SURVEY OF THE INFLUENCE OF SOME STRUCTURAL PARAMETERS ON THE OPERATION OF THE RECOIL MECHANISM OF THE 100MM CANNON ON THE T55 TANK

KHẢO SÁT ẢNH HƯỞNG MỘT SỐ THAM SỐ KẾT CẤU ĐẾN SỰ LÀM VIỆC CỦA MÁY HÃM LÙI CỦA PHÁO 100MM TRÊN XE TĂNG T55

Quoc-Trinh Tran
Military Technical Academy (MTA)
Email: tranquoctrinh9981@yahoo.com.vn

ABSTRACT

The article presents the relationship between some structural parameters of the recoil mechanism and its operation on the 100mm canon mounted on the T55 tank. The main equipment on this tank is the D10-T2C canon that has a 100mm caliber wiht an external fume extrac. The surveyed factors include the mass of the back block, force the diameter of the regulation ring, and the output results including the maximum resistance force R_{max}, the maximum hydraulic braking force Φ_{max}, the maximum recoil stroke X_{max}, and the maximum speed of the back block V_{max}. The article utilized specialized software for the survey, ensuring an enormous computational workload within a short period and achieving high accuracy. Some conclusions drawn after obtaining the calculation results serve as a basis for the design, manufacturing, and optimal exploitation of the 100mm cannon on the T55 tank. In addition to the scientific works published in the same field, this article will further contribute to the knowledge base of engineers in the same domain.

Keywords: *Structural parameter; Mass; Regulatory ring; Recoi-machinism; 100mm cannon.*

TÓM TẮT

Bài báo trình bày mối quan hệ giữa một số tham số kết cấu của máy hãm lùi đến sự làm việc của nó trên pháo 100mm, lắp trên xe T55. Trang bị chính trên xe này là pháo D10-T2C có cỡ nòng 100mm với hệ hống hút khói bên ngoài nòng. Các yếu tố khảo sát bao gồm khối lượng khối lùi, đường kính vòng điều tiết, kết quả đầu ra bao gồm lực cản lùi lớn nhất R_{max}, lực hãm thuỷ lực Φ_{max}, hành trình lùi tối đa X_{max}, vận tốc lớn nhất của khối lùi V_{max}. Bài báo đã sử dụng phần mềm chuyên dùng để khảo sát đảm bảo khối lượng tính toán vô cùng lớn trong một khoảng thời gian ngắn và đạt độ chính xác cao. Một số kết luận rút ra sau khi có các kết quả tính toán làm căn cứ để thiết kế, chế tạo và khai thác hiệu quả cao nhất đối với pháo 100mm trên xe T55. Bên cạnh các công trình khoa học đã công bố cùng lĩnh vực bài báo này sẽ đóng góp thêm vào kho tàng kiến thức của các nhà kỹ thuật trong cùng lĩnh vực.

Từ khoá: *Tham số kết cấu; Khối lượng; Vòng điều tiết; Máy hãm lùi; Pháo 100mm.*

☞

1. INTRODUCTION

There have been many studies on recoil mechanisms for cannon and anti-aircraft guns, as presented in the documents [1], [2]… However, research on the hydraulic recoil mechanism of tank guns is still rare. During the operation of the T55 tank (figure 1), there have been many malfunctions that need to be addressed, and there is a lack of theoretical research on recoil mechanisms. Therefore, a comprehensive study on the hydraulic recoil mechanism for this tank is essential. Based on the theories of fluid flow and Bernoulli's principle, an investigation into the influence of certain structural parameters on the operation of the recoil mechanism has been conducted.

Figure 1. The T55 tank model equipped with the 100mm cannon.

2. RESEARCH CONTENT

2.1. Survey Model and Motion Equation

The motion equation of the recoil mass in the cannon is as follows:

$$\left(M_0 + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} m_i\right) \frac{dV}{dt} + \sum_{i=1}^{n} \frac{K_i}{\eta_i} m_i V^2 \frac{dK_i}{dx} =$$

$$P_{lg} - \phi - \Pi - R_f - \sum_{i=1}^{n} \frac{K_i}{\eta_i} F_i \qquad (2.1)$$

Where:

- m_i – Mass links of the of the machine mechanism;

- K_i, η_I – Gear ratio and efficiency of the machine mechanism;

- F_i – Force acting on the mass m_i;

- P_{lg} – Force exerted by the pressure of the propellant gas on the bottom of the barrel.

$$0 \le t \le t_I \quad ; \quad P_{lg} \ne 0$$
$$t_I \le t \le t_s \quad ; \quad P_{lg} = 0$$

t_I – Time corresponding to the moment the lock is fully opened.

