다공성 SiC 초단열 복사버너의 성능 연구

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Studies on the performance of a porous SiC superadiabatic radiant burner

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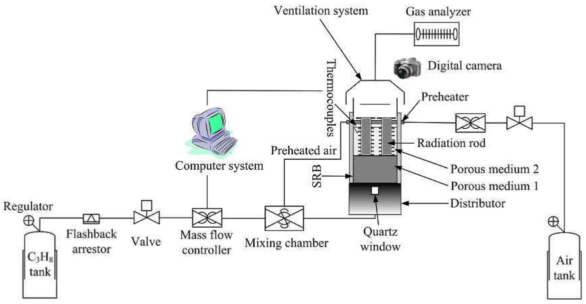
Porous medium combustion has interesting advantages such as high efficiency, ultra lean flammability limits and low emission compared with free flame combustion. Through the convection, conduction and radiation in the porous media, porous burners can recuperate heat from combustion [1-5]. In a previous study, an alumina porous superadiabatic radiant burner (SRB) with preheating pipes for external heat recirculation and finned radiation rods to extract heat from the flame and transfer it to radiating disk surface, was studied [6]. It has been demonstrated that the disk surface temperature is higher than the local gas temperature, which is available to make the radiation heat transfer to the target; however, the thermal resistance of the rod was somewhat large to achieve the performance of high disk temperature and efficiencies [6]. In the present study, both the porous foam and the radiation rods are fabricated with the silicon carbide (SiC) and the rod diameter has been increased to reduce the thermal resistance compared with the previous alumina SRB. For the SiC SRB with high conductivity and the reduced thermal resistance, the extended combustion stability limits, the enhanced temperature gap between the radiation disk surface and the local exhaust gas temperature and the enhanced thermal efficiency are expected. Also, the effects of the preheater on the performance of SRB are investigated.

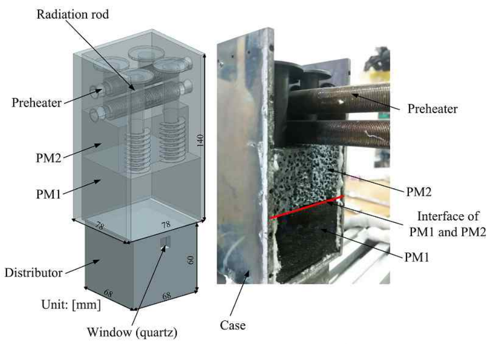
(a)



(b)

Fig. 1 SRB with two porous media, preheater and radiation rods (a) and schematics of experimental apparatus (b).

The porous SiC SRB that is shown in Fig. 1a consists of two porous media (PM1 and PM2), a preheater and finned radiation rods. With the external heat recirculation of absorbing heat from the flue gas, the cold air that enters the preheater is preheated. The preheated air and the cold fuel (propane, C_3H_8) are mixed in the mixing chamber, and the mixture is issued from the bottom of the distributor which is filled with the stainless steel beads with an average diameter of 1.5 mm for obtaining the uniform flow. The distributor is windowed by quartz to detect the flashback. The fins attached on the



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radiation rods can extract heat directly from the flame and transfer it to the radiation disks through the heat conduction and radiation. R-type thermocouples are used to measure the temperature distribution in PM2 (with coarse foam downstream), and K-type thermocouples are used to measure the radiation disk surface temperature and the local exhaust gas temperature. Fig. 1b shows the schematics of the present experimental apparatus.

