Optimization of cutting parameters of microwave expanded stem in slim cigarette

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Abstract: In order to explore the cutting optimization parameters of the processing technology of the expanded stem of slim cigarette, according to the quality characteristics of the microwave expanded stem, the samples with different combinations of cutting parameters were optimized. The results showed that under the combination of cutting parameters with a slicing thickness of 0.5mm and cutting width of 0.2mm, the high whole cut tobacco ratio, moderate small particle content, and minimum tobacco loss from cigarette end could be obtained. At the same time, the samples also had a lower hazard index and better sensory quality. This study provides a reference for technical research on the processing technology of the expanded stem of slim cigarettes.

1. Introduction

The technology of microwave expanded stem was first reported by Yunnan Industrial Research Institute [1] in 1997. Microwave heating was mainly used to replace the drying cylinder of tobacco stem in the production process. It was found that microwave heating had a particular impact on the main aroma components in the stems, mainly to change the relative content of chemical components in them. The results of sensory evaluation also showed that microwave heating could improve the sensory quality of stem to a certain extent. After that, the technology of microwave expanded stem has obtained rapid development and application. First, the chemical and sensory effects are mainly reflected in the following aspects: 1. Adding expanded tobacco stem into cigarette can not only effectively improve the combustion performance of cigarette but also reduce ligneous odor and tar, reduce cost and improve sensory quality [2-4, 8]; 2. the effect of reducing CO, HCN, B[a]P and crotonaldehyde in the mainstream smoke of microwave expanded stem is better than that of the traditional expanded stem. Second, The improvement of processing technology is mainly reflected in the following aspects: 1. The blending uniformity of secondary cut after microwave expanded stem in cigarettes is better[6]; 2. When the steam pressure, microwave power, and knife drum speed are 0.35MPa, 6kW, and 15Hz, respectively, the tobacco stem with an expansion rate of 261.12% can be obtained; 3. When the slicing thickness was 0.75-0.85mm, and the cut width was 0.30-0.35mm, the overall quality of microwave expanded stem was the best [9]; 4. When the medium temperature is 150℃~160℃, and the microwave power is 100~110KW, the total amount of aroma components increases with the increase of microwave power[10]. However, most of the above studies mainly focus on improving conventional cigarette stems, and the effects of physical properties and chemical components on the stems of slim cigarettes are less
studied. In this study, microwave expanded stem samples with different combinations of cutting parameters were optimized. The samples obtained under the optimal combination of cutting parameters can improve the adaptability of microwave expanded stem in the slim cigarette. The research results provide a reference for the technical research of processing technology of the expanded stem of slim cigarettes.

2. Materials and Methods

2.1. Test materials and equipment

Test materials: traditional expanded stem; microwave expanded stem; 2013 B brand K326 C3FS4 Pure cut tobacco (provided by a cigarette factory, with a cut width of 0.7mm); product A.

Test instruments: UT12 oven (Heraeus company of Germany), KNF240 constant temperature and humidity Incubator (Binder company of Germany); XP404S electronic analytical balance (Sensitivity: 0.0001g, Mettler Toledo company of Switzerland); YQ –2 vibration sieve, YQ –32 Cigarette Shredder (Zhengzhou Tobacco Research Institute); CH888 precision constant temperature and humidity Incubator (Thermoline company of Australia); RH– yc152 cut tobacco filling value tester (Guangzhou Runhu Instrument Co., Ltd.); av5170 cigarette weight screening instrument (the 41st Research Institute of China Electronics Technology Group Corporation); KTC80E tobacco cutter.

Sample preparation: take 50 kg of traditional expanded stem produced by conventional line and 50 kg of microwave expanded stem produced by test line, then add 210 kg pure cut tobacco, and put it into the cut tobacco storeroom for 48 hours. The cutting parameters of microwave expanded stem refer to uniform design table U5 (53). See table 1 for details. The moisture content of traditional expanded stem, microwave expanded stem, and cut tobacco was detected by "YC/T31-1996 Tobacco and Tobacco Products - Sample Preparation and Moisture Determination - Oven Method" [11]. According to the test results and setting the blending ratio (13%), the blending weight of the materials under the standard moisture content (12%) is converted, and then no flavoring is applied in the blending process of the cylinder. The prepared blended cut tobacco samples are rolled on the cigarette machine in turn. The sample number and preparation conditions are shown in table 1.1-1. The samples are balanced in a constant temperature and humidity Incubator with T = 22℃ and Rh = 60% until the moisture content is (12.5 ± 0.2)%, and the weight was screened according to (540 ± 5mg/cig) for standby use.

