Study on Ash Gray and Ash Condensation Index Evaluation during Combustion of Medium Cigarettes

Han ZHENG, Jianbo ZHAN, Zhenhua YU, Geng LI, Tao WANG, Ying ZHANG, Jiao XIE, Xu WANG, Baoshan YUE, Tingting YU, Liwei LI, Hao WANG*
R & D Centre, China Tobacco Yunnan Industrial Co., Ltd. 650231 Kunming, China
First author: ZHENG Han, zhengh@ynzy-tobacco.com
Corresponding author: WANG Hao, wanghao@ynzy-tobacco.com

Abstract. The color of cigarette paper directly affect the ash color and ash condensation quality of cigarettes. The ash color and ash condensation quality of cigarettes with black cigarette paper are studied by using the self-developed cigarette paper gray and ash condensation quality measuring equipment and taking black as the background color in this paper. The effect of black cigarette paper on the ash gray is discussed in the combustion process of black cigarette paper for the first time. The results show that the average grey value of black cigarette paper is 116.59, and the uneven grey value is mainly due to the non-uniformity of cigarette paper among different batches and the cut tobacco structure of medium cigarettes, on which the shooting from 3 different angles has a great impact. It is appropriate to calculate the grey and ash quality by taking the average value of 3-side shooting. Black background board is ideal for testing cigarette paper gray. The gray value difference of randomly selected cigarettes is too large, so it is necessary to measure in batches, and the measurement accuracy of gray value can be guaranteed only if the sample quantity is sufficient. The maximum deviation of gray value photographed by different cameras of the same cigarette is 18.17, which is 15.6% of the average value, and the average value of ash coagulation index is 90.20. The cigarette paper ash detection equipment used in this paper is accurate, which can reflect the cigarette ash performance comprehensively and objectively, and such an equipment has rich detective means, and has high automation and reliability in the analysis of detection results. It is necessary to take photos from different angles in the measurement process to ensure the accuracy of gray measurement value of a cigarette to the largest extent, as the samples showed significant differences.

1. Introduction

Cigarette paper is used to wrap the cut tobacco column of cigarettes. It can be made of flax, wood fiber or its mixture. It is a high-grade thin industrial paper. Daily cigarette paper is generally white. Color cigarette paper is a kind of characteristic cigarette paper different from white cigarette paper. Its unique personality packaging has strong personality characteristics and visual effect, giving people a refreshing feeling[1].

The main functions of cigarette paper include condensation cut tobacco and adapting to the working requirements of high-speed cigarette machine, meeting the taste requirements of cigarettes and provide exquisite appearance for cigarettes, adjusting the flammability of cigarettes and control the composition of smoke, preventing counterfeiting and stain cigarette, eliminating ignition tendency, improving safety, reducing side flow flue smoke. In addition, color cigarette paper can attract consumers' attention and make people quickly identify the brand and approximate price of cigarettes. It changes the disadvantage
of cigarette paper with single white color, providing consumers a refreshing and fashionable feeling. Cigarette paper with different colors can be produced by different dyeing processes. The colored cigarette paper produced by adding colored cotton fiber in the process of pulp production also has anti-counterfeiting effect. The color cigarette paper added with extract, tobacco fiber or other natural extracts can enhance the cigarette aroma and make the smoke soft and delicate, so as to improve the cigarette smoking quality, as these additives come from nature and can effectively reduce the impurity and irritation of cigarette paper. It has good coordination with cut tobacco aroma and can increase the sweetness and fullness of cigarette smoke[2-4].

Taking black cigarette paper as an example, considering the color particularity of black cigarette paper, using black as the background color and using the self-developed cigarette paper gray determination equipment, the gray and ash quality of cigarette ash of black cigarette paper are evaluated for the first time.

2. Experimental

2.1 Materials
Samples were selected among the cigarette with black paper sold in the market, one cigarette from each box of 20 cigarettes is selected as the sample, a total of 20 boxes of cigarettes are selected. A total of 20 samples are selected as the test samples. The test sample was placed under standard conditions for 48 hours.

2.2 Test equipment
The ash condensation index and gray in the combustion process of cigarette paper are tested by the self-developed cigarette ash condensation comprehensive test equipment. The structure of the test bench is shown in Fig. 1.

Fig. 1 Tester for full vision of cigarette combustion ash column (a: Light 1#, b: Camera 1#, c: cigarette positioning base, d: Light 2#, e: Camera 2#, f: background board, g: Light 3#, h: Camera 3#)

2.3 Calculation method

2.3.1 Combustion cone gray
1) When the collection length of cigarette combustion ash column meets the collection range of ash column grey analysis, collect cigarette combustion ash column through mechanical vision device for cigarette combustion ash column gray analysis (collection range of ash column length: 35 mm ash column picture after deducting 2 mm at the combustion end).
2) The gray value $Gray \times$ of the combustion ash column of the test cigarette sample is obtained by image gray value conversion (the floating-point method is used here, that is, $Gray \times = R \times 0.299 + G \times 0.587 + B \times 0.114$).

