SCREENING MAIN FACTORS AFFECTING THE STABILITY OF 7.62MM PKMS GUNS USING PLACKETT-BURMAN DESIGN

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ABSTRACT

This article examines the utilization of the Plackett-Burman method to analyze the primary factors influencing the stability of the PKMS 7.62mm machine gun during firing. These factors include gun-mount mass, front leg length, position of contact between the buttstock and shoulder, shooter's biomechanics, stiffness of the ground platform, and uneven stiffness of the ground platform at the rear legs. The stability of the 7.62mm PKMS gun while firing is determined by three objective functions: vertical bounce of the gun body, horizontal bounce of the gun body, and displacement of the buttstock's location on the shoulder. The findings of this study indicate that the vertical bounce and shoulder point displacement are mostly affected by three factors: front leg length, shooter's biomechanics, and the unequal stiffness of the firing platform, as determined by the survey input parameters. Concurrently, the upward movement of the gun body is primarily affected by four factors: the length of the front leg, the gunner, the unequal stiffness of the ground platform, and the stiffness of the ground platform. The findings of this study will provide a foundation for optimization research in the field of firearm design and enhancement.

Keywords: *PKMS 7.62mm machine gun; experimental planning; screening experiment; Plackett-Burman; stability.*

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1. INTRODUCTION

Experimental planning theory is a scientific discipline that focuses on the systematic methods used to organize and carry out scientific experiments, with a specific emphasis on designed experiments. Experimental planning is widely used across several domains. However, the literature pertaining to the application of experimental planning theory to weaponry is mostly classified and arduous to get. Published papers primarily serve to convey information, while in-depth scholarly works are very restricted in scope. By conducting research and analyzing gathered documents, it is possible to categorize the application of experimental planning theory in weapons into two primary research groups. The first group focuses on utilizing experimental planning theory to optimize parameters of muzzle devices, while the second group applies this theory to analyze and optimize interior ballistics design [1].

Sherif Said and his colleagues at the Department of Weapons and Ammunition, Egyptian Military Technical College, conducted a study on optimizing the structural parameters of the muzzle brake. The study aimed to maximize the performance and impact force of the muzzle brake, while minimizing the recoil force of a 12.7mm sniper rifle firing 12.7 x 99mm bullets [2]. The optimal parameters consist of the dimensions of the side aperture, the degree of inclination of the side opening, and the quantity of muzzle brake chambers. The findings presented in [2] indicate that 12.7mm sniper rifles equipped with a muzzle brake with three or four chambers do not exhibit a substantial improvement in mitigating recoil force when compared to weapons with two chambers. This paper exemplifies the use of experimental planning theory to optimize the parameters of weaponry. However, the research conducted only examined a limited number of input parameters (specifically, 3 key parameters). Furthermore, the focus of the study was only on the muzzle brake and did not include an investigation into the stability of the gun.

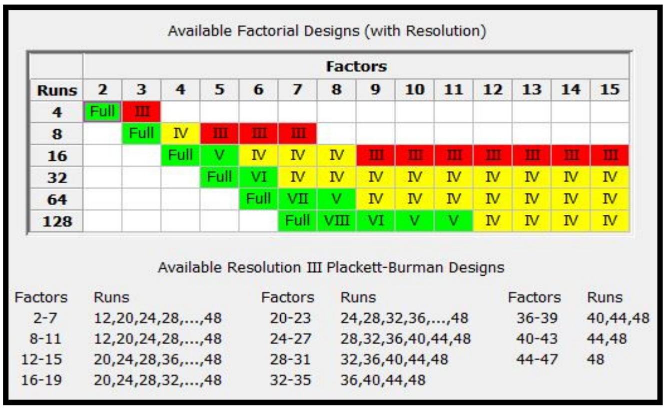
Jiang Kun and Wang Hao from Nanjing University of Science and Technology in China conduct research on enhancing the structural parameters of the perforated muzzle brake. These parameters include the angle between the barrel axis and bore axis, the angle between the bore axis and bore boundary, the length of the nozzle throat, and the outer radius of the bore [3]. The input parameters' values are derived via simulation through the use of numerical techniques. The primary focus of this research is the recoil reduction force produced by the muzzle brake. This work demonstrates the feasibility of using experimental planning theory to optimize weapon settings. However, the input parameters in this work were derived from numerical modeling rather than experimental data. The focus of the study in [4] is the baffle-chambered muzzle brake of a 12.7mm machine gun. The optimization input parameters consist of four variables: the diameter of the baffle's bore, the distance from the muzzle to the first baffle, the distance from the muzzle to the second baffle, and the inclination angle of the nozzle throat. This research addresses an optimization issue with two objective functions: the muzzle brake's performance and the sound intensity generated by the shot.

Russian scholars conducted research that used experimental planning theory to analyze and optimize internal ballistic design [1]. The focus of this author's study is the projectile launched from the 122mm D-30 gun. The input parameters required for best performance are as follows: shell weight, propellant weight, beginning pressure, and Slukkhopxki coefficient. Utilizing experimental planning theory, the authors carried out a total of 24 trials (with a combined total of 16), gathered data, and formulated an equation that describes the correlation between the goal function and the input elements.

