

Design of a Water Heater Heating System Based on Industrial Control Configuration Software WinCC

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ABSTRACT

The report presents the design and implementation of a water heater control system utilizing SIMATIC WinCC configuration software. The research highlights the transition from traditional manual control methods to automated systems, demonstrating significant improvements in efficiency, user convenience, and energy conservation. By leveraging the advanced capabilities of WinCC, the system effectively monitors and controls water levels and temperatures, integrating real-time data processing with a user-friendly interface. The project showcases enhanced operational efficiency, safety, and environmental sustainability, emphasizing the critical role of technological advancements in industrial automation.

KEYWORDS

WinCC; Energy Efficiency; Industrial Control Systems.

1. INTRODUCTION

1.1. Research Background

With the advancement and development of technology, automated engineering facilities have gradually replaced traditional manual work, and water tower level control is no exception. Traditional water heater heating control relied on manual operation, which was cumbersome and difficult to manage. However, with the progress and development of configuration software, we can now use it to control the water level and temperature of tanks.

1.2. Research Objectives

Using configuration software like WinCC, we can design a water heater control system in WinCC, and connect the system on the computer to the actual industrial system. This allows for the control of the water heater directly from the computer, simplifying the previously complex water heater control methods and making them easier to operate.

1.3. Significance and Value

Studying the heating systems of water heaters holds significant meaning and value in enhancing energy efficiency and convenience in daily life. Optimizing the design of heating systems offers several key benefits: Firstly, it improves energy efficiency by minimizing waste through intelligent control systems that regulate heating times and temperatures. Secondly, it enhances user experience by providing features such as rapid heating, stable temperature control, and remote operation, thereby increasing convenience and comfort. Thirdly, reducing energy consumption not only lowers individual and societal carbon footprints but also mitigates environmental impact, aligning with

sustainable development principles. Lastly, research and improvement in water heater heating systems drive technological innovation in areas such as smart controls, energy management, and IoT applications, advancing industrial and technological progress. Therefore, in-depth exploration of water heater heating systems is not only technically significant but also yields practical economic and ecological benefits for society and the environment.

2. PROCESS AND DESIGN REQUIREMENTS OF CONTROL SYSTEM

2.1. Introduction of SIMATIC Wincc Software

SIMATIC WinCC software, developed by Siemens, is an advanced monitoring and data acquisition solution widely used in industrial automation.

It offers powerful visualization capabilities and real-time data processing, supporting various operating systems and databases. WinCC integrates seamlessly with PLCs and devices, enabling comprehensive monitoring and control of industrial processes. It features flexible configuration options and customization capabilities, allowing users to create complex monitoring systems tailored to specific requirements. With its rich functionality and reliability, WinCC has become a leading software solution in the field of industrial automation.

2.2. Basic Process

Here is a direct translation of your description:

In the login screen, there are four buttons corresponding to their respective functions. In this interface, login operation can be performed, and entry into the main screen is only possible upon successful login. Otherwise, a dialog box "No operator permission" will pop up.

In the main screen, there is a power indicator light corresponding to whether the system is started. The light shows green when the system is started and red when it is stopped. The water tank has two input/output fields representing water level and water temperature. There are also four buttons corresponding to functions: returning to the login screen, adding water, heating, and dispensing water.

In the alarm record screen, there are two controls for displaying historical trends and showing variable changes in table form.

2.3. Control Requirements

-When the water level in the tank is below the lower limit, the solenoid valve opens for water inlet. The valve closes when the water level in the tank is above the upper limit.

-When the water temperature in the tank is below the lower limit, the solenoid valve opens for water inlet. The valve closes when the water temperature in the tank is above the upper limit.

-When the water outlet valve of the tank is opened, water discharge operation is performed, accompanied by playing a water discharge sound prompt.

3. FLOWCHART

The flowchart is as shown in Figure 1.