3) Calculate the gray value of the test sample according to Eq. (1), and take it as the gray result of the test sample.

$$Gray \ n = Gray \ x \times \eta$$

where, $\eta$ is the Calibration coefficient, $Gray \ x$ -- gray value of the sample under the condition of white balance, $Gray \ n$ - gray of test sample.

2.3.2 Ash condensation index
In the ash condensation analysis system, the ash condensation index was defined and tested[1].

3. Results and discussion

3.1 Comparison of combustion macro pictures

Fig. 2 Comparison of pictures taken by camera 1\# for different cigarettes (a) sample 2\#, (b) sample 4\#, (c) sample 10\#, (d) sample 15\#, (e) sample 19\#

Fig. 2 shows the figures of ash after combustion of different cigarette samples taken by the camera 1\#. It can be seen that the ash of different cigarette samples after combustion is rather different, and the ash color is different, and some appear gray, and some are gray or dark black. The inclination angles of ashes are different. The inclination in Fig. 2(e) is the most obvious, Fig. 2 (b) is the most straight, and the others have different slight inclination. The visible cracks have been marked with dotted boxes. It can be seen that there are obvious differences in the size of crack areas of different cigarettes, among which Fig. 2 (e) has the most obvious cracks and Fig. 2 (a) has the least cracks.

Fig. 3 Comparison of pictures taken by cameras of cigarette sample 1\# (a) Camera 1\#, (b) Camera 2\#, (c) Camera 3\#

Different angles of the same sample are shown in Fig. 3. It can be seen that there are obvious differences in the pictures of the same cigarette taken from 3 angles. Cigarette combustion deviates, and the deviation angle is different. Figs.3 (a) and 3(c) show that the cigarette tilts slightly, but the tilt angle is small, but it can be seen in Fig. 3 (b) that the tilt is obvious and the tilt angle increases. The comparison of the 3 rectangular boxes in Fig. 4 is more obvious. The ash area at the same part is different. The area in Fig.3 (a) is significantly smaller than that in Figs. 3(b) and 3(c). There are obvious cracks on the right
side of Figs.3 (a) and 3 (b), indicating that the ash condensation quality of cigarettes is poor, but the ash condensation quantity in Fig.3 (c) is good. If only the conventional single side shooting is applied, the real ash condensation effect of cigarettes cannot be fully reflected. Only the pictures from different angles can be used to comprehensively evaluate the ash condensation quality of cigarettes.

In order to quantitatively evaluate the above gray and crack area, the automatic calculation program module in the self-developed equipment was applied to calculate the mathematical statistical results of the pictures obtained by each cigarette on each camera, which are mainly divided into two parts, cigarette combustion gray and ash condensation index.

3.2 Cigarette combustion gray

| Samples | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Camera1# | 123.06 | 124.88 | 108.80 | 120.69 | 121.68 | 120.44 | 116.91 | 115.31 | 119.82 | 111.96 |
| Camera2# | 114.10 | 120.54 | 103.09 | 115.84 | 111.25 | 117.53 | 115.16 | 105.69 | 110.09 | 99.32 |
| Camera3# | 113.28 | 119.21 | 115.31 | 122.20 | 129.09 | 117.74 | 124.06 | 112.87 | 119.28 | 108.33 |
| Average | 116.81 | 121.54 | 109.07 | 119.58 | 120.67 | 118.57 | 118.71 | 111.29 | 116.40 | 106.54 |
| SD | 4.4307 | 2.4229 | 4.9942 | 2.7134 | 7.3192 | 3.8512 | 4.0841 | 4.4637 | 5.3139 |
| CV(%) | 3.793 | 1.9935 | 4.579 | 2.2692 | 6.0652 | 1.119 | 3.2442 | 3.6999 | 4.9878 |

The statistical results are shown in Table 1. It can be seen that the minimum gray value of different samples is 99.32, the maximum value is 132.46, the average value is 116.59, and the gray value difference is 33.14. The maximum deviation of the average value of different camera test values of different cigarettes is 19.08, which is 16.4% of the average value. It proves that the gray value of randomly selected cigarettes is too large. It is necessary to measure in batches, and the sample quantity is large enough to ensure the measurement accuracy of gray value. The maximum deviation of the gray value photographed by different cameras of the same cigarette is 18.17, which is 15.6% of the average value. It proves that it is necessary to take photos from different angles in the measurement process to ensure the accuracy of the gray measurement value of a cigarette to the greatest extent. Ash figures from one side alone cannot ensure the accuracy of the measurement.

