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Title

Hypervelocity impact simulations between space objects with various shapes and lattice core sandwich panels

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Abstract

Micrometeoroid and Orbital Debris (MMOD) is one of the main threats to space structures. Honeycomb core sandwich panel (HCSP) is a shielding system mainly used in unmanned space structures due to its light weight, but provides lower shielding performance because of the channeling effect. Extensive studies have been carried out on space shielding systems to improve the protective performance of HCSP. However, studies on the shielding system using lattice core sandwich panel (LCSP), which is lightweight and easy to manufacturing using 3D technology, are limited. Therefore, in this study, hypervelocity impact (HVI) simulations between space objects with different shapes and LCSP are conducted. A commercial nonlinear structural dynamics analysis code, LS-DYNA, is used for the present HVI analysis. Mie-Grüneisen's equation of state and Johnson-Cook material strength and failure models are used to represent the hydrodynamic and nonlinear structural behaviors of metallic materials. The space objects are modelled using the Smoothed Particle Hydrodynamic (SPH) method, which allows the debris cloud to be effectively represented without distortion and tangling of elements. Al2017-T4 is used as the structural material of the space object. The dimension of the space structures using the lattice core sandwich panel are 30 mm x 30 mm x 22 mm. Figure 1 indicates the detailed modelling information of the space structure. The front wall using Al6061-T6 consists of the direct impact zone, which is modelled by SPH and the indirect impact zone, which is represented by the Finite Element Method (FEM). The lattice is represented by a unit cell of body-centered cubic (BCC), and modelled using SPH. The rear walls are modelled using a hybrid FEM/SPH technique to consider the damage of the rear walls caused by the debris cloud. Figure 2 shows the simulation result when a spherical space object with a diameter of 2 mm collides with a space structure at 6.910 km/s. In contrast to the channeling effect of the HCSP, a multi-shock effect is observed in the LCSP, with only a small deformation by the dispersed debris cloud in the rear plate. In the full paper, the effect of space objects with different shapes on the ballistic performance and final failure shapes of the LCSP will be investigated.

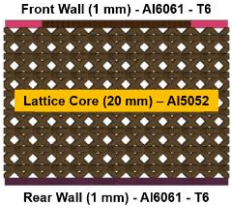

Figure 1. Modeling of space structure using the lattice core sandwich panel

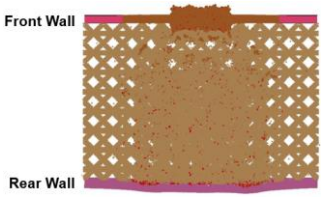

Figure 2. HVI simulation result with the sphere space object impact