Frontiers in Computing and Intelligent Systems
ISSN: 2832-6024 | Vol. 7, No. 1, 2024

Industrial Material Liquid Level Control System based on PLC

Yating Wei [1], Lulu Yang [2], Jiajia Zhou [3], Rongchao Wen [3], Xiangjiao Chen [1], Xiong Jin [1],

Zhiyang Ye [4]

[1] Wenzhou Polytechnic, Wenzhou Zhejiang 325000, China
[2] Shaoxing Shangyu District Power Supply Corporation, Shaoxing Zhejiang 312000, China
[3] Taizhou Power Supply Corporation, Taizhou Zhejiang 225300, China
[4] Wenzhou Ochang Misawa medical technology company, Wenzhou Zhejiang 325000, China

Abstract: According to the requirements of an enterprise for liquid level control of glycerine, this paper changes the traditional liquid level control mode to PLC control, improves the reliability, safety and visualization of the whole working process, makes the transmission control system has strong function and high reliability, and can be applied to the industrial field when combined with hardware. Based on the configuration software MCGS and PLC simulation industrial material level control, through FX5U-A/D acquisition signal to change the liquid level in each tank, so that the industrial material level control simulation can be carried out. In addition, the control mode can be changed through the touch screen or the button on the MCGS engineering interface to achieve different controls, and the configuration screen can monitor most of the functions of the control system.

Keywords: MCGS; PLC; Liquid Level Control; A/D.

1. Introduction

The liquid level control system is indispensable in the general industry, and the control of the level element is required in the water storage tank and sewage treatment plant. Using the liquid level control system to maintain the level height automatically, the staff can easily know the water storage status of the entire equipment in the operation room, greatly reducing the risk of the staff's work, and improving the efficiency and simplicity of the work [1-4]. With PLC and MCGS configuration software as the unit, it can be composed of various industrial control systems from simple to complex. In addition to the traditional PID control system, with the development of intelligent instruments and PLC, intelligent control systems have also been applied in recent years [5-6]. Driven by the development of automatic control theory and design methods, foreign level control systems have developed rapidly, the United States, Germany, Japan and other technology leading countries, the production and development of a series of excellent performance, practical level controller and instrument, and should be widely used in various fields of production and life. These advanced controllers can not only realize the control of the liquid level control system in various complex environments, but also use advanced algorithms, adaptive control, self-tuning control, fuzzy control, artificial intelligence and computer technology, so that the scope of application of the liquid level controller is more extensive.

2. General Design of System

The glycerol ester supply system has four liquid storage tanks, of which the South tank and the north tank are in the low position, the system 1 tank and system 2 tank are in the high position. The feed pump delivers material to the lower tank. The high level liquid pump transfers the material from the low level tank to the high level tank. The feed pump delivers material to the lower tank. The high level liquid pump transfers the material from the low level tank to the high level tank. After the material is transported to the high tank, because of the gravity of the liquid, the material can be sent to the workshop. As shown in the picture below:

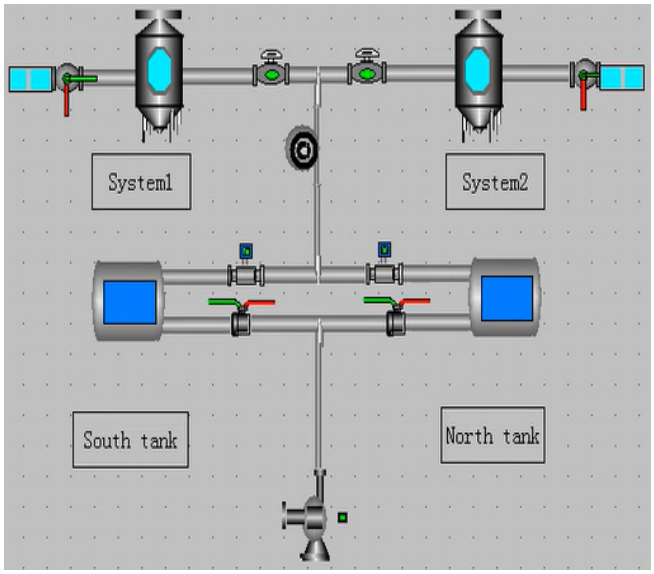

Figure 1. System composition

The control of the industrial material liquid level control system is mainly the liquid level control of high and low tanks. The principle of control is "the low level starts to increase the feeding, and the high level is stopped."

