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

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NUMERICAL SIMULATION OF CHARACTERISTICS OF DEBRIS CLOUD PRODUCED BY PROJECTILE HYPERVELOCITY IMPACT ON BUMPER

Abstract

All long-duration spacecraft in low-earth-orbit are subject to high velocity impacts by meteoroids and space debris. The impacts can damage flight-critical systems and possibly lead to catastrophic failure of the spacecraft. Historically, significant amounts of resources have been devoted to developing shielding systems for spacecraft by means of reducing the penetration potential of hypervelocity impacts. Many studies have revealed that the level of protection provided by a multi-wall structure significantly exceeds the protection level provided by an equal weight single wall of the same material (Christiansen et al., 2001). The outer bumper of a multi-wall structure protects the module-wall from direct perforation of space debris. The effectiveness of the bumper is strongly dependent on its ability to disintegrate, liquefy and vaporize the projectile and to disperse it as large as possible, and forming the debris cloud (DC). The investigation into DC characteristics is of great importance in spacecraft shield system designing, it is the important basis for DC accurate damage modeling capable to describe the DC evolution and predict the damage to the spacecraft module-wall (Piekutowski, 1996; Corvonato et al., 2001). The large number of characteristic parameters for DC accurate damage modeling is difficult to obtain all through experiment researching, it requires more sophisticated tools and methods such as SPH numerical simulation. The numerical simulation can offer some insight into the physical processes involved during DC formed. The impact peak pressure (or stress) and temperature are the key effect factors for projectile and bumper materials disintegrating, liquefying and vaporizing (Zhang et al., 2001; 2002). The DC characteristics includes axial velocity, lateral velocity, back splash half-cone angle of ejected DC, half-cone angle of penetrated DC, impact peak pressure, impact peak temperature, energy and momentum of the ejected DC, energy and momentum of the penetrated DC etc. Numerical simulations of hypervelocity impacts have been successfully conducted by many researchers (Hayhurst et al., 1997; Hiermaier et al., 1997; Clegg et al., 2005; Zhang et al., 2004). The numerical simulations of DC characteristics produced by an aluminum sphere projectile hypervelocity impact on different material bumpers at normal incidence have been carried out by using the SPH (smoothed particle hydrodynamics) technique of AUTODYN hydro-codes in this paper. The effects of impact velocity, the ratio t/d of bumper thickness to projectile diameter and bumper materials on the DC characteristics have been investigated. It is shown that the DC characteristics are different with impact velocities, t/d and bumper materials.