Experimental Study of Moisture Content Stability on the Low-speed Pneumatic Drying Process of Cut Stem

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Abstract. According to the principle of moisture control at outlet of the cut stem low-speed pneumatic drying equipment of SH23, we studied the relationship between the mixing air valve’s opening and moisture content stability of products and the relationship between the main equipment controllable process parameters and the mixing air valve’s opening by regression analysis. It provides the following basis for improving the moisture content stability by controlling the technological parameters of the equipment, the average value of the mixing air valve’s opening has a significant effect on the stability of moisture content, for each reduction of 1% moisture content in the low-speed pneumatic drying process, it is necessary to turn down the mixing air valve’s opening by about 8.175% and the influence degree of the main control parameters related to the mixing air valve’s opening is arranged.

Introduction

Pneumatic drying equipment has been more and more applied to tobacco drying process. At present, the low-speed pneumatic drying equipment has been supplied by a number of domestic equipment manufacturers. The main structure and the drying principle are basically similar [1-6]. Guang-ming Yao et al. investigated the effects of processing parameters on filling value and filamentation rate of the cut stem low-speed pneumatic drying equipment of SH23 by single factor experiment and orthogonal experiment [7]. Yan-yang Yang et al. improved the qualified rate of outlet moisture content of SH984 pneumatic drying equipment by adjusting the testing point of outlet moisture meter from the drying export to the electronic scale after air delivery of cut stem [8]. At present, there are few reports about the influence of processing parameters of the cut stem drying equipment on the stability of cut stem moisture content.

Materials and Methods

Materials

The same formula cut stem was used in the trial [9].

Experimental instrument

Online moisture meter (TM710); Oven (FD115, FD240); Environmental temperature and humidity detector (Testo 174H); The cut stem low-speed pneumatic drying equipment with energy-saving (SH23, Jiangsu Zhi Si Machinery Group Co., Ltd.)

The Work Principle of the Cut Stem Low-speed Pneumatic drying Equipment of SH23

Moisture removal pipe and cold-hot air distribution pipe are butted at outlet of circulating fan. Part of the air after moisture removal is heated in a hot stove, the other enters the mixing box directly through the bypass duct. In the mixing box, the air heated by the hot stove is fully mixed with the air coming directly through the bypass duct and enters the feed pipe. At the same time, the wet material is flashed through the flash puffing device to dry through the feed gas lock and into the feed pipe, enters the drying pipe driven by hot air. After drying, the material and hot air enter the
gas separation device together. The material is discharged through discharge gas lock. The hot air enters centrifugal dust separator and after dust removal returns to the circulating fan through the return duct to form a circulation system.

The principle of outlet moisture control: according to the comparison between the prescribed outlet moisture and the actual moisture content, adjust the mixing air valve’s opening to make the outlet water meet the technological requirements.

The main controllable machining parameters that affect the mixing air valve’s opening include: the frequency of the circulating fan, the exhaust air valve’s opening, the flow of flash-off steam, the temperature of flash-off steam and the temperature of the hot blast stove.

**Experimental Method**

Stability analysis of the mixing air valve’s opening and moisture content. First batches of production days in 2017 were selected as experimental subjects. Record the mixing air valve’s opening data, the average value and standard deviation of moisture content before and after drying. Analyze the relationship between moisture content stability and the mixing air valve’s opening by regression analysis.

Based on the data collected in the previous step, the relationship between the decrease of moisture content and the mixing air valve’s opening is obtained by running regression analysis, which provides a correction coefficient for eliminating the influence of moisture content of incoming material in single factor experiment of equipment process parameters.

Set experimental parameters for the frequency of the circulating fan, the exhaust air valve’s opening, the flow of flash-off steam, the temperature of flash-off steam and the temperature of the hot blast stove in allowable range of process specification (see Table 1). Find out the relationship between various factors and the mixing air valve’s opening by single factor experiments.

| Name of process parameter | Unit | Value1 | Value2 | Value3 | Value4 | Value5 |
|---------------------------|------|--------|--------|--------|--------|--------|
| The frequency of the circulating fan (X1) | Hz    | 31     | 32     | 33     | 34     | 35     |
| The exhaust air valve’s opening (X2) | %     | 53     | 55     | 57     | 59     | 61     |
| The flow of flash-off steam (X3) | Kg/h  | 1020   | 1035   | 1050   | 1065   | 1080   |
| The temperature of flash-off steam (X4) | ℃     | 145    | 148    | 150    | 153    | 156    |
| The temperature of the hot blast stove(X5) | ℃     | 200    | 205    | 210    | 215    | 220    |

**Test Method**

The mixing air valve’s opening is automatically recorded by the electrical converter of the equipment, and the average value and standard deviation are calculated.

