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CASING TOUGHNESS EFFECT ON ANTI-AIR FRAGMENTATION WARHEAD PERFORMANCE

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Fragmentation warheads have many applications for example anti aircraft. Anti-air fragmentation warhead performance depends on fragment size, fragment velocity and so on. In this paper, we research on casing toughness effect of two alloy steels on fragment size. We tested two type of steels with different thoughness but equal hardness. Data and test results were summarized in this paper.

Intoduction

Fragmentation missile warheads constitute one of the most widely used and developed types of ammunition. They are intended to defeat virtually all types of targets, excluding underground, underwater, and heavily armored ones. As to target type, we distinguish multipurpose fragmentation warheads and specialized fragmentation warheads intended to defeat specific targets. The latter warheads include antipersonnel warheads intended to inflict damage upon unsheltered and lightly protected personnel (with conventional weight "w" of splinters ranging from 0.1 to 1 gr), antivehicle warheads intended to defeat ground and air soft-skinned materiel (w = 1 to 10 gr), and antiarmor warheads intended to defeat lightly armored targets featuring a steel equivalent of up to 20 mm and other hard-to-hit targets like battlefield missiles (w = 10 to 100 gr).

In terms of fragmentation pattern, the following three types of warheads are distinguished(figure1):

= warheads with circular patterns;
= warheads with axial patterns;
= warheads with radially directed patterns.

Circular pattern fragmentation warheads are most commonly used. Their main advantages are the highest efficiency factor of explosive charge energy, arrangement of the warhead in any part of the missile, and engagement of targets at any side misses.

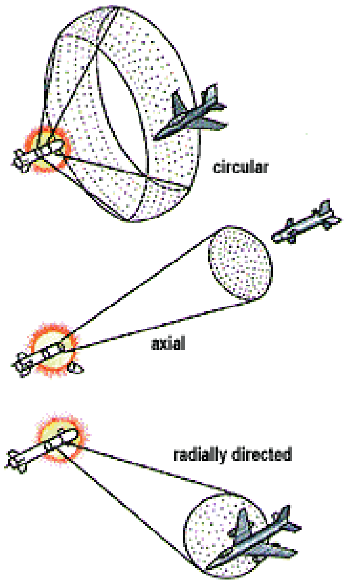

Figure1- three types of fragmentation pattern.

The warheads of missiles and rockets featuring high g-loads at launch usually employ controlled fragmentation envelopes created by grooving, using winded grooved strips, embrittled lattices produced, for example, by electron beam or laser treatment and the like. Warheads featuring relatively low g-loads at launch ($n < 100$), mainly SAM warheads, are fitted with assembled and bonded envelopes with prefabricated fragments in the form of cubes and cylinders made from steel or heavy alloys on the basis of tungsten with a 16 to 18 gr/cm3 density[1].

Work is underway to increase the incendiary effect of prefabricated fragments by adding magnesium, zirconium, and beryllium. Missile warheads are filled with mixtures of trotyl and hexogen of the TG 40 and TG 50 types or trotyl with hexogen and aluminum powder of the TGA, TGF, and other types. The use of more powerful explosives, mainly octogen (density 1.9 gr/cm^3 and detonating velocity 9100 m/s), is limited by their cost. The volumetric efficiency (ratio of explosive charge weight to warhead weight) for SAM warheads is usually within 0.4 and 0.6, and the speed of fragments is 1800 to 2500 m/s.

Effective properties on performance

HE warhead performances depend on its geometrical shape and dimensions, mass of explosive charge and explosive type, material of warhead case, initiation way and initiation point position, fuze type, etc.

Material properties that influence fragment deformation and fracture include the yield strength, tensile strength, hardness, elongation and toughness. Therefore, these factors affect on fragment size and fragment velocity.

Zecevic et al.(2004) noted a strong dependency of fragments number and their mass from the ratio R_m/R_v (R_m: tensile strength, R_v: yield strength). Steels with higher ratios R_m/R_v generated considerable higher fragments number[2].

