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SPACE DEBRIS SYMPOSIUM (A6)
Hypervelocity Impacts and Protection (3)

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NUMERICAL SIMULATION OF COMPLEX DAMAGE BEHAVIOR OF ADVANCED AEROSPACE STRUCTURES SUBJECT TO HYPERVELOCITY IMPACT

Abstract

Investigations into the complexities of Hypervelocity Impact (HVI) onto advanced aerospace structures aim to provide an accurate description of the damage evolution and propagation through the impacted structure. The complex formation of the debris cloud and violent movement of shock waves produced are causative to the intricate damage processes experienced by an impacted structure, and can lead to a significant loss of strength and stiffness, critically compromising the safety and usability of the novel space structure. Experimental testing currently proves the feasibility for application of space structures, although this typically entails expensive and complex procedures involving multi-stage gas guns, vacuum chambers and high speed x-ray photography. Recent discrete particle finite element methodologies however, such as "Smooth Particle Hydrodynamics" (SPH), are capable of modeling the intricacies of hypervelocity impact events and can provide the space industry with a tool to assess the damage tolerance of new designs whilst reducing dependency on experimental tests. Representative numerical models using the SPH discrete methodology, with the inherent ability to track particles within the debris cloud can be combined with traditional FE techniques to provide a comprehensive understanding of the impact upon subsequent structures and associated deformation and failure modes of the structure and its damage tolerance. An important extension and application of the methodology includes the evolution of models from isotropic Aluminum Alloys to Carbon Fibre Reinforced Plastics (CRFP). Current databases of empirical data are limited in their applicability and even more so when one considers composite materials. Following a HVI, composites can experience complex failure modes including delamination, front and rear face spallation and penetration of multiple laminates, which reduce the overall mechanical properties and may remove the structure from useful service. The accurate prediction of the dynamic behavior and damage response during HVI in microgravity will enable an in-depth understanding of damage patterns in partially and fully damaged composite structures. Investigations into the dynamic strength and performance of metal and composite structures during HVI impact will be conducted and the resulting numerical simulations will be compared to experimental damage assessments from literature. The paper, in its concluding sections will demonstrate the improved accuracy involved with using the above technique in modeling the intricate and non-linear dynamic behavior and damage response of aerospace structures subject to HVI. By evaluating the effect of debris impacting operating spacecraft, new developments in materials and shielding configurations can be developed for the safety and security of advanced aerospace structures in the space environment.