Research on the balance controller of HZ belt conveyor based on fuzzy control

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Abstract. HZ belt conveyor is a rubber conveyor belt with an end (or no end) installed on the driving roller and driven roller at both ends of the conveyor. Several parallel rollers and pallets are installed between the two rollers to support the weight of the material and the conveyor belt. The selection of the entire hardware of the balance control system of the belt conveyor is very important. In addition, the quality of the designed program (including the control algorithm and control accuracy) will directly affect the control performance index of the control system, and even affect the stability of the system. Therefore, in addition to hardware, program design is an important part of all links. The system designed in this paper is mainly designed by Siemens PLC300 special software STEP7.

Keywords: belt, conveyor, control balance.

1. Introduction
Double-width belt conveyor, also known as belt conveyor. It is mainly composed of frame, conveyor belt, belt roller, tensioning device, transmission device, etc. The fuselage is connected by high-quality steel plates, the frame is formed by the height difference of the front and rear legs, and the plane is inclined at a certain angle. Belt rollers, idlers, etc. are installed on the frame to drive and support the conveyor belt. There are two modes: geared motor drive and electric drum drive. The driving roller, driven roller and idler roller of the HZ belt conveyor designed in this paper are all installed on the frame. The driving roller is driven to rotate by the driving device. Relying on the friction between the rotating roller and the conveyor belt to make the conveyor belt move, so as to achieve the purpose of transporting materials. In order to make the conveyor with proper tension, a spiral tension device is also provided.

2. The structure of the double belt conveyor
The belt conveyor is composed of driving device, driving roller, driven roller, idler roller, hydraulic lifting system, hand lifting system, tensioning device, baffle, hopper, belt and frame. The components are different according to the customer's customized style.

(a). Head drive unit. It is composed of electric motor, reducer and transmission device. The power is driven by the motor and reducer to rotate the active drum (when equipped with the electric drum, it is directly driven by the electric drum), and the active drum uses the friction between it and the belt to drive the belt to run. At the same time, in order to meet the needs of conveying different materials, our
company can also design and adjust its operating speed according to the special requirements of customers. Please refer to the main technical parameter table for the relationship between specific speed and conveying volume.

(b). Driven roller. The driven roller is installed at the rear of the frame, and it is composed of a roller, two tail wheel sliding seats and bearings.

(c). Roller. The rollers are divided into trough rollers and parallel rollers. Parallel rollers are suitable for horizontal conveying

And conveyors using special belts.

(d). Tensioning device. The tightening device adopts a spiral tightening method to adjust the tightness of the belt. Note that the belt should not be too tight.

(e). Rubber conveyor belt.

(f). Rack section. It is welded with various section steels and reinforced steel plates.

3. Software design ideas

Various control algorithms, including fuzzy algorithms that can meet the needs of the system, should be operated with a certain precision. When the program is running, it is necessary to ensure that the program will not crash and that various signals can be sampled in real time; during the programming process, the system must be fully automated, operate normally, and avoid manual interference; make the human-computer interaction interface more coordinated and beautiful; Real-time display the parameters of the control system and the working status of each device, and modify the parameters as needed. The program should be modularized so that the entire control project can be divided into several independent instruction blocks, which can be called mutually when needed. This not only achieves a clear hierarchical structure, but also makes PLC programming more flexible, easy to maintain, modify and debug. According to the system control requirements, modular programming is selected. The entire program is a hierarchical structure, thus dividing the entire program framework into seven layers. As shown in Figure 1.

![Figure 1. Program structure](image-url)

(A). Communication layer between PLC and monitoring management system: data information transmission between communication modules. In the process of PLC controller program execution, the generated control instructions are classified from the command information, system state and other data information transmitted from the operation panel, and then transferred to the monitoring and monitoring. Manage system. At the same time, the data and service information transmitted by the monitoring management system are processed, and then transmitted to the control decision layer and HMI layer respectively.
(B). ITO interface layer: ITO information integration in PLC processing engineering. There are various kinds of information and data about the working state, fault condition, parameter setting and signal setting of various external connected equipment of PLC controller.

(C). HM1 layer: mainly responsible for online setting of oil temperature, oil pressure and transmission speed, control command transmission, status display, etc. It transmits information to the ITO interface layer in an "information display" state. In order to intervene in the production control process, the decision level should be transferred to the decision level through staff selection or process control instructions. In the form of parameter Settings or adjustments, it is transmitted to the data manipulation layer for parameter setting.

(D). Data manipulation layer: model operation, module operation, address operation and data information integration. It includes soft start of drive motor and calculation of power balance algorithm of multi-motor drive. The output information function of this layer is to exchange information with the control decision layer, carry out process control information from ITO interface, and transmit the processing results to the interlock layer between devices.

(E). Control decision layer: control process module integrates various transmission data according to system control requirements. The whole control process is composed of several control modules, including system initialization, AD sampling, DA output control, soft start, soft stop and power balance control. The main task of this layer is to transmit the automatic instruction to the TO layer. The flow control instructions are transmitted to the operational layer so that the corresponding data module can be invoked for operation.

