Stretch extinction limit of counterflow diffusion flames using high-temperature air

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ABSTRACT

Experimental and numerical study on the stretch extinction limit of counterflow diffusion flames consisting of fuel gases and high-temperature air up to 773 K are conducted. Carbon monoxide, methane, hydrogen and their blends are used as fuels, and the mixture of oxygen and nitrogen, and of oxygen and water vapor are used as oxidizers. The experiments are carried out by use of a Tsuji-Yamaoka type cylindrical porous burner, which gives a uniform stagnation flow field. The numerical simulations are performed on a one dimensional counterflow diffusion flame with detailed chemical reaction mechanisms and a radiation heat loss term in the conservation equation of energy. The calculated results are consistent with the experimental results for CO and methane flames using the high-temperature oxidizers.

Figure 1 shows the effect of fuel concentration and oxidizer temperature on stretch rate at extinction limit for (CH_4+N_2)/air and $(CO+H_2+N_2)$/air at 300 K and 773 K. The stretch rate at extinction limit is increased with the fuel concentration and the oxygen concentration. For (CH_4+N_2)/air flames, when the oxidizer temperature is increased from 300 K to 773 K, the stretch rates at extinction limit increases about one order. Also, for (CH_4+N_2)/air, the minimum oxygen concentration decreases as the air temperature is increased. For example, the minimum oxygen concentration can be estimated about 0.14 mole fraction in room-temperature air, and about 0.08 mole fraction in high-temperature air of 773 K.

Pure CO cannot burn in dry air because of slow burning rate of CO in air. However, if H_2, hydrocarbon or water is mixed to CO, the burning rate is drastically changed even when the amount of admixture is quite small. The result showed that, for $(CO+N_2)$/air at 300 K, the stretch rate at extinction limit increased as the H_2 concentration in fuel is increased.

When the high-temperature water vapor is used as the dilution gas in oxidizer instead of N_2, the stretch rate at extinction limit decreased because the heat capacity per unit volume of water vapor is larger than that of N_2.

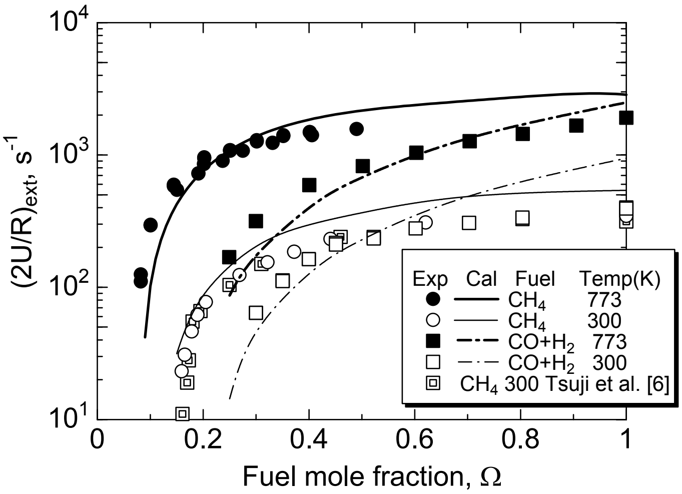

Fig. 1. Effect of fuel concentration and oxidizer temperature on stretch rate at extinction limit for (CH_4+N_2)/air and $(CO+H_2+N_2)$/air at 300 K and 773 K.