Design and Research of Belt Centralized Control Transmission Machine Based on Programmable Logic Controller

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Abstract: With the advent of the information age, the industry is also developing in the direction of automation. The application of PLC and computer communication is more and more extensive. For small and medium-sized belt conveyors, the control system is usually controlled by relays, which has poor reliability, high labor intensity and low production efficiency. Therefore, it is necessary to develop a belt conveyor control device based on PLC. Based on this, the development and the existing problems of centralized control system are analyzed firstly. Then the working principle of PLC is briefly introduced. Next we generalized the structure and electrical requirements of the belt conveyor, and finally elaborated the design of the control system, including the main equipment required, system hardware circuit and software system. We also elaborates on the anti-interference related content. The system shows good operation through debugging and can play its function in practical applications.

1. Introduction

With the rapid development of the national economy, coal mines, metallurgy, steel, power plants and other aspects have new requirements for the use of belt conveyors [1]. Belt conveyor is a continuous transportation machine and a general-purpose machine. It can transport bulk materials as well as bulk items. The electrical control of the previous belt conveyors is mostly controlled by relays and contactors. It is manually operated and has the disadvantages of high labor intensity, serious energy consumption, large maintenance and low reliability [2]. With the development of industry, the relay control system can not meet the corresponding requirements, so it is necessary to develop a special belt conveyor control system according to the requirements of different users in different industries.

2. The development of centralized control systems and existing problems

In coal mines, the transportation of coal flow is generally between several hundred meters and ten kilometers. Therefore, its transportation system must have multiple belt conveyors, coal feeders, coal bunkers, etc., to coordinate and complete long-distance transportation tasks [3]. In order to ensure the safety and reliability of the transportation system and improve the transportation efficiency, it is a technology urgently needed for modern coal flow transportation.

With the continuous expansion of mine functions and scale, the application of new technologies such as computer technology, network technology, and new industrial controller technology, the centralized control system for the belt conveyor has also been rapidly developed [4]. From a single control system to a number of centralized control systems, there are relatively expensive PLC system and low-cost single-chip application system. At present, although there are various centralized control systems on the market, the development direction is the same. That is the development of automation, intelligence, and information [5].

The integrated automation of the belt conveyor is an important part of the automatic control of the entire mine. At present, the main problems existing in the centralized control system of the belt conveyor are:

(1) In terms of safety protection, in order to improve the reliability, safety, reduce faults and

improve efficiency of the belt conveyor operation, various detection methods have been applied to fault detection of electric motors, fluid couplings, reducers and belt running systems. But these systems are independent of each other [6].

(2) The false alarm rate of the fault detection system is high. False positives will cause undesired downtime of the belt conveyor, which will stop the production of the whole mine and have a great impact on mine production [7].

(3) The information of control, operation and protection of the belt conveyor cannot be well shared with other mine control systems and cannot be integrated with the entire mine information system [8]. The video surveillance system is not standardized, there is no voice communication function, and it cannot be unattended.

3. How plc works

When PLC is put into operation, its working process is generally divided into three phases, namely, input sampling, user program execution and output refresh. The completion of the above three phases is called a scan cycle. During the whole operation, the above three stages are repeated for a certain scanning speed of PLC cpu.

(1) Input sampling stage

In the input sampling phase, PLC reads all input states and data in a scanning manner and stores them in the corresponding units in the I/O image area. After the input sampling is finished, it is transferred to the user program execution and output refresh phase. In these two phases, even if the input state and data change, the state and data of the corresponding unit in the I/O map area will not change. Therefore, if the input is a pulse signal, the width of the pulse signal must be greater than one scan cycle to ensure that the input can be read in any case.

(2) User program execution phase

In the user program execution phase, PLC always scans the user program (ladder) in order from top to bottom. When scanning each ladder diagram, it always scans the control on the left side of the ladder diagram by each contact line, and logically operate the control line formed by the contacts in the order of first left, then right, first up and then down, and then refresh the state of the corresponding position of the logical coil in the system ram storage area according to the result of the logic operation; or refreshing the state of the corresponding bit of the output coil in the I/O image area; or determining whether to execute the special function instruction specified by the ladder diagram.

During the execution of the user program, only the status and data of the input point in the I/O image area will not change, and the status of other output points and soft devices in the I/O map area or the system ram storage area and the data is subject to change, and the ladder diagrams listed above, the program execution results will work on the ladder diagrams that use these coils or data below; on the contrary, the ladder diagrams below are refreshed. The state of the logic coil or data can only go to the next scan cycle to work on the program that is listed above.

