Calculation of Helicopter Rotor-Fuselage Interaction by Moving Overlapped Grid Method

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Abstract

This paper presents rotor aerodynamic analysis including an influence of fuselage using an unsteady Euler code. The rotor-fuselage aerodynamic interaction affects to rotor aerodynamic performance in hover or low-speed forward flight conditions. Therefore, simulation tools of the rotor-fuselage interaction are useful for future rotorcraft aerodynamic design. However, the rotor downwash around the fuselage is more complex and CFD technique is expected to be helpful for understanding the phenomenon. In recent research, an actuator disk model is applied in Euler or Navier-Stokes codes to simulate rotor-fuselage interactions [(1), (2)]. In these methodologies, an inflow distribution of the rotor is necessary as an input.

In this study, rotor downwash including blade wake is computed using a CFD code and the rotor-fuselage interaction is accurately simulated. The base code of the present CFD code, ASTRA-OG, has been jointly developed by Ochi, et al. in a joint research program between Advanced Technology Institute of Commuter-helicopter, Ltd. (ATIC) and National Aerospace Laboratory (NAL) for the prediction of rotor blade-vortex interaction (BVI) noise. A moving overlapped grid method is applied in ASTRA-OG and three types of grids, inner and outer background grids, and blade grid, are used but the influence of fuselage is not considered. The computed BVI noise using ASTRA-OG is in reasonable agreement with experimental data [(4)]. In the present analysis of the rotor-fuselage interaction, the fuselage grid is added to the grid system of ASTRA-OG and the influence of fuselage on rotor aerodynamics is investigated. Figure 1 shows a new grid system for 4-bladed rotor configuration with a fuselage. The blade grids rotate in the Cartesian background grid and the flow data are exchanged between the inner background grid and the blade grids at the outer boundary of the blade grid. The same manner is used in the exchanging of the flow data between the inner background grid and the fuselage grid. The blade and fuselage grids have O-H type topology. A result of sample calculation for 4-bladed rotor with a fuselage is shown in Fig. 2. In this case, total number of grid point is 1,745,093. This figure indicates the pressure contour on the blades and the fuselage in a forward flight condition. The calculation is performed using Numerical Simulator • •(NS •) in NAL. The total peak performance of NS• •is about 9 Tflops and the total capacity of the main memory is 3TB. The calculation time per case is about a week using 62 CPUs.

