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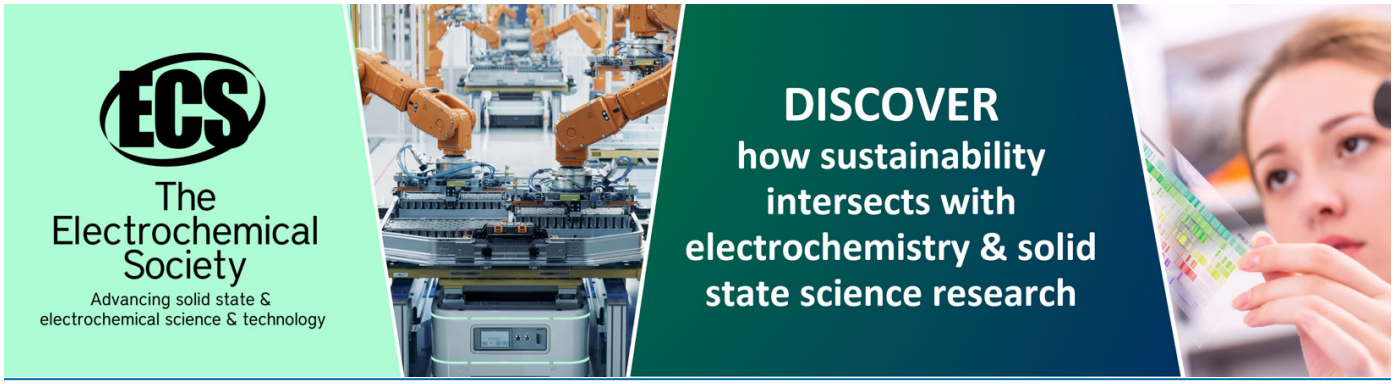

Design and Application of On-line Capsule Detecting Device for Cigarette Maker

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Abstract. In order to solve the problem that continuous online single-capsule testing of capsule-containing rolled products cannot be performed during the rolling process, according to the operating characteristics of the rolling machine, an online capsule detection device for the rolling unit was designed. The device is mainly composed of a capsule detection unit, a display operation unit, a fault diagnosis unit and a data communication unit. The system first generates a terahertz signal source and collects the terahertz signal generated after passing through the capsule in the cigarette filter to be detected, performs real-time calculation through the detection processing unit, and aligns the processed signal with the cigarette through the axis encoder, and finally rejection through the rejection valve. The ZJ17 rolling unit and cigarette products with a diameter of 5.4mm, a capsule diameter of 2.8mm, and a filter length of 30mm were tested. The results showed that the online unit of the rolling unit was used to detect the presence or absence of capsules and damaged capsules. The continuous detection accuracy of the branch is 100%, and the accuracy of the continuous detection of the online single branch for the capsule displacement of ± 4mm or more is 85%. The device realizes the online safety inspection of capsules containing rolled products containing capsules, and opens up new ideas for the quality assurance of capsules containing rolled products.

1. Detection principle

1.1 Detection principle of terahertz-based capsule detection device

Terahertz is a general term for electromagnetic waves with a frequency in the range of 0.1 to 10 THz. It lies between the familiar microwave and far-infrared bands in the electromagnetic wave spectrum. The wavelength of terahertz wave is longer than visible light and infrared light, and it has better penetrability to common dielectric materials; while its frequency is higher than microwave, it can form electromagnetic beam with better directivity, more controllable radiation range, and provide higher space Resolution; At the same time, the terahertz spectrum of many compounds has obvious fingerprint characteristics, and water and polar substances will also cause significant absorption losses to terahertz electromagnetic waves.[1-6]

The detection principle is shown in Figure 1:

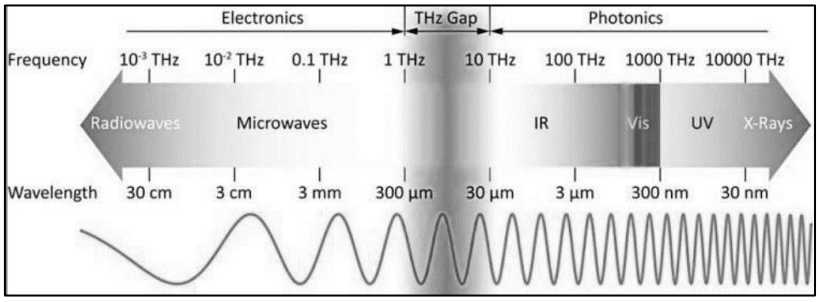

Figure 1. Terahertz band schematic

The above characteristics are conducive to the application of terahertz in industrial non-destructive testing, food and drug inspection, and security and other fields: 1. Compared with the previous X-ray detection, terahertz is highly safe and does not cause damage to human bodies and common samples 2. Compared with ultrasonic detection methods, terahertz is a non-contact non-destructive measurement. The probe does not need to be in direct contact with the sample, and at the same time allows high-speed measurement, which is more suitable for continuous operation of industrial production lines. Based on the terahertz's ability to absorb liquid moisture, the terahertz-based on-line capsule detection device is installed on the cigarette production line of the cigarette machine, which can accurately determine whether the capsules inside the cigarette meet the standard, and can accurately determine the occurrence of no capsule, broken capsule, empty Cigarettes with quality problems such as capsules can relatively accurately determine cigarettes with quality problems such as capsule displacement.