4. Overall programming of the control system
In recent years, the conveying distance and conveying volume of large belt conveyor are getting larger and larger. Therefore, the whole belt conveyor begins to adopt multi-machine drive, that is, drive motors are installed in the head, tail and middle of the belt to avoid reducing the tension of the belt and improve the working efficiency of the conveyor. In the control system designed in this paper, three motor drive drive systems are adopted, namely, a motor is installed in the head, middle and tail of the conveyor belt. This multi-machine drive can provide good production efficiency, but the output power of the drive motor is unbalanced within the capacitor, resulting in belt pull and even direct combustion of the motor. The PLC control program designed in this paper can realize the automatic control among the multi-machine drive subsystems, which ensures the output power balance of the drive motor and the soft start of the conveyor. In addition, the PLC control program designed in this paper adopts modular structure, each module is independent of each other, can call each other when needed, and the program is easy to modify, can be expanded at will.

The general program of multi-machine drive can be divided into main program, conveyor start and stop subroutine and power balance control subroutine. When the control system 1 + 4 is powered on, first enter the initialization program of the system, begin to detect the belt conveyor and driving equipment, and then set the working state of the control equipment according to the requirements. Once the system is initialized, each subroutine is executed in the preset JT startup sequence so that the entire system and device gradually enter the running state. Among them, various control signals in the controller PLC are as follows:

(A). Signal: (a). From the peripheral connected device to the controller drive motor start control signal and stop control signal; Conveyor speed signal (4-20mA); Power signal of driving motor (4-20mA); Emergency stop signal; Permitted and prohibited operation signals; (b). An emergency jump signal of the motor generated by the device driven by a signal transmitted from the controller to an externally connected device;

(B). Real-time signal monitoring of the control system: (a). After the power signal control system of the drive motor is initialized, the current sensor begins to continuously monitor the current signals of the three drive motors and control the output power motor according to the three current signals. During the monitoring process, if the current signal value exceeds 4-20 mA, the controller starts to send the motor power alarm signal. At this point, it is necessary to monitor whether the current sensor
is working properly and whether the motor is overloaded. (b). The speed sensor always monitors the speed of the output shaft of the reducer after the initialization of the speed control system. When the controller monitors the speed of the output shaft of the reducer, it instructs the controller to stop immediately. (c). After the conveyor belt speed signal control system is initialized, the conveyor belt speed signal is continuously monitored. Once the normal range is exceeded, the PLC controller will immediately issue an alarm command to check the field working status of the conveyor belt. The temperature sensor has been monitoring the oil temperature signal in the storage tank of the reducer from starting, running to braking, but if the temperature exceeds the set range, the PLC controller will send an alarm signal. After the system is initialized, the pressure sensor monitors the oil pressure signal in the reducer to ensure the normal oil pressure in the three kinds of reducer.

(C). In the working process of the conveyor, the conveyor works under the following conditions, from safe start, stable operation to safe braking. (a). In this state stop, each sensor monitoring the corresponding device. When the PLC controller receives the oil pressure and oil temperature signals of the reducer, and there is no fault signal in the system, the PLC controller will call the oil level inside the reducer zero, and send the start signal to the three driving motors, so that it is in the no-load state. After that, the oil filling capacity is added to the hydraulic weighing clutch so that the conveyor begins to soft start according to the predetermined acceleration curve. (b). Preloaded adhesive tape is prone to reverse when starting, so a certain amount of pressure should be preset on the clutch before loosening. (c). When the speed sensor monitors the start of the belt at its lowest speed, start the buffering process and let the belt run at low speed for a period of time. Acceleration As the belt runs for a period of time, its speed continues to rise along the designed acceleration curve until it reaches the specified value. Full speed When the conveyor reaches full speed, it will run at this speed until it stops. When the deceleration signal is received by the PLC controller, the conveyor will be controlled to drop according to the set deceleration curve until it stops completely. At the same time, under the condition of no load, the drive motor will be controlled to brake directly.

5. Conclusion
In this paper, the power balance of multi-motor drive is studied and analyzed comprehensively. In the program design, the main program module, soft start program module, soft stop program module and drive power balance program module of the control system are designed. The research on balance control lays a solid foundation for the successful development of belt conveyor.

References
[1] He Peng. Research on Fuzzy PID Controller Design and Simulation Based on Matlab [J]. Microcomputer Application,2017.04.
[2] Di Shuyu, Chi Huanyu. Control System Design based on PLC Coal Mine Belt Conveyor [J]. Journal of Jilin Chemical Industry,2013(3).
[3] Zheng Meiru. Simulation Research of Fuzzy PID Controller [J]. Equipment Manufacturing Technology.2016.04.
[4] Guo Fengyi, Zhang Huanqiang. Application of Fuzzy PID Control in automatic Loading System of Coal Mining Area [J]. Computer Measurement and Control.2013.07.