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THE TEST TECHNICAL RESEARCH OF SHOOTING PRECISION ON ANTI-AIRCRAFT MACHINE GUN

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Abstract

Owing to the lack of sound test establishments and feasible testing and measuring technologies, the execution of present anti-aircraft machine gun precision tests have to rely on the balloon-hung targets method or closely fixed hanging targets method, which are not only complicated and wasteful with a bad precision result, but also can only be treated as a qualitative exam rather than a quantitative evaluation.

Based on the analysis of the factors affecting the bullets dispersion of the anti-aircraft machine gun, and the precise measurement of the major parameters affecting the dispersion precision through advanced measuring technologies, this paper set up and choose a suitable ballistic calculation model to conduct precise ballistic simulation calculation. This kind of calculation helps to ascertain the dispersion of the bullets in a random area inside the test area. Then after the validation of tests, we make a scientific project to conduct the anti-aircraft machine gun precision test, and by this way, we lay the theoretical foundation and provide concrete execution method for the anti-aircraft machine gun precision test in the future.

1 Foreword

The precision test is a major program in the anti-aircraft machine gun production test. But for many years, restricted the measuring methods and the test technologies, it has not been conducted effectively. The major problems are: the commonly used balloon-hang targets method offers a very unstable solution; and the closely fixed hanging targets method provides an incredible result because of the short shooting distance, which is much shorter than the required one; the works of setting up the targets, measuring the parameters and recording the test data are enormous; the test requires a huge cost of both money and other resources and a very long period. After all this, the test is still a qualitative exam, without effective test methods and raising no corresponding technological specifications.

As anti-aircraft machine guns, they should have effective exams on the important specification of anti-aircraft shooting precision. So a new test method must be developed.

Commonly, there are three ways to get the anti-aircraft shooting precision: sheer calculation method, sheer bullets shooting method, and combination of the two. The first can hardly get a credible result due to the complexity and diversity of the factors affecting the shooting results. The second is what we adopted at present time, but is cannot be effectively conducted. This paper mainly researches the third one.

2 The analysis of the factors affecting the ballistic

The major affecting factors are: the jump angle, the muzzle velocity, the ballistic parameters, and the climate conditions and so on. Detailed analysis follows:

2.1 the shooting angle (the jump angle)

The shooting angle is made of the elevation at vertical direction of the gun-barrel axis and portrait ponderance of jumping angle. While at shooting, the shooter gives the gun a certain elevation, and after the shoot because of the jump angle of the gun, its obliquity changes a little from before the shoot. And this change of the obliquity forms a part of the jump. It is the jump angle that has a decisive impact on the bullets dispersion of the machine gun. Among all the affecting factors, the jump angle is the most difficult one to analyze and to grasp. It can only be acquired through tests.

In order to research the rule of the jump angle changes and their impact to the bullets dispersion under different jump angle conditions，this paper compares two types of machine guns, loaded with armor-piercing incendiary bullets. After the jump angle tests under different shooting angles, we can see that as the shooting angle enlarges, the jump angle also increases (except few fluctuations);

From the tests we can also see that the bullets’ dispersion area also increases as the shooting angle does (except few fluctuations).

It is obvious that the jump angle has a great impact on the dispersion of the machine gun bullets.

2.2 muzzle velocity

Muzzle velocity is decided by the bore structure, the length of the barrel, the powder and the mass of the bullets. All these factors can be controlled exactly, so the muzzle velocity is not as random as the jump angle. The muzzle velocity does have certain impact on the ballistic coefficients, which in turn affect the range of the bullets. To solve this problem, we should use the resistance coefficient of the bullet itself to calculate the ballistic. We can measure the muzzle velocity of every single bullet during a dot-shooting by using the inner ballistic radar and the multi-channel timer together, so we can reduce the discrepancies caused by muzzle velocity.

2.3 ballistic coefficients

Ballistic coefficients are important parameters to calculate the air resistance and even the ballistic coordinates. In the past we adopted the 1943 standard resistance law in the ballistic calculation, and used the coincidence calculating coefficients as the ballistic coefficients.

It is a good way to make sure the resistance coefficients by using the resistance law and the bullet' shape coefficients, and this method helped a lot in the past. But as the bullet' shape coefficients are in fact not constants and change as the mach value changes, this method is not exact.

At present, when we want to calculate the ballistic exactly, the long range tracking radar and modern data processing technology help a lot to make sure the resistance coefficient of the bullets themselves.

