Development of a Combustor with Rich Premixed Flames for a Hydrogen-fueled Micro-gas Turbine -Optimum Combustion Conditions and Combustion Characteristics of Test Combustors-

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1. Introduction

Applying a two-staged combustion method (rich-quench-lean combustion method) to a hydrogen combustor for micro-gas turbines with higher TIT was examined.

2. Estimation of optimum combustion conditions

NO concentrations and combustion efficiencies after the two-staged combustion method were calculated using a combustor model that assumed both a first reaction zone (rich burning) and a secondary reaction zone (lean burning) to be well-stirred reactors to find out the optimum equivalence ratios. CHEMKIN(1) and reaction mechanism of GRI-Mech 3.0(2) were used.

NO concentrations got low at equivalence ratios of first reaction zone, φi, over 2 shown in Fig. 1.

Combustion efficiency was the highest at φi=1 and gradually decreased with increasing φi.

In the two-staged combustion model the optimum equivalence ratio of φi to satisfy low emission and high efficiency was found to be about 2.

3. Combustion experiment of test-combustors

Combustion characteristics of can-type test combustors with the two-staged combustion method were investigated. The combustors had a combustion tube (quartz) of 122[cm^3] in volume, a swirl injector for rich premixed gases and an outer concentric nozzle for secondary air. φi and the injection velocities of premixed gases and secondary air were varied under the constant conditions of φt=0.3 and the total air mass flow rate = 16[g/s]. The injection velocities were varied by changing the injection port area of the injector or the nozzle.

A stable rich premixed flame formed in the range of φi from 1 to 3, but transition to combustion driven oscillation occurred at higher φi.

NOx and unburned hydrogen concentrations in the combustion gases were measured at the combustor exit. The tendencies of these concentrations with φi were contrary to the calculated results. Whether the flame base attached to the injector was opened or not (Fig.2) greatly influenced the flame configurations, the temperature fields in the combustors and their emissions.

References

(1) Kee, R. J., et al., Sandia National Laboratories Report No. SAND 96-8216 UC-405.
(2) Gregory P. Smith, et al., http:// www.me.berkeley.edu/gri_mech/.

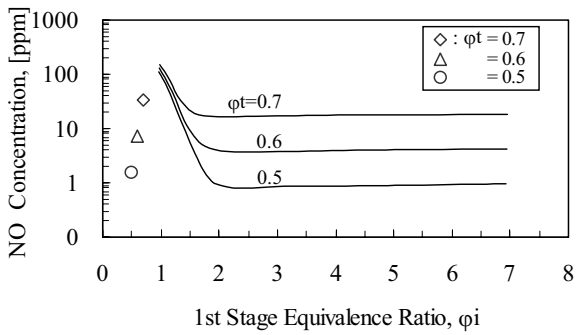
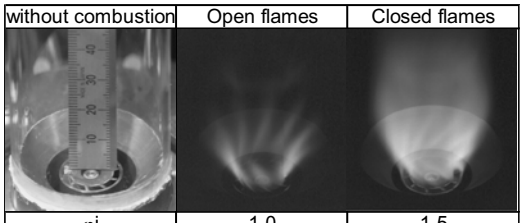


Fig. 1 NO concentration after two-staged combustion of 2[msec] (Tin=300[K], P=2[atm])



φi	1.0	1.5
Uj[m/s]	104	80
Ua[m/s]	54	63

Fig. 2 Typical flame configurations (φt=0.3, $\dot{m}_{at}$=16[g/s])

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