Dual Autocollimators Reading Type High Accuracy Zero Position Variation Detection Method

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Abstract—**In this paper, in view of the influence of shimmer sights detection in mirror installation on the adjusting frame position and shape, Research on high-precision zero detection method can eliminate shimmer sights chucking errors. The method uses a CCD camera to measure the total of zero change, dual autocollimator make shimmer sights chucking generated mounts shape change and repeat chucking difference quantitative detection, and were excluded from the CCD measured values, finally obtained a pure zero change . After verification, the value of not more than $6.48''$.**

Keywords-shimmer sights; double autocollimators; repetitive positioning difference; CCD image measuring

I. INTRODUCTION

Zero position variation of the sights is the main factor that influence the firing accuracy of weapon, it is one of the projects that must be checked before the sight experiment, and it is also an important indicator of the stability evaluation of sight.

The Shimmer sights in this paper consist of the adding micromirror before the white sight, so we need to detect the Zero position variation of white light collimator and Shimmer group ,The design of the product requires the variation is pure sight of its own, not including the clamping error of the sight and Sighting equipment fixture configuration changes caused by assembling. According to the research, At present the detection of Zero position variation only on the whole Zero position variation detection ,can not remove the clamping error of the sight and Sighting equipment fixture configuration changes caused by assembling. Taking into account the development of the sight is the real demand, It is necessary to expand the study.

II. THE MEASURING PRINCIPLE

A. Digital Readout Measuring Zero Position Variation Measurement

We know that to measure the sight Zero position variation must establish an infinity reference target, usually with parallel light tube to simulate. As shown in figure 1.1, R_g is parallel light pipe reticle, L_g is autocollimator objective lens, R_0 is sight reticle, L_0 is sight objective lens, L_1 is sight eyepiece lens, L_c is measurement CCD objective lens. R_c is measurement CCD physiognomy. autocollimator reticule center O In sight reticle image on is A, while the gun's sight reticle center O_0 corresponding to the object space point in the collimator reticule O_c .From the figure geometric relationship show: $\tan\theta = \dfrac{OO_c}{oo_g} = \dfrac{OO_c}{f_g'}$

$$\theta = \arctan\frac{OO_c}{f_g'} \tag{1}$$

Because of

$$\frac{OO_c}{f_g'} = \frac{O'O_c'}{f_c'}$$

And so
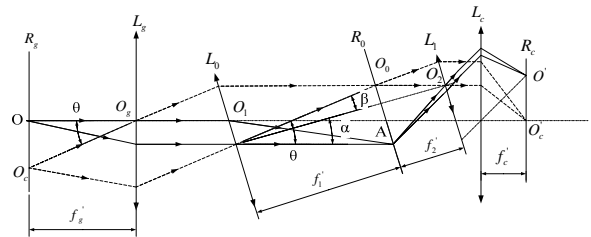
$$oo_c = \frac{f_g'}{f_c'} \cdot o'o_c' \tag{2}$$

Figure 1.1. Digital readout type zero measurement schematics move

In the formula, f_g' is collimator lens focal length, f_c' is Measurement of CCD lens focal length, $\dfrac{f_g'}{f_c'}$ can be detected in advance. $O'O_c'$ Can be measured by the CCD measurements and obtained by image processing. In formula (1) or (2) for the total zero position variation θ.

B. Repetitive Positioning Error Eliminating

Gun's sights and sight installation connections generally adopt the disassembly convenient pickup or positive definite connection, such as measured by the

formula (1) results in both pure sight go zero momentum including sight again repeated card error, repeat card error for modern sight products it is more than product request for momentum is zero, so we need to eliminate repetitive positioning error. Method as shown in figure 1.2, R_{gc} for optoelectronic autocollimator CCD image plane; B for half the lens. Optoelectronic autocollimator reticle center; O by half the lens component in optoelectronic autocollimator, like on the surface of the CCD as for the sight O', after repeated loading card mechanical axis and detection system of main axis a (that is, repeat card error), by the geometric relationship is:

$$\tan 2\alpha = \frac{o'o_{gc}}{o_g o_{gc}} = \frac{o'o_{gc}}{f'_g}; \quad \alpha = \frac{1}{2}\arctan\frac{o'o_{gc}}{f'_g}$$