2.4 climate conditions

Climate conditions include temperature, air pressure, wind speed, and wind direction. They affect the ballistic by change the air resistance and its direction. Practices have proven that in a same group of climate data, temperature and air pressure have a neglectable impact on the ballistic; wind speed and wind direction have certain impact on the flight of the bullets, but in a group of dot-shooting data, the shooting time is less than 1 minute and the wind speed difference is less than 2m/s. This group of data are acquired under the same climate condition, so the ballistic coordinates errors caused by them are very small.

3 Anti-aircraft shooting precision test technology research

3.1 basic thought

Based on the analysis above we raised the following basic thought: to use new measuring methods and advanced test equipment to get the gun and bullets related parameters (including muzzle velocity, jump angle coordinates, ballistic radial speed, mass of the bullets and climate conditions), then through simulation we get the bullets' trajectories during their flight in the air and make them accord with the real trajectories. The real dispersion will also accord with the calculated dispersion characteristics, by this way we can exam the anti-aircraft shooting precision.

3.2 test method

The purpose of the on site test is to measure out the relative ballistic parameters of the test item, and provide data for the exact calculation of the Anti-aircraft shooting precision. The main test programs include: anti-aircraft shooting jump angle measurement tests, resistance coefficient and ballistic elements measurement tests. The test method follows:

The position of the gun is on grassland or middling hard clay ground and fixed on the x-axis, which is parallel to the main target track. And 1 km in front of the zero point of the main target track, two pilot lamp should be put both in front of and behind the gun position at 300m distance. The plan is as graphic 1.

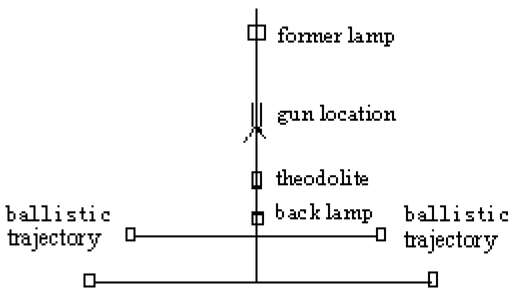

figure 1 plane lay figure about gun location

1) Anti-aircraft shooting jump angle tests: choose three machine guns. The fastener of the machine guns must be fastened. The shooting angle must be set by a quadrant according to the anti-aircraft shooting precision specifications. Under this shooting angle we conduct shoulder dot-shooting (3～5 bullets) at the jump angle target which is 35m in front of the gun position. The test will be arranged into three days, each day we use three machine guns to fire a group of 10 bullets from every group of bullets.

2) Resistance coefficient tests: use the above mentioned machine guns, and under the same test conditions we conduct shoulder single fire. The test will be arranged into

three days, each day we use three machine guns to fire a group of 10 bullets from every group of bullets.

3.3 measuring method

1) Anti-aircraft shooting jump measurement: use measuring equipment such as the muzzle velocity radar, multi-channel timer, 705 radar, full-station instrument and transit instrument and so on to measure the muzzle velocity, the climate, the earth coordinates and shooting direction tagging and so on.

Through the ballistic measuring tests we acquire the flight time （T）, muzzle velocity （V_0）, anti-aircraft shooting jump angle coordinates（x、y、z）, shooting elements, climate elements, muzzle coordinates, the radar antenna coordinates, and make them ready for the ballistic calculation.

The formula of the anti-aircraft shooting jump angle calculation:

in this formula:

x—the distance of the jump angle target 35m

y—the height of the trajectory above the jump angle target

z—the flying time of the bullet at 25m away from the muzzle

θ—the shooting angle

2) Resistance coefficient test measurement: the measuring equipment is Weibel radar. The purpose of the measurement is to get the resistance coefficient of the bullets themselves. While testing we get the trajectory radial velocity V_r of the bullets by single shootings, and make it ready for the calculation of the trajectory. At the same time we measure the parameters of the earth and climate.

Trough the parameters measurement tests of the anti-aircraft shooting jump angle, the resistance coefficient and the trajectory, we get the muzzle velocity, the anti-aircraft shooting jump angle, the trajectory coordinates, the climate parameters, the shooting parameters, the trajectory radial velocity of the bullets and so on, and they provide data for the precise calculation of the trajectory.

3.4 the data processing method

To raise the precision of the calculation of the trajectory coordinates and even the bullets dispersion, we need to choose a precise trajectory calculation model. Generally speaking, trajectory model can be divided into two types: particle trajectory model (2D, 3D) and rigid body trajectory model (4D, 5D(reduced order 6D), 6D).