The aforementioned published papers mostly concentrate on the optimization of muzzle brake characteristics and the design of internal ballistics. Nevertheless, there is a scarcity of published research on the stability of automatic firearms while firing when using experimental planning theory. When doing study on this matter, the primary emphasis in published literature is on the use of multi-body mechanics theory and weapon design theory to construct models that assess the stability of firearms during firing. Next, they examine the impact of various parameters on gun stability [5-11]. In addition, the authors used independent surveys to examine the impact of factors on gun stability. Specifically, they established a fixed set of parameters and selectively modified the parameters under investigation. This is fairly constrained and divergent from real shooting circumstances. The work aims to address the issue by examining the use of the Plackett-Burman screening test technique in experimental design. This approach is used to assess the primary elements that affect the stability of the PKMS 7.62mm machine gun during firing, as indicated by three specific metrics. This encompasses the vertical oscillation of the gun body, the horizontal oscillation of the gun body, and the movement of the shoulder point.

2. DESIGNING THE EXPERIMENT

The objective of the research is to perform experiments and analysis to identify the primary factors that affect the vertical bounce of the gun body, the horizontal bounce of the gun body, and the movement of the gun body's shoulder point during shooting. The aim is to eliminate less significant factors and focus on the most influential ones. There are several techniques available for designing screening tests, among which the Plackett-Burman design is a widely used sort of screening design. The Plackett-Burman Design (PBD), created by Plackett and Burman in 1946, is a highly efficient screening technique used to determine significant components from a multitude of parameters that impact a process [12-15]. If we choose not to use the Plackett-Burman design for the screening experiment and instead employ a complete two-level experiment, the number of tests required to execute the screening experiment with k = 6 influencing variables would be $2^6 = 64$. Undoubtedly, conducting 64 tests (excluding repeated tests) within the parameters of the thesis is challenging, particularly in a specialized area such as weapons testing. Thus, the paper employs the Plackett-Burman design for conducting the screening experiment (Fig. 1).



Available Factorial Designs (with Resolution)

	Factors													
Runs	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
4	Full	III												
8		Full	IV	III	III	III								
16			Full	V	IV	IV	IV	III	III	III	III	III	III	III
32				Full	VI	IV	IV	IV	IV	IV	IV	IV	IV	IV
64					Full	VII	V	IV	IV	IV	IV	IV	IV	IV
128						Full	VIII	VI	V	V	IV	IV	IV	IV

Available Resolution III Plackett-Burman Designs

Factors	Runs	Factors	Runs	Factors	Runs
2-7	12,20,24,28,...,48	20-23	24,28,32,36,...,48	36-39	40,44,48
8-11	12,20,24,28,...,48	24-27	28,32,36,40,44,48	40-43	44,48
12-15	20,24,28,36,...,48	28-31	32,36,40,44,48	44-47	48
16-19	20,24,28,32,...,48	32-35	36,40,44,48		

Fig. 1. Full two-level experimental design

In terms of mathematical modeling, the following first-order polynomial model was used in the design of the screening experiment:

$$Y = \beta_0 + \sum \beta_i X_i \tag{1}$$

where Y is the predicted response (objective function); β_0 is the intercept of the model; β_i is the linear coefficient, and X_i is the influencing factor. The influencing factors are denoted as follows:

- Mount weight - X_1;
- Biomechanics of gunner - X_2;
- Front leg length - X_3;
- Ground stiffness - X_4;
- Shoulder point location - X_5;
- Uneven stiffness of the firing platform at the rear legs - X_6.

The research content includes three objective functions, denoted as follows:

- Vertical movement (vertical bounce) of gun body - Y_1;
- Horizontal movement (horizontal bounce) of the gun body - Y_2;
- Movement of the shoulder point - Y_3.

Identify the significant variables for each objective function with a confidence level of 95%. The Plackett-Burman design was used in this study to assess six parameters, with a total of 12 series of shots, each consisting of three shots. The factor variable was estimated at two levels: -1 for the lowest level and +1 for the maximum level, as shown in Table 1. Table 2 displays the Plackett-Burman experimental design, including the coefficients and test ranges. Coefficients that have a confidence level higher than 95% ($P < 0.05$) are deemed to have a substantial influence on the objective functions and are taken into account for optimization.

Table 1. Plackett-Burman screening levels and experimental factors

Factors	Symbol	Experiment level	
		Smallest (-1)	Highest (+1)
Gun mount mass (kg)	X_1	2.91	3.492
Gunner's biomechanics	X_2	Thin - small (XT1)	Big (XT2)
Length of the front leg (dm)	X_3	360	440
Ground platform factor (KG/dm)	X_4	G1	G2
Position of shoulder point (dm)	X_5	- 0.4	+ 0.4
Uneven factors of ground platform at the rear legs	X_6	S1	S2

Table 2. Plackett-Burman screening experiment design

Order of firing	Gun mount mass (X_1)	Gunner (X_2)	Front leg length (X_3)	Stiffness of ground (X_4)	Shoulder point position (X_5)	Uneven stiffness of ground (X_6)
1	1	XT1	1	-1	-1	-1
2	1	XT2	-1	1	-1	-1
3	-1	XT2	1	-1	1	-1
4	1	XT1	1	1	-1	1
5	1	XT2	-1	1	1	-1
6	1	XT2	1	-1	1	1
7	-1	XT2	1	1	-1	1
8	-1	XT1	1	1	1	-1
9	-1	XT1	-1	1	1	1
10	1	XT1	-1	-1	1	1
11	-1	XT2	-1	-1	-1	1
12	-1	XT1	-1	-1	-1	-1

