The Application of High-speed Photography in Weapon Testing Field

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Abstract. With the development of modern science and technology, all kinds of testing technology are widely used in the research and development of weapons, which provides a large number of objective and accurate data for researching, improving and supporting weapons. High-speed photography is one of the important means of testing, which can record the picture of whole process from weapon ignition to hit the target. It allows researchers to make a reasonable judgment on the performance of the weapon through analyzing the pictures. And it also helps a lot in improving the performance and developing new models. Obviously, it is very meaningful. This paper will introduce the application of high-speed photography in the field of weapon testing.

The Emergence and Development of High-Speed Photography

High-speed photography is a technology that uses photographic methods to record fast-moving processes and high-speed changes for research and analysis. The high-speed camera’s exposure time usually less than a millisecond, or shooting a variety of high-speed target with more than one thousand per second. The maximum frame rate could reach the magnitude more than 104fps. The technology is used to measure the subject’s motion information which closest to real, and can reflect the temporal and spatial characteristics of the high-speed moving object intuitively and visually.

Nowadays, the high-speed photography technology has been widely used in many field that including the military field, aerospace, industrial production, film and television, sports and public life, precisely because of its ability of reflect the high-speed moving subject movement process clearly. In the field of military, aerospace and industrial production, using high-speed photography can clearly record the operation of the product. Through the analysis of the image not only can achieve product performance evaluation, but also can provide upgrading plan of the product. In the field of film and television, sports and public life, through using high-speed camera the movement process of high-speed moving objects can be recorded for the audience and providing a better sense of enjoyment. Those advantages that make high-speed photography in human life has been more and more widely used.

Development depend on demand. In order to achieve better observation results, high-speed photography technology has experienced the development from low speed, medium speed, high speed to ultrahigh speed, from visible light, infrared light, ultraviolet light to X-ray, from the macro object movement observation to microscopic mechanism. At present, the optical mechanical camera still maintain the previous level. Video tube camera is developing very fast. In the whole field of high-speed cameras, the main point of development is video tube cameras. The photographic frequency has exceeded one billion frames per second (108 frames per second). The highest level is0.8×1010 frames per second. The time resolution also spans one trillionth of a second. The highest level is 0.5 picoseconds. It’s currently approaching to the level of the fem to second.

After a long period of development, high-speed photography has gradually become more complete. It is precisely because of the unique advantages of the high-speed photography technology can objectively and truly reflect the process of high-speed moving objects. Therefore, it provide the research basis of the physical characteristics of high-speed moving objects.
The Applications of High-Speed Photography in the Field of Weapons Testing

Since the advent of the mid-19th century, high-speed photography has maintained a very close relationship with the research and production of weapons. The British first developed it. The British royal arsenal successfully used the spark as a light source to study and measure the shells flying posture. After that the high-speed photography technology gradually applied to the shells, missiles, rockets, aircraft and space vehicles and other weapons field.

Especially with the development of modern warfare, the requirements for the performance of various weapons are getting higher and higher, and all kinds of research on weapons are very important. These studies include the inner and outer trajectories of artillery, the target after striking damage process, and equipment operating state record and analysis in different environments. It provide a basis for improving weapons performance and design. Because of the modern weapons usually have the characteristics of high rate of fire and destructive power, so the images which recorded by general camera (including the projectile process and hit the target process) will not be able to enter the classical image analysis software. So it’s time for the unique advantages of high-speed photographers are revealed. It can record the movement process of high-speed moving objects, and then combine with modern computer technology, using various kinds of image and data analysis software to achieve the rationality of the research object analysis. So the trajectory, the explode process and spark discharge phenomena can use high-speed photography to aid analyze, which is very meaningful for the development of weapons. It can be said that during the research and improvement of modern weapons, high-speed photography has become an important means to aid research. It can help researchers to have a better understand for the performance of weapons, and then to achieve the development and improvement of weapons. Those are high-speed photography applicate in various types of weapons development.

The Aspect of Bullet Development

Researchers can observe the various phenomena through high-speed photography including the bullet in the gun chamber, inside and outside the muzzle, as well as hit the target. It can measure the actual speed of the bullet and the explosion situation. It also can help researchers to observe the bullet in the air around the flight changes etc.

