Model Simulation Used to Analyse the Accuracy of the Temperature Control and the Pressure Control

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Abstract. In this paper, in view of the traditional temperature control and the spray gun pressure control in the coating drum of the current medicine coating machine, the temperature control: adopting the intelligent control domain's mold and PID control method, the model simulation is used to verify the accuracy of the temperature control and the pressure control: taking the pressure of the powder outlet of the spray gun as the input of the closed-loop feedback, the pressure of the powder outlet can be kept constant and the coating demand of the medicine in the pot can be well ensured.

Keywords: Traditional Chinese medicine; Coating equipment; Pressure control, Temperature control.

1. Introduction
The coating process is an extremely important operation unit in the production of proprietary Chinese medicines. Drug coating refers to the uniform coating of a specific material on the surface of a medicine, which can be used to improve its appearance and at the same time can cover up part of an unpleasant smell, and the coating of the drug to a certain extent can play a role in improving the stability of the drug and ensure the efficacy of the drug. As an important equipment in pharmaceutical equipment, coating equipment belongs to the mechanical class of pharmaceutical equipment, and its mechanical structure is more complex. In the coating process, the domestic temperature is very important, will directly affect the quality of the drug after coating.

The coating liquid will lose when it flows in the pipeline. The pressure at the nozzle of the spray gun is different from the pressure at the node, so the pressure at the node is not easy to guarantee the same pressure as that at the nozzle of the spray gun, so the effect of the coating liquid atomization can not be achieved, and then affect the quality of drug coating. Therefore, this paper studies and designs a set of monitoring node pressure, and the node pressure feedback to the control system, can effectively improve the node pressure control system has theoretical research significance and use value.

2. Basic Structure and Working Principle of Coating Machine for Chinese Patent Medicine
The mechanical structure of different types of coating machine is basically the same. Generally can be divided into air intake system, air outlet system, spray system, drainage system, coating main body, motor drive system these basic systems. The air inlet system is usually composed of hot air fan, gas station, air inlet pipe, gas filter net and so on. The air outlet system is composed of a centrifugal fan, a filter screen and an exhaust pipe, which is used for discharging the waste gas from the coating process. The spray system is mainly composed of liquid tank, peristaltic pump, spray gun and so on. Generally, the spray gun used in coating machine adopts the imported brand with high atomization efficiency to ensure uniform spraying of coating liquid.
More than 2 minutes of idling test is carried out before the start of coating in order to judge whether the machine is in trouble or not. The coating work begins, the medicine which needs to be coated is added to the pot, the air pump is turned on and heated through a hot air fan or an electric heating wire. In the intake unit, the air is heated and fed into the intake pipe, and the air is filtered to clean dry hot air through a filter screen, and into the pan. When the temperature in the pot is heated to a certain temperature by the dry clean air of the air inlet system, the coating liquid dressing is sprayed evenly on the surface of the medicine core in the rolling coating pot by the spray gun through the peristaltic pump. While rolling with the coating pot, the coating liquid is evenly wrapped on the surface of the coating core by constant stirring through the guide plate stirring paddle. The clean dry hot air from the air inlet system can pass through the gap layer of the chip, making the coating liquid sprayed on the chip surface come into full contact with the hot air and gradually dry. The inner wall of the coating roller is a filtering net structure, which can filter the surplus liquid out of the roller in the rolling process and collect and treat it by the drainage device under the roller. The exhaust gas dried by the coating roller is filtered through the filter net by the air exhaust pipe and discharged out of the collective by the blower or is collected for other treatment. The drug coating is completed when a hard, smooth film is formed on the surface of the tablet to be coated.

3. Design of Temperature Control System in Pot

As the temperature in the pot is a large time-delay object, the mixed control mode of mold and PID control is adopted in this paper. The relevant control parameters are set by PID control and fuzzy inference, which can effectively solve the problem of control precision which is not easy to reach in traditional PID control.

At the same time, the mixed application of mode and control and PID control is used to realize the parameter self-adaptation, and the final result of mode and inference is applied to the original PID parameters to realize the parameter self-adaptation.

3.1. Establishment of Temperature Function in the Pot of Coating Machine

In this paper, the air intake system as a whole, through the whole air intake system parameters measurement and avoid the measurement of each component parameters. The self-tuning of PID control parameter process in different heat dissipation environment will be completed by mold and inference. Thus, it is only necessary to know the heat transfer function of the whole air intake system under normal conditions.
In order to measure the heat transfer function, the temperature at the outlet of the heated air duct is sampled and counted. The project heating unit heater power is 3kw, heating temperature range of room temperature to 120 °C. When the temperature at the outlet of the air duct is 100 °C, 60 sets of data are sampled every 1s in the heating process. The temperature dynamic response curve of intake system is obtained. As shown in figure 2.

