Design and test of bullet shell counter

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Abstract: In order to solve the problem of counting when the bullet shells is recovered, two different types of bullet shells counters are designed. Through theoretical analysis, the size of the slot in the slot type bullet shell counter is determined, and the best times of abrupt reverse of the slide mechanism in the chute type shell counter is determined through experiments. The comparison test of two kinds of bullet shell counter shows that: The ejection efficiency of the chute type bullet shell counter is 317.5 pieces / minute, and the counting accuracy is 99.00%; the counting efficiency of the slot type bullet shell counter is 113.2 pieces / minute, and the counting accuracy is 99.75%. The chute type bullet shell counter is suitable for high-efficiency counting when large-scale bullet shell is recycled, and the slot type bullet shell counter is suitable for small-scale accurate counting. Both kinds of bullet shell counters meet the requirements of automatic shell counting put forward by the army.

1. Introduction

The bullet is a sharp weapon to defend the country in wartime and an important material to improve the level of military training in non wartime [1-2]. According to the needs of the army, a large number of shells produced during military training need to be recovered and counted at the first time. However, the current recovery and counting method is a labor-intensive and time-consuming manual way with extremely poor accuracy. Therefore, it is urgent to develop a high-efficiency and high-precision cartridge case counter to fill the technical gap of military cartridge case recovery.

Cartridge case counter does not involve military secrets. The report of the 19th National Congress of the Communist Party of China pointed out that "we should form a deep development pattern of civil military integration and build an integrated national strategic system and capability." The development strategy of civil military integration has become an important part of national strategy.

China is stepping into a new era of deep development of civil military integration [3-7]. Therefore, the cartridge case counter is developed by civil military integration technology, which is jointly developed by universities and the army.

2. design requirements

According to the needs of cartridge case recovery during training, the design requirements put forward by the army are shown in Table 1:

| Parameter | Design Requirement |
|-----------|--------------------|
| Length    | ≤500 mm            |
| Width     | ≤500 mm            |
| Height    | ≤800 mm            |
According to the design requirements put forward by the army, two kinds of cartridge case counters are designed, which are chute type cartridge case counter and card slot cartridge case counter.

3. Chute type cartridge case counter

3.1 Overall structure
The chute type cartridge case counter is mainly composed of an outer box, a motor, a counter, a chute mechanism and a mechanism for pulling and throwing the cartridge case. Its structure is shown in Fig. 1.

![Fig.1 Internal Structure of the Chute type Bullet Shell Counter](image)

1. Upper cover of outer box; 2. Motor; 3. Counter; 4. Chute mechanism; 5. Cartridge case mechanism

In the process of use, the cartridge case is poured into the upper cover of the outer box. Under the action of motor vibration and gravity, the cartridge case slides from the cone-shaped funnel to the ejection cartridge case mechanism. The tilting cartridge case mechanism is tilted. The rotating mechanism connects the drive motor shaft through the connecting shaft hole, and rotates inside the fixed mechanism. The cartridge case entering the lowest side of the annular baffle is driven and rotated through the wedge-shaped shell shifting block. Turn the cartridge case to the direction of throwing out the slot, and throw the cartridge case out of the slot under the action of centrifugal force; after the cartridge case enters into the chute mechanism, it will slide out through the counter one by one through the counter to realize the counting function.

3.2 Design of chute mechanism
After the cartridge case is thrown into the chute mechanism, most of the cartridge cases will slide down one by one, but 2-4 shells will agglomerate and slide together. When the cartridge case passes through the optical counter in the form of agglomerates, the grating cannot be formed, resulting in the decrease of the count [8-12]. In order to avoid this phenomenon, the measures of abrupt reverse sliding trajectory are adopted to disperse the cartridge case. Considering the compactness of the structure and the technological factors of manufacturing, the abrupt reverse chute mechanism is adopted, as shown in Fig. 2.
1. Upper slide way; 2. Cartridge case; 3. Down slide

Fig. 2 Structural Diagram of Abrupt Reverse Chute

The single mutation reverse can not make the shell aggregate fully separate, and multiple mutation reverse is needed. Therefore, a multiple mutation reverse test device is designed, which selects 1-5 mutation reverse, 20 groups of each type of mutation reverse, and each group has 1000 shells. The results are shown in Table 2:

| Number of mutation reversals | Counting accuracy |
|------------------------------|-------------------|
| 1                            | 88.71%            |
| 2                            | 99.01%            |
| 3                            | 99.08%            |
| 4                            | 99.05%            |
| 5                            | 99.06%            |

