Studying the dynamic characteristics of gas-operated guns using Solidworks Motion software

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Abstract:

Introduction/purpose: This article presents a new approach to determining the dynamic characteristics of the automatic firing system of gas-operated automatic guns.

Methods: Based on the real structure of the automatic firing system of gas-operated automatic weapons, a 3D model of the gun is simulated using Solidworks software, and the dynamic characteristics of the automatic firing system are calculated on Solidworks Motion software.

Results: The obtained simulation results include displacement and velocity of the breech platform over time; the force exerted by the hammer on the bolt carrier over time; and impact force of the bolt carrier and gun body over time. These results are compared with data obtained from experiments to verify the mathematical model. The cycle of a shot according to test results is 0.0846 s and the firing rate error between theoretical and experimental results is 2.82%.

Conclusion: Research content allows users to visually evaluate the working process of all parts of the automatic firing system. The results of this research can be applied to calculations for automatic firing systems of different automatic guns. This is an important scientific basis for improving and upgrading existing automatic weapons and serving the process of designing and manufacturing new types of automatic weapons in the future.

Keywords: dynamics, automatic firing system, automatic weapons, gas-operated weapons, Solidworks Motion.

Introduction

For small automatic weapons, stability during firing is one of the factors that affect shooting accuracy, so studying the stability of weapons when firing is of significant importance for improving weapons to increase shooting accuracy. The stability of a gun is affected by many factors such as shooter's movements, surrounding environmental conditions, relative displacement, and collision of gun parts when shooting. In particular, the movement of parts in the gun's automatic firing system is a factor that can be determined. The characteristics of these movements are determined by solving the problem of the dynamics of the gun's automatic firing system when fired, see (Bien et al, 2021; Macko et al, 2021; Doan et al, 2023; Balla et al, 2010a).

Currently, there are two main methods commonly used to determine the dynamic characteristics of the automatic firing system of gas-operated automatic weapons. These are numerical methods and experimental methods. The numerical method is a method in which the establishment of a system of differential equations determining the relationship between components in the automatic firing system of a gun is carried out based on classical equations such as Newton's second law equation, Lagrange equation of the 2nd type, etc. The advantage of this method is that the calculation scope can be easily expanded and calculation options can be changed flexibly. In particular, the results of theoretical problems can be used to localize and predict experimental results during the research and design process. However, the structural shape of the parts of the automatic firing system is always complex, and the accuracy of the input parameters determined by sub-problems is not high (transmission ratio problem, efficiency problem, collision problem, etc.). Therefore, this method needs to use many assumptions, so the results obtained in all conditions are approximate and only capable of approaching reality, see (Balla & Mach, 2007; Balla et al, 2010b; Vitek, 2019). The experimental method is a method of determining the dynamic characteristics of an automatic firing system by measuring these parameters through specialized measuring equipment. The commonly used measuring equipment is mainly a high-speed camera system. The most outstanding advantage of using a high-speed camera system is its simplicity of use and quick preparation. With this method, any part of the gun can be identified.

However, the disadvantage of this method is that details with complex motion rules are difficult to determine, and high-precision measuring devices are difficult to access. In addition, the implementation cost is relatively high (Vitek, 2019; Balla et al, 2015).

Today, with the high development of science and technology in the field of computers, associated with the evaluation/improvement/ advancement of 3D simulation software (such as Inventor, SolidWorks, Adam, etc.), the application of simulation software to determine the dynamic components of structures has become easier and more accurate. There have been many studies on the application of 3D simulations in determining kinematic laws of simple structures and parts of the world, see (Fiser & Popelinsky, 2007; Fiser, 2007).

However, the application of 3D simulation software to determine the dynamic characteristics of the automatic firing system of automatic weapons is still limited. In this study, the authors applied 3D simulation software to determine the dynamic characteristics of an AK submachine gun in the Solidworks Motion working environment. The experimental process using a high-speed camera is used to determine the dynamic characteristics of the automatic machine. The dynamic simulation results are compared with the data obtained from experiments to evaluate the reliability of the implemented method.

Problem formulation

Set up a dynamic simulation model

The AK submachine gun is an automatic weapon that operates on the principle of gas extraction. The diagram of the working principle of a gas-operated automatic weapon is presented in Figure 1, see (Dung et al, 2023).

The working principle of gas-operated automatic weapons is that part of the gas in the barrel is extracted through the gas hole to provide energy for the automatic mechanism to perform the next shot. Gas-operated automatic weapons have many advantages such as simple structure, reliable operation, high accuracy, large effective range, and high rate of fire, see (Popelinsky & Balla, 2004; Allsop, 1997). With such outstanding advantages, it is widely used.

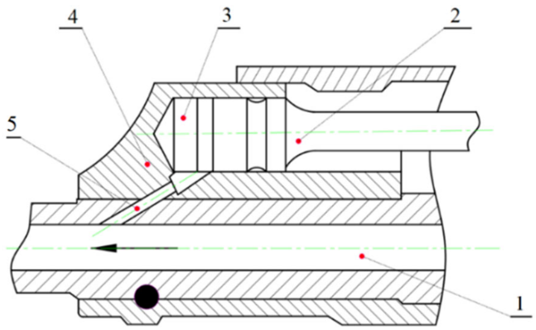

Figure 1 – Schematic arrangement of the gas piston
1 - barrel; 2 - piston rod with the piston; 3 - cylinder; 4 - gas block; 5 - gas port

The main components of the AK submachine gun are listed in Figure 2.

Figure 2 – Main components of the AK submachine gun

With such a complex structure, using numerical methods to determine the dynamic characteristics of AK submachine guns is very difficult. Therefore, this method often uses many coefficients in the calculation process such as the collision recovery coefficient, the collapsed mass coefficient (Macko et al, 2021), etc. Experimental methods make it difficult to determine the movement characteristics of the hammer, the safety lever, and the characteristics of front and rear impacts between the bolt carrier and the gun body (Vitek, 2019). In addition, the cost of this method is relatively high. Therefore, the method of using 3D computational simulation software is very suitable. The advantage of this method is that it provides intuitiveness in calculation. Determining the input parameters for this method is also relatively simple. This method gives relatively accurate and complete calculation results.

