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Introduction: High-Velocity Impact

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THE field of high-velocity impact has been a subject of many research efforts for several decades. In earlier years, solutions to complex impact problems involved either crude analytical or numerical solutions or relied heavily on empirical data from simulated experiments. For very complex impact events, empirical procedures became very expensive. In recent years, as computer capability has increased dramatically, it has opened up the possibility to investigate complex impact problems numerically and to address more of the physical features that exist in an environment that includes shock characteristics within a solid structure. Major advances in the technology include more sophisticated numerical modeling as well as developments of improved constitutive and failure models. The 47th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials conference held at Newport, Rhode Island in May 2006 was a recent symposium in which several excellent papers were presented on this topic. The four papers included in this journal publication range in topics from the consideration of nonequilibrium thermodynamics, which is a byproduct of a shock field present in a ballistic impact, to a paper capturing the phenomenon of missile impact. Each of the authors is one of the experts in his field and has been involved in impact problems for many years.

The issue begins with a paper by Lu and Hanagud incorporating dislocation-based plasticity to formulate a framework of continuum mechanics and nonequilibrium thermodynamics for solids under very high strain rates. The formulation explores the effects of a shock front on the high-velocity impact of a ballistic event. Quantum mechanic relations are included in the development to characterize the resulting heating due to plastic work and the microcharacteristics associated with the nucleation of dislocations at the shock front.

The second paper, by Voyiadjis et al., develops a micromechanical constitutive model, using the finite element method, that couples anisotropic thermoviscodamage mechanisms with thermohypoelastic deformation to handle simulations of hypervelocity impacts by blast projectiles, and considering the size of localized failure regions on the mesh arrangement and alignment. The introduction of viscosity and gradient localization parameters are incorporated in the numerical algorithms. Results show the ability to handle shear band formation in a finite element model that evaluates the impact event at high velocity.

The third paper, by Cinnamon et al., shows the application of experiments to determine the high strain-rate dependence of materials undergoing Mach-level impact events. A flyer plate experiment is used in conjunction with split-Hopkinson bar and quasi-static experiments to determine the material strain-rate sensitivity. The final material model is incorporated in a hydrocode that considers the impact event of an experimental test at the impact facility located at Holloman Air Force base in New Mexico. The simulations match previous experimental findings in terms of deformation and microstructural features extremely well.

The fourth and final paper, by Hinrichsen et al., is an application of impact physics in the evaluation of the impact damage of a transport aircraft wing brought about by a high-velocity projectile. Three steps were considered: the investigation of the effects of a simple body-on-body impact on the aircraft's wing structure; simulation of the hydrodynamic ram effects due to a high-velocity projectile impacting and traveling through a fluid-filled wing box; and adding an explosive to the projectile model to investigate the combined effects of the kinetic energy of the projectile, hydrodynamic ram, and the explosive blast at various locations and incident angles.

In all, these papers represent significant advances in the state of the art in high-velocity impact and involve contributions to improve the numerical simulation of complex impact events by addressing code developments, improved constitutive modeling, and characterization of failure processes.

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