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Structural Development and Multiscale Design Optimization of Additively Manufactured Unmanned Aerial Vehicle with Blended Wing Body Configuration

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Abstract : The research work presented in this paper is developed by the Blended Wing Body (BWB) Unmanned Aerial Vehicle (UAV) team, a fourth-year capstone project at Carleton University Department of Mechanical and Aerospace Engineering. Here, a clean sheet UAV with BWB configuration is designed and optimized using Multiscale Design Optimization (MSDO) approach employing lattice materials taking into consideration design for additive manufacturing constraints. The BWB-UAV is being developed with a mission profile designed for surveillance purposes with a minimum payload of 1000 grams. To demonstrate the design methodology, a single design loop of a sample rib from the airframe is shown in details. This includes presentation of the conceptual design, materials selection, experimental characterization and residual thermal stress distribution analysis of additively manufactured materials, manufacturing constraint identification, critical loads computations, stress analysis and design optimization. A dynamic turbulent critical load case was identified composed of a 1-g static maneuver with an incremental Power Spectral Density (PSD) gust which was used as a deterministic design load case for the design optimization. 2D flat plate Doublet Lattice Method (DLM) was used to simulate aerodynamics in the aeroelastic analysis. The aerodynamic results were verified versus a 3D CFD analysis applying Spalart-Allmaras and SST k-omega turbulence to the rigid UAV and vortex lattice method applied in the OpenVSP environment. Design optimization of a single rib was conducted using topology optimization as well as MSDO. Compared to a solid rib, weight savings of 36.44% and 59.65% were obtained for the topology optimization and the MSDO, respectively. These results suggest that MSDO is an acceptable alternative to topology optimization in weight critical applications while preserving the functional requirements.

Keywords : blended wing body, multiscale design optimization, additive manufacturing, unmanned aerial vehicle
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