Study on Stability of Detection System for the Foreign Matter on the Surface of Analgesic Pump Drug Capsule

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Abstract. A tiny material point and foreign body on the storage bag of an analgesic pump will have a bad influence in clinical use. Therefore, in the production, the surface of the analgesic pump storage bag is tested and effectively removed. There are points and foreign objects are very important steps. In this paper, the stability of the foreign body detection system for the surface of 100 ML analgesic pump storage bag was studied. Experiments show that when N=8, 9, 11, that is, 100ML analgesic pump storage bag is connected with regular octagon, regular pentagonal, positive elliptical, the side length meets the design goal. However, since the time for detecting a single 100ML analgesic pump reservoir at N=8 was less than that for N=9, 11. Therefore, the detection of the 100ML analgesic pump storage bag by N=8 is in line with the production requirements. It provides an experimental reference for the efficiency and quality requirements of analgesia pumps in production.

1. Introduction

The inspection of the appearance of the product is essential, and the surface defects of the product not only affect the appearance of the product itself, but also affect the performance of the product [1]. For example, the storage bag of the analgesic pump, a tiny material point on the storage bag, the foreign matter will have a bad influence in clinical use; The tin plate for the can is not allowed to have tiny holes on the surface; Hygienic non-woven fabrics are not allowed to have stains on the surface; The liquid crystal glass panel does not allow crystallization on the surface; The solar cell sheet is not allowed to have a broken gate or cracked. Modern high-speed production lines, unrecognizable or inefficient by the human eye, and high labor costs, have forced manufacturers to change, introducing surface visual inspection systems, allowing machines to replace manual inspections, and greatly improving production inspection efficiency [2].

Machine vision inspection technology is widely used in military, medical, microelectronics, printing, packaging, automotive and scientific research, etc. due to its fast detection speed, high measurement accuracy, automation, large amount of information, and many functions [3].

The storage bag of the 100ML analgesic pump of Tuoren Group used to manually detect the foreign matter on the surface of the storage bag. The average efficiency was 4 seconds/person, and the machine vision detection efficiency was 4S/set, due to the person in the process of detection. Because of the subjectivity in the process of detection, and the visual fatigue of the inspectors with the increase of detection time, various problems have arisen, which has caused huge economic cost and brand cost to the enterprise [4].

This paper aims to analyze the stability of the foreign body detection system for the surface of the 100ml analgesic pump storage bag [5-6], and introduce the experimental methods and results.
2. Stability Analysis
The factors affecting the stability of the 100ml analgesic pump storage bag surface material foreign body detection system are mainly light source system [7-8], image acquisition system [9-10], image processing system [11-12]. Now to ensure the parameters of the light source system, the parameters of the image processing system are unchanged, and study the effect of the image acquisition system on the stability of the foreign body detection system of the surface of the 100ml analgesic pump storage bag.

![Figure 1](image1.png)

**Figure 1.** A filamentous foreign body on the capsule of 100ML analgesic pump
(a) Foreign matter on the surface of analgesic pump drug capsule, (b) Picture after clearing

![Figure 2](image2.png)

**Figure 2.** A dotted foreign body on the capsule of 100ML analgesic pump

![Figure 3](image3.png)

