

Study on the control of air cushion head box

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Abstract. In order to solve the coupling problem between the variables of the air cushion head-box, the precision of control is improved. The operating mechanism of the flow box is analyzed and the related data are collected. The expert control algorithm for air cushion head-box is put forward. The algorithm is implemented with PLC300. The practice shows that the control algorithm proposed in this paper meets the requirements of control. The practice shows that the control algorithm proposed in this paper meets the requirements of control.

1. Introduction

Head-box is very important equipment in the whole paper making process. It is the key to connecting paper pulp preparation and paper forming and determines the quality of paper and the paper speed of the paper machine. Head-box is at the throat of the whole paper machine and is known as the heart and accelerator. It should ensure that the pulp flow on the web is evenly distributed along the width of the paper machine and could ensure the uniform distribution of pressure, speed, flow, and concentration. At the same time, the directional control and uniformity of fibers should be ensured, effective method could prevent fibers from flocculation, it could maintains stable pulp web speed ratio and pressure according to process requirements. It could be said that no paper can be copied without a good head-box. The development of the modern paper industry is difficult to achieve. The development of head-box has gone through the open. Air cushion and water conservancy, but air cushion head-box still occupies a very important position in the system of paper industry in China. When the speed of the paper machine is higher than 400m/min, a sealed air cushion head-box should be used, therefore, strengthening control of air cushion head-box is of far-reaching significance for the paper industry.

2. Mechanism analysis of air cushion head-box

2.1. Model of air cushion head-box

The head-box is mainly composed of the pulp distributor, the weir pool and the weir plate. There are many kinds of pump including to multiple pairs of pump and vertebra pump. In terms of the position of the feed, there is an intermediate pulp and a single side feed. The current single cone pipe feed has become the main flow method. The air cushion head-box ejected pulp from the weir pool to the net under the action of static pressure and air cushion pressure. The jet velocity of air cushion head-box could be expressed by equation (1)

$$v = \lambda \sqrt{2gp} \quad (1)$$



v is the jet velocity. λ is coefficient related to the opening of the lip. g is a gravitational acceleration constant. P is the total pressure. The total pressure is the main driving force in the head-box. The total pressure can be expressed by the equation (2).

$$P = P_1 + H\rho \quad (2)$$

P is the total pressure, P_1 is the pressure of the air cushion, H is the height of the serous, ρ is the pulp density. The total pressure is the sum of the pressure of the air cushion and the static pressure of pulp. When the air cushion pressure is constant, the total pressure will increase if the slurry level is raised. In the case of the same pulp position, the total pressure increases with the increase of the air cushion pressure. In general, the flow rate of the pulp must maintain a stable relationship with the speed of the net cloth from a technological point of view, so the speed ratio of the pulp and net is constantly to ensure the quality of the paper. The speed ratio of the pulp and net could be expressed by the equation (3).

$$v / \omega = c \quad (3)$$

ω is the speed of the net cloth, c the speed ratio of the pulp and net. Generally, the speed ratio of the pulp and net is a constant between 0.9-1.1. The speed of the pulp and net is constant, but in fact it is often changed, we can think of the change as a disturbance. The control of the total pressure is the core problem of the control of the air cushion head-box.

2.2. Data acquisition and analysis

Total pressure is the sum of static pressure of the pulp and the air cushion pressure, the total pressure changes will affect the pulp height, so it is necessary to study the relation between Roots blower and the pulp level. It is necessary to study the effect of the pulp pump on the pulp position and the total pressure. Their relationship is demonstrated by the output current of the pulp pump. The relationship between the input current of the pulp pump and the pulp position is shown in Table 1 and Table 2. The relationship between the input current of the Roots fan and the pulp position is shown in Table 3 and Table 4.

