Research into the effect of ammunition belt stiffness on the operation of automatic firing systems using experimental methods

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Abstract:

Introduction/purpose: This article focuses on determining the dynamic characteristics of the automatic firing system through experimental methods. Additionally, the study mentions the impact of ammunition belt stiffness.

Methods: The research findings include the displacements of the basic part (bolt carrier) and the ammunition belt of automatic weapons during firing series. To measure and determine these parameters, a high-speed camera model FASTCAM SA1.1, specifically the 675K-C1 variant, was utilized. The elastic force between the belt links was determined using deformation stamps equipped with force-measuring sensors. To validate the reliability of the method, experiments were conducted on the PKMS machine gun.

Results: The results obtained show that, when using a tape with a stiffness of 42 [N/mm], the kinematic characteristics of the basic link such as recoil velocity and recoil time change significantly compared to using a tape which has a stiffness of 98 [N/mm]. In particular, the maximum recoil velocity of the base gun can be reduced by ~8% when firing a series of 6 bullets.

These results can be applied in calculations and designs to optimize the structure of the ammunition belt and the automatic firing system. Furthermore, these findings can aid in calculating the firing rate of the gun, thus facilitating the operation of automatic weapons.

Conclusion: The testing procedure developed in this study serves as a crucial theoretical foundation for evaluating and determining the dynamic characteristics of other automatic weapon systems.

Keywords: automatic firing system, ammunition belt, 7.62 mm PKMS machine gun.

Introduction

In the final years of the 20th century, numerous armies worldwide were engaged in large-scale conflicts, utilizing infantry weapons and various other arms with great intensity. The emphasis was on improving these weapons to minimize weight, ensure reliable operation, reduce recoil force impacting the gunner, enhance shooting stability, and enable quick maneuvering on the battlefield. To address these challenges, multiple solutions were implemented, with a specific focus on studying the dynamics and stability of automatic guns. A crucial aspect of weapon design involved researching the interplay between different structures to achieve optimal solutions. This knowledge can be applied to the process of exploiting and designing weapons and equipment, particularly compact firepower mounted on racks or mobile vehicles.

The effectiveness of a soldier in combat relies heavily on the reliable performance of guns and artillery. This includes factors like shooting accuracy, stability, and the ability to function effectively in harsh conditions (Fiser & Popelinsky, 2007; Van Hung et al, 2024; Wang & Jiang, 2008). One of the causes that can impact these factors is the movement of the ammunition belt during firing. The bullets must be positioned accurately and quickly, with low energy consumption for reloading, while also avoiding vibrations and strong collisions with the gun. If these requirements are not met, the ammunition belt can disrupt the mechanisms of the automatic firing system, leading to wear and intense vibrations, resulting in inconsistent and unstable shots. Additionally, the working period and firing cycle of the automatic firing system can be affected. This can lead to issues like bullet choking or jamming, causing damage to the ammunition belt or automatic firing system, ultimately rendering the shot unable to be fired.

The movement of the ammunition feeding mechanism relies on the movement of the automatic firing system (Dingguo, 1996; Balla et al, 2015). Bullets in the ammunition belt move in different planes and at varying speeds. The movement of a subsequent shot in a series of shots is influenced by both the operation of the ammunition belt pull mechanism operation and the initial speed of the ammunition belt, as well as the forces acting on it in space. To facilitate the study of ammunition belt dynamics, previous studies have made use of several assumptions to simplify calculations (Balla et al, 2011; Balla & Mach, 2007). Figure 1 illustrates some typical computational models of ribbon dynamics.

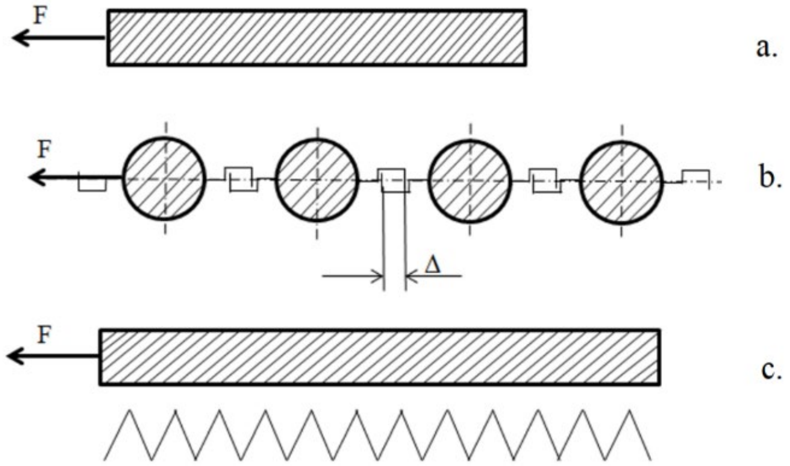


Figure 1 – Models for calculating ammunition belt movement

In the models presented in Figure 1, the ammunition belt is treated as a rigid bar affected by a pulling force, as seen in Figure 1a. In contrast, Figure 1b takes into account the bullets in the ammunition belt being connected by rigid joints and experiencing a horizontal pulling force. Finally, Figure 1c considers the ammunition belt as an elastic bar that is affected by a horizontal pulling force (Doan et al, 2023; Vo et al, 2021; Vitek, 2019). However, both theoretical calculations and testing have shown that these models are overly simplistic, resulting in significant errors and not accurately representing the movement of the ammunition belt in real-life scenarios.

Furthermore, the theory of multi-body mechanics has been utilized in various studies to examine the dynamics of ammunition belts. One notable example is the research conducted by Dingguo Zhang (Dung et al, 2023; Tien et al, 2022). In this study, the theory of many-body system dynamics was employed to construct a mathematical model for the dynamics of aircraft gun ammunition belts. Additionally, Matlab software was utilized for numerical simulation. The study also mentions a dynamic model for the ammunition belt of the Gatling machine gun (Goldberg & Goldberg, 2019; Macko et al, 2021). This model describes the continuous reloading process and identifies specific factors that affect it. Another study (Bien et al, 2021a, 2021b) analyzed the mechanical properties of a vertical ammunition belt system using a spiral guide. To simulate the impact and contact between two points in the ammunition belt, a virtual spring was utilized. It is worth noting that the impact of belts is rarely addressed in recent studies on the dynamics of automatic firing systems, as seen in (Balla et al, 2010; Hung et al, 2024; Tien et al, 2021).

