CFD Simulation of Helicopter Rotor Flow Based on Unsteady Actuator Disk Model

Actuator disks (AD) can provide characterizations of rotor wakes while reducing the computational expense associated with modeling the fully resolved blades. An unsteady AD method based on AD surface circulation distribution combined with empirical data, Blade Element Theory and Rotor Momentum Theory is considered. The nonuniform circulation distribution accounts for 3D blade load effects, and in particular, tip loses. Numerical simulations were conducted for the isolated Pressure Sensitive Paint model rotor blade in hover and forward flight using the HMB3 CFD solver of Glasgow University. Validation of CFD results in comparison with published numerical data including the Kokurek and Tangler results was performed in hover, for a range of blade pitch angles using fully turbulent flow and the k-ω SST model. In forward flight, the vortex structures predicted using the unsteady actuator disk model showed configurations similar to the ones obtained using fully resolved rotor blades. Despite the reduced grid cells number, the CFD results for AD models captured well the main vortical structures around the rotor disk in comparison to the fully resolved cases.