Table 1. The current of the pulp pump and the pulp height

Current and pulp height	Parameter values
Input current (%)	0,35,36,37.5,40,41,42.5,46,47.5,50,55
Pulp height(mm)	0,21,20,50,97,100,143,175,180,189,250
Input current (%)	30,32,37,39,43,47,48,50,52.5,55,60
Pulp height(mm)	25,95,145,120,160,175,225,275,261,380,394

Table 2. The current of the pulp pump and the pulp height

Current and pulp height	Parameter values
Input current (%)	0,35,36,37.5,40,41,42.5,46,47.5,50,55
Pulp height(mm)	0,21,20,50,97,100,143,175,180,189,250
Input current (%)	29,31,36,40,45,47,48,51.5,52,56,62
Pulp height(mm)	27,100,148,129,165,179,228,295,261,390,400

Table 3. The current of the Roots fan and the pulp height

Current and pulp height	Parameter values
Input current (%)	1,2,12,14,21,28,38,43,50,54,57
Pulp height(mm)	0,0,171.5,126,149,130,358,324,387,391,410
Input current (%)	1,10,11,15,30,36,38,39,45,48,50
Pulp height(mm)	0,176,172,125,123,370,360,349,320,315,346

Table 4. The current of the Roots fan and the pulp height

Current and pulp height	Parameter values
Input current (%)	1,3,12,15,20,26,38,43,50,54,57,61
Pulp height(mm)	0,0,171.5,126,149,130,358,324,387,270,320
Input current (%)	3,11,16,33,35,37,40,46,49,53,55
Pulp height(mm)	0,178,172,125,123,370,360,349,320,315,346

The pulp position starts to rise at the 33% output current of the pulp pump. At the beginning, the rising rate of pulp height is very low. When the output current is greater than 35%, it always rises again and the rate of rise is almost unchanged. When the input current of the pump is greater than 33%, the total pressure begins to rise. When the input current is greater than 65%, the rising speed of the total pressure is up to the highest, the total pressure continues to increase.

3. Control algorithm of head-box

The main analysis method in the classical automatic control theory is based on the steady mathematical model of the controlled object. This method ignores the nonlinear and time-varying of the actual system. It is difficult to establish a mathematical model for a very accurate industrial control object. For the same head-box, the model of the head-box is greatly changed if the length of the pump is changed. In any paper, a more advanced control algorithm is proposed for the control of a convective slurry box. The expert control system does not rely on the mathematical model of the system, relying solely on the experience of the operator. The usual expert control system only solves the problem of a special domain. Its reasoning results are used for the user's auxiliary decision. Expert control rules require independent automatic decision making objects. Its functional requirements must have continuous reliability and anti-interference. The rules are shown below.

If $\Delta P \geq QH$ and $\Delta L \geq GH$ then $o_1 = 0.7s$ and $o_2 = 0.2s$;
 If $\Delta P \geq QM$ and $\Delta L \geq GM$ then $o_1 = 0.5s$ and $o_2 = 0.4s$;
 If $\Delta P \geq QL$ and $\Delta L \geq GL$ then $o_1 = 0.4s$ and $o_2 = 0.6s$;
 If $\Delta P \geq QH$ and $\Delta L \geq GL$ then $o_1 = o_1 + 0.1s$ and $o_2 = o_2 + 0.1s$;
 If $\Delta P \geq QH$ and $\Delta L \geq GH$ then $o_1 = o_1 + 0.05s$ and $o_2 = o_2 - 0.1s$;

ΔP is the deviation value of the total pressure. ΔL is the deviation value of the pulp position. QH , QM and QL are the deviation thresholds of the total pressure. GH , GM and GL are the deviation thresholds of the pulp position, s is the adjustment range of the regulator, o_1 the output value of s pulp input, o_2 is the output value of air input. The control rules in the running process are as follows.

If $\Delta P \geq 0$ and $\Delta L \geq 0$ then adjusting the control parameters of the air loop;
 If $\Delta P \geq QM$ and $\Delta L \leq 0$ then keeping the original parameters;
 If $\Delta P \leq QL$ and $\Delta L \geq 0$ then keeping the original parameters;
 If $\Delta P \leq 0$ and $\Delta L \leq 0$ then adjusting the parameters of the feed pulp loop;