If you use the immediate I/O command during program execution, you can directly access the I/O point. If you use the I/O command, the value of the input process image register will not be updated. The program will be taken directly from the I/O module value, the output process image register will be updated immediately, which is somewhat different from the immediate input.

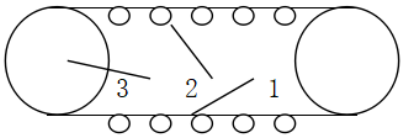
(3) Output refresh phase

When the scanning user program ends, PLC enters the output refresh phase. During this period, the CPU refreshes all the output latch circuits according to the corresponding state and data in the I/O image area, and then drives the corresponding peripherals through the output circuit. At this time, it is the real output of PLC.

4. Structure and electrical requirements of the belt conveyor

4.1 Structure of the Belt Conveyor

The belt conveyor consists of belts, frames, drive rollers, reversing rollers, load rollers, return rollers, tensioners, and cleaners. The schematic diagram of the composition structure is shown in Figure 1, and the schematic diagram of the transportation of the raw material transporter is shown in Figure 2.



1-Belt; 2-stick; 3-drive wheel

Figure 1 Composition of the belt conveyor

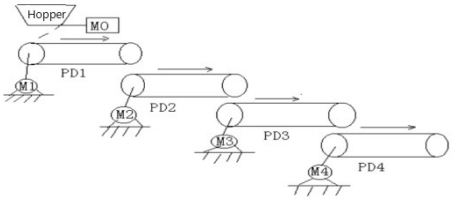


Figure 2 Schematic diagram of the transportation of the raw material belt conveyor

4.2 Electrical Control Requirements for Belt Conveyors

1) Start the last belt conveyor first, then start each belt conveyor from the back to the front every 15s.

2) When stopping, first stop the first belt conveyor. After the delivery is completed, stop the belt conveyors from front to back every 30s.

3) When a belt conveyor fails, the belt conveyor and the front belt conveyor stop immediately, and the belt conveyor of the belt conveyor stops after the conveyor is finished. For example, if the motor M2 fails, M1 and M2 stop immediately. After 30s delay, M3 stops, and after 30s, M4 stops.

5. Design of control system

5.1 List of Major Equipment

The main equipment list of the centralized control PLC program of the belt conveyor centralized control system is shown in Table 1 below:

Table 1 Program main equipment

name	Model parameter	Remarks
Ps 407 20a power supply	6ES7 407-ORA02-OAAO	Power module (20a)
CPU 414-2 DP	6ES7-414-2XK05-OABO	Cpu414-2, 512kb program memory / 512kb data memory
DI16xUC 120/230V	6ES7 421-1FH20-OAAO	Digital input module (16 points, 120/230vuc)
DI16xUC 120/230V	6ES7 421-1FH20-OAAO	Digital input module (16 points, 120/230vuc)
DI16xUC 120/230V	6ES7 421-1FH20-OAAO	Digital input module (16 points, 120/230vuc)
D016Xac120/230V/2A	6ES7 422-1FH00-OAAO	16 points output, 120/230vac, 2a

5.2 Hardware Circuit Main Circuit Diagram and Description

In Figure 3, through the closing of QF1, the current passes through the coil of the contactor, so that the main circuit is sucked, so that four motors are started, and the belt conveyor is controlled. The coil KM1 controls the motor M1, the coil KM2 controls the motor M2, and the coil KM3 control M3, coil KM4 control M4. In the main circuit, if a motor fails, the circuit can be cut off by the corresponding low-voltage electrical appliance. The knife switch QF acts as a power supply isolation. The fuse FU acts as a circuit backup short-circuit protection. The thermal relay FR has a protection against motor overload and matches the inverse time characteristic of the motor.

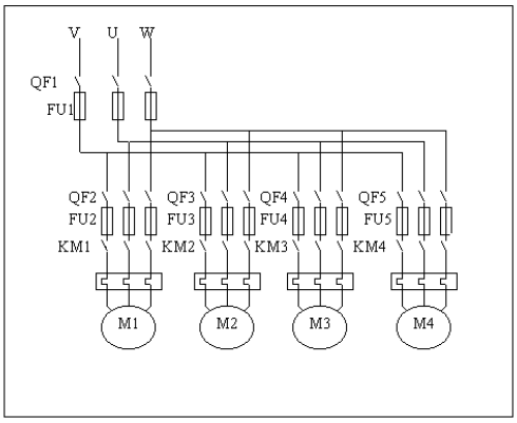


Figure 3 main circuit diagram

5.3 Software Design of the Control System

5.3.1 Software Design Ideas

According to the processing technology requirements and user needs, taking into account the safety of each device, the requirements of fault protection and alarm operation status display, and the coordination function of each device, the entire control program is programmed in ladder language. When considering the failure of the belt conveyor, the time between each belt conveyor operation is controlled by a timer. In the centralized control mode, after the system is started, each motor is started in sequence through timer control.