(1) Low-position liquid pumping process

When the liquid supply pump adds liquid to the south/north tank, the liquid supply pump only works in the "manual" control mode, but when the liquid level reaches the up limit or upper limit, the liquid supply pump only works in the "manual" control mode, but when the liquid level reaches the upper limit or upper limit, the system automatically turns off

the liquid inlet switch of the south/north tank. Take the southern tank as an example, the operation process of adding liquid to the low tank is as follows:

Step 1: Manually open the liquid supply pump.

Step 2: Click the South/North switch tank button to make the text box of the south tank appear (to indicate that the South tank is in operation) and the South/North switch button will display the font of the South tank. After the liquid supply pump is started, when the liquid level of the south tank is less than or equal to the lower limit level, the switch handle of the liquid inlet switch of the south tank will automatically turn green. After the liquid pump and the south tank inlet switch are opened, the liquid is added to the south tank. When the liquid level of the south tank reaches the upper limit of the liquid level, the liquid inlet switch of the south tank will automatically close, and the south tank will stop adding liquid.

Step 3: After filling, turn off the liquid pump switch and the liquid inlet switch of the south tank.

Step 4: The liquid feeding method of the north tank is the same as that of the South tank. Just click the "South/North tank switch" button to switch to the North tank position.

(2) High-position liquid pumping process

The high level liquid supply pump adds liquid to the system 1/2 tank. The high level liquid supply pump works only when the south/north tank outlet switch is on and the system 1/2 tank inlet switch is on. However, the system automatically turns off the system 1/2 inlet switch when the liquid level reaches the upper limit or upper limit. Taking system 1 tank as an example, the procedure for adding liquid to system 1 tank is as follows:

Step 1: When the liquid level of the south/north tank reaches the upper limit and the liquid level of the system 1 tank is less than or equal to the lower limit, the liquid outlet switch of the south/North tank and the liquid inlet switch of the system 1 tank are opened, and the high liquid delivery pump starts to feed the liquid.

Step 2: Click the System 1/2 tank switch button to make the system 1 tank text box display (to indicate that system 1 tank is running) and the system 1/2 switch button will display the word System 1; When the liquid discharge switch of the south tank is opened, when the liquid level of system 1 tank is less than or equal to the lower limit liquid level, the switch handle of the liquid intake switch of system 1 tank will automatically turn green and start to add liquid to system 1 tank; When the liquid level of system 1 tank reaches the upper limit of the liquid level, the liquid inlet switch of the south tank will automatically close, and the south tank will stop adding liquid.

Step 3: After filling the liquid, turn off the high liquid pump, the liquid inlet switch of system 1 tank, and the liquid outlet switch of south/north tank.

The liquid feeding method of system 2 tank is the same as that of system 1 tank, as long as the "System 1/2 switch" button is switched to the position of system 2 tank.

3. The Application Value of Traditional Embroidery in Modern Fashion Design

Traditional embroidery art still has wide application value in contemporary fashion design. For modern fashion design, it still has a very strong sound. First of all, we need to break the integrity of the design. Traditional embroidery art is often lack of abstractness, and the pattern image is very complete, but it has the characteristics of rigidity. It is not conducive to the long-term promotion of traditional ideas, and modern fashion design in the process of integration must break through the limitations of traditional embroidery, the integrity of the continuous to be broken, in order to innovate. For fashion designers, we can divide the patterns properly and pick up the relevant composition methods to make them more in line with modern people's clothing aesthetics. For example, when designing a dress, you can combine embroidery art to form a hollow way, so as to decorate the waist line and make the design effect of the whole curve more prominent. The second is to strengthen the aesthetic level of clothes and make them more in line with people's understanding of beauty. Traditional embroidery art is rooted in traditional culture, so the pattern is very exquisite and meticulous, which makes embroidery art unique and coquettish. It can enhance the aesthetic feeling of modern fashion design, so as to optimize contemporary fashion design. At present, many designers will actively try embroidery techniques in the process of design, so as to enhance the artistic value of clothing design, and even properly use embroidery techniques in foreign high-definition clothing, so as to further improve the quality of clothing.