In general, previous studies on ammunition belt dynamics have been relatively simplistic and do not accurately reflect real-life ammunition belt movement. The interaction between the automatic firing system and the ammunition belt as well as the influence of various ammunition belt parameters on the loading process have not been thoroughly studied. Additionally, the impact of ammunition belt stiffness on the operation of automatic guns using gas extraction has not been addressed. The dynamic parameters of both the ammunition belt and the automatic firing system are affected by numerous random input factors, making it impossible for mathematical models to fully capture the complexity of the system. To improve the accuracy of studying ammunition belt dynamics, this study utilized experimental methods. These experiments not only provide valuable data on ammunition belt dynamics, but also play a crucial role in the calculation, design, manufacturing, and improvement of weapon models. The results of these tests allow for a comparison between theoretical calculations and actual data, providing a measure of the accuracy of the theoretical model.

Problem formulation

Theoretical basis

Many physical and mathematical models have been established to determine the dynamic parameters of automatic firing systems worldwide. Among them, the model presented in the document is relatively complete and clear (Macko et al, 2021).

In this article, the physical model of the automatic firing system is presented as shown in Figure 2 and Figure 3.

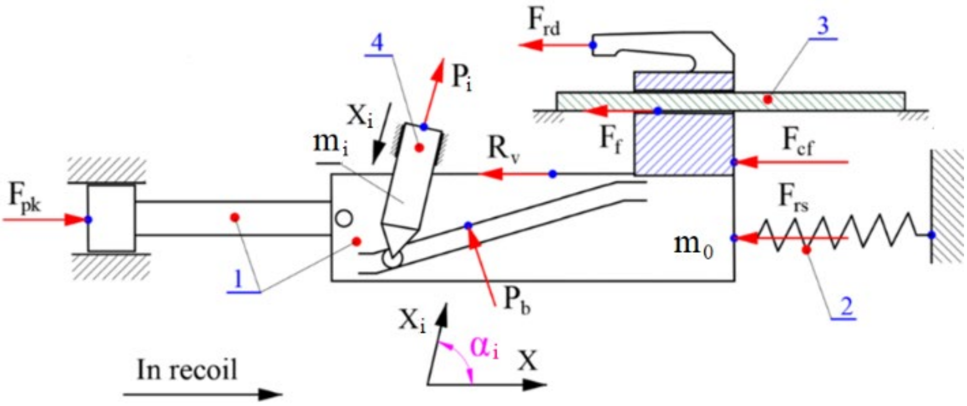


Figure 2 – Forces acting on the bolt carrier when reversing

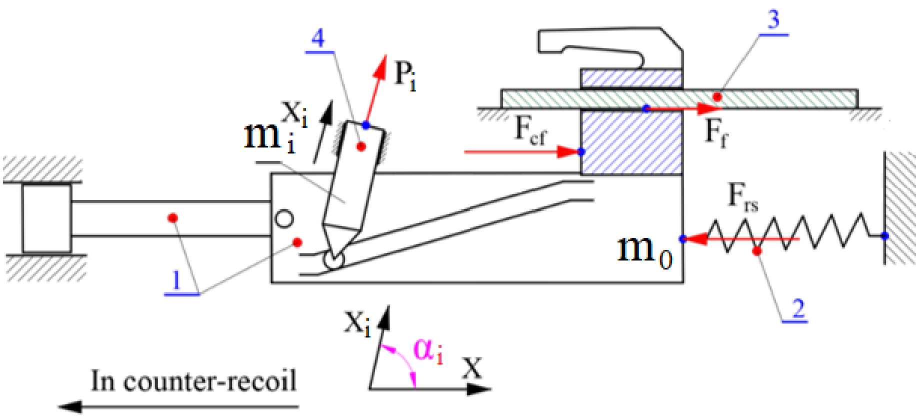


Figure 3 – Forces acting on the bolt carrier when pushed up

Symbols in Figure 2 and Figure 3: 1. the bolt carrier and the piston; 2. the return spring; 3. the guide rail on the weapon casing; 4. the *i*-th working mechanism; F_{pk} – the force of the combustion gas pressure acting on the piston; P_i – generalized force effects on the *i*-th working mechanism; x – displacement of the bolt carrier relative to the gun body; x_i – displacement of the *i*-th working mechanism relative to the gun body; F_{rs} – the force of the return spring; F_{cf} – collision force between the bolt carrier and the gun body; F_{rd} – the force to remove a cartridge from the cartridge belt; R_v – cartridge case extraction force; P_b – resistance of the cartridge belt; F_f – friction force between the bolt carrier and the gun body.

The link diagram between the bolt carrier and the feed lever is shown in Figure 4.

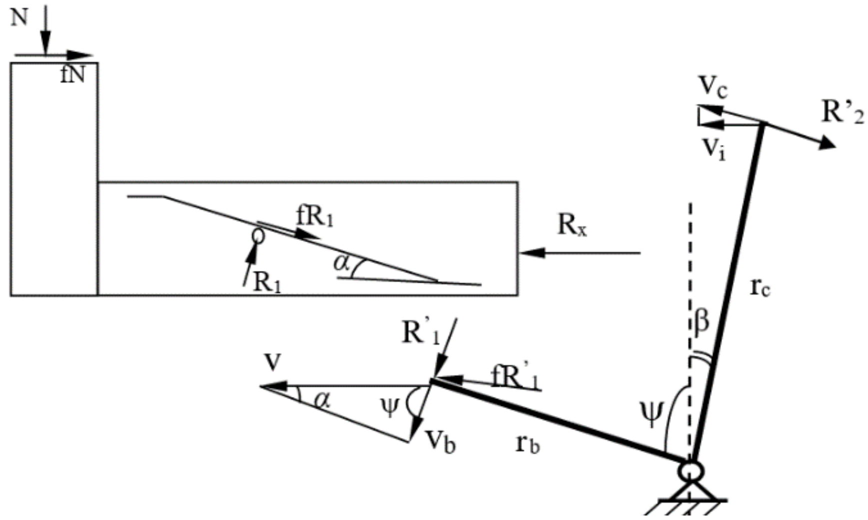


Figure 4 – Link diagram between the bolt carrier and the feed lever

The second type Lagrange equation is used to establish the mathematical model for this model.

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_j}\right) - \frac{\partial T}{\partial q_j} + \frac{\partial \Pi}{\partial q_j} = Q_j \quad (j = 1, 2, \ldots). \tag{1}$$

where: T – total kinetic energy of the whole system; Π – potential energy of the system; q_j – independent generalized coordinate; Q_j – generalized force; and j - number of degrees of freedom.

