A Research Based on the metering and detecting Device for Industrial dispenser of non-contact technology

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Abstract. Based on the non-contact detection technology, for the needs of on-site measurement for industrial dispenser, the dispenser device is designed and utilized non-contact laser measuring technology with high precision for measurement of length and speed to measure the coordination of displacement stroke and speed. According to "GBT 26799-2011 technical conditions for General Dispenser ", several key parameters are detected by comparing the experimental results, to meet the metering requirements of industrial dispenser.

1. Introduction
With the advance in the technology revolution, the invention of dispenser used widely significantly reduces the cost of manual labor, realizes automation and meanwhile enhances accuracy, which has important meaning for improving the quality of products. The dispenser, named also glue spreading machine, is a kind of automation equipment controlling fluid and dropping it or paint on the surface or the inner side of products. The dispenser mainly uses glue, paint or other liquid to drop, inject or coat on the right place of products to draw a point, a line, a circle and a curve.

Principle of operation[1]: condense air and send it into a glue container(injector); press glue into the pipe connecting a piston chamber; when the piston slides up, the chamber is filled with the glue; when the piston slides down and push the glue into the end of the injector, the glue is pressed out of the mouth of the injector; the value of glue dripping is decided by the distance of the piston sliding down, which is controlled by hand or by a software system.

The more extensive application of the industrial dispenser means the more measuring requirements. The industrial dispenser is commonly huge, hard moved and only fit for on-site measurement. So the application of the non-contact detection technology is a great affection on the on-site measurement for the industrial dispenser.

2. The analysis of the present situation of the research at home and abroad and the problems[2]
At present, the measuring of the industrial dispenser is in its beginning stage, and there is still no fit measuring device for the industrial dispenser. Influenced by some related industries, the measuring methods of every parameters are disorganized and disconnected, which means only measuring one parameter in the system each time. The whole course is repetitive, fussy and inefficient. Some enterprises manufacturing dispensers have done some research for the measuring of the industrial dispenser in theory, but the results aren’t perfect, limited by its own situation and lack of some parameters. The requirement of the on-site measuring of the industrial dispenser is one important factor[3] restricting the development of the detection technology of dispenser.
3. **The technical base and the technological route**

According to ‘GBT 26799-2011 general technical specifications of dispenser’, the performance indicators of industrial dispenser includes: programming function, effective stroke, repeat-ability, glue injection, movement speed, dispensing speed, system tightness, overload test.

**Experimental method[4]:**

- **Programming function:** set different glue injection pressure, moving speed, glue injection time and other functions, and verify it by actual point and glue injection
- **Effective stroke:** set the maximum effective stroke of the X, Y, Z axis, make glue injection on the PVC board according to the standard, use the detection device for the measurement of the X, Y axis working stroke on the PVC board and up and down movement of the working stroke, measure value not less than the effective stroke of the X, Y, Z axis
- **Repeat-ability test:** the dispenser primarily measures the repeat-ability for the start and end movement point of the X, Y, Z axis
- **Glue injection repeat:** set the trajectory of a typical, the glue capacity of syringe are 100%, 50%, 10% of the three conditions for each test, take 5 tablets of sample for each glue capacity, weigh them by analytical balance, the percentage of weight deviation, as the injection repeat-ability.
- **Moving speed:** under the no-load conditions, the accuracy for the maximum track speed of the X, Y, Z single axis is measured respectively
- **Dispensing system tightness:** in the dispensing head the glue mouth is closed, the pressure adjusted to 1.25 times the work pressure, maintain 1 minutes, check the leakage condition of the work pressure system
- **Dispensing speed:** set the maximum dispensing speed, use dispensing standard method, measure the typical dispensing time with the measuring device, calculate the number of dispensing per minute
- **Noise:** noise generated in the dispenser in the no-load operation condition, should not be more than 70dB (A). The overload test may cause damage to equipment, analytical balance is available for measurement of glue injection repeat, sealing and noise detection device has been mature, so the research content is suitable for detection device for the programming function, effective stroke, repeat-ability, movement speed, glue speed of the industrial dispenser. The technology route is shown in the diagram:

![Diagram of Technology Roadmap](image)

4. **The detection method of the device is different from the traditional method[5]**

4.1. **Traditional methods and principles**
Use typical dispensing procedures on a PVC transparent board with a thickness of 0.1 - 1mm, the dispensing area is (10x10) dot matrix, dispensing distance is 3mm. The dispensing track is shown in the following figure:

After dispensing, measure the X, Y, Z axis work stroke and up and down movement stroke of the dispensing head on a PVC board with vernier caliper, compare the value measured again with the effective stroke of dispensing machine, and then get the result. Disadvantages of this method: high consumption of consumables, low accuracy, high cost, speed and effective travel shall be measured separately, huge quantity of work.

