Numerical simulation of characteristics of debris cloud produced by projectile hypervelocity impact on bumper

W. Zhang, G. S. Guan, C. X. Jiang and B. J. Pang

Hypervelocity Impact Research Center, Harbin Institute of Technology, P. O. Box 3020, No.2 Yikuang Street, Harbin 150080, P. R. China (E-mail: zhdawei@hit.edu.cn)

All spacecraft in low orbit are subject to hypervelocity impacts by meteoroids and space debris. These impacts can damage spacecraft flight-critical systems, which can in turn lead to catastrophic failure of the spacecraft. The numerical simulations of characteristics of debris cloud produced by projectile hypervelocity impact on bumpers with constant areal density at normal have been carried out using the SPH technique of AUTODYN in this paper. The debris cloud characteristics includes axial velocity, lateral velocity, back splash half-cone angle of ejected debris cloud , half-cone angle of penetrated debris cloud, impact peak pressure, impact peak temperature, ejected energy and momentum, penetrated energy and momentum etc. The impact velocities are from 3km/s to 15km/s. The bumper materials are Kevlar, magnesium, aluminum, titanium, molybdenum, lead and tungsten. The ratio t/d of bumper thickness to projectile diameter is from 0.25 to 3.5. The effect of impact velocity, t/d and bumper materials etc. on the debris cloud characteristics has been investigated. It is shown that the debris cloud characteristics are different with various impact velocities, t/d and bumper materials. The impact peak pressure and temperature increases with the increasing of impact velocity and bumper density, but the peak pressure and temperature don't vary with the ratio t/d. The axial and lateral velocity increase linearly with the increasing of velocity, the axial velocity is larger than lateral velocity. The axial and lateral velocity vary with the bumper density increasing in third order equation, the axial and lateral velocity decrease with the t/d increase in third order equation. The penetrated energy, momentum and ejected momentum increase slightly with the velocity increase, ejected energy decreases slightly with the velocity increasing, the penetrated energy and momentum are distinctly larger than the ejected energy and momentum. The ejected energy, momentum and penetrated momentum decrease slightly with the bumper densities increase, penetrated energy increases slightly with the velocity increase. The ejected energy and momentum, penetrated momentum increase with the t/d increasing, penetrated energy decreases with the t/d increase, the penetrated momentum are distinctly larger than the ejected momentum. The half-cone angle of penetrated and ejected debris cloud increase with the velocity increase, the half-cone angle of penetrated debris cloud decreases with the t/d increase, the half-cone angle of ejected debris cloud doesn't vary with t/d. The half-cone angle of penetrated and ejected debris cloud increases with the bumper densities increase in third order equation.