Design of Fully Intelligent Quality Error Prevention System for Tobacco Production Line Based on Configuration Software and PLC Program

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Abstract—Aiming at the problems of wrong brand, mixed batch and wrong transmission of electronic parameter information in the production of cut tobacco of different brands in the tobacco industry, a fully intelligent quality error prevention system based on WinCC configuration software and PLC distributed control program is designed. The information of the production and manufacturing execution system in the general control room and the brand, batch and other information stored in the PLC of the bottom electric control cabinet is compared and verified instead of manual self-inspection. If the information is consistent, production is allowed. Otherwise, the equipment locks itself and sends alarm feedback. The design and application of the system realize the automatic error prevention of process equipment and the implementation accuracy of production control parameters, to ensure that the production process meets the requirements of process technology, effectively avoid major quality accidents, and finally guarantee the product quality.

1. Introduction
The tobacco-making process is a crucial link in the cigarette manufacturing process [1]. If there are omissions in the process control, the product quality will be seriously affected. Once the market feedback of defective products occurs, it will cause immeasurable losses to the market competitiveness and public recognition of enterprises. In the process of cigarette production and processing, through the analysis of previous process problems or product quality problems, it is found that most quality problems are caused by errors [2]. In the process of tobacco production and processing, according to different formulas, tobacco leaves need to be processed in groups by brand and batch, and the production management control system sends control parameters and production process data to local equipment by batch. To ensure the internal quality of finished cut tobacco with high quality, the processing process needs to be accurately controlled in strict accordance with the process requirements to ensure that the key process variables of each process meet the production process requirements. In view of the characteristics of many production brands, complex processing steps and high control accuracy in the tobacco-making process, the production brand information, formula raw material information, equipment operation parameters and process parameters should be checked manually in different processing procedures, which is quite prone to errors, resulting in quality hidden dangers of wrong brands and mixed batches. Thus, preventing quality accidents of wrong brands and mixed batches in advance is the focus problem that needs to be solved urgently in the whole tobacco industry [3]. The causes of errors are mainly attributed to data information transmission errors, human operation
errors or defects in the PLC control program [4]. For example, during production, the tasks of entering and changing the leaf storage cabinet are frequent. With the continuous increase of production brands, its control system lacks the functions of automatic selection and judgment of the cabinet and accurate control at the time of storage, and only depends on manual verification, which is easy to cause errors in incoming and outgoing materials and substandard storage time, and even serious quality accidents [5]. The quality error prevention system of the tobacco production line is an information comparison system based on the PLC control program, which monitors the whole flow and whole process of data information transmission of the industrial Ethernet layer and production management layer through the PLC program of the equipment control layer. Siemens STEP7 language is applied to the program, and the read real-time production information and electronic work order information are compared in turn in the PLC control system to realize accurate error prevention in the information transmission process of all links of tobacco production [6].

2. Design of Error Prevention System

2.1 System architecture

PROFINET combined with PROFIBUS DP architecture is adopted by the centralized control system network of the tobacco production line of Shijiazhuang cigarette factory. According to different functions, the architecture can be divided into the equipment control layer, the centralized monitoring layer and the production management layer to undertake respective information transmission tasks. The redundant ring network in the workshop is composed of the backbone network of optical fiber and several SCALANCE x414 switches. The structure of the system network is shown as Fig. 1. Besides, I / O server, PLC, section control field operation terminal, etc. are connected to industrial Ethernet Gigabit ring network; and the monitoring client computer, server and historical real-time database of central control to interact with PLC through I / O server, OPC and other channels. The network configuration level is shown in Fig. 2.

![Fig. 1 System network architecture of tobacco production line](image1)

![Fig. 2 Network configuration hierarchy diagram of tobacco workshop](image2)

The equipment control layer adopts the control mode based on Industrial Ethernet PROFINET fieldbus, which is composed of PROFINET Industrial Ethernet connection control master station and field I / O substation [7]. With Siemens Simatics7-400 PLC as the core, the batch production task is
transmitted by PLC to the execution unit of field equipment by using PROFINET, PROFIBUS and other communication protocols to complete the real-time monitoring and control of various process parameter variables, and transmit the collected process data to the centralized monitoring and control layer [8]. Other components that cannot be connected to PROFINET network are connected to the system network in the form of PROFIBUS DP, PA fieldbus or analog output.

The centralized monitoring system network is composed of a PROFINET optical fiber Gigabit ring network built by the industrial switch of SCALANCE414-3e / SCALANCE X408-2 and a central control LAN built by management switch. The on-site section control computer is connected to the optical fiber ring network through SCALANCE 414-3e / SCALANCE X408-2 for data communication, with each master station of PLC. The centralized control layer realizes the functions of remote control and equipment status monitoring through WinCC human-computer interaction interface. The monitoring system is mainly composed of a monitoring client computer, an I/O server, a monitoring server, an application server, a historical real-time database server, a web server, a file server, an engineer station and a network management monitoring station [9].