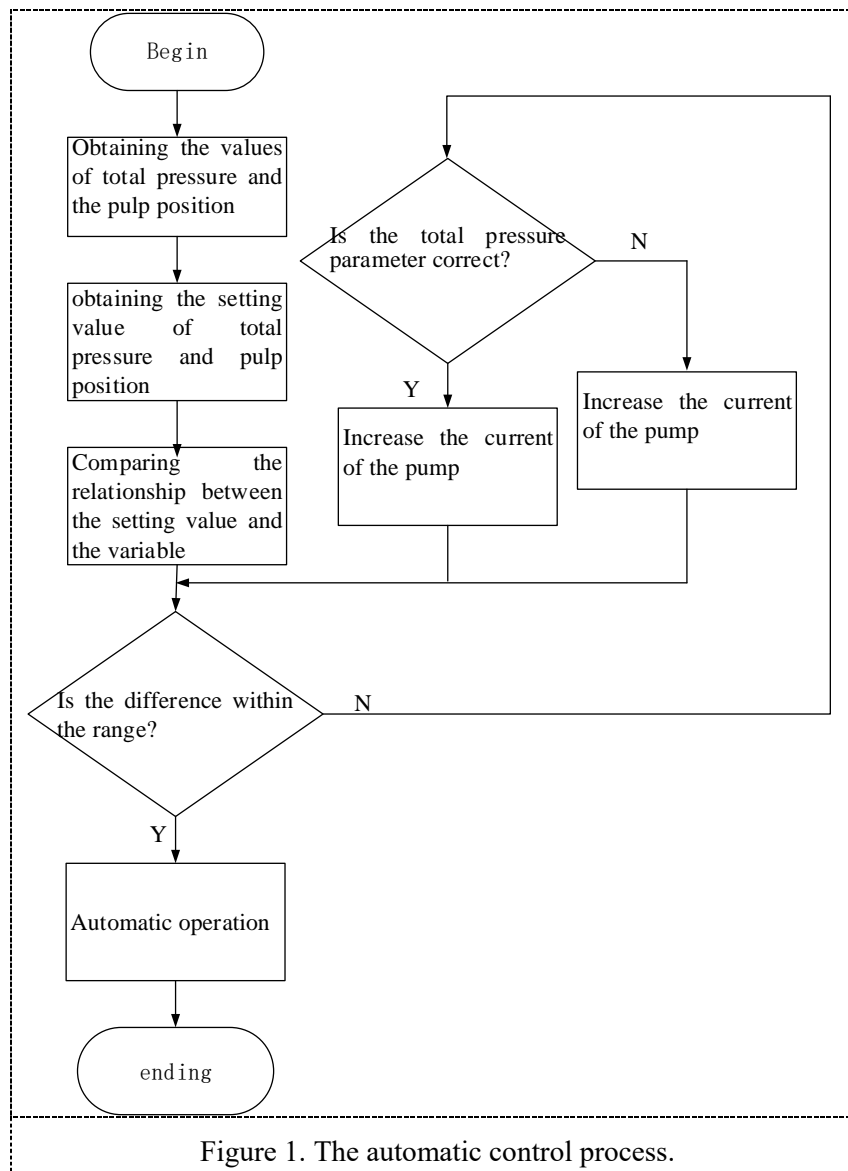
4. The realization of the control system of the head-box

4.1 Performance analyses of equipment

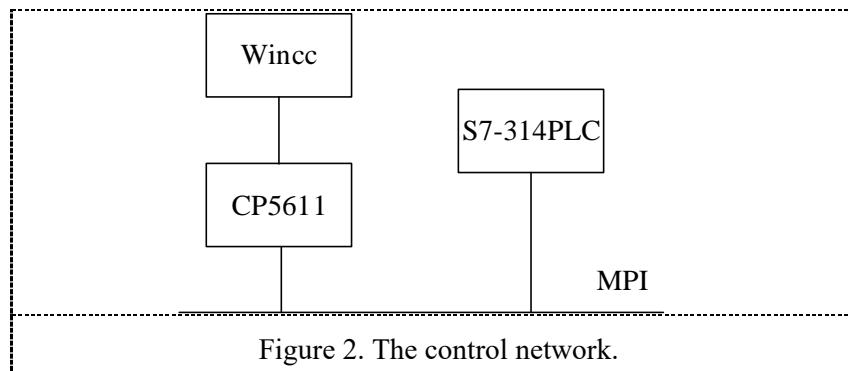
The modular design of SIEMENS S7-300 is mainly composed of the power module, CPU module, signal module, function module, interface module, communication module and power module. The power module is to convert the 220 volt voltage to the DC24 volts voltage to provide the operating voltage rating of each module. CPU is mainly a scan of the other blocks of OB1 is a constant call between blocks in the process of work. The simulation amount collected from the site may be less than zero and may even be greater than 27648 of the maximum value. The main function of the block OB1 is the interface between the operating system and the user program. DB shared data blocks store user data areas for all logical block calls. The interrupt program is an interrupt design triggered by an event when the speed ratio of the network and pulp of the paper machine is relatively large. Because the environment of the paper is very bad, the selection of the frequency converter is relatively good for the environment. This design selects the products of ABB company, in which the pump frequency converter is selected to select ACS800. The setting of the frequency converter is mainly macro definition, motor identification, motor starting and stopping. The analog input of ACS800 is done by internal setting. Before the system is debugged, the it must be operated manually to determine the operation of the motor. The analog input is the voltage signal of the 0~10 volts or the current signal of the 4~20mA. It is a noteworthy problem that the current signal received by the ABB converter is a signal of the 0~20mA, which does not match the standard signal. When the standard current signal is selected, the frequency converter must be disposed accordingly. The transmitter is used to convert the electric quantity or non-electric quantity supplied by the sensor to the standard range of DC voltage or DC current 0~10 volts or the analog input module of 4~24m. The input impedance is about 250. The interference voltage on the circuit is low in the module, so the analog current signal is suitable for remote transmission. There are only two lines outside the two wire transmitter. Its connection mode is relatively simple and its anti-interference ability is stronger.

