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EXPERIMENTAL STUDY ON BALLISTIC LIMIT OF AN ADVANCED IMPEDANCE-GRADED MATERIAL SHIELD

Abstract

Impedance-graded-material-enhanced Whipple shields have excellent protective performance, which has been proven by previous studies, and a preliminary exploration of the reasons for their superior shielding capability has been conducted. In this study, the ballistic limit was determined for improved impedance-graded-material-enhanced Whipple shield: Ti/Al/Mg shield. A series of hypervelocity impact experiments were conducted to study the ballistic limit of a Ti/Al/Mg improved shield, which consists of a high-acoustic-impedance coating based on our early Al/Mg shields. The Ti/Al/Mg bumper is superior to the Al/Mg bumper in that less damage to the rear wall occurs. The results of shock pressure and specific internal energy show that a high-acoustic-impedance titanium alloy coating can generate higher shock pressures and induce a greater temperature increase, which is more effective for fragmenting an impacting projectile. The preliminary ballistic limit curve was generated. This curve suggests that the shielding capability of a Ti/Al/Mg shield is significantly greater than that of aluminum and Al/Mg shields, where the bumper has the same areal density. The critical projectile diameter for Ti/Al/Mg shields is an improvement of approximately 30.7% compared with aluminum shields. Finally, to explore the transition velocities of the ballistic limit curve of the Ti/Al/Mg shield, a theoretical analysis was conducted, the transition velocity from Region II to Region III is 6.2 km/s compared with 7.0 km/s for aluminum projectiles impacting the aluminum bumper. However, the transition point in the experimental ballistic limit curve is not apparent, and the critical projectile diameter increases with increasing velocity in the range of 3.0–8.0 km/s.