3. EXPERIMENTAL PROCEDURE

3.1. Measuring devices

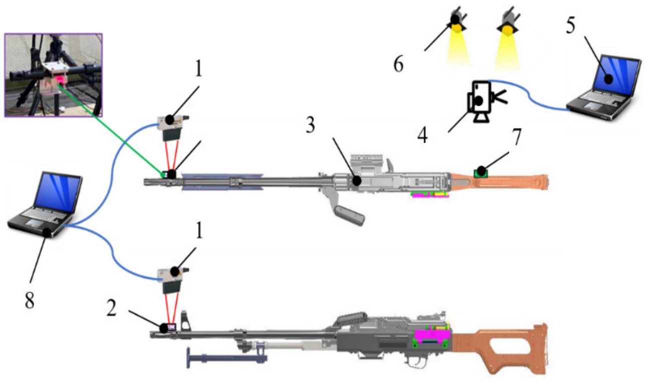


Fig. 2. Layout diagram of testing equipment

1. Sensor laser HF-750C; 2. The reflective plane; 3. The 7.62mm PKMS machine gun; 4. Camera FASTCAM SA1.1 model 675K - C1; 5. The computer has TEMA software installed; 6. Lights; 7. Marks on the gun; 8. The computer has software installed

Once the screening experiment has been designed, proceed to run the experiment. The goal of the experiment is to ascertain three parameters of the objective function: the vertical displacement (vertical bounce) and horizontal displacement (horizontal bounce) of the gun body, by measuring the displacement of the muzzle and the displacement of the shoulder point. Fig. 2 displays the schematic of the experimental arrangement. Fig. 3 displays the experimental images. Table 3 provides a comprehensive overview of the content, purpose, measurement methods, and precise sites associated with each exam.

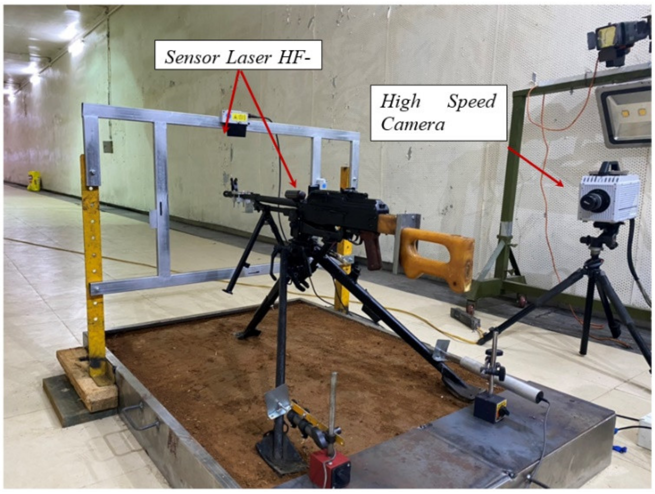


Fig. 3. The experimental setup

The experiment took place at the Weapons Technical Center, which is part of Le Quy Don Technical University. Two HF-750C laser sensors were used to quantify the vertical and horizontal rebound of the gun body. The HF-750C laser sensor functions by using the technique of optical triangulation.

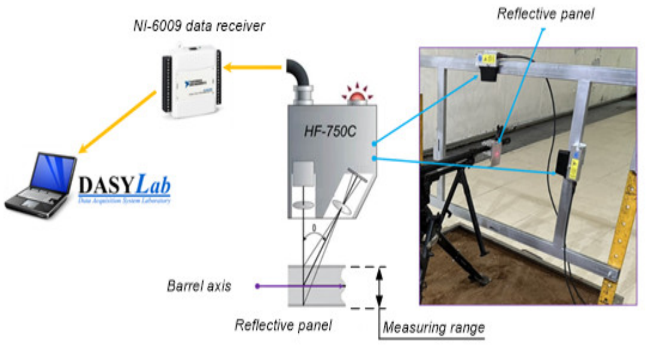


Fig. 4. The principle diagram for measuring the horizontal and vertical bounce of the gun body

The two sensors are affixed to the frame and facilitate the transmission and reception of signals via the reflecting plane. Reflective planes are positioned above the rifle barrel, oriented at right angles to one another. The signal is sent to the NI-6009 data receiver. The data receiver is linked to a computer equipped with DasyLab processing software. Fig. 4 displays the fundamental diagram of measurement. Table 3 displays the specs of the HF-750C laser sensor.

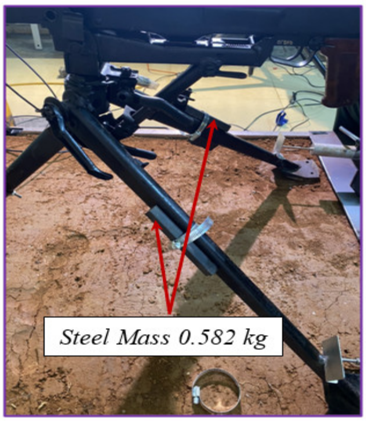
Table 3. Content and equipment for screening experiments

Order	Content of experiments	Measuring means	Location	Testing purpose
1	Experiment to determine the vertical displacement (vertical bounce) of the gun body	The measuring system uses laser sensor HF-750C	The Weapons Technical Center, Le Quy Don Technical University	Collect data set for objective function Y_1
2	Experiment to determine the horizontal displacement (horizontal bounce) of the gun body	The measuring system uses laser sensor HF-750C	The Weapons Technical Center, Le Quy Don Technical University	Collect data set for objective function Y_2
3	Experiment to determine the displacement of the shoulder point	The measuring system uses a FASCAN SA1.1 projectile camera model 675K-C1	The Weapons Technical Center, Le Quy Don Technical University	Collect data set for objective function Y_3

The FASCAN SA1.1 projectile camera system, namely the model 675K-C1, is used to measure and quantify the displacement of the shoulder point. The collected data will be examined using the TEMA software.

