radical concentration (OH) are made in the
microflames for the first time. The probe volume is 0.02 ´ 0.04 ´ 0.04 mm3. In addition, photographs and 2-D
OH imaging techniques are employed to illustrate the flame shapes and reaction zones. Several important
features are identified from the detailed measurements of microflames. Qualitative 2-D OH imaging indicates
that a spherical flame is formed with a radius of about 1 mm as the tube diameter is reduced to 0.2 mm.
Raman/LIPF measurements show that the coupled effect of ambient air leakage and preheating enhanced
thermal-diffusive of H_2 leads to lean-burn conditions for the flame. The calculated characteristic features and
properties indicate that the buoyancy effect is minor while the flames are in the convection-diffusion controlled
regime because of low Peclet number. Also, the effect of Peclet number on the flame shape is minor as the flame
is in the convection-diffusion controlled regime. Comparisons between the predicted and measured data indicate
that the trends of temperature, major species, and OH distributions are

properly modeled. However, the code
does not properly predict the air entrainment and pre-heating enhanced thermal-diffusive effects. Therefore,
thermal diffusion for light species and different combustion models must be considered in the simulation of
microflame structure.

Keyword：Microflames, Raman scattering, LIPF, Numerical simulation