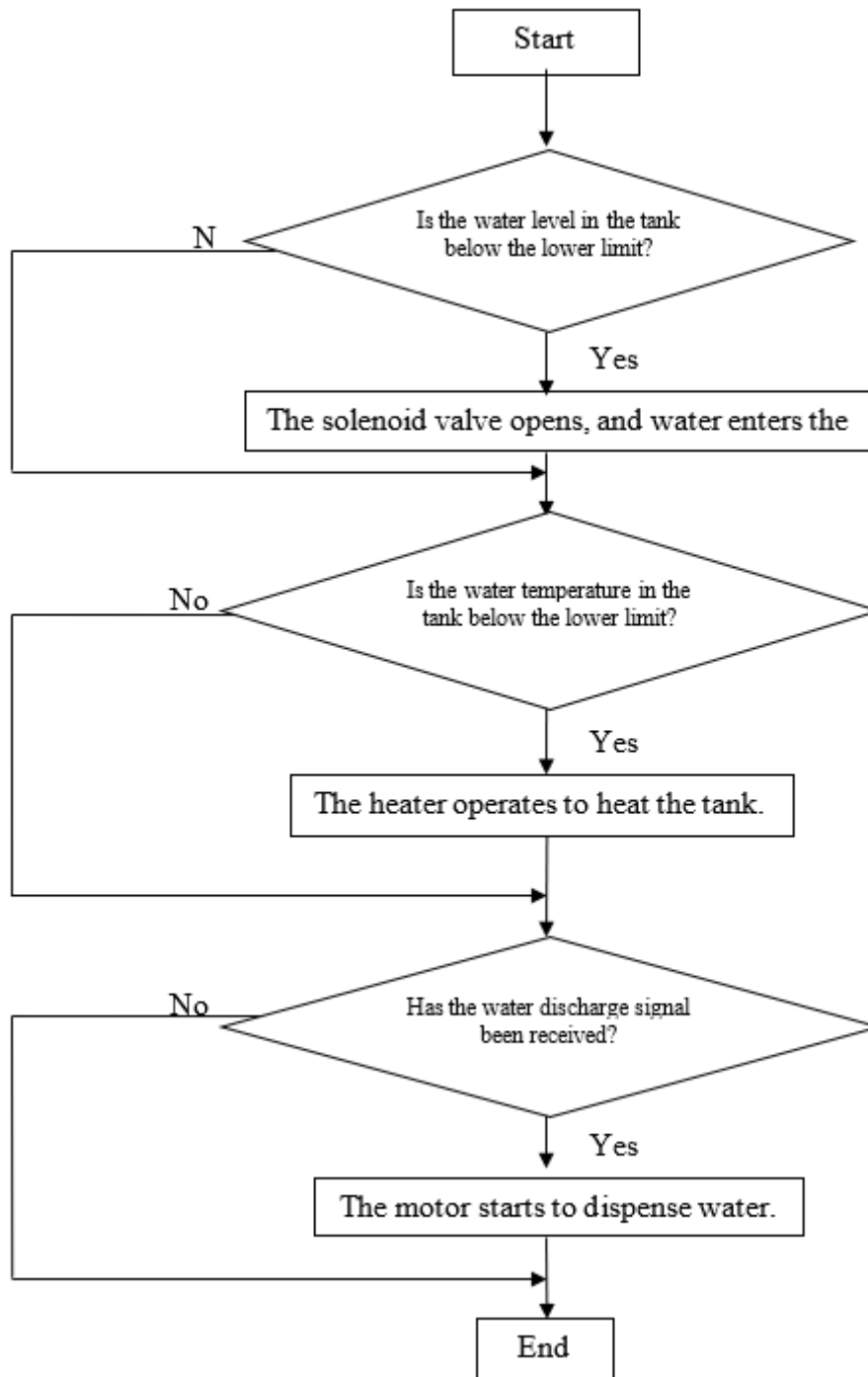


Figure 1. The flowchart

4. VARIABLE MANAGEMENT

In the WINCC Project Manager, click on "Variable Management" to create internal variables

Create the following variables:

- Variable "shuiwei" to represent the water level in the tank, data type: 32-bit floating point number.
- Variable "shuiwen" to represent the water temperature in the tank, data type: 32-bit floating point number.
- Variables "switch" and "switch1" to represent the operational status of power switches, data type: binary variable.

Each variable is as shown in Figure 2.

变量 [water]										查找
名称	注释	数据类型	长度	格式调整	连接	组	地址	线性标定	AS 值	
1 shuiwei		32-位浮点数 IEEE 754	4		内部变量	water		<input type="checkbox"/>		
2 shuiwen		32-位浮点数 IEEE 754	4		内部变量	water		<input type="checkbox"/>		
3 switch		二进制变量	1		内部变量	water		<input type="checkbox"/>		
4 switch1		二进制变量	1		内部变量	water		<input type="checkbox"/>		
5										
6										
7										
8										
9										

Figure 2. Each variable

5. USER MANAGER

In the graphic editor, create a new "Login Screen". Upon opening the screen, place buttons labeled "User Login", "Enter Screen", "Configuration System", and "Exit System", accompanied by static text for clarification. Additionally, use the "Standard" graphics tools to insert an image into the screen, as shown in Figure 3.



Figure 3. A new "Login Screen"

Double-click on "User Manager" in the project manager. In the pop-up window, right-click on "User Manager", add a new group, then within the new group, right-click to add a new user. Set the corresponding username, group name, and password as shown in Figure 4.

Select the appropriate permissions and functionalities for the user as shown in Figure 5.