Table 1 Uniform design of cutting parameters combination U5 (53)

| Test No. | Slicing thickness (mm) | Cutting width (mm) | Microwave expanded stem No. | Blending ratio (%) | Rolled sample No. |
|----------|------------------------|--------------------|-----------------------------|--------------------|-------------------|
| 1        | 0.3                    | 0.3                | WB1                         | 13                 | WBJ1              |
| 2        | 0.4                    | 0.5                | WB2                         | 13                 | WBJ2              |
| 3        | 0.5                    | 0.2                | WB3                         | 13                 | WBJ3              |
| 4        | 0.6                    | 0.4                | WB4                         | 13                 | WBJ4              |
| 5        | 0.7                    | 0.6                | WB5                         | 13                 | WBJ5              |

2.2. Test method

Filling performance of cut stem: the filling value tester was used to determine the filling value of cut tobacco according to the method in "YC/T152-2001 determination of cut tobacco filling value" [12]. Five samples were taken for each parameter combination.

Processing characteristics of cut stem materials: 1000g of cut stem samples with different cutting parameters were taken and balanced in a constant temperature and humidity incubator with T = 22℃ and Rh = 60% for 48h. The structure, whole cut tobacco ratio, and small particle content of cut stem were measured according to the method of "cigarette process specification" and "YC/T178-2003" [13].
Sensory quality: referring to GB5606.4-2005[14], the sensory evaluation was conducted on the microwave expanded stem rolling samples and the blended cut tobacco rolled samples with a 13% cut stem blending ratio, and scored and described.

Refer to "GB/T22838.2-2009 Determination of physical properties of cigarette and filter rod" [15-19] for the detection of cigarette physical properties: (1) Put the rolled samples into a constant temperature and humidity incubator, balance at 22℃ and 60% for 48 hours, and the weight were screened according to 900±5mg/cig. Under the condition that the weight, circumference, and length indicators of each sample are consistent, the changing trend of draw resistance and hardness indicator of the two kinds of stem-rolling samples under different blending proportions are analyzed. (2) The balanced samples were screened according to the draw resistance of 940 ± 30Pa and hardness of 68 ± 2%, and then the cigarette weight difference was analyzed. In the process of the experiment, it is necessary to verify the uniformity of the samples after screening and analyze the data of sample uniformity verification according to CNAS-GL03:2006, and conduct the sample difference analysis under the condition that the samples meet the uniformity requirements.

3. Results and Analysis

3.1. Effect of cutting parameters on physical properties of microwave expanded stem

Table 2 Test results of filling value and structure

| No. | Moisture content% | Standard-fill value (cm³/g) | Percentage of weight in each size interval% | Whole cut tobacco ratio% | small particle content% |
|-----|-------------------|----------------------------|------------------------------------------|------------------------|------------------------|
|     |                   |                            | ≥3.35mm | 3.35~2.5 mm | 2.5~1.0 mm |                            |
| WB1 | 12.72             | 6.66                       | 2.58    | 19.73       | 63.43     | 22.31                       | 13.44                       |
| WB2 | 13.15             | 7.07                       | 4.53    | 29.59       | 57.97     | 34.12                       | 7.41                        |
| WB3 | 13.43             | 6.82                       | 4.28    | 29.78       | 55.93     | 34.06                       | 9.36                        |
| WB4 | 13.35             | 7.39                       | 6.70    | 39.15       | 50.59     | 45.86                       | 3.34                        |
| WB5 | 13.27             | 7.28                       | 8.99    | 43.61       | 45.41     | 52.59                       | 1.88                        |

It can be seen that with the increase of slice thickness, the percentage of whole cut tobacco ratio increases obviously. The best filling value of the WB4 sample was obtained by the No. 4 cutting parameter combination, and the lowest filling value of the WB1 sample obtained by the No. 1 cutting parameter combination. In terms of small particle content, the WB1 sample is the highest; the WB5 sample is the lowest.

3.2. Effect of cutting parameters on physical properties of cigarette

Table 3 Determination of physical properties of rolled samples under different cutting parameters

| No. | Tobacco loss from cigarette end (mg/cig) | Dust content (%) | Permeability% | Draw resistance Kpa | Hardness% |
|-----|------------------------------------------|-----------------|--------------|---------------------|----------|
| WBJ1| 4.22                                     | 2.63            | 31.497       | 1.9993              | 62.4     |
It can be seen that the WBJ3 sample has the lowest tobacco loss from cigarette end, the highest hardness, the most significant draw resistance, and moderate permeability. WBJ2 has the highest tobacco loss from cigarette end and the lowest hardness. In general, the physical indicators of the samples meet the relevant quality requirements.

