Structure and Power Design of 80 mm Warhead

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Abstract. This paper mainly conducts numerical simulation and analysis of the warhead structure of 80 mm assault ammunition, which needs to realize the effective penetration of 400 mm into the C35 concrete target and carry out the killing of incoming bullets. Before the first level of warhead design: effective penetration level before the warheads main function is to 400 mm C35 concrete goals, to achieve tactical technique index by shaped charge, bar type jet formation, medicine type cover adopt ball is short of cover, material is copper, medicine cover type choose such as wall thickness, and wall thickness of 2.52 mm, dynamite to choose B, using Ls-Dyna software simulation. The results show that the structure design has good jet forming, which can easily penetrate the 400 mm C35 concrete target plate, and the opening diameter is more than 20 mm. Through the hole opening diameter of the front rank warhead, it is finally determined that the diameter of the incoming bullet is 20 mm and the killing force is effective.

1. Introduction
Mostly urban warfare in the modern war, and in the street, the main target for buildings, Bridges, airport runway, highway, etc., it is steel bar concrete structure, and effective way to destroy these goals is to high energy explosives into these buildings, inner explosion and explosion product can effectively destroy the enemy buildings and effective force, etc., series engines play is by far the most effective weapons [1]. The shaped charge jet formed by the front stage shaped charge penetrates holes of a certain diameter and depth on the reinforced concrete target, and the bullets of the rear stage along the hole continue to penetrate depending on the kinetic energy, and then detonate the rear stage bullets and damage the personnel, equipment and other targets hidden after the work. In modern war, it is especially important to obtain the oppressive fire control when the enemy and us are engaged in a small and localized war. The launch platform of the assault bomb has high mobility, and the proportion of its use on the battlefield increases gradually, which is particularly important for the research on the penetration of the fortification of the assault bomb and its post-work target effectiveness [2]. As a basic theoretical study, the study on the damage effectiveness of the assault weapon is helpful to understand and master the existing capabilities and deficiencies of the weapon, to define its use value, to provide a
reliable basis for the development and decision-making of the weapon and equipment, and to create conditions for improving the combat capability of the weapon and equipment. The research on the damage efficiency of the attack bomb can provide the theoretical basis for the structure design of the warhead, provide the basis for the choice of the damage means, and also provide some reference for the protection design of the target.

2. Structural design of assault warhead

2.1. Determination of shell wall thickness
After consulting the data of forming rod jet, the selection of shell wall thickness should be kept within the range of 0.036 ~ 0.144 times of charge diameter. Within this range, the jet form and performance are stable, and the rod jet will not break. Select 0.053 do.

2.2. Determine the size of the drug cover
According to the characteristics of metal jet formed by shaped charge, rod jet is selected. The size of the charge cap directly affects the type of jet flow. In this paper, the secondary aperture spherical cap was selected with a cone angle of 145° and a diameter of 70 mm.

2.3. Determination of the wall thickness of the drug type cover
The wall thickness of the cartridge case usually has a direct influence on the efflux, and the optimum wall thickness increases with the decrease of material density, the increase of cone angle, the increase of the aperture and the thickening of the warhead shell. As the target has a greater influence on the efflux, the wall thickness of the mask should also be increased, which is usually selected according to B = (0.034~0.038) Do. In this paper, the wall thickness of the drug type mask should be 2.52 mm according to 0.034Do.

2.4. Design of explosives
In this paper, B explosive is selected as the main charge. The charging height is 1.13Do=90.4 mm.

The charge diameter Do determines the value of the outer diameter Dc and inner diameter Di of the charge cover. By increasing the value of Do, the penetration depth and the value of Di can be increased. When determining the charge diameter Do, professional process factors should be taken into account, and the gap between the opening and the shell of the charge mold should be fully filled when casting the charge. If the pressure charge is not equipped with a charge cover, the strength of the contact part between the charge column and the cover mouth should be guaranteed, and no obvious blocking phenomenon should occur [3]. The charging diameter can be determined by the following equation:

\[ D_0 = D_c + 2\varepsilon \]  \hspace{1cm} (1)

Where, \( D_c \) — Outer diameter of cartridge cover, mm; \( \varepsilon \) — Charge thickness at cover opening, mm.

In order to select 2 mm to meet the sub-aperture charge, \( D_0=74 \) mm was calculated according to Equation (1).

2.5. Warhead blast high design
With the rapid development of the target, the requirement of blast height has also changed. The size of the blast height also affects the penetration depth. In this paper, according to the type 69 40 mm rocket, the blast height of 3.75 times the diameter of the warhead is 300 mm.

