CALCULATE DESIGN STRUCTURE, RELOADING OF 37MM K39 ANTI-AIRCRAFT CANNON

TÍNH TOÁN THIẾT KẾ CƠ CẤU TỐNG ĐẠN TRÊN PHÁO PHÒNG KHÔNG 37MM K39

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ABSTRACT

This paper presents a design calculation method and ejection mechanism for the 37mm K39 anti-aircraft canon. By choosing a reasonable terminal velocity along with the characteristics of the ejection spring, the article calculates the characteristics of springs and the process of loading cartridges into the chamber. Calculated results hardness C of the spring and the length of the body throw cartridges. The calculation results of the paper can be used as a reference for the design of similar weapons.

Keywords: *Anti-aircraft artillery; Throw cartridges; Springs; Cannonball.*

TÓM TẮT

Bài báo trình bày một phương pháp tính toán thiết kế cơ cấu tống đạn cho pháo phòng không 37mm K39. Bằng việc chọn vận tốc cuối của viên đạn hợp lý cùng với các đặc tính của lò xo tống đạn, bài báo tính được các đặc trưng của lò xo cũng như hành trình tống đạn vào buồng đạn. Kết quả tính được độ cứng C của lò xo và chiều dài của thân máng tống đạn. Kết quả tính toán của bài báo có thể dùng làm tài liệu tham khảo cho thiết kế các loại vũ khí tương tự.

Từ khóa: *Pháo phòng không; Tống đạn; Lò xo; Đạn pháo.*

1.WHY SOLVE THIS PROBLEM

In the anti-aircraft weapon system, the automatic machine is an important and important part basically, it's used to auto-fire from the second shot. This part has a complex structure, works with high precision, and has strict requirements. The throw cartridge is one of the automatic machines.

In this article, only the throw cartridges with forced lines and inertia lines of the 37 mm anti-aircraft cannon are mentioned. Some previous articles have been published about the 37mm cannon's automatic machine but sketchy and lack data such as [1], [2]...

So that, this article will supplement information about the throw cartridges for the 37mm anti-aircraft cannon.

2. RESEARCH CONTENT

2.1. Principle of forced line and inertia line throw cartridges for vertical bolts

Figure 1 below illustrates the type of forced line and inertia line throw cartridges on the 37mm cannon and is depicted in 3D type.

When the throw cartridge spring is at its maximum compression, the cartridge entered between the two throw cartridge butterfly, the two throw cartridge butterfly bodies were in the wide groove and at the rear end.

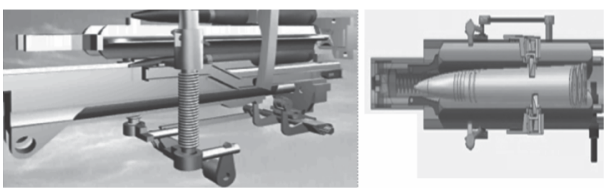

Figure 1. 3D model of the throw cartridge mechanism.

In figure 2, when the firing lock 6 rotates down by the trigger force, the back end of the shot lock is down, unblocking the 7 pieces, spring 5 expands and pulls the spring handle up, bringing the butterfly piece and the cartridge. The butterfly piece moves all the way through the narrow groove in the chute, it ran to the wide trench again and stopped holding the cartridge body, the cartridge followed inertia and entered the chamber.

In the locking process, firing takes place, and the cartridge speed when entering the cartridge chamber is about 6.5m/s. If the speed is too fast, it can remove the warhead from the shell, if the speed is too slow, the rate of fire will be reduced. So controlling the fire speed requires careful calculation of the throw cartridge spring.

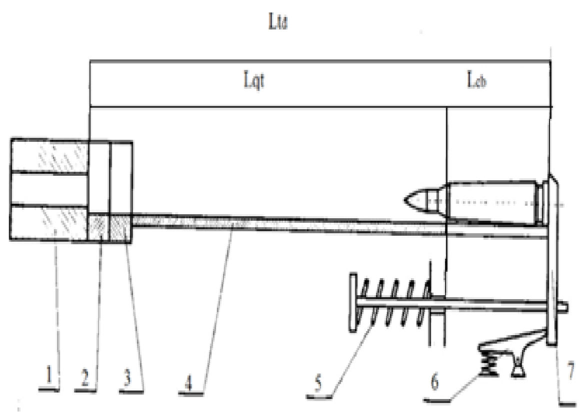

Figure 2. The principle of the throw cartridge mechanism [1]
1-Barrel; 2-Bolt; 3-Barrel bolt box; 4- Chute; 5-Spring; 6-Lock shot; 7- Throw cartridge piece.