In the formula, $O'O_{gc}$ can be read by optoelectronic autocollimator. α can adjust the frame of attitude change in beta in (1) measured θ shall be excluded.
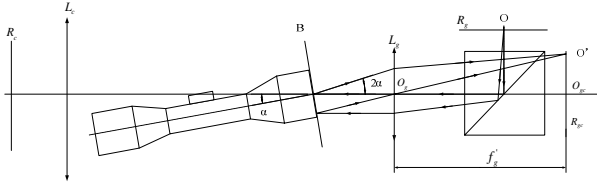

Figure 1.2. Half the semi-permeable eliminate duplicate card error principle diagram

C. Installation Micro Lens Group to Eliminate the Error

Shimmer sights (white light sights+ shimmer group) when detecting micro lens assembly cards to adjust the plane of the shape and position of the impact, which leads to adjust the attitude changes and the introduction of measurement error, the measurement result includes three parts: go sight zero momentum、 sight repeat card error and installation micro lens group after the adjustment of attitude change. So you need to install after micro lens group to measure and adjust the frame of attitude change shall be excluded. The method is shown in figure 1.3, R_{g1} for optoelectronic autocollimator 2 reticle; R_{gc1} as the 2 CCD optoelectronic autocollimator face reading; L_g for optoelectronic autocollimator 2 lens; F plane mirror; Optoelectronic autocollimator 2 reticle center O_1 by half the lens component in optoelectronic autocollimator 2 CCD as like to O_1', on the surface of the packed card micro lens group after the plane mirror and optoelectronic autocollimator 2 axis vertical plane Angle (adjust shape variation) for β, known by geometric

relations: $$\tan 2\beta = \frac{o_1'o_{gc1}}{o_{g1}o_{gc1}} = \frac{o_1'o_{gc1}}{f'_{g1}};$$

$$\beta = \frac{1}{2}\arctan\frac{o_1'o_{gc1}}{f'_{g1}};$$
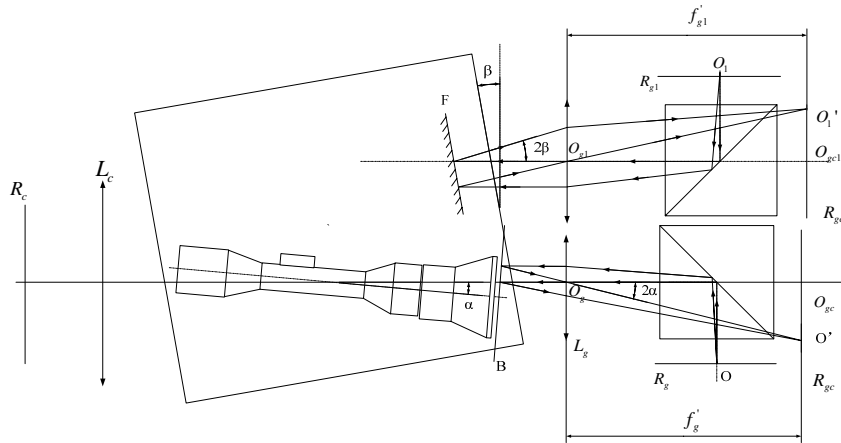

Figure 1.3. card micro lens group to eliminate the error of the principle

Similarly, β can adjust the frame of attitude change in beta in (1) measured θ shall be excluded.

III. THE IMPLEMENTATION PROCESS

From the above analysis, to move a pure measurement of the zero position variation, need two sets of photoelectric autocollimator, A measurement was repeated chucking errorα, And cater to simulate infinity collimator target. Another measure due to the loading rack shimmer mirror group lead to adjustments in the amount of change

in attitudeβ. So the zero position variation the entire amount is: θ-α-β; White light sight collimator zero position variation:θ₁-αShimmer mirror group zero position variation: θ₂ =θ-(θ₁-α)-β

Figure 2.1 experimental device for three-dimensional map. White sight mounted on the adjusting rack, Adjust the rack to make the white light sight cross points, lines and optoelectronic autocollimator 1 cross line close to overlap. This regulation of plane mirror two-dimension adjustment frame, so that the photoelectric autocollimator

2 reticle after reflection from a plane mirror image and the original photoelectric autocollimator 2 reticle coincidence,

