Review of Intelligent Development of Cigarette Maker’s Control System

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Abstract. In recent years, the electronic control system of cigarette maker has been developed rapidly. The embedded IPC replaces the traditional "PLC+ high-speed processing board card" and is applied in the electronic control system of ultra-high speed winch unit, which solves the problem of poor stability of the original multi-platform. Under the new EtherCAT architecture, the intelligent development of the electronic control system of cigarette maker has become a new trend. In order to better improve the intelligent function of the electronic control system of cigarette maker, the intelligent development trend of the electronic control system of cigarette maker based on embedded IPC will be elaborated in detail.

1. Introduction
At the beginning of the 20th century, the cigarette maker electrical control system generally adopts PLC as the core of the control system, which can only handle the control tasks of more than 10ms, because the high-level short time (1-2ms) pulse signal and the tasks with strict time requirements can only be completed by the single-chip microcomputer system. In recent years, the embedded industrial computer realizes real-time control through precise synchronous time base, using distributed clock and super sampling technology, and the execution of the program has the highest certainty, which guarantees the fast task processing of less than 10ms, by distributed clock and super sampling technology, the control program can realize the recognition of the high speed pulse signal accurately, cigarette track shift and sampling/rejecting valve tasks such as precise control. In addition, the embedded IPC conforms to the standard high-speed OPC data interface, which is in line with the basic conditions of intelligent manufacturing. Therefore, this paper mainly starts with the principle of embedded IPC, and gradually discusses the development status and trend of intelligent manufacturing. [1-7]

2. Introduction to control system of cigarette maker
The automatic control tasks of the cigarette rolling machine electrical control system can be roughly divided into the following three types:

2.1. Logical control task
This part of the control system includes the tobacco supply. The cigarette maker starts and stops control, material supply (paper supply, glue supply, ink supply) control, the main drive control, the manual control of the machine, as well as the temperature control of the machine, valve island (air) control, fault treatment. Most of these tasks are implemented by a series of logical instructions, involving relatively
few mathematical calculations. The execution time of the logical instruction is short, which will not lead to the program cycle time too long in the case of a large number of programs. At the same time, there is no strict time requirement for the task itself, which belongs to the process control, so it can be realized by the PLC program.

2.2. Heavy computing tasks
It includes weight control of cigarette (tobacco density) and quality inspection of cigarette (bear, air leakage, suction, etc.). The vast majority of these tasks are carried out by mathematical calculations, involving relatively few logical instructions. Because of the mathematics calculation instruction, especially the floating-point arithmetic execution time is long, if by the PLC program to achieve, in the case of a large number of programs will lead to the program cycle time is too long, is not conducive to the control of other processes, so, these tasks generally will not use PLC and use the computer to achieve.

2.3. Real-time response task
It includes the material supply (filter, paper and glue) control, cigarette sampling and elimination when the machine is started and stopped. These tasks with strict requirements on processing time can also be called real-time tasks, whose main characteristics include fast and positioning. Fast means that the task-related input/output is refreshed quickly and the program scan time is short. Positioning refers to the control of rising/falling edge of timing pulse in the process of cigarette delivery in the drum groove of the receiving machine, because the time of passing through each detection sensor and sampling/removing valve is very short (1~2ms). For high frequency pulse, PLC can not accurately identify, so, these tasks generally need to be with the real-time operating system of the MCU to achieve. It is because of the characteristics of the automation control task of the electrical control system of the winding unit that most of the electrical control system of the winding unit has adopted the control mode of "PLC+ proprietary system" since 1990s. These proprietary systems are single-chip systems with real-time operating systems, which cannot form a standard hardware platform with good openness and easy for users to master. Therefore, from around 2010, a new system architecture began to be applied in the tobacco industry, namely the embedded IPC control system based on EtherCAT.[8-10]

3. Mechanical and electrical control system of winding based on embedded IPC Methods and steps

3.1. Architecture and communication mode of embedded IPC electronic control system based on EtherCAT
The system adopts two sets of IPC from Germany Beckhoff company as the control core of the electronic control system, and the communication with the upper computer adopts the EtherNet protocol. The overall communication topology is shown in figure 1:
Such a communication architecture can not only meet the needs of large amount of communication data, but also meet the requirements of high real-time. IPC1, as the logical control part of the whole machine, connects VE/SE/MAX, valve island, servo and other parts through Profibus. IPC2 is adopted for SRM, CIS, HIP and other functional modules with high real-time requirements. This architecture provides the following benefits:

