Research on the Design of Electrical Control System of Production Machinery

Yangliu Liu

judge memorial catholic high, State of Utah, America

Abstract. The principles of feasibility, rationality, compatibility and reliability should be followed in the design of electrical control system of production machinery. The design should meet the design requirements on the basis of repeated simulation tests. The electrical control system design of production machinery mainly includes the schematic design and technological design of electrical control. This paper analyzes the basic methods and design points of schematic design and technological design to provide references for related researchers.

1. Introduction

Production machinery is one of the main driving forces for the development of industrial production in China, and the electrical control system of production machinery has been widely used. However, with the in-depth development of the industrial industry, the industry has higher and higher requirements for the performance of production machinery and equipment. Therefore, people pay more and more attention to the design of electrical control system. This paper will explore the principle and process of electrical control system design of production machinery, based on electrical schematic design and process design to achieve the design of electrical control system of production machinery, analyze and research the design rules and methods of electrical control system of production machinery.

2. Design Principles of Electrical Control System of Production Machinery

The design of electrical control system of production machinery should follow certain criteria [1]. The general principles of its design mainly include the following points: first, the feasibility principle of design. We want to make electrical control meet the needs of production machinery and technology to the greatest extent. Only in this way can the maximum value of the electrical control system be realized, and the maximum effectiveness of the production machinery and equipment can be brought into play. Therefore, we must firmly grasp the design principle and steps of electrical control circuit, and each step should be implemented according to the design criteria. Second, the principle of rationality of design. On the premise of meeting the requirements, the control circuit should be simple, economic, reliable, and easy to operate, adjust and maintain. In order to make the mechanical design and operation have no practical effect, the design of the mechanical system is of no practical significance. Therefore, in the design of electrical control system, we should make the correct choice of circuit and link. Third, the principle of design compatibility. In the design of electrical control system, we need to focus on the compatibility of system and machinery in the design, otherwise the system cannot achieve the control of machinery, and the products designed cannot meet the application requirements. The fourth is the reliability principle of design. We ensure that the control system works safely and reliably. Generally speaking, the whole electrical control system should have high reliability and can work safely for a long time [2].
3. Design Process of Electrical Control System of Production Machinery

First of all, we can establish the power design scheme according to the electrical design specification [3]. Then, we choose the type of motor and design a reasonable schematic diagram. Then, we get the main technical parameters by calculation and verify them. We select the required electrical components, components after the development of the relevant list, the preparation of mechanical design instructions. In order to make the process of manufacturing electrical control system more efficient and implement the technical indicators proposed in the principle design, process design must be carried out to provide effective drawing data for the debugging, use and maintenance of machinery. In the process of designing content, the schematic diagram should be strictly designed. Schematic diagram is the key of electrical control system of production machinery, which can provide effective evidence for subsequent process design and technical data formulation. The most basic design task of electrical control system design of production machinery is to design and compile necessary drawings and data for equipment manufacturing and maintenance according to control requirements. The design process of electrical control system for production machinery is shown in Figure 1.

![Design process of electrical control system for production machinery](image_url)

Figure 1. Design process of electrical control system for production machinery

4. Electrical Schematic Design of Electrical Control System of Production Machinery

4.1. Basic Methods.

There are two main methods of electrical schematic design in electrical control system design of production machinery, which are empirical design method and logical design method [4].

The empirical design method is to select the basic unit circuit according to the specific production requirements or combine the mature circuit design according to certain conditions, and then modify and supplement according to the actual situation, so as to make it a complete circuit meeting the control requirements and design requirements. The advantage of this method is that the design method is simple and there is no fixed program. The whole process is based on the mastery of the basic links of electrical control system design and the higher analysis ability of electrical control system circuit. For beginners, it
is easier, but for experienced electrical designers, it can make the design task faster to complete, effectively improve the efficiency of the work. Therefore, in the actual design, the empirical design method has been widely used. However, the empirical design method also has some limitations, that is, the scheme of the electrical control system designed by this method may not be well considered, and the designer's lack of experience may also cause the design scheme to be poor, thus affecting the reliability of the electrical control system. Therefore, in the actual design process, it is necessary to carry out repeated audit, and simulation experiments should be carried out when conditions permit. Once the problem is found, it should be modified in time until the design of the electrical control system circuit meets the production requirements.

