Resistance force from a powder layer during low-velocity impact: Variations due to porosity and ambient pressure

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The investigation of impact and penetration behavior in powder layers is important for understanding the impact and penetration behavior into the regolith layer on the surface of small bodies. Experiments involving the vertical impact of centimeter-sized cylindrical and spherical projectiles into submillimeter to millimeter-sized particle layers at speeds of 0–4 m/s have been explained by a model where inertial forces and depth-dependent resistive forces act independently on the penetrating projectile. Proportionality coefficients (hereinafter referred to as the "two resistance coefficients") related to the internal friction angle of the powder were derived from these experiments (Katsuragi and Durian, 2013).
In this study, experiments under both reduced and atmospheric pressure conditions were conducted to investigate how the two resistance coefficients vary with the porosity of the particle layer. The porosity was changed by using particle layers composed of particles of different sizes ranging from 5 to 59 microns. The internal friction angle of each particle layer was determined through shear tests. The impact velocity was about 2 m/s. Coils were attached to the particle container, and the induced electromotive force generated as the magnetic projectile passed through each coil was recorded to analyze the deceleration behavior. The projectile's penetration depths, both during penetration and after it came to a stop, were measured under the same experimental conditions as those used for recording the deceleration behavior, using a flash X-ray system.
The results showed that the penetration depth increased with increasing porosity and that the penetration depth under atmospheric pressure was greater than that under reduced pressure. This trend is consistent with previous measurements of penetration depths of spheres (Clark and McCarty, 1963). The two resistance coefficients obtained under reduced pressure were approximately 2 to 3 times higher than those measured under atmospheric pressure for all particle layers and tended to increase with the internal friction coefficient.

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