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THE DESIGN OF SMALL-CALIBRE TANDEM WARHEAD AGAINST TANK WITH REACTIVE ARMOUR

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In the design of the small-caliber tandem warhead, restricted conditions are proved to be more than those of big-caliber one. On the basis of a great many of experiments, this paper presents some proposals concerning the design of the small-caliber tandem warhead that include the determination of standoff, the arrangement of body shielding off explosive, unloading pressure structure, delaying explosive train, the chose of delay time and so on.

INTRODUCTION

Since M. Held proposed the thought of reactive armor against shaped charge jet in 1974 [1], researching work on this technology carries out in succession. M. Mayseless and his colleagues described the mechanism of the interaction of reactive armor with jet [2].

Researching work includes two aspects. One of them is how to disturb jet more efficiently with reactive armor. S. Frilling and his colleagues analyzed the disturbing effects of the different configuration of reactive armor on jet and obtained the configuration of maximum disruption against jet [3]. The other is how shaped charge gets rid of disturbance of reactive armor. For defeating tank and amour vehicle with reactive armor, single shaped charges have been changed into tandem warheads with two shaped charges, for example, AT-14HP-T and so on. The acting mechanism of tandem warhead is that the first shaped charge ignites reactive armor and the second shaped charge attack main armor after the exploding action of reactive armor faints. Reference [4] presents another method against reactive armor that the first shaped charge of the tandem warhead produces a hole on the reactive armor and doesn't ignite it, the second shaped charge jet penetrates the main armor through the hole.

The proposal of reference [4] demands that the first shaped charge should have more explosive amount. In the design of a small-caliber tandem warhead, restricted conditions are more than those of big callber one, so the method of reference [4] is not propitious to small-caliber shaped charge. It is difficult to make small-caliber tandem warhead successfully penetrate tank with reactive armor. Only when the design is reasonable and perfect, is the product available.

DETERMINATION OF STANDOFF

Because the reactive armor is put on the tank, the distance between the second shaped charge and the main armor should be followed increased. In other word, the distance of real standoff should be increased. Besides, for avoiding exploding field of the first shaped charge to interfere the second shaped charge jet, the distance between two shaped charges should be long enough. So the standoff of the second shaped charge is increased again. We know when the standoff is over optimum distribution, the longer the standoff is, the shorter the penetrating depth is. The experiments show when the length of standoff is less than 6.5 times warhead caliber, good penetrating result can be obtained in the design of small-caliber charge.

THE BODY OF SHIELDING OFF EXPLOSIVE

Since the real standoff of the second charge should be not more than 6.5 times the charge caliber, the distance between two charges is restricted by standoff. For protecting the second shaped charge, it is necessary that the body of shielding off explosive be placed between two charges.

The action of the body is to intercept exploding productions and fragments produced by the first shaped charge going to the second liner. Since the body is in the way where main jet goes through, its position and structure have an effect on the second jet in different degrees. So in the design of the body, both the effect of shielding off explosive and the loss of the second charge jet are considered.

According to reference [5], the super-pressure of shock wave produced by the first shaped charge is as follows:

$$\Delta P=20.06/R+1.94/R^2-0.04/R^3 \quad (1)$$

where $R=r/\omega^{1/3}$ is relative distance

r is distance from exploding center

$\omega=\omega_i Q_i/Q_{TNT}$ is TNT equivalent explosive amount

ω_i is the first shaped charge explosive amount

Q_i is the exploding heat of the first shaped charge explosive

Q_{TNT} is TNT exploding heat

Equation (1) gives the super-pressure value in different point. On the basis of the values, we determine the material, structure and position of the body, then calculate and analyze the loss of the second shaped charge jet (main jet).

The procedure of main jet penetrating the body belongs to stationary, ideal and incompressible hydrodynamics. According to reference [5], the equation (2) deriving from the above theory is as follows:

$$L=l(\rho_j/\rho_t)^{1/2} \quad (2)$$

where

L is penetrating depth

l is jet length

ρ_j is jet density

ρ_t is target body density

The equation (2) shows the longer the jet length is, the higher the penetrating depth is; the lower the target density is, the higher the penetrating depth is. In the tandem warhead, if jet does not stretch sufficiently and meets the body of shielding off explosive, the loss amount of jet is larger. When jet stretches sufficiently, it is long and thin. The body only "eat" few of jets, the variation of jet length is smaller. We know by equation (2) that the loss of penetrating depth L is smaller. So the position of the body is important to the main jet. Besides, equation (2) tells us also the lower the target density is, the higher the penetrating depth is. Therefore when we select the kind of material of the body, except paying attention to its strength, its density would be paid attention too.

