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Influence of Grid Arrangements and Fuselage on the Numerical Simulation of the Helicopter Aeromechanics in Slow Descent Flight

Siegfried Wagner[1], Markus Dietz[1], Martin Embacher[1]
Carsten Schneider[1] and Ewald Kraemer[1]

Summary

The intention of the present paper is to investigate the influence of different grid arrangements on the numerical simulation of a helicopter rotor in slow descent flight. In addition, the influences of the fuselage on the aerodynamics of the rotor are investigated.

The well known HART-II test case has been chosen for the investigations as a reference whereby the HART-II test is a joint German/French/Dutch/US project to study rotor wakes and the aeroacoustics under the influence of higher-harmonic pitch control (HHC) inputs. The HART-II test case is characterized by the occurrence of Blade-Vortex Interactions (BVI) and can thus be considered as very ambitious with respect to the aerodynamic simulation. It has been subject to previous investigations at the Institute of Aerodynamics and Gas Dynamics of the University of Stuttgart. A local mesh refinement technique using tube-shaped vortex-adapted Chimera grids was developed in order to improve the vortex conservation in the numerical simulation and thus to allow for the quantitative reproduction of BVI induced air loads. The preliminary results were published in [1] and [2].

Despite the good reproduction of BVI air loads especially at the retreating blade the simulations in [2] still featured deficiencies: The rotor blade trailing edge tab turned out to be one crucial point when trying to correctly capture the blade dynamics with the coupled dynamic/aerodynamic method. However, the tab influence was not yet investigated in detail because the blade mesh arrangement at that time in the numerical simulation was not sophisticated enough. In the present paper the grid was extended by the multi block capability of the grid deformation tool to more accurately resolve the tab influence on the blade. Vortex-adapted grids were applied within the frame of the Chimera technique to prevent a too early numerically caused dissipation of the tip vortices because of a coarse grid.

Furthermore, the former simulations were restricted to an isolated rotor. The generic fuselage present in the experiment was not included in the simulation. And finally the application of vortex-adapted grids was restricted to inviscid modelling in a first step to study the influence of the grid refinement. The purpose of the

[1]Institute of Aerodynamics and Gas Dynamics (IAG), University of Stuttgart, Pfaffenwaldring 21, D-70569 Stuttgart, Germany

present paper is to address these open aspects and to study the improvements while removing the constraints mentioned above. The comparison of the numerical simulations with wind tunnel experiments shows the improvement in the prediction of the aeromechanics of the helicopter by the various measures mentioned previously that were incorporated into the numerical simulation procedure and into the corresponding computer program. The numerical simulations were run on the high performance vector computer NEC SX-8. The use of 8 nodes (64 CPUs) was necessary in order to perform the computations with 75 million grid points in a reasonable time.

References

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