The application of photography in ballistics has been more than a hundred years, and it became a useful tool for the study of inner ballistics, intermediate ballistics, and outer ballistics and end-point trajectories. As long ago as the last century forty years, most of the existing photographic techniques, including transducers, have appeared or being studied. In 1984, Ernest Maher recorded a bullet flight in Prague with spark photography. In 1909, Kronz made a 5000-second spark camera. In 1938 the Western side of the company made the Fastax camera, so far many units are still in use.

The Aspect of Shell Development

Researchers can use high-speed photography to observe the various phenomena including shells in the gun chamber, inside the artillery and outside the muzzle, and during flying and before and after hit the target. It can help to measure the projectile flight speed, acceleration, stability and rotation. It can help to study the burning situation of propellant in the artillery. It also can measure the explosion process of the shells (including penetrating armor, etc.) and the scope of the explosion, as well as the bombing of the damage process and scope.

Its essence is to link the spatial information and the time information of the transient change process. The spatial information expressed by the image, and the shooting frequency, the time scale or the shooting time expresses the time information. Therefore, high-speed photography is the national defense scientific research and industrial shooting range commonly used one of the important test equipment, which used for bullet ballistic posture test and shell speed measurement.

The Aspect of Rockets and Missiles Development

The high-speed photography is recording analysis model Wind tunnel experiment, engine commissioning and launch test. Especially recording the rocket and missile launch process
including the initial section, flight attitude, inter-stage separation, multi-warhead guidance and engine combustion process, and set some dynamic characteristics etc.

**The Aspect of Nuclear Weapons Research**

Recording the early stages of nuclear explosions, the formation and development of fireballs, the state of smoke, the formation of craters, the expansion and reflection of shock waves, the knocking of air, the ejector and the settlement of the surface etc.

**The Aspect of Detonators, Fuze, Gunpowder, Explosive Development**

Study the working process and mechanism of detonators and fuze. Recording and measuring the burning, explosion processes, and speeds of gunpowder and explode process of gunpowder and explosive. The perturbation of the ambient air at the time of the outbreak and the position of the shock wave at each stage during the explosion.

Such as underwater explosion. The explosive explode under water, which will have a shock wave, and bubble pulse, and both of which will have a huge damage to the target. There are many advantages to the study of the propagation of shock waves and the motion of bubbles by high-speed photography. It can visually observe a series of near-complete dynamic processes such as shock deformation process of shock wave, bubble generation, pulsation and collapse. Then the effect of ammunition in the water under the effective assessment and analysis.

**Other**

Study aircraft takeoff, flight, drop bombs, launch missiles, landing etc. In addition, in the weapons industry production and military transport and other aspects can be widely used in a variety of high-speed photography technology.

From the projectile to the rocket missile and even the aircraft flight process, high-speed photography is widely used in various types of weapons testing. It allows researchers to obtain a large number of observed images, and observe the target to dynamics analysis. It undoubtedly play an important role in access to a variety of physical data, providing a basis for the determination of weapons performance, and helping the researchers to infer the main factors that affecting the operation of weapons, so that to improve weapon performance.

**The Commonly Used High-Speed Photographers in Weapons Testing**

With the development of technology, there is a variety of types of high-speed photographers derived to meet the various observation needs of researchers. According to the observe ability, the high-speed photography is divided into low frequency, intermediate frequency, high frequency, ultra-high speed and x ray. There are some of the high-speed photographers commonly used in weapon testing.

**The Intermittent High-Speed Camera**

Intermittent high-speed camera based on the ordinary film camera by increasing the speed of the chip to achieve high-speed. It belongs to low frequency. The film relies on the intermittent mechanism for intermittent movement. The advantage is that it can get better image quality, and has a high positioning accuracy and resolution. The resulting frame is very suitable for film screening, and thus easy to analyze the study. The United States, Britain, France, the former Soviet Union and other countries are producing such a camera. From the frequency point of view, this camera in resent 10 years did not greatly improve. In recent years, those countries have done some work on small and light. In the future, it should also be low noise, high frame stability, versatility and so on. At present, this camera used in shooting missiles and rockets and other high-speed flight targets initial track and posture.
The Compensated High-Speed Camera

