SPACE DEBRIS SYMPOSIUM (A6)
Hypervelocity Impacts and Protection (3)

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BALLISTIC LIMIT THICKNESS AND WEIGHT OF FLEXIBLE MATERIALS FOR SUB-MILLIMETER STEEL SPHERE IMPACT AT 6 KM/S

Abstract

When unmanned spacecraft in low earth orbit is designed, debris protection has to be considered. JAXA has prepared the standard and handbook for debris protection design of unmanned spacecraft. Designers should choose structure material which has enough protection capability against debris impacts. However, it is impossible for some components, for example, expandable structures and wire harnesses. They are made of vulnerable material for debris impact, and their damage can cause mission failure. To protect these components, designers need flexible debris bumper. Therefore, the authors propose fabric bumper shield made of high strength fiber. Fabric can install complex shape structure. Consequently, it can be expected to apply the bumper to expandable structures. High strength fiber fabric has been used as a bulletproof jacket. Thus, there are many studies on low velocity impacts on high strength fiber fabrics. High strength fiber fabrics are also known to be useful for protection from high velocity impacts. Alamido or ceramic fiber fabrics are used as a part of the Staffed Whipple Bumper installed on the International Space Station. However, sub-millimeter debris impact data of the high strength fiber fabrics have not been obtained enough to use them as a debris bumper shield. The purpose of this study is to know ballistic limits of the high strength fiber fabrics against sub-millimeter debris impacts. Hypervelocity impact experiment results of alamido and glass fiber fabrics are reported in this paper. Hypervelocity impact experiments were performed to Kevlar (alamido fiber) clothes, Beta Cloth (glass fiber fabrics coated with aluminum), and Nextel (ceramic fiber) clothes. Steel spheres less than 1 mm in diameter impacted on the stacked fabrics at 6 km/s. In this study, ballistic limit is defined as “non perforation of the projectile”. Ballistic limit thickness and weight of the fabrics were calculated from perforated layers. The Beta Cloth was the thinnest bumper, and the high modulus Kevlar cloth was the lightest bumper. To stack thinner clothes seems to be effective to be improved protection capability of a fabric bumper.