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Research on the Influence of Some Structural Parameters of a gas Chamber on the Movement of a gas-Operated Automatic Mechanism

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Abstract: This article has established a mathematical model to evaluate the influence of several structural parameters of the gas chamber on the movement of the gas-operated automatic mechanism during single and series firing. Parameters such as the area of the gas block hole, the gap area between the piston and the gas chamber, and the area of the gas exhaust hole significantly affect the movement of the automatic machine. The velocity of the bolt carrier, the movement cycle of the bolt carrier, and the pressure in the gas chamber are used to evaluate the influence of these parameters. Numerical calculations are applied to the PKMS machine gun. Calculation results show that: The maximum velocity of the bolt carrier corresponding to the number of gas exhaust holes on the PKMS machine gun is 0 holes, 1 hole, and 2 holes, respectively 4.913 m/s; 3.625m/s; 2.424 m/s. The calculation results are the scientific basis to evaluate the reliability of the gas exhaust section adjustment part during the firing process, providing the necessary energy to supply the automatic machine to work in adjustment cases. This result can be applied to survey and calculate the design of gas chambers for machine guns working on the principle of gas block.

Keywords: gas chamber; bolt carrier; energy of the shot; automatic mechanism; PKMS machine gun

1. INTRODUCTION

Nowadays, with the development of the sciences, the military field also has great progress. Automatic weapons are increasingly optimal design technology as well as powerful on the battlefield. They are designed in the direction of increasing the rate of fire, and muzzle velocity while ensuring accuracy shooting suit each case in fight. One of the methods to enhance stability for the automatic machines for infantry weapons operates according to the principle of gas block can adjust the force of the gas pressure to the top of the piston. In the infantry weapons for Army Vietnam, the adjustment of the gas chamber pressure mainly through two main methods:

- Change the cross-sectional area of the gas block hole: light machine gun RPĐ, anti-gascraft machine gun 12,7mm, machine gun SGM, v.v.

- Change the gas exhaust area: Machine gun PKMS size 7,62mm.

The gas chamber on the PKMS machine gun is shown in Figure 1. This gas chamber is tensioned with the gun barrel and prevented from rotating by a pin. On the gas chamber, there is a hole containing a stopper for the combustion gas adjustment ring, next to which are engraved the numbers 1, 2, and 3 to distinguish when adjusting. These combustion gas exhaust holes are used to adjust the gas pressure applied to the piston surface when fired. The characteristics of the gas block mechanism are simple structure, convenient to use, easy to preserve, and easy to remove soot, but the disadvantage is that an additional piston orienting part must be installed or a piston and gas chamber must be manufactured, appropriate clearance to ensure self-aligning of the piston when it enters the gas chamber. In addition, the effectiveness of combustion gas pressure in the gas chamber is low. That's why the gas block mechanism of the PKMS machine gun, the connection between the bolt carrier and the piston, has a large gap, so during the exploitation and use process or the design and manufacture, it is necessary to pay attention to the influence of the gas block hole area. , the initial volume of the gas chamber, and the gap area between the piston and the wall of the gas chamber.

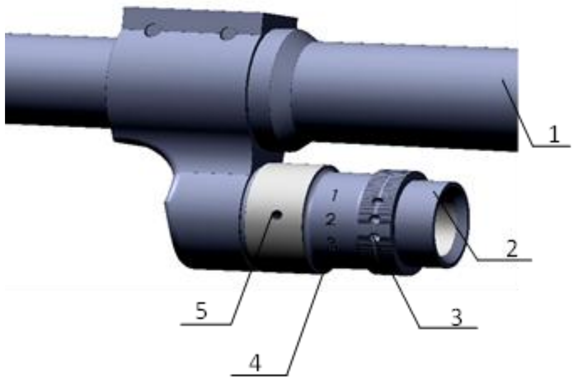

Figure 1. Structure of the gas chamber on the PKMS machine gun
1. Barrel; 2. The tube contains the piston head;
3. The hole contains the adjusting ring retaining tab;
4. Adjustment number; 5. Exhaust hole

For gas block mechanisms that provide power for automatic machines to work, medicinal gas is extracted from the gun barrel into the gas chamber through the gas block hole on the barrel. The gas flow flows into the gas chamber, creating the necessary pressure to apply to the piston face, pushing the basic link of the automatic machine recoil to automatically work. Therefore, the momentum of the medicinal gas in the gas chamber will depend on many parameters of the gas block mechanism.