3. Material model

The material parameters used in the finite element simulation model are all selected from Ls-Dyna's own material library. The air adopts ideal gas; Copper Cu-OFHC for drug cover; COMP B for explosive, density 1.717 g/cm³, detonation velocity 7980.001 m/s, detonation pressure $2.95 \times 10^7$ kPa; Duralumin AL 2024-T4 for shells; The target plate is made of C35 concrete. The material model is shown in Table 1.

| Material       | Equation of state | Material model          | Failure parameter (FS) |
|----------------|-------------------|-------------------------|------------------------|
| CU-OFHC        | GRUNEISEN         | JOHNSON_COOK            | None                   |
| COMP B         | JWL               | HIGH_EXPLOSIVE          | None                   |
| AL 2024-T4     | GRUNEISEN         | JOHNSON_COOK            | None                   |
| C35 Concrete   | None              | CONCRETE                | None                   |

4. Numerical simulation of assault warhead

4.1. Numerical simulation of front warhead

ALE algorithm is adopted to realize the dynamic analysis of fluid and solid coupling. Lagrange algorithm is adopted for the shell and target plate, and the solid element is automatically coupled. TG modeling was adopted for the model. The model file was written down in the input keyword, and named model.k and Mode2.k, which was opened by LS-Prepost. Grid details and tolerance problems were viewed, and adjustments and modifications were made. The central initiation point of the model was selected. The time step was 5 μs, and the total calculation was 400 μs.

![Figure 1. Grid diagram of the model.](image)

4.2. The formation of rod jet

In the simulation results, it is found that the detonation occurs when $t=0$ μs; When $t=5$ μs, the top of the shell is slightly raised, as shown in Figure 2. At this moment, the stress distribution corresponding to the shell starts from the position of the detonation point. At this moment, the stress and velocity of the nodes on the cartridge case do not change significantly.
Then the detonation wave propagates in the charge, and with the propagation of detonation wave, the shell expands gradually. When \( t = 10 \, \mu s \), the detonation wave propagates to the top of the charge cap and begins to squeeze the charge cap, as shown in Figure 3.

**Figure 2.** Central detonation map.
The formation of the jet

It can be clearly seen in Figure 4 that the detonation wave pressure at the top of the charge cap is the largest. The top of the detonation wave propagation charge cover is extruded first, and the bottom of the charge cover is finally extruded, and the jet head velocity is high \(^{[4]}\).
Figure 4. The formation of the jet.

When \( t = 50 \ \mu s \), use the control file to delete the shell; The rod jet continues to move steadily and elongates until it reaches the target plate, as shown in Figure 5. At this point, the jet has been fully formed, and the velocity of the jet head reaches 3.642 km/s. Consistent with data obtained from data access. The entire jet formation process is consistent with the theory, so the simulation results have reference value.

![Figure 4](image)

a Remove shell  b Jet stress distribution  c The velocity distribution of the jet

d Jet fast contact target plate  e Jet pressure diagram  f Jet velocity diagram

Figure 5. The jet before contact with the target plate.

Figure 6 shows the velocity change curve on the Z-axis of the entire jet. At the beginning, the velocity rose rapidly, but when it came into contact with the target plate, the Z-axis velocity decreased significantly. In Figure 6, corresponding to Figure 7, at the beginning is the accelerating process of jet flow. When it comes into contact with the target plate, the velocity is decreasing.
4.3. Penetration target board

When \( t = 60 \mu s \), the jet began to contact the target plate, and the velocity began to drop sharply due to obvious resistance. Meanwhile, it entered the pit opening stage, as shown in Figure 8.

See Figure 9. As the jet penetrates deeper into the target plate, it enters into a quasi-stationary process. In this stage, because the bursting pressure is not very high in this stage, the energy of the jet changes slowly, and the armor breaking parameters and hole diameter change little, which is basically independent of time. Among them, because the target plate is concrete and brittle material, the target plate appears to be broken.
Subsequently, it enters the fracture jet penetration stage: in the later stage of penetration, with the jet stretching, the jet begins to fracture, and the jet velocity and diameter after the fracture do not change, and the jet particles continue to penetrate the target plate [5], as shown in Figure 10.

At last, it enters the termination stage, during which the change is relatively complicated. Due to the fracture of the jet, the opening aperture is very small, but due to the sudden pressure relief at the tail, the aperture at the end of the jet becomes larger, as shown in Figure 11.
4.4. Pore size measurement
After the target plate experienced rod jet penetration, the aperture as shown in Figure 12 appears, which needs to be measured to provide a basis for the design of rear stage warhead. The maximum aperture measured is approximately 36 mm; The minimum aperture is about 20.6 mm; See Figure 13. The diameter of the rear warhead is selected to be 20 mm in order to ensure the full entry of the rear warhead to kill and injure the rear warhead.

5. Conclusion
Numerical simulation and analysis are carried out on the structure of 80 mm assault shell warhead, so that it can effectively penetrate through 400 mm C35 concrete and kill with incoming bullet. First of all, the design of the front warhead, including the design of the capsule structure, charge selection and so on. TG software was used for modeling pre-processing, then Ls-Dyna was used for simulation analysis, and the structural design of the assault bomb was optimized according to the simulation results. The main function of the forestage warhead is to effectively penetrate the C35 concrete target of 400 mm. In order to achieve the tactical technical indexes, shaped charge is adopted to form the rod jet, then the charge cover is adopted the ball missing cover, the material is red copper, the charge cover is selected with equal wall thickness and the wall thickness is 2.52 mm, the explosive is selected B explosive, and Ls-Dyna software is used for simulation. The results show that the structure design jet forming is good, can easily penetrate the 400 mm C35 concrete target board, and the hole diameter reaches more than 20 mm. The hole diameter of the forward warhead is finally determined to be 20 mm in diameter of the incoming bullet, killing the living forces.
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