Helicopter stabilizer optimization considering rotor downwash in forward-flight

Abstract

Purpose – To reduce the aerodynamic drag of a rotorcraft stabilizer in forward flight taking into account downwash effects from the main rotor wake (power-on conditions).

Design/methodology/approach – A shape design methodology based on numerical optimization, CAD-in-the-loop approach and high-fidelity CFD tools was set-up and applied to modify the horizontal empennage of a rotorcraft configuration. This included the integration of both commercial and in-house CAE tools for parametric geometry handling, adaptive mesh generation, CFD solution and evolutionary optimization, within a robust evaluation chain for the aerodynamic simulation of the different design candidates generated during the automatic design loop.

Geometrical modifications addressed both the stabilizer planform and sections, together with its setting angle in cruise configuration, accounting for impacts on the equilibrium, stability and control characteristics of the empennage.

Findings – An overall improvement of 11.1% over the rotorcraft drag was estimated at the design condition (cruise flight, power-on) for the stabilizer configuration with optimized planform shape, which is increased to 11.4% when combined with the redesigned airfoil to generate the empennage surface.

Originality/value – The proposed methodology faces the empennage design problem by explicitly taking into account the effects of main rotor wake impinging the stabilizer surface in forward flight conditions and using an automated optimization approach which directly incorporates professional CAD tools in the design loop.

Keywords RotorCraft, Helicopter, Forward Flight, CFD, Optimization, CAD-in-the-loop.

Paper type *Research paper*

Introduction

During forward-flight operation of conventional helicopter configurations a tail mounted horizontal stabilizer surface may be immersed in the wake generated by the main rotor and convected downstream, depending on both the rotorcraft advance ratio and the tail boom length (Fletcher, 2007). An aerodynamic drag evaluation of the tail unit in cruise flight conditions should therefore take into account downwash effects from the main rotor (Steijl, 2007) as well as the impact of