Research on the Main Charge’ Stability of Certain Electric Firing Cluster Tear Bomb

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Abstract—In order to study the main charge’ stability of certain electric firing cluster tear bomb, the sampling research was carried out from the storage period, the storage period and the over storage period of the ammunition. The dispersion and stability of the samples main charge’ components were characterized and tested in different years by SEM, DSC and other methods. The SEM diagrams of the main charge show that the components are still distributed evenly after long-term storage, and there is no obvious change in quality. The DSC results show that the stability of main charge is excellent, this is due to that the displacements of the melting endothermic peak and decomposition exothermic peak between unstored and stored main charge are less than 2 °C.

1. Introduction
At present, among anti-riot ammunition equipped in PAP, certain electric firing cluster tear bomb is a kind of non-lethal ammunition whose caliber is the largest, whose range is the farthest, whose coverage is the widest, and whose dispel effect is the best. It is the important equipment for dispersing the crowd, and it has played an extremely important role in handling large-scale mass emergencies, especially [1-3].

Its mechanism of action is that: firstly, under the action of high-temperature and high-pressure gunpowder gas, the tearing agent filled in the bullet is ignited, and at the same time the screw thread connecting the cartridge case and the cartridge holder is cut and broken; secondly, the projectile opens the warehouse, the bullets are scattered and the end effects are realized (Fig.1). The targets lose temporarily their ability to resist because those eyes, skin, and upper respiratory tract are stimulated.

Usually, the storage period of the ammunition is 5 years whose main charge will slowly decompose and react with each other during long-term storage. Stability is an important index to measure the difficulty degree of pyrotechnic agent decomposition in a certain storage time, that is, stability is the measure degree to maintain its physical and chemical characteristics and achieve the expected pyrotechnic effect, which is of great significance for the safe storage and reliable use of anti-riot ammunition[4-5].

In order to provide theoretical basis and technical support for ammunition’s reliable using, those main charges are selected as samples in four stages of new product(storage 0a), normal storage period (storage 3a), full storage period (storage 5a) and over storage period (storage 6a), and their stability performances are tested and analyzed, respectively.
2. Experimental

2.1 Main raw materials and instruments
Materials: Certain electric firing cluster tear bombs are provided by Engineering University Equipment Development Center of PAP.
Instruments: Electronic balance, JM-B2003, Cixi Red Diamond Weighing Apparatus Co., Ltd.; JJ-1 precision booster electric stirrer, Shanghai Pudong Physical Optical Instrument Factory; Scanning Electron Microscope(SEM), Evo-50, produced by Carl Zeiss, Germany; Differential Scanning Calorimeter(DSC), DSC204F1, manufactured by Netz Corporation; Gas chromatograph: GC6891N, Beijing Hengtong Ruili Instrument Co., Ltd.

2.2 Experiment Method
SEM microscopic characterization of main charge: The sample is a multi-component mixed system. In order to observe the dispersion of each component in the system, the sample’s surface is firstly sprayed with gold; then SEM is used to observe the sample’s surface morphology and distribution of various components.
DSC testing of main charge: In order to test the stability of the sample, the DSC204F1 tester produced by the German Netz Company is used in the temperature range from room temperature to 590 ℃, and the whole process is carried out under the protection of N₂. The testing process refers to GJB5891.17-2006[6].
Main charge’s component content testing: The main charge of certain electric firing cluster tear bomb is mainly composed of oxidant, flammable agent, tearing gas and adhesive. Through physicochemical analysis, the component contents were tested by solvent separation method and gas chromatography method.

3. Results and discussion

3.1 Microstructures of main charge
The Fig.2 (a, b, c, d) is the main charges’ SEM images after storage for 0, 3, 5 and 6a, and the Fig.3 (a, b) is the main charges’ SEM images magnified 10000 times after storing 5a and 6a, respectively.
As seen from Fig.2, after the main charge in the system are stored by different times, there is no obvious change in the dispersion status, and the entire system is uniform; at the same time, the main charge of the full storage period (5a) and the super-storage period (6a) ammunition were observed under a 10000x microscope (as shown in Fig.3), it can be found that the components particle size is uniform, the surface is smooth, and there is no obvious cracking or agglomeration for the full storage period (5a) or the super-storage period (6a). This further proves that the main charge has a good stability because there is no significant physical and chemical change between its components each other during storage, and this is the guarantee for the ammunition to attain its expected tactical effect [7-9].

