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Hypersonic Air-breathing and Combined Cycle Propulsion, and Hypersonic Vehicle (7)

Author: Mr. Sasi Kiran Palateerdham
University of Rome "La Sapienza", Italy, sasikiran.palateerdham@uniroma1.it

Mr. Lakshmi Narayana Phaneendra Peri
Scuola di Ingegneria Aerospaziale "La Sapienza", Italy, phanindra.p123@gmail.com
Dr. Antonella Ingenito
Sapienza University of Rome, Italy, antonella.ingenito@uniroma1.it
Prof. Choubey Gautam
National Institute of Technology Silchar, India, gautamnits19@gmail.com

ADVANCES IN MIXING AND COMBUSTION MODELLING IN SUPERSONIC FLOWS

Abstract

Understanding mixing in compressible flows is pivotal in advancing scramjet technology for future aerospace applications. Explorations into improving mixing encompass different techniques, including vortex generators, cavities, and the crossflow injection. These strategies exhibit potential in augmenting mixing efficiency, but concurrently, they introduce a challenge: heightened total pressure.

Inadequate mixing results in incomplete combustion, ultimately diminishing both engine efficiency and thrust, efficient mixing often comes at the expense of elevated total pressure losses. The challenge of balancing efficient mixing and pressure losses in scramjet technology is a critical issue, still open. In this context, advanced simulations, experimental testing, and optimization techniques are fundamental to address this challenge. In fact, achieving the right balance is a key to realizing the full potential of scramjets for future hypersonic flights, where both high efficiency and high thrust are required.

In this context, the research aim to analyse the characteristics of turbulence in compressible flow, by means of a theoretical analysis and to validate this analysis by means of large eddies numerical simulations of the HIFiRE test case. research work provides an investigation of the effect of shocks development and interaction with the mainstream by means of LES. The flow field within the HIFiRE-2 combustor has been analysed at different conditions. Combustion models have used implemented to account for the kinetic times. LES simulations of the HIFiRE-2 scramjet showed the direct and mutual effects of the shock waves interaction with the vorticity, the heat addition, friction, mixing, boundary layer separation on the total pressure losses.