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# Research on Fully Automatic and Efficient Environmentally Friendly Film Roll Tissue Packaging Equipment Based on Labview and PLC

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**Abstract: This paper analyzes the load, packaging film parameters, packaging process working parameters, driving parameters, system parameters and machine model of the fully automatic environmental protection film roll toilet paper packaging equipment with a production efficiency of 220PPM. The bore, rod meridian, speed parameters and electrical control schematic diagram of each cylinder of the pneumatic system are analyzed; The PLC control program, LabVIEW parameter setting and process monitoring interface were analyzed.**

**Keywords: environmental protection film; Roll toilet paper packaging machine; PLC ; LabVIEW ; Pneumatic system**

## 1 INTRODUCTION

In recent years, in the United States, South Africa, Italy, South Korea and other developed countries have found that these countries or some of their states have begun to put forward very high requirements for environmental protection, and legislation to replace plastic film packaging toilet paper with environmentally friendly film packaging; At present, Italy has produced an environmentally friendly paper packaging machine with a production efficiency of 220PPM (paper per minute), but because its price is very expensive, tissue manufacturers in the United States, South Africa, South Korea and other places have put forward the demand for high efficiency (80-220PPM), high-quality, low-cost environmentally friendly film tissue packaging machines, and the market demand is large; Based on this, this paper conducts research and analysis on the key technologies of 220PPM fully automatic environmental protection film roll tissue packaging machine, and the main contents of the research include the key parameters of the whole machine equipment, the speed and time parameters of each movement, the schematic diagram of the pneumatic system, the schematic diagram of the electrical control system, the PLC control program, and the LabVIEW proctoring interface[1].

## 2 PACKAGING EQUIPMENT OVERALL SCHEME RESEARCH AND DESIGN

Packaging machine needs to automatically complete the delivery of toilet paper, send packaging film, packaging, change direction, paper, automatic replacement of packaging film 6 processes, the production efficiency of the equipment is up to 220PPM, the diameter of the sanitary roll paper that needs to be packed is 80 ~ 120mm, the height is 90, the maximum diameter of the packaging film drum is, the width is 410, the voltage is 380V, the weight of the whole machine is controlled within, and it can be calculated that the time required for packaging each roll is 0.273s, the working pressure of the pneumatic system is 6 bar, and the flow rate / min.-110mm1200mm-460mm6000kg 为 100L

### *2.1 TORQUE RESEARCH AND CALCULATION OF PACKAGING MACHINE*

According to the moment of inertia of the hollow cylinder [2-3]:

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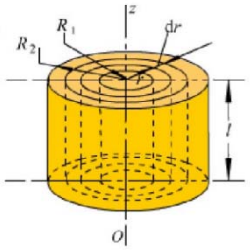


$$dm = \rho dV = \rho \cdot 2\pi r dr \cdot l$$

$$dJ = r^2 dm = \rho \cdot 2\pi l r^3 dr$$

$$J = \int dJ = \int_{R_1}^{R_2} \rho \cdot 2\pi l r^3 \, dr$$

$$= \frac{1}{2}\rho\pi l(R_2^4 - R_1^4) = \frac{1}{2} l\rho\pi(R_2^2 - R_1^2)(R_2^2 + R_1^2)$$

$$\because m = l\rho\pi(R_2^2 - R_1^2) \quad \therefore J = \frac{1}{2} m(R_2^2 + R_1^2)$$

The quality, acceleration and torque parameters of the environmental protection film are calculated, as shown in Table 1 below.

**Table 1 Environmental protection membrane parameters**

| Sanitary roll diameter /mm | /min | Membrane speed mm/s | Acceleration rad/s2 | Time /s |
|---|---|---|---|---|
| 120 | 220 | 10591.15 | 65.377 | 0.27 |
| quality | Hollow radius | Large Radius | Moment of inertia /kg.m2 | Torque Nm |
| 478.99 | 60 | 600 | 87.08 | 5.69 |

According to the production efficiency, roll size, packaging film size, the torque required for environmentally friendly film rolling and other parameters can be calculated, as shown in Table 2 below.

