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Projected area and drag coefficient of high velocity irregular fragments that rotate or tumble

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Abstract

3 degrees of freedom (DOF) exterior ballistic computer models are used in fragment studies to calculate individual trajectories of each fragment based on drag coefficient and the projected (presented) area in the direction of velocity of center of mass. The expectation of a randomly distributed projected area is commonly used for fragments that tumble (random rotation) during flight. We forecast a model where the expected drag coefficient is dependent of shape and Mach number. Rotation or tumbling only affects the expected projected area. Models of projected areas during tumbling and rotation are presented. An examination of the data by McCleskey (1988) indicates that the volume of the fragment to the power of 2/3 is a better parameter to characterize the drag coefficient of the fragments than the maximum projected area. Hydrocode simulations are used to verify results and to study projected area and drag coefficient of fragments.

Keywords: Fragments, form factor, Mach number, drag coefficient, Cauchy area, tumbling

1 Introduction

Range of 3D-rotating irregular fragments from warheads can currently not be simulated directly by computational fluid dynamic **(**CFD) simulations due to the long computer run time. Even 6 degrees of freedom (DOF) exterior ballistic computer models are commonly not used due to inaccurate models of torques on irregular fragments during flight. In general, the arbitrary shaping of the investigated fragments makes direct numerical simulation or strict analytical study highly complicated and prohibitively expensive when applied to the whole ensemble of fragments. Approaches to estimate drag of the arbitrary body have been based on mimicking that the body drag can be described by the correcting coefficients to well-studied regular shapes like spheres or ellipsoids (Hidy 1984 and Lerman 1979).