PREDICTION OF FRAGMENT DISTRIBUTION AND TRAJECTORIES OF EXPLODING SHELLS

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Abstract. A semi-empirical model allowing for prediction of natural fragmentation of exploding shells is described. The initial velocity, projection angle, size and location, obtained for each fragment, are used by a point mass trajectory routine to determine the overall fragment distribution on the ground and to model fragments hitting a three-dimensional object. Examples of validation against experimental data for 105-mm shell and a mortar bomb are shown. The proposed model is useful for munition assessments, including a prediction of safety hazard in a credible accident.

INTRODUCTION

This study focuses on the natural fragmentation of shells. Although sophisticated numerical methods using hydrocodes are currently available for fragmentation prediction, these can be time-consuming to learn and require lengthy computation. Moreover, the reliability of prediction is sensitive to input parameters which are not readily (if at all) available. Here we describe a fast turn-around semi-empirical model.

Most of the available semi-empirical models have two major problems. Either they use Mott distribution in which case they fail to predict the actual fragment distribution or using an input distribution they fail to predict fragment velocity distribution. The proposed model employs different approaches. Two major elements which distinguish it are: the geometrical transformation featuring some nonlinear effects and allowing for initial velocity modelling in geometrically complex shells with varying case thickness; and the introduction of the empirically based classification of fragments to the natural fragmentation modelling methodology. The latter alleviates any need for undesired model calibration.

In comparison with controlled fragmentation, designs relying on natural fragmentation provide the benefits of the low manufacturing cost and high strength during firing. However, for natural fragmentation mass distribution is difficult to assess. For a prediction of fragment mass distribution, the best known is the Mott equation [1]. References [2,3] provide a review of this and other methods based on statistical distributions. Such methods are largely concerned with finding a general distribution formula and omit specific information about physics related to a particular design. Consequently the models which use statistical distributions frequently require a calibration against experimental data, which reduces their predictive value. In contrast, the proposed method relies strongly on the varying magnitude and angle of the initial velocity of fragments as well as build of the shell.

DESCRIPTION OF THE MODEL

Figure 1 shows a representative shell for which the proposed fragmentation model was developed. As in any reliable model it is important to provide an accurate geometry representation and for realistic shells, a CAD geometry should be used.

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