18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Impact-Induced Mission Effects and Risk Assessments (3)

Author: Prof. Zizheng Gong
Beijing Institute of Spacecraft Environment Engineering, China Academy of Space Technology (CAST), China

SHAPE AND ORIENTATION EFFECTS ANALYSIS FOR CYLINDER PROJECTILES IMPACTING WHIPPLE SHIELD AND ITS PRELIMINARY BLE

Abstract

Ballistic limit equations (BLEs) are used for the Performance evaluation of spacecraft shield in a meteoroid and space debris environment. Traditional BLEs are typically developed using hypervelocity impact tests with standard spherical projectiles. However, it is showed that the vast majority of orbital debris are not spherical, and cylinder projectiles can be more damaging than equal mass spherical projectiles. If spacecraft shield is designed using spherical projectile-based BLEs, the design will be non-conservative. In this paper, the hypervelocity impact test and numerical simulation were conducted for the cylindrical projectile with different ratio of length to diameter (L/D) and different impact orientation. By analyzing the damage characteristics of debris cloud and back wall under different impact parameters, the effects of L/D and impact orientation on fragmentation of projectile were studied. The results show that both the fragmentation degree and the damage ability of the projectile are closely related to the L/D and impact orientation, and the influence is coupled. Under the premise of ensuring the same mass of the projectile, the impact damage capacity of the projectile increases with the increase of L/D when the attack angle is 0, and the relationship between the damage capacity and the L/D even reverses when the attack angle is 90. Based on the regular knowledge of the influence of the L/D and impact orientation of the cylindrical projectile on the protective characteristics, the ballistic limit equation which can describe the damage ability of the cylindrical projectile with different L/D and impact orientation is established by modifying the classical Cour-Palais damage equation by using the principle of mass equivalence. The ballistic limit equation provides a reference for the exploration of shape and orientation effects in the hypervelocity impact of non-spherical projectiles.

Keyword: Hypervelocity impact, ballistic limit equations, cylinder projectiles, ratio of length to diameter, shape and orientation effects.