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Title

Numerical rebuilding of a free-flying ring interfering with a two-dimensional shock wave

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Abstract

In the frame of the ATD3 working group, coordinated by ESA and CNES, a test case was proposed, representative of the interaction between two fragments generated by the break-up of a space vehicle during the re-entry.
The test was performed experimentally at the VKI Institute, and is described in detail in [1]. A ring is initially suspended over a cylinder, and when the flow enters the test chamber the wires are cut and the ring follows a trajectory over the cylinder, interacting with the shock wave generated by the cylinder itself.

Through the experimental trajectory analysis, the aerodynamic coefficients for a number of different positions of the ring were calculated and are provided in [1]. The main goal of the test case is to numerically simulate the experiment and rebuild the ring trajectory and attitude.
The simulations were performed with the NExT code, developed at CIRA. It is a multiblock structured code, able to solve hypersonic flows including chemical and thermal nonequilibrium. Since the code uses structured grids, a particular effort has been made in generating a topology that allows to deform the grid without changing the cells number and distribution for each block. Two strategies have been followed, by using on one side the grid generator ZENGRID, available at CIRA, and on the other side the commercial grid generator ICEMCFD. In both cases the grid generation was automated in order to dynamically adapt the mesh to the ring position. When ZENGRID is used, some of the features of the mesh may be parameterized to accommodate for several ring positions and angles. In case of ICEMCFD, the automatization was achieved by using the ICEMCFD scripting language.
Both approaches allowed to obtain a reasonably good comparison with experimental data, considering the complexity of the test. The main discrepancies are an overestimation of the drag coefficient, which however does not affect too much the ring trajectory. The differences between numerical results and experimental data will be discussed in detail in the paper.

Furthermore, a different approach is being currently evaluated, based on overset method, which involves overlapping grids in specific areas to improve the mesh resolution. This approach, available through ANSYS Fluent CFD solver, will be compared with respect to the one previously described, in order to assess the potential improvement in accuracy. In this latter case, a shock-capturing mesh adapting procedure will be tested too.

References

[1] D.G. Kovacs, G. Grossir, O. Chazot, “Hypersonic Aerodynamics of a Free-Flying Ring Interfering with a Two – Dimensional Curved Shock Wave — An Experimental Test Case” 2nd International Conference on Flight Vehicles, Aerothermodynamics and Re-entry Missions & Engineering (FAR) 19 - 23 June 2022. Heilbronn, Germany