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NUMERICAL MODELLING OF IMPACTS ON WHIPPLE SHIELDS AT 2.6 – 5 KM/S WITH MATERIAL VARIABILITY TO CAPTURE VARIATION IN FRAGMENTATION AND SHIELD PERFORMANCE

Abstract

Impacts on aluminium Whipple shields in the velocity regime between low velocity and intermediate velocity typically result in a mixed-phase debris cloud, with one large solid fragment as well as multiple smaller fragments. The solid fragments in these debris clouds can inflict great damage to spacecraft, as the velocities are relatively high (around 3-4 km/s), but not high enough to fully fragment the projectile on impact with a bumper. When repeating experiments around this velocity regime, a scatter can be found in the results, where the size, shape and orientation of the large solid fragment varies from test to test, leading to a scatter in the performance of the Whipple shield, with some tests passing and some failing for the same configuration.

In this paper, numerical simulations are performed in the IMPETUS Solver using a Smoothed Particle Hydrodynamics (SPH) method and the results are compared against three repeated impact tests from Færgestad et al [1]. Traditional AA6061-T6 dual-wall Whipple shields are impacted by AA1100 spherical projectiles at three impact velocities (2.6, 3.25 and 4 km/s), and each test is repeated. The numerical simulations in this paper aim to replicate the scatter found in the test results by incorporating material variability in the material model, thereby generating a variation in the size, shape and orientation of the largest fragment. The results show that incorporating material variability in a numerical model is important, especially in the velocity regime investigated, to ensure models are robust and reliable.

[1] R.M. Færgestad, L. Olivieri, C. Giacomuzzo, S. Lopresti, G. Pitacco, A. Francesconi, T. Cardone, K.A. Ford, J. K. Holmen, O. S. Hopperstad, T. Børvik, Hypervelocity impact against aluminium Whipple shields with systematic parameter variation: An experimental and numerical study (2024). To be submitted for possible journal publication.