4. Hardware Design of Control System

(1) PLC

FX5U is a new generation of small PLC CPU module of Mitsubishi MELSEC iQ-F family. It integrates digital input/output channel, analog input/output channel, large network communication interface, RS485 communication interface, support high-speed counter and high-speed pulse output, support external IO module display, support SD card and other functions. It's very powerful. According to the practical application of this design, we choose FX5U-64M.

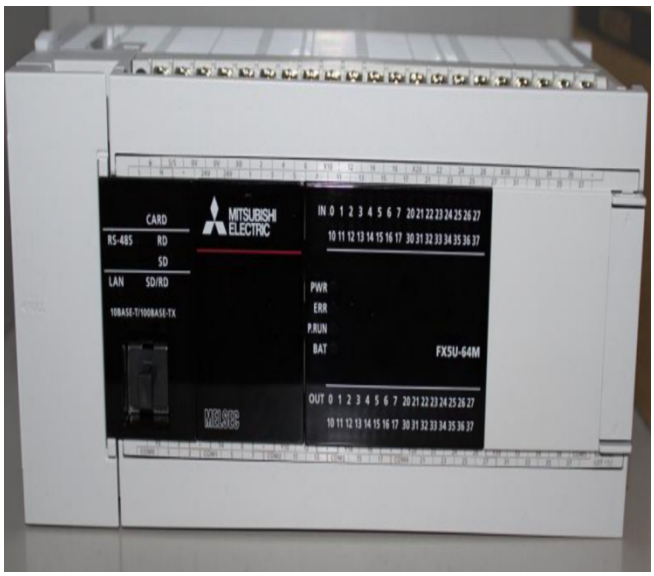

Figure 2. FX5U-64M

(2) A/D module

The function of the analog input is to convert the analog signal of the industrial field standard into the digital signal that the PLC can process. The analog quantity generally requires sensors, transmitters and other components to convert the analog quantity into a standard electrical signal, and the general standard current signal is 4 ~ 20mA, 0 ~ 20mA; The standard voltage signal is 0 ~ 10V, 0 ~ 5V or -10 ~ +10V.

The CPU module of Mitsubishi FX5U itself integrates two

analog inputs and one analog output channel, and its signal type is 0~10V voltage signal. If you need to connect the analog current signal sensor in the project or the analog channel of the CPU module itself is not enough, you can use the extended analog module.

Figure 3. FX5-4AD-ADP

(3) Non-contact liquid level detector

Considering the manufacturer's transformation requirements (non-contact type) and the system itself has certain acid resistance requirements, the anti-corruption type ultrasonic level transmitter is selected, and YEZON company's model is PY233 integrated ultrasonic level meter. Intelligent integrated non-contact continuous level measuring instrument, suitable for various process control systems. Integrated instrument for non-contact continuous level measurement of liquid and measurable solid materials. Liquid measuring range 5m.

Figure 4. Integrated ultrasonic level meter

(4) Touch screen

TPC7062TX is a set of embedded integrated touch screen with a Cortex-A8 CPU as the core (600MHz main frequency). The product design uses a 7-inch high-brightness TFT LCD display (resolution 800×480) and a four-wire resistive touch screen (resolution 4096×4096). At the same time, MCGS embedded configuration software (running version) is preinstalled, with powerful image display and data processing functions.

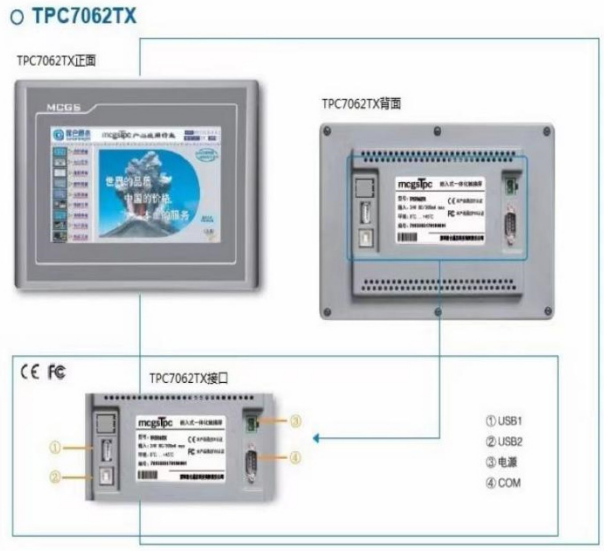

Figure 5. Touch screen

5. Software Design

(1) MCGS configuration software design

MCGS (Monitor and Control Generated System, General monitoring system) is a Microsoft based, used to quickly construct and generate the host computer monitoring system configuration software system. MCGS provides users with a complete solution and development platform to solve practical engineering problems, which can complete on-site data acquisition, real-time and historical data processing, alarm and security mechanism, process control, animation display, trend curve and report output, and enterprise monitoring network functions. The structure of the user application system generated by MCGS embedded version is composed of five parts: master window, device window, user window, real-time database and operation strategy. Configuration required variable distribution is shown in the following table 1.

