Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: STRMAT / SUSTAV

Corresponding author: Saeed HOSSEINI
e-mail of corresponding author: saeed.hoseini@aut.ac.ir

Type: Oral

Status of corresponding author: Student
For student corresponding author:

Title

Wing Structure Optimization of a Truss-Braced Wing Regional Jet Aircraft with Strength, Stiffness, and Stability Requirements

Authors

Saeed HOSSEINI, Hamid Reza OVESY, Mohammad Ali VAZIRY-ZANJANY*
Department of Aerospace Engineering, Amirkabir University of Technology, Tehran, 15875-4413, Iran.
** Corresponding author: saeed.hosseini@aut.ac.ir*

Abstract

A framework for high-fidelity wing structure analysis, sizing and optimization using finite element method is developed. This framework, which can be applied to both cantilever and truss-braced wings, takes into account the strength, stiffness and stability criteria.

The wing geometry, including the external surfaces and structure architecture, is extensively parametrized using knowledge-based engineering rules within a high-fidelity and industry-standard CAD tool. The application of parametric and associative modeling rules enables the possibility for fast geometry and structure architecture update. This implementation covers both updating the existing geometrical elements (e.g., changing the wing spar location), and also the creation and deletion of structural elements (e.g., add or remove ribs depending on the wing span).

The external wing loads are extracted by filtering from hundreds of load cases, from which the most critical load conditions are used for the sizing process. In the loading process, variation of weight, center of gravity, speed, altitude, and throttles level are considered. The Vortex Lattice Method is used for the estimation of aerodynamic load distribution along the wing span. In addition, the weight is distributed along the wing span, and discrete loads such as engine thrust and engine weights are also considered.

Based on the developed wing geometry and calculated loads, the wing finite element model using shell and beam element is created automatically by Visual Basic scripts. This model is used in three sequential sizing process: strength, stiffness, and stability. For strength sizing, the shell model and applied loads are used to find the optimum structural weight. The updated finite element model is then condensed (by applying geometrical, stiffness, and mass condensation) into the stick model, which is used in sizing according to flutter speed requirements. The results of the stiffness sizing are used to update the wing shell model, and the strut structure is sized for buckling requirements, particularly for negative load factors. The computed optimum wing is used along with secondary items weight to estimate the wing structural weight.

Preliminary results show that the structural weight of a very high aspect ratio (aspect ratio of 20) truss-braced wing is higher than high aspect ratio (aspect ratio of 11) cantilever wing by nearly 30%, when sized for strength requirements. On the other hand, the flutter requirements have not affected the CLW, while the outboard section of the TBW required more stiffness to pass this requirement. was The effect of strut configurations (number of strut and jury), wing-strut attachment point (vertical, longitudinal, and lateral locations), and type of wing-strut connections on the wing weight is investigated.