1. Title
FY 2001 Ground-based Research Announcement for Space Utilization Research Report

2. Research Term
FY 2001~2003

3. Research Fields
Space Utilization Technology Development

4. Research Categories
Phase I(A)

5. Research Theme
Development of a gas-gun-type space debris impact simulator for 10-km/s impact and a novel evaluation method of shielding ability of bumper materials

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8. Summary of Research
8.1 Objective/Significance
The objective of this research is to develop a gas-gun type of space-debris impact simulator for 10-km/s impact and an evaluation method of bumper shield. Because bumper materials of space infrastructures are in physical states such as solid, liquid, gas, plasma, or in mixed phase under the hypervelocity impact of space debris, the success of this research project can be applied to a scientific study regarding the dynamic response of fracture and deformation of materials in such physical states, and can also be applied to an engineering study on the shielding ability of aerospace materials and debris-bumper systems.

8.2 Method
i) Improvement and performance analysis of the system>
   The existing three-stage light-gas gun and peripheral parts are improved for aiming at speed up to 10-km/s and for its utilization in space environment research. Its performance in searching for optimum conditions in the hypervelocity range is also analyzed.

ii) Development of a new launching method of spherical projectiles>
   For the study on the shielding ability of bumper materials, projectiles and debris clouds must have no disturbance in their flights under low-pressure atmosphere. Thus, a new method of sabot separation utilizing projectile accelerating gas, that is, active separation of sabot, is applied to the launching of spherical aluminum projectiles.

iii) Development of an analytical model for evaluating bumper-shielding ability>
   For the evaluation of
bumper shielding against projectile impact, flash X-ray radiographs are used to characterize the relationships among the fine structure of a bumper material, projectile-impact condition, and the spatial distribution of physical quantities of a debris cloud produced. These data are used to predict the damage caused by a chain impact of a debris cloud on an adjacent material. Steel materials are impacted by plastic projectiles such as simulated ice in space to predict damages by two-dimensional computer simulation.

8.3 Results
   i) Improvement and performance analysis of the system> A new method of projectile acceleration was examined, and the theoretical effect and superiority of the preheating gas were verified. The maximum velocities obtained were 8.9 km/s for 0.6-g projectile and 7.0 km/s for 1.4-g projectile at the two-stage mode and 7.2 km/s for 1.0-g projectile at the three-stage or preheating mode.
   ii) Development of a new launching method of spherical projectiles> The active separation of sabot was realized in the projectile launch in the velocity ranges of 2.60 to 4.84 km/s and 3.30 to 5.70 km/s, respectively, for a small two-stage light-gas gun and a two-stage operation of the three-stage light-gas gun. A physical model for relating a projectile velocity to an impulse working on a sabot was proposed and applied to predict sabot separation at higher velocities. Projectiles and debris clouds were not disturbed in their flight.
   iii) Development of an analytical model for evaluating bumper-shielding ability> Debris clouds produced from monolithic aluminum and ceramic-fiber-reinforced aluminum bumpers were quantified by calculating debris spatiality to match X-ray radiographed findings, that is, CODSMAX, and were correlated with the fine structure of the bumper materials and impact conditions. A depth profile equation was derived and successfully reproduced the debris-chain-impacted damages using CODSMAX data. A new computational model was developed to reproduce spall fractures and damages of standard steel materials in a wide range of impact velocity.

8.4 Potential for Space experiments
Both of the experimental apparatus and the evaluation method developed will enable the study of the effect of space environment from the viewpoint of materials science and the engineering tests of the bumpers for the design of space infrastructures.

9. Publication List

10.URL