2012 International Conference on Applied Physics and Industrial Engineering

The Control System Design of Rotary Li/MnO₂ Button Battery Product Line Based on Human-computer interface

Qi Xiangyang¹, Lin Shuzhong¹, Sun Lixin²

¹Advanced Mechatronics Equipment Technology Tianjin Area Major Laboratory
Tianjin Polytechnic University
Tianjin, China P.R

²School of Mechanical Engineering
Hebei University of Technology
Tianjin, China P.R

Abstract

In this paper, human-computer interaction was applied as the main features. Human-computer interface programs and programmable logic controller (plc) programs were combined application and address matching and the same address communication mode were adopted. Through the buttons of human-computer interface to trigger the read address set. And further corresponding virtual relays of the plc addresses area were activated. In this paper, Li/MnO₂ button battery product line control system was introduced as an example. In the system, according to the process route of product line some areas were set including parameter setting area, single working place debugging area, equipment running area and the alarm browsing area. In order to protect the normal operation of the product line, interlock programs were used to ban parameters modification and single station debugging, avoiding the occurrence of malfunction. At the same time, the fault diagnosis technology was used to have designed a more optimal alarm pattern. The control system has been tested in practice to get good results.

© 2011 Published by Elsevier B.V. Selection and/or peer-review under responsibility of ICAPIE Organization Committee. Open access under CC BY-NC-ND license.

Keywords—human-computer interface; address matching; Li/MnO₂ button battery product line; interlock programs; fault diagnosis

1. Introduction

Li/MnO₂ button battery as the energy battery has been widely used in electronics, telecommunications, aviation, aerospace and toy industries. According to CR2032 type Li/MnO₂ button battery process requirements, the production process has been developed as follows: in the negative shell with Gathering Power Nets and lithium isolation paper soaked by electrolyte and MnO₂ were added in the order. Then
under the premise of ensure electrolyte full absorbed, positive shell has been assembled and sealed. Therefore, the production line mainly included cutting lithium into pieces process, pressure lithium into circle process, cutting paper process, injection electrolyte process, adding MnO₂ process, adding positive shell process, sealing process, testing process and packing process. PLC with high control precision, easy operation, better universal, high reliability can adapt to the harsh environment of industrial site. So PLC was used as the core of the product line control system. According to Li/MnO₂ button battery line specific conditions OMRON programmable controller and expansion modules were adopted as the core control part of product line. In order to facilitate the operation of product line and create a good human-computer interface environment, HITECH's PSW3260 series touch screen was used. RS-232C was applied in communication between human-computer interface and PLC. Parameter setting, action adjusting, production status and alarm display could be realized. The control system block diagram has been shown in Figure 1.

The control relationship between Processes

The rotary intermittent organ was used in the product line as the main body. It is easy to the layout of control system. Accurate positioning improved the accuracy of the data collection. The flow chart has been shown in figure 2.

In order to ensure synchronization running of all processes in the product line, detecting sensors were installed in each work place. If some materials were not in work place, the turnplate would automatically stop working. Once the materials arrived at work place, the sensor got the signal of materials and turnplate operated automatically again. This ensured the whole coherence. The product line was also equipped with blockage sensors. When blockage phenomenon happened, machine would alarm and stop automatically.
2. The communication control realization of human-computer interface and PLC

Human-Computer Interaction studied on the interaction technology between human and computer. HCI was the communication between the user and computer, which were bidirectional information exchange of a variety of symbols and actions between human and computer. Eventually, the purpose of people would be transformed into actions of product line or feedback messages. As a window of human-computer interaction, touch screen played the role of a bridge of communication. Through the touch screen, the running status and product efficiency of product line could intuitively be obtained. PLC’s operating parameters can be modified through it, too. When the buzzer alarm, touch-screen interface would automatically jump to the alarm information interface and display the corresponding station of possible causing failure.

2.1 Hardware configuration of human-computer interface and PLC communication

The product line adopted HITECH's PWS-3261-type touch screen which was a kind of 10.4"(640Hx480V) LCD and analogy mode color touch panel. And it was a sort of high-function human-computer interface which was the same with variety harsh environment. The external communication ports of the touch-screen included two 25-pin serial ports, named COM1 and COM2 ports. In the control system, COM1 port was used in the upload from pc and COM2 port as communication port and the PLC. In the communication between touch screen and PLC, the communication protocol complied with the standard RS232C serial communication protocols. Communication cable configured for PLC side for 9 holes and touch screen COM2 port side for 25 holes. Connection cable configured as shown in Figure 3.

![Diagram of Communication Control Realization](image)

Figure 2. Control Relations among Working Procedure

![Diagram of Cable Configuration](image)

Figure 3. the Cable Configure of SerialPort Communication between Human-computer Interface and PLC
2.2 The communication software design between touch screen and PLC

- The main interface design
  In the main interface, the whole control system has been divided into 4 parts, including system settings area, equipment running area, the debugging area and the alarm browsing area. Click the different buttons would turn to corresponding interface. The address matching and the same address communication mode were adopted in program design.

- System Setting area
  The control area was divided into two parts: the motor frequency adjusting part and time parameters of all work place adjusting part. As shown in Figure 4.

