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Survey of The Relationship Between Firing Angle and Distance of Heavy Rifles

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ABSTRACT: This paper presents the results of a study on the relationship between firing angle and range when firing 12.7mm and 14.5mm heavy rifles under the same weather conditions. Relevant information includes aiming angle, firing angle, bullet trajectory height, range, and the lethal kinetic energy of the projectile. Using specialized software to calculate the external launch algorithm, the authors calculated the range for the 12.7mm and 14.5mm rifles. The research results can be used as a reference in weapon design, optical sight design … especially in the case of heavy rifles.

KEYWORDS: heavy rifle; firing angle; aiming angle; firing range; bullet trajectory height; direct firing range.

I. INTRODUCTION

Infantry weapons include pistols, rifles, submachine guns, light machine guns or heavy machine guns… among which rifles are fitted with optical sights to become sniper rifles. Legendary sniper rifles include the SVD using 7.62mm ammunition, the T5000 using 7.62 or 8.6mm ammunition, the Barrett M82 using 12.7mm ammunition… Currently, the trend for sniper rifles is to gradually increase the caliber to shoot further and destroy more types of targets. Calibers of 14.5mm, even 20mm or 23mm are being used. Some information about structural data is presented in documents [1] [3] [7]; information about muzzle brake, gun stability, bullet kinetic energy is presented in documents [2] [4] [5] [6].

When a bullet flys through the air, aerodynamic drag is generated due to the mutual interaction between the bullet and the air. This phenomenon arises from two causes: friction between the air and the surface, which creates frictional force, and the unbalanced pressure on the bullet's surface, which produces pressure drag. Additionally, there is vortex drag caused by the spinning motion of the bullet's tip in the air, gravity, and inertial forces, as described by Coriolis force [8]. Because of drag force and the projectile's launch angle, there are moments such as the M_R overturning moment, the surface friction moment M_{ms}, and the aerodynamic drag moment M_c. These moments reduce the projectile's range.

Fig. 1 The 12.7mm and 14.5mm gun model

II. CONTENTS

A. Relationship between firing angle and range of 12.7mm ammunition.

Input parameters: In the calculation, we use a 12.7mm B-32 round, with a projectile mass of 48 grams. When fired from the barrel, the projectile reaches a velocity of 820 m/s. Taking air resistance into account, the trajectory of the projectile is no longer a parabola; the rear branch of the trajectory curves downwards more rapidly. Using ballistic trajectory calculation software, we obtain the following results table

Table 1. Results of the projectile trajectory of a 12.7mm round

Angle of fire 00-00	Orbital altitude (m)	Distance to the top of the trajectory (m)	Flight time (s)	Bullet velocity (m/s)	Kinetic energy of the bullet (kG.m)	Distance (m)
2,2	0,02	51	0,13	780	1498	100
2,5	0,09	102	0,26	741	1352	200
3,1	0,20	154	0,40	703	1217	300
3,9	0,36	207	0,55	666	1093	400
5,0	0,59	261	0,70	631	980	500
6,1	0,90	316	0,86	597	877	600
7,2	1,3	372	1,03	564	783	700
8,3	1,8	429	1,21	532	697	800
9,4	2,4	487	1,40	501	618	900
11	3,2	546	1,61	471	547	1000
12	4,1	606	1,83	443	488	1100
14	5,2	667	2,06	416	426	1200
16	6,5	730	2,31	390	375	1300
18	8,1	795	2,58	366	330	1400
20	10,1	861	2,86	347	293	1500
23	12,5	927	3,16	328	265	1600
25	15,3	993	3,47	314	243	1700
28	18,5	1059	3,79	308	226	1800
31	22,1	1125	4,12	294	213	1900
34	26,1	1191	4,47	287	203	2000

Observations of the results: We see that if the target height is 1.8m, the direct firing range is 800m; at this point, the kinetic energy of the projectile Ey is 697 kG.m, meaning this energy is sufficient to penetrate a 2mm thick carbon steel plate. Similarly, at a firing angle of 34 millimeters, the flight range is 2000m; the kinetic energy of the projectile is 203 kG.m - sufficient to inflict casualties. The maximum possible firing range is over 4000m. The relationship between firing angle and range can be represented by the graph below:

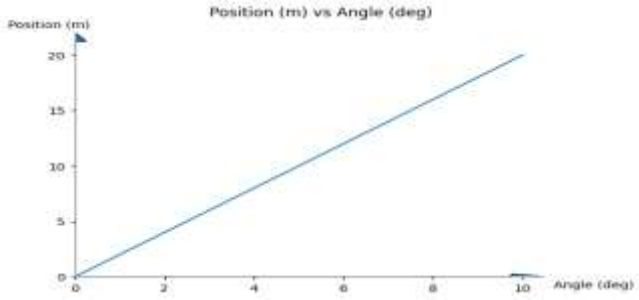

Fig. 2. Graph showing the relationship between firing angle and distance of a 12.7mm projectile.

B. Relationship between firing angle and range of a 14.5mm bullet

Input parameters: We use a 14.5mm armor-piercing bullet, with a mass of 63.6 grams. Upon firing, the bullet reaches a velocity of 1012 m/s. Using ballistic trajectory calculation software, we obtain the following results table:

Table 2. Results of the projectile trajectory of the 14.5mm round

Angle of fire 00-00	Orbital altitude (m)	Distance to the top of the trajectory (m)	Flight time (s)	Bullet velocity (m/s)	Kinetic energy of the bullet (kG.m)	Distance (m)
0,6	0,02	51	0,10	961	2993	100
1,1	0,06	102	0,21	911	2688	200
1,7	0,13	154	0,32	862	2406	300
2,5	0,24	207	0,44	814	2148	400
3,3	0,40	261	0,57	768	1910	500
4,2	0,61	316	0,70	725	1700	600
5,3	0,87	372	0,84	687	1528	700
6,7	1,2	429	0,98	651	1372	800
8,1	1,6	487	1,13	620	1245	900
9,5	2,1	546	1,30	590	1127	1000
11	2,6	606	1,46	560	1016	1100
13	3,3	666	1,64	530	910	1200
16	4,2	727	1,83	500	810	1300
18	5,1	789	2,03	475	730	1400
20	6,2	825	2,24	450	656	1500

Observations of the results: we see that if the target height is 2.1m, the direct firing range of the gun is 1000m; at this point, the kinetic energy of the projectile Ey is 1127 kG.m. Similarly, at a firing angle of 20 millimeters, the flight range is 1500m; the kinetic energy of the projectile is 656 kG.m - a very high level for inflicting casualties. The relationship between firing angle and range can be represented by the graph below:

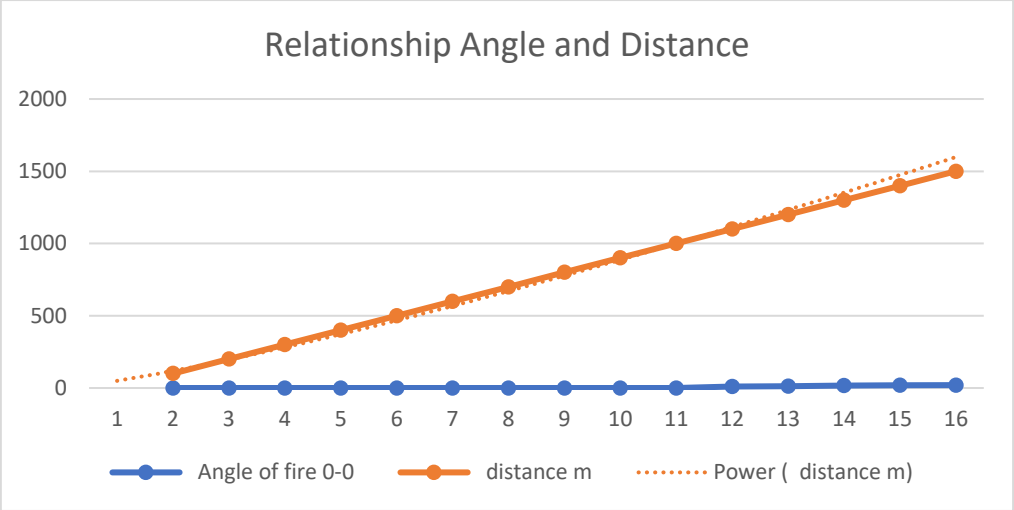

Fig. 3. Graph showing the relationship between firing angle and range of a 14.5 mm projectile