Creation of the parts geometry and the assembly mechanism

The automatic firing system of the AK submachine gun is a system with a complex structure. The connection between the details in the automatic firing system is in the form of pins, elastic springs, profile cams, or impact types. The assembly structure of the automatic firing system is divided into 8 main components as follows: gun body; bolt carrier and piston; carrier spring; hammer; safety lever; and magazine. The parts of the automatic firing system of the AK submachine gun are simulated according to the actual size of the part on Solidworks software as shown in Figure 3. In the Solidworks Assembly environment, it is necessary to click mate to assemble the gun parts.

Figure 3 – 3D model of the AK submachine gun:
1 - gun body; 2 - return spring; 3 - bolt carrier and piston; 4 - hammer;
5 - safety lever; 6 - magazine, 7 - bolt

The stages of the SolidWorks Motion research

A motion study can be created from the Tools → Add-Ins menu and accessed from a Motion Study tab at the lower portion of the graphics area.

- Click Properties to set value in the Frames per second field. Activate Animate during the simulation and Show all Motion Analysis message options;

- Under Motion Analysis, click Advanced Options to Select GSTIFF solver, see (Nedelcu et al, 2020, 2011).

External forces acting on the automatic firing system

External forces acting on the automatic firing system when firing are shown in Figures 4 and 5. These forces have a cyclic nature when firing in series.

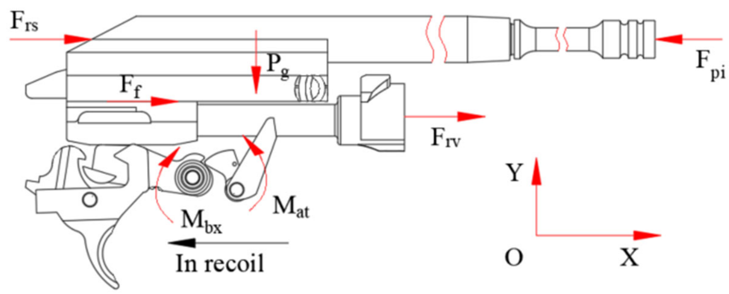

Figure 4 – External force acts on the automatic firing system when the bolt carrier recoils

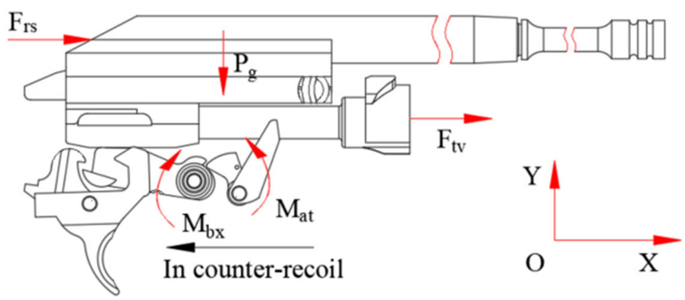

Figure 5 – External force acts on the automatic firing system when the bolt carrier is pushed up

The symbols of the force components in Figure 4 and Figure 5: F_{pi} – combustion gas pressure force acts on the piston; F_{rs} – force of the bolt carrier spring; F_f – friction force between the bolt carrier and the gun box; M_{bx} – torque of the torsion spring acts on the hammer; M_{at} – torque of the torsion spring acts on the safety lever; F_{rv} – bullet shell withdrawal force; F_{tv} – force that pushes the bullet into the chamber; and P_g – gravity of the bolt carrier.

- The force due to the combustion gas pressure in the gas chamber acts on the piston

For automatic firing systems of gas-operated automatic weapons, the force exerted on the piston by the combustion gas pressure in the gas chamber is the energy for the automatic machine to work. Therefore, this is the input parameter to solve the dynamic problem of a gas-operated automatic machine. The force due to combustion gas pressure in the air chamber depends on the pressure in the air chamber and the piston cross-sectional area.

There are many methods to determine the pressure law in the air chamber. The Blagonrarov method does not reveal the law of variation of combustion gas pressure in the gas chamber over time, so it is not used currently, see (Allsop, 1997). The Mamontop method has solved the above deficiency, however, the calculation process is very complicated (Allsop, 1997). Calculation using the Bravin method is simpler and the results are also relatively accurate. Currently, with the development of computer science, the combustion gas pressure in the gas chamber is determined by simultaneously solving the interior ballistics equation, the gas chamber thermodynamic equation, and the motion equation of the automatic machine, see (Dung et al, 2023). However, the calculation volume of this method is too large, and continuously adjusting the calculation process is inappropriate. Therefore, the Bravin method chosen to determine the pressure in the air chamber is appropriate when the main concern is the pressure in the air chamber.

The equation for determining the combustion gas pressure in the gas chamber using the Bravin method is as follows:

$$p_b = p_\varphi e^{\frac{-t}{b}}(1-e^{-\alpha\frac{t}{b}}) \quad (1)$$

The combustion gas pressure force in the gas chamber is determined according to the formula:

$$F_{pi} = p_b S_p \quad (2)$$

where: p_φ - gas pressure in the barrel at the moment the bullet passes through the gas hole. This pressure value is determined by solving the interior ballistics problem or by experimental methods; *e* - natural logarithm base; *t* - time during which the burning gas acts on the piston; α - coefficient takes into account the influence of the structural parameters of the air chamber (the method for determining this coefficient is presented in detail in the document (Fiser & Popelinsky, 2007)); and *b* is the Bravin coefficient. The results of calculating the pressure force in the gas chamber F_b are shown in Figure 6.

