Study on Stability of Wind Wire Feeding System in Cigarette Factory

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Abstract. This paper studies the high efficiency and stability of the continuous application of the wind wire feeding system. Combined with the technological transformation of the cigarette factory's roll production process characteristics and equipment layout adjustment, this paper optimizes the wind wire feeding operation mode, improves the upgrading space of the system, integrates the system structure, meets the process requirements of medium cigarette production, and solves the problem of large wind speed fluctuation in the process of cut tobacco air feeding The wind speed control is not accurate, so as to save energy consumption and ensure the reliable operation of the wind wire feeding system. The wind wire feeding system is mainly used for the continuous and uniform transportation of tobacco materials such as sheet tobacco and cut tobacco, and has the function of buffer and adjustment between various processes, realizing the automatic transportation of cut tobacco from the silk workshop to the cigarette machine, which has good popularization value.

Keywords: Wind Wire Feeding System; Cigarette Factory; Optimize Operation Mode.

1. Introduction

This paper studies the high efficiency and stability of the continuous application of the wind wire feeding system. Combined with the technological transformation of the cigarette factory's roll production process characteristics and equipment layout adjustment, this paper optimizes the wind wire feeding operation mode, improves the upgrading space of the system, integrates the system structure, meets the process requirements of medium cigarette production, and solves the problem of large wind speed fluctuation in the process of cut tobacco air feeding The wind speed control is not accurate, so as to save energy consumption and ensure the reliable operation of the wind wire feeding system. The wind wire feeding system is mainly used for the continuous and uniform transportation of tobacco materials such as sheet tobacco and cut tobacco, and has the function of buffer and adjustment between various processes, realizing the automatic transportation of cut tobacco from the silk workshop to the cigarette machine, which has good popularization value.

2. Cigarette Machine Layout

G9 / G10 equipment is located in Zone III of wind wire feeding system, and G11 equipment is located in Zone IV of wind wire feeding system. 1. Most of the three zones are ultra-high-speed units. There are differences in the process indexes of air supply pressure and speed given by ultra-high speed cigarette machine and medium speed cigarette machine. The different process indexes lead to large fluctuation range of wind speed and inaccurate wind speed control, which reduces the stability of wind wire feeding system, resulting in disconnection of tobacco and frequent shutdown of cigarette machine due to no tobacco. 2. G9 / G10 / G11 belong to the middle cigarette production unit. The dust removal equipment in zone 3 and zone 4 shall be started at the same time for the simultaneous production of three units, resulting in unnecessary energy waste. Through the integration and optimization of medium cigarette equipment, the impact on the air supply of medium cigarette cut tobacco in the production of different models of units is reduced and the stability of the system is improved.

At present, the layout of wind wire feeding system is divided into four areas, each of which is 1 control 9. At present, zone 1, zone 2 and zone 3 operate at full load, and zone 4 controls three cigarette air feeding equipment. For the replacement of cigarette equipment and the introduction of double feed ultra-high speed cigarette machine in the future, the existing wind wire feeding system can no longer meet the needs of continuous upgrading of equipment and higher process indicators, how to reasonably and effectively plan the system distribution is one of the important research contents to improve the reliability, stability and sustainability of the system.