2.2. Calculation of throw cartridge spring and throw cartridge body

To calculate the throw cartridge spring, we choose the throw cartridge velocity diagram and compression characteristics of the throw cartridge spring are as shown in Figure 3 below:

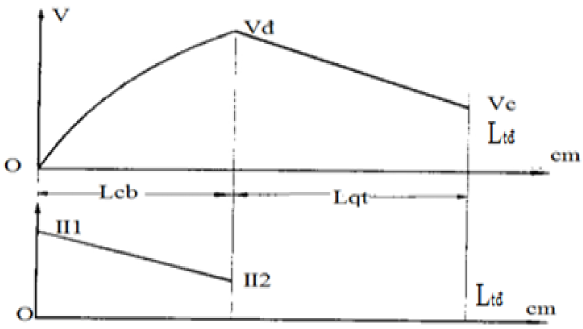

Figure 3: Velocity and compression characteristics of the throw cartridge spring [1]

Initially, the spring is compressed to the value Π_1, after expanding it compresses to Π_2, when going up the cartridge initially has zero velocity, then increase to V_d. At the end of the line, the cartridge's velocity reaches V_c.

To calculate the spring, we consider the equation of conservation of energy for all systems.

Here, energy loss due to friction, spring deformation, etc…. is taken into account.

$$\frac{M.V_d^2}{2} = L_{cb}\left(\frac{\Pi_1 - \Pi_2}{2} - Q'\right) \qquad (1)$$

In equation 1: Shooting angle φ; M: moving mass of the system; M_{td}: Mass of throw cartridge butterfly; M_d: Mass of the cartridge; M_b: Mass of spring and spring pin. M_{lx}: Mass of spring.

Π_1; Π_2: Spring compression at the start and end of the forced throw.

For 37mm anti-aircraft canons, the value Π_1/Π_2 is usually chosen to equal 2.

Forced stroke $L_{cb} \leq 0.7\lambda_{min}$. And:

$L_{td} = L_{cb} + L_{qt}$ hay: $L_{qt} = L_{td} - L_{cb}$

The equation for conservation of energy written for the throw inertial would be:

$$\frac{M_d}{2}\left(V_d^2 - V_c^2\right) = Q'_d L_{qt} \qquad (2)$$

We have V_d: $V_d^2 = V_c^2 + 2\frac{Q'_d}{M_d} L_{qt}$ (3)

With: $Q'_d = M_d g.(f\cos\varphi + \sin\varphi)$, (4)

So: $V_d^2 = V_c^2 + 2g(f\cos\varphi + \sin\varphi)L_{qt}$

Substituting V_d into (1) and transforming we get the expression Π_2:

$$\Pi_2 = \frac{M\left[V_c^2 + 2g(f\cos\varphi + \sin\varphi)L_{qt}\right]}{(1+m).L_{cb}} \qquad (5)$$

According to documents [3], [4] we have:

Spring weight: 460g; Weight of spring pin: 800g; The mass of the throw cartridge butterfly: 800g;

Forced ejection stroke: 13 cm; Inertial ejection stroke: 53.7cm;

Forced distance: 13 cm; Inertial distance: 53.7cm;

Coefficient of friction f: 0.1; Firing angle φ: 0 degrees; Gravitational acceleration g: 9.81m/s^2.

Russia's YOB 167 explosive ammunition has a warhead weight of 0.732 kg, and a propellant mass: of 0.205 kg.

China's YOB 167H explosive ammunition has a warhead weight of 0.720 kg, and a propellant mass: of 0.205 kg.

The Russian YOБ 167 penetrating ☞

cartridge has a warhead mass: of 0.758 kg. China's YOБ 167H ammunition has a warhead weight of 0.610 kg.

