Propagation Characteristics of Turbulent Methane-Air Premixed Flames at Elevated Pressure in a Constant Volume Vessel

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HIGHLIGHTS

• High-speed simultaneous OH PLIF and PIV is performed to investigate local flame displacement speed in a constant volume vessel under different initial pressure and turbulent conditions.
• CH chemiluminescence measurement shows that there is no significant difference in the global flame propagation speeds between the cases with 0.1 MPa and 0.2 MPa in the turbulent conditions.
• The 2D local flame displacement speed obtained by the high speed simultaneous OH PLIF and PIV shows smaller values than the global flame propagation speeds.

ABSTRACT

Characteristics of flame propagation of turbulent methane-air premixed flames are investigated by CH chemiluminescence imaging and high-speed simultaneous OH planar laser induced fluorescence (PLIF) and particle image velocimetry (PIV) measurements at 10 kHz in a constant volume vessel with well-controlled initial turbulence, pressure and equivalence ratio environment. The obtained images show the convoluted flame structures with increased turbulence intensity. The global flame propagation speed, which is obtained from the CH chemiluminescence images, increases accordance with turbulence level for the turbulent conditions. However, no significant difference is observed in the global flame speed between the cases with 0.1 MPa and 0.2 MPa in the turbulent conditions. With the radius of the quasi-spherical flame, the global flame speed for the turbulent cases increases almost linearly due to the increase of flame surface area. Velocity fields and distribution of flame front (Fig. 1) obtained by high-speed simultaneous OH PLIF and PIV are used to obtain the 2D local flame displacement speed from the local fluid velocity and flame-normal vector using a geometrical relation of these fields. The 2D local displacement speed for the turbulent conditions has relatively large deviation, and the increase of the mean local displacement speed relative to the laminar case seems to be well scaled with the turbulent velocity fluctuation.

Fig. 1 Examples of instantaneous fluid velocity (vectors and colored distribution) and flame front (red line) for laminar (a), turbulent (b) cases.