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ENHANCING WHIPPLE SHIELD PERFORMANCE THROUGH NUMERICAL ANALYSIS AND INNOVATIVE MODIFICATIONS

Abstract

Whipple shields have been widely used as a primary protection system for spacecraft against hypervelocity impacts of micrometeoroids and orbital debris. However, the effectiveness of the shield depends on various factors such as the size, velocity, and incidence angle of the impacting particle. In this study, a numerical investigation is conducted to simulate the behaviour of Whipple shields under different impact conditions and to propose modifications to improve the shield's effectiveness.

To simulate the effect of particles on the Whipple shield, a numerical model is created using the finite element approach on ANSYS Workbench. The model considers the particle size, velocity, incidence angle as well as the thickness and spacing of the shield layers. The results show that the Whipple shield effectively reduces particles' impact energy and minimises the damage to the spacecraft. The simulation also reveals that the shield's performance is highly dependent on the spacing between the layers. A decrease in the spacing leads to a significant increase in the shield's effectiveness.

Several modifications are proposed to improve the Whipple shield's performance, including changes to the thickness, and spacing of the layers and the use of novel materials. The results show that reducing the thickness of the shield layers while maintaining the same total thickness significantly improves the shield's effectiveness. Furthermore, using high-strength and ductility materials can provide a more robust shielding system.

The findings of this study provide valuable insights into the behaviour of Whipple shields under different impact conditions and suggest potential modifications to enhance the shield's effectiveness. The proposed modifications can inform the design of more effective and reliable shielding systems for future space missions and could have important implications for the safety of space travellers and the success of space exploration missions.