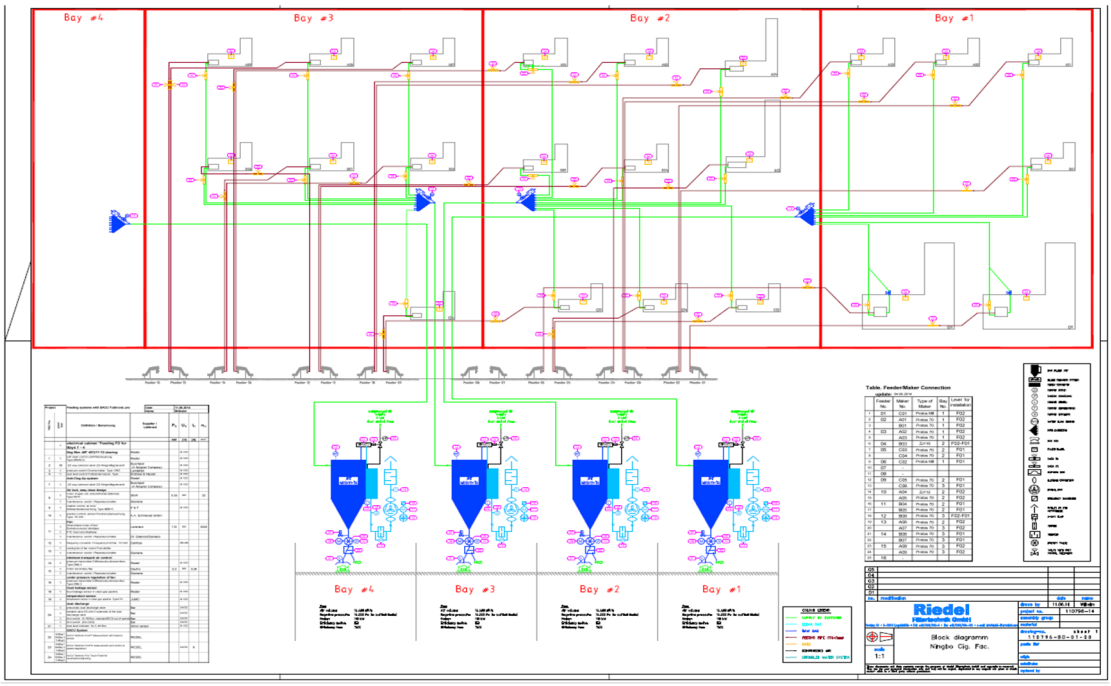


Figure 1. Overall layout of wind wire feeding system

3. Control Principle

If the principle of wind speed control is incompatible with the hydraulic design of the whole system, the wind speed will be oscillatory and unbalanced or cannot be accurately controlled. Due to the unique process principle of wind wire feeding, which is an intermittent, random and uncertain production process, the total air volume required under different wire suction conditions is different, and the branch pipe wire suction air volume is required to be constant. During the wire suction process of the cigarette machine, the continuous change of material gas ratio causes the change of two-phase flow resistance, and the cross-sectional area of the wire collector decreases with the continuous suction of cut tobacco, The resistance will continue to increase, and various factors require reliable and advanced control methods to ensure the stability of wire feeding wind speed.

3.1 Wind Speed Control Principle

The self-contained feeding system of the cigarette machine is quite complex. The basic principle is that cut tobacco is sucked into the wire collecting box at the upper part of the blanking gate of the wind feeding mechanism through the wind suction pipe, and the broken dust and dust enter the bag dust collector through the dust discharge pipe through the screen. When the cut tobacco is stored to the set amount, the proximity switch sends a signal, and the wire suction valve in the return air pipe is closed; When the blanking gate is opened for blanking, the proximity switch sends a control signal again, the wire suction valve is opened, and the cut tobacco is sucked again. Due to the randomness of cigarette machine wire suction, if the total air volume provided remains unchanged, the wind speed in each wire feeding pipe will be different under different wire suction conditions. At the same time,

in the process of wire suction, the change of material gas ratio and cross-sectional area of wire collecting box leads to the change of resistance. Even if the static pressure in the cluster is stabilized, it will still affect the stability of wind speed. At this time, it is necessary to eliminate the resistance changes caused by the above factors by adjusting the pneumatic control valve of centralized air supplement and the pneumatic control valve in the branch pipe, so as to maintain the stability of transmission wind speed.

3.2 Control Method

PID control theory. PID control theory PID control is one of the control methods based on feedback theory. Feedback control theory includes three links: measurement, comparison and implementation. The measurement link obtains the measured value and obtains the deviation value after comparing with the expected value. This deviation value is used to adjust the action of the controller. The structure is shown in Figure 2.