用户管理器				
用户 [Group_1]				
用户名	组名称	密码	智能	
1 liukening	Group_1	●●●●●		
2 xiefei	Group_1	●●●●●		
3 yusi	Group_1	●●●●●		
4				
5				
6				
7				

Figure 4. Set the corresponding username, group name, and password

	功能	权限
1	用户管理	<input checked="" type="checkbox"/>
2	数值输入	<input checked="" type="checkbox"/>
3	过程控制	<input checked="" type="checkbox"/>
4	画面编辑	<input checked="" type="checkbox"/>
5	改变画面	<input checked="" type="checkbox"/>
6	窗口选择	<input checked="" type="checkbox"/>
7	硬拷贝	<input checked="" type="checkbox"/>
8	确认报警	<input checked="" type="checkbox"/>
9	锁定报警	<input checked="" type="checkbox"/>
10	解除报警	<input checked="" type="checkbox"/>
11	消息编辑	<input checked="" type="checkbox"/>
12	开始归档	<input checked="" type="checkbox"/>
13	停止归档	<input checked="" type="checkbox"/>
14	编辑归档值	<input checked="" type="checkbox"/>
15	归档编辑	<input checked="" type="checkbox"/>
16	动作编辑	<input checked="" type="checkbox"/>
17	项目管理器	<input checked="" type="checkbox"/>
18	远程激活	<input checked="" type="checkbox"/>
19	远程组态	<input checked="" type="checkbox"/>
20	Web 访问 - 仅监视	<input checked="" type="checkbox"/>

Figure 5. Select the appropriate permissions and functionalities for the user

Right-click on the project file in the project manager, select "Properties". In the project properties dialog box, navigate to the "Shortcuts" tab. Assign Ctrl+1 to the login action and Ctrl+2 to the logout action, as shown in Figure 6.

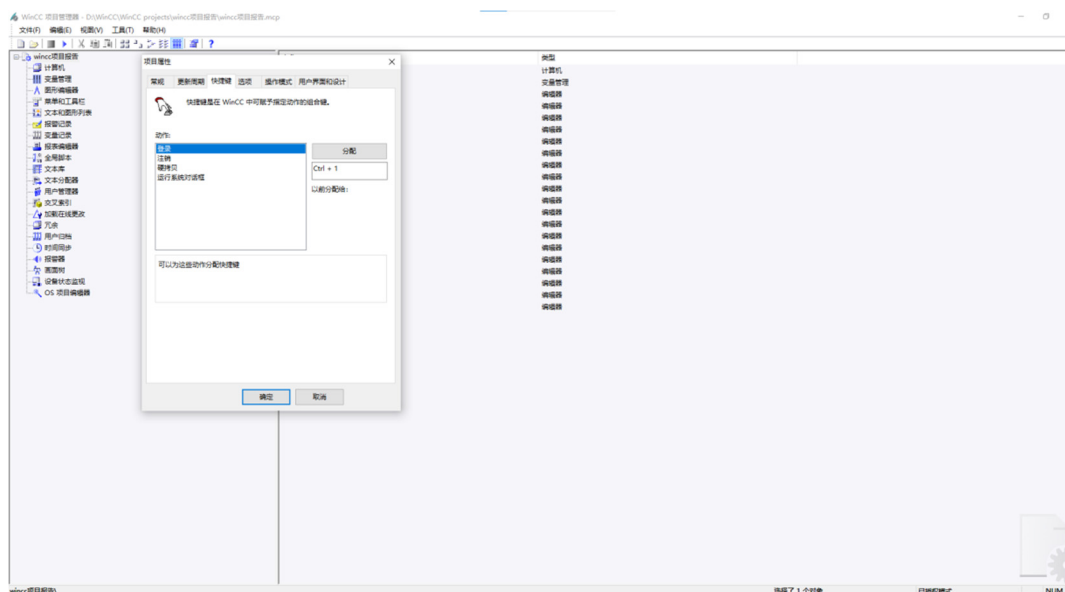


Figure 6. Assign Ctrl+1 to the login action and Ctrl+2 to the logout action

Select the "User Login" button in the login interface, and in the "Events" section, set its "Release Left" action to execute a C action. Input the code shown in Figure 7 to complete the implementation

of the login button's functionality. Similarly, set a C action for the "Release Left" action of the "Logout" button to implement its functionality.

```
#include "apdefap.h"
void OnLButtonDown(char* lpszPictureName, char* lpszObjectName, char* lpszPropertyName, UINT nFlags, int x, int y)
{
    //WINCC:TAGNAME_SECTION_START
    // syntax: #define TagNameInAction "DMTagName"
    // next TagID : 1
    //WINCC:TAGNAME_SECTION_END

    //WINCC:PICNAME_SECTION_START
    // syntax: #define PicNameInAction "PictureName"
    // next PicID : 1
    //WINCC:PICNAME_SECTION_END
    #pragma code ("useadmin.dll")
    #include "PwRT_api.h"
    #pragma code( )
    PwRTLogin("c");
}
```

Figure 7. The code

For the "Exit WinCC Runtime" button, use the System Functions in the dynamic wizard to configure it to "Exit WinCC Runtime System".

For the "Enter Screen" button, right-click on it to open the configuration dialog. In the "Mouse Click" section, select "Change Screen on Mouse Click". Choose the main screen to switch to when clicking the "Enter Screen" button, enabling the screen switching functionality.