The data of cut stem moisture content is recorded by on-line moisture meter every 5 seconds, and the average value and standard deviation were calculated.
The online moisture meter is calibrated periodically according to the technological standard to ensure its accuracy.

Results and Analysis
Influence of the Average Value of the Mixing Air Valve’S Opening on Moisture Content Stability

![Regression Analysis Result](image)

Illustration: SD(D) is short for the decrease of standard deviation of moisture content. MAVO(A) is short for the average value of the mixing air valve’s opening.

![Distribution Analysis](image)

Figure 1. Regression analysis of SD(D) and MAVO(A).

Figure 2. Distribution and analysis of standard deviation of the mixing air valve’s opening.

Conclusion: It can be seen from Figure 1, the average value of the mixing air valve’s opening has a significant effect on the stability of moisture content. With the increase of the average value of the mixing air valve’s opening, the greater the difference between the standard deviation of moisture content before drying and after drying is, the larger the increase of moister content stability of products is.

The reason may be: 1. Statistical analysis of experimental data shows that the standard deviation
of the mixing air valve’s opening is about 12%, and the maximum deviation is about 20% (see
Figure 2). The average value of the mixing air valve may cause the control value of the air valve’s
opening to exceed the throttle control range; 2. The mixing air valve is controlled by butterfly valve,
the closer the opening to the extreme value is, the lower the control sensitivity is. Both of these
reasons will result in the increase of the stability of moisture content with the increase of the
average value of the mixing air valve’s opening.

Illustration: MC(D) is short for the decrease of moisture content. MAVO is short for the mixing
air valve’s opening.

Conclusion: In order to increase the decrease of moisture content, the mixing air valve’s opening
should be lower, that is, to get drier products, lower parameters of the mixing air valve’s opening
should be required. It can be seen from the figure 3 that for each reduction of 1% moisture content
in the low-speed pneumatic drying process, it is necessary to turn down the mixing air valve’s
opening by about 8.175%.

Influence of Main Control Parameters on the Mixing Air Valve’S Opening

Illustration: X1 is short for the frequency of the circulating fan. X2 is short for the exhaust air
valve’s opening. X3 is short for the flow of flash-off steam. X4 is short for the temperature of
flash-off steam. X5 is short for the temperature of the hot blast stove. M (AC1~5) is short for the
mixing air valve’s opening after corrected related to X1~5.
Conclusion: 1. The main equipment control parameters significantly related to the mixing air valve’s opening are the frequency of the circulating fan, the exhaust air valve’s opening and the temperature of the hot blast stove. The correlation between the flow and the temperature of flash-off steam and the mixing air valve’s opening is weak. 2. According to the slope of fitting line, it can be judged that the influence degree of the control parameters on the exhaust air valve’s opening is arranged from large to small as follows: the temperature of the hot blast stove > the exhaust air valve’s opening > the frequency of the circulating fan. The temperature of the hot blast stove and the frequency of the circulating fan are positively related factors, the rest is negative related factor. 3. With the increase of the frequency of the circulating fan, the change range of the mixing air valve’s opening decreases.

Summary and Discussion

The average value of the mixing air valve’s opening has a significant effect on the stability of moisture content. With the increase of the average value of the mixing air valve’s opening, the greater the difference between the standard deviation of moisture content before drying and after drying is, the larger the increase of moister content stability of products is.

For each reduction of 1% moisture content in the low-speed pneumatic drying process, it is necessary to turn down the mixing air valve’s opening by about 8.175%.

The main control parameters related to the mixing air valve’s opening are the frequency of the circulating fan, the exhaust air valve’s opening and the temperature of the hot blast stove. The influence degree is arranged from large to small as follows: the temperature of the hot blast stove > the exhaust air valve’s opening > the frequency of the circulating fan.

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