

Design of Ammonia Water Tank Automatic Control System Based on S7-1200 PLC

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Abstract: Ammonia water is volatile, flammable, explosive and corrosive, which brings great difficulties to industrial storage and management. This paper presents an automatic control system for ammonia water tank based on Siemens S7-1200 PLC. The system is equipped with liquid level detection, ammonia concentration detection, pump units and valve actuators. The program development and human-machine interface configuration are completed by using TIA Portal software. It supports manual and automatic operation modes, which can real-time monitor the liquid level inside the tank and ammonia concentration in the surrounding environment. The system automatically starts and stops the ammonia unloading pump, transfer pump and spray valve, and triggers an alarm when the ammonia concentration exceeds the threshold. Simulation results show that the proposed system has reliable control logic and stable operation. It can effectively reduce the loss of volatile ammonia water and improve the safety of on-site operation.

Keywords: Ammonia water tank; S7-1200 PLC; Automatic control; TIA Portal; Liquid level detection

1. INTRODUCTION

1.1 Research Background and Significance

Ammonia water is widely used in industrial denitrification and desulfurization. However, its strong volatility and flammable & explosive characteristics put forward strict requirements for storage management. Traditional ammonia water storage systems usually suffer from ammonia escape, delayed liquid level control and insufficient safety early warning. The application of PLC technology can realize intelligent monitoring and interlock protection for ammonia water tanks, so as to reduce material loss and potential safety hazards. In recent years, intelligent control of hazardous chemical storage tanks has become a research hotspot in industrial automation. The integrated solution combining PLC, sensors and HMI has been widely applied in the storage scenarios of ammonia water and liquid ammonia, which presents obvious advantages in improving control accuracy and operation safety.

1.2 Domestic and Overseas Research Status

Many overseas researchers have conducted in-depth studies on ammonia detection, storage tank automation and PLC integrated control systems. Ningrat et al^[1]. (2026) established an ammonia gas monitoring system based on PLC and HMI, and realized linkage control between ammonia concentration and ventilation equipment, which verified the practicality of PLC in real-time ammonia monitoring. Budzynski^[2] (2024) proposed a novel ammonia aeration control algorithm to optimize the control logic of ammonia-containing fluid systems and enhance the dynamic stability of parameter regulation. Carrasco et al^[3]. (2024) designed an automatic chemical solution preparation system using PLC, and completed closed-loop control of temperature and pressure for ammonia water systems, providing a reference for the automation design of hazardous liquid storage tanks. Vadivukkarasi et al^[4]. (2025) combined PLC, SCADA and Internet of Things technologies to realize remote centralized

management of liquid storage tanks, expanding the application scope of storage tank control systems.

In addition, IoT and high-precision sensing technologies have been gradually applied to ammonia monitoring. Puji^[5] (2023) developed an on-line ammonia concentration monitoring system for petrochemical industrial zones based on gas sensors and embedded technology. Yang et al^[6]. (2023) established a dynamic ammonia leakage model and optimized leakage detection and early warning for low-temperature ammonia storage equipment. Nawaz et al^[7]. (2025) systematically summarized the sensor selection, communication architecture and application trends of ammonia monitoring systems, and confirmed that the combination of multi-sensor fusion and PLC logic control is the mainstream scheme for industrial applications.

According to existing literature, PLC technology has been fully verified in the monitoring and control of ammonia-containing media. Nevertheless, dedicated integrated control systems integrating liquid level detection, gas concentration monitoring, pump & valve linkage and safety alarm for industrial ammonia water tanks are still insufficient. This is the main research objective of this paper.

2. SYSTEM OVERALL DESIGN SCHEME

2.1 Design Requirements and Principles

Combined with the physical and chemical properties of ammonia water, the system shall meet the following requirements: real-time detection of liquid level and ambient ammonia concentration; interlock control of pumps according to high and low liquid level; automatic spray dilution and alarm when ammonia concentration exceeds the limit; switching between manual and automatic modes. All equipment shall have explosion-proof and anti-corrosion performance. The whole system is required to be expandable and easy for maintenance.

2.2 System Composition

The hardware of the system mainly includes S7-1200 PLC controller, liquid level sensor, ammonia concentration sensor, ammonia unloading pump, transfer pump, spray valve, multi-way control valves and touch screen HMI. The sensors collect analog signals and transmit them to PLC. PLC drives actuators according to control logic, and HMI is used for parameter display, operation and alarm checking.

3. HARDWARE SELECTION AND I/O ADDRESS ASSIGNMENT

3.1 Selection of Core Hardware

1.PLC Controller: Siemens S7-1214C DC/DC/DC CPU is selected. It features small size and strong anti-interference ability, which fully meets the control demands of small and medium-sized automatic systems.

2.Analog Module: The supporting analog module is configured to receive standard 4~20 mA current signals from sensors.

3.Sensors: RZ-700 capacitive liquid level gauge and QB10N ammonia gas detector are adopted. They are suitable for corrosive environments and output standard industrial analog signals.

4.HMI: KTP700 Basic PN touch screen is used to realize on-site visual operation, data monitoring and alarm prompt.

5.Storage Tank: PE anti-corrosion storage tank is selected, whose sealing performance and corrosion resistance satisfy the storage requirements of ammonia water.

3.2 PLC I/O Address Assignment

The system is divided into digital input, digital output and analog input. The address mapping of buttons, sensors and actuators is shown in Table 1.