Set up an experimental model

Purpose, objects, and testing conditions

- Testing purpose

The following parameters are determined by experimental methods: elastic force, displacement law, and velocity of the ammunition belt link in the ammunition belt when firing series with belts of different stiffnesses. In addition, the law of displacement and velocity of the breech of the automatic firing system is also determined when firing in series with belts of different stiffnesseses. These parameters are the scientific basis for evaluating the impact of ammunition belt stiffnesses on the working process of the automatic firing system.

- Test subject

+ PKMS machine gun (Figure 5) and K53 ammunition at level 1, still packaged in a zinc box at a storage temperature of 20^{0}C;

Figure 5 – The PKMS Kalashnikov 7.62 mm machine gun

+ Two belt samples with different stiffnesses were used for testing (Figure 6). A prototype belt made in Russia and a belt made in Vietnam were softened to reduce stiffness. The stiffness of these tapes was determined experimentally by the Testometric M500-100AT tensile and compression testing system. This system is controlled by a computer, and WinTest^{TM} Analysis software running on the Windows^{TM} operating system was used. Some basic parameters of the Testometric M500-100AT tensile and compression testing machine system are shown in Table 1. The stiffness of the straps is determined based on the graph obtained in combination with Hooke's overturning test. After 5 measurements, the average stiffness of the belts is determined in Table 2.

Figure 6 – Belts used for the testing

Table 1 – Basic parameters of the Testometric M500-100AT tensile and compression testing system

	Machine capacity: 100kN
	Speed range: 0.001 to 500mm/min in steps of 0.001mm/min
	Crosshead travel (excluding grips): 1059mm
	Throat: 420mm

Table 2 – Belt stiffness for two different samples

Belt model	Made in Russia	Made in Vietnam
Medium stiffness [N/mm]	98	42

- Test conditions

+ The test was conducted at the Weapons Testing Center - Le Quy Don Technical University;

+ Ambient temperature 20^{0}C, humidity 50%, no wind;

+ Gun prices are considered fixed, not affected by external factors.

The simulation belt link is made to measure the elastic force

To determine the elastic force of the belts, the principle of deformation stamp force measurement was utilized (Wang & Jiang, 2008). The simulated belt link was made from a material similar to that of the ammunition belt of the PKMS machine gun, with manufacturing dimensions shown in Figure 7.

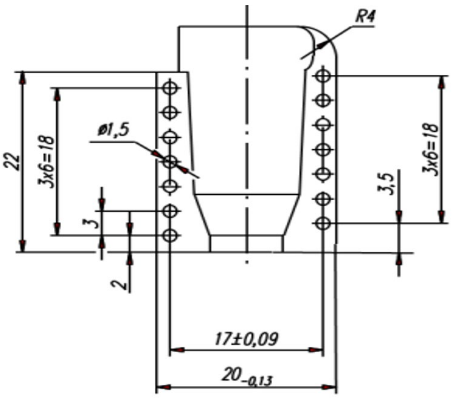


Figure 7 – Dimensions for manufacturing the simulated belt links

A sensor is attached to the simulated belt link and it is then installed into the ammunition belt to measure the elastic force between the belt links during a series of 7.62mm PKMS machine gun firings, as depicted in Figure 8.

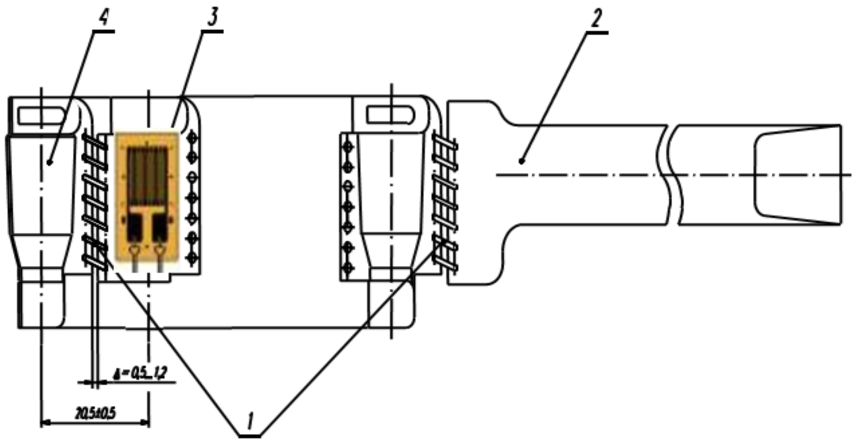


Figure 8 – Ammunition belt with the sensor attached:
1 - springs connecting the belt links; 2 - ammunition belt puller;
3 - simulated belt link with sensor stickers; 4 - belt link

The simulated belt link is installed on the belt, which is then calibrated to determine the conversion factor.

Figure 9 – Force measurement system calibration equipment

Measuring devices

- FASTCAM SA1.1 high-speed camera 675K - C1

The FASTCAM SA1.1 high-speed camera system is utilized for measuring the belt movement and the displacement of the basic part. This system consists of a Fastcam SA1.1 high-speed camera with the basic parameters listed in Table 3, a computer for installing PFV software and storing information, a lighting system, and a connection cable. The PFV software allows for control of the high-speed camera from a computer, while TEMA software is used for processing the records and collecting necessary data (Fiser, 2007; Bien et al, 2021a, 2021b).

Figure 10 – SA1.1 High-speed camera system

Table 3 – Some basic parameters of the high-speed camera SA1.1

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

- DEWETRON 4000 dynamic signal analyzer

The sensor for measuring the elastic force of the belts is connected to the DEWE-4000 multi-function measuring system (Figure 11). DEWE-4000 is a multi-function measuring system that synchronizes mechanical, thermal, deformation, pressure, and force parameters.

Figure 11 – DEWE-4000 multifunction measuring system

Figure 12 – Modul DAQN – BRIDGE

To connect the belt elastic force measuring sensor to the DEWE-4000 multi-function measuring system, the DAQN - BRIDGE channel module available in the machine (Figure 12) is used. The main technical characteristics of these modules are as follows:

- They can be used synchronously with resistive stamp measuring sensors with a spherical structure, with sensor sensitivities of 0.1, 0.2, 0.5, 1.0, 2.0, and 5.0 mV/V.
- Selecting the working mode corresponding to the above sensitivities of the sensor and filter modes can be done manually or by software.
- The sensor's stable DC power supply is provided by Modules 2.5, 5, 10 and 15 volts.
- The measuring range of the spherical resistors is from 120 Ω to 10 k Ω.
- Output impedance is lower than 10 Ω.
- The signal is received from the measuring sensor through the 9-pin jack.