1.2 Terahertz-based capsule detection device

The core sensor machine processing system based on the terahertz capsule detection device includes the following parts: terahertz wave source: 300GHz continuous terahertz source; terahertz imaging system: custom lens optimized detection area; image capture system: high-speed terahertz detection array; image acquisition And digitization: image acquisition card; image processing and decision-making: image processing module; control execution module: PLC, pneumatic rejection equipment, etc.

Signal processing steps:

I. Cigarettes are packaged in a tipping paper package in an upstream process and delivered to the inspection area. The terahertz wave generator emits a high-frequency electromagnetic wave with a frequency of 300 GHz and irradiates the lower side of the cigarette filter through a collimating optical system.

II. The terahertz array detector and its attached imaging lens are located above the filter. By using the cigarette position signal provided by the position sensor on the production line to synchronously trigger the terahertz detector and set the appropriate exposure time, the terahertz imaging images corresponding to each cigarette filter can be obtained separately.

III. The computer of the control center uses digital image processing technology to perform threshold segmentation and edge detection on the collected filter terahertz images to obtain geometric features and corresponding position and size parameters in the image, which are then compared with the corresponding parameters of the standard filter. The comparison is performed to determine whether the filter burst is qualified, and the corresponding parameters and the cigarette number are sent to the database system for easy tracking and tracing. For the cigarettes that are judged to be unqualified, a signal is sent to the rejection device for rejection.[7-8]

Schematic diagram after signal processing:

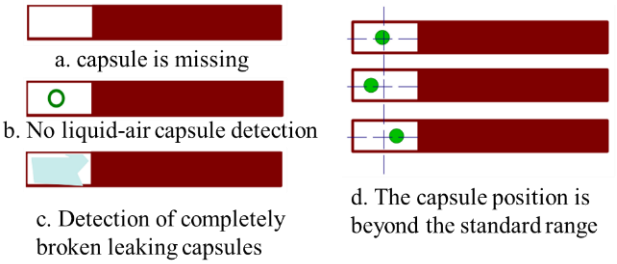

Figure 2. Schematic diagram of capsule defect detection

2. Device design

2.1. Hardware design and transformation

A. Mechanical content:

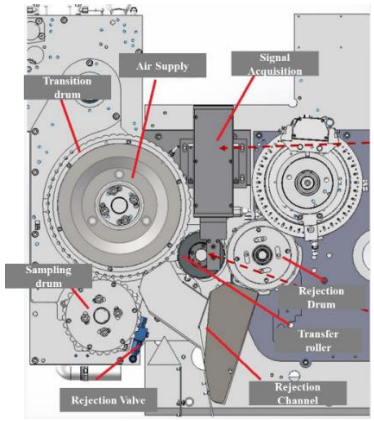

Figure 3. Device location layout

a. Add a terahertz device between the detection wheel and the transition wheel;

b. The sampling wheel is redesigned as a sampling rejection wheel, and a high-speed rejection valve is installed so that the wheel body has both sampling and rejection functions.

B. Terahertz source and line scan camera

a. The terahertz-based capsule detection device is mainly composed of a terahertz source generator, a terahertz receiver, a terahertz signal processor, and a shaft encoder.

1) Terahertz generator and terahertz receiver Terahertz processor: Generate a terahertz source and acquire a terahertz signal.

2) Terahertz processor: The central processing unit of this device collects, processes and controls the terahertz of each unit.

3) Axis encoder: Synchronized with the host speed, accurate filter rod position.

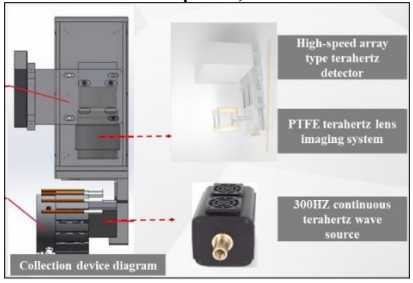

Figure 4. Signal acquisition device

2.2. Software Design and Application

A. Integration with cigarette electrical control cabinet system

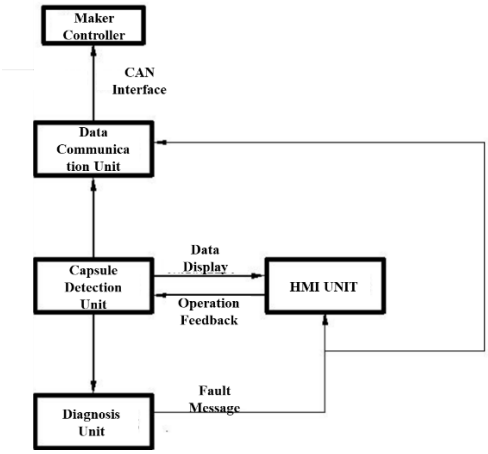

Figure 5. Electrical communication architecture

The entire device is connected to each other through a high-speed sensor bus, and the detection device and the cigarette machine are connected in a synchronous CAN communication manner to ensure data synchronization between hardware signals and software signals.