The study of the problem model to evaluate the effect of structure of the gas chamber on the movement of the automatic machine on the PKMS gun when firing is very important. It gives us a more general look at the design calculations as well as the exploitation process for automatic weapons based on the principle of gas block. By that, assessed the correlation between the adjustment of the gas pressure in the gas chamber to the movement of the bolt carrier and the stabilization of the gun. On the other hand, the assessment of the effect of the structure of the gas chamber as a basis for the exploitation, use, and improvement of PKMS machine guns.

In the world, there have been many research projects on gas-operated guns. The works [4-8] mainly focus on researching the operation of gas-operated automatic machines. Research [9-11] has shown the influence of losses occurring in the gas chamber such as heat loss, flow constriction loss, or friction loss. In addition, the influence of the position of the gas block hole, the diameter of the gas block hole, and the initial volume of the gas chamber are also presented in the literature [12-16]. However, there have been no studies that have built a model to study the relationship between the gas block hole cross-section and the gas exhaust hole cross-section. Therefore, research on the overall influence of this relationship on the operation of automatic gas-operated machines is very necessary. In this study, the authors focused on studying the relationship between the cross-sectional area of the gas block hole and the area of the gas exhaust hole, thereby investigating its influence on the operation of automatic gas-operated machines.

2. SET UP THE CALCULATION MODEL

2.1 The assumptions

To establish a mathematical model to determine the pressure law in the gas chamber when taking into account the change in the gas exhaust cross-section of the gas chamber, some assumptions are used as follows:

- Propellant fire according to geometric rule;

- The fire environment has the same pressure;

- The rule firing rate of the propellant is determined by the formula u = u1.p;

- In the combustion process, the gas from the barrel into the gas chamber is critical and stable. The losses that affect, the loss of energy in the thermodynamic processes are approximated by the coefficients of influence.

- Except for springs and elastic parts, other links are considered to be absolute solids, dynamically linked with each other, with variable or constant transmission ratios.;

- Use reduced mass instead of distributed mass. The reduced mass setpoint can be arbitrary, usually the two-way contact point or the set point of the applied external force.

- With translational motion, the reduced mass m is equal to its mass *M*: *m=M*

2.2 SET UP A SYSTEM OF GAS CHAMBER THERMODYNAMIC EQUATIONS

The operational model of the gun automatic machine has been established in Figure 2. The working process of the automatic machine is determined from the moment the bullets move through the gas block hole, At this time, the gas is extracted through the gas block hole into the gas chamber. The gas pressure acting on the piston pushes the bolt carrier backward.

At this stage, the part of the gas is released through the gap between the gas chamber and the piston, the part of the gas is released through the gas exhaust hole in the gas chamber. The structure of the PKMS gas chamber creates three working modes:

- Mode 1: The gas exhaust hole is sealed (the gas adjustment ring in position 3).

- Mode 2: A gas part into the external environment by a gas exhaust hole (the gas adjustment ring in position 2).

- Mode 3: A gas part into the external environment by two holes exhaust (the gas adjustment ring in position 1).

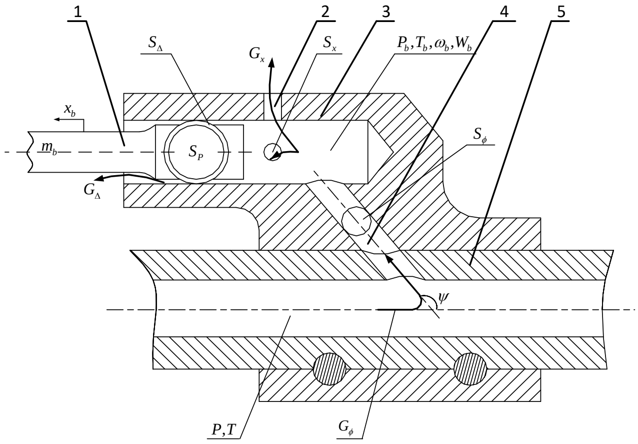

Figure 2. Physical model of gas port device

1. Piston; 2. Exhaust hole; 3. Gas chamber;

4. Gas port hole; 5. Barrel.

The automatic machine of PKMS guns operates according to the gas block principle when firing. Therefore, to assess the influence of the structure of the gas chamber on the motion of the automatic machine we proceed with all three problems: The interior ballistic problem; the thermodynamic problem of the gas chamber; and the Automatic machine dynamics problem.

