LAMINAR PROPAGATION OF LEAN PREMIXED FLAMES IGNITED IN STRATIFIED MIXTURE

E. Delangle, B. Lecordier, C. Lacour, A. Cessou
armelle.cessou@coria.fr
CORIA UMR 6614 - CNRS, Université et INSA de Rouen, Normandie Université, Saint Etienne du Rouvray, France

In many practical systems, combustion through stratified mixtures is envisaged to reach lean combustion. This stratified mode of combustion increases the fuel efficiency and lowers CO_2 emissions. The characteristics of stratified combustion are different from the premixed combustion and the prediction of flame propagation through stratified mixture is not a straight forward one due to their memory effect: the local flame properties depend on the one hand on the local mixture and on the other hand on the composition of the mixture burnt from ignition. For instance, this type of combustion is envisaged in direct-injection spark-ignited (DISI) car engines to limit the fuel consumption and the pollutant emission in some regimes. One of the advantages of stratified combustion, when the flame is ignited in a rich mixture and propagates in a lean mixture, is the expansion of the lean flammability limits and increasing of flame speed compared to equivalent homogenous mixture, because of a higher temperature and a richer composition of the burned gases.
The present work investigates unsteady propane-air flames propagating through mixture layers with different amplitudes of mixture gradient. The flames are outwardly propagating after ignition in the middle of laminar stratifications generated in a constant volume vessel. Before ignition the chamber is fed with a lean mixture, the laminar stratification is produced by injecting a laminar richer jet. A previous investigation was dedicated to lean flammable mixtures. The quantitative analysis of the flame properties by simultaneous PIV-PLIF measurements has shown that the flame propagating through the homogeneous lean mixture has properties depending on the ignition condition in the stratified layer. The purpose of the present investigation is to enlarge this analysis to flame propagating toward lean non-flammable mixtures. For this investigation, three laser diagnostics are combined simultaneously: PIV for the aerodynamics properties, with a specific post-processing to carry out the flame speed and the fresh gas velocity at the entrance of the preheat layer, anisole-PLIF to obtain the instantaneous mixture field in the isothermal fresh gases, and OH-PLIF to identify if the flame is locally propagating or not.
When ignited in rich mixture, the flame propagating in the lean mixture is back-supported and the time of this back-support is longer for the richer mixture at ignition. The ignition in richer mixtures compensates the non-equidiffusive effect of lean propane flame and sustains its robustness to stretch. The flame propagation in the lean homogeneous mixture is enhanced by the ignition in a richer stratified layer. This enhancement is due to a better robustness to stretch and to an increase in the flame speed and the burning velocity.

10.4405/profic2014.C4