MCGS embedded version is composed of five parts, including master window, device window, user window, real-time database and operation strategy. The main page of the user is shown as follows fig 6.

(2) PLC program

The system 1/2 tank liquid level signal is realized by the PLC analog triangle wave output program. The system is designed to change time by 80s, so the time relay T0 is used in the program as the main part of the simulation of triangular waves. when T0 is less than 4000, the multiplication command MUL is used to put the result of T0 multiplied by 1 into D10. At this time, the range of numbers in D10 will gradually increase from 0 to 4000, which simulates the rising part of the triangular wave; When... When T0 is equal to 4000, use the multiplication command MUL to put the result of T0 multiplied by 1 into D12, and then use the subtraction command SUB to put the result of 1 times 8000 minus D12 into D10. At this time, the range of numbers in D10 will be gradually reduced from 4000 to 0, which simulates the descending part of the triangle wave. PLC simulated triangular wave output program is shown below fig 7:

Table 1. Auxiliary register variable list

Auxiliary register	Data object	Function description
M0	North/south tank switch button	South/North tank switch
M1	System 1/2 tank switch button	System 1/2 tank switch
M11	South tank liquid inlet switch	Control liquid flowing into the south tank
M12	North tank liquid inlet switch	Control liquid flowing into the North tank
M13	System1 tank liquid inlet switch	Control liquid flowing into the system1 tank
M14	System2 tank liquid inlet switch	Control liquid flowing into the system2 tank
M15	South tank liquid outflow switch	Control liquid flowing out of the South tank
M16	North tank liquid outflow switch	Control liquid flowing out of the North tank
M17	System1 tank liquid outflow switch	Control liquid flowing out of the system1 tank
M18	System2 tank liquid outflow switch	Control liquid flowing out of the system2 tank
Y11	The liquid level of the south tank reaches the lower limit	Indicates that the liquid level of the south tank reaches the lower limit
Y12	The liquid level of the south tank is between the upper limit and the lower limit	Indicates that the liquid level of the south tank is between the upper limit and the lower limit
Y13	The liquid level of the south tank reaches the upper limit	Indicates that the liquid level of the south tank reaches the upper limit
Y14	The liquid level of the north tankreaches the lower limit	Indicates that the liquid level of the north tank reaches the lower limit
Y15	The liquid level of the north tank is between the upper limit and the lower limit	Indicates that the liquid level of the north tank is between the upper limit and the lower limit
Y16	The liquid level of the north tank reaches the upper limit	Indicates that the liquid level of the north tank reaches the upper limit
Y21	The liquid level of the system1 tank reaches the lower limit	Indicates that the liquid level of the system1 reaches the lower limit
Y22	The liquid level of the system1 tank is between the upper limit and the lower limit	Indicates that the liquid level of the system1 tank is between the upper limit and the lower limit
Y23	The liquid level of the system1 tank reaches the upper limit	Indicates that the liquid level of the system1 tank reaches the upper limit
Y24	The liquid level of the system2 tank reaches the lower limit	Indicates that the liquid level of the system2 tank reaches the lower limit
Y25	The liquid level of the system2 tank is between the upper limit and the lower limit	Indicates that the liquid level of the system2 tank is between the upper limit and the lower limit
Y26	The liquid level of the system2 tank reaches the upper limit	Indicates that the liquid level of the system2 tank reaches the upper limit