a) Equation to conserve the volume of medicinal gas in the gas chamber
During the process of gas flowing into the gas chamber, the volume of combustion gas changes because the gas flows from the bore into the gas chamber. The combustion gas flows into the environment through the gap between the piston and cylinder and the exhaust hole.
According to the law of conservation of mass, the mass of burned gas in the gas chamber is written as a differential equation as follows [9]:

$$\frac{d\omega_b}{dt} = G_\phi - G_\Delta - G_x \quad (1)$$

Where:

ω_b - Mass of burning gas in the gas chamber;

G_ϕ - The gas mass flows from the bore into the gas chamber through the gas block hole;
The gas flow from the bore into the gas chamber is determined according to the following formula [9]:

$$G_\phi = \xi_G A_1 \mu_\phi S_\phi \frac{p}{\sqrt{RT}} + \left(1-\xi_G\right) A_2 \mu_\phi S_\phi \frac{p}{\sqrt{RT}} . A_2(\pi) \quad (2)$$

Where: $\pi = \frac{p_b}{p}$; $\xi_G = \begin{cases} 1 \Leftrightarrow \pi \le \left(\frac{2}{k+1}\right)^{k/(k-1)} \\ 0 \Leftrightarrow \pi > \left(\frac{2}{k+1}\right)^{k/(k-1)} \end{cases}$

μ_ϕ - The flow loss coefficient of the gas flow through the gas block hole depends on $\lambda, \chi, \psi, \varepsilon$ and is determined experimentally.

G_Δ - Combustion gas flows to the environment through the gap between the piston and cylinder. This value is calculated according to the following formula:

$$G_\Delta = \xi_4 A_1 \mu_\Delta S_\Delta \frac{p_b}{\sqrt{RT_b}} + (1-\xi_4) A_2 \mu_\Delta S_\Delta \frac{p_b}{\sqrt{RT_b}} . A_2(\pi_1) \quad (3)$$

S_Δ - Clearance area between piston and cylinder;

T_b, p_b, W_b - Gas state parameters in the gas chamber;

ξ_4 - Control coefficient;

μ_Δ - Gas flow loss coefficient.

$$\pi_1 = \frac{p_a}{p_b};\ \xi_4 = \begin{cases} 1 \Leftrightarrow \pi_1 \le \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}} \\ 0 \Leftrightarrow \pi_1 > \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}} \end{cases}$$

If there are no gas resistance grooves on the piston body then $S_\Delta = S_{\Delta tk} = \pi d \Delta$.

G_x - The flow of medicinal gas flows into the environment through the exhaust hole.

When the piston moves a certain distance, the combustion gas is partially or completely exhaustd from the gas chamber.

The gasflow from the gas chamber to the environment through the exhaust hole is calculated according to the following formula:

$$G_x = \xi_x A_1 \mu_x S_x \frac{p_b}{\sqrt{RT_b}} + (1-\xi_x) A_2 \mu_x S_x \frac{p_b}{\sqrt{RT_b}} . A_2(\pi_1) \quad (4)$$

Where:

ξ_x - Control coefficient;

S_x - Exhaust hole area;

μ_x - Gas flow loss coefficient.

b) Set up the equation for changing the volume of the gas chamber

During the gas extraction process, under the effect of combustion gas pressure, the piston moves backward. When the piston moves backward, the volume of the gas chamber increases. The change in gas chamber volume is expressed through the following equation:

$$\frac{dW_b}{dt} = S_p . v_b \quad (5)$$

Where:

$\frac{dW_b}{dt}$ - Change in volume of the gas chamber;

S_p - Piston surface area;

v_b - Piston movement velocity.

c) Energy conservation equation

The energy conservation equation for combustion gas in the gas chamber is determined according to the following formula:

$$\frac{dQ}{dt} = \frac{dU}{dt} + p_b \frac{dW_b}{dt} \quad (6)$$

$\frac{dQ}{dt}$ is the rate of change of heat in the gas chamber during the process of generating work and exchanging heat with the outside, it is determined by the following parameters: Amount of gas flowing into the gas chamber, amount of gas flowing out of the gas chamber, energy loss due to heat exchange between combustion gas and gas chamber walls.

