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

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INVESTIGATION INTO DAMAGE OF AL-FOAM STUFFED WHIPPLE SHIELD UNDER HYPERVELOCITY PROJECTILES IMPACT

Abstract

The Whipple shield is the conventional shield type used to protect space structures by hypervelocity meteoroids and orbital debris impacts. Comparing the conventional Whipple shield, the Al-foam stuffed Whipple shield is the low weight/high resistance shielding systems. The damaged area and the crack length on the second wall can be used to evaluate the protection ability of Al-foam stuffed Whipple shield. The main factors affecting the protection ability of Al-foam stuffed Whipple shield from hypervelocity impact are thickness of bumper, protection spacing, relative density of Al-foam, the arrangements of Al-foam. The impact tests were performed onto Al-foam stuffed Whipple shields, each of them consisting of a 1mm thickness 2A12 aluminum alloy bumper with a 3mm thickness 5A06 aluminum alloy rear wall. The spaces between bumper and rear wall was 100mm. Relative density of the Al-foam stuffed were 11.7%, 13.5%, 16.8%, 26.8% and 31.1% respectively. For this study, aluminum alloy spheres were launched, with the protection of sabots, at velocities between 3.79km/s and 4.43km/s. The diameter of projectiles ranged from 6.35mm to 7.00mm. The impact angle was 0 for all the tests. The projectile velocities were measured by magnetic induction. The pressure of nitrogen gas in the first stage reservoir ranged from 3MPa to 15MPa. The pressure of hydrogen gas in pump tube ranged from 0.1MPa to 0.12MPa. This paper discussed the results obtained from all impact tests performed by launching aluminum spheres onto Al-foam stuffed Whipple shield configuration. It was found that Al-foam had a significant effect on small debris, so that Al-foam shouldn't be placed on the first layer. And it was found that when Al-foam was put behind, performance of shield can be elevated, because microstructure of Al-foam induced multiple shocks to the projectiles, which resulted in dramatically increase of proportion of liquefaction and gasification and effective disperse of momentum. The results show that relative density and the arrangements of the Al-foam stuffed are the main factors affecting the protection ability of Al-foam stuffed Whipple shield from hypervelocity impacts.