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DAMAGE CHARACTERISTICS OF SPACE DEBRIS SHIELDS BY SIMULTANEOUS IMPACTS OF
MULTIPLE HIGH-SPEED PROJECTILES

Abstract

The increasing frequency of space activities has resulted in an increase in the number of space debris on the orbit, and the probability of multiple impacts at the same location on an orbiting spacecraft or simultaneous impacts at adjacent locations has greatly increased. Therefore, it is necessary to study damage and protection problems of multiple space debris impacting spacecraft at the same time. In this paper, based on the damage results of space debris shield by impact of single hypervelocity projectile, the coupled damage of Al-plate Whipple shield by simultaneous impacts of high-speed multiple projectiles is studied by experiment and numerical simulation. For this study, a two-stage light gas gun is used to launch multiple Al-sphere projectiles impacting on Al-plate Whipple shield and woven stuffed shield in test chamber respectively. In the impact test, a special sabot is designed, and one, two, four and six projectiles are fired simultaneously to impact on targets respectively. The damage modes of Al-plate Whipple shield and the basalt fiber cloth stuffed shield by simultaneous impacts of two or more Al-sphere high-speed projectiles are obtained. The main factors affecting damage of shield by simultaneous impacts of multiple high-speed projectiles are studied. Through the numerical simulation of damage of Al-plate Whipple shield by simultaneous impacts of multiple high-speed projectiles, effects of projectile spacing, projectile velocity and projectile number on damage of Al-plate Whipple shield are analyzed, and ballistic limit velocity of Al-plate Whipple shield by simultaneous impacts of multiple high-speed projectiles is studied. At the same time, the critical spacing between impact points of two projectiles which lead to the failure of shield under certain conditions is analyzed. The study focus on damage of rear wall of shield by simultaneous impacts of multiple high-speed projectiles and influence of spacing between impact points of two projectiles on damage and protection characteristic of shield. The results indicate that when two projectiles with a certain range of projectile spacing impact bumper of Al-plate Whipple shield a transverse interaction will occur, which will cause transverse movement of projectile after penetrating bumper. Under the same impact condition, the critical spacing between two projectiles causing the most serious damage to the rear plate exists. At the same time, when three projectiles with spacing between two projectiles as twice diameter of projectile impact Al-plate Whipple shield, rear wall of shield is most severely damaged.