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MODELLING HYPERVELOCITY IMPACTS ON WHIPPLE SHIELDS USING A COUPLED FINITE ELEMENT-DISCRETE ELEMENT METHOD

Abstract

The limitations on projectile velocity and size in conventional hypervelocity launchers make numerical methods useful tools when investigating capabilities and ballistic limits of protective Whipple shields. A debris cloud typically consists of a combination of solid, liquid, and vaporised material, and different combinations of velocity and shield thickness produce different fragmentation and phase change responses in the projectile. Since the solid fragments pose the most significant threat to the successive shield layers, numerical methods should be capable of accurately describing the geometry and distribution of solid fragments and distinguishing them from the less threatening liquid and vaporised debris cloud elements.

In this paper, a coupled finite element-discrete element method is applied in LS-DYNA, where solid elements are converted to discrete elements when a fracture criterion or a critical temperature is reached. The method has been applied to Whipple shield configurations found in the literature and compared to the available experimental and numerical results. The results show that the coupled method is able to describe the material failure during hypervelocity impact with a relatively simple modelling approach and is further able to determine the capacity of Whipple shields. Numerical ballistic limit curves were determined and compared to the semi-empirical ballistic limit curves from the literature and were found to give similar results.