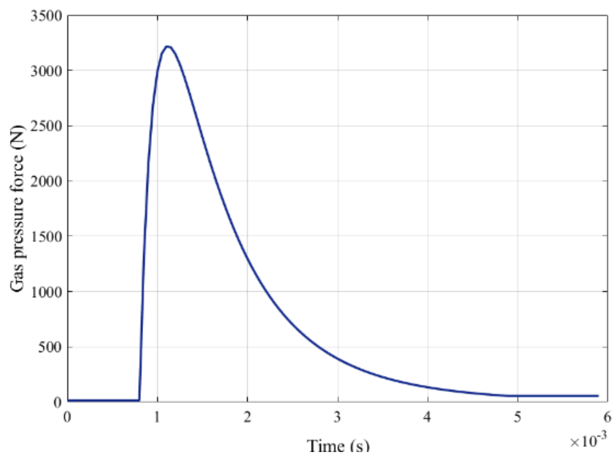

Figure 6 – Graph of combustion gas pressure force in the gas chamber

- The force of the return spring

This force acts on the weapon casing and the bolt carrier throughout the whole functional cycle. The return spring force significantly influences the function cycle of the weapon. It is usually considered linear and is determined by the following formula:

$$F_{rs} = F_{rs0} + k_{rs} \cdot X \quad (3)$$

where F_{rs0} is the return spring pre-tension force; k_{rs} is the stiffness of the return spring; and X is the deformation of the return spring.

The hardness of the return spring is determined by experimental methods. The return spring of the AK submachine gun and the fixture for the experiment are shown in Figure 7.

Figure 7 – Return springs

The jig model for the experiment is presented in Figure 8. The hardness of the return spring is determined experimentally using the ST-1000 SALT multi-purpose tensile and compression machine. When compressing the spring, the display screen of the compression machine will display the force according to the compression of the spring, see Figure 9. Based on the results obtained experimentally, the stiffness of the push-back spring is determined according to Huc's law.

Figure 8 – Deploy an experiment to measure spring hardness

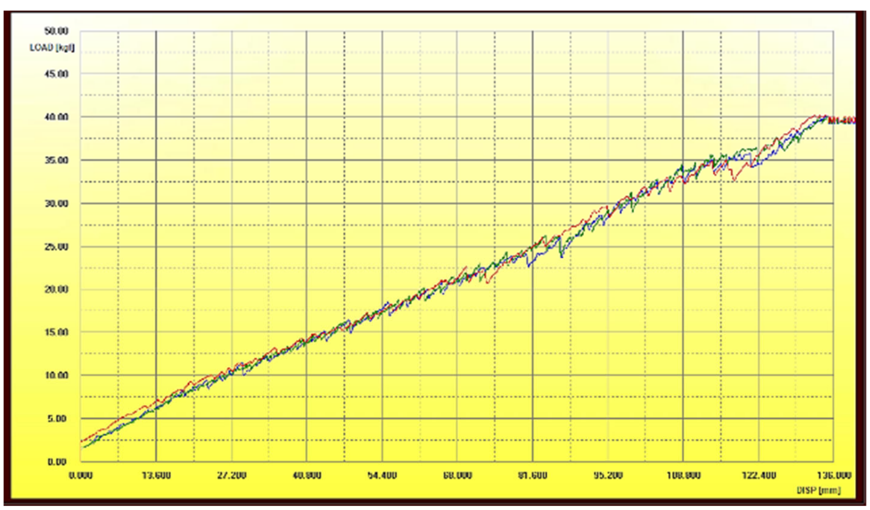

Figure 9 – Graph of compression force versus spring compression

- The friction force between the bolt carrier and the gun box

Friction force calculation is a very complex and important problem in calculating the dynamics of the automatic firing system. The friction force is the variable force during the movement of the breech block carrier, and it depends on a lot of factors. The friction force acting on the automatic firing system occurs in many positions, such as the friction force between the breech block carrier and the receiver assembly, the friction force between the breech block carrier and the bolt, the friction force between the breech block carrier and the working mechanisms, the friction force is caused by the collision, etc. In practice, however, the friction force between the breech block carrier and the receiver assembly is much larger than other friction forces. Therefore, to simplify the analysis, the authors only consider the friction force between the breech block carrier and the receiver assembly while the other friction forces are neglected. The effect of this simplification on the accuracy of the final solution is negligible.

The friction force between the breech block carrier and the receiver assembly is proportional to the normal contact force, as given in equation (4):

$$F_f = \mu \cdot N \tag{4}$$

The coefficient μ is called the coefficient of friction. Often two values of μ are quoted: the coefficient of static friction μ_s, which applies to the onset of sliding, and the coefficient of kinetic friction μ_k, which applies during a sliding motion. The coefficient of friction between the breech block carrier and the receiver assembly is determined by the experiment, see (Fiser & Popelinsky, 2007); N is the reaction force of the gun box acting on the bolt carrier.

The normal contact force is determined by the following formula:

$$N = m_\Sigma \cdot g \tag{5}$$

where m_Σ is the total breech block carrier mass and g is the acceleration of gravity.

- Force to withdraw the bullet case

The force required to remove the empty cartridge case from the chamber acts until the chamber is completely clear of the cartridge case. This force is determined by the friction force, F_{ms}, between the cartridge case and the chamber wall, which is determined by the propellant gas pressure acting on the inner surface of the cartridge case. The diagram used to calculate the cartridge case extraction force is illustrated in Figure 10, see (Tien et al, 2021).

