Diploma Thesis:
Abstract

Computational Aerodynamic Study and Optimization of Parametrically Designed Winglets for a Multirole Unmanned Aerial Vehicle, in Single and Multiphase Flow and Comparison With Experimental Wind Tunnel Results

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Increasing the range of aircraft and reducing fuel costs are essential in the aeronautics sector. According to the international literature, this can be achieved with special devices at the ends of the wings, the so-called winglets, since they manage to reduce the induced drag. Aim of the present research is to find the optimal winglet for the wing of the UAV ethERAs, and to study if the flight over wildfire affects the aerodynamic performance. Optimal is defined as the one with the highest aerodynamic efficiency or lift-to-drag ratio. The programs CATIA V5 and Spaceclaim were used for the parametric design of the winglets, while the Poly-Hexcore method of the ANSYS Mosaic Meshing technology was used for the construction of the computational mesh. The CFD simulations were performed using the turbulence model SST k-ω and the program ANSYS Fluent. The flight through smoke was simulated as a two-phase flow of air and anthracite particles, using the Euler-Lagrange method and the DPM model. For the validation of the results, experiments were conducted using a wind tunnel and a 3D printed scale model of the wing with the optimal winglet. For safety reasons, the two-phase flow was simulated as an air-sand particle flow. The results show that four of the five winglets that were designed, have a positive effect on the aerodynamic efficiency of the wing, as they manage to reduce the size of the wingtip vortex. The so-called "Blended" winglet offers the highest efficiency, which is 8.92% higher than that of the "Simple" wing without a winglet, for the usual flying conditions (20 m/s, 0°). It also performs better than "Simple", for every velocity and angle of attack that was studied. The CFD simulations are in accordance with the experimental results, despite some slight deviations, and the two-phase flow seems to reduce the aerodynamic efficiency. We conclude that CFD simulations are a powerful tool to draw faster and cheaper conclusions, the flight over wildfires reduces the aerodynamic efficiency, and the "Blended" winglet is the optimal choice for the UAV ethERAs.

Key words:
CFD, ANSYS Fluent, Poly-Hexcore, SST k-ω, CATIA V5, UAV, winglet, Eppler 420