Design and Implementation of Automatic Spray System based on the Servo Control System

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Abstract. The brush type plasticizer system in KDF2 filter rod maker tends to result in wide variation in triacetin addition and material waste. In order to improve the quality of filter rod, an automatic triacetin spraying system based on an atomizing technology was designed, wherein PLC and touch screen acted as main controllers. Heated triacetin was pumped into a manifold under high-pressure then evenly sprayed on the running tow by nozzle. By means of the built-in positioning function of PLC and servo positioning module, the tow speed was tracked, the plasticizer valve was accurately controlled to adjust the flow rate of triacetin. By detecting the triacetin temperature and level in the plasticizer booth, triacetin temperature and volume were automatically maintained. The practical testing results showed that the filter rod hardness greater than or equal to 80%. Triacetin was sprayed evenly and the system ran smoothly and reliably.

Keywords: Filter rod maker, Triacetin; Spraying, Filter rod hardness, Programmable logic controller( PLC), Servo positioning

Introduction

Filter rod rigidity is a key technical indicator of influence tobacco quality in production process. The triacetin system of filter rod maker is mainly used on plastic filter rod and control hardness, it is a key device for filter rod quality. The traditional way is that it use centrifugal force of glue brush rotation spin coating to moving tow surface, the triacetin was uneven droplets, it is difficult to achieve uniform spin. In order to improve the quality of filter rod, we must real-time control the volume of triacetin, keep pace between triacetin with moving speed (maker speed), keep the amount of triacetin to stabilization about unit area tow. Therefore, author is based on filter rod maker improvement as a background in Hangzhou Cigarette Factory, and introducing a new spray system of triacetin automatically to substitute traditional brush glue way.

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Project Choice

The traditional way is that it use centrifugal force of glue brush rotation spin coating to moving tow surface, the triacetin was uneven droplets, it is difficult to achieve uniform spin. Therefore, In order to improve the quality of filter rod, we must real-time control the volume of triacetin, keep pace between triacetin with moving speed(maker speed), keep the amount of triacetin to stabilization about unit area tow, reducing the hardness of standard deviation for filter rod.

There are two project of triacetin applying: the one project is spin coating for double-brushes, this project more apply to filter rod maker, the characteristic is double-brush up and down infliction, and increasing the acceptance area of tow, the uniformity is improved, which is helpful to save the glycerin and increase the hardness, but it cannot solve the abuse that glycerides larger particles and standard deviation greater hardness in rotation and imbruing of brush\textsuperscript{[2]}. Another method is atomized applied, this method is currently used on the company’s KDF4 machine of HAUNI company, the characteristics of this method is to mix air of partial pressure and glycerides through nozzle, produce small particles completely atomized, the glycerol room divided into two layers, the lower atomization, the upper applied, the event door in the middle layer control glycerides spray, to add the amount of glycerides in tow accurately. Through the comparison, we find that the scheme does not solve the nonlinear and time delay in the process of applying glycerol ester, there is not much improvement on the hardness index of filter rod, but the second scheme can be directly applied to optimize the process of glycerol ester, the hardness index has been greatly improved. So we decided that development new glyceride applying device based on the second scheme.

1 Hardware Design

Glycerol ester atomization technology is mix certain pressure air and esters using the glycerol spray device, produce small particles with complete atomization. The device directly sprayed on the glycerol ester have loose tow, To achieve accurate control of adding amount of glycosides, make the filter quality index to steady and avoid the "glue hole" and dry sticks.

1.1 System structure

This system mainly consists of PLC, touch screen, active door, control motor for door, the reflux pipe, glycerol box, atomizing nozzle, temperature heater, glycerol pump motor and etc., as shown Fig.1. The KDF2 machine at different speeds (0~400m/min), can be real-time tracking speed of the machine, automatically adjust the amount of glycerol ester, implement glycerol ester of uniform spraying on per unit area. The system adopts SIEMENS S7-300 series PLC as the main controller. To complete the process of analog switch and switch input and output detection control and the control of the system. The touch screen as man-machine interface to communicate with the PLC system, and complete the data exchange, and display information set. The atomizing nozzle adopt solid nozzle, in order to improve the
atomization effect of glycosides, glycerol in the spraying box on the bottom box in the radial direction center as a benchmark, even installed seven atomizing nozzle.

Figure 1. System block diagram.

Figure 2. The working principle.

1.2 Working principle

The working principle as shown Fig.2. The system first to inject the glycerol ester in glycerol box, the float switch monitor the liquid level of box. When the host is running and tow through, the device will open booster pump and pre-heater, it will send the glycoside oil of pressure to oil collector, through seven atomizing nozzle, it made the glycosides oil of atomization to spray to tow motion belt, and reclaim excess glycerol by return pipe. The glycerol flow is sync-adjusted real time by servo-control module to control active door through according to tow speed, and kept synchronized with the machine speed changes, to ensure the glycerol quantity uniform on the tow. When the door is stop, the active door will closed, the excess glycerol will back into the glycerin tank through return pipe. The active door control the spray area for move-tow, when the nozzle atomized the concentration, size and height unchanged, use active door to block off the area of up-glycerol, the door opening is more small, the glycerol area on the tow through this door is more small, the servo positioning module is that it realize precise control of degree of opening, it consist of PLC, touch-screen, rack, pinion, servo amplifier and servo-motor.
2 Control System Design

2.1 Major flow

The major flow of control system as shown Fig.3. At first, the system will run and check itself, PLC and touch-screen and servo system will initialize. The initialization flows include AD-module initialize, pump-motor close, pre-calefaction module close and etc. When the initialization flows are finish, the spray-system will check itself, mainly include communication detection, level detection, the servo system detection and active door return the initial point. The major flow as follows:

(1) PLC detected the communication status between PLC and touch-screen. If the communication is intermit, then cue communication abnormality information, and waiting for communication recovery, if the communication is natural, then detection the glycerol level.