![Figure 2. Dynamic response curve of outlet temperature.](image)

It can be seen from the diagram that the temperature dynamic curve is S-shaped, and the change process of temperature has the characteristics of large inertia and large time-delay object. The transfer function is described as:

$$H(t) = \frac{A}{Tt + 1}e^{-bt}$$

A is the system gain coefficient, b is the lag coefficient and t is the time coefficient. First, the response curve is determined, and then the transfer function coefficient is determined by drawing method. Finally, the lag coefficient $b \approx 3$ is determined. In addition, in the step response curve, the slope obtained by taking the point at 0.717 of the curve is $1/T$, and $T \approx 6.3$ is obtained. The transfer function is obtained by substituting it into the formula. Get the transfer function:

$$H(t) = \frac{A}{6.3t + 1}e^{-3t}$$

3.2. Analysis of PID Control Parameters

PID control is a linear control method. In the experiment, we use the step response method of Ziegler Nichols empirical method to adjust the relevant parameters of the closed-loop link, as shown in Table 1. Using Ziegler Nichols empirical method, it is necessary to draw tangent lines to get points in the step response curve. The basic method is to take a point at 0.72 of the response curve to draw the tangent line at this point. The intersection of tangent line and x-axis and y-axis will produce intersection point, and the parameters can be calculated according to the step response parameter
setting table. According to the tangent method, \( a \approx 0.7 \) and \( b \approx 3 \) are obtained from the step response curve. Further adjustment can be made according to the site conditions.

| Controller | Scale factor | Integral coefficient | Differential coefficient |
|------------|-------------|----------------------|-------------------------|
| P          | 0.9/a       | --                   | --                      |
| PI         | 0.8/a       | 3b                   | --                      |
| PID        | 1.1/a       | 2b                   | b/2                     |

4. Design of Spray Gun Pressure Control System

After the coating dressing is pumped out from the booster pump in the pump room, a higher pressure is required at the nozzle of the spray gun to atomize the liquid medicine, so as to improve the coating effect.

The spray gun pressure control system designed in this paper is mainly composed of pressure sensor, signal conditioning circuit, controller, frequency converter, variable frequency motor and booster pump. The pressure of the traditional Chinese medicine liquid in the pipeline is monitored online by the pressure transmitter. After the signal conversion, the frequency output by the frequency converter is controlled by the controller, so as to adjust the speed of the variable frequency motor and the medicine pump, so as to stabilize the pressure of the liquid medicine at the nozzle of the spray gun, as well as the uniformity and better penetration of the spray droplets. We monitor the pressure at the outlet of the booster pump and the nozzle of the spray gun, and feed back the monitored pressure value to the control system through the pressure sensor, so as to form a multi node closed-loop feedback system, which can make the pressure at the nozzle stable within the set working pressure error range, which can greatly improve the quality and efficiency of liquid medicine atomization.

4.1. Overall Scheme Design

The system consists of main control system and node:

The main control system includes MCU main controller, receiving module, auxiliary power supply, switching circuit and display module. The pressure sensor at the node monitors the pressure value of the drug outlet, and all nodes transmit the data to the receiving module through the signal conversion circuit. The receiving module receives the pressure value transmitted from three nodes, through calculation, adjusts the frequency value of frequency converter in real time, so as to ensure the stability of pipeline pressure. The block diagram of the main control system is shown in Figure 3. The node includes pressure sensor, receiving module and MCU unit. The pressure sensor monitors the pressure value at the node.
4.2. Introduction to Parameter Requirements of Spray Gun Pressure Control System

The multi node liquid pressure control system mainly uses pressure sensors to monitor the pressure values of each spray node. Then the communication between the main control system and the node is carried out through the wireless transmission module. The system parameter requirements are as follows:

(1) Node measurement requirements.

The measurement requirements of three nodes are shown in Table 2.

| PRESSURE RANGE / MPA | SAMPLING PERIOD / S | NODE NUMBER RANGE (3 NODES) | ACCURACY / MPA |
|----------------------|---------------------|-----------------------------|-----------------|
| 0.6~1.6              | 1                   | 1001-1003                   | ±0.1            |

(2) Communication network requirements.

Data transmission between the pressure node and the main control system, the data collected by the pressure node should be able to be stably transmitted upward, and the communication reliability should be high and the speed should be fast. At the same time, the main control system should ensure that it can communicate with each pressure transmitting node, so as to avoid the interference between each module and the information transmission cross between each node, resulting in information error.

5. Conclusions

In this paper, a hybrid application of fuzzy control and traditional PID is used to control the temperature in the coating equipment pot, and the multi node pressure control system is used to measure and control the pressure of the medicine pump, pipeline and spray gun. Temperature control: the simulation results show that the closed-loop feedback PID control system designed in this paper can realize the self-tuning of control parameters at the same time of fast and stable temperature measurement. Spray gun pressure control: through the test, the node pressure variance of multi node system is improved from 63%~66% to 98%~99% compared with single node system. Thus improving the spray effect, the pressure at the mouth of the spray gun is an important index to measure the spray effect of the dressing, which directly determines the quality of the coating.
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