Equation (2.1) can be rewritten:

$$P_{lg} - M_0 \frac{dV}{dt} = \phi + \Pi + R_f + \sum_{i=1}^{n} \frac{K_i}{\eta_i} F_i + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} m_i V^2 \frac{dK_i}{dx} + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} m_i \frac{dV}{dt} \qquad (2.2)$$

On the other hand, we can also write the motion equation of the block moving backward in the form:

$$M_0 \frac{dV}{dt} = P_{lg} - R \text{, or: } \frac{dV}{dt} = \frac{P_{lg} - R}{M_0} \qquad (2.3)$$

Substituting the expression we just found into the equation above, we have:

$$R = \frac{\phi + \Pi + R_f + \sum_{i=1}^{n} \frac{K_i}{\eta_i} F_i + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} m_i \frac{P_{lg}}{M_0} + \sum_{i=1}^{n} \frac{K_i}{\eta_i} m_i V^2 \frac{dK_i}{dx}}{1 + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} \frac{m_i}{M_0}} \qquad (2.4)$$

From (2.4), we can determine the expression for the hydrank braking force:

When $0 \le t \le t_I$:

$$\Phi = R\left(1 + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} \frac{m_i}{M_0}\right) - \Pi - R_f - \sum_{i=1}^{n} \frac{K_i}{\eta_i} F_i - \sum_{i=1}^{n} \frac{K_i}{\eta_i} m_i V^2 \frac{dK_i}{dx} -$$

$$- \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} \frac{m_i}{M_0} P_{lg} \qquad (2.5)$$

When $t_I \le t \le t_\lambda$, then $P_{l\bar{g}} = 0$; therefore:

$$\phi = R\left(1+\sum_{i=1}^{n}\frac{K_i^2}{\eta_i}\frac{m_i}{M_0}\right) - \Pi - R_f$$

$$-\sum_{i=1}^{n}\frac{K_i}{\eta_i}F_i - \sum_{i=1}^{n}\frac{K_i^2}{\eta_i}m_i V^2\frac{dK_i}{dx} \qquad (2.5a)$$

Note: In expressions (2.5) and (2.5a), the force to machine's motion resistance is the components:

$$\sum_{i=1}^{n}\frac{K_i}{\eta_i}F_i\ ,\ \sum_{i=1}^{n}\frac{K_i}{\eta_i}m_i V^2\frac{dK_i}{dx}\text{và}$$

$$\sum_{i=1}^{n}\frac{K_i^2}{\eta_i}m_i\frac{dV}{dt}.$$

The structure of the recoil mechanism is show in figure 2.

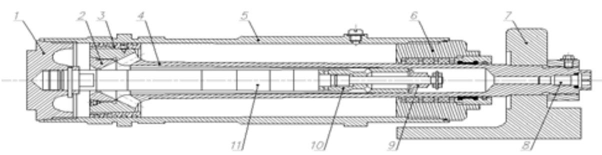


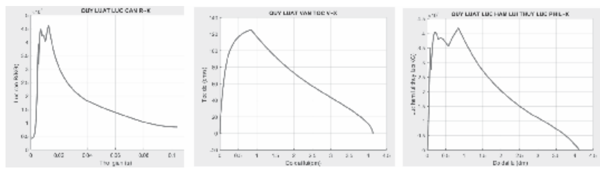
Figure 2.1. Recoil mechanism of the 100mm canon D10T2C on T55 tank
1 - Front cover; 2 - Adjusting ring;
3 - Piston jacket; 4 - Reverse lever;
5 - Reverse tube; 6 - Rear head; 7 - Device body;
8 - Nut; 9 - One-way valve cover; 10 - Valve body;
11 - Adjusting lever.

2.2. Results of solving equations

Input parameters for solving the problem: Parameters are declared directly in the calculation program. Use Matlap software to solve the system of differential equations of motion [3], [4], [5].

Sequentially solving the differential equations of the back block with varying mass of 1880 kg, 2200 kg, and 1700 kg. The diameters of the regulation rings are 0.36 dm, 0.35 dm, and 0.34 dm.

