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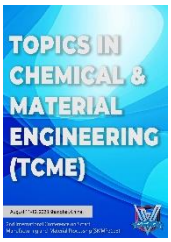

REVIEW ARTICLE

OPTIMIZATION DESIGN OF AUTOMATIC REVERSING CONTROL METHOD FOR AUXILIARY MATERIALS OF TOBACCO STORAGE CABINET EQUIPMENT

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ABSTRACT

In order to solve the problems that the paving car and the paving belt do not automatically reverse and the distribution car does not move when the tobacco leaf storage cabinet is fed, the storage cabinet feeding system is optimized and improved. firstly, the hardware of the storage tank feeding system is improved, the detection switch of deceleration bit and limit bit is added in the hardware, the speed reduction and limit detection switch are added in the hardware to adjust the speed and limit position of the paving car; Secondly, the program control of the storage cabinet feeding system is improved. Combined with the improved hardware detection switch, the feeding pre-self-inspection mode, time control mode and production control logic are optimized and designed. The feeding processes of tobacco leaf storage cabinet and tobacco cut storage cabinet in Shijiazhuang Cigarette Factory were tested, the results show that in the improved storage cabinet feeding system, the feeding failure rate is reduced by 83.7% because the proximity switch is not triggered, the number of times of the feeder car rushing out is reduced by 84.6% because the proximity switch is not triggered, and the storage cabinet is damaged for 0 times because the feeder car rushing out of the proximity switch. The technology can effectively solve the problems of paving car and the paving belt reversing and distribution car inching, reduce the failure of storage cabinet feeding system, and effectively improve production efficiency.

KEYWORDS

Storage cabinet feeding, reverse, hardware improvement, control logic optimization

1. INTRODUCTION

In the tobacco production line, the equipment of tobacco storage cabinet mainly solves the problem of balancing the temperature and humidity of tobacco leaves and the connection between the processes before and after production is not restricted and affected in the production process. Generally, the tobacco leaves produced in this process do not directly enter the next process for production, but enter the storage cabinet to store the materials horizontally, so that the moisture and temperature of tobacco leaves can be balanced, and the tobacco leaves produced in the next process can be prepared at the same time (Pengchao et al., 2022; Kefeng et al., 2019; Kefeng, 2013; Yunpeng, 2013). In order to ensure the continuous feeding production of the tobacco storage cabinet, the equipment can operate normally and meet the requirements of the material tile cabinet; Wangxudong mentioned the new stack seeking control mode and effectively solved the phenomenon of tobacco leaf agglomeration, but the stack seeking control mode could not effectively balance the moisture content and temperature of tobacco leaf, affecting the stability of tobacco leaf process quality; Wang Chaoping studied the dual vehicle synchronous positioning system of the distribution vehicle and the paver and solved the problem of synchronous operation of the paver and the distribution vehicle, but the reliability of the reversing problem of the paver has not been solved; Wangyingbin and others optimized the operation logic program of the distribution vehicle, solved the problem of changing the storage cabinet, but did not solve the problem of non inching distribution during the feeding process of the storage cabinet (Xudong, 2017; Chaopeng et al., 2017; Yingbin et al., 2005).

2. PROBLEM ANALYSIS

2.1 Existing Problems

The feeding of tobacco storage cabinet is composed of tobacco distribution conveyor belt, tobacco paving conveyor belt, cabinet body, reversing proximity switch, laser rangefinder, etc. as shown in Figure 1 (Farah, 2022; Qiuqiong, 2022; Run et al., 2022). During the process of materials entering the storage cabinet, the materials are evenly spread into the cabinet through the equipment such as the belt entering the cabinet, the tobacco distribution conveyor belt, the tobacco auxiliary material belt, etc. (Anonymous, 2022; Jun et al., 2020; Tarbell, 2023). The specific control process of tobacco entering the cabinet is as follows: when the cabinet number is selected, the tobacco distribution conveyor belt will automatically find the selected cabinet number through the laser rangefinder, during the feeding production, it will carry out reciprocating inching travel within the boundary of the cabinet, and the inching travel is controlled by the reversing switch, the travel reversing of the tobacco leaf paving conveyor is mainly to trigger the proximity switch signal, and the control program gives the paving motor reverse command. When the tobacco leaf paving conveyor moves to one end of the cabinet, and the metal baffle triggers the proximity switch, the tobacco leaf paving conveyor and the tobacco leaf paving conveyor belt will reverse, and the tobacco leaf distribution conveyor will inch one step until the cabinet entry is completed (Mahyar et al., 2023; Luis et al., 2022). The control logic is shown in Figure 2. When the tobacco leaves are put into the tobacco storage cabinet, the tobacco paving conveyor truck often does not automatically change direction when walking to the top of the cabinet, resulting in discontinuous material entering the cabinet or uneven

