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Study of Inherent Safety Mine hoist based on modern design methods

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Abstract—As a modern security design, Inherent Safety means that equipment and facilities is able to contain the inherent fundamental features to prevent accidents. Mine hoist is the most important equipment in the coal production. How to achieve safe, reliable, efficient production has been the focus study at home and abroad. Inherent safety is reflected in hoist design, primarily through the design measures to improve the operation of hoist safety and reliability. In this paper, Inherent Safety theory is applied in the design of mine hoist, to proposed the design method by using the software of PRO/E PLC, Labview etc..

Keywords-Mine hoist; Inherent Safety; PRO/E; PLC; Labview

I. INTRODUCTION

In coal production, mine hoist is the equipment to carry coal, gangue, materials, workers and equipments along the rockshaft, the only way linked underground and aboveground, known as mine throat. Mine hoist is a large-scale reciprocating machinery which has the feature of own big inertia, load changes, running speed, and wide range et al.. The advantages and disadvantages of its operating performance, not only directly affect the normal production and coal production efficiency, but also relate to equipment and personal safety. In recent years, mine hoist failures and accidents have happened at home and abroad which have paid a heavy price to coal companies. Therefore, the production technology and safety of mine hoist are higher, and its mechanical manufacturing technology and electrical control technology has been an important research area to the international machine building industry and the electric control industry.

Inherent Safety means that equipment and facilities is able to contain the inherent fundamental features to prevent accidents. Inherent Safety lies in design, through continuous improvement, to prevent accidents due to the equipment itself failures. Inherent safety is reflected in hoist design, primarily through the design measures to improve the operation of hoist safety and reliability. In this paper, Inherent Safety theory is applied in the design of mine hoist, to proposed the inherent safety design method by use the software of PRO/E PLC, Labview etc.

II. INHERENT SAFETY THEORY

The term of inherent safety originates the development of world space technology in the

1950s. The concept is widely accepted closely linked with scientific technological progress and human understanding of safety culture. The concept of inherent safety produced after the World War II which became major safety concept in many industrialized countries since the mid 20th century.

Inherent safety design as the basic method of hazard control, by selecting safe materials, process routes, mechanical equipment, devices, to eliminate or control hazards source rather than relying on "additional" security measures or management measures to control them. As inherent safety design, firstly analyze and identify hazards that may occur in system, and then choose the best methods to eliminate, control hazards, which reflected in project design.

Ⅲ. THE DESIGN OF INHERENT SAFETY MINE HOIST

Mine hoist mainly includs the working device, control system, transmission system and drag, protection systems and other components. To the inherent safety mine hoist design, mainly the mechanical system, control system and monitor system is the major part to considered.

A. In-depth investigations to find malfunction

The concept of inherent safety is required safety all the time in the product design process. That is, the equipment has little malfunction as much as possible during the operation and has long normal operation cycle length. How can design inherent safety equipment, the most important thing is understanding enough to the equipment, especially in work. After in-depth research, fully understanding the situation, try the best to reduce or eliminate the fault in the design. After in-depth understanding of research, design product.

B. Mechanical System

The traditional method of product has long design cycle, high costs. However, the virtual prototype technology has the advantage in saving the design cost, shortening the design circle, by using the method of modeling, simulation first and then builds the physical prototype. Therefore, the virtual design is the developing trends of mechanical design. In mechanical system design, the application of virtual prototype is used to design mine hoist, not only speeded up the design process, also simulated a variety of conditions to the virtual prototype to discover design faults, to improve the design, to improve mine hoist performance.

Mine hoist mechanical system is composed of spindle, roller, reducer, motor, brakes and other components. In its design, virtual design software PRO / E is applied to establish hoist prototype, application of simulation software ADAMS is used to simulate and optimize the design. Specific process shown in Figure 1:

C. Control system design

Mine hoist control system includes start, run, brake, etc., the requirements in control system are:

In normal hoist operation, participation in hoist speed control, brake the hoist when reaching the destination, known as the service braking;

In case of emergency, can quickly slow down as required, brake hoist, to prevent the expansion of the accident, that is the safety braking; Participate in the hoist speed control when decelerati; To double-roller hoist, should brake the moving roller and fix roller respectively when regulating rope length, replacement level and changing rope, so that, moving roller would not move when spindle rotates with the fixed roller.

