15th DAAAM INTERNATIONAL SYMPOSIUM
"Intelligent Manufacturing & Automation: Globalization – Technology – Men – Nature"
3-6th November 2004, Vienna, Austria

INFLUENCE OF WARHEAD DESIGN ON NATURAL FRAGMENTATION PERFORMANCES

Zecevic, B.; Terzić, J. & Catovic, A.

Abstract: *Design of the HE warhead is confronted with series of contradictory requirements. Lethal efficiency of HE warhead depends on the form and dimension of the warhead, quantity and type of explosive, warhead case material, warhead case thickness, fuse type, explosive train etc. Influence of warhead design on lethal efficiency is very complex.*

Key words: *warhead, natural fragmentation, fragment velocity, design, lethality.*

1. INTRODUCTION

Lethal efficiency of the HE warhead is a function of fragments velocity, geometrical shape and mass of natural fragments and their spatial distribution. Fragment velocity depends on the explosive mass and warhead metal case mass ratio, detonation rate and explosive density. Natural fragments spatial distribution (including their geometrical shapes and masses) is a complex function depending on internal and external geometry of the warhead case surface, warhead case mechanical properties (tensile strength and toughness) and energetic characteristics of the explosive.

An ability to predict the HE warhead fragmentation performances is derived from comprehensive data base with collected information on warheads natural fragmentation performances, including numbers, initial fragment velocities, warhead case material properties, fragment shape features and spatial fragment distributions etc.

2. EXPERIMENTAL RESEARHES OF FRAGMENT SPATIAL DISTRIBUTION

Natural fragmentized projectiles or warheads result in a wide range of random fragments distribution (masses and geometry). Expansion of the warhead case under detonation products pressure causes splitting of the warhead body into various sized fragments. The spatial fragments distribution around a detonating warhead is not uniform. The spatial fragments distribution is limited within a fan with small angular deviation. For a single-point initiation, the bulk fragments concentration is placed within polar sector angle of 80^0 to 105^0, referred to the projectile nose (Gold et. al., 2001). At the arena fragmentation test, fragments concentration density per steradian is measured when projectile or warhead are put in horizontal position at a certain distance from the ground (fig.1).

Experimental researches carried out by the authors were aimed on natural fragmentation performances estimation (number, mass and fragment form) of the warhead when the warhead or projectile design shape is changed. Spatial fragments distributions were determined through arena tests.

When it is necessary to compare lethal efficiencies for similar warheads, then a projectile or a warhead is put on the ground in the vertical nose-down position.

After the warhead explosion, number of hits and punctures at wooden sectors are counted and then hits number and punctures number per m^2 are calculated for each sector.

Fig. 1 Arena fragmentation test (measurement the fragments concentration density per steradian)

From such obtained data, dependency of fragments concentration density per m^2 as a function of sector distance is established. Further, a characteristic distance, at which fragments concentration density of 1 puncture per m^2 is obtained, is determined from the above function. This distance is called the warhead efficiency radius, which means that warhead with greater efficiency radius has corresponding greater lethal zone.

Fig. 2 Arena fragmentation test (measurement the fragments concentration density per m^2)

Experimental fragmentation tests were carried out with four types of HE warheads 128 mm M62, 128 mm M87 (Zecevic et al., 1986), 105 mm M1 and 155 mm M107 (Anon, 1983).

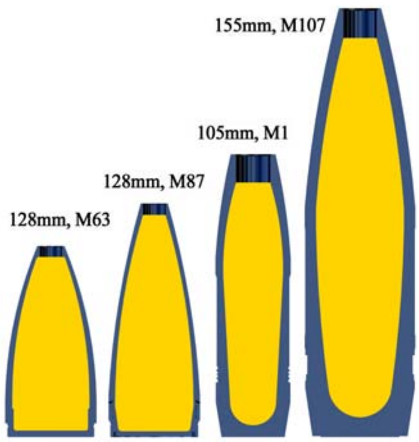

Fig. 3 Warheads

Fragments concentration density per steradian (spatial fragments density) for each polar sector of the arena:

$$d(\theta)=\frac{N_{sec}(\theta)}{A_{sec}(\theta)/R_{sec}} \quad [frags/steradian] \qquad (1)$$

where N_{sec} is fragments number which are stopped by wooden sector's panel with area of A_{sec} at distance of R_{sec} from the warhead detonation center and for a referred polar angle (fig.4).

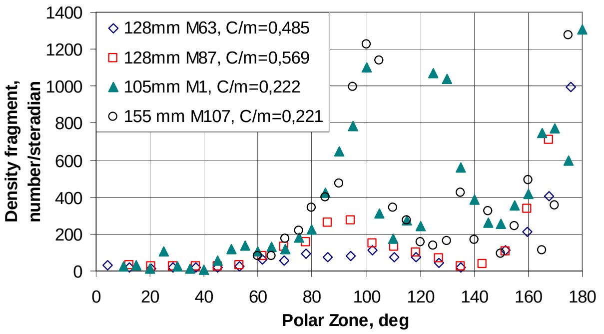

Fig. 4 Fragments concentration density per steradian as a function of polar zone

Fragments concentration density per arena sector's area at certain distance from the warhead detonation center:

$$d(R_i)=N_{pen}(R_i)/A(R_i) \qquad (2)$$

where N_{pen} is number of punctures at arena sector made of wooden panels, A is the sector's area and R is radial distance between the warhead explosion center and a certain sector (fig.5).

