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Effect of Exit Annular Area on the Flow Field Characteristics of an Unconfined Premixed Annular Swirl Burner

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Abstract : The objective of this study was to explore the impact of variation in the exit annular area on the local flow field features and the flame stability of an annular premixed swirl burner (unconfined) operated with premixed n-butane air mixture at equivalence ratio (ϕ) = 1, 1 bar, and 300K. A swirl burner with an axial swirl generator having a swirl number of 1.5 was used. Three different burner heads were chosen to have the exit area increased from 100%, 160%, and 220% resulting in inner and outer diameters and cross-sectional areas as (1) 10mm&15mm, 98mm2 (2) 17.5mm&22.5mm, 157mm2 and (3) 25mm & 30mm, 216mm2. The bulk velocity and Reynolds number based on the hydraulic diameter and unburned gas properties were kept constant at 12 m/s and 4000. (i) Planar PIV with TiO2 seeding particles and (ii) OH* chemiluminescence were used to measure the velocity fields and reaction zones of the swirl flames at 5Hz, respectively. Velocity fields and the jet spreading rates measured at the isothermal and reactive conditions revealed that the presence of a flame significantly altered the flow field in the radial direction due to the gas expansion. Important observations from the flame measurements were: the height and maximum width of the recirculation bubbles normalized by the hydraulic diameter, and the jet spreading angles for the flames for the three exit area cases were: (a) 4.52, 1.95, 28^o, (b) 6.78, 2.37, 34^o, and (c) 8.73, 2.32, 37^o. The lean blowout was also measured, and the respective equivalence ratios were: 0.80, 0.92, and 0.82. LBO was relatively narrow for the 157mm2 case. For this case, particle image velocimetry (PIV) measurements showed that Turbulent Kinetic Energy and turbulent intensity were relatively high compared to the other two cases, resulting in higher stretch rates and narrower lean blowout (LBO).

Keywords : chemiluminescence, jet spreading rate, lean blowout, swirl flow
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