Table 1. PLC Input/Output Address Assignment

Address	Description	Address	Description
I0.0	System Start Button	Q0.0	System Running Status Indicator
I0.1	System Stop Button	Q0.1	Automatic Operation Indicator
I0.2	Automatic Mode Button	Q0.2	Manual Operation Indicator
I0.3	Manual Mode Button	Q0.3	Ammonia Unloading Pump
I0.4	Spray Valve Open Button	Q0.4	Transfer Pump
I0.5	Spray Valve Close Button	Q0.5	Spray Valve
I0.6	Ammonia Unloading Pump Open Button	Q0.6	Alarm Indicator

Address	Description	Address	Description
I0.7	Ammonia Unloading Pump Close Button	Q0.7	Valve 1 Drive
I1.0	Valve 1 Start Button	Q1.1	Valve 2 Drive
I1.1	Valve 1 Stop Button	Q1.2	Valve 3 Drive
I1.2	Valve 2 Start Button	IW4	Ammonia Water Level Detection (Analog Input)
I1.3	Valve 2 Stop Button	IW6	Ammonia Concentration Detection in Air (Analog Input)
I1.4	Valve 3 Start Button	—	—
I1.5	Valve 3 Stop Button	—	—

4. SYSTEM SOFTWARE DESIGN

4.1 Software Platform

TIA Portal V15.1 is adopted as the development platform. It integrates ladder diagram programming, HMI configuration and online simulation functions to complete the whole software design.

4.2 Control Program Design

The program is designed in modular form, including seven main functional modules:

1.Start-Stop Control Module: Realize system power-on, power-off logic and running status indication.

2.Manual-Automatic Switching Module: Interlock between manual mode and automatic mode for commissioning and normal operation.

3.Analog Signal Processing Module: Convert 4~20 mA current signals from sensors into digital values of PLC, and then convert them into actual engineering values.

4.Pump Control Module: Automatically start and stop ammonia unloading pump and transfer pump according to liquid level, to prevent pump idling and liquid overflow.

5.Spray Valve Control Module: Automatically open the spray valve for dilution when ambient ammonia concentration exceeds the set value, with delay reset function.

6.Valve Control Module: Realize manual and automatic on-off control of multi-way valves.

7. Alarm Module: Trigger local sound-light alarm and HMI text alarm when ammonia concentration is over limit.

4.3 HMI Design

Two functional interfaces are designed for the touch screen:

1. Main Monitoring Interface: Display real-time ammonia liquid level, ambient ammonia concentration and operating status of all equipment. It is equipped with mode switching and manual operation buttons for on-site operation.

2. Alarm Interface: Automatically pop up alarm information when ammonia concentration exceeds the threshold. Operators can view and confirm alarms on this interface.

5. SYSTEM SIMULATION AND TEST

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5.1 Subsections

The joint simulation of PLC and HMI is carried out by using PLCSIM function of TIA Portal. The specific steps are as follows:

1. Complete program download and communication connection, and switch CPU to RUN mode.
2. Simulate the change of liquid level and ammonia concentration to test the interlock action of pumps and valves.
3. Verify core functions including manual-automatic switching and alarm triggering.

The simulation results are shown in Figure 1. The system responds quickly with accurate interlocking logic. The alarm function works normally and data is displayed correctly on the human-machine interface. The overall control scheme meets the design requirements.

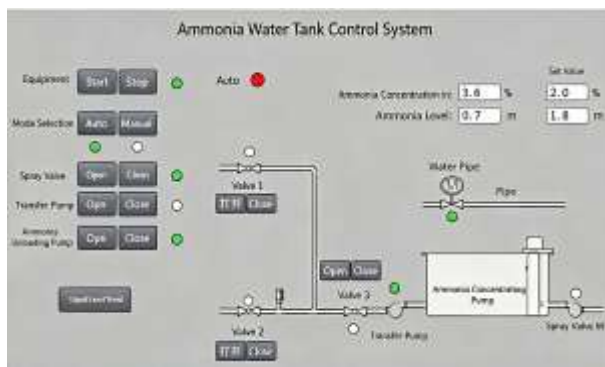


Figure. 1 Ammonia Tank Control System Simulation HMI

6. CONCLUSION

This paper designs an automatic control system for ammonia water tank based on S7-1200 PLC. Combined with sensor detection, PLC logic control and touch screen configuration, the system realizes all-weather automatic management of liquid level and ambient ammonia concentration. The system has simple structure, high reliability and convenient operation. It can effectively solve the problems of material loss and insufficient safety protection during ammonia water storage. It is suitable for the automatic transformation of ammonia water tank areas in chemical industry, thermal power and other fields, and has good practical application value.

7. REFERENCES

- [1] Ningrat W C. Implementation of PLC Outseal as a Controller of Ammonia Gas Circulation in Chicken Coops with HMI Modbus Monitoring[R]. ResearchGate, 2026.
- [2] Budzynski G. Total ammonia aeration control (TAAC) theory – An innovative ammonia-based aeration controller[J]. AQUA-Water Infrastructure, Ecosystems and Society, 2024, 73(3): 396-406.
- [3] Carrasco Romero D J, Cabrera Blum J V. Design of an automated system for chemical solution production[R]. ESPOL.FIMCP, 2024.
- [4] Vadivukkarasi K, Bhargava S. Mixing and Filling Operations using PLC, SCADA and IoT[C]. 2025 International Conference on Automation and Smart Systems, IEEE, 2025.
- [5] Puji R. Ammonia (NH₃) Concentration Monitoring System for Petrochemical Industrial Areas Based on IoT[J]. ZETROEM, 2023, 5(2): 203-205.
- [6] Yang Z, Hou Z, Guo C, et al. Dynamic modeling and leak detection of ammonia leakage in food cold storage system[J]. Journal of Food Process Engineering, 2023, 46(12): e14483.
- [7] Nawaz M, Khan A, Ali S. A Systematic Review for Ammonia Monitoring Systems Based on the Internet of Things[J]. IoT, 2025, 6(4): 66.