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A numerical method for the ballistic performance prediction of the sandwiched open cell aluminum foam under hypervelocity impact

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Abstract

Voronoi tessellation theory is applied to model the cells and ligaments in the open aluminum foam material. The cores of the cells are first generated by packing random spheres into the specified spatial domain. Weighted Voronoi tessellation is then applied to make the cellular structure of the foam material. For the open cell foam, the ligaments are created from the edges in the multiple polyhedron geometry.

Hypervelocity impact simulation is conducted with the smoothed particle hydrodynamics method in LS-dyna. The finite element reconstruction technique is applied based on the particle output for the fragmentation analysis. The modeling and simulation techniques are verified by comparing the simulation results with testing results. The failure shown in the numerical prediction is consistent to the test result.

The stress wave propagation in the foam material, which is extracted from the simulation output, is very different from that in the homogeneous material. The stress wave can only propagate inside the ligaments, and is diffused by the cellular structure. The important tensile failure pattern in the homogeneous material, which is generated by the reflection of the compressive wave on the free surface, is not observed in the foam material. The diffusion of the stress wave spreads the impact effect to a large area, leading to the enhanced dissipation of the impact energy, which increases the ballistic limit of the foam panel.

Key words: aluminum foam, hypervelocity impact, stress wave, Voronoi tessellation, SPH