**Table 2 Environmental protection membrane drive rolling parameters**

| Sanitary roll diameter /mm | /min | Environmental protection membrane speed mm/s | acceleration$rad/s^2$ | Time /s |
|---|---|---|---|---|
| 120 | 220 | 10591.15037 | 65.37 | 0.27 |
| Mass kg | Hollow radius | Large Radius | Moment of inertia /kg.m2 | Torque Nm |
| 42 | 11 | 44 | 0.043 | 0.0028 |

Considering that the environmental protection film drive has a support drum, a drive drum, an intermediate transition drum, friction, etc., the actual calculation will enlarge the drive roll torque by 10 times to select the drive motor torque of 2.39N.m, power 750W, voltage 380V.

In the process of rolling paper and finished paper transportation, by the rolling paper belt 1, packaging process forward belt 2, finished paper belt 3 a total of three sets of belt transmission, according to the weight of the roll, friction coefficient, resistance, can calculate the torque and power of the driving belt, as shown in Table 3 below.

**Table 3 Paper belt parameters**

| Working conditions | Safety | Weight kg | coefficient of friction | Wheel diameter | Drive resistance N | Torque NM | Power w | Angular velocity r/min |
|---|---|---|---|---|---|---|---|---|
| Roll paper feed belt 1 | 2 | 2.5 | 1.5 | 100 | 73.5 | 3.68 | 32.32 | 84 |
| Roll paper feed belt 2 | 2 | 1.88 | 1.5 | 100 | 55.13 | 1.38 | 12.12 | 84 |
| Finished paper feed belt 3 | 2 | 1.25 | 1.5 | 100 | 36.75 | 0.92 | 8.08 | 84 |

## 2.2 *RESEARCH AND ANALYSIS OF VARIOUS PARAMETERS OF THE PACKAGING PROCESS*

The packaging process includes the upper end of the cylinder to push the roll paper to the lower belt 3, in the process of the same

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time by the gear lever to roll the paper in the front and back of the left and right four directions of the packaging film pushed to the top, the surrounding film with the film to reach the belt 3, by the stepper motor to drive the belt 3 steps forward, walk forward to the first step in the process of the left end of the roll film pushed backward, the right end push fork pushed the right end film to the left, and then the upper and lower guard rod pushed the upper end film down, the first step ended at the same time the center ejector rod 1 pushed the film at both ends of the roll paper to the center hole, completing the first step; The stepper motor drives the leather to take away the second step, the center ejector rod 2 again pushes the film further towards the center, and at the same time that the third step is completed, the center pusher 3 pushes the film deeper into the center again, that is, to complete a finished paper package. Since in the step process, each step is obtained with a finished paper, so efficient production efficiency can be achieved, and the working process parameters of the packaging process are shown in Table 4.

**Table 4 Working parameters of each process of the packaging process**

| Working conditions | location | Stroke/mm | Speed m/s | Time |
|---|---|---|---|---|
| 1 | The upper cylinder pushes the roll paper to the lower end of the belt | 240 | 1.8 | 0.134 |
| 2 | Right push fork side packing | 130 | 1 | 0.13 |
| 3 | Belt 3 steps further | 140 | 0.6 | 0.23 |
| 4 | Wrap on both sides of the roll paper | 10 | 0.5 | 0.02 |
| 5 | Center ejector 1 | 30 | 0.5 | 0.06 |
| 6 | Belt 3 steps further | 125 | 2.4 | 0.052 |
| 7 | Center ejector 2 | 30 | 0.5 | 0.06 |
| 8 | Belt 3 steps further | 125 | 0.6 | 0.208 |
| 9 | Center ejector 3 | 30 | 0.5 | 0.06 |
| 10 | Belt 4 steps further | 125 | 0.6 | 0.208 |
| The time required to complete a single roll of paper packaging | | | | 0.27 |

