Application of ControLogix Control Platform in the Coke Oven Dedusting System

Zhai Sheng¹, Xu Zhao¹, Xu Zhichao¹ and Chan Jiaming¹
¹Dalian Institute of Science and Technology, 116052, China
²Corresponding author Email: zhaishengdl@163.com

Abstract. Taking the coke oven dedusting system of a chemical plant as the research object, the coke oven dedusting monitoring system is designed. This system mainly uses the software and hardware of the ControlLogix control platform of Rockwell Company. In the system design, the process flow of coke oven dedusting system is analyzed, the system control scheme and the configuration of software and hardware are given in details. In addition, the control software and human-machine interface are designed and developed, and the design idea is provided. The practical results show that the system is good at dedusting effect, convenient in maintenance, and reliable and stable in operation. It has achieved good economic and social benefits.

1. Introduction
With the development of economy, the demand for coke is increasing. However, the country's requirements for environmental protection are higher and higher, and the dust emission index is correspondingly more and more stringent, so higher requirements are put forward for the emission of coke oven dust. At present, in the coking industry of our country, in view of the problems of large amount of dust emission and serious environmental pollution during coking, the dry bag type dedusting system is widely used, and some economic and social benefits have been achieved[1].

Taking the coke oven dedusting system of a chemical plant as the research object, the coke oven dedusting surveillance system is designed. The technological process and control requirements of coke oven dedusting system are introduced, and the design and implementation scheme of ControlLogix control system is offered. As a result of the adoption of this system, the degree of automation is further improved, the operation interface is simple and easy to understand, and the requirements for the professional quality of the post operators are low. At the same time, it improves the surrounding environment of the work and the plant settings, and responds to the requirements of the sustainable development of the national energy and environment.

2. Process Flow
The project is the coal charging and discharging dedusting system of coke oven in a chemical plant. Because a large number of dust and harmful gases will be produced in the process of coal loading and coke discharging, they must be purified through the dedusting system so as to reduce their environmental pollution.

The discharging dedusting system is mainly divided into three parts: fan system, ash cleaning system and ash conveying system. The fan system includes high-pressure fan, hydraulic coupling, fan inlet valve, water-cooling system and monitoring instruments for fan protection (bearing temperature, motor stator temperature, bearing vibration, hydraulic coupling inlet and outlet temperature, pressure, etc.); the
ash cleaning system consists of stop valve, pulse control valve, bin wall vibrator, double-layer dust discharge valve; the ash conveying system consists of scraper and bucket elevator.

When coke oven is coking, firstly, the coke pusher sends the signal of dedusting and speed-up to the fan unit of the dedusting system. Under the control of the hydraulic coupling, the fan unit operates from idle speed to high speed. The inlet valve of the fan slowly closes with the speeding up of the fan unit. When the fan speed reaches a certain degree, the coke pusher starts to push. In the process of pushing coke, a large number of paroxysmal high-temperature smoke and dust will be produced on the coke side. Under the action of thermal buoyancy and negative pressure suction generated by fans, these smoke and dust will be introduced into the regenerative cooler through connecting pipes. The cooler cools the high-temperature smoke to below 120℃. After the coarse separation of the ash hopper guide device, the gas containing the dust is sent to the pulse bag filter, which is fine separated when passing through the filter bag, and the purified air is discharged into the atmosphere through the exhaust funnel. After the coke is discharged, the coke pusher provides the deceleration signal from the dedusting fan unit, then the fan unit will turn from high speed to idle operation, and the fan inlet valve will gradually open during the deceleration of the fan unit[2].

3. Control Requirements
The control requirements of the discharging dedusting system mainly include the following aspects:

(1) Fan Speed Control
The speed of the fan unit is adjusted and controlled by the scoop actuator of the hydraulic coupler, which receives the 4-20 mA control signal from the AO module. At 4 mA, it corresponds to low speed. At this time, the opening of scoop actuator is 15%, and the output speed of hydraulic coupler is 260 r/min; at 20 mA, it corresponds to high speed, the opening of scoop actuator is 55%, and the output speed of hydraulic coupler is 900 r/min. At the same time, the scoop actuator feeds back the opening to the AI module of the control system in real time.

(2) Air Compressor Interlock Control
The air for back blowing and cleaning and pneumatic valve is provided by the air compression station. The system working pressure is 0.3-0.6MPa, and the consumption is 6m³/min. If the system pressure is too low, the dedusting and back blowing effect will be greatly reduced; if the pressure is too high, the service life of the filter bag will be reduced or even damaged, so the system pressure must be interlocked with the start and stop of the air compressor. When the pressure is lower than 0.3MPa, the air compressor will automatically start to replenish the air volume; when it rises to 0.6MPa, it will automatically stop.

(3) Valve Opening Control
The dedusting system adjusts the opening of the air distribution valve and the electric flap at the inlet of the fan unit according to the rotation speed of the fan unit. Both the air distribution valve and the electric flap are 4 - 20 mA analog signal interfaces, which are convenient to connect with the AI and AO modules of the control system. When the fan is running at low speed, the air distribution valve is fully open and the electric flap is closed to 20%; when the fan is running at high speed, the air distribution valve is closed and the electric flap is opened to 60%.