After transformation, equation (6) is rewritten as follows:

$$\frac{dp_b}{dt} = \frac{1}{W_b}\left(K_G G_\phi kRT - G_\Delta kRT_b - G_x kRT_b - K_{Tb} p_b - kp_b S_p v_b\right) \quad (7)$$

$K_{Tb} = \frac{k-1}{R} A \sigma_{Tb} v_{Tb} \left(F_{b0} + \pi d_b X_b\right)$ - Loss function due to heat transfer through the gas chamber wall.

From methods (1), (2), and (4), the thermodynamic differential system in the gas chamber is given as follows:

$$\begin{cases} \frac{d\omega_b}{dt} = G_\phi - G_\Delta - G_x \\ \frac{dW_b}{dt} = S_p . v_b \\ \frac{dp_b}{dt} = \frac{1}{W_b}\left(K_G G_\phi kRT - G_\Delta kRT_b - G_x kRT_b - K_{Tb} p_b - kp_b S_p v_b\right) \end{cases} \quad (8)$$

2.3 SET UP THE SYSTEM OF DIFFERENTIAL EQUATIONS OF MOTION OF AUTOMATIC WEAPON

The automatic gun motion equation can be obtained by mechanical analysis using Lagrangian equation type II.

According to [1], the system of equations of motion of the automatic gun is as follows:

$$\begin{cases} \left(M_b + \sum_{i=1}^{n} \frac{K_i^2}{\eta_i} \varepsilon_i m_i\right) \frac{dv_b}{\eta_i} + \sum_{i=1}^{n} \frac{K_i}{\eta_i} \varepsilon_i m_i v_b^2 \frac{dK_i}{dl_b} = \xi_5 \left(F_b - \sum_{i=1}^{n} \frac{K_i}{\eta_i} \varepsilon_i F_i\right) \\ \frac{dl_b}{dt} = \xi_5 v_b \end{cases} \quad (9)$$

Where:

M_b, v_b - mass and velocity of base part;

l_b - movement distance of base part;

K_i, η_i - transmission ratio and efficiency of the second working part *i*;

F_b - external force acting on the base part;

F_i - external force acting on the working part *i*;

$\varepsilon_i = \begin{cases} 0 \Leftrightarrow l_b < x_{0i} \\ 1 \Leftrightarrow x_{0i} \le l_b \le x_{ci} \\ 0 \Leftrightarrow l_b > x_{ci} \end{cases}$ - control variable;

The system of equations (12) can be abbreviated as follows:

$$\begin{cases} M_{11}\ddot{l}_b + M_{12}\dot{l}_b^2 = P_A \\ \dfrac{dl_b}{dt} = v_b \end{cases} \tag{10}$$

$M_{11} = M_b + \sum_{i=1}^{n} m_i \dfrac{K_i^2}{\eta_i}$ - reduced mass of the system at the base part;

$M_{12} = \sum_{i=1}^{n} m_i \dfrac{K_i}{\eta_i}\dfrac{dK_i}{dl_b}$ - the secondary force of inertia;

$P_A = F_b - \sum_{i=1}^{n} \dfrac{K_i}{\eta_i} F_i$ - the reduced force of the system.

For gas-operated weapons, the motion of the base stage is determined when solving the following equations: System of interior ballistics differential equations, the system is fully presented in the document [10]; system of differential equations of gas chamber thermodynamics (8) and system of equations of motion of automatic machines (9). The system of equations describing the motion of an automatic machine is fully presented as follows:

$$\begin{cases}
\dfrac{dv}{dt} = \xi_1.\xi_3.\dfrac{p.S}{\varphi.\mathrm{m}} \\
\dfrac{dl}{dt} = \xi_1.\xi_3.v \\
\dfrac{dz}{dt} = \xi_2.\dfrac{p}{I_k} \\
\dfrac{d\omega_k}{dt} = \xi_2.\chi.\omega(1+2\lambda z)\dfrac{p}{I_k} - G_\phi - G_n \\
\dfrac{dW}{dt} = \xi_2.\dfrac{1}{\delta}\chi.\omega(1+2\lambda z)\dfrac{p}{I_k} + S.v.\xi_3 \\
\dfrac{dp}{dt} = \dfrac{1}{W}.\left[\xi_2.f.\chi.\omega(1+2\lambda z)\dfrac{p}{I_k} - K_t.p - K_p.p.\dfrac{dW}{dt} - K_p.G_n - K_p.G_\phi\right] \\
\dfrac{dp_b}{dt} = \dfrac{1}{W_b}.\left[K_G K_p.G_\phi - \xi_4.K_{Tb}.p_b - k.p_b.\dfrac{dW_b}{dt} - K_{pb}.(G_\Delta + G_x)\right] \\
\dfrac{d\omega_b}{dt} = G_\phi - G_\Delta - G_x \\
\dfrac{dW_b}{dt} = \xi_5.S_p.v_b \\
\left(M_b + \sum_{i=1}^{n}\dfrac{K_i^2}{\eta_i}\varepsilon_i m_i\right)\dfrac{dv_b}{\eta_i} + \sum_{i=1}^{n}\dfrac{K_i}{\eta_i}\varepsilon_i m_i v_b^2\dfrac{dK_i}{dl_b} = \xi_5\left(F_b - \sum_{i=1}^{n}\dfrac{K_i}{\eta_i}\varepsilon_i F_i\right) \\
\dfrac{dl_b}{dt} = \xi_5 v_b
\end{cases} \tag{11}$$

