Ground Gen Airborne Wind Energy Conversion Systems: Tools for Conceptual Design and Rapid Prototyping

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Abstract

Airborne Wind Energy System (AWES) are quickly coming to fruition, with increased energy production while reducing the cost of implementation and materials. This thesis develops a new computational model for a tethered AWES and characterizes a new rapid prototyping method with the objective of supporting the design and rapid prototyping complex geometries to increase stiffness and strength. Vortex lattice method (VLM) code efficiently estimated the aerodynamic coefficients and wind tunnel tests showing little discrepancy from the VLM model. The power model showed similar results to other researched models from Myles Loyd, and Fchener. Furthermore, the model showed that a bridle can add a significant increase in pitch stability and the ability to increase pitch authority without a horizontal stabilizer. Wind tunnel results confirm high lift capabilities of the delta wing geometry with angle of attack up 90°, although the power generation is not optimal due to the small aspect ratio of the main element. Using 3D printed nylon (PA12) and carbon fiber reinforced polymer (CFRP), thermal and mechanical properties were characterized to determine the feasibility of using the 3D printed structure as a core and a mold. It was determined that the weight percent composition of the PA12 had about 1.5% water and 14% carbon platelet, which the water can adversely affect chemical adhesion and the carbon improves mechanical properties. Additionally, the PA12 also had the thermal stability to withstand the cure temperatures of the CFRP. Through tensile tests, it was determined that within the linear region the PA12 exhibited isotropic behavior. However, for ultimate failures, the PA12 exhibited anisotropic behavior, using the coordinate system of the 3D printer, with the X direction absorbing 2.4 times more energy with a higher strain and ultimate failure. It was shown that stronger adhesion occurred adhesion between the PA12 and the CFRP using a lower cure temperature and vacuum. The lower temperature avoids residual stresses caused by the difference in coefficient of thermal expansion. The adhesion strength verified that the 3D printed PA12 structure can be used as a core and mold for rapid prototyping applications. Further development of AWES are then discussed.

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