3.2. Preparing for the test sample

a) Original gun mount (2.91kg)



b) Increasing weight gun mount (3.492kg)

Fig. 5. The changing weight of the gun mount

In order to effectively conduct the tests outlined, it is necessary to create jigs and ensure optimal firing conditions. Concerning the weight of the firearm, denoted as X_1, the minimum and maximum values observed are 2.91kg (X_{1min}) and 3.492kg (X_{1max}), respectively. To do this, a weight of 0.582kg was fastened to each leg of the tripod, as seen in Fig. 5.

Two marksmen were selected to fire the shot for the purpose of examining the biomechanics (X_2) of shooting. One shooter had a towering and substantial physique, whereas the other exhibited a slim and diminutive stature (Fig. 6).

Fig. 6. Two kind of shooters

The front leg joint has the ability to modify the leg length within a range of 360mm to 440mm for the front leg length condition (X_3). The anterior limb was extracted from the authentic limb, and then the limb articulation was included, as seen in Fig. 7.

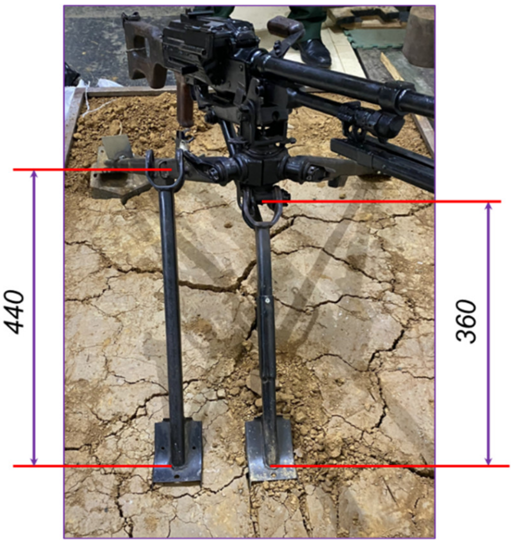


Fig. 7. Length of the front leg: 360mm and 440mm

Regarding the ground stiffness state (X_4), the survey was conducted in two scenarios: one where the soil is compacted (G1) and another where the soil is loose (G2) (Fig. 8).

Fig. 8. The platform for the shot (soil tray) is compacted

In relation to shoulder point conditions (X5): The shoulder point varies between -0.4dm (X_{3min}) and +0.4dm (X_{3max}). This situation may be altered by constructing an articulation that enables the adjustment of the shoulder point's location while firing. The redesigned grip is derived from the original pistol grip (Fig. 9).

a) Raise shoulder points +0.4dm

b) Lower shoulder points -0.4dm

Fig. 9. Grip structure when raising or lowering the shoulder point

Concerning the issue of inconsistent stiffness in the ground platform at the two rear legs (X6): The impact of the unequal rigidity of the firing platform is assessed in both the scenarios of minimal and maximum stiffness. This study was conducted using surveys in actual combat scenarios using firearms, under two specific conditions:

The condition of unequal stiffness is characterized by one leg firmly planted on the ground while the other leg is tilted.

The example of unequal stiffness is most apparent, occurring when one leg is positioned on a tilted surface and the other leg is on a brick basis (Fig. 10).