5.3.2 Program flow description

First, PLC power-on initialization, then press the start button (00000), M4 motor starts first, then start M3, M2, M1 motor every 15s. When the motor needs to stop working, just press the button (00001), then the first motor stops working immediately to avoid feeding, and then stops the M2, M3, M4 motors every 30s. When the motor fails, press the fault button (each motor has a fault button), the motor and the motor before this motor stop working immediately, and stop the motor behind the 30s timer.

In the program, 01000, 01001, 01002, 01003 control the motor M4, M3, M2, M1; 01004 as the fault alarm light, 01006, 00007, 01008, 01009 fault output, 01005 is the parking output. The timing of each motor start time control. When the start button 00000 is pressed, the coil KM4 is energized, the KM4 main circuit is energized, the contactor is closed, the motor M4 is started, and then every 15s (controlled by the timers tim000, tim001, tim002) KM3, KM2 KM1 coil is energized, the main circuit is closed, and the corresponding motor starts to work. Next is the parking process, press the parking button (00001) to stop the M1 motor, and then stop in the order of M2, M3, M4 every 30s. The protection of the electrical equipment (short circuit, overload, over current, etc.) cuts off the circuit to ensure safety. In the event of a fault, it is manually controlled. When the M2 motor fails, the 00004 button can be pressed, and the M2 and M1 motors stop immediately. Then cut through M3 through the timing of t004, and cut off M4 by t003 timing 30s.

5.4 Anti-Interference Design

5.4.1 Main sources of interference

There are many sources of interference in the PLC control system. It is divided into two types: internal interference and external interference. Internal interference is a problem of PLC itself. External interference includes conducted interference and radiated interference [9]. Conducted interference is through electrical signal of the line entering the PLC control system includes the interference and grounding interference introduced by the external line such as the power line and the signal line; the radiation type interference is the interference signal of the radiated electromagnetic field entering the PLC system through induction [10].

1) Power line introduces interference

The normal power supply of the PLC system is powered by the grid. When the load on the grid, such as large power equipment, AC/DC transmission, etc., starts and stops, the grid voltage will fluctuate, resulting in harmonics. Harmonics are transmitted to the power supply through the transmission line, causing the PLC control system to malfunction.

2) Signal line introduces interference

These interference signals are mainly transmitted to the PLC control system through two ways. One is the power grid interference that is connected to the power supply of the transformer power supply or the common signal meter, which is often neglected; the second is that the signal line is interfered by the space electromagnetic radiation. The interference introduced by the signal will cause the I/O signal to be abnormal and the measurement accuracy to be reduced. In severe cases, the component will be damaged. For systems with poor isolation performance, the signals will interfere with each other, causing the common system bus to reflow, causing the logic data to change.

3) Grounding interference

The ground wire of the PLC application system includes system ground, shield ground, AC ground and protection ground. The grounding system chaos will cause uneven distribution of potential at each grounding point, causing ground loop current and affecting the normal operation of the system. For example, the cable shield must be a little grounding, if both ends are grounded, there is a ground potential difference, causing current to flow through the shielding layer, affecting the normal operation of the PLC.

5.4.2 Anti-interference measures

(1) Anti-power supply interference

1) Using a dedicated power supply, the power supply should be separated from the large power supply equipment to avoid the impact on the power supply voltage when the large power equipment starts and stops.

2) The double-shielded isolating transformer is used between the controlled AC power supply and the PLC machine. The shielding layer of the primary winding is connected to the neutral line to isolate the interference of the power supply. The shielding layer of the secondary winding and the PLC system control cabinet are co-located to make the interference signal enter the ground.

3) Install an AC voltage regulator or an AC low-pass filter between the isolation transformer and the PLC to filter out high-frequency pulses to improve power supply stability, thereby reducing grid voltage fluctuations to the PLC supply voltage impact.

