Optimization of Wing Structural and Aerodynamic Performance Through Non-Uniform Rib Spacing Based on Stress Distribution

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Improving structural efficiency in aircraft wings is a critical objective in aerospace engineering, particularly as the industry moves toward more sustainable and lightweight designs. Wing ribs play a central role in maintaining aerodynamic shape and distributing loads, and are traditionally spaced uniformly, commonly at a standard ratio of 0.2 times the chord length based on the Burgess rule. Since stress distribution along a wing is inherently imbalanced, with peak stress concentrations near the root and significantly lower stresses toward the tip, non-uniform rib spacing can be tailored to target more even stress distribution. Additionally, with the increasing feasibility of additive manufacturing, more complex and customized internal geometries, such as variable rib spacing, are now practical to implement. A baseline wing model with uniform rib spacing was created through SolidWorks and analyzed in ANSYS to obtain stress data under consistent tip load conditions. Stress values were sampled along the center span of the wing, and an inverse relationship between stress and spacing was applied while preserving the total number of ribs with a scaling constant, k. A second wing model incorporating this non-uniform spacing was modeled and comparative analysis showed a reduction in peak stress and overall stress variation, indicating improved distribution of structural loads. However, the percentage increase in average stress was notably greater than the reductions observed in maximum stress and stress range, revealing an important tradeoff associated with this redistribution.

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