Table 1. Values of control coefficients

ξ_1		ξ_2		ξ_3	
$p < p_0$	$p \geq p_0$	$z < 1$	$z \geq 1$	$l < l_d$	$l \geq l_d$
0	1	1	0	1	0
ξ_4		ξ_5		ξ_{xa}	
$l < l_\phi$	$l \geq l_\phi$	$S_p \cdot p_b > F_{lx0}$	$S_p \cdot p_b \leq F_{lx0}$	$l_b \geq l_x$	$l_b < l_x$
0	1	1	0	1	0

The system of equations (11) is solved by Maple software with initial conditions of this system of equations discussed above at the time $t=0$ is $v(0)=0$, $l(0)=0$, $z(0)=z_0$, $\omega_k(0)=\omega_0$, $W(0)=W_0$, $p(0)=p_0$, $p_b(0)=pb_0$, $W_b(0)=Wb_0$, $l_b(0)=0$, the interior ballistic parameters, the gas chamber parameters and the motion parameters of the automatic weapon are determined.

3. SURVEYING THE EFFECTS OF SOME STRUCTURAL PARAMETERS OF THE GAS CHAMBER

The PKMS machine gun is an automatic gas-operated weapon, with an open gas chamber, and a long recoil piston. When firing, a part of the gas flows from the barrel through the port hole and flows into the gas chamber. The pressure of the gas in the gas chamber to the piston is transmitted to the bolt carrier pushing the bolt carrier backward. This is what causes automatic movement.

3.1 Input parameters

The input parameters are used to solve the system of differential equations of dynamics of the automatic weapon of the PKMS machine gun as shown in Tab. 2.

Table 2. Input parameters

Parameters	Symbol	Value	Unit
Parameters in the interior ballistic problem			
Mass of powder charge	ω	$3.2 \cdot 10^{-3}$	kg
Caliber of gun	d	$7.62 \cdot 10^{-3}$	m
Projectile mass	m	$9.6 \cdot 10^{-3}$	kg
Total pressure impulse	I_{k0}	$229 \cdot 10^{3}$	Pa.s
The shape coefficients of powder	χ $\lambda\chi$	1.06 -0.06	
Co–volume of powder gas	α	10^{-4}	m^3/N
The powder density	δ	$1.6 \cdot 10^{4}$	N/m^3
Adiabatic index	k	1.25	
Specific energy of powder	f_0	$102 \cdot 10^{3}$	J/kg
The coefficient of projectile fictitious mass	φ	1.206	
Constant heat transfer coefficient in the barrel	σ_T	0.9	
Relative temperature difference	ϑ_T	0.7	
Specific gas constant of propellant gases	R	8.3	J/Kmol
Acceleration of gravity	g	9.81	m/s^2
Gas port hole area	S_ϕ	$19.48 \cdot 10^{-6}$	m^2
The cross-sectional area of the barrel	S	$48.2 \cdot 10^{-6}$	m^2
Distance between the initial position of the base of the projectile and the position of the gas vent	l_ϕ	0.37	m
Displacement of the projectile inside the barrel	l_d	0.55	m
Initial pressure	p_0	39.2	MPa
Initial volume of the combustion chamber	W_0	$3.8 \cdot 10^{-6}$	m^3
Initial internal surface area of ammunition chamber	F_k	$6 \cdot 10^{-4}$	m^2
Thermodynamic parameters of the gas chamber			
Diameter of piston	d_p	$1.4 \cdot 10^{-2}$	m
Diameter of the gas chamber	d_b	$1.42 \cdot 10^{-2}$	m
Piston surface area	S_p	$1.539 \cdot 10^{-4}$	m^2