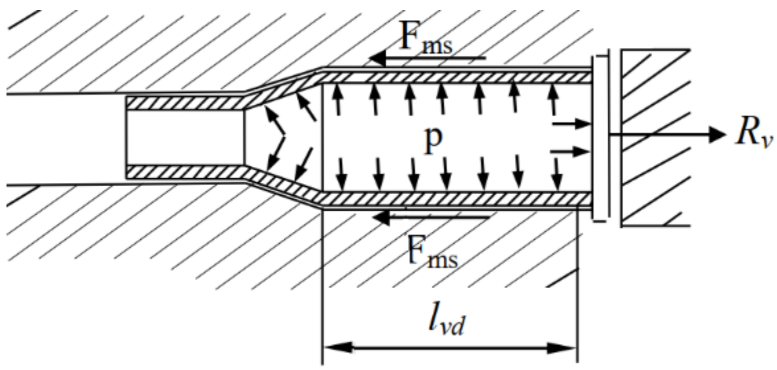

Figure 10 – Diagram to calculate force when extracting the cartridge case:
R_v - the force of casing withdrawal; p is the pressure in the combustion chamber;
F_{ms} - the friction force between the casing and the bullet chamber wall;
l_{vd} - the length of the cylindrical part of the casing

Normally, small automatic weapons usually use cartridges which are cylindrical cartridge cases and short. Therefore, the cartridge case extraction force, R_v is determined according to the following approximate formula, see (Tien et al, 2022; Dung et al, 2023):

$$R_v = 2\pi f \cdot l_{vd} \cdot E_n \cdot \delta \cdot \Delta \tag{6}$$

where: *f* – coefficient of friction between the cartridge chamber and the cartridge case; l_{vd} – length of the cartridge case in the cartridge chamber; E_n – modulus of elasticity of the cartridge case material; *δ* – wall thickness of the cartridge case; Δ – relative interference (the magnitude of this value depends mostly on the maximum pressure and the cartridge case material).

- Gravity of gun parts

The object's gravity is located at the center of the object. This force is perpendicular to the horizontal plane and has a vertical downward direction. The magnitude of these forces is determined according to the following formula:

$$P_g = m \cdot g \tag{7}$$

where m is the mass of the object and *g* is the acceleration of gravity.

Install forces in Solidwork software

After determining the rules of the forces acting on the bolt carrier during the process of recoil and return, the results are exported to a spreadsheet on Excel software. They are then added to the Solidworks environment. The setting parameters are shown in Figures 11-16.

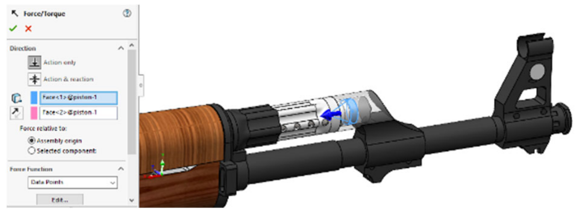

Figure 11 – Set the position and the set point of the gas chamber pressure force

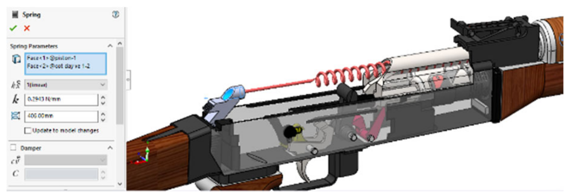

Figure 12 – Set the direction, the magnitude, and the set point of the return spring

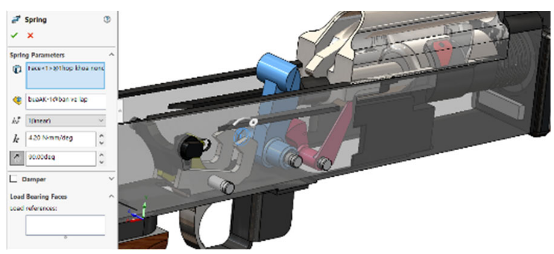

Figure 13 – Set the direction and the magnitude of the hammer's torsion spring

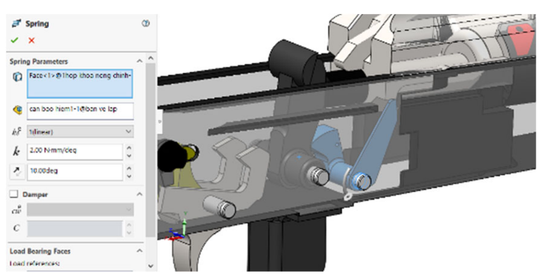

Figure 14 – Set the direction and the magnitude of the torsion spring of the safety lever

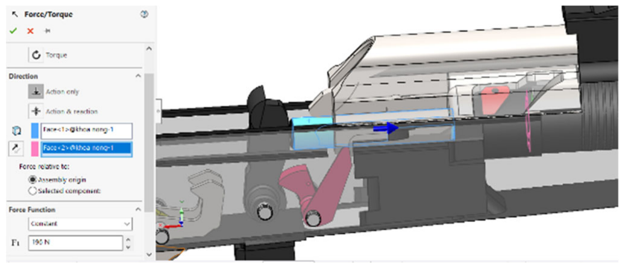

Figure 15 – Set the direction and the magnitude of the bullet casing force

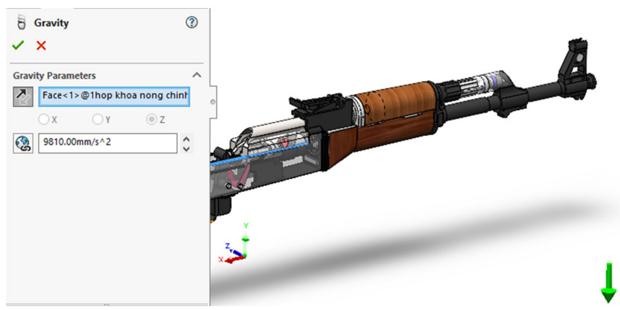

Figure 16 – Set the direction and the magnitude of gravity

After establishing the direction and the magnitude of the forces in the Solidworks environment, the contacts when moving the parts of the automatic firing system on the AK submachine gun need to be established. The contacts are set up with the parameters entered as shown in Figure 17.

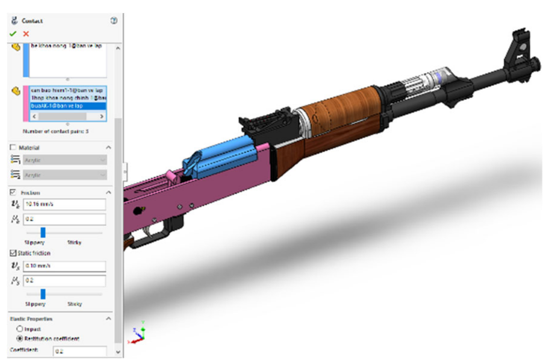

Figure 17 – Set up the contacts between the parts in the automatic firing system

Results and the discussion

Problem solution

After setting the initial parameters and connections between the parts of the AK submachine gun, a calculation model is established as shown in Figure 18. The calculation process is performed in the following order:

Click Calculate to run the computational model. During the computing period, the Motion Analysis Messages window will display specific information.