Table 2. List of Data Register variables

Data register	Data object	Function description
D20	Upper limit of liquid level	Save the setting value of the upper limit of the liquid level. When the system starts, the PLC is transmitted to MCGS
D21	Up limit of liquid level	Save the setting value of the up limit of the liquid level. When the system starts, the PLC is transmitted to MCGS
D22	Low limit of liquid level	Save the setting value of the low limit of the liquid level. When the system starts, the PLC is transmitted to MCGS
D23	Lower limit of liquid level	Save the setting value of the lower limit of the liquid level. When the system starts, the PLC is transmitted to MCGS
D14	South tank liquid level value input	Liquid level of south tank signal input
D15	South tank liquid level	Display liquid level value of south tank
D24	System1 tank liquid level value input	Liquid level of system1 tank signal input
D25	System1 tank liquid level	Display liquid level value of system1 tank
D34	North tank liquid level value input	Liquid level of south tank signal input
D35	North tank liquid level	Display liquid level value of north tank
D44	System2 tank liquid level value input	Liquid level of system2 tank signal input
D45	System2 tank liquid level	Display liquid level value of system2 tank

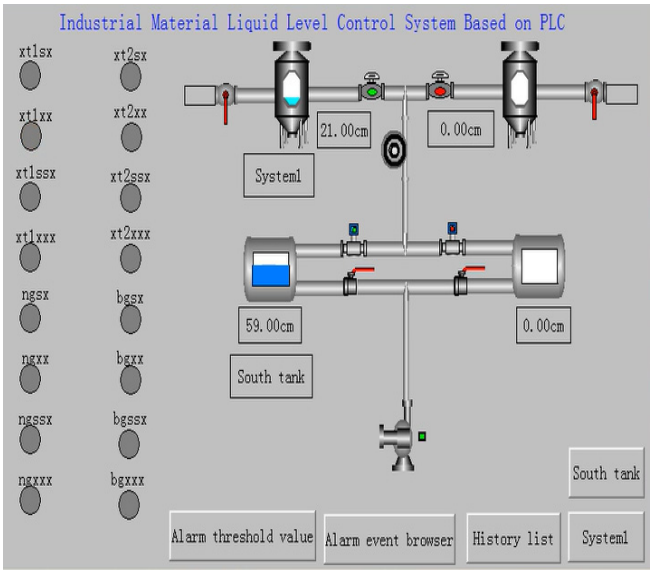

Figure 6. MCGS user window

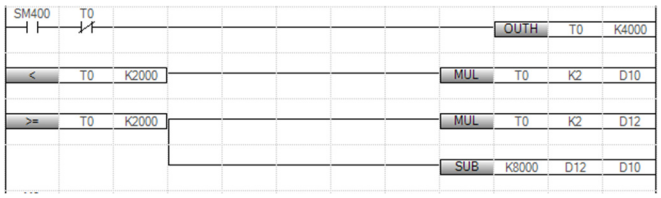

Figure 7. Triangular wave program

PLC built-in analog input program is composed of transfer instruction MOV and division instruction DIV. Take the south tank analog input program as an example: when the normally closed contact M0 is on, the data in the analog input channel SD6020 is transmitted to D14. Since the upper limit of the liquid tank level is 100, and the maximum value of the analog input is 4000, the D14 is divided by 40 using the division command and the data is transmitted to the south tank level D15. The input program of A/D module is as follows:

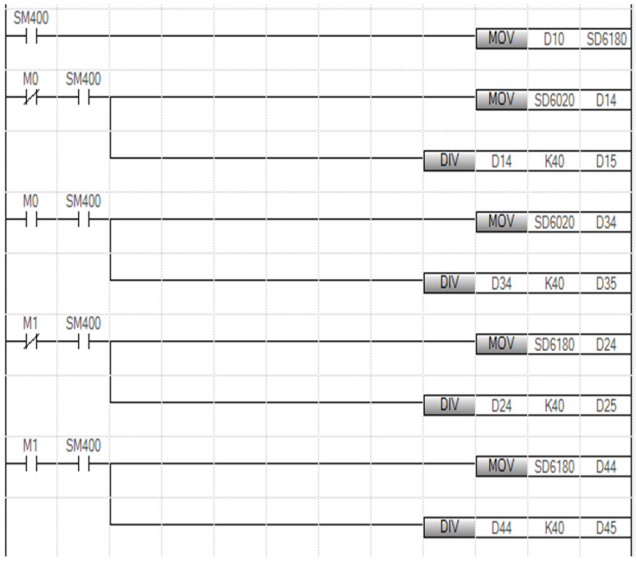

Figure 8. PLC analog input program

6. Experimental Results and Analysis

(1) Alarm threshold setting

Click the "Alarm threshold value" button on the main page, you can jump to the "Alarm threshold value" window, the interface displays, the user to set the liquid level threshold according to needs, as shown below:

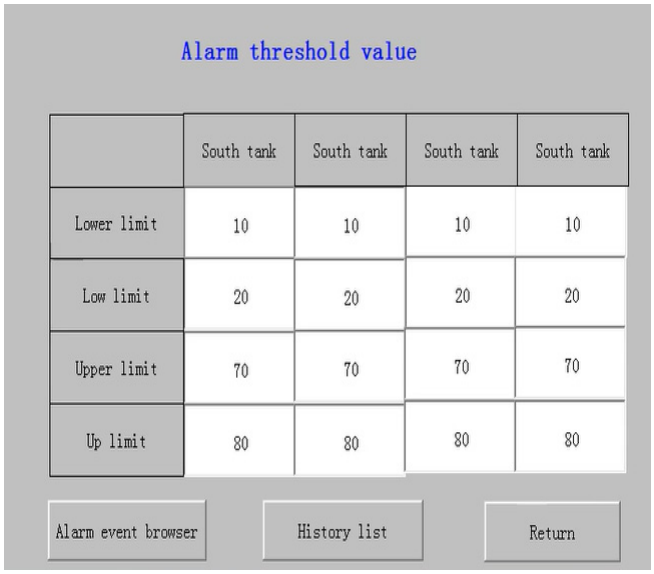

Figure 9. Alarm threshold setting

(2) Liquid level control

Take South tank and system 1 tanks as an example. When the liquid level of the south tank is lower than the lower limit, turn on the liquid pump switch to add liquid to the south tank, and the low limit alarm lamp of the south tank (ngxx) as well as the lower limit alarm lamp of the south tank (ngxxx) turn red. When the liquid level of system 1 tank is greater than the upper limit, the liquid supply switch of system 1 tank will automatically be closed to stop the liquid filling, and the up limit alarm light of system 1 as well as the upper limit alarm light of system 1tank (xt1ssx) will turn red.

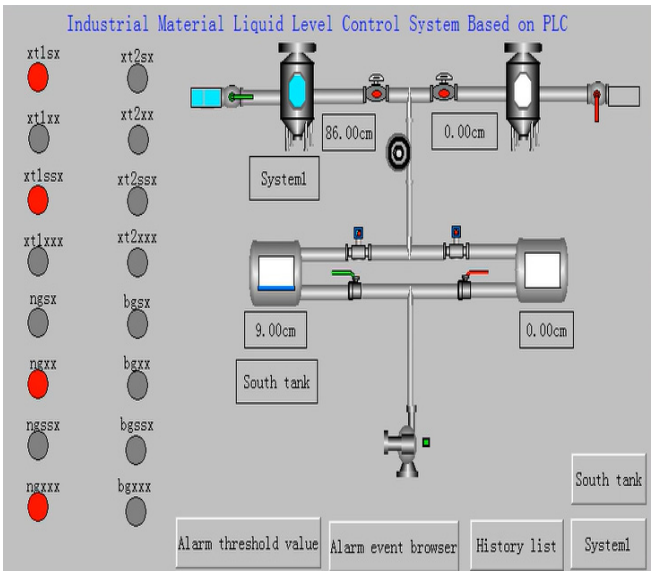

Figure 10. South tank and System 1 tank liquid level control

Take south tank and system 2 tank as an example. When the liquid level of system 2 tank is greater than the upper limit, the liquid inlet switch of system 2 and the liquid outlet pump of system 2 are automatically turned off, and the up limit alarm lamp of system 2 (xt2sx) as well as the upper limit alarm lamp of system 2 (xt2ssx) turn red.

