Design and application of double closed loop weight control system for cigarette maker

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Abstract. In order to solve the problem that the precision of cigarette weight control system is not high enough in cigarette machine production, a double closed loop weight control system of cigarette machine is designed according to the characteristics of cigarette machine control system. This system takes IPC as the control core. Firstly, the current cigarette weight is obtained, then the weight deviation is calculated, and then the distance to be moved by the actuator is calculated based on the deviation. Then the current position of the actuator is obtained, and the target position of the actuator is calculated. The results show that the long-term deviation of the weight control system using the double closed-loop control method can be reduced to less than 4.0mg during the production of the target weight of 490mg cigarette, which is 0.8mg lower than that of the single closed-loop control method. This technology can improve the quality of cigarette process and reduce the overall consumption.

1. Introduction

The high-quality development of the industry has put forward higher requirements for cigarette products and promoted the supply-side structural reform. Under such challenges, the company has launched fine cigarettes, short cigarettes, medium cigarettes and other products to meet the diversified needs of the market. Compared with conventional cigarettes, the weight of the above-mentioned cigarettes is lighter and the relative deviation in the production process is relatively large. Therefore, the conventional cigarette weight control system cannot meet the needs of the stability in the production process. For this reason, the double closed loop weight control system of cigarette machine is designed to meet the stable production requirements of unconventional cigarette. [1-7]

2. The system design

Firstly, the principle of weight control system is introduced, and then according to the principle and the structure of cigarette maker, the double closed-loop control method is designed.

2.1. Principle of weight control system

Logical control task

The process diagram of cigarette weight detection and control of cigarette machine is shown in Figure 1. Tobacco sucked the negative pressure adsorption, wind on the belt belt on the adsorption of tobacco with the movement of the belt, when tobacco after leveller, excess of tobacco will be split off, the rest of the tobacco through the leveller, after cigarette paper package, create smoke, smoke article after microwave weight detection, microwave after weight information transfer to weight control system, the weight of the controller according to the current value and YanZhi YanZhi weight weight value difference, pass need to adjust the position of the flat position controller, flat position controller based on numerical control level of upper and lower position.
Based on the above process flow chart, the block diagram of the weight control system is as follows:

2.2. Double closed-loop control system design

In order to lift the weight control accuracy, it is necessary to design a piecewise double closed-loop weight control method according to its characteristics. The method is based on the closed-loop feedback principle, as shown in FIG. 3. The control structure is a typical cascade control structure. The outer ring detects and controls the weight of the cigarette, while the inner ring detects and controls the position of the belt. The outer ring controller is a two-stage PID controller (only P of the proportional link), while the inner ring controller only performs a linear transformation. The control block diagram is as follows:
Control algorithm explanation:

This algorithm adopts a two-part P control and gives as shown in the above formula, the controller in each computation period n (n is YanZhi), calculation of microwave values and the target weight deviation, when the deviation is less than the dividing line between the value of n, in the proportion of weight ring using a small inhale weight deviation coefficient calculation for belt needed to move the distance, the distance of migration and the location of the current belt absorption value belts of target location is calculated, and then in belt control loop, the servo motor which can adjust the PID self-tuning based on position control, a control cycle is complete.

Here, there are two other Settings. First, a dead zone should be set, that is, the dead zone of the belt suction position. When the weight deviation occurs, the belt suction needs to move to offset the deviation. Secondly, the deviation value is a cumulative value, and only when the accumulated deviation in one direction reaches the dead zone will the movement be carried out, instead of discarding each deviation.

The main purpose of the above approach is to make the movement of the belt more reasonable, smooth and fast, in order to better reduce the weight control system deviation value. Based on the above algorithm, the following important control parameters are formed, which are explained as follows:

1) Boundary N value: it is used for the boundary value of fast and slow proportional coefficient;
2) Large fast proportional coefficient IXM: When the deviation is greater than N value, this value is used for proportional control;
3) Small slow proportional coefficient IXM: When the deviation is less than N value, this value is used for proportional control;
D: When the calculated displacement of the belt is less than this value, the belt does not move; When the calculated displacement of the belt is greater than this value, the belt suction movement.
4) Control period T: refers to the number of cigarettes as a control period.
5) Lag of the splitting tool: represents the control dead zone;

3. Parameter adjustment

3.1. The basis of adjustment

Control dead zone D: The measuring range of the belt position sensor is -10V--+10V. With 10-bit ND, the minimum measurement accuracy is 20/1024=0.0195V. According to the invention patent applied by the project -- a representation method of filling value, which involves the following relations:

1) According to the upper and lower limit spacing C within the range of [-7V, +7V], the conversion relation between the volts of the belt and the number of millimeters can be obtained as 0.27mm/V;
2) The spacing between the limit position under the belt and the flat plate x= n-c +b;
3) The relationship between the production position of the belt and the spacing y between the belt and the flat plate is:

\[
y (\text{mm}) = 4.32 (\text{mm}) + (7+P) (\text{V}) \times 0.27 (\text{mm/V})
\]

Step 2. Simulate the relationship between the filling value Z and the position volts P of the belt:
According to the relationship in Step 1, the length L and weight W of the nozzle-free cigarette of this specification, the relationship between the simulated filling value Z and the position volts P of the drawing belt is as follows:

\[
Z = \frac{59 \times 9 \times 10^{-3} (\text{cm}^3)}{W (\text{g})} = (3297.51 + 143.37P) \times 10^{-3} / W \text{ (cm}^3/\text{g}) ;
\]

On the basis of this theory, we can get under the setting of the weight 700 mg and 650 mg, filling it hypothesis is 5.5, 50 mg of weight deviation corresponding belt position deviation is 1.92 V, the weight of the V corresponding to each deviation about 26 mg, suction belt position sensor further calculated by the measuring accuracy of 0.0195 V corresponds to the weight of about 0.5 mg, because we adjust the unit of weight minimum is 1 mg daily, so dead zone is set to 0.039 V reasonable setting.

Control period T: The time interval between two control operations, in units of 16 cigarettes. The range is 1 to 255, with a factory value of 3. As a rule of thumb, pick 2 to 4. When t=2, it means that every 32 cigarettes is used to calculate the control once, and the control cycle is 32*59mm=1888mm, which is basically equal to the length of the belt to the microwave, and it is more appropriate as the control cycle.

The fast proportional coefficient IXM is large, the slow proportional coefficient IXM is small, and the boundary value N needs to be determined by experiment.

Test specifications: 89mm in length, 490mg in weight of nozzle-free smoke, production speed 6000 PCS/min.

After parameter setting, the optimal parameter combination can be obtained as follows:

Mean long-term standard deviation: 3.6mg; Long term standard deviation SD value: 0.23mg Weight deviation Mean: 1.4mg weight deviation SD value 0.21mg.

3.2. Results comparison
The test results of the weight control system using the double closed-loop control mode are compared with the operation results of the traditional single closed-loop weight control system, and the comparison is as follows:

| Group          | mean of long-term standard deviation | SD value of long-term standard deviation | Mean of Weight deviation | SD value of Weight deviation |
|----------------|--------------------------------------|-----------------------------------------|--------------------------|-------------------------------|
| Single closed  | 4.4                                  | 0.29                                    | 1.7                      | 0.25                          |
| Double closed  | 3.6                                  | 0.23                                    | 1.4                      | 0.21                          |

4. Conclusion
The weight control system of cigarette maker using double closed loop control method can significantly reduce the long-term standard deviation of cigarette maker weight, has significant benefits on improving the stability of product quality, and has a relatively obvious effect on unconventional cigarettes, so it has the value of popularization and application.

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