The initial position and the study's time are determined as follows:

The initial position of the mechanism is determined as shown in Figure 18.

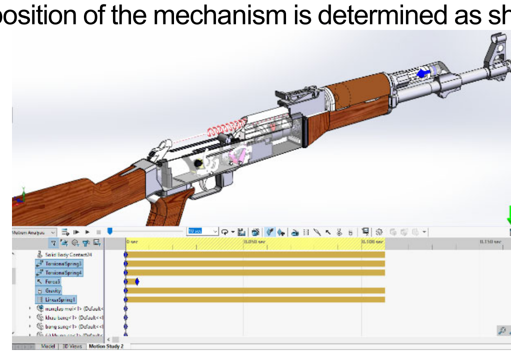

Figure 18 – Dynamic computational model of the automatic firing system

After the calculation is finished, the following options will be available:

- Click Results and Plots to see the parameters as a function of time;
- In this section, select the parameters that need to display the results such as displacement, velocity, acceleration, applied force, and moment of the part of interest, see Figure 19. These parameters can also be exported to an Excel table.

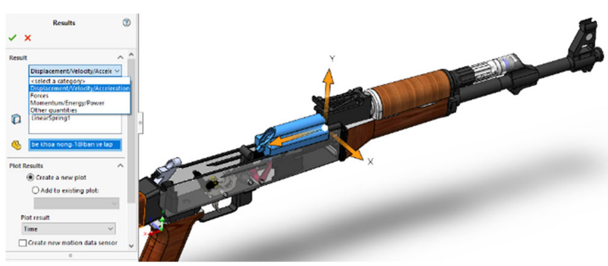

Figure 19 – Select the parameters to display

The results presented in Figures 20 to 25 are the dynamic parameters of the automatic firing system of the AK submachine gun when firing. These parameters include the velocity of the bolt carrier, the movement law of the bolt carrier, the law of rotation angle of the hammer, the force of the hammer acting on the bolt carrier, and the collision force between the bolt carrier and the gun body.