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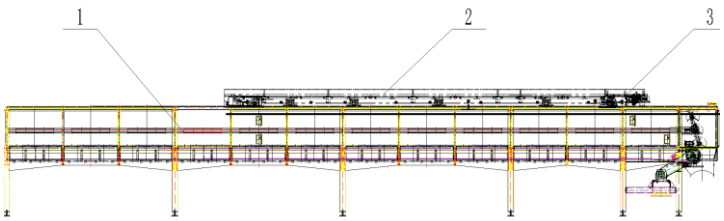
spreading, which can not reach the balance of moisture content and temperature of tobacco leaves. In serious cases, the tobacco paving conveyor truck collides with the stop on the top of the cabinet, resulting in damage to the cabinet or tobacco paving conveyor truck, reducing production efficiency and seriously affecting the process quality of tobacco leaves.



1 cabinet 2 Tobacco paving conveyor belt 3 Tobacco paving conveyor truck

Figure 1: Schematic diagram of storage cabinet structure

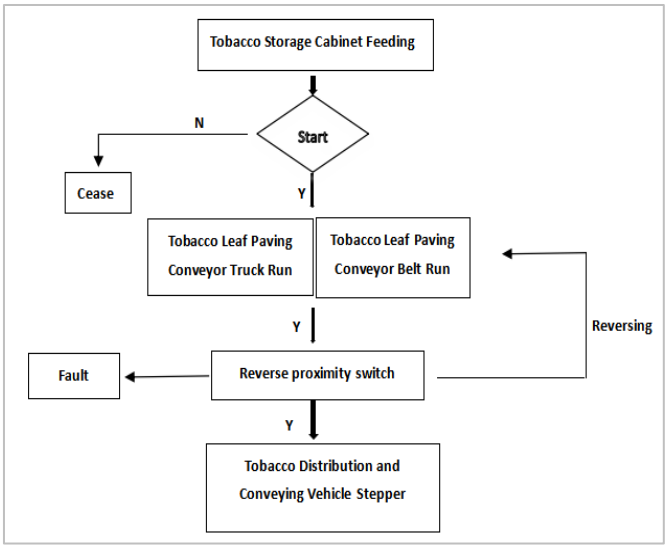


Figure 2: Control logic diagram of cabinet entry system

2.2 Cause Analysis

In view of the problems that the tobacco paving conveyor does not automatically change direction and the tobacco distribution conveyor does not move when the tobacco paving conveyor enters the cabinet, a three-month fault record is made for the feeding process of the tobacco storage cabinet, as shown in Table 1. Through the analysis of fault records and control procedures, it is concluded that the following aspects are the main causes. First, the appearance of the reversing metal detection baffle installed on the tobacco paving conveyor is deformed, resulting in the failure of the reversing proximity switch to trigger, resulting in no reversing and no inching; Second, the proximity switch has been affected by the walking vibration of the paver for a long time, which makes the proximity switch loose and can not be triggered; Third, when the proximity switch is triggered during the travel of the tobacco paving conveyor, the metal baffle of the tobacco paving conveyor will rush out of the proximity switch due to its large inertia. Even if the proximity switch is triggered, it will directly rush out due to its inertia; Fourth, the commutation control condition is single, resulting in feeding failure after the commutation switch has no signal.

Table 1: Storage cabinet feeding fault records

Process Section	Detection of sensing blank	Proximity switch loose	The tobacco paving conveyor truck rushes out	The tobacco distribution conveyor does not move	The tobacco paving conveyor belt does not operate	Other
Leaf storage cabinet	5	6	4	1	2	0
Tobacco storage cabinet feeding section 1	3	6	2	0	0	1
Tobacco storage cabinet feeding section 2	4	4	3	0	0	0
Tobacco storage cabinet feeding section 3	5	4	4	0	1	1

Note: the recording time is from March to June 2022.

