Séminaires @ ICARE

The "Turbulent Flame Speed" - Recent Developments

by

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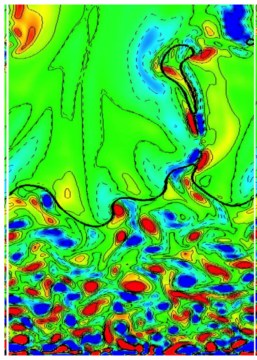

The determination of the turbulent flame speed is of great practical importance providing, for example, the mean fuel consumption rate in a combustor operating under turbulent conditions. Early phenomenological studies resorted to geometrical and scaling arguments to deduce expressions for the turbulent flame speed. The common denominator of these expressions is an increase in turbulent flame speed due to an increase in flame surface area, with a quadratic dependence on turbulent intensity.
The objective of this work is to extend these results to higher turbulence levels where the effects of flame folding and creation of flame pockets become ubiquitousand have nontrivial implications on the flame propagation speed. Using a hybrid Navier-Stokes/front-capturing methodology within the context of the hydrodynamic theory, we extract scaling laws for the turbulent flame speed that depend on turbulence and combustion characteristics as well as on flow conditions, without invoking turbulence modeling assumptions and/or adjustable parameters. The results are currently limited to "two-dimensional turbulence" and to mixtures of only positive Markstein length (e.g., lean hydrocarbon-air or rich hydrogen-air mixtures). For such mixtures the hydrodynamic, or Darrieus-Landau instability may affect the flame propagation but thermo-diffusive influences that could further contaminate the flame surface with small-scale structures are absent. We show that the dependence of the turbulent flame speed on turbulence intensity transitions from a quadratic law at low intensities to a sub-linear scaling at higher turbulence levels, in agreement with the experimental record. The increase in speed with increasing turbulence intensity is primarily due to the increase in the flame surface area as envisioned by the pioneering work of Damköhler, while the leveling in the rate of increase of the turbulent flame speed with turbulence intensity (the so-called bending effect) is due to frequent flame folding and detachment of pockets of unburned gas from the main flame surface area. The increase in turbulent flame speed is less than the increase in flame surface area due to stretching effects.