Chhabildas et al.(2001) noted first, the average fragment mass is significantly smaller for the material in its heat-treated condition than in its as-received condition. Second, the framing camera results indicate that the dynamic ductility of the material in its heat-treated condition is less than that of the material in its as-received condition, and the heat-treated cylinders vented sooner than the as-received cylinders[3].

Our experiments were done with shear control fragmentation. The shear control method of fragmentation derives its name from the ability of the technique to control both the initiation locations of shear fractures in the metal case and the orientation of the planes along which the fractures propagate. This method uses families of mechanical stress raisers in the form of a grid system processed into the inner surface of the metal case.

Pearson(1978) introduced shear control method[4]. The shear control method has been used effectively with a variety of plain carbon and alloy steels representing a hardness range of from about 75 RB to 40 RC, with the tensile strength range of from about 400 MPa to 1300 MPa [5].

We research on shear control fragmentation with helix shear. Because of the wide use of steel alloys in fragmenting munitions, their fragmentation properties are generally well characterized. We have recently investigated comparison of performance of two alloy steels.

This paper compares the fragmentation characteristics of DIN 1.7035 , 25CrSiNiMo6 alloy steels with shear control methods in their heat-treated condition.

Description of Experiments

We considered casing toughness effect on fragment size. These experiments were conducted using test items of two different cylinder materials. Casing was fabricated using two alloy steels: DIN 1.7035 , 25CrSiNiMo6.

These alloy steels received to 40 RC hardness with heat treatment. But their toughness were different (See table1).

Table1. Properties of two alloy steels.

Kind of steel	Hardness (RC)	Toughness (N/mm^2)
DIN 1.7035	40	112
25CrSiNiMo6	40	135

The experiments were designed to quantify the performance of the material in terms of fragment mass distribution. The basic experimental set-up used for measuring fragment size is illustrated in Figure 2. Air distance between warhead and water should be 1.0 times warhead diameter or larger than it.

The configuration of warhead was a cylinder. Charge to mass (C/M) ratio of approximately 1.2 and center initiation were chosen. A PETN booster was used to initiate the HMX main charge.

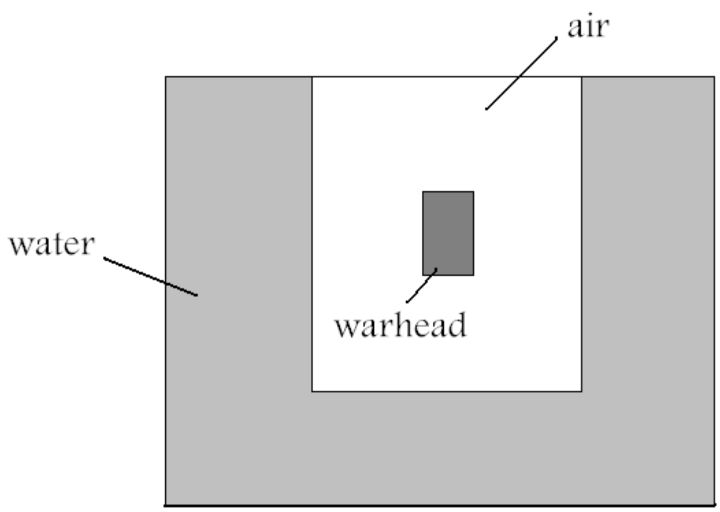

Figure2. Shematic test set-up.

Fragment Mass Distribution results

Recovered fragments from each test were cleaned and weighed (See Table2). The table provides a comparison of the fragment mass of materials for each of the two steels with weight higher than 1gr. Effective fragments should have weight more than 1 gr for anti-air warhead.

Table2. Classification of effective fragments results for two alloy steels.

Weight(gr)	Number of fragments (DIN 1.7035)	Number of fragments (25CrSiNiMo6)
1<w<2	96	161
2<w<3	61	63
3<w<5	43	34
5<w	27	17
Total	227	275

Conclusions

Effective fragments number for 25CrSiNiMo6 alloy steel was more than DIN 1.7035 alloy steel. Therefore, higher toughness with the same hardness has higher effective fragments number. As a result, higher toughness has higher performance with helix shear control method for anti air warheads. Of course, researches on this topic should be continued to obtain better results and relations between toughness and fragmentation properties of materials.

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