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Detail Topometrical FEM Optimization of Wing Structural Panel

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Abstract: The detail topometrical optimization of the critical wing part of the aircraft is presented in this article. The integral lower wing structural panel of the aircraft in the CS-23 Commuter category is selected for the optimization. The first case demonstrates significant weight savings using the modern FE optimization methods for determined structural constraints. The practical aircraft operation and additional regulation requirements affect optimization constraints in the second case. The detail optimization also consists of the FE model validation, stress analyses and complex load capacity analyses, which are necessary for designed structural modifications with an optimal stress distribution.

Introduction

The modern finite element optimization methods allow to design an optimal stress distribution on complex structural parts. The structural optimization is a process of such design which fulfills all the requirements and minimizes weight or other efficiency decreasing factors. The weight of the structure is the objective function of an optimization. The structural shape and dimensions constitute a design space.

Accuracy and usability of the optimization process could be divided to certain stages. First, the preliminary study of the optimization possibilities and estimated weight savings could be done. The general constrains according to mainly the structural or material requirements are applied. This case could demonstrate significant weight savings and other advantages.

The second stage involves more practical requirements into account. The real aircraft operation, certain specific load cases and certification requirements must be used in the aircraft design. The next stage reflects also the production costs, manufacturing technique and technological demands.

The initial and also the second detail optimization stages of the wing structure are presented in this paper. The utilization of modern optimization methods, real operation conditions and certification requirements are described in detail.

Optimized aircraft structure

The presented optimization and analyses were made on a demand of the aircraft producer and the main purpose was to obtain the optimal structural design and to select locations for weight savings at the wing structure of the L 410 NG aircraft, which is designed in CS-23 Commuter category. An inspected aircraft part is the complex metal semi-shell wing structure with attached engine mounts, integral fuel tanks and rudders.

The main focus was put on the integral lower wing panel, presented in Fig. 1. There each skin or stringer segment could be produced with different thickness on this milled wing panel. All strength, stiffness and certification requirements specified by the producer must be fulfilled. Also the Damage tolerance philosophy is utilized in this design to increase the aircraft fatigue durability.

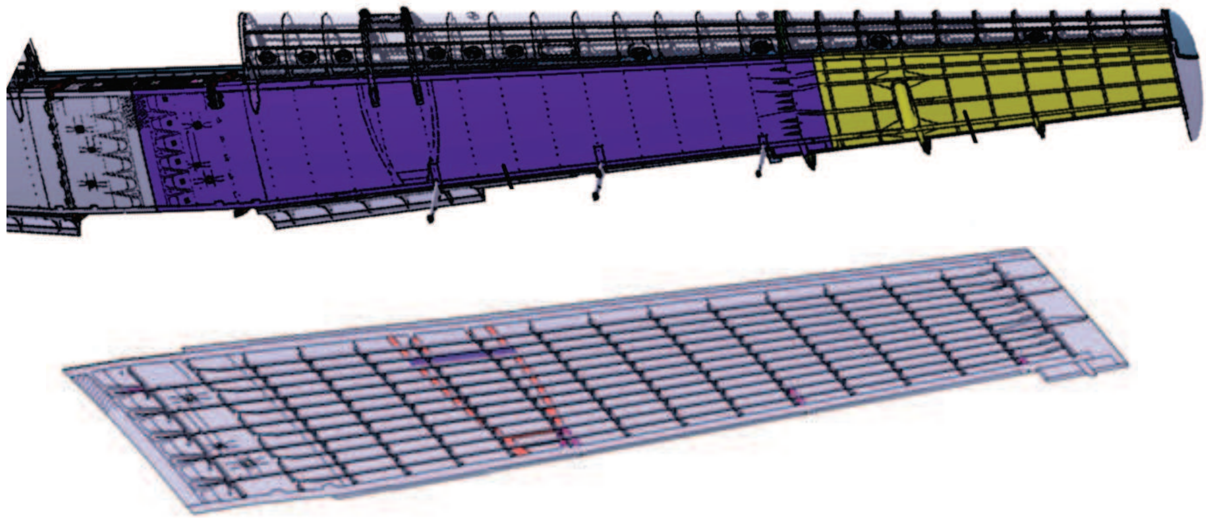

Fig. 1: Detail of wing structure and optimized lower wing panel

Optimization process

For our purposes, the deterministic gradient methods implemented in the MSC.NASTRAN software were used. The specific types of the structural optimization are topological and topometrical optimizations.

The topometrical optimization is the proper shape optimization solution for this case, where distances and number of stiffeners must be kept in the design. Its example is presented in Fig. 2, where only the element thicknesses of panel skins and stringers are modified to the maximal material utilization.

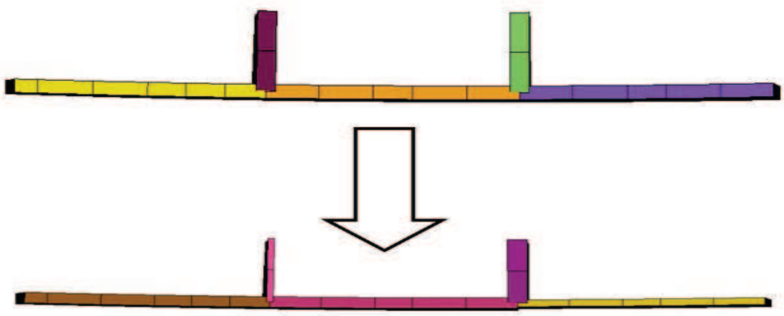

Fig. 2: Example of thickness optimization of panel skins and stringers

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