## 2.3 *PACKAGING MACHINE MODEL DESIGN RESEARCH*

The packaging machine model developed by the research and development is shown in Fig. 1, the roll parameters that the roll feeding system 1 can transport are 80 to 120mm in diameter and 90-110mm in height for toilet paper rolls, and the screw adjustment is adjusted according to the actual size of the toilet paper, and the automatic conveying process is completed by using belts, servo motors, control systems, etc. Packaging system 2 can manually adjust the size of the range, the time is about 20 minutes, the use of cylinders, crank slide mechanism, servo motors, stepper motors, control systems, etc. to complete the entire packaging process; Environmental protection film feeding system 3 will be wrapping paper according to the required length of cutting and packaging paper according to a certain speed of paper feeding, can achieve different lengths of packaging paper for cutting, cutting length range of 285-410mm, width of 410-460mm, with the roll packaging paper to complete the packaging, the mechanism mainly includes belts, pulleys, tightening devices, cutting mechanisms, tensioning mechanisms, servo motors, control systems, etc., the maximum diameter of the packaging film reel is, Width of 410-460mm, about 300kg, the use of cylinders, reducers, clamping mechanisms, belts, pulleys, belt tensioning mechanisms, servo motors, control systems, etc. will automatically transport environmentally friendly packaging paper to the packaging position, packaging the roll toilet paper, the packaging process includes pushing the drum to the designated position, respectively, the reel of the upper and lower, left and right, the center of the packaging film for packaging; The conveyor mechanism migrates the roll paper step by step at a set speed, and the roll toilet paper is packed step by step during the process; 1200mmThe finished paper output system redirection mechanism 6 will first change the direction of the finished paper (as shown in Fig. 2) to facilitate the collection of toilet paper, and the good change of the finished paper is transported to the collection location; Control system 5 is to control the entire system, including drivers, controllers, sensors, transformers, control cabinets, wiring harnesses, etc.; 4 is the safety fence system, mainly used for the isolation of the

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entire system from the outside, to prevent danger, the wiring harness of the control system is fixed from the fence.

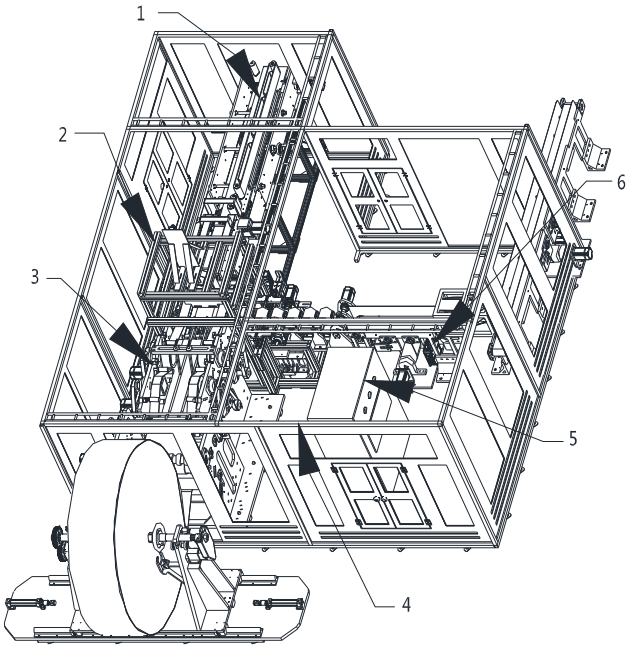


**Fig. 1 Model of the whole packaging machine**

Roll feeding system; 2- Packaging system; 3- Environmental protection membrane feeding system; 4- Safety fence system; 5- Electrical control cabinet system; 6- The finished paper output system changes direction mechanism