3. Optimization and Improvement of Tobacco Storage Cabinet Control Logic

By analyzing the feeding equipment of tobacco storage cabinet, the hardware and control logic were improved and optimized. Firstly, the control detection hardware was optimized and improved, and the deceleration position proximity switch and limit position safety travel switch were added; Secondly, the program control logic is optimized, and the pre self-test mode, time control mode and production control mode are designed to eliminate the problems that can lead to the non-automatic reversing of the tobacco feeding conveyor and the non inching of the distribution conveyor.

3.1 Hardware Improvement

3.1.1 Decelerate Position Proximity Switch

In order to avoid that the reversing proximity switch is not recognized due to the large inertia of the tobacco paving conveyor, the hardware is

improved. A decelerating position proximity switch is installed before the reversing proximity switch, so that the tobacco paving conveyor can decelerate ahead of the reversing proximity switch, i.e. decelerate, to avoid the large inertia caused by the weight of the tobacco paving conveyor, After triggering the commutation proximity switch, it causes no commutation or untimely commutation, resulting in the failure of travel. The schematic diagram of its installation position is shown in Figure 3.The proximity switch belongs to a position sensor with switching value output, which is not directly in contact with the moving parts. When the detected object approaches the sensing surface of the switch, the detection element generates an electromagnetic field, and then controls the on or off of the switch to make the switch act. Its principle structure is shown in Figure 4.

1 Reversing proximity switch 2 Decelerate position proximity switch

Figure 3: Installation diagram of deceleration position proximity switch

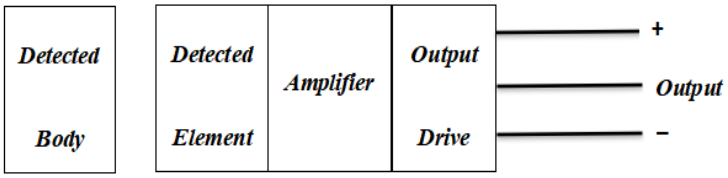


Figure 4: Schematic diagram of proximity switch

3.1.2 Limit Position Safety Travel Switch

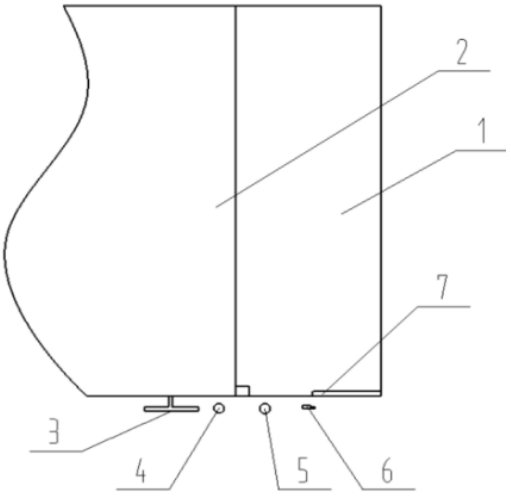
In order to avoid the failure of deceleration and commutation detection when the tobacco storage cabinet enters the cabinet, limit position travel switches are installed at both ends of the cabinet to protect the cabinet equipment and safety. The working principle of the travel switch is to use an external object to hit the roller of the travel switch, and the transmission rod and the rotating shaft act together to make the cam push the bump block, so as to push the microswitch to act rapidly. When the external bump block on the roller is removed, The return spring can reset the travel switch. When the tobacco paving conveyor truck hits the travel switch, the tobacco storage cabinet feeding system stops and the feeding operation is prohibited. The installation diagram is shown in Figure 5.

3.2 Optimization of Program Control Logic

The program control logic was optimized in combination with the newly added deceleration and limit switches in the hardware improvement. In order to avoid the failure of tobacco storage cabinet due to a single control condition in the production process, that is, the proximity switch was not triggered, the pre self check mode, time control mode and new production control logic were added in the control logic during the program optimization.

3.2.1 Pre self Check Mode

The pre self check mode refers to that when the storage cabinet equipment is automatically started after entering the cabinet, the paver and the paver belt carry out operation detection, and walk back and forth in the cabinet for 2 weeks. The control conditions for self detection are the positive and negative feedback detection of the paver, the positive and negative feedback detection of the paver belt, the signal detection of the proximity switch of the cabinet deceleration position, the proximity switch detection of the cabinet commutation position, etc, When a switch signal is detected or the motor feedback signal is detected incorrectly, the cabinet will send a feed alarm in the pre self-test mode. If all the detection signals are normal after 2 weeks of walking, the feed production will start. The pre self check mode control process is shown in Figure 6.