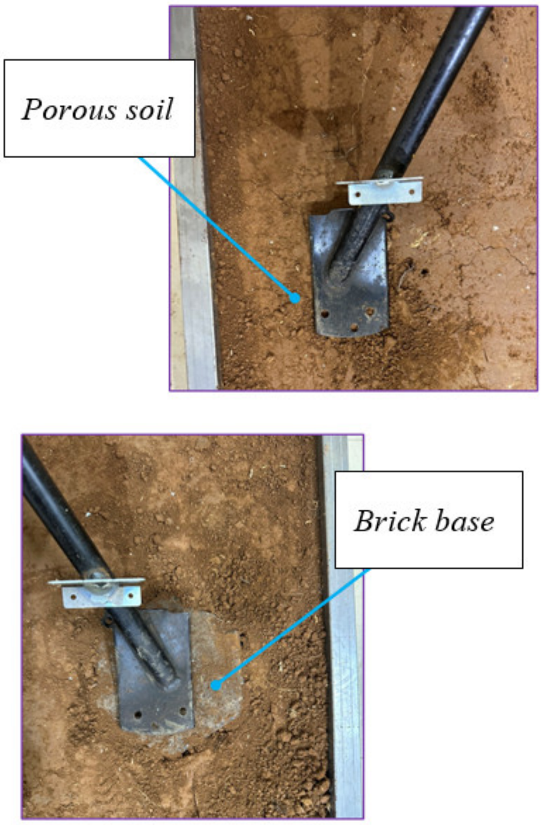


Fig. 10. The uneven stiffness

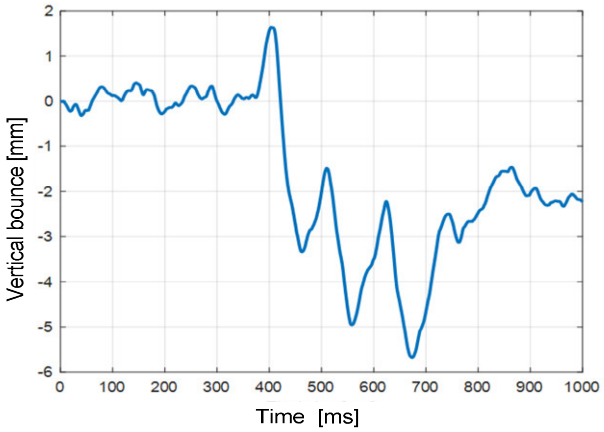
3.3. Experimental results

Once the experimental equipment has been prepared, proceed to perform a test fire. Table 4 displays the outcomes of 12 firing series. Figs. 11, 12, and 13 provide graphs illustrating the firing outcomes.

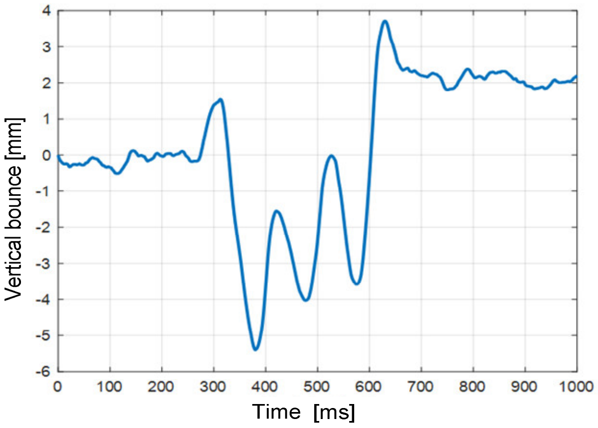
Table 4. The results of test-firing screening

Order of firing	Gun mount mass	Gunner	Font leg length	Stiffness of platform	Shoulder point position	Uneven stiffness of platform	Vertical bounce (mm)	Horizontal bounce (mm)	Displacement of shoulder point (mm)
1	1	XT1	1	-1	-1	-1	4.51	1.49	6
2	1	XT2	-1	1	-1	-1	5.21	1.92	8
3	-1	XT2	1	-1	1	-1	6.15	1.99	9

4	1	XT1	1	1	-1	1	5.68	2.16	9
5	1	XT2	-1	1	1	-1	4.71	1.73	7
6	1	XT2	1	-1	1	1	6.71	2.45	10
7	-1	XT2	1	1	-1	1	6.31	2.45	10
8	-1	XT1	1	1	1	-1	5.46	1.99	7
9	-1	XT1	-1	1	1	1	5.01	1.84	7
10	1	XT1	-1	-1	1	1	4.51	1.47	6
11	-1	XT2	-1	-1	-1	1	5.4	1.92	8
12	-1	XT1	-1	-1	-1	-1	3.89	1.4	6