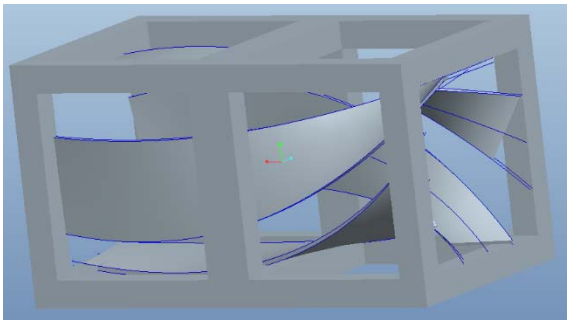

**Fig. 2 Reversion adjustment mechanism**

## 3 PNEUMATIC SYSTEM RESEARCH AND DESIGN

### 3.1 CYLINDER PARAMETER ANALYSIS AND STUDY

The pneumatic system includes a push rod cylinder with the top of the drum to guide the packaging position, a push rod cylinder on the packaging side, a central jack cylinder that packs the center membrane of the packaging drum, a packaging film auxiliary cutting needle cylinder and a packaging film replacement cylinder, and the cylinder speed, flow and time parameters of each position action are shown in Fig., and the air compressor flow and pressure parameters are calculated.

**Table 5 Parameters of each cylinder**

| location | Bore/mm | Rod diameter/mm | Speed mm/s | Stroke/mm | quantity | Total traffic | Reciprocating time/s | 1 second round trip | Flow rate cm^3/s |
|---|---|---|---|---|---|---|---|---|---|
| Upper end cylinder | 20 | 10 | 1200 | 300 | 1 | 22.6 | 0.266 | 3.76 | 377 |
| Push fork cylinder | 16 | 0 | 1000 | 130 | 1 | 12.1 | 0.26 | 3.85 | 201 |
| Membrane replacement cylinder | 32 | 12 | 50 | 200 | 2 | 4.82 | 8 | 0.125 | 40.2 |
| Center pusher cylinder | 20 | 10 | 2000 | 400 | 1 | 37.7 | 0.4 | 2.5 | 628.3 |

### 3.2 PNEUMATIC SYSTEM SCHEMATIC ANALYSIS AND RESEARCH

Pneumatic original Fig. as shown in Fig. 3 [4-6], by the compressor assembly, gas storage tank assembly, filtration component, dryer assembly, triple, three-position four-way

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electromagnetic reversing valve, throttle valve, cylinder composition, through electrical control to achieve cylinder extension and retraction repeated work; Calculated according to the load cylinder speed, the working pressure is 6 bar and the maximum working flow rate is 130L/min.

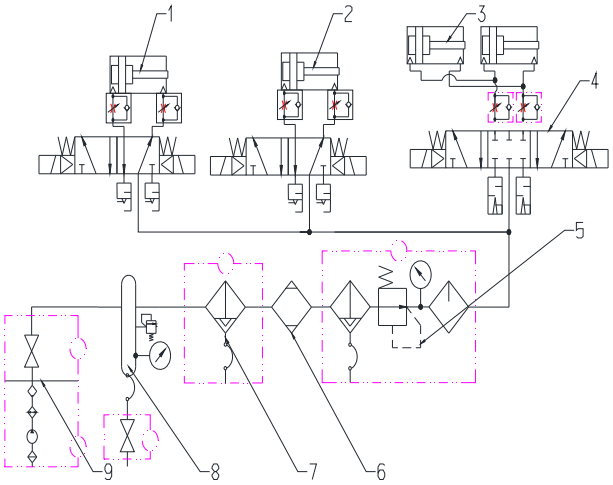


**Fig. 3 Principle of pneumatic system**

1-Needle cylinder; 2- Center jack cylinder; 3- Packaging film replacement cylinder; 4- Electromagnetic reversing valve; 5- Triplets (filters, pressure reducing valves, oil-water separators); 6- Dryer; 7- Coarse filtration; 8- Air receiver; 8-9- Compressed air station

## 4 ELECTRICAL CONTROL SYSTEM RESEARCH AND DESIGN

Electrical control system hardware is mainly composed of air-opening, drive, servo motor, touch screen, etc. [7-8], as shown in Fig. 4, of which the servo drive, servo motor a total of 16, voltage of 380V, a single motor power of 750W, torque of 2.37Nm, through the touch screen can be set to the parameters of the servo drive and motor.