1) advanced ETHERCAT and Profibus-DP field industrial bus technologies are adopted;
2) low failure rate. IPC controller greatly improves system performance due to its advantages of shockproof, dustproof and anti-interference.
3) intuitive and convenient operation. The computer interface is convenient for the operator to know the equipment status, modify the process parameters, query the output, consumption, etc., and has the function of fault display and alarm.
4) convenient maintenance. Because of the use of international common software, hardware, factory technicians easy to grasp, at the same time spare parts can be purchased at home;
5) add a data collection system, which can conveniently display the consumption of auxiliary materials such as cigarette paper, pine paper and filter rods used in each shift and the statistics of various production data;
6) because of the use of high-performance industrial control computer, it can provide network interface for the computerized management of production workshops.

3.2. Hardware design and transformation

The servo drive system is also an important part in the evolution of the winding electromechanical control system. Based on the architecture in figure 1 above, the servo drive system's self-frame is illustrated as follows:

The motors using servo are as follows:
1) in terms of control mode of SE part M1 main motor, SIEMENS S120 servo system is used to replace the original LENZE ac speed regulating system. After the transformation can be more accurate control of starting and stopping, greatly reduce the consumption of raw materials.
2) in the control mode of M16 needle roll motor in part VE, SIEMENS S120 servo system is used to replace the original direct velocity system.
3) in terms of the control mode of M9 steep Angle lifting motor in part VE, SIEMENS S120 servo system is used to replace the original direct flow rate system of LENZE.
4) as for the control mode of the SE part of the glue supply, SIEMENS S120 servo system is used to replace the original electromagnetic clutch to measure the glue supply, reduce the consumption, and adjust conveniently.
5) in the aspect of automatic regulation and control of the circular pressing plate in SE part, SIEMENS S120 servo system is used to replace the original manual control, so that accurate automatic regulation of the circumference can be carried out.

3.3. Detection system

Based on embedded IPC winding machine, because of the processing capacity and processing speed of a great deal of improvement, therefore, can widely use a lot of quality detection sensors, the following examples of several typical cases:
3.3.1 Missing filter detection
Optoelectronic switch is adopted for detection of missing filter:

Figure 3. Missing Filter detection schematic diagram

3.3.2 Loose end Detection
Loose end detection is carried out by infrared sensor, which is used to detect the filling amount of cigarette end:

Figure 4. Loose end Detection schematic diagram

3.3.3 Optical Tipping paper inspection sensor (OTIS)

Between the transmitter on the detection head OTIS and the receiver on the OTIS sensor, the cigarette passes over the pick drum. The beam of the transmitter passes through the cigarette in parallel by means of an optical lens. The defective shape of the cigarette or the upturned part reduces the amount of light passing through the receiver. The part of the light that is blocked by the shape defect is the size of the shape defect. The greater the amount of light blocked, the greater the flaw in the cigarette.

3.3.4 Detection of smoke leakage, pressure-drop and ventilation
Leakage detection air pressure supply means that the air pressure of 4bar supplied by the unit is directly sent to the detection wheel through the adjustment of the precision pressure regulating valve as the air source for leakage detection. As can be seen from the figure, the air pressure used to measure the supply cigarette is not fixed, and the inlet air pressure is adjusted by the test results.

Figure 6. Physical indicators System structure diagram
The air leakage detection pressure supply is to adjust the air pressure of the unit 4bar to a constant pressure of 1.7kpa through the pre-pressure generating device and input it into the air storage chamber (volume module), and then transfer it to the ignition end of the cigarette for smoke leakage detection. The system has the function of automatic adjustment, so that a stable air pressure (1.7kpa) can be obtained. The fluctuation of air pressure of the unit and the removal of smoke in MAX (max-y4.1) during the operation of the unit will not bring the fluctuation of detection air pressure, so the detection accuracy of the system is high. We added volume module and pressure generating device in the transformation scheme to achieve the stability of pre-pressure.