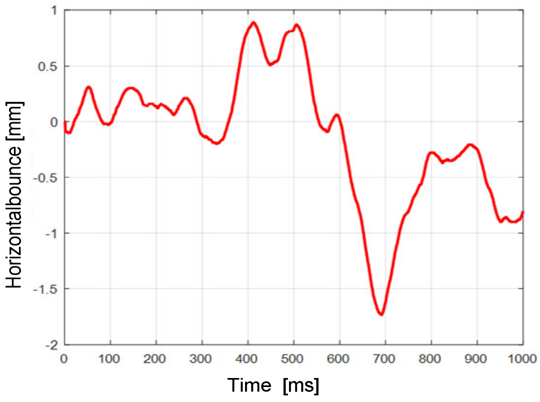


a) The 4th shots

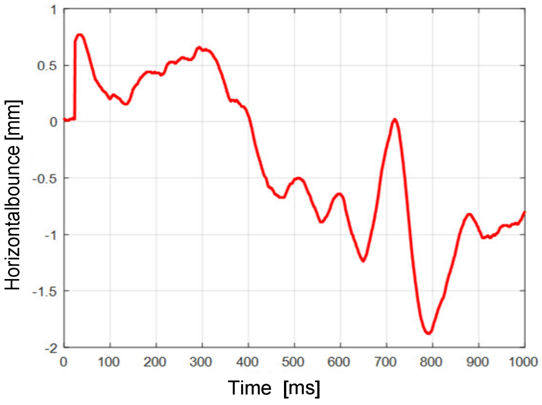


b) The 11th shots

Fig. 11. Vertical bounce of the gun body at the 4th and 11th shots

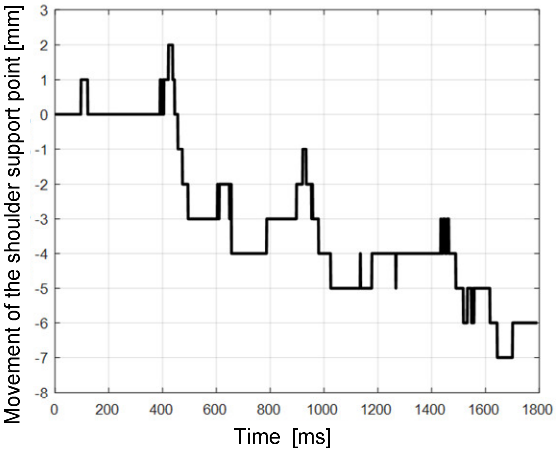


a) The 5th shot

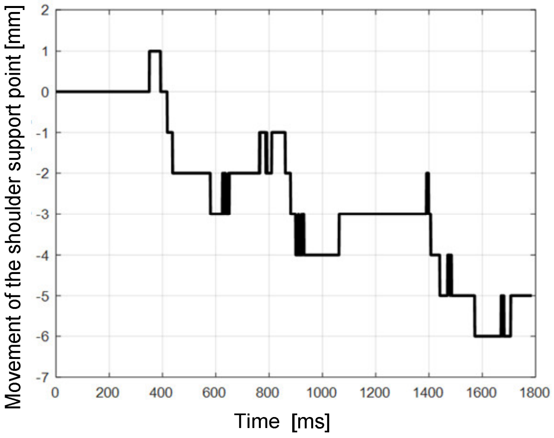


b) The 9th shot

Fig. 12. Horizontal bounce of the gun body at the 5th and 9th shots



a) The 8th shot



b) The 10th shot

Fig. 13. Graph of shoulder point displacement in some shots

4. SCREENING THE MAIN FACTORS AFFECTING THE STABILITY OF THE 7.62MM PKMS MACHINE GUN WHEN FIRING

Upon receiving the screening experiment results, utilize the MINITAB software to conduct an assessment of the key factors that impact the stability of the gun during shooting. This analysis should be based on the three objective functions mentioned earlier: vertical recoil, horizontal recoil, and shoulder point displacement.

4.1. The main factors affecting vertical bounce

We generate a plot showing the primary impacts of six experimental factors on vertical bounce using MINITAB software, as seen in Fig. 14.

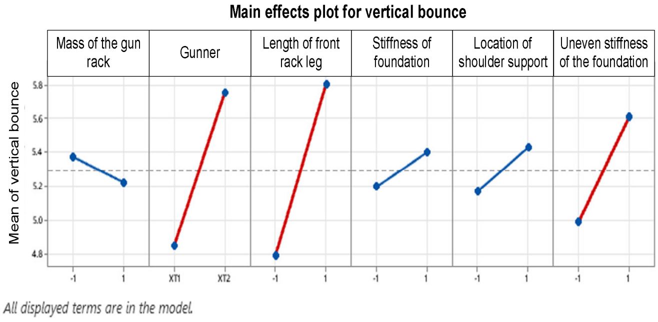


Fig. 14. Plot of main effects on vertical bounce

From Fig. 14, we have some assessments as follows:

Regarding the front leg length factor, when the front leg length increases from the minimum value (level -1) to the maximum value (level +1), the vertical bounce of the gun body increases from 4.78833mm to 5.80333mm. The slope of this graph may be calculated by subtracting the y-coordinates (5.80333 - 4.78833) and dividing the result by the difference in x-coordinates (2). The calculated slope is 0.51. The graph exhibits the steepest slope, indicating that the length of the front leg is the primary element that significantly impacts vertical bounce. Similarly, the elements influencing vertical bounce will be ranked in order of strength, as follows: front leg length, gunner, unequal stiffness of the platform, location of shoulder point, ground platform stiffness, and gun mount mass. Also using MINITAB software, we obtain a Pareto chart of six influencing factors, as shown in Fig. 15.

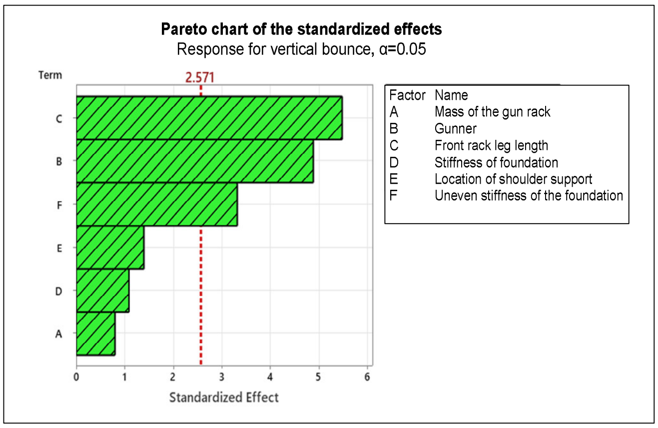


Fig. 15. Pareto chart of six influencing factors

The chart shown in Fig.15 displays a dashed red line representing the limit. This line has an abscissa value of 2.571 and a significance level of α = 0.05. Based on this information, we may determine the area that eliminates the null hypothesis. Additionally, the graphic indicates that three elements surpass the established limit line: the length of the front leg, the gunner, and the unequal stiffness of the ground platform. The objective function is primarily influenced by three key aspects. This aligns perfectly with the result derived from the examination of the normalized impact chart shown before.

To once again confirm the three main influencing factors mentioned above, we proceed to find a regression model. Through the software, we have a regression equation for the vertical objective function as follows:

$$\begin{aligned} Y_1 &= 5.2958 - 0.0742X_1 + 0.4525X_2 + 0.5075X_3 \\ &\quad + 0.1008X_4 + 0.1292X_5 + 0.3075X_6 \end{aligned} \tag{2}$$

where Y_1 - Vertical bounce [mm]; X_1 - Mount weight; X_2 - Biomechanics of gunner; X_3 - Front leg length; X_4 - Ground stiffness; X_5 - Shoulder point location; X_6 - Uneven stiffness of the firing platform at the rear legs.