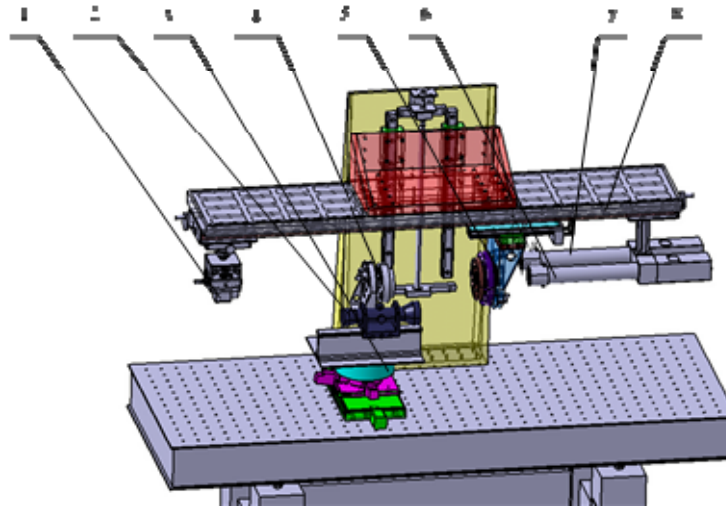Locking plane mirror two-dimensional adjusting rack.

Figure 2.1. system of three dimensional map
1 measurement of CCD,2. The sight,3 adjusting rack,4. The plane mirror component,5. Half the lens component,6. Optoelectronic autocollimator 1,7.Optoelectronic autocollimator 2,8. Lifting platform

Assemble the shimmer mirror group on the front end of the white light sight. Adjust the adjustment frame so that the image after reflection from a plane mirror of the photoelectric autocollimator 2 reticle will re coincidence with the original photoelectric autocollimator 2 reticle. This reflective reticle position reset through the flat mirror, can remove influence on the adjusting frame during the process of assembling shimmer mirror group. Use the two-dimensional with force feedback push the half mirror fit in the front end surface of shimmer lens group object frame. Write down the reflection reticle that photoelectric autocollimator 1 through half mirror and the offsetθ_{X1} 、 θ_{Y1} of photoelectric autocollimator 1 original cross lines, and by measuring the CCD and related software program measuring the offset that white sight reticle with respect to the photoelectric autocollimator 1 reticle θ_{x1} 、 θ_{y1}.

Re-install the white sighting telescope and shimmer mirror group that after test. Adjust the adjusting mount, making photoelectron autocollimator 2 reflected cross engraved lines by the reflector coincide with Original photoelectron autocollimator 2 cross engraved lines. Then there are two cases in phase CCD surface:

1) Photoelectric autocollimator's cross engraved lines and white sighting telescope cross engraved lines are in the field of view measuring CCD. Using 2D adjusting mount with force feedback to make half mirror push fit in front end surface of the shimmer mirror group object frame. Note the time of photoelectron collimator 1 reflected cross engraved lines by the reflector offset to the original photoelectron autocollimator 1 cross engraved lines is θ_{X2}、 θ_{Y2} , and by measuring the CCD and associated software to measure the offset photoelectron

autocollimator 1 reflected cross engraved lines by the reflector offset to the original photoelectron autocollimator 1 cross engraved lines is θ_{x2}、 θ_{y2}.

2) Cross engraved lines of sight are not in the field of view of measuring CCD. Now sight's repeat chucking error is greater than the measurement range of the measurement CCD. Adjust mounts to make sight's cross engraved lines back to the field of view of measuring CCD, excluding partial duplicate chucking error by adjusting the adjusting mount. And repeat 1) process.

Make the before test and after test subtraction by CCD detector to measure sights: $\Delta\theta_X = \theta_{X2} - \theta_{X1}$ and $\Delta\theta_Y = \theta_{Y2} - \theta_{Y1}$.

This part of the result of the error includes chucking error, and includes sight pure zero change. The repeating errors of chucking can get by he offset photoelectron autocollimator 1 reflected cross engraved lines by the reflector offset to the original photoelectron autocollimator 1 cross engraved lines: $\Delta\theta_x = \theta_{x2} - \theta_{x1}$

and $\Delta\theta_y = \theta_{y2} - \theta_{y1}$.

