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DAMAGE AND FATIGUE OF SHIELD WITH TYPICAL DEFECTS BY IMPACTS OF HIGH-SPEED PROJECTILES AT DIFFERENT AMBIENT TEMPERATURE

Abstract

Space environment is a major cause for the induced fault of spacecraft in orbit. Space environment is mainly including vacuum environment, temperature environment, electron irradiation environment, etc., among them, the temperature environment is a main factor influencing the performance of spacecraft surface structure. The space debris shield is usually located in the outermost layer of the spacecraft, and temperature change of the protective material is very intense, which material performance are influenced by ambient temperature. At the same time, with the increase of the number of space debris, the probability of multiple impacts on the same part of the spacecraft increases. After spacecraft is impacted by space debris, there may be craters, cracks and other defects in shield. Therefore, it is necessary to study effect of different ambient temperature on fatigue damage of shield with craters and cracks under high-speed projectile impacts. For this study, a two-stage light gas gun is used to launch Al-sphere projectiles impacting on Al-plate Whipple shield with craters and cracks on bumper in test chamber at different ambient temperature. The effects of craters and cracks on protection performance of Al-plate Whipple shield are analyzed. Based on the existing ballistic limit equation, the impact limit curve of Whipple shield with crater and crack defects was obtained by numerical simulation. By comparing the shape change of projectile, the propagation of stress wave in projectile and shield, the change of projectile velocity and the transformation of system energy composed of projectile and shield, the mechanism of the effect of defect on protection performance of shield is analyzed using numerical simulation method. At the same time, the effects of crater and crack defects on the fatigue strength of shield are studied, and the influence of residual stress on the fatigue strength of shield is analyzed. The study focus on damage and fatigue of shield with crater and crack defects by impacts of high-speed projectiles at different ambient temperature. The results indicate that the crater and crack defects on bumper of Al-plate Whipple shield reduce the protection performance of the shield. Compared with shield without defects, the residual velocity of projectile breaks through the shield with craters and cracks is relatively larger. The thermal stress caused by the change of space environment temperature aggravates the fatigue damage of the defective protective structure.