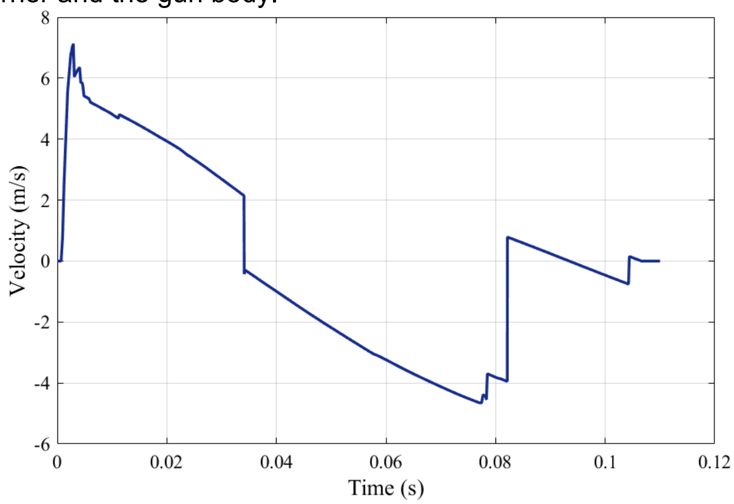

Figure 20 – Graph of the velocity of the bolt carrier over time

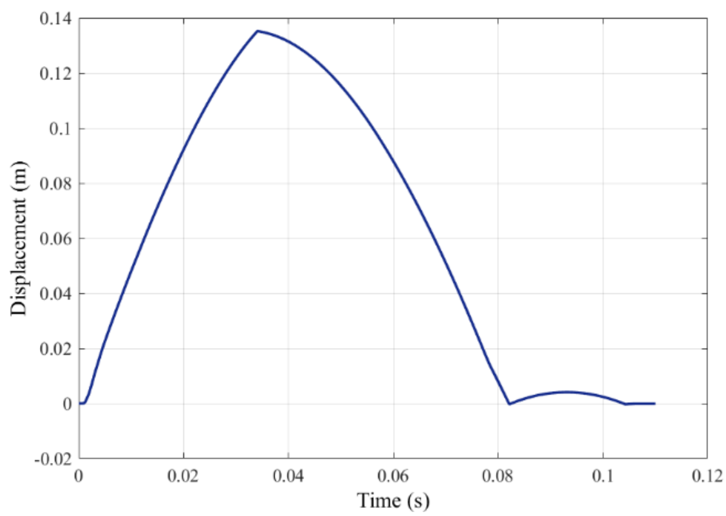

Figure 21 – Graph of the displacement of the bolt carrier over time

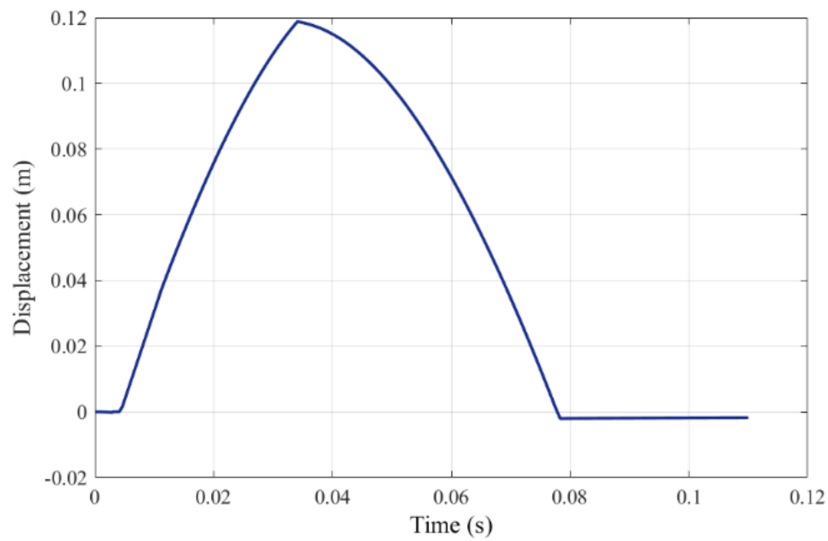

Figure 22 – Graph of the displacement of the bolt over time

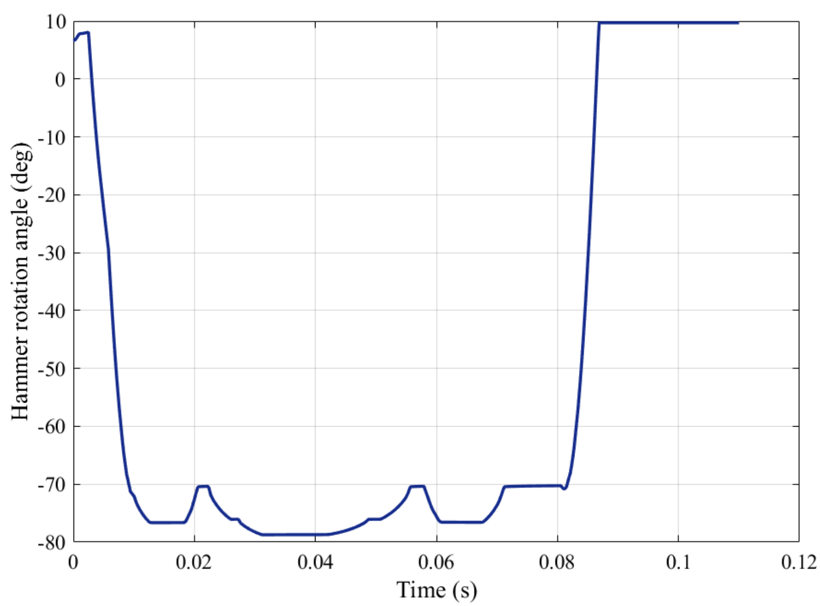

Figure 23 – Graph of the hammer rotation angle over time

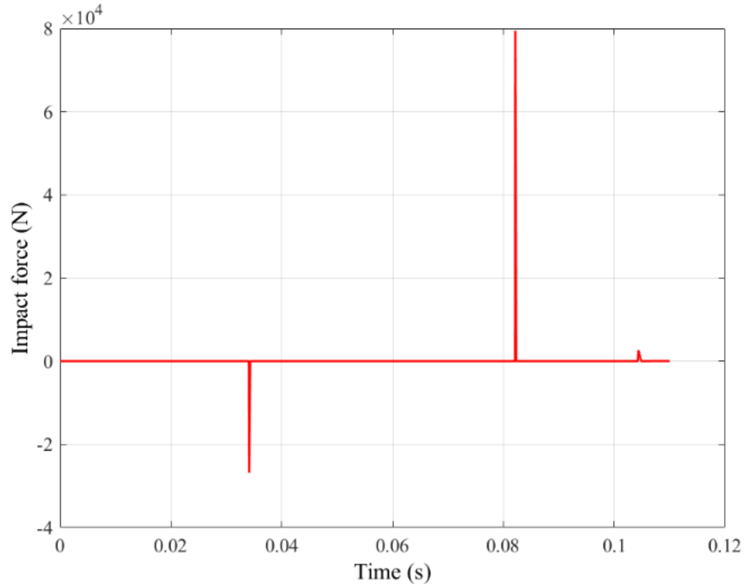

Figure 24 – Graph of the impact force between the breech and the gun body over time

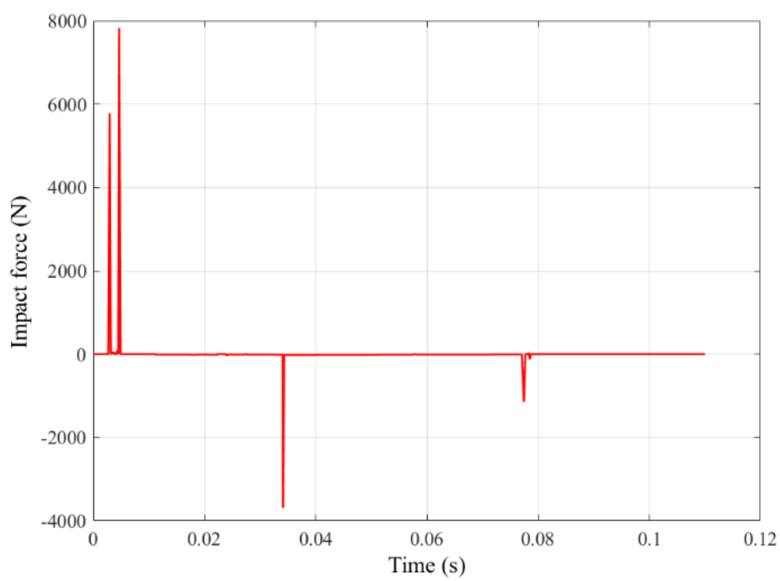

Figure 25 – Graph of the impact force between the bolt and the bolt carrier over time

Some comments are pointed out as follows:

The special points of the graph in Figures 20 and 21 show the moment of collision of the bolt carrier with the other parts of the automatic machine. The time it takes for the bolt carrier to move back is less than the time it takes for the bolt carrier to be pushed up. After an impact at the top position, the bolt carrier bounces back a distance before the hammer hits the firing pin to fire.

The change in the direction of movement of the bolt is shown in Figure 22. At this time, there is a collision between the breech bolt and the bolt carrier when the bolt moves within the cam-shaped section of the bolt carrier.

When the bolt carrier moves backward, the hammer is pressed down and it rotates around the axis (see Figure 23). This impact reduces the speed of movement of the bolt carrier, which is the cause of the decrease in the rate of fire.

