CHARACTERISTICS OF FLAME FRONT SURFACES IN PREMIXED TURBULENT COMBUSTION*

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A widely held belief in the combustion community is that the chemical and hydrodynamic structure of a stretched laminar premixed flame can be preserved in a turbulent flow field over a range of conditions collectively known as the flamelet regime, and the premixed combustion in most of the practical devices falls within the domain of this regime. The major assumption in the laminar flamelet concept as applied to the turbulent premixed flames is that the flame front behaves as a constant-property passive scalar surface, and an increase in the wrinkled flame surface area with increasing turbulence intensity is the dominant mechanism for the observed flame velocity enhancement. At high Damköhler numbers, a premixed flame front can be taken as consisting of regions of reactants and products separated by thin laminar flamelets. Since the instantaneous behaviour of these thin layers is the same as those of laminar flames, turbulent burning velocity can be approximated by the product of the flamelets surface area and laminar burning velocity corrected for the effect of stretch and flame curvature. However, there is a growing body of experimental evidence that the approaches based on the flamelet hypothesis may not be always valid over the range of conditions of practical interest. The two closures that are widely used for estimating a measure of the wrinkled flame surface area in premixed flames are based on the flame surface density concept and fractal geometry. A critical assessment of the experimental fractal data available in literature indicate that the fractal parameters are not capable of correctly predicting the premixed turbulent flame propagation rates using the available fractal area closure model. A similar conclusion can be reached after examining the surface density data from flames of different geometries including spark-ignition engine flame fronts. The assumption made in fractal and surface density approaches that the turbulent flame front is a passive scalar surface may not be justified, and the applicability of the flamelet approach may be limited to a much smaller range of conditions than presently believed.

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