Abstract

Numerical models have been developed in LS-DYNA to develop understanding of hypervelocity impacts (HVI) of space debris on protective shields around satellites (Whipple shields). Capturing the debris cloud after impact to accurately predict the damage caused is one of the key challenges concerning HVI. Traditionally smooth particle hydrodynamics (SPH) has been used to develop numerical simulations. However, a method incorporating a combined FEM and DEM (discrete element method) has been used to convert elements to particles upon reaching a damage threshold.

A parameter study has been performed in the original paper to investigate some important material and numerical parameters, i.e.

- Density (virtual materials only),
- Mesh size,
- Fracture parameter W_c,
- Friction coefficient.

This project aims to extend the parameter study by using different materials to gain a better understanding of HVI mechanics and to identify the most important material parameters. Existing and well-known materials will be implemented in the numerical simulations. The three common materials used in space applications are lightweight materials: aluminium, carbon fibre reinforced composites (CFRP) and additive manufactured (AM) metals, of which the first two will be considered in the analyses.

The project will consist of two parts:

Part I
Parameter study of metals. This includes a study on a variety of aluminium alloys. For comparison, steel alloys will also be considered mainly due to having a higher density. Material cards are readily available, and implementation should be straight forward.

Part II
Parameter study on composites. The existing model was initially developed to account for isotropic materials therefore requires modifications to be able to simulate orthotropic composites. The second part of the project extends to the implementation of composite materials with orthotropic behaviour. The aim being to explore the behaviour of multiple ply, orthotropy and intralaminar adhesion. This may pose a series of challenges due to the nature of the composite materials and therefore an emphasis on Part I may be further considered.

Different alloys and materials will be compared by qualitative analysis of the debris cloud as well as quantitatively by means of the following simulations results:

- Residual velocity and debris cloud diameter
- Conversion of elements to particles due to temperature
- Percentage of solid material in debris cloud.