Reference

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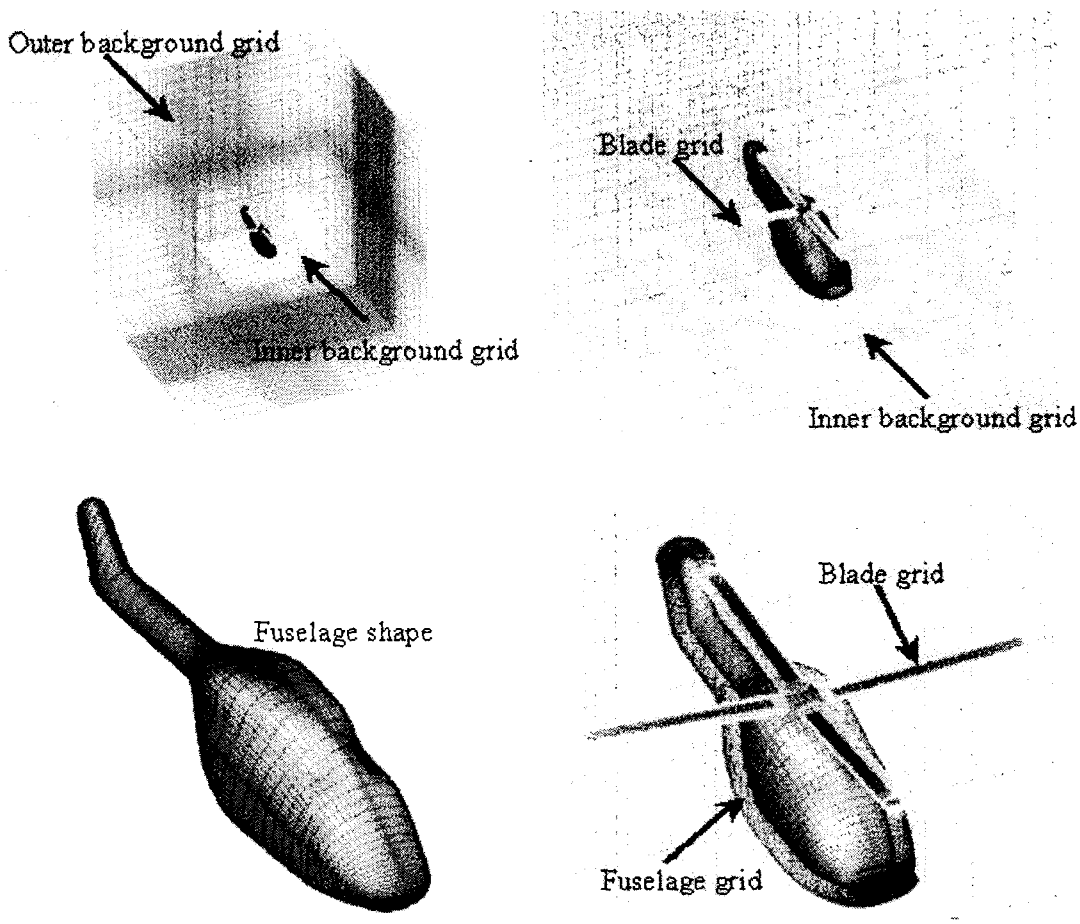

Fig.1 Grid system for 4-bladed rotor configuration with fuselage

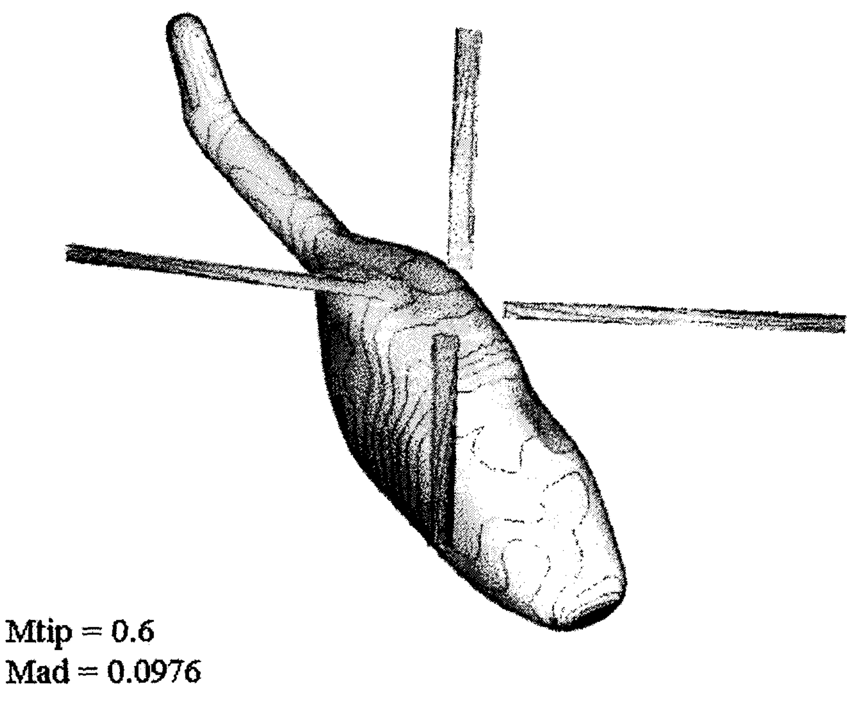

Fig.2 Calculation result of 4-bladed rotor with fuselage in forward flight condition.