Application of PLC and SCADA in auto-control systems for silo grain handling

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Introduction

Vertical silo finds its great favors in the field of grain, feeds, foodstuff and light industries because of its characteristics of high mechanization, large capacity, quick circulation, less area occupation, etc Nowadays, concrete and steel plated silos are widely used for grain storage, and the silo storage in proportion to general capacity of China grain depot is annually increased

To realize silo mechanization operation, the electrification and auto-control systems are absolutely necessary for the coordinated control over the various grain handling equipment of conveying, cleaning, weighing, ventilating and dust-removing High-reliable PLC is specifically designed for industrial control This PLC ensures 20-year continuous normal operation without mistakes Its inserted module is exchangeable within a few minutes, in case of hardware failure due to any accident.

Instead of traditional mimic panel and operation desk, man-machine interface is adopted All operational functions are carried out by SCADA user's operation and monitoring configuration interface based on the micro-computer under the condition of Windows. Computer configuration man-machine interface makes the features of direct sight, dynamic display and user's friendliness.

Brief introduction of silo process

Shanghai Mechanization Grain Depot bears the responsibility of receiving, dispatching, intermediate transportation and storage of free flow bulk grain, mainly wheat and maize. The technological design is in focus on 35,000-ton silo and its working tower is integrated with full production line of flat warehouse, specific railway and 10,000t-grade wharf

This concrete vertical silo is composed of 33 bins including 21 silos (in 3 parallel rows with 7 silos each) and 12 star silos. This silo is of 9m ID with grain stacking height of 29.5m The working tower is 9-storeyed structure building

200t/h wharf equipment for in-taking grain from waterway: the coming grain is to be put into the silo when it is conveyed, pre-cleaned and weighed by two 200t/h-production lines in the working tower, and/or to be sent to rail wagon directly or to be packed in flat warehouse for storage Aspirator for dust-removal system is equipped at the places where grain gravity-drop difference occurs on the processing route.

200t/h equipment such as 2 sets of scales, a pre-cleaner, belt conveyors, en-masse chain conveyors and elevators are installed in the working tower to fulfill the functional operations of in-taking, pre-cleaning, weighing, re-circulating from bin to bin and out-taking

Functional system

All equipment on production line are auto-controlled and interlocked by PLC During normal operation, these equipment are to be turned on respectively in an order of conversed process flow and to be turned off in an order of process flow. At the time when failure occurs, computer makes its solutions by alarming, sequential stop, emergency stop and completely instantaneous stop respectively on the basis of failure condition An integration of central control and local switch, automatic and manual modes are adopted for convenience of maintenance operation System process is simultaneously displayed by the computer

Start-up, stop of the interlocking equipment according to technological flow

In addition to conveyors, weighing machines, and pre-cleaner, the silo in Shanghai Grain Depot No.7 is equipped with dust-removal system and magnetic separator to meet the technological requirement for large-sized silo operation, electrical protection and anti-explosion safety measures. To put production line into operation, dust-removal system should be turned on at the very beginning, then the other relevant equipment be turned on respectively in an order of process counter-flow. All involved equipment will be stopped respectively in an order of process flow and the dust removal system be stopped at the end, while 'stop operation button' is pressed. At the time when failure occurs, the equipment from source to the faulty equipment will be stopped immediately and the dust removal system will also be stopped then.

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Route auto-selection and start-up/stop equipment according to the selected silo bins

The process control can be divided into 8 divisions containing more than 20 processing operations A main local manual control / stop / remote control selection switch is located in a central control room (CCR) to prevent local switch from random operation. Each equipment has its manual maintenance / stop / remote selection switch PLC controls the operation from the control room, when remote position is selected. And local manual switch is positioned at 'start-up / stop' for equipment maintenance and testing Several emergency push-buttons are equipped on each floor of the working tower in order to stop all involved equipment, if necessary. Complete control system possesses with 3 sub-systems: CCR manual operation, automatic operation and simulation Manual operation from CCR – each equipment can be started-up / stopped easily as a separated unit. Computer screen displays all inspection signals and equipment real-time status. There's no interlocking between any other process equipment Automatic operation – when process selection, bin selection, confirmation and start-up are made, dust removal system will automatically be running and the related equipment will also be running sequentially in an order of process counter-flow in compliance with the requirement of the selected operation route. Simulation is for the purpose of training and exhibition.

