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Turbulence Chemistry Interaction via Eddy Dissipation Model for Scramjet Analysis and Design

Jimmy-John O.E. Hoste [a] [1], Marco Fossati[a], Ian J. Taylor [b] and Rowan J. Gollan [c]

[a] University of Strathclyde, Glasgow, G1 1XJ, United Kingdom
[b] University of Glasgow, Glasgow, G128QQ, United Kingdom
[c] University of Queensland, Brisbane, QLD4072, Australia

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Scramjets are conceptually highly efficient engines for operation at hypersonic speeds and are of interest as an accelerator in access-to-space systems [1]. The purpose of the present work is to introduce RANS methods into the preliminary design of scramjets in order to increase the level of fidelity when compared to approaches based only on low-fidelity methods. Specifically the objective is to provide a methodology capable to address the effect of turbulence / chemistry interaction (TCI) on the overall performance of the propulsive system. Scramjets operating at high Mach numbers ($\approx$ 7-12) are characterized by a combustion process that can be thought as primarily mixing limited, i.e. the combustion chemistry is fast relative to the mixing time scales. Therefore, a TCI approach such as the Eddy Dissipation Model (EDM) [2] is introduced. A relevant consequence of a mixing limited combustion process that is fully exploited by the EDM, is the fact that the mechanism of reaction could be greatly simplified allowing for cost-effective yet reasonably accurate simulations when compared to other high-fidelity methods where the whole mechanism of reaction has to be taken in full consideration. This characteristic becomes quite relevant when considering for example hydrocarbon fuels. In this work, the HyShot II [3] mixing-limited scramjet combustor will be considered. Numerical predictions will be compared to experimental pressure traces measured in the HEG shock tunnel with hydrogen fuel. Eventually, the performance of the HyShot II configuration obtained with hydrogen will be compared with that obtained by using a hydrocarbon fuel.

REFERENCES

[1] SO Forbes-Spyratos, MP Kearney, MK Smart, and IH Jahn. Trajectory design of a rocket-scramjet-rocket multi-stage launch system. In *21st AIAA International Space Planes and Hypersonics Technologies Conference*, page 2107, 2017.

[2] BF Magnussen and BH Hjertager. On mathematical modeling of turbulent combustion with special emphasis on soot formation and combustion. In *Symposium (international) on Combustion*, volume 16, pages 719–729. Elsevier, 1977.

[3] S Karl, K Hannemann, A Mack, and J Steelant. CFD analysis of the HyShot II scramjet experiments in the HEG shock tunnel. *AIAA Paper*, 2548, 2008.

[1] corresponding author: jimmyjohn.hoste@strath.ac.uk