After the material, structure and position of the body are designed in optimization method, it is necessary to do experiments to prove whether the design is reasonable or not.

UNLOADING PRESSURE

The first shaped charge connects with the second by the tube tbat we call connecting tube and the cone with the body of shielding off explosive. For protecting the body from destroy, the tube should have the function of unloading pressure. At the same time, the tube should have enough strength to ensure explosive train in normal action. If the strength of the tube is not sufficient, the acting time of fuse is increased, the penetrating percentage of warhead is decreased. In addition, if the acting time of fuse is delayed, the explosive device arriving at the first shaped charge is easy to be broken.

There are two kinds of methods of unloading pressure. One is that the connecting tube adopts brittle material. When the first shaped charge explodes, the connecting tube breaks momentarily under the action of explosion. The other is windowing method on the connecting tube.

According to our experience, when the area of unloading pressure is competent, the equidistribution windows should be adopted for increasing the strength of connecting tube.

DELAY EXPLOSIVE TRAIN

The studies show that two fuses construction is not fit for the tandem warhead of small-caliber. If the fuse is placed ahead of the second shaped charge, the penetrating depth of the second shaped charge is approximately decreased by 12%. In the tandem warhead of small-caliber, it is better to lay the fuse after the second shaped charge. The initiation of the first shaped charge is finished by the simple explosive device that we call the first explosive device. It consists of detonating cord and the first detonator without in-

itiating explosive. The initiation of the second shaped charge is finished by delay explosive device that we call the second explosive device. It consists of delaying detonating cord and the second detonator without initiating explosive.

The explosive train is as follows:

Fuse → the second explosive device → the second shaped charge
Fuse → the first explosive device → the first shaed charge

or

Fuse → the first explosive device → the first shaped charge → the second explosive device
→ the second shaped charge

DELAY TIME

The procedure of reactive armor interfering jet is divided into several stages. According to different plates moving characteristics, we decide reasonable delay time. The simple configure of reactive armor is as follows:

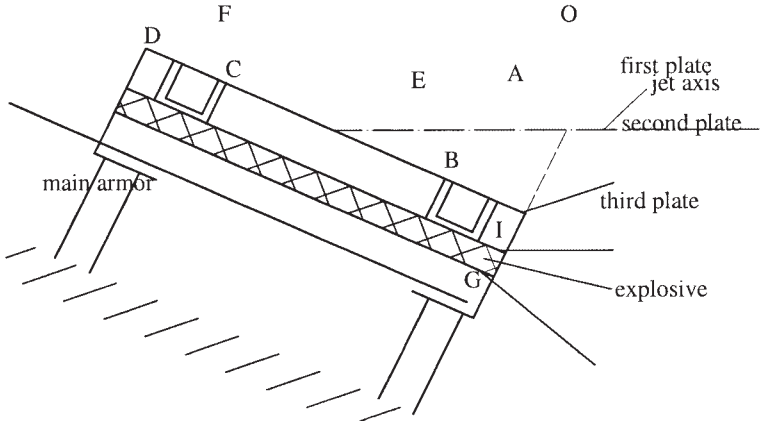

Fig. 1. Simple configure of reactive armor

Once reactive armor is ignited by jet, the three plates of reactive armor move in different velocities. The third plate moves to main armor in velocity v_1 and stops for a moment after arriving at main armor, then moves backward in velocity v_2, $v_2 < v_1$. The part EF of the second plate moves to the first plate in velocity v_1. After two plates meeting, they move together in velocity v_3, $v_2 < v_1$. After the part EI of the second plate arriving at the part AB, two blocks move together in velocity v_4, $v_2 < v_4 < v_3$. We know from Fig. 1 the main jet is no longer interfered by blocks of reactive armor after the point G of the third plate flying over the axis of jet.

X-ray experiments and calculation show the time during which the third plate flies off the axis of jet is more than 1 ms. Adopting long delay time is not good for small-caliber

shaped charge. So we look for the time during which the main jet is interfered as small as possible.

We know the higher the jet velocity is, the higher the penetrating depth is. The top velocity of jet is the highest, so the top parts of jet can't be interfered. We hope the tip of jet just arrives at point O when block EI just flies off point O and the third plate is stopping at main armor. According to the thought above, we calculate and determine the delay time. The experimental results are satisfactory.

CONCLUSION

According to the experimental results of small-caliber tandem warhead, the conclusion is drawn as follows:

1. The length of standoff would be smaller than 6.5 time the diameter of charge.
2. The body of shielding off explosive should be put reasonably in the middle of two charges.
3. It is necessary to design unloading pressure device.
4. The detonating device of igniting the first shaped charge should be smaller and simpler.
5. Short delaying time is satisfactory

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