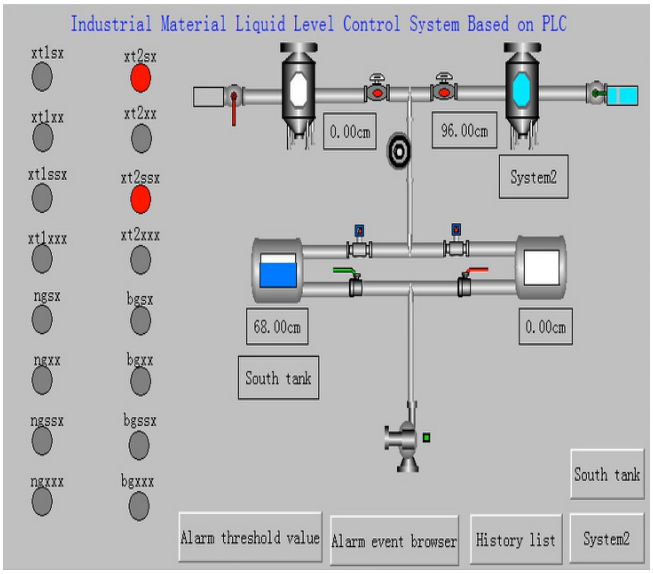

Figure 11. South tank and System 2 tank liquid level control

(3) Data query

Click the "History list" button on the main page, you can jump to the "Data query" window, you can query the historical data and real-time data of different tank level as shown below:

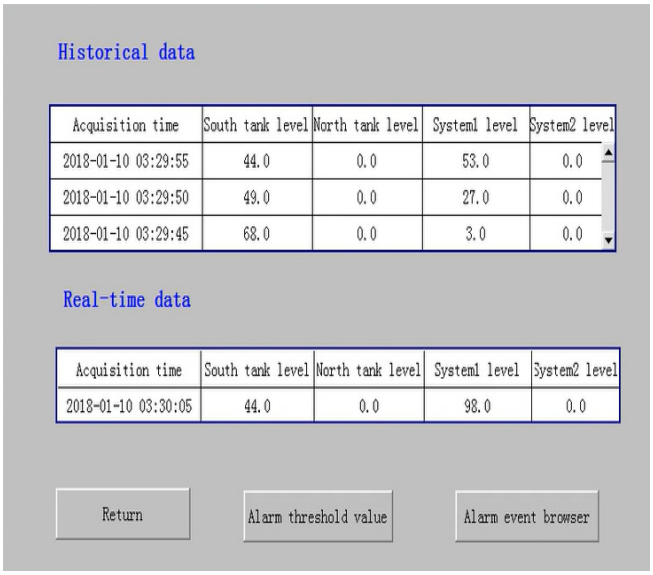

Figure 12. Data query

The experimental results show that when the south tank adds liquid to the system 1/2 tank, the liquid level of the system 1/2 tank is lower than the lower limit under normal circumstances, and the system 1/2 tank inlet switch can be opened when the lower limit is reached. In the manual case, the high level liquid pump needs to manually open the button to make it feed liquid to the system 1/2 tank. When the liquid level alarm, the light on the left side of the main page will turn red and issue a warning; In the "alarm browse" interface can see the alarm record; On the Report Output page, you can view historical and real-time records. The design was completed flawlessly.

7. Conclusion

In the process of system design and implementation, we make full use of the collaboration ability of PLC and MCGS configuration software. The configuration interface is designed by MCGS configuration software. The original functions and new functions of the system, except for the necessary valve switches, are implemented through the touch screen interface. The touch screen can display the liquid level height, working status, alarm information, and flexibly switch multiple control interfaces. Through simulation experiments, our system can effectively control the material level, and carry out sound and light alarm and automatic adjustment when the material level exceeds the set range. This system can add PID link to realize the precise control of the system.

References

[1] Yao Xiaoning. Programming and Application of Mitsubishi FX5uPLC [M]. China Machine Press,2021.

[2] Wang Yousong. Analysis and Research on Automatic control System of sewage lifting pump Station in Urban sewage treatment plant [J]. Urban Housing, 2019, 27 (08): 235-236.

[3] Xiao Jun, Geng Qingtao. Plc-based level separation control system for sump tank of sewage pumping station Design [J]. Instrument Technology,2020(09):31-36.

[4] Zhao Jinyu, DAI Yongsheng, LI Ran et al.Boiler System Based on PLC and Touch Screen Control [J]. Electronic World, 2020(10):143-144.

[5] Zhang Tianyu. Method of PID parameter tuning and Formulation of Control Strategy of Automatic Regulation System -- Review of Analysis and PID Tuning of Automatic Regulation System [J]. Materials Protection, 2020,53 (09) : 170.

[6] Zhou Zhaosong. Research on Design and Development Principle and Practical Application of Mitsubishi FX Series PLC [J]. Science and Technology Innovation Herald, 2019(22) : 75-76.