To ensure the safety of people and the measuring equipment, the distance from the measuring sensor to the location of the measuring equipment must be greater than 50 m. Therefore, a specialized shielded cable to prevent interference on the transmission line is used to transmit measurement signals from the sensor to the center.

The signal from the measurement sensor (about a few tens of mV) is transmitted from the sensor to the DAQN - BRIDGE module, where the measurement signal is amplified to a few volts and sent to the PCI-DAS1620/16 ADC CARD for processing and display. This signal is stored on Dasy Lab 11.0 software.

Test diagram

- Diagram determining the elastic force between the belt links

To determine the elastic force between the belt links, a test model is built as shown in Figure 13. The actual implementation image is presented in Figure 14.

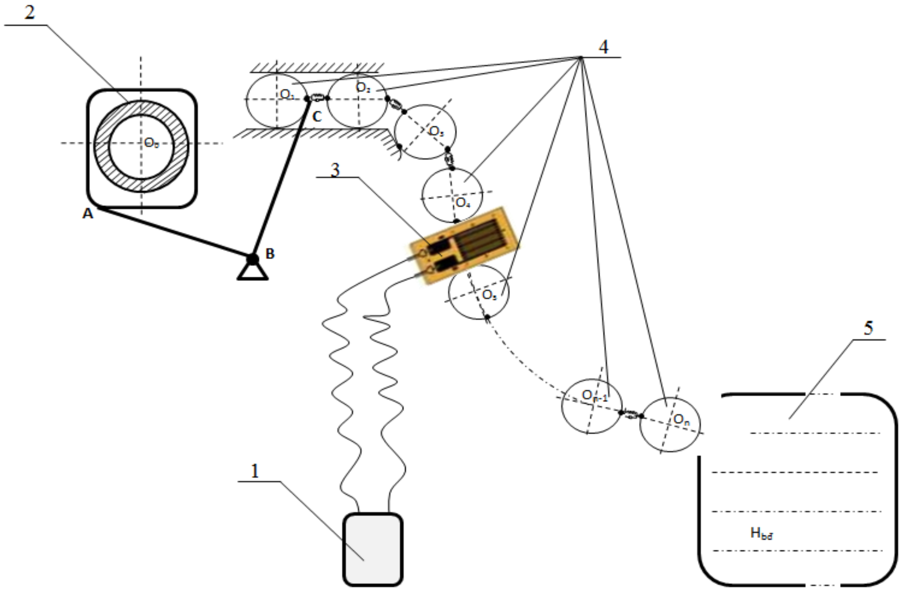


Figure 13 – Diagram of the testing system for measuring the elastic forces between the belt links:
1 - DEWETRON 4000 dynamic signal analyzer; 2 - PKMS machine gun;
3 - the simulated belt link is installed in the ammunition belt; 4 - bullets on the belt;
5 - ammunition belt box

Figure 14 – Simulated belt link installed on a machine gun ammunition belt

The operating principle is as follows: after replacing the simulated belt link with a real one, the belt puller will draw the belt inward to feed ammunition during firing. A sensor attached to the simulated belt link will record its deformation when stretched. The DEWETRON 4000 dynamic signal analysis system will then convert the tensor strain into force which is exported to the elastic force data file between the belt links.

- Diagram to determine the displacement of the ammunition belt

The test model to determine the displacement and velocity of the belt link is set up as a diagram in Figure 15.

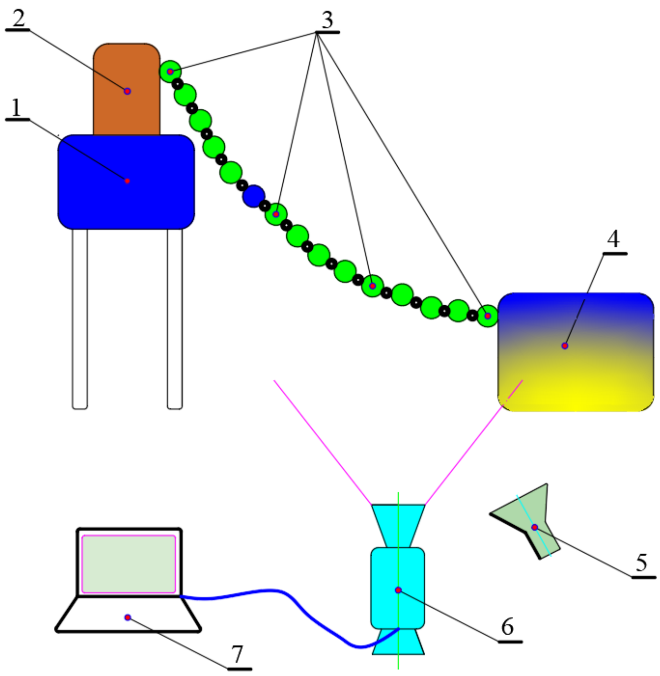


Figure 15 – Schematic diagram of the experimental model:
1 - specialized gun rack; 2 - PKMS machine gun;3 - ammunition;
4 - ammunition belt box; 5 – lighting system;
6 - FASTCAM SA1.1 high speed camera 675K - C1; 7 – computer

In this test, the high-speed camera FASTCAM SA1.1 model 675K - C1 was arranged in an appropriate position to record the movement of the bullet belt when firing multiple shots and then export the data file, displacement, and velocity of each bullet in the ammunition belt, see Figure 16.

Figure 16 – Experimental setup in the tunnel

- Displacement and velocity test diagram of the bolt carrier

The test model was set up to measure the displacement of the base part of the PKMS machine gun automatic firing system when firing in series, as shown in Figure 17.