The equipment of the production management layer exchanges information through Ethernet to realize the production management, data acquisition, process standard management, quality evaluation of the production process and WEB release of the tobacco workshop. This layer can access and use WinCC data, process the comprehensive information during system operation, and provide complete statistical data reports and various analysis charts such as production task execution.

2.2 Design Ideas
PLC control technology is used to compare the electronic work order information data with standard process parameters and specific production instructions with the real-time data displayed on the production site in the system, as shown in Fig. 3. It is allowed to execute when the information is consistent, otherwise, it will send alarm feedback or stop, and operate again after correction. In the server of the central control room, the electronic parameter package distribution channel is created uniformly, and the process parameter data package is established according to the brand and process. Further, the channel setting of moisture meter, outlet moisture and other process parameters of each brand form a complete formula parameter table, which is then distributed to the corresponding local production process [10]. Before starting production, the central control room will distribute the information of production brand, batch and other electronic parameters to each production process section. The electric control master station of PLC in the field process section receives the relevant electronic parameter information through network transmission and carries out secondary comparison and verification, so as to ensure the error prevention management in the production [11].

Fig. 3 The overall design scheme of error prevention system
2.3 Control Flow
Step 1: The operator in the central control room logs into the central control system of tobacco making from the database server and selects a record of a data table in the corresponding production process section according to the production scheduling plan.

Step 2: The production brand information and batch information of the current planned production scheduling batch are added to configure the process parameters of each current process section, and the work order information is automatically generated. In addition, the saved process parameter data package can also be directly retrieved from the system to configure the process parameters.

Step 3: The process parameters of each process section are manually checked and verified, and the data package of process parameters will be distributed to the PLC of each section on site after clicking task execution.

Step 4: Before production, the automatic error prevention system will recheck the parameters. The electronic parameter package information sent by the general control room and the actual production information data of the on-site operation screen will be compared in a real-time cycle in the on-site electric control master station of PLC. If the information comparison is consistent, the equipment is allowed to produce, otherwise, an alarm feedback message will be sent. The flow of information comparison is shown in Fig. 4.

Fig. 4 Flow chart of information comparison processing

2.4 Scheme Implementation
(1) Program configuration and network

During the hardware configuration, the PLC equipment is configured in PROFINET network and Siemens S7-400 PLC is used, as shown in Fig. 5.
According to the programming requirements of modular indirect addressing, the error prevention program is written in PLC. A function block for the error prevention alarm is designed, and the background data block is configured to call the calculation process value and output value. At the same time, the content or parameters of the background data block can be displayed on the monitoring screen. 25 data link points, 17 input points, 6 output points and 2 temporary variables are established inside the function block, as shown in Fig. 6.

A new function block of FB380 is created for error prevention monitoring of alarm and shutdown. This function block can be run when programming different error prevention points.

Programs in the function block are written with the ladder diagram programming, and the comparison instructions of CMP are used to compare the string information of the internally stored process parameter data packet with the received data packet bit by bit in the comparison module. If all are consistent, the on-off signal at the front end of the program will be executed and the execution of the production to start instruction be started. In case of inconsistency, the on-off signal cannot be started and reset, and finally, the production order cannot be executed, and abnormal feedback is given.

At the same time, the background data block of DB is configured, and different background data blocks can be run when writing each error prevention program point, so as to display the calculation data and alarm information in the block in the monitoring screen.
3. Application Effect
To verify the application effect of the full intelligent quality error prevention system, the equipment alarm information for 3 months is counted continuously, and the stability and accuracy of the system are tested and verified by artificially setting some abnormal conditions. When the work order information received by the field operation screen is consistent with the electronic parameter package information issued by the central control, the equipment is allowed to start operation, and the accuracy of manual verification is 100%. In case of batch error, brand error, mismatch of feed liquid weight, wrong feeding proportion and other abnormalities, the quality error prevention system will send out alarm prompt in time to prohibit the continuous operation of the equipment and prevent serious process quality accidents, so as to verify the stable operation and efficient identification of the error prevention system.

4. Conclusion
In the process of tobacco production, the full intelligent quality error prevention system of tobacco production line based on WinCC configuration software and PLC gives early warning of errors, which is set when the server in the central control room sends the electronic parameter package information to the production equipment at the local field equipment control layer. In addition, the functions of real-time pre judgment and alarm of process quality problems are added to key equipment and processes such as storage tank feeding and discharging, moisture meter detection, flavouring and feeding. The real-time information comparison is completed in the bottom PLC, which can comprehensively realize the treatment of error prevention at key quality risk points in each process of tobacco making, reduce the probability of process quality accidents, and in particular, prevent the occurrence of major quality accidents such as wrong brand and mixed batch. In a word, the application of the quality error prevention system in the tobacco production line of Shijiazhuang cigarette factory has shown good results, reliable operation and strong effectiveness. It not only improves the automatic error prevention and diagnosis ability of the control system, but also ensures the internal quality of cut tobacco, and realizes the intelligent production and control of tobacco making process equipment.

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