Parameters	Symbol	Value	Unit
Radial gap area between piston and gas chamber	S_Δ	$5.5\cdot10^{-6}$	m^2
The area of the exhaust hole	S_x	$4.15\cdot10^{-6}$	m^2
Initial volume of the gas cylinder	W_{b0}	$1.45\cdot10^{-6}$	m^3
Initial internal surface area of the gas chamber	F_{b0}	$4.14\cdot10^{-4}$	m^2
Exhaust hole location	l_x	0.012	m
Constant heat transfer coefficient in the gas chamber	σ_{Tb}	0.9	
Relative temperature difference	ϑ_{Tb}	0.7	
Kinetic parameters			
The mass of the piston and bolt carrier	m_b	0.86	kg
The mass of the bolt	m_{kn}	0.1477	kg
Mass of spring	m_{lx}	0.036	kg
Initial compression force of the return spring	F_{lx0}	50	N
Mass of the cartridge	m_{vd}	$9.2\cdot10^{-3}$	kg
Stiffness of return spring	C	500	N/m
Bolt cam profile angle	α_1	45	deg
Efficiency of the bolt carrier to the bolt	η_1	0.69	

The results of solving the system of equations (11) with the above input parameters are as follows:

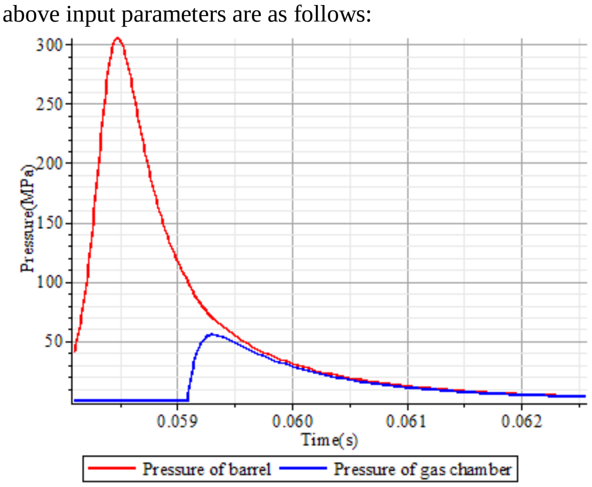

Figure 3. Pressure graph over time

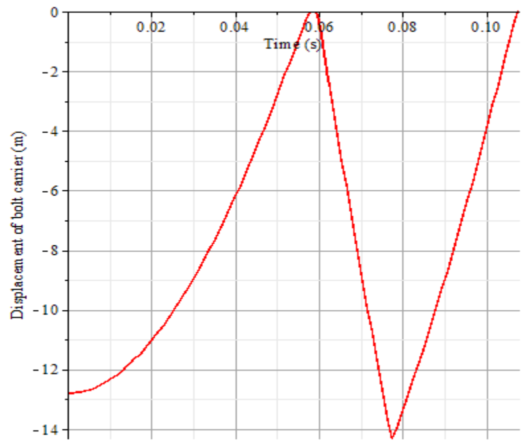

Figure 4. Graph of displacement of the bolt carrier over time

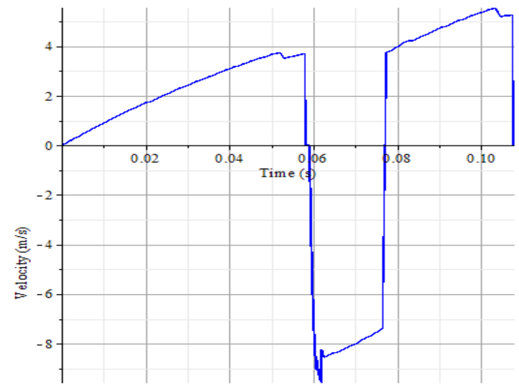

Figure 5. Velocity graph of the bolt carrier over time.