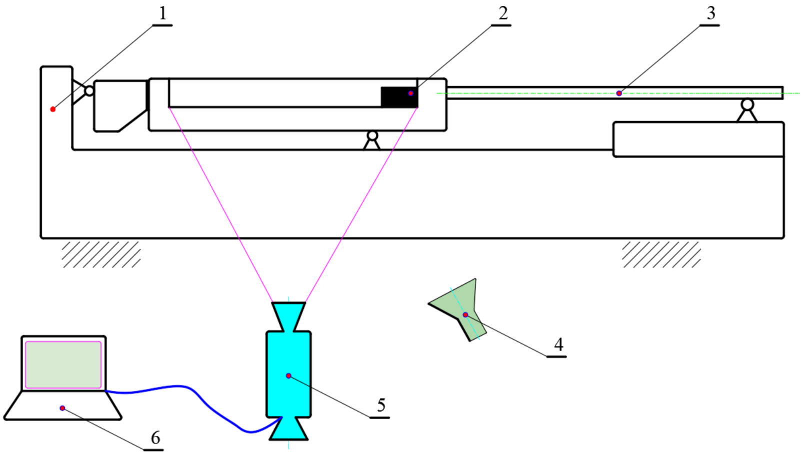


Figure 17 – Displacement measurement test diagram of the bolt carrier: 1 - specialized gun rack; 2 - bolt carrier; 3 - gun barrel; 4 - lighting system; 5 - FASTCAM SA1.1 high-speed camera 675K - C1; 6 – computer

To facilitate the process of observing the movement of the bolt carrier, the bolt box cover part is cut. The high-speed camera FASTCAM SA1.1 model 675K - C1 is used to record the bolt carrier movement when firing in series. The recorded data is exported into graphs and images of the bolt carrier movement.

Figure 18, Figure 19, and Figure 20 show the images obtained by the high-speed camera FASTCAM SA1.1 model 675K - C1. The maximum recording speed was 675000 fps at 64x16 pixels of the base part at different positions during burst firing.

Figure 18 – Bolt carrier of the PKMS machine gun in the firing position

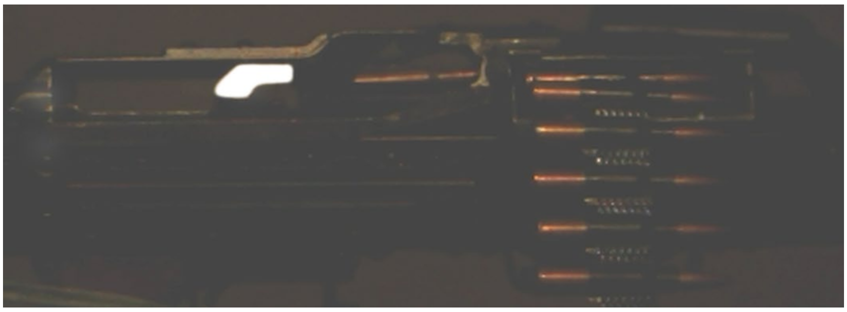


Figure 19 – Bolt carrier of the PKMS machine gun when backing up and withdrawing the cartridge case

Figure 20 – Bolt carrier of the machine gun when in the bottom position

Results and discussion

Problem solution

Elastic force between the belt links

During automatic fire, the platform pulls the ammunition belt in as the bolt carrier moves backward. This process ensures that the ammunition belt is always pulled, preventing any gaps from appearing between the belt links. The pulling force of the belt causes the connection between the first and second links to elastically deform, allowing them to move together during the first shot. This process is then repeated for the subsequent links in the belt. Experiments have shown that the elastic force between the belt links is at its highest during the first shot and varies depending on the stiffness of the bullet belt. Graphs depicting the elastic force between the belt links for a series of 6 bullets, each corresponding to a bullet belt of different stiffness, can be seen in Figure 21 and Figure 22. The maximum elastic force values for the belt links are listed in Table 4.

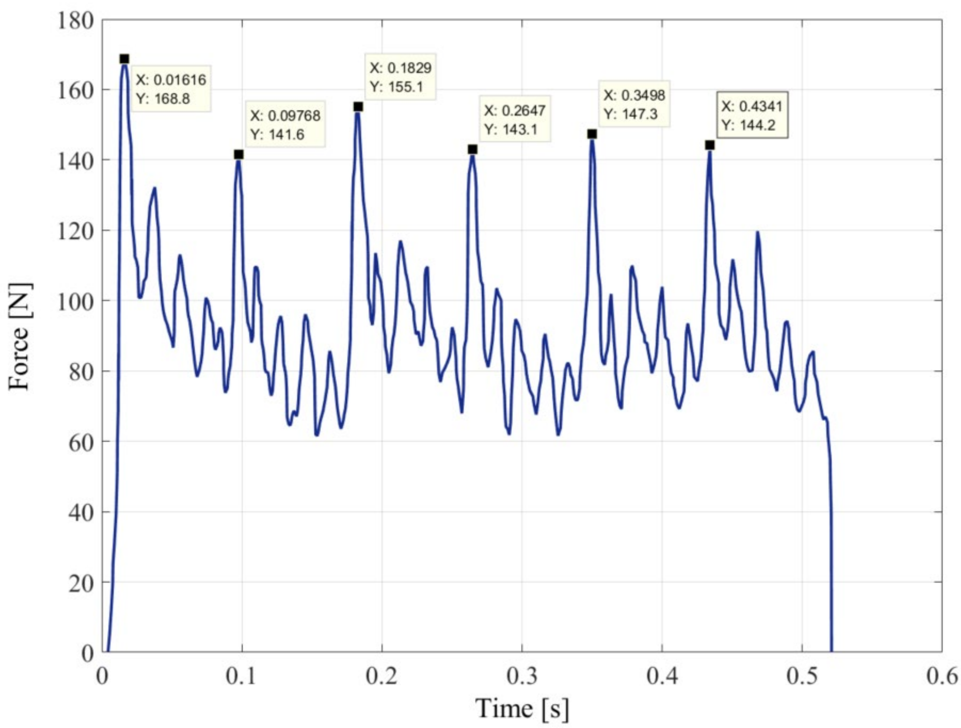


Figure 21 – Elastic force between the belt links during a series of firing with the belts of a stiffness of K=42 [N/mm]

