10th International Conference on Composite Science and Technology
ICCST/10
A. L. Araújo, J. R. Correia, C. M. Mota Soares, et al. (Editors)

Abstract ID-134

INFLUENCE OF THE ELASTOMER LAYER POSITION ON THE LOW-VELOCITY IMPACT BEHAVIOR OF COMPOSITE/STEEL/ELASTOMER LAMINATES

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Keywords: Hybrid composite, FML, Laminate, Low-velocity impact, Impact behavior

Summary: In aeronautical applications Carbon-Fiber Reinforced Plastics (CFRPs) have been established due to their advantageous stiffness- and strength-to-weight ratio. Problematically, aerospace structures are often subject to impact by sand, rain, hail and larger objects like runway debris. However, conventional CFRPs show a weak erosion resistance. Furthermore, the impact of larger objects can cause serious damage to the CFRP structure without being detectable during regular maintenance (barely visible impact damage). These specific requirements raise the demand for new material combinations to benefit from the favorable material properties of the different components.
The aim of our present work is to identify a beneficial combination of several materials to obtain an increased impact resistance at usual impact events, focusing on low-velocity impacts like hail strike. The intention is to quantify the benefit of composite/steel/elastomer structures in case of low-velocity impact for application in a laminar wing leading edge with an integrated resistance heating. For this purpose, in addition to the damage tolerance of the structure and especially of the heating structure, the smoothness of the surface is a determining factor for the quality of the hybrid structure.
In the experiment, a typical CFRP structure for a wing leading edge is covered with a thin stainless steel foil for erosion resistance. A CFRP layer surrounded by GFRP layers for electrical insulation simulates a resistance heating between steel foil and CFRP main structure. Previous studies investigated the influence of different steel foil thicknesses and the addition of an elastomer layer in the same layup. It was shown that both parameters have a decisive influence on the low velocity impact response. In the present work the influence of the elastomer layer position on the low-velocity impact behavior is assessed. Three different positions are investigated: Between the heating structure and the CFRP main structure, in the center plane of the CFRP main structure and in the lower third of the CFRP main structure.
The low-velocity impact tests are conducted with a drop weight tower with a hemispherical steel indentor on flat 100 mm x 150 mm specimens. Six different energy levels between 5 and 50 J are tested three times at each of the three sample configurations. After impact, the surfaces are inspected visually, the indentation depth is measured, and the damage area is determined by ultrasonic C-Scan. First results show that the position of the elastomer layer significantly influences the dent depth and the extent of the delaminations. Both parameters can be reduced by over 50 % by the change of the elastomer layer position. Further analysis of the ultrasonic C-Scans as well as the impact energy evolutions will clarify the damage mechanisms. In order to successfully apply the proposed hybrid composite on aircraft structures, the occurring damage modes and their order of occurrence are investigated.