A METHOD FOR PREDICTING NATURAL FRAGMENTATION OF WARHEADS

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Abstract. The purpose of this study is to develop a new method to estimate the natural fragmentation of axis symmetrical warheads. The method is able to predict the projection of fragments at various projection angles, including the fragmentation velocities, types and sizes. It is fairly close to Mott's fragmentation predictions for cylinders, and to trial data for 105-mm and 81-mm shells. The model captures essential characteristics of natural fragmentation.

INTRODUCTION

The purpose of a fragmentation warhead is to generate multiple fragments with adequate mass and velocity to damage the target(s) within its intended lethal zone. There are several ways by which the fragmentation of the casing can be achieved including: natural fragmentation, shear control, metallurgical fragmentation control, inserts, pre-formed fragments, and mass focusing. Fragmentation control is used because the fragment mass distribution is very difficult to assess for natural-fragmentation warheads. However, natural fragmentation is still used in some military applications because it is cheap and provides high strength during firing. There is also a need to assess safety of existing warheads. Although numerical modelling using hydrocodes like AUTODYN or DYNA are currently available for prediction of natural fragmentation, these can be time-consuming to learn and to model the warhead. Moreover, the reliability of prediction is sensitive to input parameters, which are not readily (if at all) available.

This study attempts to develop a new semi-empirical method of predicting natural fragmentation of axis-symmetrical warheads. This will aid in the assessment of the overall lethality of a natural-fragmentation warhead.

FRAGMENTATION PROCESS

The fragment size and types obtained (during the fragmentation process) are dependent on case grain size, brittleness, toughness, case thickness, confinement, and explosive fill. The physical processes involved in fragmentation are as follows:

- The detonation of a warhead generates an explosive pressure of around 4×10^6 pound per square inch that is imparted to the metal case in several microseconds.
- The detonation wave continues along the inner surface of the warhead and exerts pressure on successive cross-sections.
- The cross-sections expand at very high strain rates in a short period of time, resulting in plastic expansion (up to 50% for steel cylinders) and in reduction of wall thickness (probably with strain hardening), until a critical stress for failure is reached.
- The warhead shell fractures into fragments by a combination of shear and brittle fractures.
- After initial fragmentation, the fragments are accelerated continuously by expanding gases, until the gases can escape freely between the fragments. In the meantime, the fragments continue to break up (that is, secondary fragmentation), probably caused by tensile fractures from the interaction of release waves propagating from positions of initial fractures, and by shock-induced vibration.

FRAGMENTATION MODEL

In the proposed method, to model the fragmentation process, the warhead is first divided into small elements, as shown in Figure 1. For the calculation of fragment velocity of each element, we used a methodology proposed in [1], as it appears to be fast and well-suited for differing-in-thickness and general-in-shape warheads. This calculation involves the transformation of the geometry of the warhead into the hollow sphere as shown in Figure 2, assuming constant charge mass and casing mass as well as constant surface area of the charge. Then the Gurney energy balance technique is applied [2-4]. For details on the procedure of the velocity calculation and its validation refer to [1].

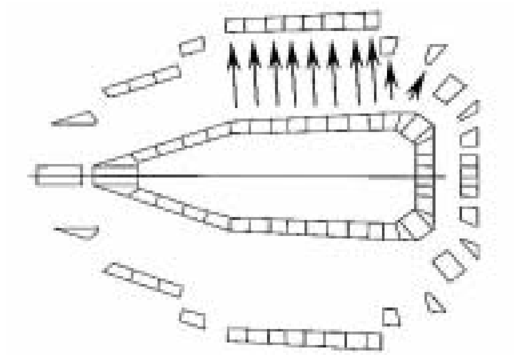

Figure 1. Illustration grouping of elements based on similar fragment velocities and projection angles.

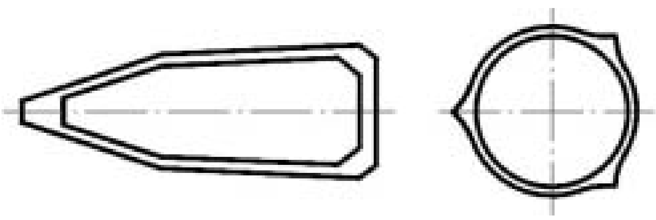

Figure 2. Transformation of warhead into spherical warhead.

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