6. CREATING SCREENS

In the login screen, use the "Standard" intelligent objects to insert graphical objects such as images. The screen includes four buttons: Login, Logout, Exit WinCC Runtime System, and Enter Main Screen, each corresponding to its respective function. Additionally, include an input/output field to display the current username, as shown in Figure 8.



Figure 8. The login screen

After entering the startup screen, design it by adding a circular shape as a power indicator light and three input/output fields to display water level, water temperature, and power switch status. Place

three buttons corresponding to power control, water discharge, and system exit to enable system startup and shutdown functions. Include static text for clarification, as shown in Figure 9.



Figure 9. After entering the startup screen

In the main screen, use the WinCC library to add a water tank and valves. Use the "Standard" tools to draw pipelines using the "polygonal pipe" feature, and modify the style with lines to simulate water flow. Add circular indicators as lights and input/output fields to display water level information. Use rectangles to represent changes in water level and temperature within the tank. Incorporate buttons to enable corresponding functionalities, and include static text for explanations, as illustrated in Figure 10.

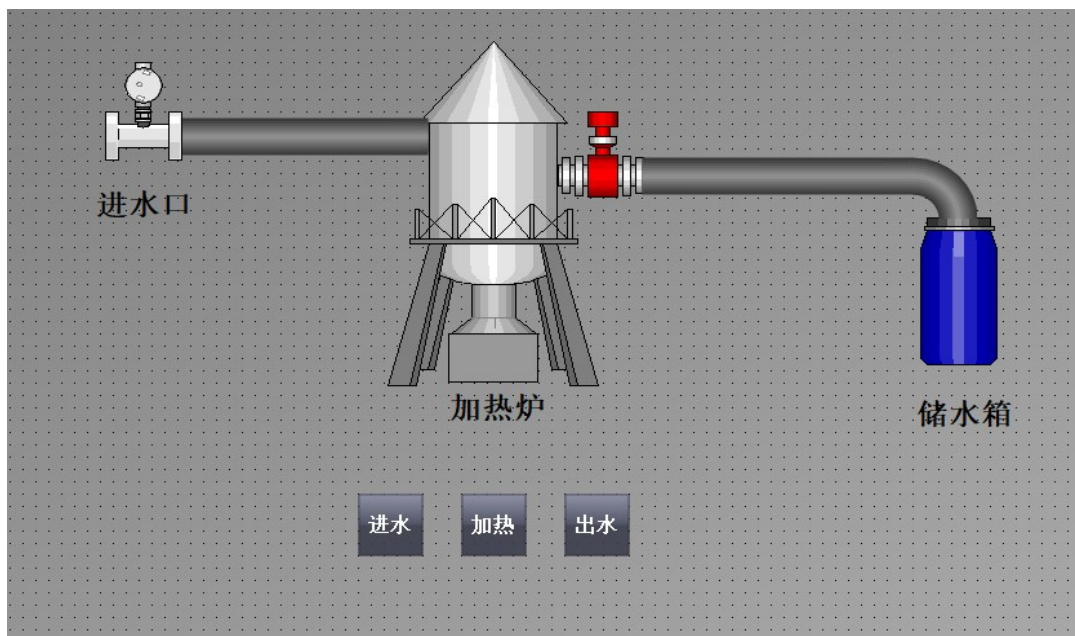


Figure 10. The main screen

In the alarm screen, place the "WinCC AlarmControl" component to display alarm records. Additionally, add a button to return to the main screen, as shown in Figure 11.

	日期	时间	编号
80	11/06/24	11:58:56	上 80
81	11/06/24	11:58:57	上 81
82	11/06/24	11:58:58	上 82
83	11/06/24	11:58:59	上 83
84	11/06/24	11:59:00	上 84
85	11/06/24	11:59:01	上 85
86	11/06/24	11:59:02	上 86
87	11/06/24	11:59:03	上 87

Figure 11. The alarm screen

In the variable record screen, place the "WinCC OnlineTrendControl" component to display historical trend graphs and the "WinCC OnlineTableControl" component to show variable value changes. Additionally, include a button to return to the main screen, as depicted in Figure 12.

	日期	时间	编号
1	04/06/24	11:12:38	上 2
2	04/06/24	11:22:37	上 4
3			
4			
5			

Figure 12. The variable record screen

7. CONNECTION OF RELEVANT VARIABLES AND C SCRIPTS

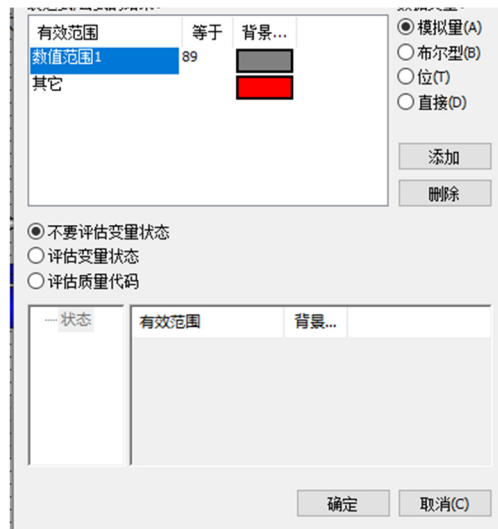


Figure 13. Set this parameter on the main screen

In the main screen, click on the "Power" indicator light. In the "Object Properties", under "Effects", set "Global Scheme" to "No". Then, right-click on "Background Color" under "Color", open the dynamic dialog box, and configure the "Analog" settings as shown in Figure 13.

