

Analysis And Correction of Triple Flame Propagation

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After analyzing the structure of a tribrachial flame, a correction is proposed to capture its propagation speed in under-resolved conditions. This propagation speed, defined as the speed of the flame front relative to the flow, is a key feature of the tribrachial flame. It plays an essential role in the flame behavior, specifically, the propagation speed drives the stabilization location of the flame and the propagation of the edge flame in case of local extinction. Those two phenomena are believed to account in the combustion efficiency for diffusion flame scenarios, which is an important topic nowadays.

The tribrachial flame gets its name by its characteristic structure of three branches found at the edge of a diffusion flame and in stratified / multi-regime combustion [1]. This structure leads to a flow expansion creating curved branches. An analytical value of the propagation speed has been derived by Ruetsch et al. [2], and has been found constant for a range of low mixture fraction gradient (low curvature).

However, this intrinsic characteristic of the tribrachial flame tends to be lost in under resolved conditions. This is the first conclusion of the study. Thus, there is a need of a corrective model. The author proposes the introduction of an efficiency applied to the source term at the triple point of the tribrachial flame.

The study is constructed around two-dimensional mixing layer simulations with a Thickened Flame framework. The flame resolution is tracked through a Flame Resolution Index ($FRI = \delta_l^0 / \Delta x$) linked to the thickening factor F given by the TF model (activated locally with the classical Takeno index).

As stated, the zone of interest for the correction is the triple point of the tribrachial flame. This point is extracted through an innovative Triple Flame Index derived from physical observation on the orthogonality of the mixture fraction and the progress variable gradient at the triple point (similarly observed in [3,4]).

The corrective model is then constructed from the under resolved propagating tribrachial flames, where the retrieved propagation speed is correlated to a defined efficiency e_{TFP} for a given thickening factor F .

References

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