IV.   THE EXPERIMENTAL AND DATA ANALYSIS

A. *Excluding Installation Error*

Figure 3.1 shows the experimental setup, Through experiments, Verified using this method to remove the repeating errors of chucking is feasible. Can measure CCD photoelectric autocollimator and Measurement CCD camera's readings, by subtraction, As shown in Table I.
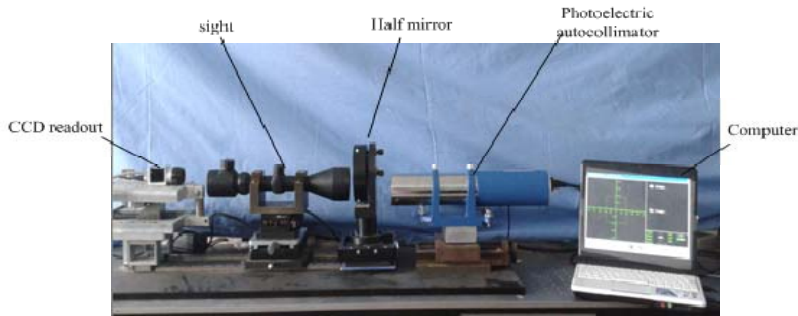
Figure 3.1. experimental setup

TABLE I. READING THE RESULTS

No.	Reading CCD camera readout		CCD photoelectric autocollimator readings		The difference between the two	
	$\Delta\theta_X$	$\Delta\theta_Y$	$\Delta\theta_x$	$\Delta\theta_y$	$\Delta\theta_X - \Delta\theta_x$	$\Delta\theta_Y - \Delta\theta_y$
1	1°13′42.6″	-1°11′29.46″	1°13′21.0″	-1°12′35.3″	21.60″	65.84″
2	-1°21′30″	-1°48′20.43″	-1°21′54″	-1°49′23.7″	24.00″	63.27″
3	-2°25′34.2″	-2°22′9.86″	-2°25′54.6″	-2°23′9.2″	20.40″	59.34″
4	-2°28′13.6″	-1°4′56.93″	-2°28′36.4″	-1°6′4.5″	22.80″	67.57″
5	-2°3′33.12″	-1°4′56.93″	-2°3′59.4″	-2°4′39.7″	26.28″	63.27″
Mean	-1°25′1.66″	-1°30′22.72″	-1°25′24.68″	-1°55′0.48″	23.016″	63.858″
RMS σ					2.26″	3.11″

Experimental data obtained by the s value is not greater than $6.48″$ (0.03mil), The test data is reliable, and fully meet the military requirements.

B. *Shimmer Group Frame Installation Lead to the Shape Changes and Position of Adjustment Measurement*

Experiment, after the installation shimmer mirror group adjusting mount position change beyond the high accuracy requirement. Table II is after the installation shimmer Mirror Group adjusting mount position change measured data.

TABLE II. PHOTOELECTRIC AUTOCOLLIMATOR 2READINGS RESULTS

No.	First position	Installation shimmer Mirror Group	After installing shimmer mirror group deformed Δ
1	X: 399.6″ ; Y: 477.4″	X: 643.1″ ; Y: 605.7″	X: 243.5″ ; Y: 128.3″
2	X: 406.1″ ; Y: 484.3″	X: 649.3″ ; Y: 610.9″	X: 243.2″ ; Y: 126.6″
3	X: 408.1″ ; Y: 484.0″	X: 649.9″ ; Y: 611.1″	X: 241.8″ ; Y: 127.1″
4	X: 407.7″ ; Y: 486.2″	X: 650.0″ ; Y: 614.6″	X: 242.3″ ; Y: 126.6″
5	X: 405.3″ ; Y: 484.9″	X: 653.8″ ; Y: 618.6″	X: 248.5″ ; Y: 133.7″

As can be seen from the experimental data after the installation shimmer mirror group adjusting mount position change. This part of the error has been exceeded high accuracy sight pure zero change's requirement, so it must be removed.

C. *Error Analysis*

The main factors of error has the following points

1) Calibration error; Due to the human eye alignment error in the calibration process, that is not with the CCD image plane mirror surface coincide, and is not perpendicular to the axis.

2) The CCD and optoelectronic autocollimator reading error due to there is the spacing and the size of CCD photosensitive pixels for the CCD readout process, and adopts the error introduced by binarization processing

3) Half the lens repeat alignment error; Due to half the lens alignment needs to contact with the front facet of sight, After bonding is different from the first of errors arising.

V. Conclusion

Using dual autocollimator to realize the shimmer sight line alteration detection with high accuracy. It can eliminate the influence of adjusting frame configuration changes which is caused by repeated chucking error and shimmer group installation. We construct a prototype to achieve the implementation equations of testing and function, we have detected adjusting frame configuration changes which is caused by repeated chucking error and shimmer mirror group installation. The results showed that the double autocollimator method can effectively eliminate the impact of the above errors, and achieve second-level precision testing.

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