(2) Anti-input and output interference

1) When there is an inductive load at the input end, in order to prevent the back electromotive force from damaging the module, connect the RC surge absorber or varistor RV to the AC signal input terminal, and connect the freewheeling diode VD or varistor RV or stabilize at the DC signal terminal. Voltage diode VS or RC surge absorber, etc. If the inductive load in parallel with the input signal is large, it is best to use relay relay.

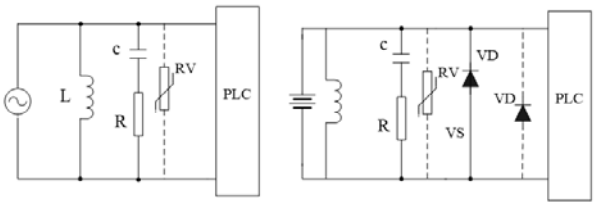


Figure 4 Input anti-interference circuit

2) The output load of PLC may cause interference, and corresponding measures should be taken to control it, such as DC output terminal connected to the flow tube or varistor or RC surge absorber protection circuit, AC output terminal connected to the RC absorber or varistor transistor and triac output terminals are connected with shunt resistor protection. When the controller contacts the switch output, the output anti-interference circuit should be used to reduce and eliminate interference.

3) Grounding system anti-interference

The PLC control system is a high-speed low-level control device, which should be directly grounded. Due to the influence of signal cable distribution capacitance and input device filtering, the signal frequency between devices is generally lower than 1, so the grounding of the PLC control system should be grounded at one point. The grounding wire should be thicker to reduce the ground potential difference between the various circuit components, thereby reducing the interference of the ground circulation. In addition, the shielding ground and the protective ground cannot be connected with the power ground, the signal ground, and the like. It can only be independently connected to the grounding bronze medal.

5.4.3 Equipment selection

When selecting equipment, first choose products with high anti-interference ability, including electromagnetic compatibility (EMC), especially anti-interference ability, such as floating system technology, good isolation performance PLC system; secondly, should understand the anti-interference indicators given by the manufacturer, such as the common analog ratio, the differential analog ratio, the withstand voltage capability, the work of allowing the electric field strength and the high-frequency magnetic field strength; and the other is to examine it in similar work application performance. In the selection of foreign imports, we must pay attention to: China adopts 220v high internal resistance grid system, while Europe and America is 110v low internal resistance grid. Due to the large internal resistance of China's power grid, the zero potential drift is large, the ground potential changes greatly, and the industry electromagnetic interference at the enterprise site is at least 4 times higher than that in Europe and the United States, and the anti-interference performance of the system is higher. The PLC products that can work normally in foreign countries may not be able to operate reliably in domestic industries, which is necessary when using foreign products. According to China's standard (GB/T13926) reasonable choice.

5.4.4 Integrated anti-jamming design

The main contents include: shielding the PLC system and external leads to prevent electromagnetic interference from space radiation; isolation and filtering of external leads, especially principle power cables, layered arrangement to prevent conductive electromagnetic interference from being introduced through external leads; correct design of grounding points and the grounding device to improve the grounding system. In addition, software must be used to further improve the safety and reliability of the system.

6. System debugging

The basic operations of programming with CX-P are: create a new project, create a program, compile the program, transfer the program on the PC to the PLC, transfer the program in the PLC to the PC, and the program in the PC and the PLC. The program is compared, monitored during the

execution of the PLC program, online programming, etc.

When the start button 00000 is pressed, the last belt conveyor M4 (01000) starts to start. After the passage time is 15 seconds, the M3, M2, M1 belt conveyors are sequentially started. When stopping, the front belt conveyor M1 (01003) should be stopped first. The stop button is 00001. Press this button to control the normally closed contact through the coil 01005, stop the 01003 motor, and stop the M2, M3, M4 belt conveyors in sequence through the control of the program. This is the normal start and stop control. In case of failure, press the corresponding belt conveyor's fault button to stop the motor and alarm in time. At this time, the timer starts to be timed, and all the motors stop working after a while. In addition, there will be four faults. The buttons are connected in parallel and connected together on an alarm. If there is a fault, it can be alarmed in time to enable the relevant personnel to pay attention.

7. Conclusion

The centralized control system designed in this paper has been put into operation, has reached the expected design requirements, and works well. The successful operation of the centralized control system realized the automatic operation and automatic detection of the coal mine ground transportation system, improved the automation management level of the coal mine, improved the production efficiency, reduced the staffing and accident rate, and ensured the safety and reliability of the coal mine production. .

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