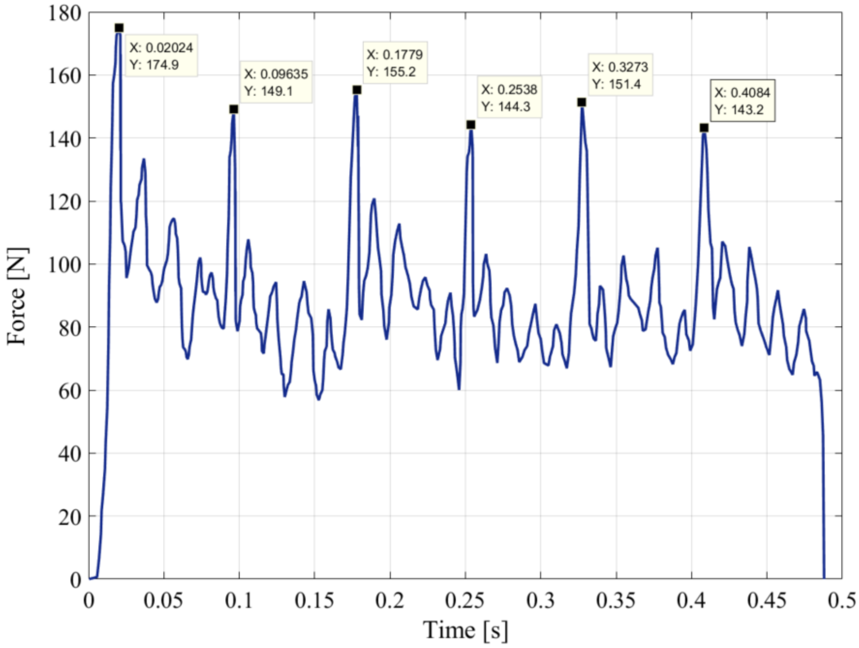


Figure 22 – Elastic force between the belt links during a series of firing with the belts of a stiffness of K=98 [N/mm]

Table 4 – Maximum elastic force at the belt link when firing a series of 6 shots

Order of firing	Maximum elastic force [N] with K=98 [N/mm]	Maximum elastic force [N] with K=42 [N/mm]
1	174.9	168.8
2	149.1	141.6
3	155.2	155.1
4	144.3	143.1
5	151.4	147.3
6	143.2	144.2

Displacement and velocity of each belt link during burst firing

The ammunition belt was observed with a high-speed camera FASTCAM SA1.1 model 675K - C1. The maximum recording speed was 675000 fps at 64x16 pixels. The movement of the ammunition belt is observed when firing in series with Russian test belts with a stiffness of K=98 [N/mm] and Vietnamese belts with a stiffness of K = 42 [N/mm], see Figure 23.

Figure 23 – Image of the bullet belt movement during burst firing

The displacement trajectory and displacement velocity of the belt link during a series of firing corresponding to the stiffness K=42 [N/mm] and K=98 [N/mm] are shown in Figure 24 and Figure 25.

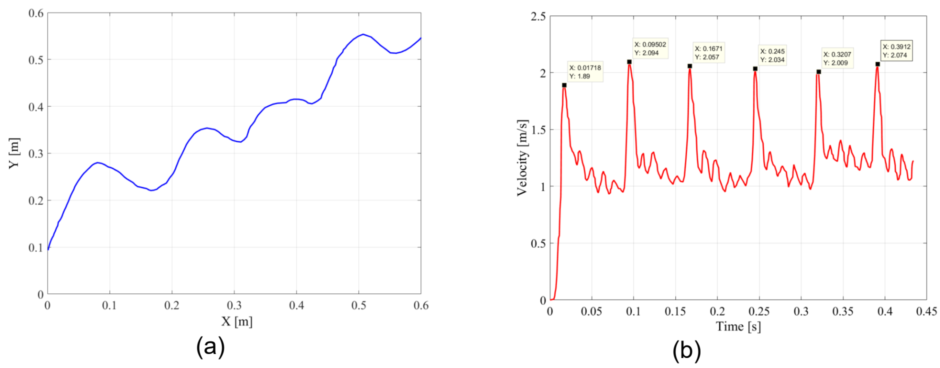
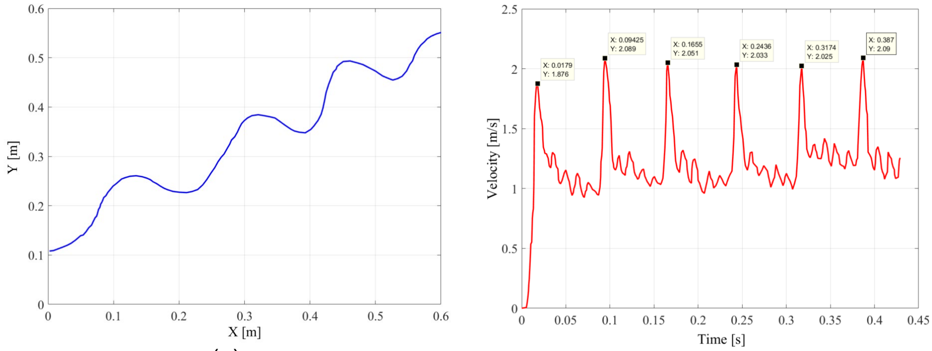


Figure 24 – Displacement trajectory and displacement velocity of the belt link when firing in series with a belt with stiffness of K= 42 [N/mm]:
a) displacement trajectory; b) displacement velocity

The maximum speed of the belt link corresponding to different belt stiffness is shown in Table 5 and Table 6.

Table 5 – Maximum speed of the belt link with a belt stiffness of K=42 [N/mm]

Order of firing	1	2	3	4	5	6
Maximum speed [m/s]	1.89	2.094	2.057	2.034	2.009	2.074



(a) (b)

Figure 25 – Displacement trajectory and displacement velocity of belt link during a series of firing with the Russian prototype belt with a stiffness of K= 98 [N/mm]:
a) displacement trajectory; b) displacement velocity

Table 6 – The maximum speed of the belt link with a belt stiffness of K=98 [N/mm]

Order of firing	1	2	3	4	5	6
Maximum speed [m/s]	1.876	2.089	2.051	2.033	2.025	2.09

Displacement and displacement velocity of the bolt carrier

The displacement and displacement velocity of the bolt carrier can be determined based on the images obtained from the Fastcam SA1.1 high-speed camera. TEMA software was used to process images as well as to collect necessary data. The displacement and velocity of the base link with different belt stiffnesses are shown in Figures 26 - 29. The motion parameters of the base link when firing in series with different belt stiffnesses are presented in Table 7 and Table 8.

