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EXPERIMENTAL AND NUMERICAL ANALYSIS OF THE CRATER SHAPE OF PERFORATED ALUMINUM SPHERES SIMULATING SRM SLAG

Abstract

SRM slag, which is discharged from Solid Rocket Motors and contains porosity, constitutes a dominant form of space debris. According to the modeling of the space debris environment by ESA/MASTER, most debris ranging from 0.1 to 1 mm in diameter that frequently collides with low Earth orbit satellites is SRM slag. Furthermore, ISO states, "Solid rocket motors shall be designed and operated so as not to release space debris larger than 1 mm in their largest dimension into Earth orbit." However, this rule is determined based on experiments conducted with projectiles that lack porosity since SRM slags are extremely difficult to obtain. Moreover, only their size is mentioned. It is plausible that the impact of SRM slag is less severe than that of debris lacking porosity because the mass of SRM slag is reduced due to porosity. In this study, to enable more realistic debris design, the aim is to develop numerical calculations capable of simulating SRM slag impacts by conducting experiments using a two-stage light gas gun. During the impact between SRM slag particles, craters with two valleys are observed. For hypervelocity impact and numerical simulations, projectiles with uniaxial holes and small porosity were used. When projectiles collide along the vertical axis with a single target, craters featuring two valley-like structures were obtained. The errors in crater size and diameter between experiments and simulations were at least 12%. This result suggests that SRM slag impacts can be replicated through numerical simulations when considering the accuracy of the value used for plastic strain in the numerical simulation. The fact that craters obtained with SRM slag were smaller than those obtained with solid spheres used in the test indicates that the impact of SRM slag is less severe than that of solid spheres, suggesting a need for revising ISO regulations. By constructing a numerical simulation model of SRM slag, accurate risk assessment can be performed even if acquiring SRM slags is difficult.