2014 Sessions

Hariharan N., Egolf T.A., Sankar, L.N., "Simulation of Rotor in Hover: Current State and Challenges," AIAA 2014-0041, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

A helicopter is subjected to a wide variety of flight conditions with disparate objectives; these include efficient cruise and hover, and high-performance maneuvering. The hover condition remains a very important design consideration because it represents the true value of the helicopter, and it is a limiting design point in terms of power requirements. Accurate numerical prediction of rotor-blade aerodynamic parameters such as thrust, torque and efficiency requires an accurate modeling of the vortex wake. Despite tremendous advancements in the ability to preserve the tip vortex from first principles, the capability to consistently and reliably predict performance parameters for a new rotor-blade has still been elusive. These challenges provide the motivation for the AIAA Applied Aerodynamics Technical Committee Rotorcraft Simulation Working Group's efforts to evaluate hover simulation capabilities across government organizations, industry and academia. The AIAA Applied Aerodynamics Rotor Simulation Working Group aims to bring together government, industry and academic participants to evaluate and further rotor-in-hover performance predictions. The invited session at SciTech 2014 is the first step to assess different approaches for the prediction of baseline S-76 rotor planform. Future plans include a full workshop at SciTech 2015 to evaluate prediction of performance for S-76 planforms with various tip-shapes.

Jung, M.K., Hwang, J.Y., Kwon, O.J., "Assessment of Rotor Aerodynamic Performances in Hover Using an Unstructured Mixed Mesh Method," AIAA 2014-0042, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

In the present study, numerical simulations were conducted to assess rotor aerodynamic performances in hover flight conditions. To calculate the flow around the helicopter rotors in a high-order manner, an unstructured mixed mesh flow solver was developed. The proposed mixed mesh methodology involves body-fitted prismatic/tetrahedral mesh in the near-body region around the blade and adaptive Cartesian mesh in the off-body region. In the off-body region away from the blade, high-order schemes and solution-adaptive mesh refinement were adopted to enhance the accuracy of the vortex resolution in the wake region. To interpolate the flow variables between the two mesh regions, an overset mesh technique was applied. Validation of the present mixed mesh flow solver was made for a two-bladed Caradonna-Tung rotor configuration by comparing the aerodynamic loadings and the vortex trajectories with experimental data. Then, the flow solver was applied to the S-76 rotor configuration, and the aerodynamic performance, such as rotor thrust, torque and figure of merit, were compared with experimental data. The flow characteristics around the rotor, such as the tip vortex trajectory, circulation strength of the tip vortex for the wake age, were also assessed.

Brocklehurst A., Barakos, G.N., "Evaluating Tail Rotor Tip Shapes using Computational Fluid Dynamics," AIAA 2014-0043, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

In order to obtain further improvements in helicopter rotor performance it is essential to employ a prediction method which has sufficient resolution to accurately evaluate changes to the design of the blade tip. The Helicopter Multi-Block (HMB) CFD method is well suited to this task and provides the capability to capture the compressible and viscous flow experienced near the tips of the blades for any given surface geometry. The code has been previously validated against published rotor data and is here compared to model tail rotor test data from the 1980's for rectangular NACA0012 blades having a range of linear twist. A series of example tail rotor blade (TRB) tip designs are put forward for evaluation, and the design concepts behind each tip shape are briefly explained. Euler calculations were initially used to obtain an indication of the potential changes in hover induced power that might arise from the use of an enhanced tip shape, or from a tip with anhedral. Subsequently, two of the most promising tip shapes together with the datum blade were selected for further evaluation in forward flight and were then studied in more detail in hover using the HMB Navier-Stokes solver with a modified k-ω turbulence model. Steady Navier-Stokes predictions were obtained over a wide range of pitch angles such that the induced power factor could be determined and the trends in profile power could also be established for the selected tip shapes. It was found that a Kuchemann-type tip gave benefits in both induced power and profile power compared to the datum rectangular blade. These benefits were further enhanced by the use of anhedral for this high solidity rotor below stall. However, local separation was found to occur near the radial station of the anhedral break, suggesting that a more gradual anhedral blend may be preferable in a final design. The flat Kuchemann tip showed no such tendency and stall monitoring techniques revealed a delay in the onset of stall of about 1 degree of pitch relative to the datum blade. During this investigation it was found that the use of a carrier blade with a large root cutout and zero twist, together with some hub-geometry simplifications considered necessary for a steady solution, gave rise to some inboard flowfield variations at moderate to high pitch angles, although this had only a minimal effect on the loading in the tip region. It is concluded that for this type of rotor configuration an unsteady approach would enable the rotor hub and blade attachment components to be taken into account to obtain a truly realistic simulation.