4.2. The method and principle for the device

The three coordination displacement, stroke and velocity of the dispenser are measured by using a high precision non-contact laser length and measuring speed measurement technique. The groundbreaking of electrical and optical design, the automatic signal acquisition, the unique digital signal processing calculation and the latest single signal integrated circuit processing are adopted. The device doesn’t employ any moving parts, use 100% solid state digital processing technology. The principle of laser Doppler velocimetry (LDV) is shown in figure:

\[
d = \frac{\lambda}{2 \sin \kappa}; \quad v = \frac{d}{t}; \quad t = \frac{1}{f}; \quad L = \int_0^T v dt;
\]

The working diagram of the device is as follows:
4.3. **Key technologies**

Use the laser Doppler Technology, focus on moving targets in 300mm, analyze the spectrum of reflection, add reflector on three elongated strips of the X, Y, Z axis by non-contact method, and then focus on the reflector, make the device gain movement and speed to obtain the main parameters of effective stroke and speed measurement, and then use the pressure gauge and analytical balance to judge the repeat-ability, stability and tightness of the dispensing machine; Finally, compare the data with the data of the controller to realize the test for the device of programming function, effective stroke, repeat-ability, moving speed, dispensing speed, sealing performance and noise index; At the same time, this device meets the compatible test of the manual and semi-automatic dispensing machine[6].

4.4. **Test method of main parameters**

The device mainly tests the programming function, effective stroke, repeat-ability, moving speed and dispensing speed of the industrial glue dispenser. The method is as follows:

As shown, the non-contact measuring method measures the displacement and velocity of the X axis, and the displacement is obtained at the time of displacement. Thus, the effective stroke, repeat-ability and moving speed are obtained.
Similarly, the parallel reflections are placed on the Y and Z axes to measure the effective travel, repeat-ability, and movement speed of the other two axes. The speed of dispensing speed is obtained by measuring the speed of dispenser. As follows:

a. Move the reflecting device components to fix on the nozzle of the dispensing machine; if the X axis is measured, the reflecting surface parts should be similarly with the X axis; if the Y and Z axes are measured, and the corresponding reflector parts should be parallel to the axis and no loosening.

b. Use a tripod to support the device, and adjust it to the same high degree as reflection surface component at the injection head of the glue dispenser, open the switch, project the laser onto the reflective face piece, in the consideration of the incident angle of the reflecting wave and the error, try to make the laser projection direction vertical to the reflection face.

c. Set the dispensing procedures, set the maximum displacement of the three X, Y, Z axis; after that, start the measurements, the X axis direction measurement as an example: the record of detection device in current displacement of P0, and then begin to measure direct comparison, after time T, the displacement speed $V_t$ to the X axis, according to the formula, the position in the direction of X axis at the same time $P_t = V_t T$, it can be seen that the effective stroke can be obtained $P_x = P_t - P_0$; obtain Y axis, Z axis effective travel by the same method.

d. In a certain direction, the sample is measured N times for the effective stroke, the average value of the measurement is:

$$\bar{p} = \frac{1}{n} \sum_{i=1}^{n} P_i$$

The standard deviation of single experiment is

$$s(\bar{p}) = \sqrt{\frac{\sum_{i=1}^{n} (p_i - \bar{p})^2}{n-1}}$$

The repeat-ability of this measurement can be obtained in this direction $u(p)$:

$$u(p) = s(\bar{p})$$

Measure $u(p)$ in the direction of other axes,

Finally, the repeat-ability of this measurement is obtained $u(p)_{\text{max}}$.

After obtaining the effective stroke, repeat-ability and moving speed, the data is compared with the output data of the industrial glue dispenser so as to realize the verification of the programming function, and finally to realize the detection of the industrial dispenser.