![Figure 4. System Setting area](image)

(1) Speeds change of motor was achieved by adjusting the frequency of transducer. According to the three multifunction input terminals of transducer, $2^3$ step speeds can be obtained. In this system, the 7-speed was adopted. It was meaningless for 000-speed that the three terminals were disconnected in the PLC program. Step speed setting as shown in Table 1.

Table I. Step speed setting

| speed     | Control terminal |
|-----------|------------------|
| Step-speed 1 | III 0 0 1       |
| Step-speed 2 | III 0 1 0       |
| Step-speed 3 | III 0 1 1       |
| Step-speed 4 | III 1 0 0       |
| Step-speed 5 | III 1 0 1       |
| Step-speed 6 | III 1 1 0       |
| Step-speed 7 | III 1 1 1       |

Transducer terminal No. corresponded to PLC addresses and the PLC status addresses allocation, as shown in Table 2.

Table II. Transducer Address Setting

| Project            | Transducer terminal No. |
|--------------------|-------------------------|
| corresponding PLC address | DI3 100.03 | DI2 100.02 | DI1 100.01 |
| corresponding PLC Status Address | HR0.03 | HR0.02 | HR0.01 |
(2) Step speed setting of motor in human-computer interface, as shown in table 3.

**TABLE I. STEP SPEED PROGRAM SETTING OF HUMAN-COMPUTER INTERFACE**

| Step-speed of human-interface | 1-7 |
|-------------------------------|-----|
| Corresponding PLC Address     | HR1.01-1.07 |

Corresponding PLC program has been shown in figure 5.

![Figure 5. Step-speed setting of motor in PLC program](image)

(3) The time parameters adjustment part of work places

The DM zones of PLC had memory storage function. Once the parameters had been put from the touch screen, data would be sent to the DM area of PLC through the serial port and the setting time of timer of PLC has been changed. The ultimate purpose of the action order changing has been realized. For example: Delay data in sealing keeping pressure process was set to write to the DM115 of PLC. Corresponding PLC program has been shown in figure 6.
Figure 6. Time parameter setting of sealing work place in PLC program

- All work places debugging area

The main function of the area was used for debugging single work place. The writing and reading address of the area was IR16.04 of PLC. The program interlock was applied. The product line must be shut down if entering the area in normal running case. Once entering the area current data would be lost and automatic operation function cancel, which was a good way to prevent the occurrence of mistake action. PLC program has been shown in figure 7.

Figure 7. The PLC program of going to debugging area in touch screen

There were three parts in the area, including motors control part, single work place control part and auxiliary control part. In the motors control part, the four buttons were used for debugging and controlling the start and stop of four motors, including reeling isolation paper motor control, delivering belt motor control, turntable motor control and Lithium belt delivering motor control. Single work place control part included all 38-work places buttons of product line, which were used for single working place debugging and determined the program changes case and made certain the correct position of new parts. Auxiliary control part included closing the release the valve, testing the buzzer and resetting the turntable. At the same time, current running speed phase also was displayed in the area. But step-speed could not be modified in the area. Interface must be transformed to system settings area when modification was needed. Program interface of debugging area has been shown in Figure 8.

Figure 8. All debugging buttons of whole product line
• Equipment running area

Equipment running area was the interface of the product line normal running. The numbers of qualified products and the numbers and the causes of nonconforming products could be seen from the current interface. In order to ensure unfinished parts were not left in the product line, an automatic clear end working procedure was added in the area. When stop button was pressed, the latter part of the product line to continue to work until all the parts assembled. The interface was kept at equipment normal operation and could not be turn to the system settings area because of interlock program. This avoided the parameters change resulting in mistaking action. The program interface of equipment running area has shown in Figure 9.

![Figure 9. Equipment Running Area](image)

• Alarm browsing area

In the area fault diagnosis technology were applied and the current alarm circumstances could be displayed, which has pointed the problem and possible causes. If material was shortage or material blocked, once material arrived product line would comeback normal running and the interface would automatically jump back to equipment running area.

The area was divided into three parts: the historical alarm part which displayed the alarm and time happened; the current alarm part which indicated the reason of the current stopping; alarm frequency part which has shown malfunction times of each work place. The PLC program of touch screen going to alarm browsing area has been shown in figure 10.

![Figure 10. The PLC program of touch screen going to alarm browsing area](image)

Program interface of alarm browsing area has been shown in Figure11.
3. Conclusion

The control system of the Li/MnO₂ button battery automatic product line discussed in the article was based on human-computer interaction. In this system, the human-computer interface program and PLC program were combined by the same address parameters set. Through human-computer interacting parameters setting of PLC were complete, that was to say coming true the product line parameters revised. At the same time fault diagnosis function were set, too. Automatic shutdown in malfunction happening achieved the automatic protection. Combined with a buzzer alarm and touch screen display formed a more optimal alarm system. The control system was successfully applied to the practice.

References

[1]Qi xiangyang. Research On the Remote Data Collect of Product Line Control System Based Internet. master degree paper.tianjin. hebei university of technology,2005,4 .
[2]Sun lixin,lin Shuzhong,Zhang yingxin,Sun huilai,Qi xiangyang. Control system design on Li/MnO2 button baterry product line.baterry,2004,34(2):102-103.
[3]OMRON PLC, CQM1H serial programming manual.OMRON company.1999,9,135-167,197-435.
Industrial human-computer interface.ADP3 window software manual Hitech Electronics Corp publishing.