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Hypervelocity Impacts and Protection (3)

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THE INFLUENCE OF MECHANICAL LAMINATE PROPERTIES ON THE HYPERVELOCITY IMPACT RESISTANCE OF FIBER METAL LAMINATES

Abstract

Orbital debris is an ever-growing threat for spacecraft longevity. Current structural solutions for protecting spacecraft systems take advantage of composite materials, because of their high specific strength. Fiber metal laminates (FMLs), such as GLAss fiber REinforced aluminum (GLARE), combine the high strength-to-weight ratio of composites with the durability and impact resistance of aluminum. These FMLs have already demonstrated superior shielding capacity under low velocity impact. However, their shielding performance under hypervelocity impact (HVI) still must be investigated. Such investigation is preferably performed by numerical simulation to avoid conducting many expensive experiments. In this study, finite element simulations were performed to model the impact between a stationary GLARE target plate and a stainless steel particle with a relative velocity of 2 and 5.6 km/s respectively. The numerical simulation results show debonding between the aluminum sheets and individual composite layers at each time increment. The model also indicates good agreement with the damage of the target plates, in the form of the breakage of fibers and the petalling of the aluminum sheet on both the front and back sides compared with the experimentally tested plates. In addition, the numerically predicted damage meets the delamination areas detected post-mortem in experiments with ultrasonic scans. After this verification of the numerical model, the impact simulations of GLARE and monolithic aluminum panels with the same areal density were made respectively at multiple velocities in the range of 2 to 5.6 km/s. The shielding performance of GLARE and aluminum was compared to determine which has the superior impact resistance under varying impact energies. After that, a sensitivity study was done to evaluate the influence of both intralaminar and interlaminar properties of the FML panels, such as yield strength of the fibers, the areal density and adhesive strength between the adjacent aluminum and GFRP layers, on their impact resistance performance. The different roles of each constituent were evaluated by the energy absorption ratio during the penetration process. Characterizing the sensitivity of each material parameter helps to build a better understanding of the impact response of FMLs and to facilitate improvements to the shielding configuration.