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EXPERIMENTAL COMPARISON OF AL SPHERE HYPERVELOCITY IMPACT ON AL-FOAM SANDWICHED SHIELD AND AL-FOAM STUFFED SHIELD

Abstract

Aluminum foam is a new type of material for shield of spacecrafts for it bears favorable characteristics when subjected to hypervelocity impact of space debris. The large number of cell walls that a projectile impacting a cellular material will find along its path provides a good way of inducing a high number of consecutive shocks on the impactor, thus effectively absorbing its energy and reducing the penetration depth of the debris inside the structure. An Al-foam Sandwiched Shield and an Al-foam Stuffed Shield were presented under the concept of light-weight shield structure and their shield performances were compared through hypervelocity impact experiments using two-stage light gas gun. The total shield space was 100mm for the both. In the Al-foam Sandwiched Shield, an Al-foam plate was sandwiched between two Al 2A12 plates of 0.5mm in thickness each to form a composite bumper. In the Al-foam Stuffed Shield, the front bumper was an Al 2A12 plate of 1mm in thickness and the Al-foam plate was placed in the middle of the front bumper and the rear wall. The rear wall was an Al 2A12 plate of 2mm in thickness for both shields. The base materials of the open-cell foam used were Al-Si alloy ZL102 and pure aluminum respectively. They were made into different thicknesses to keep the same areal density so that the shield performances can be compared for the two different base materials. The porosity of the two foams was 58% and the mean hole diameter was 1mm. The total bumper areal density, rear wall excluded, was about 0.8g/cm2. The projectile launched was 2017 aluminum sphere with its diameter fixed to be 3.97mm and the impact velocity was between 2.6-6.3km/s with a 0 degree incident angle. The damages of the bumpers included and the rear wall were examined thoroughly after impact and compared to each other to evaluate the shield performance of different configurations and the influence of different base materials as well. The experimental results indicated that within the speed range tested, the Al-foam Stuffed Shield has significantly better performance than the Al-foam Sandwiched Shield. And for a same shield configuration, the base material of Al-Si alloy used can produce slightly better performance than that of pure aluminum.