1 cabinet; 2 Tobacco paving conveyo; 3 Metal sensor; 4 Decelerate position proximity switch; 5 Reversing proximity switch; 6 Limit position travel switch; 7 Impact rubber block

Figure 5: Schematic diagram of travel switch installation

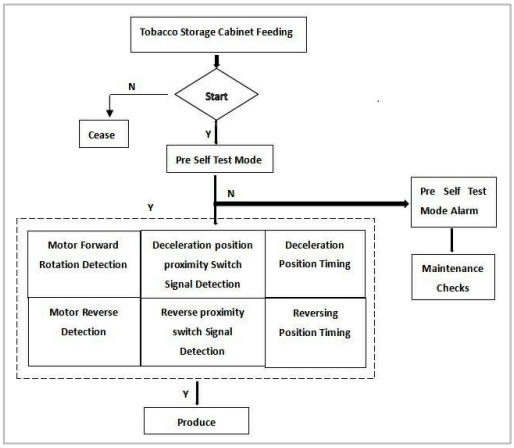
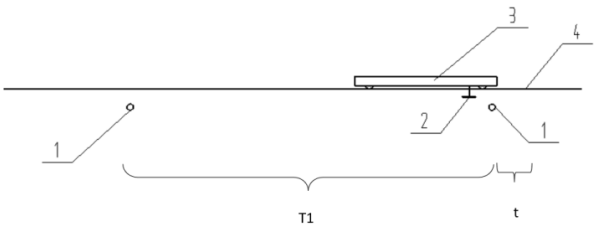


Figure 6: Pre-self-check mode control logic relationship

3.2.2 Time Control Mode

There is only a single control condition for the tobacco paving conveyor, the reversing of the paving conveyor belt and the inching of the tobacco distribution conveyor in the tobacco storage cabinet, that is, to trigger the reversing proximity switch signal. In order to avoid the signal of the proximity switch becoming a single condition for reversing, the control conditions in the original program control logic are improved and optimized, and the time control mode is added. The improved control condition is that the time and the reversing proximity switch carry out the reversing control. When controlling the time, when the tobacco storage cabinet is feeding, in the cabinet pre self-test mode, the tobacco paver will add a certain delay time t to the time T_1 from triggering the reversing proximity switch at one end to triggering the reversing proximity switch at the other end. Avoid that the tobacco paving conveyor does not reverse because the reversing proximity switch cannot be triggered. After the reversing time is reached, the reversing proximity switch will reverse whether it is triggered or not. When the proximity switch can be triggered, the trigger time T_1 will be updated at any time with the operation of tobacco paving and conveying to avoid reversing the tobacco paving and conveying vehicle before it reaches the proximity switch due to the acquisition error of T_1 time. The schematic diagram of time acquisition is shown in Figure 7.The actual reversing time of the paver is T:

$T = T_1 + t,$ t——Delay commutation time;



1 Reversing proximity switch 2 Metal sensor 3 Tobacco paving conveyor 4 cabinet

Figure 7: Time control time acquisition diagram

3.2.3 Production Control Logic Relationship

The logic relationship of production control is that after the pre self inspection mode is completed, the tobacco storage cabinet entry system enters the production control mode. During the process of tobacco storage cabinet feeding from pre self inspection mode to production control, considering uncontrollable factors such as smoke and dust at the production site, environmental temperature and humidity, manual batch change and group maintenance, the proximity switch of deceleration position or reversing position was not triggered during tobacco storage cabinet feeding. The analysis of the cabinet entry shows that in the normal production, the main phenomena of the cabinet entry are: a. the decelerating position proximity switch is triggered, and the reversing proximity switch is triggered, so the normal production; b. The decelerating position proximity switch is not triggered, and the reversing proximity switch is triggered; c. The decelerating position proximity switch is triggered, and the reversing proximity switch is not triggered; d. The decelerating position proximity switch is not triggered, and the reversing position proximity switch is not triggered. The control logic relationship is shown in Figure 8, and for the program optimization design, if any proximity switch is not triggered, it will generate an alarm prompt, which will not cause the cabinet entry to stop. In this case, the cabinet entry will enter the corresponding time control mode.

