Silesian University of Technology
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Doctoral dissertation

Optimisation of Unmanned Aerial Vehicle of Unlimited Flight Endurance

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Abstract

Unmanned aerial vehicles (UAVs) are an increasing part of air traffic, from military applications, through traffic observation, to telecommunications applications. The capabilities of UAVs are appreciated in many industries and the flight parameters they offer are not limited by crew limitations. The rapid development of the control method, automatic flight control, the development of the materials used, and the introduction of accurate numerical methods of analysis and design, allows to achieve of higher flight speeds, increase the endurance of the flight and leads to reaching stratospheric flight altitudes. The combination of extended flight endurance at high altitudes has created a completely new group of unmanned aerial vehicles HALE UAV (High Altitude Long Endurance - Unmanned Aerial Vehicle).

The purpose of this doctoral dissertation was to determine the research and optimisation methodology of the HALE UAV aircraft and the optimisation of the internal structure of the main wing for the Twin Stratos 1:7 structure based on a parametric model coupled with the results of a numerical aerodynamic analysis. As part of the work, all design stages were presented, such as the applied parameters, the method of optimisation, and the results obtained. Optimisation analysis were developed in the Ansys environment, which allowed for the coupling of numerical aerodynamic, material, structural, and optimisation analyses.

The result of the author's work is the development of the optimal internal structure of the main wing of the TS17 unmanned aerial vehicle (Twin Stratos 1:7) and the development of a four-stage methodology for designing and conducting analyses for HALE UAV aircraft. As part of the work, the author also presented a map of optimisation results obtained for the developed internal structure depending on the location of the main wing spar and the number of layers stiffening the structure.

The optimisation tests carried out were used to determine the location of the main load-bearing spar along the reference chord and to determine the arrangement of the roving layers stiffening the spar along the span of the optimised wing. The results were obtained based on numerical analysis of the model of the analysed object, taking into account the thickness of individual composite layers, the parameters of materials selected based on design assumptions, and the exact direction of the fibres of the composite structures used. The analysis were carried out based on a fixing system of the analysed object reflecting the unusual arrangement of the fuselages. The optimal shape of the tested structure was determined based on the parameters of maximum displacement, maximum stress within the structure, and the Tsai-Wu failure criterion.