Right-click on the input/output field "Water Level" to open the configuration dialog box. Connect it to the variable "shuiwei", as shown in the left side of Figure 14.



Figure 14. Water level setting

Select the "Add Water" button near the water tank. Right-click on "Mouse" under "Events", choose "Release Left", and select C action. Input the code to implement the tank's functionality. Use the same method to set up the "Heat" button for the tank.

Select the "Dispense Water" button. Right-click on "Release Left" under "Events", select C action, and input the code as shown in Figure 15. Also, add the sound file shown in Figure 16 to complete the implementation of water dispensing with sound playback functionality.

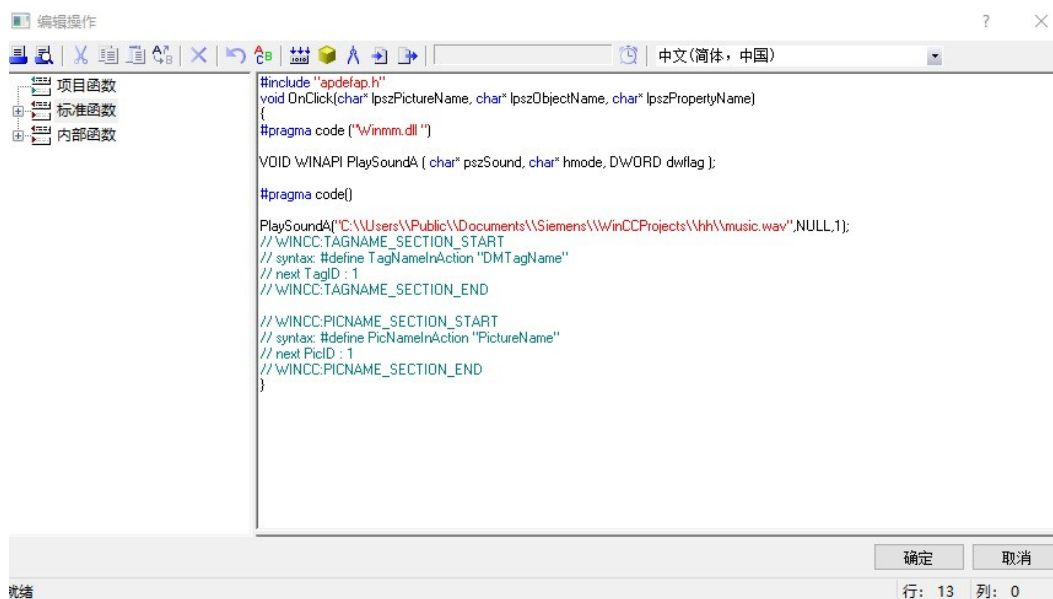


Figure 15. Input the code

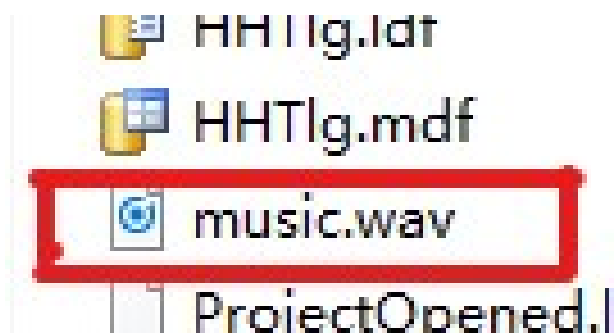


Figure 16. add the sound file

8. ALARM RECORD

Double-click on "Alarm Record" in the project manager, then click on "Limit Monitoring". Add variables and set upper and lower limits. Here, set the upper limits for both water level and water temperature in the tank to 100, and the lower limits to 80, as shown in Figure 17.