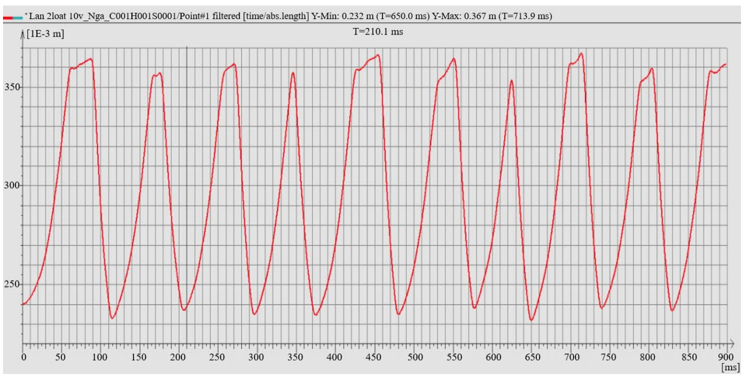


Figure 26 – Displacement of the bolt carrier corresponds to a Russian belt whose stiffness is K=98 [N/mm]

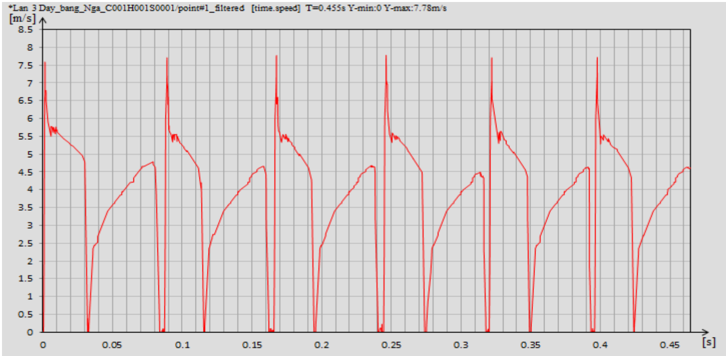


Figure 27 – Velocity of the bolt carrier corresponding to the Russian belt with K=98 [N/mm]

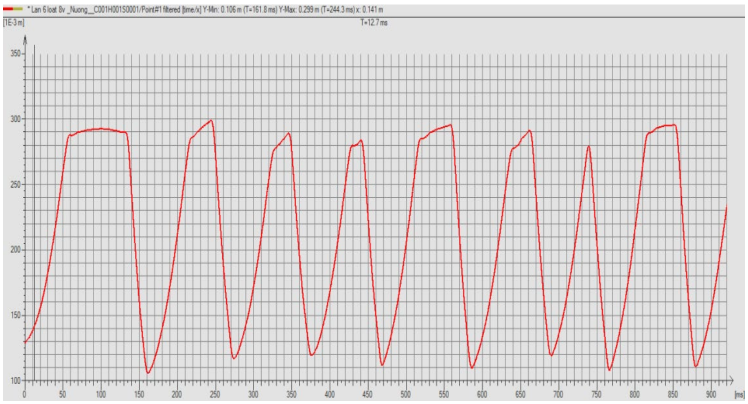


Figure 28 – Moving the bolt carrier with a Vietnamese belt with a stiffness of K=42 [N/mm]

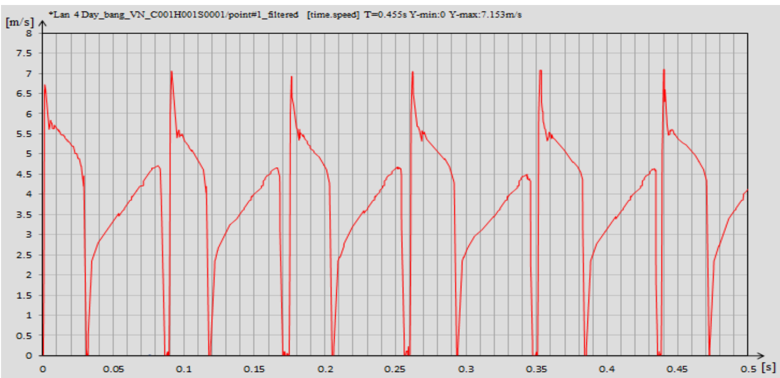


Figure 29 – Velocity of the bolt carrier with the Vietnamese belt with a stiffness of K=42 [N/mm]

Table 7 – Motion parameters of the bolt carrier corresponding to the Russian belt with a stiffness of K=98[N/mm]

Order of firing	Maximum recoil velocity of the bolt carrier [m/s]	Maximum push-up velocity of the bolt carrier [m/s]	Recoil time of the bolt carrier [s]	Working cycle of the bolt carrier [s]
1	7.59	4.748	0.0281	0.0865
2	7.71	4.755	0.0276	0.0869
3	7.76	4.752	0.0265	0.0845
4	7.78	4.698	0.0278	0.0878
5	7.71	4.731	0.0269	0.0881
6	7.72	4.741	0.0271	0.0855

Table 8 – Motion parameters of the bolt carrier corresponding to the Vietnamese belt with a stiffness of K=42 [N/mm]

Order of firing	Maximum recoil velocity of the bolt carrier [m/s]	Maximum push-up velocity of the bolt carrier [m/s]	Recoil time of the bolt carrier [s]	Working cycle of the bolt carrier [s]
1	6.722	4.739	0.0294	0.09045
2	7.068	4.725	0.0273	0.08937
3	6.931	4.729	0.0289	0.08955
4	7.057	4.498	0.0282	0.08955
5	7.080	4.631	0.0268	0.08972
6	7.153	4.684	0.0259	0.08969

Based on the results obtained, some comments are made as follows:

- With the Russian belt with a stiffness of K=98 [N/mm], the displacement of the bolt carrier remains relatively stable during a series of shots. However, there is a noticeable change in displacement at the top and bottom positions (see Figure 26). This can be attributed to various processes taking place at these positions, such as the closing of the bolt, the withdrawal and ejection of the cartridge case, and the firing process. In contrast, the maximum recoil velocity of the bolt carrier during the first shot is only 7.59 [m/s], which is lower than in subsequent shots (see Figure

27 and Table 7). This can be explained by the fact that the belt puller must initially overcome the weight of the entire ammunition belt, resulting in increased resistance in the automatic firing system. As a result, the first shot takes longer to complete compared to subsequent shots.

- With the Vietnamese belts of stiffness of K=42 [N/mm]: the period of each shot increases, which means the period of operation of the automatic firing system increases, see Figure 28, and Figure 29. However, this change only increases within certain limits shown in Table 8.

- The survey results have shown that variations in belt resistance directly affect the duty cycle of the automatic firing system, leading to a decrease in shooting accuracy. Specifically, when the stiffness of the bullet belt is increased, the shot cycle is reduced, resulting in a higher rate of fire (refer to Tables 7 and 8). It is important to note that this change can be influenced by various factors, but our findings confirm a clear correlation between the belt stiffness and the shot cycle, independent of other factors.

