CellSkin - a new flexible shell structure for a morphing wing aircraft

Abstract:
Morphing wing technologies offer a promising perspective for improving aerodynamic performance of future aircraft. For a shape-changing leading edge with variable camber a new shell structure with high bending stiffness in spanwise direction and relatively low bending stiffness in chordwise direction is developed. The flexibility of the shell structure is achieved by a new design, called CellSkin, which is a highly anisotropic, lightweight composite sandwich. The face sheets are made of unidirectional CFRP layers and a +/- 45° GFRP top layer. The core consists of narrowly spaced, I-beam type shear webs which are made of thin braided GFRP tubes. These tubes are aligned in x-direction. If loaded by a transverse force, the core behaves like a conventional, highly shear stiff composite core in xz-direction, whereas in yz-direction it is shear flexible due to elastic S-type deformation of the GFRP shear webs. Regarding to an acceptable numerical effort the structure is modelled with a homogenization approach. A micro-scale model of a repeated unit cell with periodic boundary conditions is used to determine the stiffness matrix of a transverse shear flexible Reissner-Mindlin shell element. A macro-scale shell
model of a flat plate with the parameters of a reference design was used to simulate its stiffness in a three point bending test. The reference design was built and subsequently measured with a three point bending test. With the measured results the finite element model is validated. The unit cell model is furthermore used for a numerical optimization of the CellSkin. Design goal is a decrease of the transverse shear stiffness in y-direction, combined with proper stiffness in x-direction. Design variables are the global geometry parameters height and shear web spacing, as well as the stacking sequence and the layer thicknesses. A transverse shear anisotropy factor of over 700 could be reached.

Stichworte:
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