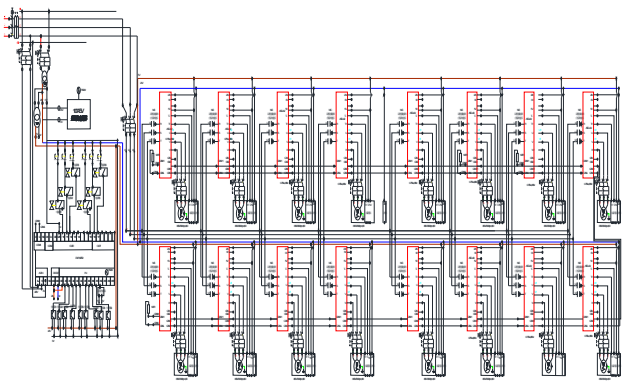

**Fig. 4 Principle of electrical control**

## 5 EXPERIMENTAL RESEARCH ANALYSIS BASED ON LABVIEW AND PLC

The overall mechanism of the automatic packaging machine is complex, the speed control of the test analysis of a single belt, the PLC program [8-11], the monitoring interface and fault monitoring, the PLC control program is shown in Fig. 5 below [12-17], the LabVIEW monitoring program is shown in Fig. 6, the monitoring interface is shown in Fig. 7 [18-20], and the experiment is shown in Fig. 8. Automatic packaging machine needs to have an interface to complete parameter setting, production efficiency and other data display and fault monitoring, this article uses LabVIEW interface to achieve, through the interface to set the speed, fault monitoring and data display