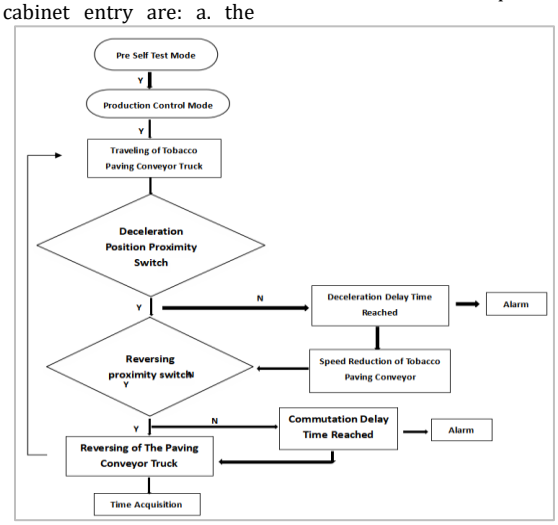


Figure 8: Production control logic relationship

4. Effect Verification

After the optimization and improvement of the feeding hardware and control logic method of the tobacco storage cabinet, the improved effect was verified on the spot. The verification test equipment selected the sections with different production environment on the spot, namely the cut tobacco storage cabinet section (with more smoke) and the leaf storage cabinet section (with higher temperature and humidity).

4.1 Test Design

Material: "Diamond Series" cigarette leaf silk.

Equipment: Hebei Baisha Tobacco Co., Ltd. cut tobacco storage section production line, including 1 section of cut tobacco cabinet, 2 sections of cut tobacco storage cabinet, 3 sections of cut tobacco storage cabinet, a total of 23 groups of cabinets, and Leaf storage cabinet, a total of 8 groups of cabinets.

Methods: before and after the improvement of tobacco storage cabinet feeding, the number of times that the feeding and spreading transport vehicle of tobacco storage cabinet had no reversing, the number of times that the reversing proximity switch had not been triggered (the number of times that the spreading transport vehicle rushed out of the proximity switch and the number of times that the reversing proximity switch had not been triggered), and the number of times that the tobacco storage cabinet cabinet was damaged (the number of times that the spreading transport vehicle crashed into the end of the cabinet after rushing out of the proximity switch). The test time is 3 months.

4.2 Data Analysis

It can be seen from table 2 that under different production environments, the improved deceleration position proximity switch has no trigger times and has a large number of times to rush out. The program optimizes and designs the deceleration position time control mode. The tobacco paving conveyor truck delays arrival deceleration, which greatly improves the trigger reversing position proximity and the times to rush out of the paving conveyor truck. Among them, the feeding failure caused by the lack of starting of the reversing proximity switch was reduced by 83.7%, the number of times the paver truck rushed out was reduced by 84.6% due to the lack of triggering of the reversing proximity switch, and the cabinet damage caused by the paver truck rushing out of the proximity switch was 0. The failure rate of tobacco storage cabinet feeding system was significantly reduced, and the production efficiency was effectively improved.

Table 2: Test data of cabinet entry system of tobacco silo before and after modification

Process Section	BEFORE IMPROVEMENT			AFTER IMPROVEMENT				
	Commutation without triggering		Cabinet damage	No trigger deceleration position signal		Commutation without triggering		Cabinet damage
	Times of rushing out	No trigger times		Times of rushing out	No trigger times	Times of rushing out	No trigger times	
Leaf storage cabinet	4	11	2	4	9	1	3	0
Tobacco storage cabinet feeding section 1	2	9	2	2	8	0	1	0
Tobacco storage cabinet feeding section 2	3	8	1	3	9	0	2	0
Tobacco storage cabinet feeding section 3	4	9	1	3	6	1	0	0
Total	13	37	6	12	22	2	6	0

Note: the test time before improvement is from April to July 2022, and the test time after improvement is from August to November 2022.

5. Conclusion

Through optimizing and improving the design of the tobacco storage cabinet feeding system, the hardware detection was improved and added, that is, the deceleration position proximity switch and the limit position proximity switch; The program control logic was optimized, and the pre self inspection mode, time control mode and production control logic relationship were designed, which greatly reduced the feeding failure of tobacco storage cabinet and improved the production efficiency. Taking the leaf storage feeding system and wire storage feeding system of Hebei Baisha Tobacco Co., Ltd. as the object, the optimization, improvement and test were carried out. The results showed that the feed failure rate of the improved tobacco storage cabinet feeding system was reduced by 83.7% due to the non triggering of the proximity switch, and the number of times the tobacco paver truck rushed out was reduced by 84.6% due to the non triggering of the proximity switch, and the cabinet damage caused by the proximity switch of the paver truck was 0.

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