限制值 [全部]					
变量	共用信息	消息号	比较值	比较值	
1 shuiwei	<input type="checkbox"/>	0			
2 上限	<input type="checkbox"/>	1	100		
3 下限	<input type="checkbox"/>	2	80		
4 ✖					
5 shuiwen	<input type="checkbox"/>	0			
6 上限	<input type="checkbox"/>	3	100		
7 下限	<input type="checkbox"/>	4	80		
8 ✖					
9 ✖					
10					

Figure 17. water level and water temperature Settings

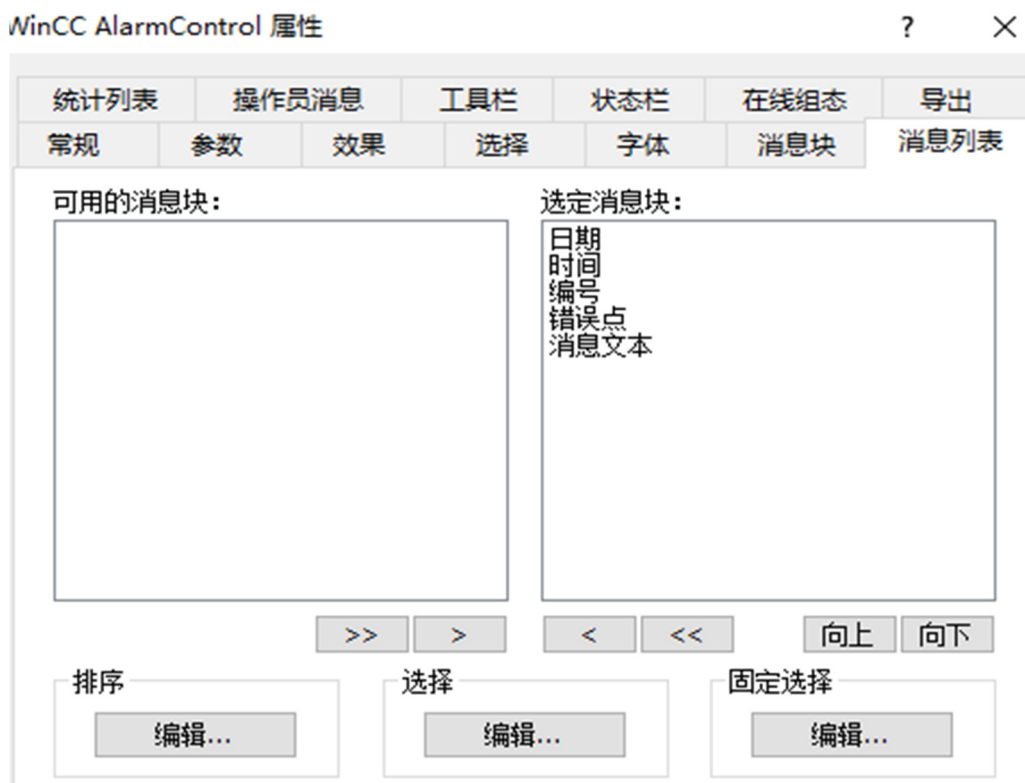


Figure 18. Create a new screen named "Alarm Screen"

Click on "Messages" and set alarm information for respective message numbers.

Create a new screen named "Alarm Screen". Add the "WinCC AlarmControl" component to the screen. Double-click on the control to open the configuration dialog box. Configure the message list and other settings, and add "Error Point" and "Message Text" to the selected message tabs, as shown in Figure 18.

Click on "Computer" in the project manager. Double-click on the right side to open computer properties. In the "Startup" tab, check "Alarm Record Runtime System", as shown in Figure 19.

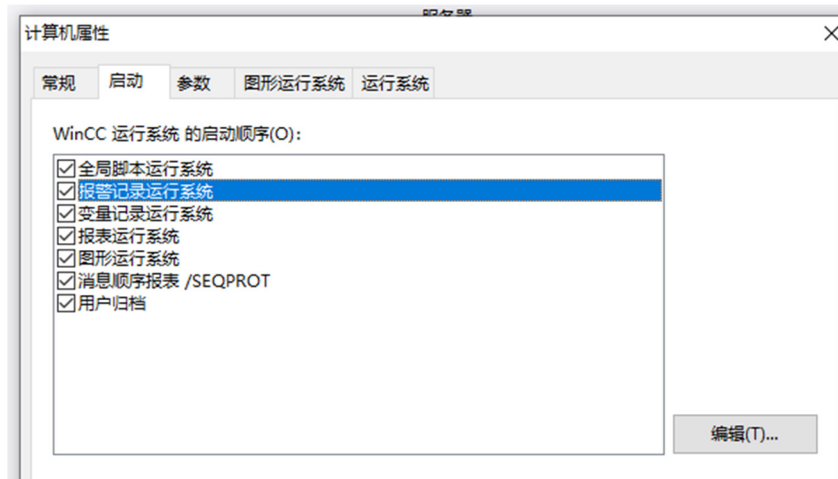


Figure 19. check "Alarm Record Runtime System"