B. System architecture design

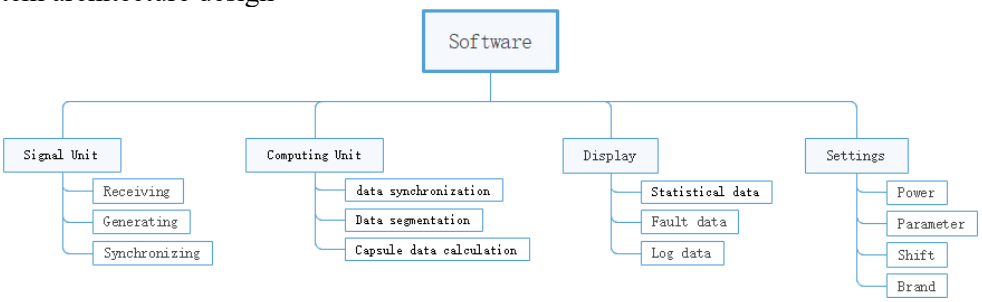

Figure 6. Software platform structure

C. Functional description of each module

Capsule detection module:

The module first completes the signal processing of the capsule detection sensor, processes the collected signals, completes the removal of cigarettes and the issue of alarm signals; completes the information communication and data adjustment functions of a single cigarette: including current, voltage, and frequency Communication output and input (value adjustment) of data such as value, output, rejection, test result, detection threshold, rejection count, and rejection steps.

Display operation module:

This module is the human-machine interface display module of this device, which completes the adjustment of related parameters (sensor voltage value, frequency value gain, detection threshold); realizes display of various types of detection information, including equipment operation information, monitoring information, detection information, etc. Record parameter change records Recall the saved parameter records; there are also some systematic settings.

Fault diagnosis module:

As a status monitoring function of this device, this module realizes the fault alarm function, the setting of monitoring points (current, high voltage, frequency signal, synchronization signal, shaft encoder signal, shutter signal light), and whether to remove cigarettes when there is a fault.

Data communication module:

Complete the function of data communication with the splicing unit to send detection values and various logs.

3. Application effects

Test model: CDTM cigarette machine ZJ17D fine support model is used as test model to carry out online application effect test.

Test brand: Liqun (Jiangnan Yun), specifications: 97mm fine cigarette, filter length 30mm, diameter 5.4mm, capsule diameter 2.8mm, capsule center point is located at the filter center point.

Test process method:

Test1) Verification of missing capsules, empty capsules, broken capsules, etc .: Artificially make 1,000 defective capsule filter rods, 100 at a time, for a total of 10 groups to verify the effect. Indicator requirements: 100%

Test2) Capsule offset verification: The rejected products are re-tested by off-line instruments. Each time, 100 pieces are taken out, and a total of 10 groups are used to verify the effects. Index requirements: ≥80%

Test 1)

Test sequence	Sample size	Sample simulated defects	Actual detected defects	Effective recognition rate
1	100	110	110	100%
2	100	120	120	100%
3	100	130	130	100%
4	100	140	140	100%
5	100	150	150	100%
6	100	160	160	100%
7	100	170	170	100%
8	100	180	180	100%
9	100	190	190	100%
10	100	200	200	100%
Total	1000	1550	1550	100%

Conclusion: meet the requirements of indicators.

Test 2)

Test sequence	Sample size	Sample simulated defects	Actual detected defects	Effective recognition rate
1	100	110	90	81.82%
2	100	120	103	85.83%
3	100	130	106	81.54%
4	100	140	110	78.57%
5	100	150	120	80.00%
6	100	160	141	88.13%
7	100	170	153	90.00%
8	100	180	166	92.22%
9	100	190	172	90.53%
10	100	200	167	83.50%
Total	1000	1550	1328	85.21%

4. Conclusion

A ray-type sensor is used as the core to design the online capsule detection device of the splicing unit. This device can continuously and continuously detect the capsules in cigarette products at the full speed of the splicer: among them, the capsule is missing, the capsule is empty, and the capsule is broken The detection accuracy rate is 100%; the accuracy of capsule offset detection above 8mm is 85.2%.

Acknowledgments

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