Each sub-system owns 6 flow-processes such as grain intake, outtake, re-circulate from bin to bin, deliver into flat warehouse directly, dispatch to flat warehouse, synchronous operation of intake and outtake from silo to warehouse. Route selection can be done freely and easily. What the operator should do is just to choose bins, confirm and activate by the mouse on the condition of determined operation route.

Automatic resolution of alarming, sequential stop, emergency stop on the basis of equipment failure

Auto-switch and thermo-relay for electrical control system are to keep the equipment from short-circuit and overloading. Speed sensor and belt misalignment switch are equipped on each elevator. Material block switches are mounted on each horizontal conveyor. Level sensors are set up onto each silo bin And manual /automatic diversion switches for start / stop of the equipment are installed at each story in working tower. All signal information from on-site sensors are transmitted by PLC input / output interfaces, MCC cabinet operates involved equipment This technology reaches the higher automation level.

This safe and reliable system ensures the display of the equipment real-time status and its auto-solution for all operations, and let the operator make manual emergency stop operation by pressing on-site emergency button and emergency button on the display according to the situation of faulty equipment

Silo management system for real-time inventory control

This functional design is presented by real-time inventory display of both upgraded data of the handled or remained products (grain) in silo and simulation of the level changes of the products in silo based on the weighing information from auto-scales and computer conversion.

System formation

The silo remote control system in Shanghai Grain Depot No. 7 consists a set of COMPAQ486-66 computer as the SCADA workstation, a power source cabinet, a PLC cabinet with a power distributor, MCC cabinet for control of 10 motors, 2 large-screen displays of 37 and 20 inches, a 5 kVA isolated transformer, 3 sets of 1kVA on-line UPS. American Allen-Bradley PLC-5/25 cor'troller consisting of a main rack and 3 expanded racks is installed into a PLC cabinet

In this automatic control system Series 486 industrial micro-computer manages bulk grain handling in the silos, while PLC controller fulfill auto-control over the equipment operation. It is equipped with the process simulation to display equipment real-time status and to send both video and audio alarms promptly when failure operation happens to the equipment And the installation of local manual switches is additionally satisfied for the system requirements of reliability, visualization and applicability.

System hardware architecture

PLC is used for operation control over the equipment in compliance with process demand. PLC communicates with SCADA, equipment status can be real-time reflected by SCADA and the instructions from SCADA can be real-time responded.

Series PLC-5 programmable controller produced by American ALLEN-BRADLEY Co. is utilized for the PLC

I/O module is of insertable module structure Hardware failure can be resolved within a few minutes. Available quantity of separated I/O ranges from 16 to 3072 points

Estimated I/O points in Shanghai Grain Depot No. 7 are about 1120, and the virtual I/O points are decreased to 928 because of our optimized design. So this PLC 5/25 type PLC with max Supporting 1024 I/O points are adopted for the system.

PLC 5/25 is a large capacity programmable controller from PLC-5 series. Its module structure and standard hardware technique can be randomly arranged according to the detailed needs. This PLC has maximum 21K memory, EPROM13K, selectable 1024 I/O points, 8 racks including

one local rack and 7 remote racks, communication interface including DH+ and remote I/O interfaces. Executive time for program scanning is 8ms/1K bit. Available for connection with various modules of PLC-5 series, for communication with multi-networks through DH-PLUS network, for user's program and testing with ladder diagram, words entry and flow process of system functional control.