Tab.2 Statistical Table of Mutation Reverse Times and Counting Accuracy Rate

According to the test results, when the number of mutation reversals is less than 2, the counting accuracy increases with the number of mutation reversals; when the number of mutation reversals is more than 2, the counting accuracy basically maintains at about 90%. This error is the design principle error. When two shells are thrown into the chute mechanism at an angle close to parallel, the two shells will slide to the exit in a synchronous manner without collision with other shells, resulting in counting error. Considering the volume factor of the cartridge case counter, the chute mechanism is selected for two abrupt changes, and the structure is shown in Fig. 3:

1. V-shaped short chute, 2. U-shaped chute, 3. V-shaped long chute, 4. T-shaped chute bracket, 5. Bracket fixing hole

Fig.3 Double Mutation Reverse Chute Mechanism
4. **Slot type cartridge case counter**

As shown in Fig. 4, the overall structure of the bayonet shell counter is shown in Fig. 4, which is composed of an outer box, a cartridge mechanism, an outlet chute, an internal bracket, a motor, a motor gearbox and a counter.

![Fig.4 Structure Diagram of Slot Type Bullet Shell Counter](attachment:image)

In the process of use, the cartridge case is poured into the upper cover of the outer box. After the power is turned on, the cartridge case slides from the cone shaped funnel to the cartridge clamping mechanism under the action of motor vibration. The cartridge case is clamped into the slot by the cartridge clamping mechanism, and discharged into the outlet chute one by one through the cartridge discharge slot. The counter is located at the lower side of the discharge slot to realize the counting of bullet shells. The cartridge mechanism is the core mechanism of the slot type bullet case counter, which is composed of a rotating cartridge plate and a fixed chassis. Its structure is shown in Fig. 5.

![Fig.5 Structure Diagram of Cartridge Mechanism](attachment:image)

The rotating chuck is installed inside the fixed chassis. The rotary chuck is composed of a disc body, a cartridge groove, a bullet case block and a drive shaft mounting groove. The edge of the
rotating chuck is provided with a cartridge groove, and the bullet shell block is symmetrically welded at the gap of the cartridge groove. In the process of rotation, the block of bullet case is used to move the cartridge case to make the sub cartridge case fall into the cartridge slot. The middle part of the rotating chuck is provided with a driving shaft installation groove, which is used to connect the drive motor shaft. The fixed chassis is composed of chassis disc body, annular baffle plate, bullet discharging groove, gearbox connecting hole and through-hole. An annular baffle plate is installed at the edge of the chassis body, and a variable speed connecting bolt hole is arranged at the middle of the bottom of the chassis plate body to fix the driving motor and the gearbox.

5. Performance comparison of two kinds of cartridge case counter

Two kinds of cartridge case counters are shown in Fig. 6:

In order to test the counting efficiency and counting accuracy of the two kinds of counters, 400 groups of tests were carried out, and 200 shells were tested in each group. The counting efficiency and accuracy were tested respectively.

The single counting efficiency formula and counting accuracy formula are as follows:

\[ \eta_v = \frac{200}{t_p} \times 60 \]

In:
\( \eta_v \): Single count rate;
\( t_p \): Time required to discharge 200 shells.

\[ \xi = \frac{\kappa}{400} \times 100\% \]

In:
\( \xi \): Counting accuracy of counter;
\( \kappa \): Count the exact number of groups.

The test results are shown in Table 3

| Counter type | Mean value of ejection rate (v/min) | Counting accuracy (%) |
|--------------|------------------------------------|-----------------------|
| Chute type   | 317.5                              | 99.00                 |
| Slot type    | 113.2                              | 99.75                 |

According to the test results, the chute type cartridge case counter has high efficiency and low counting accuracy, while the slot type cartridge case counter has high counting accuracy but low efficiency. In addition, the counting accuracy of the chute type cartridge case counter is 99% less than that of the chute counting accuracy of 99.08%. There are two reasons: one is that after a certain amount of cartridge case is filled by the pulling and throwing mechanism, the number of agglomerates thrown out increases, which leads to the decline of counting accuracy; on the other hand, the change of statistical method is another reason for the error.
6. Conclusion
In order to meet the needs of the field forces for the recovery and counting of cartridge cases, two kinds of cartridge case counters are designed. The size of the slot in the slot type cartridge case counter is determined by theoretical analysis, and the optimal number of abrupt reverse changes of the chute mechanism in the chute counter is determined through experiments. Two kinds of cartridge case counter are compared. The results show that: the ejection efficiency of chute type cartridge case counter is 317.5 pieces / min, and the counting accuracy is 99.00%; the counting efficiency of slot type cartridge case counter is 113.2 pieces / min, and the counting accuracy is 99.75%. Therefore, the chute type cartridge case counter is suitable for the large-scale recovery of cartridge case at brigade level, and the card slot type cartridge case counter is suitable for small-scale continuous platoon level. The module counts accurately.

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