RESEARCH ON THE APPLICATION OF MICROWAVE NONDESTRUCTIVE TESTING TECHNOLOGY FOR DETECTION OF CAPSULE FILTER ROD OR CAPSULE CIGARETTE

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Abstract

In the producing process of capsule filter rod and capsule cigarette, the defects of capsule particle which include breakage, loss and position offset were easy to occur because of the technology of capsule filling, filter rod cutting, and cigarette winding.

Because the capsule was buried in the filter rod or in the cigarette, it was difficult to judge its normal by our eyes without breakage, but the dielectric constant of the capsule was different from the dielectric constant of the filter rod or the cigarette. The difference of their signal would be appeared in the area whether it own a capsule or not. According to the principle of dielectric constant detection in microwave resonator, the signal of the filter rod in the length direction was collected by a microwave resonator sensor. The leakage, location, and breakage of capsule particle in the filter rod were detected according to the difference of the signal intensity. A detector was designed based on the microwave resonance cavity perturbation technique. The detector was mainly composed of a filter rod feeding device, a filter rod conveying device, a microwave detection unit and a sorting device.

The designed detector and the established algorithm featured higher accuracy which got 0.1mm for detecting the position of capsule and good recognition effect for defects or absence of capsule. The detector provides a rapid and accurate quality detection method for capsuled-filter rods.

Objectives and Device

According to the microwave cavity perturbation method, by measuring the resonant frequency and quality factor of the resonator, the complex permittivity of the material can be calculated[1]. That is:

$$\varepsilon' = 1 + \frac{V_0}{2V_S}\frac{f_0 - f_S}{f_0}$$

$$\varepsilon'' = \frac{V_0}{4V_S}\left(\frac{1}{Q_{LS}} - \frac{1}{Q_{L0}}\right)$$

F is resonance frequency;
Q is quality factor;
V is volume.

In the dielectric constant table, the dielectric constant of the organic solvent in the capsule is about 32, and the dielectric constant of most dry matter is 1~5. There are great differences between the two substances. According to the principle of dielectric constant detection in microwave resonator, the signal of the filter rod in the length direction was collected and amplified by a microwave resonator sensor[2].

Based on the microwave technology[3], a rapid testing device for the quality of the capsule filter rod is designed, which is mainly composed of the feeding unit, the filter rod conveying unit, the microwave detection unit and the separation device. Furthermore the testing software is developed. As showing in Fig.1.

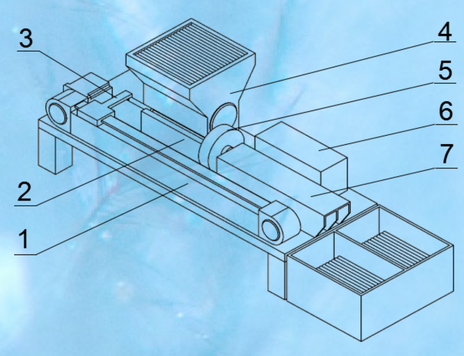


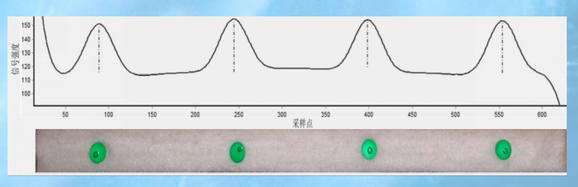
Fig.1. Structure of capsuled-filter rod detector

1 one-dimensional driving platform
2 filter rod groove
3 rod pushing block
4 material device
5 microwave cavity
6 microwave signal processing module
7 separation device

Results

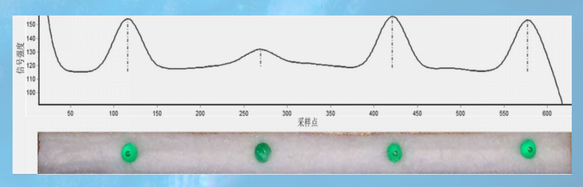
The test results are shown in Figure 2. The length of the filter rod is L=120 mm, its diameter is D=7.8 mm, and the location of the capsule in the filter rod is P1=15 mm, P2=45 mm, P3=75 mm, P4=105 mm. The distance between the adjacent capsules is 30mm.

Position	Desity
P1=15 mm	P1=normal
P2=45 mm	P2=normal
P3=75 mm	P3=normal
P4=105 mm	P4=normal



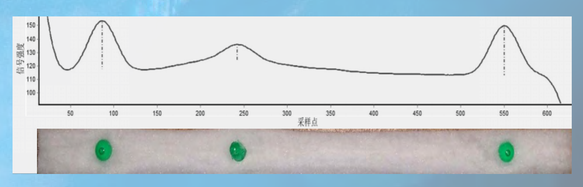
Normal

Position	Desity
P1=15 mm	P1=normal
P2=50 mm	P2=leaking
P3=75 mm	P3=normal
P4=105 mm	P4=normal



Position offset and leaking

Position	Desity
P1=15 mm	P1=normal
P2=45 mm	P2=leaking,
P3=0 mm	P3=0
P4=105 mm	P4=normal



Loss and leaking

Fig.2. Detection of capsule status

Conclusions

A detector was designed based on the microwave resonance cavity perturbation technique. The detector and the specially constructed algorithms provide higher precision which got 0.1mm for detecting the position of capsule and good recognition effect for defects or absence of capsule. The detector provides a rapid and accurate quality detection method for capsuled-filter rods.

References

[1] Trabelsi S, Krazsewski A W, Nelson S O. New density-independent calibration function for microwave sensing of moisture content in particulate materials[J]. IEEE Transactions on Instrumentation and Measurement, 1998, 47(3): 613-622.

[2] Kik A. Complex permittivity measurement using a ridged waveguide cavity and the perturbation method[J]. IEEE Transactions on Microwave Theory and Techniques, 2016, 64(11): 3878-3886.

[3] ZHU Lijun, GAO Feng, HU Xingfeng, et al. Method for detecting defects of aromatic beads in aromatic bead filter sticks: China,104897531A[P]. 2015-09-09.