9. REPORT FUNCTIONALITY

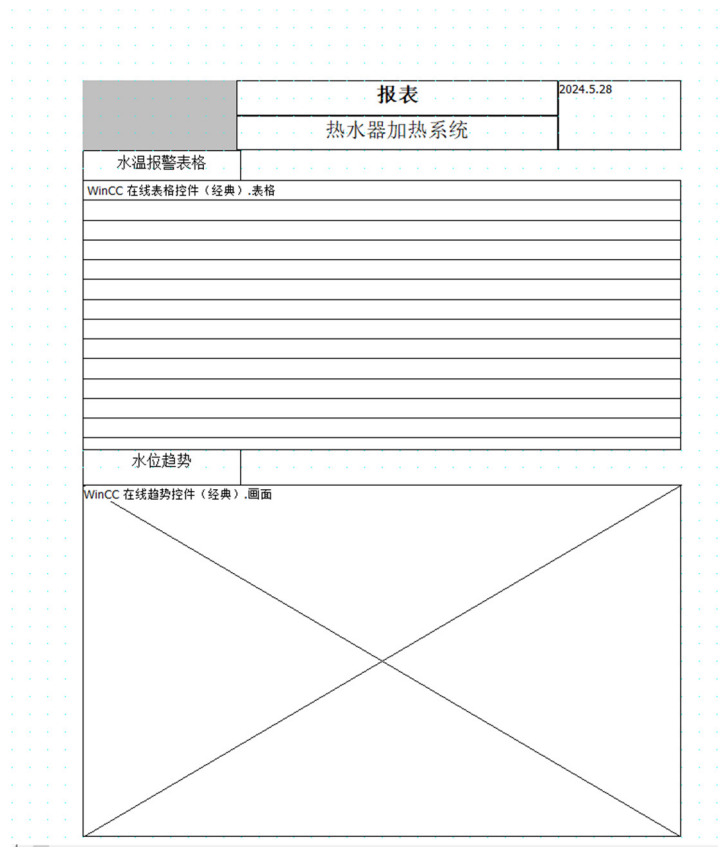


Figure 20. Page layout

In the project manager, click on "Report Editor". Right-click on "Layout" and select "Chinese (Simplified, China)". Create a new page layout. In the newly created layout, insert "Alarm Record Report" in the static section, and insert the table from "WinCC Alarm Control (Classic)" in the dynamic section, as shown in Figure 20.

In the alarm screen, double-click on "WinCC AlarmControl" to open the configuration dialog box. In the "General" tab, under "View Current Print Job", select "Report Alarm Logging RT Message Sequence", as shown in Figure 21.

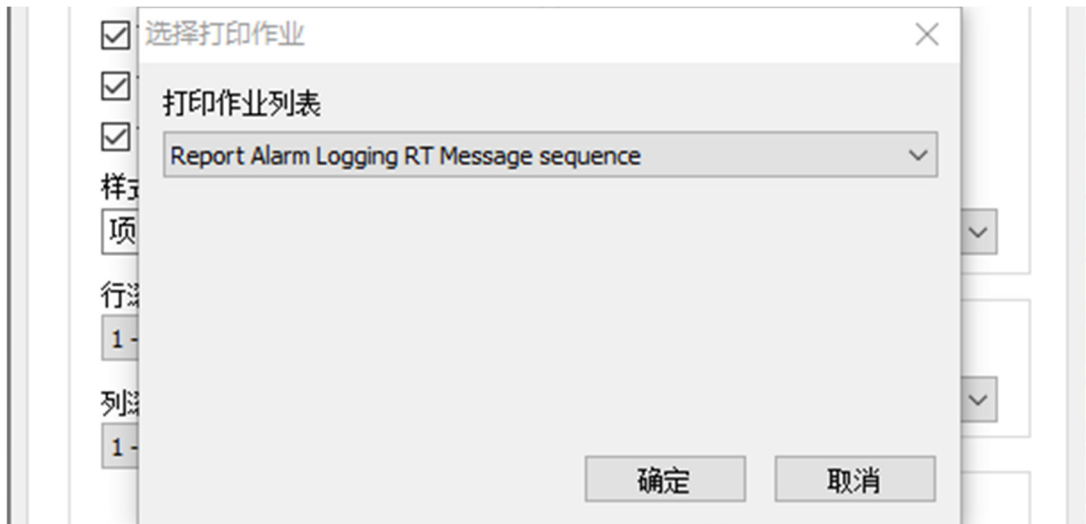


Figure 21. The alarm screen setting

In the project manager, click on "Computer". Double-click on the right side to open computer properties. In the "Startup" tab, check "Report Runtime System", as shown in Figure 22. Additionally, add a "Return to Main Screen" button and configure its screen switching functionality using the same method as described above.



Figure 22. Set the system boot sequence

Click "Run", in the "Print Job" of the "Report Editor" in the project manager, find "@Report Alarm Logging RT Message sequence", right-click to print, and perform the printing operation for the report. The report cover is shown in Figure 23.