The regression model data is shown in Table 5. The regression model's information is also shown in Table 5. Upon examining the p-value column, it is evident that the weight of the gun mount, rigidity of the ground platform, and shoulder position exhibit very high p-values (0.46, 0.327, and 0.223, respectively) when compared to the significance threshold α (which is 0.05). Consequently, the model-building outcomes remain unaffected by the three aforementioned parameters. However, three parameters - the length of the front leg, the gunner, and the unequal stiffness of the ground platform - have p-values that are much lower than the significance threshold α (0.003, 0.005, 0.021, respectively). Therefore, these factors have a substantial impact.

Table 5. Regression model information for vertical bounce objective function

Term	**Effect**	**Coef**	**SE Coef**	**T-Value**	**P-Value**
Constant		5.2958	0.0928	57.08	0.000
Gun mount mass	-0.1483	-0.0742	0.0928	-0.80	*0.460*
Gunner	0.9050	0.4525	0.0928	4.88	**0.005**
Font leg lenght	1.0150	0.5075	0.0928	5.47	**0.003**
Stiffness of platform	0.2017	0.1008	0.0928	1.09	*0.327*
Shoulder point position	0.2583	0.1292	0.0928	1.39	*0.223*
Uneven stiffness of platform	0.6150	0.3075	0.0928	3.31	**0.021**
Model summary					
S	**R-sq**	**R-sq(adj)**		**R-sq(pred)**	
0.321385	93.19%	85.02%		60.79%	

Furthermore, based on Table 5, it is evident that the coefficient of determination (R-sq) exceeds 90% (specifically 93.19%), providing strong evidence that the regression model well represents the data.

4.2. The main factors affecting horizontal bounce

By using the same procedure as for vertical bounce using the MINITAB software tool, we generate the main effects graph and the pareto chart for the six experimental factors on horizontal bounce. These charts are shown in Figs. 16 and 17.

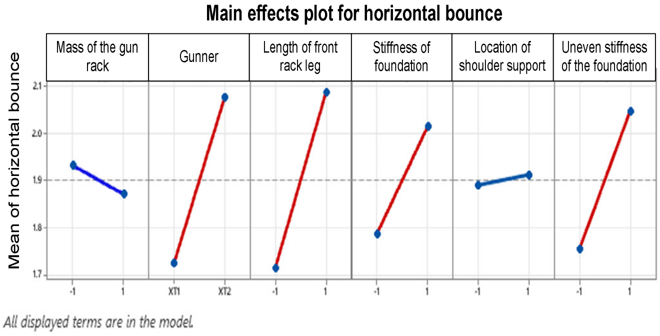


Fig. 16. Graph of main effects on horizontal bounce

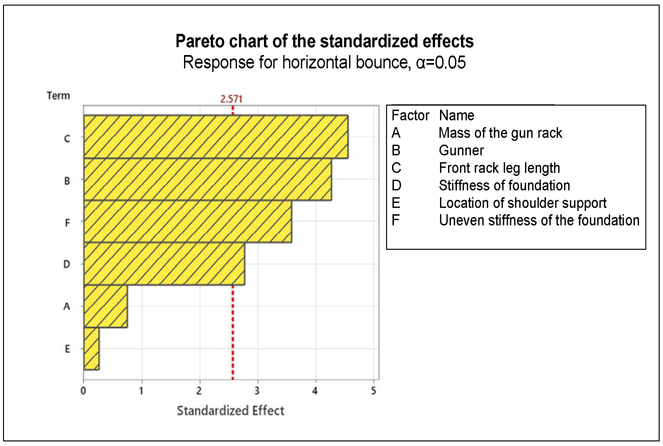


Fig. 17. Pareto chart of six factors affecting horizontal bounce

The information for the regression model is presented in Table 6.

Table 6. Regression model information for the horizontal bounce objective function

Term	Effect	Coef	SE Coef	T-Value	P-Value
Constant		1.9008	0.0412	46.12	0.000
Gun mount mass	-0.0617	-0.0308	0.0412	-0.75	0.488
Gunner	0.3517	0.1758	0.0412	4.27	**0.008**
Font leg lenght	0.3750	0.1875	0.0412	4.55	**0.006**
Stiffness of platform	0.2283	0.1142	0.0412	2.77	**0.039**
Shoulder point position	0.0217	0.0108	0.0412	0.26	0.803
Uneven stiffness of platform	0.2950	0.1475	0.0412	3.58	**0.016**
Model summary					
S	**R-sq**			**R-sq(adj)**	
0.142764	92.31%			83.08%	

Upon analyzing the graphs and information tables of the regression model, it becomes evident that there are four primary factors that significantly impact the horizontal bounce of the gun body. These factors, listed in descending order of influence, are front leg length, gunner, uneven stiffness of the ground platform, and stiffness of the ground platform.

Using the program, we have obtained the regression equation for the objective function related to horizontal bouncing, which is as follows:

$$\begin{aligned} Y_2 &= 1.9008 - 0.0308X_1 + 0.1758X_2 + 0.1875X_3 \\ &\quad + 0.1142X_4 + 0.0108X_5 + 0.1475X_6 \end{aligned} \quad (3)$$

where Y_2 - Horizontal bounce [mm]; X_1 - Mount weight; X_2 - Biomechanics of gunner; X_3 - Front leg length; X_4 - Ground stiffness; X_5 - Shoulder point location; X_6 - Uneven stiffness of the firing platform at the rear legs.

Equation (3) accurately represents the relative importance of the six elements included in the screening test.