Logic design method is to use logic algebra in circuit design. According to the process requirements of production machinery, each link in the control circuit is regarded as logical variables, and the relationship between these variables is expressed by multiple logical relations according to the control requirements. After these relations are simplified, the corresponding circuit design diagram is given. The logical design method can make the best design scheme, but in the actual use process, the design is more difficult and the process is complex. Sometimes, some new concepts have to be used, so the logical design method is rarely used alone in the conventional design. The advantage of logical design method is that it can optimize the design scheme, but the disadvantage is that in the actual use process, the design is difficult and the process is complex, and sometimes it may need to combine with new ideas. Therefore, in the conventional design, the logical design method needs to be combined with other methods. When the schematic design meets the requirements of production process, it is necessary to fully understand and master the mechanical performance, structure and its actual situation. Then, through the consideration of control mode, reverse direction, start-up, speed regulation and braking, the interlocking and protection devices are designed, and then the type and voltage value of circuit power supply are controlled.

4.2 Design Points.
In the design of electrical schematic diagram, in addition to meeting the above general principles of electrical control system design, we also need to pay attention to the following points. First of all, we should pay attention to the selection of the type of power supply and the size of voltage in the control circuit. 220 V power supply or 380 V power supply can be directly used in simple control circuit, as the components used are not complex. However, when the control circuit is more complex, we may need to reduce the control voltage to 24 V, 48 V or 110 V. At the same time, the control power transformer should be used, so that the safety of the electrical control circuit in operation can be guaranteed, which requires the stability and reliability of electrical components and devices. Secondly, attention should be paid to safety, especially whether the connection of coil and contact of electrical components conforms to national standards. For example, from the figure below, we can find that although the position of electrical components or contacts in the diagram is changed, its working principle is not affected, but this does not mean that it is safe in the actual operation process. Third, when drawing the electrical schematic diagram, in order to distinguish the types and functions of the electrical appliances in the control circuit, each electrical appliance and its components are represented by certain graphic symbols, and each electrical appliance has a text symbol, and each component belonging to the same electrical appliance is represented by the same document character number. The electrical appliances with the same function are all represented by a certain number. Because each electric appliance performs different actions in different working stages, the contact is closed and opened when it is closed, but only one case can be indicated in the schematic diagram. Therefore, it is stipulated that the contacts of all electrical appliances indicate normal positions, that is, the positions when the coil is not energized or the machine has not yet operated. For example, for contactors and electromagnetic relays, it is the position where the electromagnet is not attracted, and for the travel switch and button, it is not pressed.
5. Technological Design of Electrical Control System of Production Machinery

5.1. Basic Methods.
In this link, the control system should be divided into several parts according to the principle design diagram formulated before. Then, according to the actual complexity, each component is divided into several units, and the incoming and outgoing line numbers involved in each part are sorted out, and the connection mode is adjusted. In order to prevent interference, the strong and weak current should be separated. In order to facilitate debugging and inspection, it is necessary to combine those vulnerable components and devices that need regular adjustment and maintenance in the same unit. The drawing method of wiring diagram includes direct wiring method and symbolic marking wiring method. When there are few components in the electrical system and the connection relationship is relatively simple, the direct wiring method can be used to directly draw the wiring between the components. When there are too many components and the connection relationship is more complex, it is necessary to use the symbol marking connection method. The connection relationship is represented by the symbol label at the terminal. When drawing the electrical control wiring diagram, the following principles should be adopted according to the layout of electrical components and devices and relevant national regulations. The position of each component in the wiring diagram shall be consistent with the actual installation position. The marking on components and wiring base shall be consistent with that in schematic diagram. Thin lines should be used in drawing to clearly show the relationship and direction of wiring.