There are many factors affecting the gray value of cigarettes, mainly including the quantitative and air permeability of cigarette paper, which are only the two main factors affecting cigarette ash and combustion speed, as well as combustion supporting agent, potassium and sodium ions and cut tobacco matching energy. Quantitative and air permeability cannot completely determine the quality of cigarette
ash and the speed of combustion. The mixing of reconstituted tobacco leaves has an important impact on the ash condensation ability of cigarettes, and the cigarette making technology also has an important impact on the ash condensation ability of cigarettes. The air permeability of cigarette paper increased, the quantity increased, the content of ash coagulant increased, the content of citrate combustion supporting agent decreased, the ash condensation capacity of cigarette paper increased. The obvious difference of samples is mainly due to the non-uniformity of cigarette paper between different batches and the great influence of cut tobacco structure on cigarettes. Future research could be concerning the quantitative control of cigarette paper and the quality ratio control of potassium/sodium salt. The combustion speed of cigarette paper and cut tobacco can be reasonably matched to ensure that cigarettes have good ash condensation effect, gray and strong ash holding capacity. The developed ash condensation cigarette paper has higher ash whiteness, fewer cracks, less ash falling and straight ash column, which is suitable for cigarette products of different specifications at the same time.

Table 2 Statistics of sample ash condensation index, variance and standard deviation

| Samples | 1<sup>st</sup> | 2<sup>nd</sup> | 3<sup>rd</sup> | 4<sup>th</sup> | 5<sup>th</sup> | 6<sup>th</sup> | 7<sup>th</sup> | 8<sup>th</sup> | 9<sup>th</sup> | 10<sup>th</sup> |
|---------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Camera1# | 94.46        | 94.22        | 88.67        | 94.3         | 92.98        | 92.32        | 87.93        | 92.62        | 91.85        | 89.13        |
| Camera2# | 90.12        | 95.49        | 76.42        | 88.36        | 84.75        | 89.88        | 89.66        | 88.63        | 89.05        | 79.09        |
| Camera3# | 90.70        | 94.56        | 88.37        | 90.84        | 92.28        | 92.18        | 93.17        | 88.13        | 93.14        | 87.21        |
| Average  | 91.76        | 94.76        | 84.49        | 91.17        | 90.00        | 91.46        | 90.25        | 89.79        | 91.35        | 85.14        |
| SD       | 1.9238       | 0.5368       | 5.7053       | 2.436        | 3.7256       | 1.1187       | 2.19         | 2.0092       | 1.7072       | 4.3515       |
| CV(%)    | 2.0966       | 0.5665       | 6.7529       | 2.672        | 4.1395       | 1.2231       | 2.4154       | 2.2375       | 1.869        | 5.1108       |

Table 2 lists the comparison between the statistical method standard deviation and the set ash index of 20 cigarette samples. It can be seen that the difference between the index values is 19.07. The maximum deviation of the average value of different camera test values of different cigarettes is 10.27, which is 11.3% of the average value. It proves that the ash condensation index value of randomly selected cigarettes is too large. It is necessary to measure in batches, and the sample quantity is enough to ensure the measurement accuracy of ash condensation index. The maximum deviation of the gray value photographed by different cameras of the same cigarette is 12.25, which is 13.6% of the mean value. In the measurement process, figures from three angles can best ensure that the measured value of the ash condensation index of a cigarette is close to the true value. Shooting on one side alone can not ensure the accuracy of the measurement.

The ash condensation condition of cigarettes under simulated artificial puff and smoldering state is numerically calculated according to the area proportion, which is conducive to the objective evaluation of ash condensation index. According to the self-developed cigarette ash condensation analysis software,
through the calculation of ash condensation index, the ash condensation ability of different brands of cigarettes is evaluated, and the influence of cigarette paper ash condensation performance on cigarette combustion performance is analyzed. The results show that the response of ash condensation analysis software is rapid, and the index can be regarded as an important index and effective means to measure cigarette ash condensation performance. This index can be applied to the evaluation of cigarette comprehensive performance, and the cigarette paper plays an important role in cigarette ash condensation performance. The cigarette paper ash detection equipment used in this paper has accurate test, which can comprehensively and objectively reflect the cigarette ash performance, which has rich detection means, automation and high reliability of detection result analysis.

4. Conclusion
1) The average gray value is 116.59. The maximum deviation of the gray value photographed by different cameras of the same cigarette is 18.17, which is 15.6% of the average value. It proves that it is necessary to take photos from different angles in the measurement process to ensure the accuracy of the gray measurement value of a cigarette to the greatest extent. Shooting on one side alone can not ensure the accuracy of the measurement. The obvious difference of samples is mainly due to the non-uniformity of cigarette paper between different batches and the great influence of cut tobacco structure on cigarettes.

2) The average value of ash condensation index is 90.20, and the difference between the values of ash condensation index is 19.07. The maximum deviation of the average value of different camera test values of different cigarettes is 10.27, which is 11.3% of the average value. It proves that the ash condensation index value of randomly selected cigarettes is too large. It is necessary to measure in batches, and the sample quantity is enough to ensure the measurement accuracy of ash condensation index. The cigarette paper ash detection equipment used in this paper has accurate test, which can comprehensively and objectively reflect the cigarette ash performance, rich detection means, automation and high reliability of detection result analysis.

3) There are differences in three groups of data from different angles of the same cigarette. It is necessary to take three side shooting and then take the mean value for measurement and calculation. This method can improve the reliability of the test results.

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