The compensated high-speed camera continuously fed. Usually through the prism, mirror and lens to achieve compensation. It belongs to intermediate frequency. The compensated camera is one order of magnitude higher than the intermittent. It not only characterized by a clear image, but also shot with standard frame and easy to direct display. Therefore, the scope of application is very wide. In particular, the most widely used prism compensation camera. Its structure is simple and good quality. According to statistics, in the recent use of high-speed cameras, this type of camera accounted for about 80%. This camera is widely used in the research, production and experimentation of modern conventional weapons because of its high frequency and large number of frames. Especially for measuring bullets, shells, rockets, missiles and torpedoes such as flight trajectory and posture, etc.

The Video Tube High Speed Camera

This kind of camera is a kind of ultra-high speed camera, which uses the image tube to make high-speed shutter. The tube has two effects in the camera. One is the shutter effect. The other is to convert faint or invisible images into visible images. The pipe acts as a shutter when switching. This camera belongs to UHF. Its biggest feature is short exposure time, high time resolution, wide spectral range and light gain and so on. Therefore, in recent years, many countries have invested more human and material resources to focus on research. The highest level of the current world is the photographic frequency of 0.8×10^10 frames per second. The scanning type tube camera, which scanning speed has reached 6.6×10^10 cm/s (that is the two times of light speed), the time resolution is 0.5×10^-12 seconds (that is, half a picoseconds). British and Soviet joint development of the camera tube’s time resolution is half a picoseconds.

Due to the urgent needs of weapons development and scientific research work, especially the need for cutting-edge weapons development, this camera, not only develop fast, but also apply more and more widely. Britain, the United States, the Soviet Union, France and other countries attach great importance to the development of such cameras, in particular in the fled of studying high-speed flying bodies, nuclear weapons, laser fusion, high temperature plasma, and measurement of explosives and other applications. In high-speed photography technology, the development of variable-speed tube high-speed camera is very promising. Therefore, it is the focus of future research and development.

The X-ray High-Speed Camera

X-ray high-speed camera based the principle that X-ray can penetrate the opaque objects, which shows the situation inside the object. It can be relatively quiet to show the internal changes in the process. The gas discharge tube and the hot cathode type X-ray tube manufactured at the beginning of the 19th century and the beginning of the twentieth century, and the flash X-ray tube of the field emission cathode made by C.M. Slack in 1948. Since then, with the development of high-voltage nanosecond pulse technology, there are large-scale rapid X-ray camera equipment being manufactured. With the development of production and science and technology, high-speed X-ray cameras have been widely used, especially in the field of ballistic and explosive mechanics. Researchers used X-ray high-speed cameras to achieve the 7.26 mm rifle bullets in the chamber and in the muzzle area of high-speed movement and microsecond detonation process of shooting. This is very important for the study of the explosion process and the development of conventional weapons.

It can be seen that at different stages of different types of weapons, the researchers can choose from high-speed photographers with different frequency bands and shooting capabilities from the photographic and economic perspectives to complete measurements between low-speed and ultra-high-speed ranges. Which makes the researchers in the conduct of weapons testing more targeted, you can get a better test results. With the performance of some of the test process, to solve the problem that sensor cannot be directly installed, through high-speed photography, the
researchers can indirectly obtain the observation data, which for equipment research and improvement is very important.

Summary

With the development of modern weapon technology, the characteristics of high speed and big power are more and more obvious. At the same time, the application of high-speed photography technology becomes more and more important. It can help researchers to record the images of various kinds of weapons operation process. It has become the basis for the analysis of various types of physics, and can effectively reflect the operational characteristics of weapons. It also determine the performance of weapons is qualified basis. The data obtained after the analysis will help researchers to improve the weapons and new models of research and development, these have effectively promoted the development of weapons technology.

At the same time, with the development of technology, high-speed photography technology is developing toward shooting faster, recording image pixels higher, longer record time and more intelligent. Those means make high-speed photography in the weapons test can play better The role of the researchers to better analyze the performance of weapons to provide protection, In the future, high-speed photography in the weapons test will be more widely used.

References