(2) If the glycerol is lack, then the system will startup fuel solenoid valve and alarm, if the glycerol is full, then the system will close valve, and stop glycerol injection, if glycerol is enough, then the system will detect servo System Status.

(3) If the input is closed, then the servo system is operating normally, if the input is cut, then the servo system being failure, it shown the failure and alarm, and the machine will stop.

(4) If the system is normal, then PLC will perform the operation is that active door return the initial point.

(5) If the active door finished to return the initial point, then the touch-screen enter into main interface. The interface shown current door opening, length of the rod, content of glycerol in the rod and current pressure.

(6) When startup the machine, the system must satisfy glycerol normal level, oil temperature normal, servo system normal and active door locate the initial point.

(7) If the glycerol level, servo system and oil temperature all normal, then the system is waiting, wait for the startup signal of the machine, when the machine is run, the signal light is light.

(8) Detection the system status. If the system being to maintain, then the startup signal was shielded until the system finished maintain.

(9) If the startup signal is effective, and glycerol spray switch is closed, then open pump and active door, carrying out glycerol spray to operate.

(10) If you need to adjust the flow rate of glycerol, then enter the control interface of flow, the implementation control operation of flow during spraying.

2.2 Glycerides heating subroutine

The process of glycerides heating subroutine. At first we start the PLC to measure the temperature of glycerides box. If the temperature is normal, then the subroutine will return the main program; if the temperature is too low, then the subroutine will start the heater; if the heater exceeds a set time (t1), and the glycerides temperature is still lower that the limit, then the PLC shown the fault signal of heater, and return the main program. If the temperature exceeds the limit, then stop the heater. T23 and T24, for low and high temperatures delay fault discrimination respectively.
3 Test And Analysis System

According filter rod technology standards, standard hardness range of eligible filter rod greater or equal to 80% in our factory. Randomly selected three groups of test data, before and after the modification of glycerides materialized control system, the filter rod production specifications as shown Tab.1. Adjust the device to run at different speeds, and randomly selected 20 filter rods, the hardness test results as shown Tab.2. According to the results of the data, the 3 groups of test data of the hardness requirements all standard.

Table 1. Filter rod production specifications.

| machine | production grade | production specifications | number of samples (branch) |
|---------|------------------|---------------------------|---------------------------|
|         |                  | draw resistance (mm)      | weight (20cig/g)          | circle(mm) |
| K1#     | short-mouth filter | 270±20                    | 12±0.5                   | 24.25±0.25 | 20 |
| K2#     | Long-mouth filter | 260±20                    | 14±0.5                   | 24.25±0.25 | 20 |
| K3#     | Long-mouth filter | 260±20                    | 14±0.5                   | 24.25±0.25 | 20 |

Table 2. Test results of hardness index of filter rod.

| machine | set value of glycerol (mg/branch) | average hardness | standard deviation value of hardness(SD) | average value of hardness(P) | number of hardness standard | standard rate of hardness(%) |
|---------|----------------------------------|------------------|------------------------------------------|-----------------------------|-----------------------------|----------------------------|
| K1#     | 45                               | 83.02            | 1.3586                                   | 0.8784                      | 20                          | 100                        |
| K2#     | 55                               | 82.17            | 1.6506                                   | 0.7051                      | 20                          | 100                        |
| K3#     | 55                               | 81.10            | 1.5772                                   | 0.7921                      | 20                          | 100                        |

4 Ends

The key technology of the reform of the system is to control the temperature and the pressure of glycerol of AF2 process section in KDF2 machine. Only effective and stable control of the temperature of the glycerides, it can protect the viscosity and
fluidity of glycerides, and only effective and stable control of the pressure of glycerol, it can ensure the size and flow of the nozzle, to stabilize the upward spray area of the rectangular spray column with the two necessary conditions can make the tow speed and stability, spraying in tow surface amount of glycerol can be stable and uniform. Servo control system is the key to control the amount of glycerol spraying. Valve opening and in other conditions for a stable opening the small, through the movable door window area of glycerol spraying surface smaller sprayed onto a less movement tow surface amount of glycerol, conversely, the greater the degree of opening, the more the amount of spray. Obviously, as long as the servo system to accurately control the door opening can be precisely controlled by the amount of glycerol spray. PLC module as the core of the control system, the completion of analog input, switching input state detection, switching output control and the whole process control system. The touch control screen is used to replace the original mechanical hand, through the realization of the man-machine interface, complete the relevant data, information, status display and parameter settings, it can also communicate with PLC, data acquisition and remote control.

References
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