**Figure 3.** No foreign body was found on the capsule of 100ML analgesic pump

The diameter of the 100ml analgesic pump reservoir is \( R = 13.55 \text{mm} \), the height of the detection area is \( H = 8 \text{mm} \). The vertical distance from the plane through which the detection zone is farthest from the camera (parallel to the camera) to the center of the 100ML analgesic pump reservoir is \( L3 = 5.468 \text{mm} \) (\( L3 = \left( \frac{R}{2} \right)^2 - \left( \frac{H}{2} \right)^2 \)). The plane through which the detection area is closest to the camera (parallel to the camera), and the vertical distance from the plane through which the detection area is farthest from the camera (parallel to the camera) is \( L4 = 1.307 \text{mm} \) (\( L4 = \frac{R}{2} - L3 \)), the depth of field of the camera is 3mm, greater than 1.307mm, so the detection area meets the requirements of the image acquisition system. The circumference of the 100ML analgesic pump storage bag is \( L = 2\pi R = 42.57 \text{mm} \), and its inner regular pentagon length corresponds to the arc length \( L_1 = L/5 = 8.514 \text{mm} \), and the regular pentagon side length \( L_2 = \sin(360/(5*2))R = \sin36\times13.55 = 7.964 \text{mm} \), \( L_1/L_2 = 1.069 \). If the regular hexagon is inscribed, the arc length corresponding to the side length is \( L_1 = L/6 = 7.095 \text{mm} \), and the length of the regular hexagon is \( L_2 = \sin(360/(6*2))R = \sin30\times13.55 = 6.775 \text{mm} \), \( L_1/L_2 = 1.047 \).
If the arc length corresponding to the length of the inscribed octagon is \( L_1 = L/8 = 5.321 \text{mm} \), the length of the regular octagon is \( L_2 = \sin(360/(8*2)) \cdot R = \sin(22.5) \cdot 13.55 = 5.185 \text{mm} \). If the arc length corresponding to the length of the inscribed hexagon is \( L_1 = L/9 = 4.73 \text{mm} \), the length of the regular hexagon is \( L_2 = \sin(360/(9*2)) \cdot R = \sin(20) \cdot 13.55 = 4.634 \text{mm} \). If the arc length corresponding to the length of the inscribed elliptical side is \( L_1 = L/11 = 3.87 \text{mm} \), the length of the regular elliptical side is \( L_2 = \sin(360/(11*2)) \cdot R = \sin(16.4) \cdot 13.55 = 3.817 \text{mm} < (8/2) \text{mm} \).

In theory, the smaller the value of \( L_1/L_2 \), that is, the more single detection times of the 100ML analgesic pump storage bag surface material foreign body detection system, the more accurate the detection [10].

3. Experimental Methods and Results

After adjusting the detection system of surface material foreign body for 100ML analgesic pump storage bag, keep the parameters of the system unchanged.

Test object A: qualified 100ML analgesic pump reservoir.

Test object B: Unqualified 100ML analgesic pump reservoir (there is a black spot with an area of 0.25mm²);

The circumferential surface of a single 100ML analgesic pump storage bag is divided into \( N \) times to complete the test;

The test was repeated for A and B, respectively, as shown in Table 1 below.

### Table 1. Experimental scheme

| Object | N Value | Repeated detection times |
|--------|---------|--------------------------|
| A      | 5       | 100                      |
| B      | 5       | 100                      |
| A      | 6       | 100                      |
| B      | 6       | 100                      |
| A      | 8       | 100                      |
| B      | 8       | 100                      |
| A      | 9       | 100                      |
| B      | 9       | 100                      |
| A      | 11      | 100                      |
| B      | 11      | 100                      |

### Table 2. Experimental results

| N   | A Test Results | B Test Results |
|-----|----------------|----------------|
|     | OK  | NG | OK  | NG |
| 5   | 100 | 0  | 19  | 81 |
| 6   | 100 | 0  | 11  | 89 |
| 8   | 100 | 0  | 100 |    |
| 9   | 100 | 0  | 100 |    |
| 11  | 100 | 0  | 100 |    |

4. Experimental Conclusions

From Table 2, we can see,

When \( N = 5 \), the qualified product A is repeatedly tested 100 times, the test result is all OK, and the non-conforming product B has been detected as OK 19 times, that is, 19 times missed.

When \( N = 6 \), the qualified product A is repeatedly tested 100 times, the test results are all OK, and the unqualified product B has been tested as OK for 11 times, that is, 11 missed tests.
When N=8, the qualified product A is repeatedly tested 100 times, the test result is all OK, and the non-conforming product B has 0 times detected as OK.

When N=9, the qualified product A is repeatedly tested 100 times, the test result is all OK, and the non-conforming product B has 0 times detected as OK.

When N=11, the qualified product A was repeatedly tested 100 times, the detection result was all OK, and the non-conforming product B was detected as OK 0 times.

The design goal is met when N=8, 9, and 11. Since the time for detecting a single 100ML analgesic pump reservoir at N=8 was less than that for N=9,11, the 100ML analgesic pump reservoir was tested by N=8.

5. References

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