Conclusion

When researching the dynamic problem of the automatic firing system, taking into account the characteristics of the ammunition belt is extremely necessary. With the results obtained, some conclusions can be drawn as follows:

- The experiments described in this study provide an important theoretical foundation for determining kinematic parameters (displacement and displacement velocity) of the bullet belt and the bolt carrier of the automatic firing system which operates on the principle of gas extraction.

- High-speed cameras can be used to experimentally determine the motion parameters of objects with high moving speeds and complex working environments.

- The experimental determination of the elastic force between bullet belt links yields results that are relatively consistent with reality, making it an important parameter in the study of bullet belt dynamics.

- The use of measuring devices ensures high accuracy, reliability, and stability in the measurement of physical quantities.

- The method for determining dynamic parameters is reasonable, consistent, and reliable. The results obtained from this research can be used in design calculations to optimize the structure of the belt and automatic firing system, as well as to calculate the firing speed of the gun for the exploitation process. Additionally, these results can be used to verify corresponding mathematical models.

- The procedure used in this paper can serve as a reference for practical methods in other weapon systems.

The authors' next research will focus on surveying, analyzing, and evaluating the effects of changing the gap between ammunition belt links and the number of bullets in the ammunition feeding process. This will provide specific parameters for evaluating the impact on the reliable functioning of the automatic firing system.

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Investigación mediante métodos experimentales sobre el efecto de la rigidez de los cinturones de municiones en el funcionamiento de sistemas de disparo automático

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

Resumen:

Introducción/objetivo: Este artículo se centra en determinar mediante métodos experimentales las características dinámicas del sistema de disparo automático. Además, el estudio menciona el impacto de la rigidez del cinturón de municiones.

Métodos: Los resultados de la investigación incluyen los desplazamientos de la parte básica (portacerrojos) y del cinturón de municiones de armas automáticas durante series de disparos. Para medir y determinar estos parámetros se utilizó una cámara de alta velocidad modelo FASTCAM SA1.1, específicamente la variante 675K-C1. La fuerza elástica entre los eslabones de la correa se determinó mediante sellos de deformación equipados con sensores de medición de fuerza. Para validar la fiabilidad del método, se realizaron experimentos con la ametralladora PKMS.

Resultados: Los resultados obtenidos muestran que, cuando se utiliza una cinta con una rigidez de 42 [N/mm], las características cinemáticas del eslabón básico, como la velocidad de retroceso y el tiempo de retroceso, cambian significativamente en comparación con el uso de una cinta que tiene una rigidez de 98 [N/mm]. En particular, la velocidad máxima de retroceso del arma base se puede reducir en ~8% al disparar una serie de 6 balas. Estos resultados se pueden aplicar en cálculos y diseños para optimizar la estructura de la cinta de municiones y el sistema de disparo automático. Además, estos hallazgos pueden ayudar a calcular la velocidad de disparo del arma, facilitando así el funcionamiento de las armas automáticas.

Conclusión: El procedimiento de prueba desarrollado en este estudio sirve como base teórica crucial para evaluar y determinar las características dinámicas de otros sistemas de armas automáticas.

Palabras claves: sistema de disparo automático, cinturón de municiones, ametralladora PKMS de 7,62 mm.

Исследование влияния жесткости патронной ленты на эффективность системы серийной стрельбы экспериментальными методами

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

Резюме:

Введение/цель: Данная статья посвящена определению динамических характеристик системы серийной стрельбы экспериментальными методами. Помимо того, в исследовании изучено влияние жесткости патронной ленты.

Методы: Результаты исследования выявили смещение затворной рамы и патронной ленты автоматического оружия во время серии выстрелов. Для измерения и определения этих параметров использовалась высокоскоростная камера модели FASTCAM SA1.1, в частности вариант 675K-C1. Усилие и предел упругости между звеньями патронной ленты измерялись с помощью тензодатчика. С целью валидации надежности метода были проведены эксперименты на пулемете ПКМС.

Результаты: Полученные результаты показали, что при использовании ленты с жесткостью 42 [Н/мм] кинематические характеристики основного звена, такие как скорость и время отдачи, значительно изменены по сравнению с использованием ленты с жесткостью 98 [Н/мм]. В частности, максимальная скорость отдачи может быть снижена на ~8% при серии из 6 выстрелов. Данные результаты могут быть использованы в расчетах и проектировании и оптимизации патронной ленты, а также системы серийной стрельбы. Кроме того, эти результаты могут помочь в расчете скорострельности, тем самым облегчая эксплуатацию автоматического оружия.

Вывод: Процедура испытаний, разработанная в ходе данного исследования, представляет важный теоретический фундамент для оценки и определения динамических характеристик других систем автоматического оружия.

Ключевые слова: система серийной стрельбы, патронная лента, 7,62-мм пулемет ПКМС.

Истраживање ефеката крутости реденика на функционисање система за рафалну паљбу помоћу експериманталних метода

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ОБЛАСТ: математика, машинство

КАТЕГОРИЈА (ТИП) ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: У овој студији се помоћу експерименталних метода одређују динамичке карактеристике система за рафалну паљбу. Такође, разматра се и утицај крутости реденика.

Методе: Резултати истраживања укључују помераје основног дела (носача затварача) и реденика аутоматских оружја за време рафалне паљбе. За мерење и одређивање ових параметара коришћен је модел камере велике брзине FASTCAM SA1.1, варијанта 675K-C1. Сила еластичности између спојница реденика одређена је помоћу елемената за мерење деформације опремљених сензорима за мерење силе. Ради валидације поузданости метода експерименти су рађени на митраљезу ПКМС.

Резултати: Показано је да се при употреби траке крутости 42 N/mm, кинематичке карактеристике основне спојнице, као што су брзина трзања и време трзања, у знатној мери мењају у поређењу са употребом траке која има крутост од 98 N/mm. Конкретно, максимална брзина трзања може се редуковати за ~8% при опаљивању серије од 6 метака. Ови резултати могу да се примене у прорачунима и пројектовањима ради оптимизације структуре реденика и система за рафалну паљбу. Наведени налази могу да помогну и при израчунавању брзине паљбе, чиме се олакшава управљање аутоматским оружјем.

Закључак: Поступак испитивања развијен у овој студији суштински представља теоретску основу за процењивање и одређивање динамичких карактеристика других система аутоматског оружја.

Кључне речи: систем за рафалну паљбу, реденик, PKMS митраљез калибра 7,62 mm.

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