Experimental study on initial ballistic characteristics of cased telescoped ammunition

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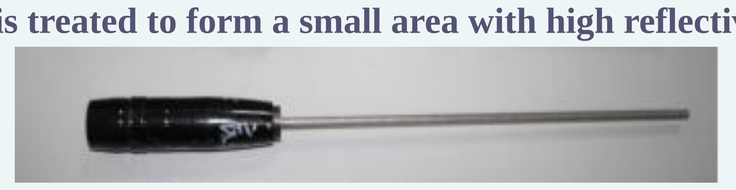
Introduction

In order to study the characteristics of velocity and attitude in the initial motion of the projectile of the CTA, a special projectile for the initial ballistic test was designed, and an initial ballistic test system based on the high-speed camera was built. The loading process after firing was observed and the loading velocity was measured. The results show that the loading speed of the projectile is about 30m/s. The initial ballistic parameters of the projectile can be studied quantitatively and the motion attitude of the projectile can be examined qualitatively by using the initial ballistic test system based on the high-speed photography.

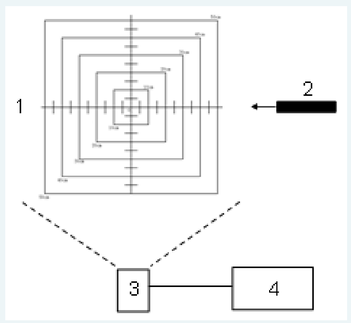
Experiment Test System and Principle

As shown in figure 1, a thin metal rod is installed on the head of the projectile to ensure that the quality of the tested projectile is the same as that of the formal projectile, so as not to change the initial ballistic performance under the actual charge condition. The front end of the metal rod is treated to form a small area with high reflectivity.



•Fig. 1 Projectile for testing the initial ballistic characteristics of the CTA

A test system for the projectile initial ballistic characteristics is built based on the high-speed photography (as shown in figure 2).



1- background plane; 2- rod of projectile; 3- high-speed camera; 4 - computer

•Fig. 2 Schematic diagram of the initial ballistic test system of the CTA

Data Processing Method

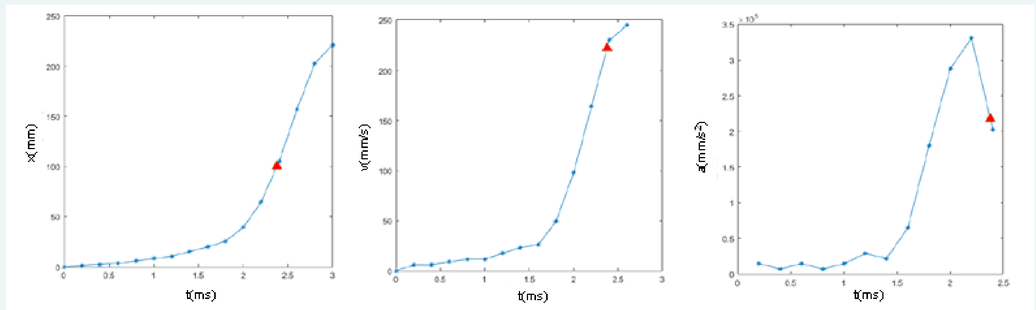
Pixel coordinate system *uov* is a two-dimensional rectangular coordinate system that reflects the arrangement of pixels in the camera CCD/CMOS chip. The origin *o* is located in the upper left corner of the image, and the *u*-axis and the *v*-axis are parallel to the both sides of the image plane. The pixel coordinate system is not conducive to the coordinate transformation, so the image coordinate system *XOY* needs to be established. The unit of its coordinate axis is mm, and the transformation relation is

$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} 1/K_1 & 0 & u_0 \\ 0 & 1/K_1 & v_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

As shown in figure 3, in the section observed by the high-speed camera, the extension line of the projectile axis when the cartridge is loaded in place is taken as the benchmark, indicating that the upward inclination is positive and the downward inclination is negative.

•Fig. 3 Schematic diagram of the projectile pitch inclination

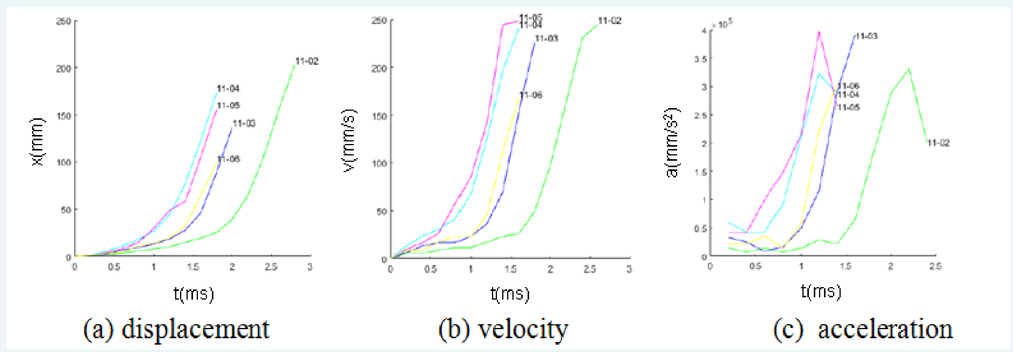
Experimental Result and Analysis



(a) displacement (b) velocity (c) acceleration

•Fig. 4. Typical curves of the tested projectile over time

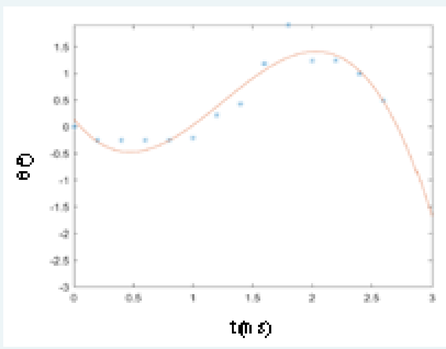
The typical displacement, velocity and acceleration parameters of the same shot projectile changing with time are shown in figure 4. To facilitate the observation of the motion parameters of the projectile at a certain position, the displacement of 100mm is selected as the characteristic point, as shown in the red triangle in the figures. The displacement - time curve of the projectile under test is smooth, which truly reflects the initial ballistic motion law of the projectile



(a) displacement (b) velocity (c) acceleration

•Fig. 5. Curves of a tested projectile group with time

The displacement, velocity and acceleration curves of a group of 5 shots over time are shown in figure 5. The distance of the projectile from the initial position to the rifling embedded in the bearing band is 20mm. During this process, the acceleration of the projectile is random, and the acceleration value fluctuates within the range of 1000~16000 m/s2, which may reveal the instability of the gas pressure in the bore at the initial ballistic stage.



•Fig. 6. Typical curve of the projectile pitch inclination with time

The typical pitch inclination of the tested projectile is shown in figure 6. There is an obvious trend of variable periodic fluctuation.

Conclusion

(1) Within about 0.8ms after the projectile is started, the projectile motion acceleration has certain randomness, which may reveal the instability of the gas pressure in the chamber at the initial ignition stage. And the loading speed of the projectile is about 30m/s.

(2) The high-speed photography is scientific and effective in quantitatively examining the motion parameters of the displacement, velocity and acceleration in the initial ballistic process. However, due to the problem of the observation angle, the high-speed photography can only be used to qualitatively observe the projectile's initial motion attitude, so the projectile attitude testing method needs to be further improved.