5. Comparison of experimental results of two methods

At the site, working travel: X axis 300 mm; Y axis 300 mm; Z axis 100 mm; maximum speed 1000 mm/sec, repeat-ability: ±0.05mm, running speed: the limited stroke of the X axis is carried out by the automatic adhesive dispenser maximum 10 m/sec with hot melt tape, and ten measurements are made by the traditional method and the detecting method of the device respectively. The data is as follows:

5.1. Data measured by traditional method

| Table 1 X axis point 300mm measuring column |
|---|---|---|---|
| time | value | time | value |
| 1 | 302.2 | 6 | 301.2 |
| 2 | 301.8 | 7 | 301.2 |
| 3 | 301.5 | 8 | 302.0 |
| 4 | 302.1 | 9 | 301.9 |
Table 2 Y axis point 300mm measuring column

| time | value | time | value |
|------|-------|------|-------|
| 1    | 299.5 | 6    | 302.1 |
| 2    | 301.2 | 7    | 300.8 |
| 3    | 300.5 | 8    | 301.1 |
| 4    | 301.3 | 9    | 300.7 |
| 5    | 300.2 | 10   | 299.2 |

Table 3 Z axis point 100mm measuring column

| time | value | time | value |
|------|-------|------|-------|
| 1    | 101.4 | 6    | 102.1 |
| 2    | 102.1 | 7    | 101.3 |
| 3    | 101.3 | 8    | 102.2 |
| 4    | 101.3 | 9    | 101.9 |
| 5    | 101.8 | 10   | 101.6 |

X axis point 300mm, \( p, s(p), u(p) \) are respectively 301.76, 0.407704, 0.407704 mm.
Y axis point 300mm, \( u(p) \) is 0.863069 mm.
Z axis point 100mm, \( u(p) \) is 0.365148 mm.
The traditional method \( u(p)_{\text{max}} \) is 0.863069 mm.

5.2. Non-contact laser method

Table 4 X axis point 300mm measuring column

| time | value | time | value |
|------|-------|------|-------|
| 1    | 300.2 | 6    | 300.2 |
| 2    | 300.2 | 7    | 300.2 |
| 3    | 300.2 | 8    | 300.0 |
| 4    | 300.1 | 9    | 300.2 |
| 5    | 300.2 | 10   | 300.1 |

Table 5 Y axis point 300mm measuring column

| time | value | time | value |
|------|-------|------|-------|
| 1    | 300.2 | 6    | 300.1 |
| 2    | 300.2 | 7    | 300.1 |
| 3    | 300.3 | 8    | 300.1 |
| 4    | 300.3 | 9    | 300.2 |
| 5    | 300.2 | 10   | 300.2 |

Table 6 Z axis point 100mm measuring column

| time | value | time | value |
|------|-------|------|-------|
| 1    | 100.2 | 6    | 100.3 |
| 2    | 100.2 | 7    | 100.3 |
| 3    | 100.3 | 8    | 100.2 |
| 4    | 100.3 | 9    | 100.2 |
X axis point 300mm \( p, s(p), u(p) \) are respectively 300.14, 0.069921, 0.069921 mm.
Y axis point 300mm \( u(p) \) is 0.073786 mm.
Z axis point 100mm \( u(p) \) is 0.052705 mm.
The non-contact laser method \( u(p)_{\text{max}} \) is 0.073786 mm.

5.3. Methods comparison
In the direction of the X axis of the dispensing machine, the results of 10 effective stroke measurements are compared with each other, as shown in Figure:

![Figure 6 Influence of different methods on effective stroke](image)

As can be seen from Figure, the results of the non-contact laser type device are better than that of the traditional method, and are closer to the standard values.
A total assessments of 3 axial repeat-ability are performed by different methods, as shown in Figure:

![Figure 7 Effects of different methods on reproducibility](image)

As illustrated in Figure, the repeat-ability of the non-contact laser device is less than that of the traditional method, so the accuracy is higher than the traditional dispensing method.

6. Conclusion
The non-contact laser device is with higher accuracy, more stable and flexible characteristics than that of the traditional method, at the same time, the device can be traced to a higher standard device, ensure that the value of effectiveness and reliability of transmission, meet the measuring requirements of industrial dispenser.

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