Fig. 2 shows the temperature distribution along the axial centerline of the PM2 of the SiC SRB for premixed C_3H_8/air flames of fuel-equivalence ratio ϕ = 0.40 and various fuel flow rates (1,400-1,600 sccm) at normal temperature and pressure (NTP). The peak temperature for all the flames is higher than the adiabatic flame temperature (AFT) which is computed using the NASA CEA (Chemical Equilibrium with Applications) code [7], indicating the superadiabatic effects of the SRB. The locations of peak temperature are at 20 mm downstream from the interface of PM1 and PM2. Considering heat losses to the surroundings even with thermal insulation under practical operating condition, this superadiabatic effect is remarkable. With a preheater, the combustion stability limits of ϕ have been extended from 0.43 without the preheater to 0.24 for the SiC SRB. Also, the stability limits of ϕ for the SiC SRB has been extended from 0.28 to 0.24 compared with the previous alumina SRB due to the stronger internal heat recirculation through the high thermal conductivity of SiC.

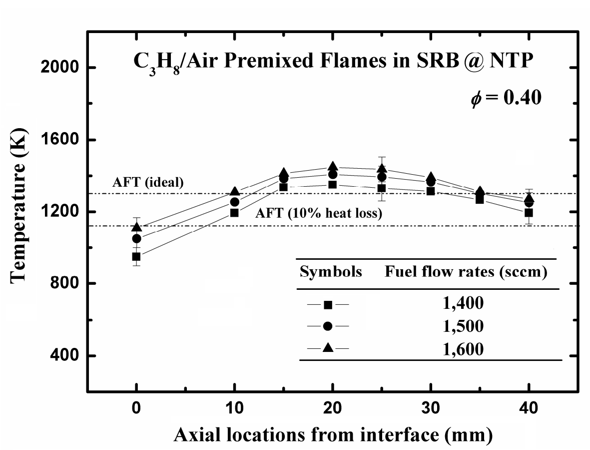

Fig. 2 Temperature distribution along axial centerline of PM2 in SiC SRB for premixed C_3H_8/air flames of ϕ = 0.40 and various fuel flow rates at NTP.

Fig. 3 shows the measured disk and flue gas temperature at the same axial location for premixed C_3H_8/air flames of ϕ = 0.40 and various fuel flow rates (1,000-1,600 sccm) at NTP. With increasing fuel flow rates, both the disk and flue gas temperatures increase due to the intensified burning in PM2. Because of the enhanced heat conduction through the radiation rods having high thermal conductivity, the average temperature difference between flue gas and disk surface has been increased from 45 K to 57 K compared with the previous alumina SRB.

Compared with the alumina SRB, the maximum thermal efficiency of the SiC SRB has also been improved (30.4% vs. 24.8% for the alumina SRB) due to the reduced exhaust gas temperature since the more heat generated from the flame is extracted through the modified radiation rods and conducted through the rod stem to the disk surface.

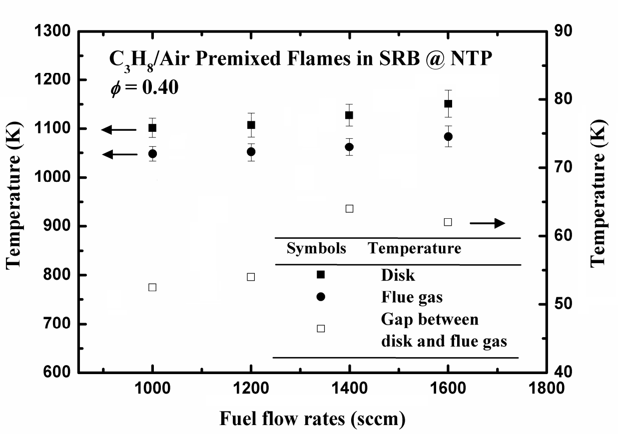

Fig. 3 Disk and flue gas temperature in terms of various fuel flow rates for premixed C_3H_8/air flames of ϕ = 0.40 in SRB at NTP.

Through modifying the radiation rod diameter (and also the fin diameter) and replacing the foam materials, the present SiC SRB shows the extended combustion stability limits to the ultra fuel-lean condition. The increased temperature gap between the radiation disk surface and the local exhaust gas temperature and the enhanced thermal efficiency have been achieved. Thus, SiC SRB seems to be acceptable for practical application.

Acknowledgement

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