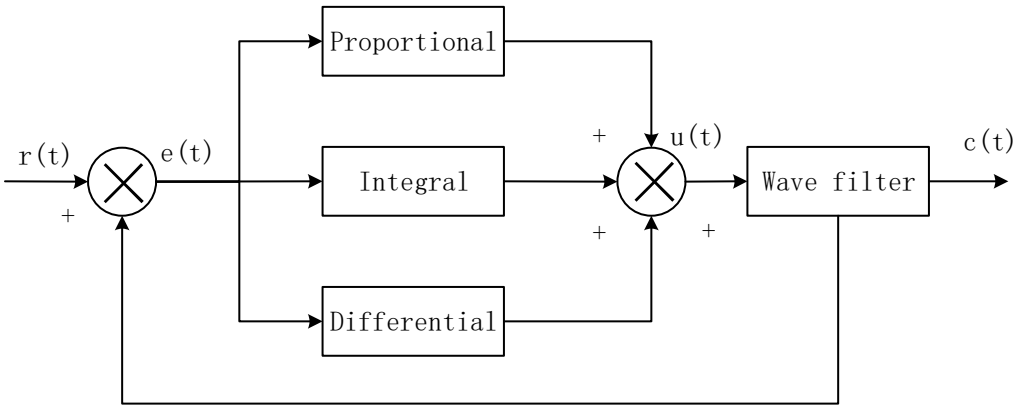


Figure 2. PID control flow chart

The PID controller controls the control object by generating the control quantity $u(t)$ according to the proportional, integral and differential operation of the difference $e(t)$ between the given value $r(t)$ and the measured value $c(t)$. K_P represents the proportional coefficient, T_I and T_D represent the integral time constant and differential time constant respectively, and the expression can be written as:

$$u(t) = K_p\left(e(t) + \frac{1}{T_t}\int_0^t e(t)\,dt + T_D\frac{de(t)}{dt}\right) \tag{1}$$

PID control parameters have a great impact on the effect of PID control. The specific functions of each parameter are as follows:

(1) Proportional adjustment

Proportional adjustment is to adjust according to the deviation. When the deviation between the output and the expectation is large, the proportional link will produce a control quantity proportional to the deviation, and its action intensity can be measured by K_p. If the value of K_p is increased, the regulation function of the system is strengthened, the action is sensitive, and the deviation of the system is reduced. However, if K_p is too large, the system will oscillate and even diverge. Too small K_p will prolong the regulation process of the system and slow the response of the system.

(2) Integral adjustment

Integral adjustment is adjusted according to the existence of deviation, and its output is directly proportional to the deviation integral. The integration link can improve the control accuracy. Due to the continuous accumulation of error, the integration function increases, which can quickly eliminate the deviation of the actuator. The function of the integration link is directly proportional to the integration time constant. The integral action is conducive to eliminate the error, but too large integral

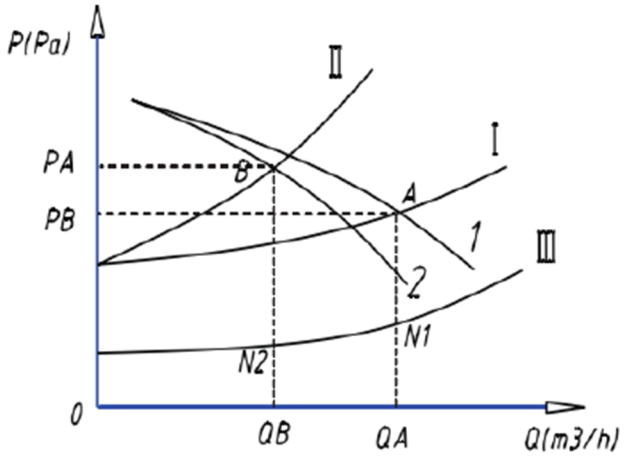
action is easy to cause overshoot and prolong the adjustment time, while too small integral action is not conducive to eliminate the deviation.

(3) Differential regulation

Differential adjustment adjusts the controller according to the variation of deviation. Because the differential link is connected with the derivative of deviation, it can predict the trend of deviation change and control it in time before the deviation changes sharply. Therefore, the differential link has a good effect on the object with large lag. The size of its effect is measured by T_D. the larger T_D, the greater the regulation effect is, the faster the system response is, the overshoot is reduced and the stability is increased, but it will also make the anti-interference of the system worse. The smaller the T_D is, the smaller the regulation effect is, and the system is prone to overshoot.

