Simultaneous optimization of unconventional stiffener layouts and composite layups applied to large cylindrical shell structures

Ph.D. Defense – Florent SAVINE

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Room Pierre Contensou - ONERA Châtillon

Zoom videoconference link: please request link by sending an e-mail to florent.savine@onera.fr

In front of the jury composed of:

M. Marco Montemurro, Professeur, Ecole Nationale Supérieure d'Arts et Métiers	Reviewer
M. Joseph Morlier, Professeur, Institut Supérieur de l'Aéronautique et de l'Espace	Reviewer
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M. Corrado Maurini, Professeur, Sorbonne Université	Examinator
Mme. Angela Vincenti, Maître de Conférence HDR, Sorbonne Université	Thesis director
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M. Yannick Guerin, Ingénieur, CNES	Guest

Abstract

This thesis addresses the challenge of designing lightweight load-bearing space-launcher structures. The objective of the thesis is to develop a method capable of simultaneously optimizing innovative stiffener layouts and composite layups. For this purpose, the bi-level framework for the optimization of composite laminates is taken as basis. In the first-level structural optimization, the local anisotropic material properties of the variable-thickness and variable-stiffness skin of the structure, parametrized by the polar parameters, are simultaneously optimized with the stiffener layout, via a gradient-based algorithm. The optimization of the stiffener layout relies on a component-based topology optimization method developed in this work, that allows to iteratively update a finite-element model of the stiffening structure made of structural elements (beams and shells), without re-meshing. By this process, the global structural stiffness is maximized considering constraints on mass, buckling and force fluxes. In the second level of the framework, laminates realizing the optimized first-level properties are retrieved either by solving an optimization-based identification problem, or analytically by assuming non-conventional stacking sequences (Quasi-Trivial and Double-Doubles). The method is developed and validated on academic test cases, and finally applied to pre-sizing a launcher skirt provided by CNES. Innovative stiffened composite structure concepts are proposed, significantly lighter than the optimized reference metallic design of CNES.

Key words

Component-based topology optimization; bi-level composite optimization; variable-stiffness and variable-thickness design; layup retrieval; gradient-based method; finite elements