4.3. The main factors affecting shoulder point displacement

Upon completing the statistical data processing of the experimental screening, we have generated the major effects graph and the Pareto chart for the six experimental factors affecting the displacement of the shoulder pressure point. These charts are shown in Figs. 18 and 19. The regression model data is shown in Table 7.

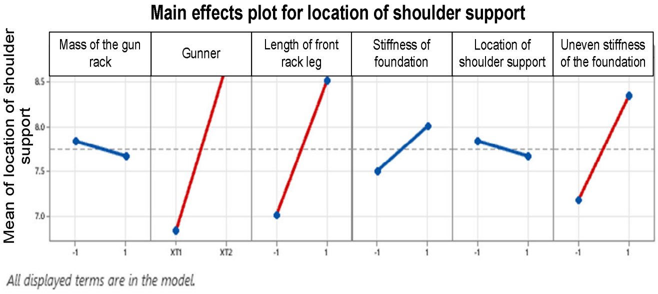


Fig. 18. Graph of main influences on shoulder point displacement

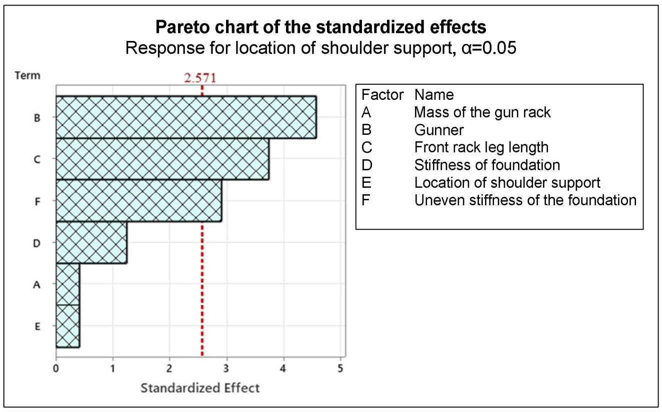


Fig. 19. Pareto chart of six factors affecting shoulder point displacement

Table 7. Regression model information for the shoulder point displacement objective function

Term	Effect	Coef	SE Coef	T-Value	P-Value
Constant		7.750	0.201	38.62	0.000
Gun mount mass	-0.167	-0.083	0.201	-0.42	0.695
Gunner	1.833	0.917	0.201	4.57	**0.006**
Font leg lenght	1.500	0.750	0.201	3.74	**0.013**

Stiffness of platform	0.500	0.250	0.201	1.25	0.268
Shoulder point position	-0.167	-0.083	0.201	-0.42	0.695
Uneven stiffness of platform	1.167	0.583	0.201	2.91	**0.034**
Model summary					
S	**R-sq**		**R-sq(adj)**		
0.695222	90.03%		78.08%		

The regression equation for the shoulder point displacement objective function is below:

$$\begin{aligned} Y_3 &= 7.750 - 0.083X_1 + 0.917X_2 + 0.750X_3 \\ &\quad + 0.250X_4 - 0.083X_5 + 0.583X_6 \end{aligned} \tag{4}$$

where Y_3 - Shoulder point displacement [mm]; X_1 - Mount weight; X_2 - Biomechanics of gunner; X_3 - Front leg length; X_4 - Ground stiffness; X_5 - Shoulder point location; X_6 - Uneven stiffness of the firing platform at the rear legs.

These data indicate that the shooter, the length of the front leg, and the uneven stiffness of the ground platform are three crucial factors that influence shoulder point displacement, similar to their impact on the vertical bounce objective function. The differing component that has the most influence. The length of the front leg is the primary determinant in vertical bounce, whereas the gunner has the most significant impact on the displacement of the shoulder point in the screening experiment.

5. CONCLUSION

Conducting screening trials to identify the primary elements that influence the stability of the 7.62mm PKMS machine gun while firing is a crucial research subject for improving these factors. The paper used the Plackett-Burman screening experiment method, which comes from experimental planning theory, to look at the main factors that affect the cannon's vertical and horizontal bounce, as well as the shooter's shoulder point and how stiff the ground platform is at the back legs. The six input elements included gun mount mass, front leg length, shoulder point location, the shooter's biomechanics, and the stiffness of the ground platform. The outcomes of the screening variables are as follows:

The regression equations in the screening test are obtained as follows:

$$\begin{cases} Y_1 = 5.2958 - 0.0742X_1 + 0.4525X_2 + 0.5075X_3 \\ \quad + 0.1008X_4 + 0.1292X_5 + 0.3075X_6 \\ Y_2 = 1.9008 - 0.0308X_1 + 0.1758X_2 + 0.1875X_3 \\ \quad + 0.1142X_4 + 0.0108X_5 + 0.1475X_6 \\ Y_3 = 7.750 - 0.083X_1 + 0.917X_2 + 0.750X_3 \\ \quad + 0.250X_4 - 0.083X_5 + 0.583X_6 \end{cases} \tag{5}$$

where X_1 - Mount weight; X_2 - Biomechanics of gunner; X_3 - Front leg length; X_4 - Ground stiffness; X_5 - Shoulder point location; X_6 - Uneven stiffness of the firing platform at the rear legs; Y_1 - Vertical bounce [mm]; Y_2 - Horizontal bounce [mm]; Y_3 - Shoulder point displacement [mm].

In further investigations, the authors will concentrate on maximizing the most influential parameters derived from this investigation.

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