Sheng, C., Zhao, Q., Wang, J., "S-76 Rotor Hover Prediction Using U^{2}NCLE Solver," AIAA 2014-0044, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

For this research, the Sikorsky S-76 rotor hover performance is predicted using an unstructured grid Navier-Stokes CFD solver U^{2}NCLE. The S-76 rotor with a swept tapered tip is selected for numerical validations with the experimental data. The rotor Figure of Merit (FM) is predicted over a blade collective angle from 4° through 12°, which is accommodated using a mesh deformation method. The Spalart-Allmaras's new detached eddy simulation (DES), coupled with a local correlation-based transition model (LCTM) and a stall delay model (SDM), is used to predict the onset of boundary layer transition and flow separation on blade surfaces. Rotor blade sectional loadings and trajectories of trailing tip vortices are also evaluated at a given trimmed thrust value.

Baeder, J.D., Medida, S., Kalra, T.S., "OVERTURNS Simulations of S-76 Rotor in Hover," AIAA 2014-0045, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

A compressible Reynolds Averaged Navier Stokes (RANS) solver (OVERTURNS) is used to perform high-fidelity CFD simulations of the S-76 rotor test cases. Parameters such as thrust and power coefficient, spanwise loading distributions as well as pressure profiles and spanwise vorticity magnitude profiles are plotted. The computational domain consists of a C-O topology structured blade mesh and a cylindrical background mesh for wake capturing. The simulations are run for a range of collective pitch values. In addition, a case of 10° collective pitch is studied in greater details by analyzing the tip vortex characteristics.

Jain, R.K., Potsdam, M.A., "Hover Predictions on the Sikorsky S-76 Rotor using Helios," AIAA 2014-0207, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

Computational Fluid Dynamics validation of the S-76 model-scale rotor in hover is performed using the HPCMP CREATE™-AV Helios software suite. High-resolution, time accurate, simulations are performed for a range of collective angles for two tip Mach numbers. Performance, airloads, and tip-vortex trajectory data

from the simulations are presented and analyzed. The predictions are compared against the available test measurements and very good agreement is obtained for the entire range of collective angles studied.

Narducci, R., "OVERFLOW Simulation of Rotors in Hover: The Boeing Company," AIAA 2014-0208, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

OVERFLOW calculations of hover flow fields including performance predictions are presented for the model-scale S-76 rotor. The calculations use a time-accurate approach and explore solutions across a range of thrust conditions and tip Mach numbers. Comparisons are made among the CFD solutions and available experimental data for thrust-power, Figure of Merit, distributed air loads, and vortex trajectories. Sensitivity of hover performance to tip shape is also predicted and compared to test data. Suggested areas for further study conclude the paper.

Tadghighi, H., "Helios Simulation of Rotors in Hover: The Boeing Company," AIAA 2014-0209, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

Hover flow field and performance predictions for a model-scale S-76 rotor using HELIOS (Helicopter Overset Simulations) CFD (Computational Fluid Dynamics) code are presented here. The predictions use a time-accurate approach and examine solutions across a range of thrust conditions and tip Mach numbers. Comparisons are made between the CFD solutions and available experimental data for thrust, power, Figure of Merit, distributed air loads, and vortex wake trajectories. Suggested areas for further study conclude the paper.

Marpu, R.P., Sankar, L.N., Egolf, T.A., Hariharan, N., "Analysis of a Rotor in Hover using Hybrid Methodology," AIAA 2014-0210, AIAA SciTech 52nd Aerospace Sciences Meeting, 13-17 January 2014, National Harbor, Maryland.

The AIAA Applied Aerodynamics Technical Committee's Rotorcraft Simulation Working Group put together standardized evaluation of the S-76 planform in hover. The objective of this paper was to construct a hybrid analysis framework for the baseline S-76 planform and compute performance predictions for various collective settings and compare with experiments. The hybrid method consists of a near-body rotor-blade Navier-Stokes solver coupled with a farfield Lagrangian wake evolution model. Apart from thrust, torque coefficients and rotor figure of merit, the computed wake structure and surface pressure distributions are also obtained. The paper concludes with some observations on the suitability of hybrid methods for hover computation.