3.4. Weight Control
The weight system architecture of the retractable electromechanical control system based on embedded IPC is as follows:

![Weight control diagram](image)

The function of IPC2 is to calculate the machine speed and the diameter of paper disk according to the axial knitting signal, and realize the automatic splicing function of cigarette paper and paper and paper. To realize the function of detecting and removing waste; Control of MAX cigarette material transportation; Block detection and periodic fault detection of each drum part of MAX; PROTOS 90E, PROTOS 1-8, and PROTOS 2-2 are adopted to transmit the status information of cigarette through internal CRDX (real-time data related to cigarette) to the cigarette detection part and the cigarette weight control part.

3.5. Intelligentization based on IPC
In unified electronic platforms, specification design and electric control system integration, twin, cloud and edge using digital computing, big data and visualization technology, combined with the whole life cycle of complex equipment management and manufacturing value-chain theory, with cigarette companies supporting the demand of intelligent manufacturing as the center, creating "cloud, tube, end" the integration of technical framework (cloud server group is located in changde cigarette maker, tube or the Internet, end is situated on the edge of the range hood products calculation end), implement the data, experience and knowledge in machine company and a cigarette, cigarette between flow and sharing, promote the intelligent level of the existing machine; At the same time, the model of "Internet +" is adopted to build the customer service center, so as to improve the intelligent level of tobacco enterprise services. It mainly contains two functions, namely service intelligence and device function intelligence. Service intelligence includes: one machine one gear, namely the whole life cycle management; Expert service, that is, efficient troubleshooting; Intelligent maintenance, namely based on 3D visual maintenance guidance; Service center, namely spare parts, operation, dispatching service. Device
functional intelligence includes: intelligent platform, namely control system upgrade; Intellisense, i.e. full-state data service; Intelligent diagnosis, that is, all-round self-diagnosis; Intelligent analysis, that is, optimization analysis based on big data.

4. Beneficial effects
Based on embedded IPC control system, the software of cigarette maker is programmed by the TwinCAT software. The logic control, high-speed signal processing, weight control, cigarette quality testing automation tasks such as centralized control are executed by the EtherCAT fieldbus connects like the input and output signals. Combining digital twinning, cloud and edge computing, big data and artificial intelligence, visualization and other technologies, as well as the whole life cycle management and manufacturing servitization theory of complex equipment, to create an integrated technical framework of "cloud, manage and terminal" is sure to promote the intelligentization of tobacco, service and production.

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References:
[1] Bai shuangxing. Design and implementation of industrial field data acquisition network system based on Internet of things [D]. Beijing jiaotong university, 2019.
[2] Li xiaoying. FPGA design and implementation of multi-device data acquisition system based on optimized EtherCAT protocol [D]. Tianjin university of technology, 2019.
[3] Luo qiang. Discussion on design of electronic control system of cigarette maker based on embedded IPC [J]. Journal of science and technology economy, 2017 (20) : 77.
[4] Liu bin. Research on electronic control system of home-made ultra-high speed winding unit [J]. Henan science and technology, 2017 (07) : 112-113.
[5] Liu bin. Application of embedded IPC in ultra-high speed cigarette maker [J]. Computer knowledge and technology, 2016,12 (05) : 186-187.
[6] Xu xiaolong. Development and application practice of PLC control system of cigarette unit [J]. Computer knowledge and technology, 2016,12 (05) : 247-249.
[7] Li qingyun. Application of embedded IPC in the design of electronic control system of cigarette maker [J]. Electronic technology and software engineering, 2015 (23) : 204.
[8] Wang hui. Electronic control system design of cigarette maker based on embedded IPC [J]. Journal of hunan university of arts and sciences (natural science edition), 2015,27 (02) : 91-94.
[9] Liu bowen. Diagnosis and application of new high-speed cigarette rolling machine [J]. China science and technology information, 2015 (02) : 158-159.
[10] Wen deming, zhou qifeng. Application of embedded IPC in new-type cigarette rolling machine [J]. Microcomputer information, 2011,27 (05) : 110-111 + 148.