8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

A PARALLEL RANS SOLVER BASED UPON THE IMMERSED BOUNDARY AND DOMAIN DECOMPOSITION METHODS

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Key Words: *Compressible Flows, Finite Volume, Local Refinement.*

ABSTRACT

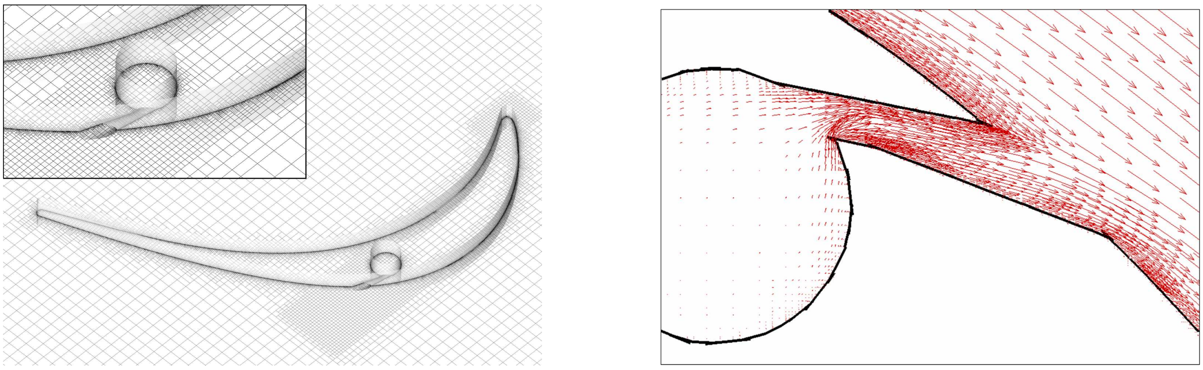
The aim of this work is to provide a parallel code for computing viscous flows in complex geometries, based on the immersed boundary (IB) approach and the Reynolds-averaged Navier-Stokes (RANS) equations.

The RANS solver developed by the authors in the last five years [1-5] is parallelized using the MPI protocol and a domain decomposition strategy, so as to obtain a balanced partition of the computational grid thus allowing a considerable speed-up on a number of processors of the order of one hundred. In the IB approach, the presence of a complex boundary is replaced by a forcing term which mimics the effect of the body on the flow. Such a technique allows one to employ a simple locally refined Cartesian grid so as to avoid the generation process of a body-fitted grid, which, in the case of complex three-dimensional geometries becomes extremely difficult and time-consuming, easily exceeding the time needed to obtain the flow solution. The grid generation procedure is also parallelized so as to generate grids containing ten millions cells or more on a hundred or so processors, within a few minutes. The heat equation will be solved at all Cartesian cells within the solid body, coupled with the RANS flow equations, so as to assess the structural integrity of the body.

The simulation of a film-cooled highly-loaded linear turbine cascade will be considered as a suitable test case for validating the proposed methodology. The geometry of the blade is provided in [6] and coincides with the configuration T106-300-4 which is characterized by fan shaped cooling holes with 30 degrees streamwise inclination, 10 degrees diffusion angle, and an additional laid-back angle of 10 degrees. One row of holes, with pitch-to-chord ratio equal to 0.05, is drilled into the suction side of the blade at 40% of the chord. The holes communicate with the main channel which spans the core of the blade. A preliminary result is shown in figures 1 and 2 which show the (locally refined) grid and a local view of the streamlines.

Moreover, the solver will be employed to support the design of modern low-cost reusable space vehicles, such as the prototype designed and built by the Italian Aerospace Research Centre (CIRA) in the Italian unmanned space vehicle research program which aims realizing flying test beds (FTB) to develop and demonstrate key technologies needed for future reusable launch vehicles. Such a winged

re-entry vehicle has been employed in his first mission to investigate the final transonic part of the orbital return phase, focusing on the aerodynamic characterization of the vehicle rudders for different angles of attack and rudder deflections. In the final paper, the numerical predictions of the proposed code will be compared versus the aerodynamic and structural data measured and recorded during this flight.



(a) geometry and grid

(b) local view of velocity vectors

Figure 1: T106-300-4 test case.

REFERENCES

[1] P. De Palma, M. de Tullio, G. Pascazio, M. Napolitano, An immersed-boundary method for compressible viscous flows, European Congress on Computational Methods in Applied Sciences and Engineering ECCOMAS 2004, Jyvaskyla, July 24-28 2004.

[2] P. De Palma, M.D. de Tullio, G. Pascazio, M. Napolitano, An immersed boundary method for compressible viscous flows, Comput. Fluids 35 (2006) 693.

[3] M. D. de Tullio, P. De Palma, G. Iaccarino, G. Pascazio, M. Napolitano, Immersed boundary technique for compressible flow simulation on semi-structured grids, 4th International Conference on Computational Fluid Dynamics ICCFD4, Ghent, July 10-14 2006.

[4] M. D. de Tullio, A. Cristallo, E. Balaras, G. Pascazio, P. De Palma, G. Iaccarino, M. Napolitano, Recent advances in the immersed boundary method, European Conference on Computational Fluid Dynamics ECCOMAS CFD 2006, P. Wesseling, E. Onate and J. Priaux (Eds), TU Delft, The Netherlands, September 5-8 2006.

[5] M.D. de Tullio, P. De Palma, G. Iaccarino, G. Pascazio, M. Napolitano, An immersed boundary method for compressible flows using local grid refinement, J. Comp. Phys. 225 (2007) 2098.

[6] H. Brandt, W. Ganzert, L. Fottner, A presentation of detailed experimental data of a suction side film cooled turbine cascade, Paper ASME 2000-GT-0296.