4. Optimize Dust Removal Control

When the fan speed remains unchanged, adjusting and changing the opening of the main air valve will change the characteristic curve of the pipe network system and the fan, as shown in Figure 3:



I- Characteristic curve of pipe network system before change, *QA*- Flow before change, *II*- Characteristic curve of pipe network system after change, *QB*- Flow after change, *III*- power, N- Air volume, *PA*- Wind pressure before change, 1- Fan characteristic curve before change, *PB*- Wind pressure after change, 2- Fan characteristic curve after change

Figure 3. Fan characteristic curve

It can be seen that when the control system reduces the valve opening and reduces the air flow through the pipeline, the pipe network flow decreases $Q_B<Q_A$, and the system working point moves from point a to point B. at this time, the corresponding pipe network wind pressure increases slightly ($P_B>P_A$), the fan power decreases ($N_2<N_1$), and the energy consumption also decreases to a certain extent. Based on the discontinuous characteristics of production materials of cigarette unit, N branch pipes are often cut off unpredictably in the wind wire feeding system, resulting in sudden air flow fluctuation in the main pipe and affecting other branch pipes, resulting in wind speed fluctuation of other branch pipes. When one or more cigarette units in the system are shut down and cut off, how to effectively adjust the air volume of the main pipe and make up air for the corresponding branch pipes of each cigarette unit, so as to reduce the impact of one or more cigarette units in the system on the balance of the system. Because the working condition of wind wire feeding is highly unpredictable and changes rapidly, and each change is a drastic change of each branch pipe from scratch or from presence to absence. In actual operation, according to the law of conservation of energy and mass, as well as the Bernoulli equation and continuity equation of hydrodynamics, when any m return air branch pipes are cut off instantaneously due to the shutdown of cigarette unit, The wind speed of the remaining N branch pipes still in the working state in the whole wind wire feeding system will inevitably increase, break the pressure balance between nodes, and change the characteristics of the

whole pipe network, so as to break the air flow balance of the whole system and fall into fluctuation. The working conditions of the wind wire feeding system are rapidly changing and unpredictable. Establish an effective real-time corresponding model between the opening of each valve and the air volume and air pressure at each monitoring point, "dynamic approximation with variable strain", so as to realize the ideal condition of stable and balanced wire feeding wind speed of each cigarette machine group in the wind wire feeding system.

4.1 Kirchhoff's Law

Kirchhoff's law includes Kirchhoff's current law and Kirchhoff's voltage law. They are one of the important laws in electricity. This electrical law can also be applied to fluid network to analyze the relationship between node flow and pipe section wind resistance in pipe network diagram.

From the incidence matrix $B(G)=(b_{ij})_{m\times n}$ and branch flow Q_j of the pipe network diagram, the node flow balance equation of the pipe network can be established, and this certain law can be written in the form of analytical formula.

$$\sum_{j=1}^{n} b_{ij} Q_j = 0 \tag{2}$$

Where b_{ij} is the symbolic function of the flow direction, that is, the element of the basic incidence matrix; Indicates the association between node i and branch j. $i=1,2,\cdots,m$; $j=1,2,\cdots,n$. Q_j — j Branch flow. Q is a column vector with dimension n, representing the branch flow, $Q^T=(Q_1,Q_2,\cdots Q_n)$.

4.2 Multidimensional Early Warning Model

For the early warning of wind wire feeding and dust removal control system, the fault risk ranking of equipment is more instructive than the specific fault probability value. How to establish a multi-dimensional early warning model, scientifically, timely and accurately analyze the potential hazards in the operation of the system, start the corresponding risk response plan, provide strong support for the safe and stable operation of the wind wire feeding system, and is very important to effectively improve the reliability and stability of the operation of the whole wind feeding system. At present, when the wind wire feeding equipment fails, there is only a simple light alarm, and there is no other effective real-time alarm mode. How to improve its early warning function is one of the research contents of this subject. In case of system failure or equipment failure, effective early warning signals can be provided as soon as possible. The system will use the grey system theory and its correlation analysis to calculate the correlation degree between the data of the wind wire feeding system to be analyzed and the operation of cigarette equipment.

5. Conclusion

This paper mainly studies the high efficiency and stability of the continuous application of the wind wire feeding system. Combined with the characteristics of the production process and the existing equipment layout of the cigarette factory, this paper optimizes the wind wire feeding operation mode and improves the upgrading space of the system. And integrate the system structure to meet the process requirements of cigarette production, solve the problems of large wind speed fluctuation range and inaccurate wind speed control in the process of cut tobacco air feeding, save energy consumption and ensure the reliable operation of wind wire feeding. It is found that the normal operation of a single cut tobacco air feeding system can save 10% energy consumption and effectively improve the stability of cut tobacco air feeding control.

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