A conservative mesh overlapping technique for aero-propulsive applications

David PUECH
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In this talk, we will address several issues encountered in numerical simulations of complex aero-propulsive flows about space launch vehicles.

The aerospace industry has always been very keen to use numerical modelling for the design of space launchers, since few critical problems are easily accessible to physical experiments. For instance, it is extremely difficult to maintain a rocket engine switched on in a wind tunnel or to reproduce accurately the motion of launcher stages during the stages separation phases, in a wind tunnel. This motivated the development by Ariane Group of its own calculation tool, FLUSEPA, since the early 90’s.

First, the robustness of this tool must allow it to cope with extremely violent transient phases (engine ignition ...), with high energy reactive flows (hypersonic or propulsive) about bodies in relative motion. Therefore, the proposed methodology based on the geometric intersection allows the use of an evolutionary mesh topology and is perfectly conservative. In addition, the original numerical schemes were chosen for their robustness and ability to simulate very steep phenomena (strong shock waves interactions...).

Recently, with the advent in an industrial context of numerical simulations of very large eddies (RANS-LES hybrid models), accuracy and numerical efficiency have become crucial features. Therefore, the new developments in FLUSEPA rely mostly on the High Power Computing techniques, efficient space-time integration schemes and mesh adaptation methods.

Adaptive Mesh Refinement of unstructured overset grids for aeropropulsive flows

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In this talk, we will describe how ArianeGroup plans to improve the FLUSEPA code regarding its grid adaptation strategy for the numerical simulation of the aerodynamics loads on space launchers.

This work is part of an effort to develop numerical industrial tools for the simulation of unsteady compressible flows about bodies in relative motion. FLUSEPA, an ArianeGroup CFD code, relies on a high-order Finite Volume formulation and a conservative overlapping of meshes using geometric intersections. In the overlapping regions, the calculation of the fluxes between overlapping mesh and cut cells is done on the exact geometric intersection surfaces: this allows the advection of shocks and unsteady structures.

Recently, an Adaptive Mesh Refinement (AMR) technique for unstructured hexahedron meshes has been implemented in FLUSEPA. This method eases the mesh construction process and ensures a local resolution adapted to the physical properties captured. In order to be functional, the AMR module has to be consistent with the pre-existing space-time numerical schemes (i.e. conservativity and accuracy) and also keep the algorithmic performance. Thus, the obtained solution is divided between several processes with a load balancing specific to the explicit temporal adaptive scheme and a high-order conservative projection of the variables for the refined cells. These two properties guarantee a reliable global numerical strategy. Several test cases have been run using this module and validate its formal use.

Pierre Brenner
R&D Engineer in ArianeGroup

Will be here to answer questions.