

# **GAS-EXPANSION INFLUENCE ON TURBULENT-FLAME PROPAGATION**

**R. C. Aldredge**

Mechanical and Aeronautical Engineering  
University of California, Davis, CA 95616-5294, USA  
[aldredge@ucdavis.edu](mailto:aldredge@ucdavis.edu)

## **EXTENDED ABSTRACT**

The potential for greatly enhanced combustion rates on one hand and safety concerns related to fire spread on the other have sustained much interest in an improved understanding of the dynamics of turbulent premixed combustion. To this end, models based on consideration of the turbulent premixed flame as an ensemble of wrinkled laminar flamelets have been useful in providing for predictions of the mean burning-rate as well as possible influences of turbulent-flame dynamics on the flow-field properties upstream and downstream from the flame [1]. When attention is restricted to reactant flows having large overall chemical activation energies and low turbulence intensities, a Clavin-Williams quasi-planar laminar-flamelet structure may be assumed, providing for simplified solutions of the governing flow-field conservation equations and an associated evolution equation describing the flamelet dynamics [2-4]. Further mathematical formulation leading to solutions in terms of statistical properties of the turbulence far upstream from the flame has been useful for predicting burning speeds as well as the extent of turbulence modification near the flame, for conditions of relatively low chemical heat release (such that the laminar flamelet is intrinsically stable for all wavenumbers characteristic of the excitation turbulence far upstream) [5, 6].

In the present work a mathematical formulation based on earlier approaches [2-7] is developed and employed to obtain predictions of turbulent-flame speeds and statistical characterization of the turbulent flow near the flame for the case of arbitrarily large reactant chemical heat release. As buoyancy and flame-stretch effects are both neglected in the present formulation, the results are necessarily limited to conditions under which these influences are not destabilizing, such as for flames with positive Markstein numbers [8] propagating in tubes of sufficiently small diameter. Under such conditions the destabilizing influence of the Darrieus-Landau instability [9, 10] is dominant over an intermediate range of wavenumbers, for which

buoyancy and flame-stretch influences are weak. In the present study, flamelet surface wrinkles associated with this range of wavenumbers are excited by isotropic, homogeneous and stationary turbulence introduced far upstream from the flame. The resulting flamelet dynamics remain stable for large chemical heat release as long as the unstable zero-frequency modes are suppressed by the turbulence excitation field.

It is shown in the present work that the turbulent-flame speed varies inversely with a power of the temperature ratio across the flame when the temperature ratio is large. This power is a function of the ratio of the integral length scale to the Taylor microscale, characterizing an initially isotropic excitation turbulence through which the flame propagates. Variations in turbulence kinetic energies and vorticity across the flame and in hydrodynamic zones upstream and downstream from the flame are evaluated also. The results, which are valid for flame propagation in weakly turbulent flow (where the propagation speed is proportional to the square of the turbulence intensity upstream far upstream from the flame) extend earlier predictions that were limited to the regime of relatively small chemical heat release.

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