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Study of Antiriot Bomb Fragments Non-lethal Effect

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Abstract: In order to ensure the safe use of non-lethal ammunition and improve the non-killing ability of fragment, the commonly used non-lethal ammunition police riot bomb is selected as the research object. Paper establishes the mathematical model of the moving fragment, and primary materials case preliminary by analyzing and comparing the properties of different materials, finally verified by experiments. The results show that the PA66 fragment of non-lethality is best, ABS natural fragment blow performance. According to the results of the study, PA66 is selected as the primary material.
Keywords: antiriot bomb, fragment, non-lethal effect

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1. INTRODUCTION

Riot bomb blow mainly by shock wave and fragment effect produced by projectile kinetic energy. The specific timing and occasion of riot bomb requires bomb's body has the lowest killing ability to staff. When the projectile charge under certain conditions, the performance of the key factors of fragment shape, quality and impact is the body materials [1]. At present, high performance plastics have been widely used in police grenades and non-lethal ammunition, without compromising on the comprehensive performance of the projectile, the use of plastic materials, can greatly reduce the weight of the projectile, and is expected to be on the plastic fragment wound to a minimum, to satisfy tactical and technical index.

2. MATERIAL SELECTION

2.1 Requirements for the material properties of the projectile crushing performance

When the projectile charge under certain conditions, trauma ability to human is mainly related to speed, quality and shape of fragment. In order to reduce the fragment injury and ensue the non-lethal of projectile fragments satisfy the requirements, materials should have good crushing performance. The breakage of the material is closely related to its internal structure and fracture mode [2].

The fracture modes of polymers are brittle fracture and ductile fracture. The natural

fragment brittle fracture, fracture of ductile fracture in the body, but in the role of high plastic projectile under impact load, the general also showed brittle fracture. In addition, the control of fragment structure, due to the stress concentration sensitivity of projectile of different materials, will also lead to brittle ductile transition. Brittle fracture is generally caused by tensile stress, and there is no shear yield, so the crushing performance is better than that of ductile material.

2.2 Preliminary selection of projectile material

According to the above principles and material options, taking into account the requirements of the riot bomb shell material properties, select six kinds of widely used plastic materials, respectively ABS, PVC, PE, PA66, PC, POM, carry out the comprehensive method of the number of the six kinds of materials using statistical screening, see Tab.1.

Tab.1 Statistical quantization tables for several materials

Material / Performance	ABS	PE	PVC	PA66	PC	POM
strength	4×3	5×3	4×3	3×3	5×3	2×3
economic efficiency	3×2	3×2	4×2	1×2	1×2	2×2
tensile strength	2×2	1×2	2×2	4×2	3×2	3×2
processability	4×2	4×2	3×2	3×2	2×2	1×2
hardness	4×2	1×2	4×2	4×2	4×2	3×2
heat resistance	3×2	1×2	2×2	3×2	3×2	3×2
low temperature resistance	1×1	2×1	2×1	3×1	2×1	1×1
weather resistance	2×1	2×1	1×1	2×1	3×1	2×1
corrosion resistance	2×1	3×1	3×1	1×1	1×1	1×1
wear resistance	3×1	2×1	2×1	4×1	1×1	5×1
Score	52	44	50	49	48	39

Table 1 shows that ABS, PVC and PA66 have the best comprehensive performance, so we choose the general thermoplastic material ABS, PVC and the general engineering plastics PA66 as the test material. Among them, the comprehensive performance of ABS is the best, and it is used as the material of riot bomb. In order to improve the ABS fragmentation of the projectile, we consider to be modified, because the glass fiber reinforced ABS increased brittleness of projectile fragmentation should be improved, so the choice of 15% and 30% increase compared glass fiber reinforced ABS composite [3-4].

3 MATHEMATICAL MODEL

Shell broken moment said the expansion rate of the fragment velocity. Shell fragment is formed after crushing, under the influence of detonation products will continue to accelerate, until the fragment movement of air resistance and the detonation product given thrust phase equilibrium, fragment reach maximum speed. After the fragment flying speed gradually increased with the increase of flight distance attenuation. Before forming shell fragment velocity and the fragment is closely related to the deformation rate, in addition, on the projectile, due to the difference of deformation velocity, as well as the product of detonation pressure degree of difference, causes each fragment velocity each are not identical. Therefore, what we call the velocity, strictly speaking, is a general average [5-6].

For military munitions produces metal pieces, from the Angle of the kinetic energy, has established the theory of fragment velocity expressions. So far, most of the law and formula are derived from the kinetic energy of the basic expression. Below using the energy conservation condition of fragment velocity is derived, reference Gurney energy method of hypothesis, assuming that glitter instantaneous explosion, with no thought of flying for explosion product along the axial; Shell wall thickness, such as; After the blast form equals the fragment velocity; Ignoring the reaction zone after the influence of the rarefaction wave. And set:

E_c——The kinetic energy of fragments; E_s——Reaction of light energy release;

E_m——Shell material failure energy; E_g——Explosive kinetic energy;

E_e——Explosive internal energy; E_i——The energy of the shell to the surrounding air;

E_h——The total energy released by flash explosive.

According to the law of conservation of energy:

$$E_h = E_m + E_g + E_e + E_c + E_i + E_s \tag{1}$$

(1) The calculation of the reaction mechanism model based on the minimum free energy method for the total energy released by the combustion and explosion of flash agent.

(2) The kinetic energy of fragments E_c. A total of N fragments, total mass is M, can be obtained by assuming:

$$E_c = \sum_{i=1}^{N} \frac{m_i}{2} v_0^2 = \frac{v_0^2}{2} \sum_{i=1}^{N} m_i = \frac{1}{2} M v_0^2 \tag{2}$$

(3) The light energy released by the explosion of the flash agent can be calculated.