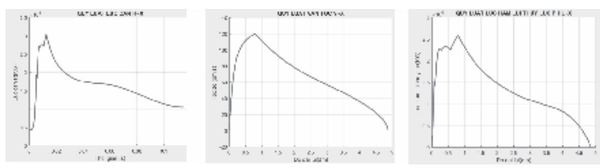
*Initially, the weight of the back block is 1700 kg when applying the mass reduction solution for the equipment body. With that mass, we calculate the motion characteristics of the equipment body, resulting in a maximum retreat length of 4.130 dm. The other values obtained and the characteristic curve are shown in the following figure 2.2:



R = 46313kG *V_{max} = 125.06 dm/s* *Resistance Φ*

Figure 2.2. Characteristics of the recoil mechanism motion when M_o = 1700kg-D_v = 0.34 dm

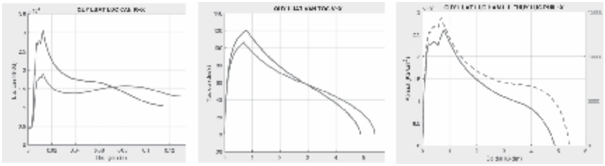
• The standard mass of the reverse block is 1880 kg; with this mass, we calculate the motion characteristics of the device body, resulting in a maximum reverse length of 4.8671 dm. Other values obtained and the characteristic curve are shown in the figure 2.3:



R = 30622kG *Vmax = 120.11dm/s* *Resistance Φ*

Figure 2.3. Characteristics of the recoil mechanism when M_o = 1880kg-D_v = 0.35 dm

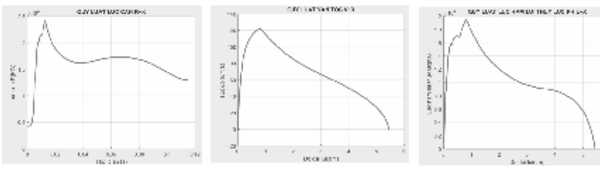
*When the mass of the recoil block is 2200 kg due to the installation of additional protective equipment on the cannon barrel, we calculate the motion characteristics of the recoil mechanism, with the maximum recoil length being 5.3966 dm. Other values obtained and the characteristic curve are shown in the figure 2.4:



R = 19114kG V_{max} = 106.16 dm/s Resistance Φ

Figure 2.4. Characteristics of the recoil mechanism when M_o = 2200kg-D_v = 0.36 dm

• In the case where the diameter of the regulation ring remains constant and only the mass of the back block changes, the retraction length is 5.4309 dm. When the mass of the back block is 1700 kg, the back block will retract 5.4286 dm. Other values obtained and the characteristic curve are shown in the figure 2.5:



R = 24227 kG V_{max} = 122.88 dm/s Resistance Φ

Figure 2.5. Characteristics of the reverse braking motion when M_o = 1700kg-D_v = 0.36 dm.

3. CONCLUSION

- When firing, the recoil body moves back; although the mass of the recoil block changes from 10% to 17%, the length of the recoil changes insignificantly. This can be explained by the constant oil flow gap; the hydraulic braking force generated in the recoil mechanism remains unchanged, so even with moderate mass changes, the length of the recoil is not significantly affected.

- In the case where the inner diameter of the regulation ring changes from 0.36 dm to 0.35 dm, or the oil flow area decreases by 0.54 cm² while the mass remains constant (1880 kg), the length of the recoil changes noticeably increase (5.638 cm).

- When both the mass of the recoil block changes (due to material changes and structural adjustments) and the oil flow area changes, the length of the recoil changes insignificantly, and the pattern of recoil length variation is not clear.

- The shapes of the characteristic curves such as the total resistance force R, maximum velocity during recoil V_{max}, and hydraulic braking force Φ are similar, and no significant differences are observed among the surveyed options.

Recommendation: Special attention should be paid to the oil flow area in the recoil mechanism as well as the recoil braking force pattern (especially when the regulation ring is worn), while less attention should be given to the mass of the back block during design calculations, as it has a minor impact. This practice is very significant in the design and repair of recoil mechanisms.❖

References:

[1]. Nguyễn Văn Dũng, "*Nghiên cứu ảnh hưởng của một số tham số kết cấu đến làm việc của máy hãm lùi pháo*". Kỷ yếu Hội nghị Khoa học và Công nghệ toàn quốc về Cơ khí lần IV - 2016.

[2]. Đào Văn Đoan, Mai Anh Quang, "*Nghiên cứu ảnh hưởng của một số tham số kết cấu hãm lùi - đẩy lên đến hoạt động máy tự động pháo 37mm K65*". Kỷ yếu Hội nghị Khoa học và Công nghệ toàn quốc về Cơ khí lần V - 2018.

[3]. Phạm Huy Chương, "*Giáo trình tính toán và thiết kế máy tự động*". NXB. Học viện Kỹ thuật Quân sự - 2016.

[4]. Trần Đăng Điện, Trần Văn Doanh, "*Bài tập Thuật phóng trong*". NXB. Học viện Kỹ thuật Quân sự - 1999.

[5]. Nguyễn Quang Lượng, Trần Quốc Trình, "*Số liệu vũ khí đạn*". NXB. Học viện Kỹ thuật Quân sự - 2010.