In order to choose the best model, we use a certain type of anti-aircraft machine gun as our subject, and under the precondition of exactly measure its trajectory parameters, we calculate each model and compare their precision. Through the comparison, we can see that no matter it is calculating the earth data or calculating the bullets height coordinates data; no matter it is under the standard climate condition or when it is windy, the reduced order 6D rigid body model is both precise and fast. So, this paper will use the reduced order 6D rigid body model to calculate the trajectory simulation[1]–[4].

A great deal of tests have proven, the pneumatic dynamical parameters are more complete and the trajectory attitude and loca can be better described by using this trajectory model, and at the same time it can reflect the impact of each force to the trajectory, so it can get rid of the non-resistance factors in the coincidence calculation and raise its precision. The concrete forms of expression can be seen in the reference [1] and [4].

3.5 the extraction of resistance coefficient [5]

This paper uses the self-resistance coefficient to calculate trajectory. The coincidence subjects are the vertical axis x and the horizontal axis y of the point of impact, the shooting angle θ, the coincidence coefficients is the resistance coefficient C_x and the jump angle coefficient $\Delta\alpha$. The concrete coincidence method is to use equation groups to calculate ballistic under realistic conditions. If the calculated range $D = \sqrt{x^2 + y^2}$ and the shooting angle θ are different from the measure ones, we should use a coefficient K_R to multiply the C_x, and we add the coefficient $\Delta\alpha$ into the θ equation, then bring the above mentioned two equations into to the ballistic to recalculate until the values of D and θ accord with the measured one.

Evaluation tests have proven that the coincidence coefficients will not change with the shooting angles; the coincidence coefficients of one ballistic are the same at every point. This proofs that the close coincidence coefficients and the far coincidence coefficients of the same ballistic can be expressed by one coefficient. If we use the 1943 standard resistance law, the coincidence coefficients will change as the flying time increases. From this we can see the self-resistance coefficients have little errors, and can use single point coincidence.

3.6 the confirmation of the dispersion precision

To bring the above calculated resistance coefficients, coincidence coefficients and together with the measured jump angle, the muzzle velocity, the climate conditions and so on into the ballistic equation, to integrate ballistic under realistic conditions and calculate the coordinates of every bullets at set time and in set area, at last we get the dispersion precision of every group of bullet in the corresponding area.

4 Evaluation tests

To evaluate the feasibility of the new method, we choose a certain type of anti-aircraft machine gun, a certain type of heavy machine gun, armor-piercing incendiary bullets and armor-piercing incendiary tracers to conduct the evaluation tests.

Through the measurement tests of the jump angle, the relative ballistic parameters and so on, we bring the above-mentioned data into the reduced order 6D ballistic equation. Through the computer ballistic simulation calculation, we get the corresponding shooting angles and every coordinates at different distances. We can see from the realistic test results (table 1), the calculated ballistic tallies with the measured one. And this proves that the method of acquiring the anti-aircraft shooting precision through a few ballistic parameters exact measurement and ballistic simulation calculation is feasible.

5 Conclusion

The analysis and test evaluation above proves that through a few shooting tests of the test sample, and then measure out the shooting parameters such as jump angle and the ballistic parameters, and choose an exact ballistic calculation model, and use the self resistance coefficient, we can ascertain the anti-aircraft shooting precision.

This method is not only feasible to the anti-aircraft shooting test, but also applicable to other anti-aircraft weapons precision tests.

Table 1 test result of Anti-aircraft precision of certain armor-piercing burning flame tracer

shooting angle \ Plane distance		200m		500m		1000m		1500m	
		y	z	Y	z	y	z	y	z
15°	count value	45.38	-5.74	98.45	-5.21	254.5	-6.00	373.67	-6.49
	fact value	46.52	-4.22	101.99	-4.7	250.85	-5.76	370.44	-6.25
	difference value	-1.14	1.62	-3.54	0.51	3.65	-0.24	3.23	0.24
30°	count value	96.632	-4.03	200.63	-4.04	520.54	-4.962	775.81	-4.21
	fact value	99.54	-4.84	201.05	-6.05	517.7	-7.02	772.6	-7.75
	difference value	-2.91	-0.81	-0.42	-2.01	2.84	-2.06	3.21	-3.54
60°	count value			647.63	-4.92	1330.1	-12.46		
	fact value			651.32	-7.81	1329.46	-10.77		
	difference value			-3.69	-2.89	0.64	1.69		

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