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MINIMUM WEIGHT DESIGN OF ORTHOTROPIC CYLINDRICAL LAUNCHER SHELL STRUCTURES SUBJECTED TO LOCAL LOAD INTRODUCTION

Abstract

Primary structures in launcher rockets are designed as orthotropic stiffened shells. In order to meet lightweight targets, more and more CFRP shell designs are used. For example, in the upper stage and payload area of the ARIANE 5 all primary structures, except the cryogenic propellant tanks, are made of CFRP.

The ARIANE 5 design of these orthotropic stiffened shells is buckling and stiffness driven. High concentrated loads due to the load introduction of the solid rocket booster thrust loads must be carried and distributed into the structure.

Since the primary design variables such as geometrical properties and laminate stacking sequences are already defined within the early design phases of the development, efficient structure dimensioning tools are needed, that can be used already in the concept phase.

This paper aims on the structural optimization of orthotropic stiffened cylindrical shell structures which are loaded globally by axial forces, transverse shear forces and launcher bending moments, and locally by high concentrated loads. In this regard a computationally efficient structural analysis and sizing tool is coupled with a structural optimization tool in order to perform optimization computations. The structural analysis tool efficiently computes the local stress distribution due to a global loading as well as the critical reserve factors for strength and stability failures also considering post-buckling load redistributions. Profit from stable post-buckling behavior can of course only be taken for panel instability failures, requiring sufficiently stiff rings in order to avoid general instability coming along with unstable post-buckling behavior.

In order to obtain a most global optimum for the structural optimization problem, the structural analysis tool is coupled to an optimization tool which uses a genetic optimization algorithm.

For designing a minimum weight structure, geometrical properties such as frame spacing, stringer spacing and stiffener dimensions as well as laminate stacking sequences of skin and stiffeners are regarded.