INNOVATIVE DESIGN WITH BI-LEVEL TOPOLOGY OPTIMIZATION

Alain REMOUCHAMPS, Michael BRUYNEEL

SAMTECH s.a.,
Liège Science Park, Angleur, 4031, Belgium
alain.remouchamps@samtech.com
michael.bruyneel@samtech.com
http://www.samtech.com

Stéphane GRIHON

Airbus,
Toulouse, 31060, France
stephane.grihon@airbus.com
http://www.airbus.com

Claude FLEURY

University of Liège,
Sart Tilman, Liège, 4000, Belgium
c.fleury@ulg.ac.be
http://www.ltas.ulg.ac.be

Abstract

Starting from results obtained in the topology optimization of two Airbus pylons, this paper proposes an innovative bi-level optimization scheme used to solve multidisciplinary optimization problems including aerodynamics (drag) and structure (mass, stiffness) requirements. The drag related to the pylon fairing depends on some global geometric design variables. For a given geometry, the minimal mass is obtained by solving a topology optimization problem with stiffness (displacement) restrictions. Mass and drag feed a cost function which is minimized with a surrogate-based optimization approach. The developed methodology is demonstrated for the multidisciplinary optimization of the Airbus pylon.

Keywords topology optimization; bi-level optimization; industrial application

1. Introduction

Since the pioneer work of Bendsoe and Kikuchi (1988), and Bendsoe (1989), topology optimization has been the subject of many researches (Bendsoe and Sigmund, 2003). It is now a mature design methodology, which is used at an industrial level. Multidisciplinary optimization has been studied for a very long time. It has found lots of applications in aeronautics, where aerodynamic and structural requirements are essential (Sobieszczanski and Haftka, 1997).

In this paper, results obtained in the conceptual design phase of Airbus engine pylons are first presented. Topology optimization is used to determine in an automatic way the optimal layout of these structures, which are submitted to several static load cases. In the optimization problem, the structural stiffness is maximized, and restrictions on the volume and on some displacements are taken into account. The design variables are pseudo-densities defined in each finite element. These take values continuously varying between 0 and 1 to represent void and solid at the solution. The SIMP parameterization is used in order to penalize the intermediate values of the pseudo-densities, which enable the interpretation of the emerging optimal layout. Two different initial concepts of the pylon are studied. The influence of some optimization parameters on the obtained results is illustrated.

Since the boundary conditions and the surrounding envelope may strongly influence the resulting topology, a strategy is then developed to parameterize the problem with respect to these parameters and to include them in a bi-level optimization scheme, in which the impact of the overall geometry or the attachments of the structure (pylon-to-wing, engine-to-pylon and nacelle-to-engine, nacelle-to-pylon attachments) on the pylon-nacelle structural lay-out and weight can be studied. In this bi-level scheme, the global design variables possibly define