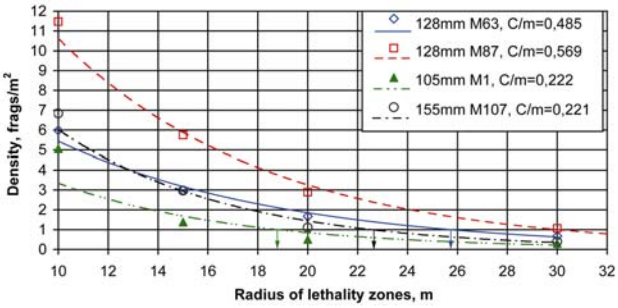

Fig. 5 Warhead lethality zone

Since the sophisticated measuring equipment for fragment velocity measurement was not available to authors, the Gurney's formula was used in order to predict initial fragments velocities (Karp, 1975). Initial fragment velocity variation for warheads filled with TNT explosive charge and for particular warhead segments was determined using methodology described in the Crull's report (Crull, 1998) (fig. 6).

3. FRAGMENTATION TESTING DATA ANALYSIS

Diagram of fragments density variation per steradian for certain polar zones shows that the greatest fragments concentration density appeared within polar zone of $110^{\pm30°}$ for artillery projectile 105 mm M1, and $100^{\pm20°}$ for 155 mm M107, but for rocket warheads 128 mm M87 and 128 mm M63 this polar zones were comprised by angles of $95^{\pm30°}$ and $100^{\pm25°}$ respectively within central polar sector of spatial distribution. At artillery projectile 155 mm M107 fragments density is 4,5 times greater than at the warhead 128 mm M87 and 12 times greater than at the warhead 128 mm M63. Fragments density within the polar zone of 160^0-180^0 was not considered because its influence on real warhead lethal efficiency was negligible. HE projectile 155 mm M107 has the greatest relative body wall thickness 0,138, while for the warhead 128 mm M87 it is 0,071. Warhead with greater body wall thickness produces more fragments with greater mean mass.

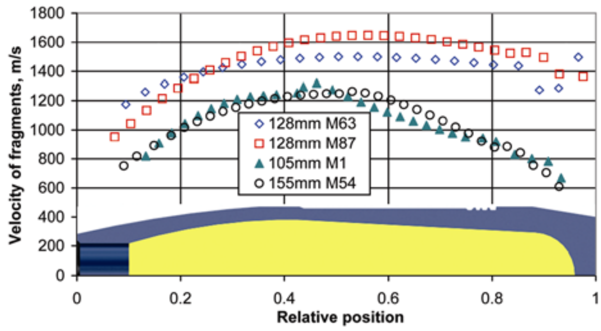

Fig. 6 Fragment velocity as a function of relative position

Maximum fragment velocities are achieved at warheads having greater explosive charge mass and metal case mass ratio *C/m*, which are appeared within central fragments polar zone. Maximum fragments velocities were produced by 128 mm M87 warhead. Fragments generated by projectiles 105 mm M1 and 155mm M107 have 30% less fragments velocity than fragments produced by the warhead M87 and more considerable variation of fragments velocities per polar zones. Warhead 128 mm M87 generates fragments with less mass but with more kinetic energy that ensure wider lethality zone. Lethal efficiency radius of the warhead 128 mm M87 is 30 m, while for the projectile 155 mm M107 it is 23 m, and for the projectile 105 mm M1 it is 19 m. These results were obtained through comparative arena fragmentation testing (Zecevic et al., 1986).

4. CONCLUSION

Influence of warhead design on lethal efficiency is very complex. Very important role play design factors as external and internal geometrical traces, relative warhead case thickness, explosive charge mass and warhead metal case ratio, type of explosive etc.

Until recently, any prediction method, which is capable to quantify particular influence of above parameters on lethal efficiency radius, has not been developed yet.

Authors shown that the warhead 128mm M87 (with greater fragment velocities and more uniform fragment velocities variation along the warhead body) has a greater lethal efficiency than the HE projectile 155mm M107 (which has greater fragments density per steradian and greater fragments mass).

5. REFERENCES

Anon (1983). *US Army Test and Evaluation Command Test Operations Procedure «Fragment Penetration Test of Armor»*, Report number TOP 2-2-722, ADA 125824.

Crull, M. M. (1998). *Prediction of Primary Fragmentation Characteristics of Cased Munitions*, UXO/Countermine Forum 1998, The Joint UXO Coordination Office

Gold, V.; Baker E., Ng K. & Hirlinger J. (2001). *A Method for Prediction Fragmentation Characteristic of Natural and Preformed Explosive Fragmentation Munitions*, ARWEC-TR-01007, US Army Armament Research, Development and Engineering Center

Karpp, R. & Predebon, W. (1975). *Calculation of fragment velocity from natural fragmenting munitions*, BRL Memorandum Report N0. 2509, USA Ballistic research Laboratories, Aberdeen Proving Ground, Maryland

Zecevic, B. & Eror, D. (1986). *Terminal Ballistic of 128 mm M87 Rocket*, FTV-270, Sarajevo