(4) Fan Set Interlock Control
According to the inlet and outlet oil temperature and pressure of the hydraulic coupler and the three-phase winding temperature of the main motor, the interlock with the main motor of the fan shall be established. When the inlet and outlet oil temperature of the coupler and the three-phase winding temperature of the main motor exceed a certain value or the outlet working pressure of the hydraulic coupler is lower than 0.03MPa, the system will give a prompt and give an alarm; if the temperature continues to rise and reaches the emergency stop temperature or the pressure drops to reach the emergency stop pressure, the control system will send the emergency stop command to the main motor to force the system to stop so as to play a protective role.
4. System Implementation Plan

4.1. Hardware Configuration
This control system adopts ControlLogix redundant control system of Allen Bradley series of Rockwell Company in the United States to detect and control the process status, display and alarm. The redundancy framework includes controller module, communication module and redundancy module. The controller selects controllogix5561 controller, and the redundant module selects 1756-RM redundant module, occupying only one slot. The corresponding communication module selects enhanced 1756-EN2T Ethernet communication module and 1756-CN2R control network communication module. Redundancy framework communicates with remote I/O through ControlNet and upper computer through Ethernet[3-4].

At the same time, 1756-IB32 digital input module is used to receive the on-off signal from the field devices; 1756-OB16E digital output module is used to control the intermediate relay coil; 1756-IF166 analog input module is used to receive the current or voltage signal from the field detection devices; 1756-IR6I thermal resistance input module is used to receive the temperature signal of the field thermal resistance.

The hardware configuration of Rockwell ControlLogix control system for coke oven dedusting is shown as Figure 1.

![Figure 1](image)

**Figure 1.** hardware configuration of the control system for coke oven dedusting

4.2. Software Configuration
The system is equipped with two upper computers as human-machine interface units in the control room, which are connected with PLC control system through RSLinx communication software, to manage and monitor the process control data and information of the whole module, and to adjust the parameters and set values of process control.

The software mainly includes programming software Logix5000, communication software RSLinx, network configuration software RSNetworx, and upper computer monitoring Software FactoryTalk View Studio. Each upper computer has the functions of both operation station and engineer station, which can be switched online[5-6].

In the upper computer, FactoryTalk View Studio can be used for picture configuration, alarm configuration, historical trend configuration, printer configuration, report configuration, etc. The process flow chart, process parameters, data recording, alarm processing and various available data can be called according to the access authority of the operator, and the output and setting parameters of the control circuit can be effectively adjusted[7].
In addition, there are alarm confirmation button, reset button, emergency stop button of key devices and audible and visual alarm on the operation console set in the control room. When there is alarm signal input, the operation console will send out an audible alarm, and the alarm light will flash, so that the operator can find and quickly troubleshoot the fault in time, recover the system, and facilitate the monitoring and operation of the module.

4.3. Designing of Control Program
Rslogix5000 is a 32-bit Windows-based software that provides a powerful programming environment for the ControlLogix PLC. It integrates many functions of PLC, such as system configuration, program editing, checking and downloading. It can be used for motion, process, sequence and control. Rslogix5000 programming software supports the following languages: structured text, function block, sequential function diagram and ladder diagram[8]. In this control system, the ladder diagram is used to complete all the programs. In the designing program, the module design method is adopted, that is, one subprogram for one device. The logic control, fault judgment and display in human-computer interface of the device are all designed in the subprogram, and the program of analog processing is the independent subprogram, and special subprogram is used for special functions. All of these subprograms are called in the main program. Each procedure is very clear. When the equipment maintenance is carried out, it can quickly find the relevant equipment, and it is very easy to find the cause of equipment failure, which improves the efficiency of equipment maintenance and production efficiency. As shown in Figure 2.

![Figure 2](image)

Figure 2. program of the control system for coke oven dedusting

4.4. Designing of Monitoring Interface
FactoryTalk View Studio is used as the upper computer monitoring software in the coke discharging and dedusting system. Through the operation pictures of system, the status of all electrical equipment and field instrument signals can be monitored directly.

In the designing of monitoring interface, in order to facilitate the user, the equipment status picture is designed to check whether it is normal, and the start condition picture is designed to check whether the conditions are met. In the start condition picture and equipment status picture, the red circle indicates that the conditions are met, and the green circle indicates that the conditions are not met. As shown in Figure 3.

In the designing of the operation panel, the following designing ideas are adopted: when a system start button on the operation panel is not displayed, the operator is reminded that the system cannot be started if the system start conditions are not met; when the start conditions are met, the system start
button is displayed, and the operator can start the system. Similarly, when the system is in the automatic state, the manual start button and the manual stop button will not be displayed.

Figure 3. picture of the control system for coke oven dedusting

In the designing of component symbols, the following designing ideas are adopted: The status of the device is displayed in different colours.

- gray indicates that the valve does not act and is not in the limit state;
- red flashing indicates that the valve is in the opening state and has not reached the limit state;
- red indicates that the valve is in the opening state and has reached the limit state;
- green flashing indicates that the valve is in the closing state and has not reached the limit state;
- green indicates that the valve is in the closed state and has reached the limit;
- yellow flashing indicates that the valve is in the fault state.

In this way, the working state of the device can be quickly judged by the colour displayed, which provides great convenience for operation and maintenance.

In addition, the trend picture and alarm picture are designed by using the trend function and alarm function in FactoryTalk View Studio. In this way, users can easily find the historical data of some process parameters, alarm events and their time, which can greatly improve the efficiency of maintenance.

5. Conclusion
The successful application of Rockwell ControlLogix control system in coke oven dedusting system of a chemical plant reflects the fully integrated automation idea in Rockwell automatic control field. Its hardware, network configuration and program designing are convenient and flexible, which greatly facilitates the later maintenance of the system. At the same time, the monitoring system of coke discharging and dedusting solves the problems of data collection and management, complex sequence control and safety interlock, stable and reliable communication with other devices, and realizes the accurate and centralized monitoring of field devices. Since the system was put into operation, it is stable and reliable, easy to operate and maintain, which is welcomed by the field staff and achieves a better expected effect.

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