3.2 Influence of gas block hole area

The composition of the gas block hole area is investigated in the equation for calculating the gasflow through the gas block hole:

$$G_n = A_n \mu_n S_\phi \frac{p_n}{\sqrt{RT_n}} \qquad (12)$$

The area of the gas block hole has a great influence on the intensity of the effect of the cháy gas in the gas chamber. The larger the area of the gas block hole, the greater the amount of combustion gas flowing into the gas chamber per unit of time (increased combustion gas flow), the energy of combustion gas lost through the gas extraction hole is also reduced, and the combustion gas pressure in gas chamber increases.

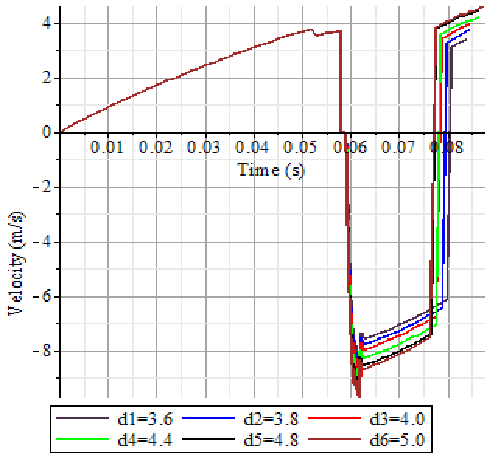

Figure 6. Graph of bolt carrier velocity over time

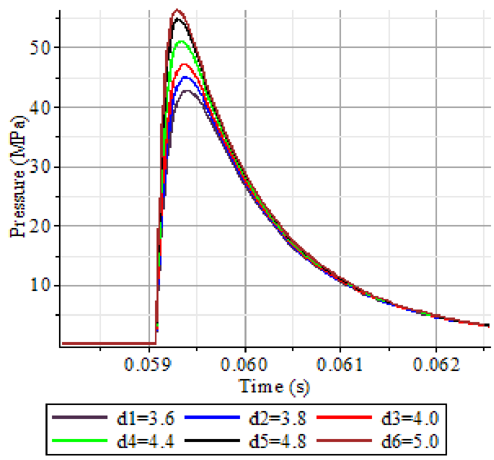

Figure 7. Graph of gas chamber pressure over time

The graph shows that the area of the gas block hole greatly affects the pressure and momentum of the combustion gas in the gas chamber. Therefore, we often change the area of the gas block hole to change the intensity of the combustion gas in the gas chamber. This method is widely used in gas-operated automatic guns. This is a convenient measure, simple in structure, and ensures the gun works normally in all conditions.

As the gas block hole area increases, the movement speed of the base link increases, the automatic cycle time will decrease, then the firing rate will increase. However, as the firing speed increases, the impact of the parts will be greater, causing the durability of the moving parts to decrease. Therefore, increasing the diameter of the gas block hole will affect the gun's life.

During operation, it is necessary to pay attention that if the gas block hole is covered with a lot of soot, it will reduce the area of the gas block hole, leading to the automatic part not moving back completely, so cleaning, unclogging, and cleaning the gas block hole will be necessary. Using specialized tools and taking good care of the gun before and after shooting is necessary for the gun to function well.

3.3 Investigate the effect of the gap area between the piston and the gas chamber

To investigate the effect of the gap area between the piston and the gas chamber wall, the gap area parameter S_x is changed, taking the values 2.10^{-6} (m^2), 4.10^{-6} (m^2), and 6.10^{-6} (m^2) respectively, the survey results are as follows:

