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NUMERICAL SIMULATION OF SMALL FRAGMENT HYPERVELOCITY IMPACT AGAINST FLUID FILLED ELEMENT IN THREE-MATERIAL STATEMENT

Abstract

Effective mechanical shielding of Space vehicles is actual problem since the flights in outer Space face the Space debris problem, especially at low Earth orbits and geosynchronous orbits. The main idea of protecting Space vehicles from hypervelocity small (character size of 1 cm order) fragments is to dissipate the impact energy in some way by the shielding layer. Simple increasing of the vehicle shell thickness is not effective as at speeds of the order of kilometers per second the depth of penetration is big and the total weight becomes unacceptable for a practical usage. The new concept suggested in the beginning of the 21-st century states that protecting the spacecraft by a honeycomb of small gas-filled containments could form a much more efficient shield with lower mass. As multi-sheet shielding concept uses thin shield elements to repeatedly shock the impacting projectile to cause its melting and vaporization, so is the new gas-filled containment shield concept still using continuous effect of pressurized gas to cause fragments slowing down, heating, melting, atomization and evaporation. Besides, using many successive layers of gas-filled spherical bumpers makes it possible to increase the area of the zone of impact energy redistribution including the side and front walls of bumpers due to the property of gas to transmit pressure in all directions, which provides a considerable advantage to the present concept as compared with multi-layer shields. The gas-filled bumper shields could be reusable, as the rate of gas phase leakage on depressurization is rather low and the loss of mass is negligible during the characteristic time of impact. In the paper, we numerically study the standalone interaction between hypervelocity impactor and the fluid-filled spherical shell as the elementary act in the composite honeycomb shield assembled of fluid filled containments. The features of initial outward penetration process are studied for wide variation of projectile and containment material properties.