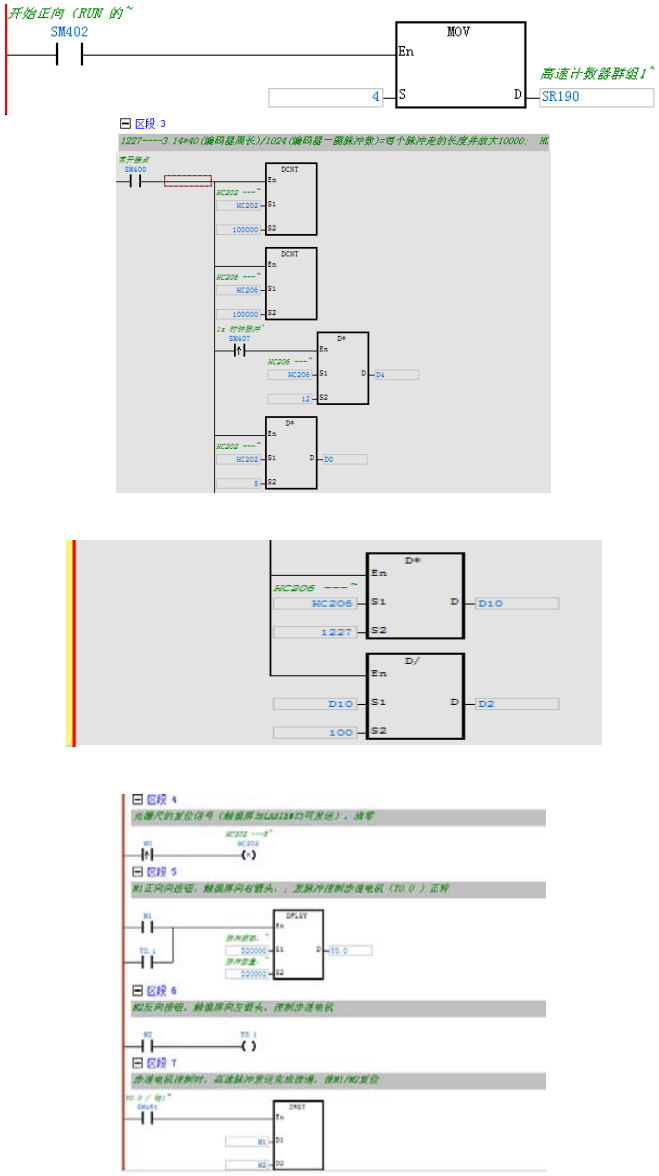


**Fig. 5 Stepper motor PLC control procedure**

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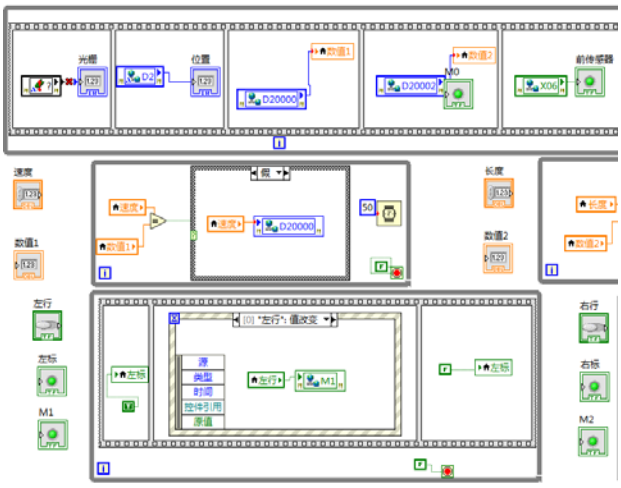

Fig. 6 LabVIEW supervisor

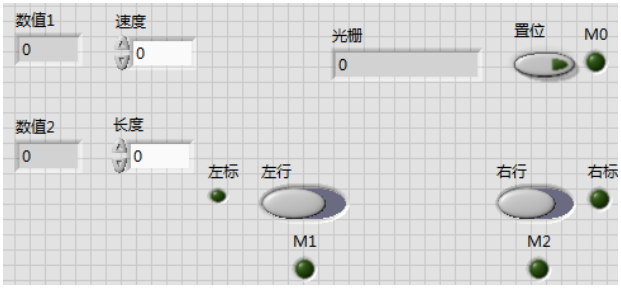


Fig. 7 LabVIEW monitoring interface

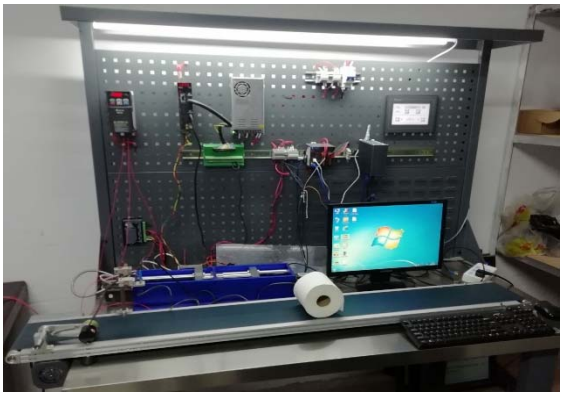

Fig. 8 Experimental picture

## 6 CONCLUSION

The content of this article is published for the first time in China.

In this paper, the load of each part of the automatic environmental protection film packaging equipment with a production efficiency of 220PPM, the parameters of the packaging film, the working parameters of each process of the packaging process, the rolling parameters of the environmental protection film drive, the parameters of the paper feeding belt, and the design of the whole machine model mechanism are analyzed.

The bore, rod warp and speed parameters of each cylinder of the pneumatic system are studied and analyzed.

The study analyzed the hardware and software of electrical control systems.

The test analyzes the control program, monitoring interface, and fault monitoring.

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