$$G_\Delta = A_1 \mu_x S_x \frac{p_n}{\sqrt{RT_n}} \qquad (13)$$

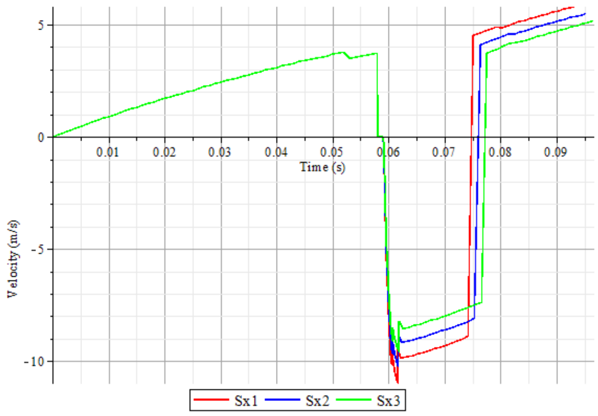

Figure 8. Velocity graph of the bolt carrier over time

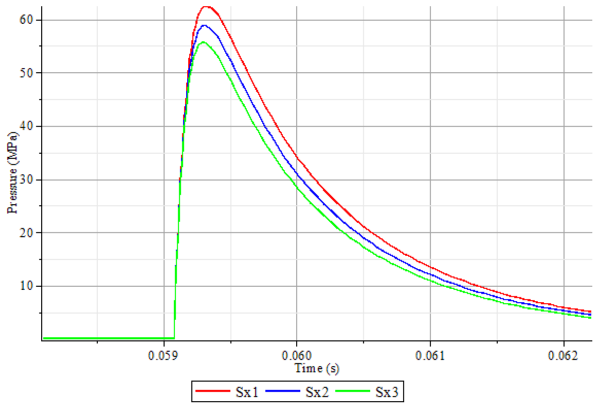

Figure 9. Graph of gas chamber pressure over time

The graphs in Figures 9 and 10 show that: the gap between the piston and the gas chamber wall has a great influence on the pressure in the gas chamber. When the gap increases, more combustion gas escapes through the gap, causing the pressure in the gas chamber to decrease.

Therefore, for a closed gas chamber, we must choose the smallest gap between the piston and the gas chamber while still ensuring good working conditions. However, this gap is usually large for open-gas chambers to ensure self-aligning conditions of the piston when moving in the gas chamber. In the design to reduce the amount of gas escaping through the gap between the piston and the gas chamber wall, solutions must be chosen such as making the piston have a concave surface to avoid the formation of a high-pressure area near the gap, and on the piston wall to do some things. Grooves to block combustion gas and reduce friction when moving.

3.4 Investigate the effect of adjusting the exhaust hole in the gas chamber

PKMS machine gun with gas chamber has 3 adjustment modes. To evaluate the influence of adjusting the gas exhaust hole on the working process of the automatic machine, the Sxa gas exhaust area values are changed corresponding to the 3 adjustment modes. The results obtained are as follows:

Table 3. Calculation results

Number of holes	S_{xa} ($m^2.10^{-6}$)	p_{tpmax} [MPa]	p_{bkmax} [MPa]	v_0 [m/s]	Cycle T(s)
0 hole	12.8	304.2	45.7	851.1	0.0844
1 hole	17.8	304.2	41.1	850.2	0.0892
2 holes	22.7	304.2	37.3	849.5	0.0951

From the results of calculations given by the above figures and the table of interior ballistics values in the special position corresponding to three adjustment values are 0 holes, 1 hole, and 2 holes: We see that the velocity and displacement graph of the bolt carrier at a firing cycle in the adjustment cases of the exhaust gas section are the same lines. Otherwise, specific values such as the maximum velocity and the final collision velocity, the duration of a cycle of motion of the bolt carrier are distinct and different when adjusted.

The final collision velocity of the bolt carrier corresponds with adjustment cases in the 0-hole, one-hole, and two-hole modes: 4.913 m/s; 3.625 m/s; 2.424 m/s. Thus, the final collision velocity values decrease markedly, corresponding to the case of increasing the exhaust area. As a result, the change of gas exhaust section helps the gunner actively reduce the shaking of the gun, thereby increasing the accuracy of the gun.

The one-cycle time of the bolt carrier corresponds to the adjustment of the exhaust section in the 0-hole, 1-hole, and 2-hole modes respectively: 0.844(s); 0.0892(s); 0.0951(s). From that specific value, We see that increasing the gas exhaust section will increase the working cycle of the gun, thus reducing the firing speed of the gun. Decreasing the firing speed of a machine gun will reduce the effectiveness of destroying targets while fighting. Therefore, the gunners need to be adjusted to suit each combat objective.

4. CONCLUSIONS

The paper presents a computational model with reasonable assumptions. With the calculated results obtained, some conclusions are drawn as follows:

- The use of a combustion gas regulator in the gas chamber is essential for machine guns with high rates of fire. Equipment that gives weapons credibility in combat;
- Investigate the effect of adjustment of gas exhaust area to the working process of the PKMS automatic guns when fired. Based on that, evaluate the element that affects the reliable working of the automatic machine; and provide a specific theory for adjusting the gas pressure in each case;

- Adjusting the size of the exhaust hole will bring efficiency in both manufacturing technology and exploitation. Reduce costs for the production process.

- The results of the paper are the scientific basis for calculating, and evaluating the reliable work of the automatic machine; It opens a new direction in the design and manufacture of gun models operating according to the gas block principle.

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