Flamelet Modeling for Applications to Supersonic Combustion

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In an effort to make large eddy simulation of scramjet combustors of engineering interest computationally more affordable, a well-established incompressible flamelet modeling approach is investigated. The first part of this investigation focuses on an apriori study of the applicability of flamelet-based modeling to both dual-mode and scram-mode supersonic combustion. For this purpose, Reynolds-averaged simulations (RAS) of the HIFiRE Direct Connect Rig (HDCR) flowpath, fueled with a JP-7 fuel surrogate and operating in the above two modes were performed. The analysis of the dual-mode operation of the HDCR flowpath showed regions of predominately non-premixed, high-Damkohler number, combustion. Regions of premixed combustion were also present but associated with only a small fraction of the total heat-release in the flow. This is in contrast to the scram-mode operation, where a comparable amount of heat is released from non-premixed and premixed combustion modes. The results of the present study reveal the potential for a flamelet approach to accurately model the combustion processes in the HDCR and likely other high-speed flowpaths of engineering interest. The second part of the investigation focuses on an apriori study of the flamelet parameterization strategies. For compressible flows, in addition to the progress variable, this includes pressure and enthalpy. For this purpose the HDCR flow field was re-computed in the post-processing step via different flamelet parameterizations to determine if the original flow field could be adequately recovered. The pressure parameterization is also compared to the previously developed pressure-scaling approach. Ongoing work includes aposteriori simulations to verify the above results.