(4) Kinetic energy of explosive product e.g. the kinetic energy of explosion products can be seen as a virtual mass explosion products to initial velocity movement of the kinetic energy, i.e.

$$E_g = \int_0^m \frac{v^2}{2} dm = \int_0^R v^2(r) 2\pi r \rho l dr = \frac{1}{4} m v_0^2 \tag{3}$$

m is the quality of projectile charge.

(5) Explosive internal energy E_e. The internal energy of an explosive product at the moment the shell is broken, equal to the work of the explosion from the point of rupture to the infinite.

Shell expansion energy to the air, also is the air dielectric absorption energy accounted for 1% of total energy, about casing failure energy accounted for 1% of total energy, so it can be ignored, the formula (2) and the formula (3) into the formula and reaction energy, total energy and gas (1), then the formula (1) can be simplified to [7]:

$$E_h = \frac{1}{2} M v_0^2 + \frac{1}{4} m v_0^2 + m_0 \frac{v_f p_f}{k-1} + \frac{0.1196n}{\lambda}$$

Can get

$$v_0 = \sqrt{\frac{4}{2M+m}(E_h - m_0 \frac{v_f p_f}{k-1} - \frac{0.1196n}{\lambda})} \tag{4}$$

According to the law of conservation of mass, the mass of the gas product is equal to the mass of the flash agent and the mass of the condensed phase product.

$$m_0 = m - n_1 M_1$$

n_1——Molar number of condensed phase products;

M_1——Molecular weight of condensed phase products;

m——Charge quantity.

According to the formula (4) is calculated, the initial velocity of fragments $v_0 = 365 m/s$.

4 EXPERIMENTAL VERIFICATION

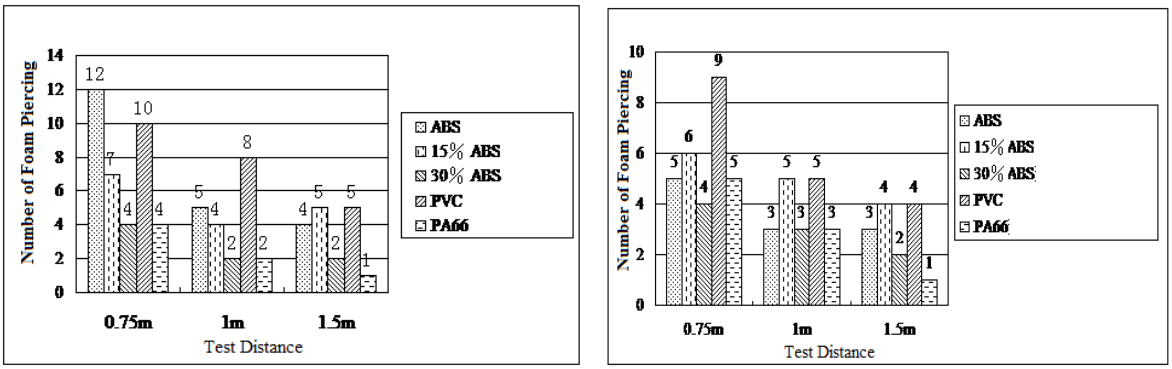
4.1 Experimental scheme

This experiment was divided into two parts, the first part of the foam and soap (General requirements for the use of soap as a simulation material for the production of soap in the factory without drying of large soap, we used soap for ordinary soap, its density is greater than the body density) as a non-biological analogue material, the sound and light bombs different body materials and control of human fragment trauma ability in different distance from the initial screening, selection of several schemes for poor trauma.

The second part of the screening results were evaluated according to the criterion of non-lethal requirements, targets are made of Kraft paper, the determination of penetration (will not through thoroughly) 300g 3 layers of Kraft paper required than kinetic energy is 10.2J/cm^2, and the minimum kinetic energy to penetrate the skin than 9.8J/cm^2 are basically the same, so the use of non-lethal effect evaluation of bovine skin to screening out the plan, to get the best way.

4.2 Experimental result

The experimental results are shown in figure 1. The results were the average of the 2 trials. The size of the foam plate is 1000 * 500 * 40mm, the soap size is 145 * 60 * 25mm, and the soap is fixed on the distance from the elastic 0.5m.



(a) Natural fragment (b) Control fragment

Fig.1 The penetration effect of foam fragment

Fig.1 (b) shows that natural fragments, penetrating ability of ABS fragment was the strongest, PA66 and 30% glass fiber reinforced ABS fragments penetration. The measurement results show that the size of the perforation, 1.5m distance, ABS fragment on foam for maximum perforation size of 12 * 30mm rectangular, diameter 24mm PVC fragment perforation, 15% glass fiber reinforced ABS fragment perforation diameter is 13mm, while the 30% glass fiber reinforced ABS and PA66 fragments of the hole diameter is 12mm and 6mm. Control fragment, PVC control fragment penetration ability is the strongest, most deadly, PA66 control of minimum lethal fragments. In addition, the perforation size measurement results show that the 1.5m distance, PVC control fragment maximum diameter perforated 18mm, while the PA66 control fragment is 10mm, and the ABS control the maximum punch diameter of 11mm fragments.

5. CONCLUSION

According to the above fragment trauma ability to sort results, selected from PA66, 30% glass fiber reinforced ABS composites, ABS control, PVC control and ABS missile projectile missile are non-lethal test criterion. The target uses Kraft paper, measured by penetration (through the penetration) of 3 layers of Kraft paper 300g required kinetic energy ratio of 10.2J/cm^2, which is consistent with the penetration of the skin than the minimum kinetic energy 9.8J/cm^2. Finally, according to the results, PA66 was selected as the material of the shell.

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