NUMERICAL EVALUATION OF IMPACT DAMAGE AND VALIDATION OF REPAIR PROCEDURE ON VEGA LAUNCH VEHICLE SOLID ROCKET MOTOR SKIRT

A. Zallo**,U. Mercurio*, S. Franchitti*, R. Borrelli*,F. Di Caprio*, M. Tirrelli**,C. Maceroni**
***Avio s.p.a – Via Ariana Km 5.2 - 00034 Colleferro (Rome), Italy*
**CIRA Via Maiorise - Via Maiorise, 1, 81043 Capua (CE), Italy*
antonio.zallo@avio.com, U.Mercurio@cira.it

Abstract

In the frame of Vega program Avio has developed the composite cases of the three stages of VEGA Solid Rocket Motors.
The structural case can be schematized as a cylindrical pressure vessel with ending domes which mainly sustains the internal pressure, due to propellant combustion, and two cylindrical Skirts, connecting the SRM to the adjacent stages, which have to sustain quite high compressive loading due to Launch Vehicle maneuver, external aerodynamic and SRM thrust.
During manufacturing, handling and integration SRMs cycles impact events can occurs and the possibility of composite damaging has to be considered and in case repaired. Such occurrence is more critical in the skirt area where is necessary to resume longitudinal strength integrity.
The aim of the present work is to present the numerical activities performed to:

1. Evaluate the impact damage on the composite skirt of VEGA Solid Rocket Motors through an Esplicit Non-linear FEM simulation;
2. Validate a repair procedure by the FEM numerical evaluation of the residual strength of the repaired of the composite skirt.

The impact damage was predicted by a FEM model, developed in LS-DYNA, aimed to reproducing the impact response of a composite laminate. In particular, impact test simulations were performed on Compression After Impact (CAI) flat specimens, which due to both the high radii of curvature of the skirts parts and the loading status which is mainly compression, are reasonably representative of the skirts full scale components. Impact simulations took into account different lamina failure modes and were performed at different energy levels, ranging from 5 J to 150 J. The repairability energy threshold was determined as the maximum impact energy level at which only one side of the specimen was damaged.

On the bases of the impact damage, evaluated at the repairability energy threshold, a repair procedure has been implemented and presented in the paper.
The procedure has currently validated only by numerical simulation, and test experimental verification is ongoing. The approach described in the paper is based upon the global-local FE Methodology:

- The global model of the entire SRM is implemented and validated in the frame of Vega Program;
- The repair scheme has been implemented on a refined 3D local FEM which also included the modelling of adhesive between the skirt and the repair patch.

Same global-local approach is also implemented on scaled skirt model, 400mm diameter, which shall be manufactured to validate the procedure by experimental compression test of the scaled skirt.
Results show good agreement, with available literature prediction, in terms of interlaminar shear stress in the overlap area between the repair patch and original material.
Finally is numerically demonstrated that the maximum compression load, on damaged and repaired 0° laminas, can be adequately smoothed and recovered: the repaired Skirt longitudinal residual strength is adequate to sustain flight loads.