The relationship between projectile trajectory altitude and projectile range is illustrated in the following diagram:

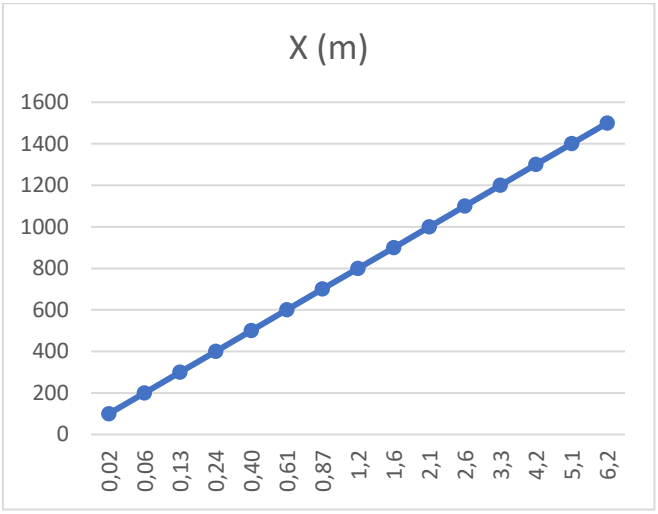

Fig. 4. Graph showing the relationship between altitude and range of a 14.5 mm projectile

C. The direct firing range of a heavy rifle

The direct firing range is understood as the range at which the bullet's trajectory height does not exceed the target's height. Therefore, the direct firing range depends on the target's height. When firing at infantry, we assume the target is 1.8m high; for crouching infantry, the height is 1.5m; for infantry in fortifications, the height is 0.5m. For armored targets, in most cases, the height is considered to be 2.7m.
Heavy rifles are used to destroy targets such as infantry, light armored vehicles, small boats, low-flying aircraft, etc.

Thus, with a 12.7mm rifle, the direct firing range against infantry is 800m; against light armored vehicles, it is less than 1000m. Similarly, with a 14.5mm rifle, the direct firing range against infantry is 950m; against light armored vehicles, it is less than 1100m. In some special cases where longer firing ranges are needed, we can still fire to destroy targets, such as causing fires or marking targets... we can still use heavy rifles for these tasks.

D. Amount of range correction in longitudinal wind for 12.7mm ammunition

When the velocity changes by 10 m/s and the longitudinal wind speed changes by 4 m/s and 10 m/s, we have the range correction as shown in Table 3 below:

Table 3. Amount of repair for 12.7 mm bullet

Distance	Amount of correction for distance, m				
	Change			Longitudinal wind speed	
	Air temperature and dose 10°C	Air pressure 10 mmHg	Initial speed 10m/s	Speed 4 m/s	Speed 10 m/s
100	2	0	2	0	0
200	5	0	5	0	0
300	8	0	7	0	0
400	11	1	9	0	1
500	14	1	11	1	1
600	17	1	13	1	2
700	20	2	15	1	3
800	23	3	17	1	4
900	26	3	18	2	5
1000	29	4	19	2	6

III.CONCLUSIONS

Heavy rifles have very high projectile velocity and kinetic energy; the range increases very rapidly with even a small increase in firing angle.

Due to air resistance, the projectile loses energy rapidly in flight, mainly due to the frontal drag of the projectile.
The direct firing range mainly depends on the target height, but is mostly below 1000m; with a good quality sniper rifle

and standard ammunition, the effective range can increase to 1500m or more.

The range of heavy rifles capable of inflicting damage on soft targets (human casualties) can extend beyond 2000m.

If weather and terrain factors are taken into account and ammunition quality is improved, it may be possible to shoot down soft targets at ranges of 3000m to 4000m.

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