The impact with the largest amplitude is when the bolt carrier is in the rearmost position and the top position (see Figure 24). In these two positions, the amplitude of collision force between the bolt carrier and the gun box is the largest, which causes strong fluctuations in the gun barrel, reducing the gun's accuracy when firing in series.

Evaluate the reliability of the calculation method

To evaluate the reliability of the new calculation method, an experimental method was used to verify the calculation model. The dynamic parameters of the bolt carrier are the basis for evaluating the ability of the automatic firing system to operate reliably. Therefore, the purpose of this experiment is to determine the displacement and the movement speed of the bolt carrier. The results obtained are the basis for verifying the established calculation method. In the experimental part of this study, we used a non-contact measurement technique. The high-speed camera system FASTCAM SA1.1 model 675K - C1 was used to measure the movement of the bolt carrier, see Figure 26 (Doan et al, 2023). This system includes a Fastcam SA1.1 high-speed camera with the basic parameters in Table 1, a computer used to install PFV software and store information, a lighting system, and a connection cable. PFV software is used to control high-speed cameras from a computer. TEMA software is used to process the records as well as collect the necessary data, (Tien et al, 2022, Vo et al, 2021). The system deployment diagram in the laboratory is shown in Figure 27.

Figure 26 – SA1.1 High-speed camera system

Table 1 – Some basic parameters of the camera

Parameters	Value
Maximum write speed	675000 fps @ 64x16 pixels
Data memory	8GB is equivalent to 5457 64x16 pixels photos or 5400 1024x1024 pixels photos
Sensor	12bit DAC

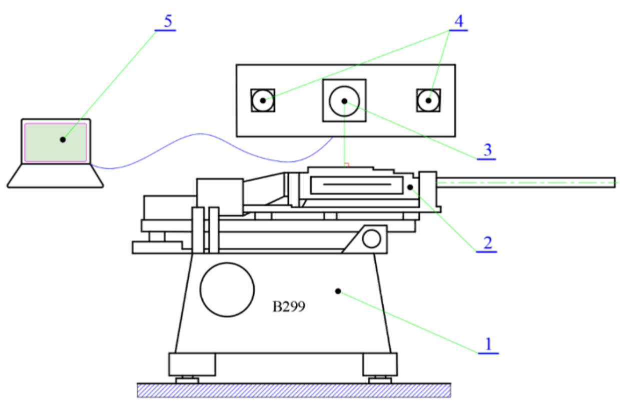

Figure 27 – Diagram of the arrangement for measuring the displacement of the bolt carrier using the SA1.1 high-speed camera system:
1 - B299 firing platform; 2 - AK submachine gun; 3 - SA1.1 high-speed camera; 4 - lighting system; 5 - computer with processing software

The testing was conducted at the Weapons Technical Center/Military Technical Academy under the environmental conditions: a temperature of 24°C and a humidity of 75%. AK submachine guns and 7.62mm ammunition are of the same batch and are insulated under the same environmental conditions. The layout diagram of the equipment used in the test is described in Figure 28. The camera installation mode is described in Figure 29.

Based on the records, the displacement and the velocity of the bolt carrier can be determined. TeMA software is used to process records as well as collect necessary data.

Figure 28 – Arrangement of the equipment in testing

Figure 29 – Set parameters of the high-speed camera

Discussion

The experimental data are used to compare with the data from the computational model. The results of comparing the displacement and the velocity of the bolt carrier are shown in Figure 30 and Figure 31.

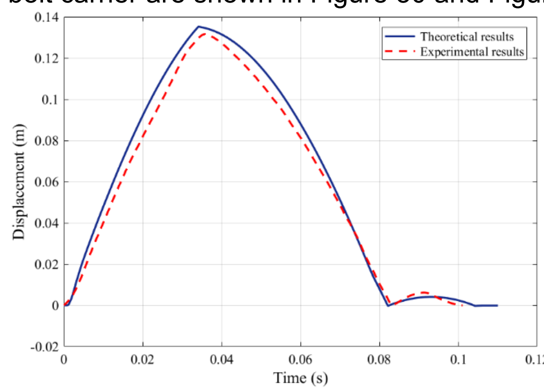

Figure 30 – Comparison of the displacement of the bolt carrier

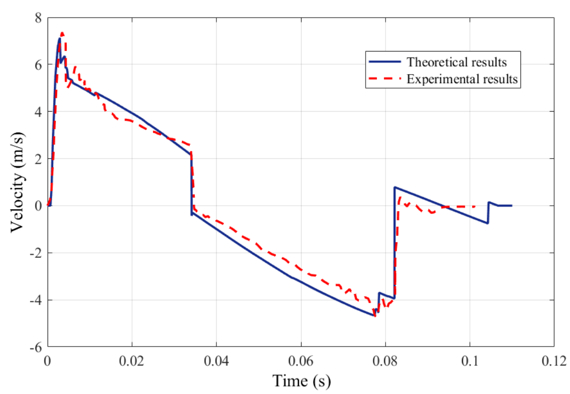

Figure 31 – Comparison of the velocity of the bolt carrier

The obtained results can be commented on as follows:

- The comparison results between the theoretical data and the experimental data show that the calculation model is highly accurate and suitable, see Figure 30 and Figure 31. The maximum deviation does not exceed 6%.

- The simulation results show that the working cycle of a shot is 0.0823s and this value is equivalent to the theoretical rate of fire of 729 (shots/minute).

The cycle of a shot according to the test results is 0.0846 s and this value is equivalent to the theoretical rate of fire of 709 (shots/minute), with an error of 2.82%.

- The comparison results demonstrate that the theoretical simulation model ensures reliability and can be used in further research and surveys on AK submachine guns.