4.2 Automatic designs of head-box

Because there is a certain relationship between the pulp level and the total pressure of the air cushion head-box, manual operation should be carried out in the starting process. When both the slurry and the total pressure reach the set value, it can be realized from manual to automatic. This will extend the starting time of the whole paper system and increase the burden of operation. The use of software is used in this article to replace manual operation. The automatic running process is shown in Figure 1. The control of the air cushion head-box, the field models to be sampled are the total pressure, the pulp position and the speed of the net. If the two wire pressure transmitter is selected in the total pressure, then the total pressure signal of the three cascade head-box must require three channel analog signals. A two line differential pressure transmitter is selected for the pulp position. The three analog signals are required. The blower is to flow inside air, so that the air cushions pressure. If the blower to mistake the motor overheating, which may be the motor burned. The role of pulp pumps is to feed the pulp inside the head-box. Generally speaking, the motor power of the pulp pump is larger, so the protection of the motor is mainly considered during the design process. In the process of production, the blower should be opened and the pulp pump is opened to prevent the slurping from the top of the pulp. After the start of the allowed signal, the system begins to determine the number of signals allowed to run the start of the head-box. The automatic control process is shown in Figure 1. If an abnormal system occurs during the starting process, self-detection will be carried out and the result of the detection will be output. At the same time, it is forced to stop until all the logical relationships of the system are set up to start. After starting the system, the system executes the user program and automatically adjusts the output of the slurry pump and the fan to know the set value of the slurry and the total pressure. In the setting of parameters, parameters must be made according to the dynamic response curve of the system.



The default transmission rate of the network is 187.5bit/s. The maximum distance between the industrial control machine and the control cabinet is 50m. If the distance between the two is more than 50m, it is necessary to add a repeater to make the maximum transmission distance of 1000m. The direct reading of data from the CP5611 in the network does not require any additional intermediate auxiliary software be added to the Wincc software. The control network is shown in Figure 2. First check whether the position of the pressure transmitter and the differential pressure transmitter are installed correctly. Check whether the communication between the host computer and the lower machine is normal, if it is normal to download the entire site to the CPU module. Generally speaking, in the parameter setting interface, there is permission to set the permission of the debugger and the engineering technician. Once the parameters are set, it is not allowed to change at random. After the parameter setting is completed, the master control screen is entered. The main control interface of the system is the operation of the starting and stopping of the convective head-box. The start and stop priority of the interface is higher than the outside gave a start and stop signal. After the system is started, the dynamic response curve of the controlled object will begin to run, and the debugger can adjust the parameters of the algorithm according to the dynamic response curve.



After the system is able to run normally, the design of the system is not finished. It is necessary to evaluate the reliability and stability of the system according to the data detected on the spot. In general, the design of the system is not optimal and must be continuously improved to make the performance of the system more and more perfect. So it is necessary to keep track of the system for a long time to ensure that the system is constantly improved and finally the system is optimized. After debugging, data analysis must be provided and a debug report is written.

5. Conclusions

The expert control algorithm proposed in this paper could be used to control the head box well. The advantage of an expert control system is that it does not need to establish a mathematical model of the object. The expert control system belongs to the intelligent control algorithm. It has a strong adaptability to the control object. The practice shows that the control precision of the expert control algorithm is 2% to the total pressure. The control precision of the expert control algorithm for the total pressure is 2.5%

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