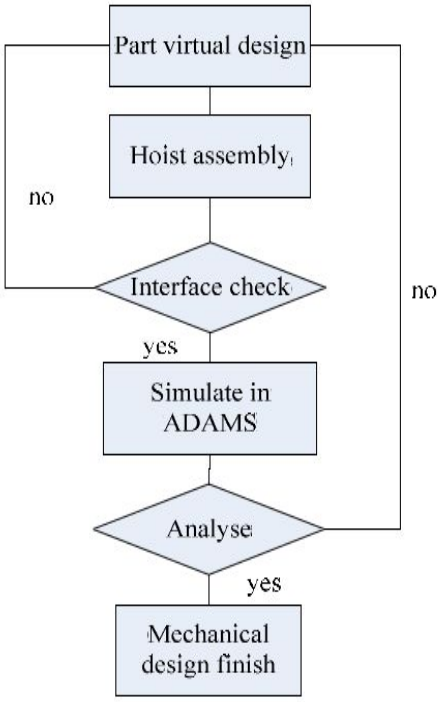

Figure 1. Mechanical system design

Most of mine hoists in China (more than 70%) use the traditional electric control system (tkd-a as the representative). Tkd control system is composed of relay logic circuits, large air contactors, tachometer generator etc., which is a touch control system. After years of development, tkd-a series of electric control system has formed its own characteristics, but its shortcomings are obvious. Its electrical circuit is too complicated, multi-line, causing hoist parking and accidents occurred due to electrical fault. With the computer and digital technology, to form a digital hoist control system of PLC has become possible. PLC control system has high control precision, parameter stability, simple hardware structure, self-diagnostic capability and communication networking function.

Mine hoist control system based on PLC technology structure shown in Figure 2, mainly including the following components: the main plc control circuits, hoist route detection and display circuits, speed detection, and signal circuits. The PLC of the main control circuits uses Mitsubishi FX2N series in Japan which more domestic applications.

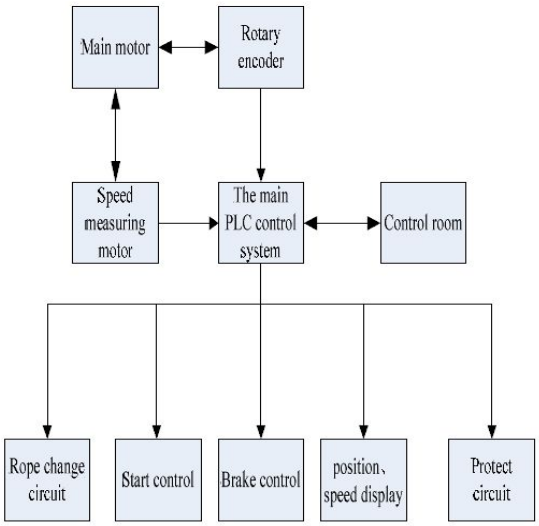

Figure 2 PLC electric control system

D. Monitoring system design

To ensure safe operation of the hoist, except for selecting the reasonable operation design parameters, the use of advanced control system, should also monitor the technological parameters on regular, conscientiously do performance test work to master the hoist performance, discover the defects in time, eliminate hidden danger, avoid unnecessary losses. In addition, the hoist operation state can be improved to work in the best conditions based on test data. Therefore, the hoist could work safely, reliably, have high efficiency, and extend its work life.

Virtual instrument technology is computer-based instrumentation and measurement technology, is loaded some software and hardware on the computer with similar appearance and performance of the actual independent instrument. The user operating the computer, like manipulating a especially conventional electronic devices

designed theirs. The essence of virtual instrument technology is that hardware softwarized technology, take full advantage of the latest computer technology to implement and expand the functions of traditional instruments.

LabVIEW (laboratory virtual instrument engineering workbench) is a graphical programming and development environment, also known as "G" language. It is widely used by industry, academia and research laboratories, accepted as the standard data acquisition and instrument control software. LabVIEW not only provides and complies with all the functions of hardware and data acquisition cards communications of GPIB, VXI, RS-232 and RS-485 protocol, and built-in library functions support for TCP / IP, ActiveX and other software standards. The software for scientists and engineers is a programming language, it provides a simple, intuitive graphical programming mode, saves a lot of development time, has complete function, best embodied style of virtual instrument.

In response to these circumstances, developed a mine hoist Integrate Performance Monitoring System based on virtual instrument LabVIEW-based. Show in Figure 3. With signal conditioning and data acquisition card to receive signals from sensors, then sent the received signal to the virtual instrument software platform, enables the following features:

（1） show speed, acceleration, braking time, displacement, oil pressure, delay time and other relevant parameters in digital, and display speed, acceleration, traction, displacement and hydraulic curves.

（2） Dynamically monitor the hydraulic oil pressure and oil pump running station, based on these parameters to avoid important braking system failure.

（3）Test brake air travel time, relay delay time and other time parameters.

（4） inquiry to the measured curve and hoist parameters; print a test report.

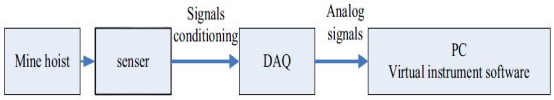

Figure 3. Diagram of test system

The monitoring system has characteristics such as compact, light weight, high precision, testing convenient and flexible, feature-rich software etc.. the system can not only display automatically test results, but also finish multiple functions, for example , data transmission, analysis, processing, storage and report printing. The system is high precision, can easily monitor the hoist operation state, to ensure the reliability of hoist operation.

Ⅳ. CONCLUSIONS

In this paper, used virtual design software to design the hoist mechanical system, PLC to design control system, applied virtual instrument software-LABVIEW to design monitor system. Therefore, the mine hoist designed has good mechanical properties and safe operation, monitoring easy.

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