3.2 Stability analysis of main charge components
In this test, under the protection of N₂, the stability performance of the standard sample and the main charge after storage for 3, 5 and 6a was tested at a heating rate of 10°C/min. The specific DSC curve is shown in Fig.4.
It can be clearly seen from Fig.4 that the DSC curves of the samples show obvious melting peaks and exothermic peaks near 93°C and 196°C, respectively. At the same time, it can also be clearly seen from Fig.5 and Fig.6 that the two peaks of the main charge are slightly floating after storing at different times, but the variation ranges are less than 2°C, they are 1.53°C and 1.25°C, respectively. It can be inferred that the original component formula of the main charge is scientifically designed and has good stability during long-term storage, which provides a fundamental guarantee for the reliable use of the ammunition[8].

Fig.4 DSC curves of unstored and stored the main charge

Fig.5 Effect of unstored different time on the melting peak value of the samples
3.3 Content analysis of main charge component

The main charge is an important part of anti-riot ammunition which determines the operational effect and operational purpose that anti-riot ammunition can achieve. Therefore, the change of its component content is one of the key indicators for examining the operational reliability of ammunition. The original formulation of the main charge component and the component content testing results after storage are showed in table 1.

| Item                | Standard requirement | 0    | 5a   | Amount of change | Result judgment |
|---------------------|----------------------|------|------|------------------|-----------------|
| Oxidant             | 30±1.0               | 30.3 | 29.5 | -0.8             | √               |
| Flammable agent     | 28±1.0               | 28.6 | 28.9 | +0.3             | √               |
| Tearing agent       | 20.0±1.0             | 20.4 | 19.5 | -0.9             | √               |
| Flame retardant     | 13±1.0               | 12.3 | 12.8 | +0.5             | √               |
| Binder              | 9.0±1.0              | 8.4  | 9.3  | +0.9             | √               |

Based on the measured data in table 1, it can be seen that after the storage process of 5a, the contents of the oxidant as the basic component and the tearing agent with the main fighting effect decrease within a certain range, whose amounts of change are 0.8% and 0.9%, respectively. This is due to the oxidant’ slowly decomposition and tearing agent’ volatilization. The contents of flammable agent, flame retardant and binder show an increasing of 0.3%, 0.5% and 0.9%, respectively. The slight increasing of flammable agent content may be due to a slow oxidation reaction which occurs during the storage process, the increasing of binder content may be due to the dynamic balance of moisture in the storage environment, and the increasing of the flame retardant may be caused by the error of the test method.

The above data is slightly deviated from the original formula, and the range of change is between 0.3% and 0.9%. However, it is found by the analysis of the overall content change that the errors are with the requirements of the index. The result further reflects that the main charge of the ammunition has excellent stability, which is consistent with the results of the DSC and SEM, and this is the premise and basis for the anti-riot ammunition to playing a normal tactical role during use [9].
4. Conclusion
The main charges of electric firing cluster tear bomb with different storage time are selected as samples, those stability is studied separately, and the conclusions are as follows:

1) SEM result of the distribution of the main charge shows that after storage different times such as 3, 5 and 6a, the surface of the each component particles of the main charge is smooth, the particle size is uniform, and there is no obvious cracking or agglomeration.

2) It is not difficult to find based the DSC curve: after long-term storage, the overall distribution of the endothermic peaks and split heat peaks of the main agent is stable, and the maximum changes are 1.53℃ and 1.25℃, respectively.

3) The test results of the main charge components’ mass content show that the quality of the agent does not change significantly with the extension of storage time, which is consistent with SEM and DSC.

To sum up, the main charge’ formula of electric firing cluster tear bomb has been designed scientifically and reasonably. The main charge has excellent stability within the shelf life (5a), which provides a fundamental guarantee for the end effect of the ammunition.

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