Conclusion

With a new approach to calculating the automatic machine dynamics of the AK submachine gun using Solidworks Motion software, the dynamic parameters of all parts of the automatic machine of the gun are determined relatively accurately. From the calculated results and the comparison with the experimental results, some conclusions are drawn as follows:

- Solidworks Motion software allows users to set up 3D calculation models so it is more intuitive. The input parameters are relatively simple and easy to set, reducing the need to calculate additional problems.
- By creating links between many parts in the automatic machine, many problems are solved simultaneously, so the calculation results are more accurate. In contrast to the theoretical method, secondary problems such as the problem of determining the hammer force and the collision problem need to be solved first. These are the input parameters for the main problem.
- The results calculated using Solidworks Motion software are relatively accurate compared to the results obtained from experiments; the error is no more than 5% for the movement speed of the bolt carrier and 3% for the firing cycle.

By using Solidworks Motion software in dynamic calculations, designers will have more advantages in designing, manufacturing, and improving other types of automatic weapons.

In the future, the models determining other dynamic characteristics of weapons will be established on Solidworks Motion software by the author. In particular, the author continues to research calculations for weapons operating according to the principle of receding barrel or free breech principle.

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Estudio de las características dinámicas de pistolas accionadas por gas utilizando el software Solidworks Motion

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CAMPO: matemáticas, ingeniería mecánica
TIPO DE ARTÍCULO: artículo científico original

Resumen:

Introducción/objetivo: Este artículo presenta un nuevo enfoque para determinar las características dinámicas del sistema de disparo automático de pistolas automáticas operadas por gas.

Métodos: Basado en la estructura real del sistema de disparo automático de armas automáticas operadas por gas, se simula un modelo 3D del arma utilizando el software Solidworks y las características dinámicas del sistema de disparo automático se calculan en el software Solidworks Motion.

Resultados: Los resultados de la simulación obtenidos incluyen el desplazamiento y la velocidad de la plataforma de recámara a lo largo del tiempo; la fuerza ejercida por el martillo sobre el portacerrojo a lo largo del tiempo; y la fuerza de impacto del portacerrojo y el cuerpo de la pistola a lo *largo del tiempo. Estos resultados se comparan con datos obtenidos de experimentos para verificar el modelo matemático. El ciclo de un disparo según los resultados de la prueba es de 0,0846 s y el error en la tasa de disparo entre los resultados teóricos y experimentales es del 2,82%.*

Conclusión: El contenido de la investigación permite a los usuarios evaluar visualmente el proceso de trabajo de todas las partes del sistema de disparo automático. Los resultados de esta investigación se pueden aplicar a los cálculos de sistemas de disparo automático de diferentes armas automáticas. Esta es una base científica importante para mejorar y modernizar las armas automáticas existentes y servir al proceso de diseño y fabricación de nuevos tipos de armas automáticas en el futuro.

Palabras claves: dinámica, sistema de disparo automático, armas automáticas, armas accionadas por gas, Solidworks Motion.

Изучение динамических характеристик газового огнестрельного оружия с использованием программного обеспечения Solidworks Motion

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РУБРИКА ГРНТИ: 55.68.00 Производство оружия
ВИД СТАТЬИ: оригинальная научная статья

Резюме:

Введение/цель: В данной статье представлен новый подход к определению динамических характеристик автоматической системы выстрелов из газового автоматического огнестрельного оружия.

Методы: На основании реальной структуры автоматической системы выстрелов из газового автоматического огнестрельного оружия моделируется 3D-модель винтовки с использованием программного обеспечения Solidworks, а динамические характеристики системы автоматической стрельбы рассчитываются с помощью программного обеспечения Solidworks Motion.

Результаты: Полученные результаты моделирования включают в себя перемещение и скорость затворной рамы за период времени; усилие, оказываемое ударником на затворную раму за период времени; и силу удара затворной рамы и винтовки за период времени. Эти результаты для проверки математической модели сравниваются с данными, полученными в результате экспериментов. Продолжительность цикла *выстрелов, согласно результатам испытаний, составляет 0,0846 секунд, а погрешность между теоретическими и экспериментальными результатами составляет 2,82%.*

Выводы: Содержание данного исследования позволяет пользователям визуально оценить рабочий процесс всех частей автоматической системы стрельбы. Результаты этого исследования могут быть применены для расчета систем автоматической стрельбы из различных видов автоматического оружия. Результаты исследования являются важной научной основой для совершенствования и модернизации существующего автоматического огнестрельного оружия и послужат в процессе проектирования и изготовления новых видов автоматического оружия в будущем.

Ключевые слова: динамика, автоматическая система стрельбы, автоматическое оружие, газовое оружие, Solidworks Motion.

Проучавање динамичких карактеристика пушака које функционишу по принципу позајмице барутних гасова помоћу софтвера Solidworks Motion

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ОБЛАСТ: математика, машинство
КАТЕГОРИЈА (ТИП) ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: Овај рад представља нов приступ одређивању динамичких карактеристика аутоматског система опаљивања код аутоматских пушака које функционишу по принципу позајмице барутних гасова.

Методе: На основу реалне структуре аутоматског система опаљивања аутоматских оружја која функционишу по принципу позајмице барутних гасова, симулиран је 3Д модел пушке помоћу софтвера Solidworks, а динамичке карактеристике аутоматског система опаљивања израчунате су помоћу софтвера Solidworks Motion.

Резултати: Добијени резултати симулације обухватају померање и брзину затварачког блока у функцији времена, силу којом ударач делује на носач затварача у функцији времена, као и силу удара носача затварача и тела оружја у функцији времена. Резултати су упоређени с експериментално добијеним подацима ради верификације математичког модела. Циклус опаљења, према *резултатима испитивања, износи 0,0846 s, а грешка брзине паљбе између теоријских и експерименталних резултата је 2,82%.*

Закључак: Ово истраживање омогућава корисницима визуелан приказ процеса рада свих делова аутоматског система опаљивања. Његови резултати могу да се примене за израчунавања аутоматских система опаљивања различитих аутоматских пушака. То представља важну научну основу за побољшање и усавршавање постојећег аутоматског оружја, као и за пројектовање и производњу нових типова тог оружја у будућности.

Кључне речи: динамика, аутоматски систем опаљивања, аутоматско оружје, оружје које функционише по принципу позајмице барутних гасова, Solidworks Motion.

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