3.3. Effect of cutting parameters on mainstream smoke of the cigarette

The mainstream smoke test results of microwave expanded stem with different combinations of cutting parameters and 13% blending ratio is shown in table 4.

| Rolled sample No. | Puff number (Puffs/cig) | Total particulate matter (mg/cig) | Corrected Tar(mg/cig) | Corrected CO(mg/cig) | Tar/Nicotine | CO/Nicotine |
|-------------------|-------------------------|----------------------------------|-----------------------|----------------------|--------------|-------------|
| WBJ1              | 6.11                    | 11.70                            | 9.81                  | 0.85                 | 8.77         | 11.58       | 10.35       |
| WBJ2              | 6.09                    | 11.69                            | 9.66                  | 0.87                 | 8.97         | 11.15       | 10.36       |
| WBJ3              | 6.25                    | 11.54                            | 9.27                  | 0.95                 | 9.00         | 9.73        | 9.45        |
| WBJ4              | 6.10                    | 12.21                            | 10.07                 | 0.88                 | 9.14         | 11.42       | 10.38       |
| WBJ5              | 6.44                    | 11.48                            | 9.57                  | 0.87                 | 8.59         | 10.97       | 9.84        |

It can be seen that there are significant differences in the components of mainstream smoke among different samples. Among them, WBJ3 had the lowest tar, the highest nicotine, and the middle CO. In terms of nicotine per unit, the tar/nicotine and CO/nicotine of WBJ3 samples were 9.73 and 9.45, which were far lower than those of the other four samples.

3.4. Effects of cutting parameters on seven harmful components in cigarette

The test results of seven harmful components of microwave expanded stem with different cutting parameters and 13% blending ratio are shown in table 5.

| Sample No. | Corrected CO(mg/cig) | HCN(µg/cig) | B[α]P(ng/cig) | Crotonaldehyde(µg/cig) | Phenol(µg/cig) | NH3(µg/cig) | NNK(ng/cig) | Hazard index |
|------------|----------------------|-------------|---------------|------------------------|---------------|-------------|-------------|--------------|
| WBJ1       | 9.1                  | 95          | 10.17         | 22.06                  | 10.74         | 7.9         | 3.68        | 8.10         |
| WBJ2       | 9.3                  | 87          | 9.52          | 21.08                  | 10.74         | 7.8         | 3.38        | 7.79         |
| WBJ3       | 9.3                  | 102         | 8.56          | 21.66                  | 10.57         | 7.1         | 4.73        | 8.07         |
| WBJ4       | 9.5                  | 99          | 9.75          | 20.50                  | 10.53         | 8.6         | 5.04        | 8.47         |
| WBJ5       | 8.7                  | 95          | 9.63          | 21.05                  | 10.50         | 7.4         | 4.10        | 7.91         |

It can be seen that there are significant differences in the release of seven harmful components except for phenol. Among them, WBJ5 had the lowest tar, WBJ2 had the lowest HCN and NNK, WBJ3 had the lowest B[α]P, NH3, and WBJ4 had the lowest crotonaldehyde. WBJ4 had the highest hazard index, and WBJ2 had the lowest.
3.5. Effect of cutting parameters on the sensory quality of cigarette

Table 6 shows the sensory quality evaluation results of microwave expanded stem with different combinations of cutting parameters and a 13% blending ratio.

| Sample No. | Aroma quality (15) | Offensive taste (10) | Concentration (10) | Smoothness (10) | Irritancy (15) | Dryness (15) | Cleanliness (10) | Comfort (15) | Total  |
|------------|--------------------|---------------------|--------------------|----------------|---------------|--------------|----------------|--------------|--------|
| WBJ1       | 12.5               | 8.5                 | 7.9                | 8.5            | 12.6          | 12.5         | 8.3            | 12.3         | 83.1   |
| WBJ2       | 12.4               | 8.3                 | 7.7                | 8.5            | 12.2          | 12.2         | 8.1            | 12.5         | 81.9   |
| WBJ3       | 12.6               | 8.6                 | 8.1                | 8.2            | 12.3          | 12.2         | 8.3            | 12.5         | 82.8   |
| WBJ4       | 12.1               | 8.2                 | 7.2                | 7.9            | 12.3          | 12.1         | 8.2            | 12.1         | 80.1   |
| WBJ5       | 12.1               | 8.3                 | 7.6                | 7.5            | 12.4          | 12.0         | 7.9            | 11.8         | 79.6   |

According to the results of sensory evaluation, the sensory quality of WBJ1 and WBJ3 samples was better than that of WBJ3 samples. Among them, WBJ1 and WBJ3 samples mainly showed full aroma, prominent burnt aroma, continuous smoke, clear fresh, and slightly bitter aftertaste.

4. Conclusion and discussion

According to the comprehensive physical properties, smoke characteristics, and sensory quality, the overall quality of the WBJ3 sample is the best. That is, the optimal combination of cutting parameters is No.3, which shows that the slice thickness is 0.5mm, and the cutting width is 0.2mm. Under the combination of cutting parameters, not only the high whole cut tobacco ratio, moderate small particle content, the minimum tobacco loss from cigarette end, tar/nicotine, and CO/nicotine can be obtained, but also the sample has lower hazard index and better sensory quality.

Based on the work carried out under the special topic of "stem processing technology" in the research section of "microwave stem processing technology" under the systematic research route of "slim cigarette" blending formula. By optimizing cutting parameters, the compatibility of microwave expanded stem and slim cigarette can be further enhanced, sensory quality, filling performance, tar reduction, and harm reduction can be improved, and it can be used as a new blending formula unit.

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