When designing the general layout of the electrical system, the purpose is to draw the electrical general layout, general installation drawing and general wiring diagram, which should be carried out on the basis of the design results of the electrical schematic diagram. Generally, it is necessary to divide the electrical control system into several parts according to certain standards, and then reduce the division conditions based on the difficulty of operation, sort out the incoming and outgoing line numbers used in each part, and optimize and adjust the connection mode of the line. The wiring diagram of electrical control device needs to clarify the overall connection relationship of the equipment, and in the specific design and drawing process, it needs to be based on the requirements of "electrical drawing wiring diagram and wiring table", and the detailed information of the wire needs to be marked and processed. In the actual operation process, it is required that the installation position of the components should be consistent with the position drawn in the wiring diagram, and the live parts in the unified electrical components should be connected with the thin solid wire frame through thin wires. At present, there are mainly two kinds of electrical control cabinet, vertical and working table. There are many kinds and structures of them. In the specific design process, it is necessary to make reasonable selection based on the specific requirements of power control system.

5.2. Design Points.
The electrical equipment design needs to divide the control system into several parts according to the principle design diagram formulated before, and then divide each part into several units according to the actual situation, and then sort out the incoming and outgoing lines involved in each part, and adjust the connection mode. In general, the electrical control system design unit division should pay attention to: similar function components need to be combined together. In addition, in order to reduce the wiring between units, the control appliances related to wiring should be in the same unit; in order to prevent interference from external factors, the strong and weak current should be separated; in order to facilitate debugging and inspection, vulnerable components and devices that often need adjustment and maintenance should be combined in the same unit. The layout drawing of components and devices is based on the principle design drawing, which shall be carried out according to the following principles: the monitor device shall be installed on the instrument panel; the heating element shall be installed above the electrical board, and the larger or heavier components and devices shall be installed below; the components and devices requiring frequent debugging and inspection shall not be too high or too low during installation. To avoid strong current and external interference, it is necessary to install shielding facilities and isolation facilities for weak current parts.
After the comprehensive analysis of PLC control technology and field bus technology, the reliability of electrical control system should be improved. Especially in the frequency conversion technology, microelectronics technology, we must comprehensively analyze the reliability. The cost of electrical control system is relatively high. If it is not reliable and safe, once there is a problem, the whole system will directly fall into a state of paralysis, and customers will bear huge losses. Specifically, in PLC control technology, at present, the most effective protection measure is to add the first level optocoupler to the input end. In this way, even if high voltage enters the circuit in the future, the primary optocoupler can replace the fuse. At this time, the fault can be eliminated in time by replacing the optocoupler.

6. Conclusion
The design of electrical control system must be based on reasonable design concept and engineering practice to ensure high quality and high efficiency of design. In the design process, it is necessary to meet the basic requirements of production machinery and process for electrical control system. The design of electrical control system should be closely combined with the actual situation to ensure that the designed electrical control system can work safely. Only in this way can we bring good benefits to industrial enterprises.

References
[1] Hao Yong, Yuan Zhi. Design of automatic inspection robot system for fully-mechanized coal mining face[J]. Coal Science and Technology, 2020, 48(8): 145-149.
[2] Wang Kai. Design of Machine Tool Electrical Control Automation System Based on PLC Technology[J]. Adhesion, 2020(6): 121-124.
[3] Lou Shuangwang, Song Jianghua. On Design Points of Electrical Control System for Production Machinery[J]. Henan Science and Technology, 2019(34): 84-86.
[4] Liu Caixia. Reform and Exploration of the Practice Course of Installation and Debugging of Electrical Control System[J]. Equipment Manufacturing Technology, 2019(7): 156-159.