Structural Analyses of Orthogrid Fuselage Panel for Integrated Ku-band SatCom Antenna

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ABSTRACT

The aim of this work is to describe the structural analyses made of an ortho-grid stiffened fuselage panel with embedded antenna tiles. The panel consists of a UniDirectional (UD) carbon fibre reinforced composite skin stiffened with ortho-grid ribs, and an transparent skin window made using UD glass fibre reinforced composite.

The panel is manufactured using thermoset prepreg materials, which are suitable for aerospace structural applications. The panel skin and the ortho-grid ribs consist of carbon fibre reinforced material: Hexcel 8552 resin and AS4 fibre. On the other hand, the transparent panel window skin consists of glass fibre reinforced material: Cytec FM906-27 resin and S2 glass 187-460 fibre.The ortho-grid ribs are laid-up using automated fibre placement over the panel skin. The panel skin has a material transition in the glass window edges through interleave plies of carbon and glass. Finally, the whole fuselage panel is cured in an autoclave.

The Fokker 100 is the target aircraft to integrate the ortho-grid stiffness fuselage panel with the integrated antenna. The forward crown panel at the top of the fuselage is selected for the ortho-grid panel location, as in this section the antenna will have the best performance with the lower loads. It should be noted that in this work no aerodynamic loads are included, and that a variation of temperature conditions is not foreseen.

Finite element numerical models are used to study the structural response of the panel for different loading cases. To reduce the computation time required to conduct the simulations, and to be able to include all details in the models developed, only a reduced section of the fuselage is analysed. Consistent boundary conditions are imposed in the reduced model in order to obtain the same results that would be reached in the simulation of the whole panel.

Even with nowadays computational capacity it is almost impossible to analyse a structural component taking into account a detailed definition of the laminate layup. For this reason, in this work a numerical multiscale strategy is proposed. The laminate is simulated with solid elements, in order to capture the real kinematics of the material, but several laminas are condensed in a single finite element. The performance of each lamina is obtained using the serial-parallel mixing theory.

The Serial-Parallel mixing theory can be defined as a phenomenological homogenization, where the behaviour of the laminate is obtained from its components constitutive response, and the stress-strain compatibility existing among them. Commonly, for UD composites, the formulation applies an iso-strain condition in fibre direction and a iso-stress condition in the other ones. This theory is capable to predict accurately the response of composites in the linear and the non-linear range.

The approach followed in current work allows the analysis of complex composite structures with an affordable computational cost, which is basic for the development of new multifunctional composite structures. The specific formulations developed have been very useful to identify and study the mechanical performance of these new structures and the localization of unknown and un-predicted hot-spots in the structure. The numerical models have been also used to design of the experimental campaign developed.