System software design

SCADA configuration control takes configuration operation interface as man-machine dialogue interface

Configuration monitoring software is In Touch Version 5.0 from American Wonderware Co. All functional operations are carried out by In Touch user's operation and monitoring configuration interface based on a set of 486 micro-computer under the condition of Windows Traditional mimic panel and operation desk are omitted

The In Touch characteristics are as follows:

- The point number and max configuration demonstration monitored by the In Touch software are of no limitation, because of the capacity Windows 3.0 management memory and the expanded storage space
- Perfect configuration function and vivid display
- Various alarming measures of digital alarm, ratio alarm, difference alarm, etc.
- Functional conversion for 11 database
- 4 real-time curving diagrams, 4 profile trend curves and alarming indications play the role of on-line instruction for the operator.
- Multi-modes for user data input
- Flexible configuration.

The user can establish configuration and version displays by operating the simple stripes, sealed configurations, words and figures or the comprehensive pagers of alarm, position, trend, combination and totalised drawings

Parametric definition

1) Design of configuration control and operation interface

Configuration interface can be divided into following three parts:

- Automatic interlocking control
- Manual control
- Mimic simulation

2) Parametric definition of configuration drawing and interface

7 main configurations and some ancillary configurations for route selection and confirmation are drawn in compliance with the technological requirements of grain in-taking, out-taking and re-circulating from bin to bin. Image display is made by easy operation Interface parametric definition is to establish the relationship and to change the color, shape and size, depending on the status of PLC I/O point and the relevant dynamic configuration

Communication between Britain SIMON electronic scale and PC SCADA

The data from electronic scale can be dynamically displayed on PC computer by the communication, and the inventory can also be reported simultaneously The patterned communication agreement between SIMON scale and PC computer is exclusive Our project engineers have made out the explanation of this communication agreement through hard-connection of scale and computer and repeated testing and analyzing in light of only one page words from SIMOM manuals. Based on the achieved communication agreement, DDE Server I/O interface drive modules are compiled for In Touch configuration monitoring software. Thus, the measured data from electronic scale can be reflected on the configuration display, the height of grain level in each bin can be simultaneously shown via computer calculation, and the inventory can be reported respectively.

Production check

The commissioning and trial operation of this system had been implemented by the Spring Festival in 1995, and load of silo grain ballast (mainly wheat) and large-scale input had begun since then:

Year	In-taking	Out-taking	Recirculating	Packing
1995	23,331t	3,634t	17,750t	6677
1996	24,655t	11,978t	25,660t	8,986t
1997	408t	4,998t	17,765t	6,230t

During 3-year-operation, overall control system is in good order, without failure. It is well accepted by the users because of its friendly man-machine interface, simplified easy-understanding operation instructions and complete alarming system for equipment failure.

Conclusion

This system gains the following advantages:

2-grade management system is adopted and computer comprehensive management system is established. Thanks to PLC for its large reduction in quantity of mediate-relay and hard-wiring, the reliability and flexibility of the system are greatly enhanced

This system is suitable not only for the requirement of silo control, but also for the other industrial requirements of process operations of rice mill, flour mill, feed mill, oil refiner, foodstuff factory and etc.. And the system is now contributed to the project of Zhengzhou Mechanization Grain Depot, World Bank Projects of Liuzhou Intermediate Grain Depot and Chenglingji Intermediate Grain Depot.

Since the system is put into operation, it has played an important role in speeding up harbour transportation. Thanks to the comprehensive functions of monitoring and controlling, material blockage and equipment stoppage are largely decreased, labour strength is greatly reduced and the management is also updated to the further high level

Based on the replacement of traditional control desk and mimic panel with computer configuration control and operation interface, this system features: direct digital control, high interference-free ability, absolute reliability and less dimension All working operations can be realized by optimizing selection of process route direction according to technological demands. And the smart operations for auto-alarm, sequent and emergent stop are created.

The application of this system reduces the labour strength, avoids inharmonious operation links and delays resolution for removal of equipment failure , decreases mistakes or errors, provides the technological environment for upgrade of equipment utilization ratio, labour productivity and capability of grain handling