Numerical Simulation of a Scramjet Intake

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Within the frame of the German Research Group GRK 1095 "Aero-Thermodynamic Design of a Scramjet Engine for Future Space Transportation Systems" a numerical and experimental analysis of a scramjet propulsion engine is being performed. The final paper presents an overview of the ongoing work on the numerical simulations of the scramjet intake.

The intake of a supersonic combustion ramjet (scramjet) mostly consists of one or more exterior compression ramps followed by an interior part (see Fig.1). Oblique shock waves generated by the ramps and the cowl lip are performing the compression of the incoming flow. To protect the pressure sensitive intake from the back pressure of the combustion chamber the isolator is used. There, the flow adapts to the back pressure using a shock train. Multiple interesting as well as physically complex phenomena may occur, such as shock-boundary layer interaction, laminar-turbulent transition, compressible relaminarization and flow separation.

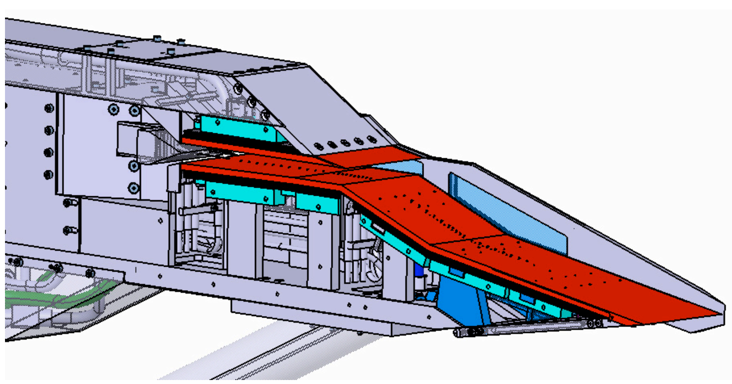

Figure 1. Typical configuration of a scramjet intake. Reproduced from Fischer and Olivier.[2]

The numerical computations within the final paper are performed using QUADFLOW. This solver is an h-adaptive and fully implicit flow solver for the Reynolds-averaged Navier-Stokes equations for compressible flow using a fully unstructured cell-centered finite volume method. It follows an integrated concept of surface-based discretization, multiscale analysis, and, on this basis, an h-adaptive grid generation applying B-Spline techniques. It has been validated extensively against different test cases.[1,4,3]

Since experimental measurements are very costly and difficult to perform, numerical computations are necessary to analyse and understand the flow phenomena. The three-dimensional high-fidelity computations are validated using experimental data for the pressure coefficient at the wall in the symmetry plane. The

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influence of the turbulence model is investigated. Therefore, a differential Reynolds stress model (SSG/LRR-ω) is compared to a Shear Stress Transport model (SST).

The performance of the intake is extremely important for the overall functionality of the propulsion system. Performance parameter such as total pressure recovery and kinetic energy efficiency are analysed and the interaction with the combustor is investigated.

References

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