MULTI-SCALE ASYMPTOTIC ANALYSIS OF A LAMINAR PREMIXED FLAME

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Due to low Mach numbers (Ma), thermoacoustics are often solved in a ‘divide and conquer’ fashion. However, the widely used decomposition into steady mean and small fluctuations is not attributed to the vanishing Ma and terms of different order co-exist. Thus, invoking a zero base flow assumption without dropping velocity fluctuations $u'$ is mathematically inconsistent. Generally, flow/acoustics-coupling cannot be described properly and the single input/single output flame model structure (SISO) is an ad hoc assumption.

Low Mach number flow is identified as a singular perturbation problem. Application of the Method of Multiple Scales to a compact flame (single time/disparate spatial scales) yields two coupled sets of equations for the different scales. The combustion process not only reacts to $u'$ but is also affected by the acoustic pressure gradient through baroclinic torque. Vice versa, combustion acts as a source of acoustic mass, momentum and energy. Consequently, an appropriate flame model should comprise multiple inputs and outputs (MIMO). The present work assesses the different coupling mechanisms by comparison with a brute force DNS of a laminar premixed flame.

References