Substitute the formula and calculate the spring compression force:

$$\Pi_2 = \frac{(0{,}8+0{,}8+1{,}5+0{,}153+0{,}063)[6{,}5.6{,}5+2.9{,}81.(0{,}1.1+0).53{,}7]}{(1+2).13}$$

$$\Pi_2 = \frac{3{,}253.[42{,}25+19{,}62.0{,}1.53{,}7]}{39} = 12{,}312 \text{ (kG)}$$

$$\Pi_1 = 2.\ 12{,}312 = 24{,}624 \text{ (kG); (by m=2).}$$

$$C = 12{,}312\ /13 = 0{,}947$$

When the shot angle is 850, the force value Π_2 = 91,404 kG.

Comparing the spring force value, we choose the high firing angle and the force value Π_2 is 91,404kG. From here calculate the spring.

Spring free length: 484mm; Out diameter of spring: 37mm; Spring in diameter: 27mm; Number of spring turns: 36 turns; The lock nut weighs is 63g.

Figure 4. Spring and throw cartridge butterfly after design

Based on the firing distance and requirements for working with the projectile mechanism, flip cartridges, stop rotating…We have the shape and size of the ejector body as shown in Figure 5 below.

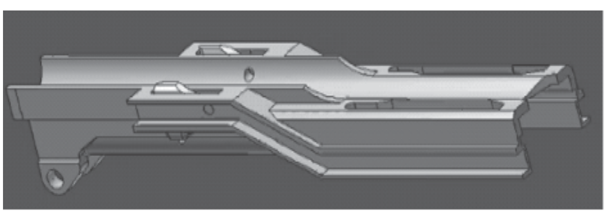

Figure 5. Cartridge chute body

Some limitations when calculating: not taking into account the impact energy loss during ejection, the impact of the warhead on the projectile ramp, the impact with the two shells...

Relationship between launch angle and spring force when V_c is constant:

Substituting different values of firing angle into formula (5), we get the corresponding velocity values. Using the resulting table, we can draw a graph as shown in Figure 6:

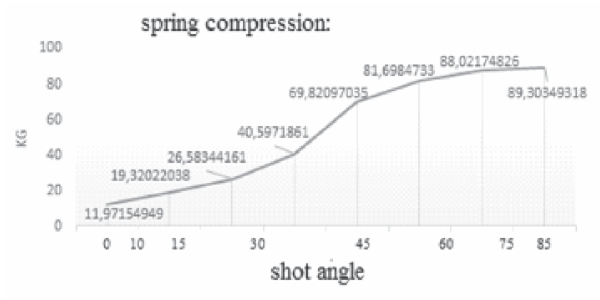

Figure 6. Relationship between firing angle and spring compression force Π_2 when Vc is const

We can see: When the firing angle increases from 0 degrees to 85 degrees, the spring force Π_2 increases, this is consistent with the fact because at the high angle the component of the cartridge's gravity plus the ejector butterfly cluster increases.

Relationship between launch angle and velocity V_c when spring force is constant:

In case the force Π_2 is constant, consider the effect of the angle of fire on the final velocity of the cartridge when entering the cartridge chamber:

If taking the force Π_2 as the average value of 50kG, only the firing angles from 0 to

20 degrees give satisfactory V_c values ($V^2_c > 0$) but the values are quite high, it decreases from 22,608m/s to 12,577 m/s.

If the force Π_2 is taken as the minimum value of 12kG at the firing angle from 0 degrees, the satisfying V_c value ($V^2_c > 0$), and here V_c reaches 6.527m/s.

3. CONCLUSION

Based on the equation of conservation of energy of all systems the motion and terminal velocity of the cartridge, we calculated some characteristics of the ejection spring and cartridge chute body.

Not only that, but it also investigated the relationship between the firing angle and the spring force as well as the cartridge velocity at the end of the journey.

The results have been calculated and designed forced throw cartridge mechanism combined with inertia. The magazine long is 66.7 cm. However, the accuracy of the calculations is limited because it ignores many energy losses, surface lubrication conditions, etc. The angle of fire has little effect on ammunition.❖

Reference:

[1]. Phạm Huy Chương; *Giáo trình Cơ sở kết cấu và tính toán máy tự động*, NXB. Học viện KTQS-1998, trang 207- 210.

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[3]. Bộ môn Vũ khí; *Giáo trình Trang bị điển hình vũ khí (Phần PPK)*, NXB. Học viện Kỹ thuật Quân sự, 1998.

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