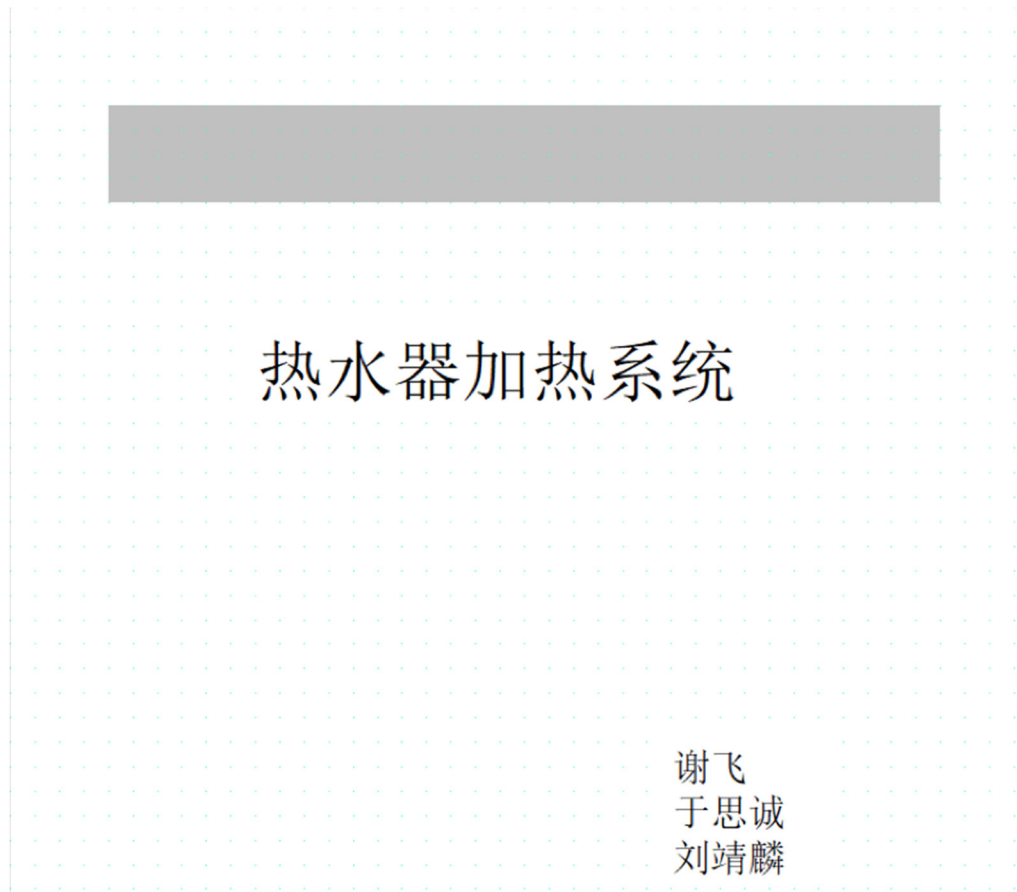


Figure 23. The report cover

10. OPERATION AND ANALYSIS

After completing the configuration work mentioned above, proceed with debugging. The project requirements should be mostly fulfilled.

In the project manager, click on "Graphic Editor". Right-click on the "Login Screen" and set it as the startup screen. Then, click the run button on the toolbar.

During runtime, the login screen will initially appear. If you attempt to directly click "Enter Screen", it will display "No Operator Permissions". After logging in with the username and password, you can proceed to enter the main screen. User members are shown in Figure 24.

用户 [Group_1]			
用户名	组名称	密码	智力
1 liukening	Group_1	●●●●●●	
2 xiefei	Group_1	●●●●●●	
3 yusi	Group_1	●●●●●●	
4 ✖			
5			
6			
7			

Figure 24. User members

The screen after entering the main interface is shown in Figure 25.

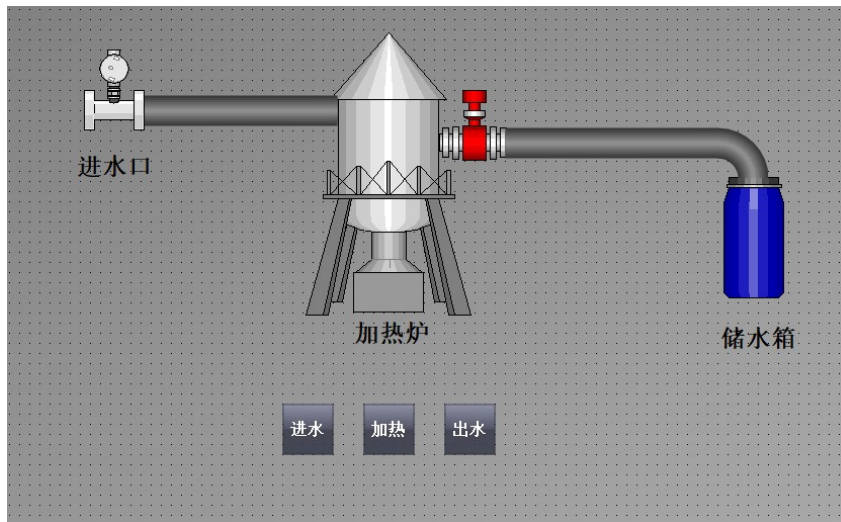


Figure 25. The screen after entering the main interface

Upon observation, the main interface can successfully implement the required functionalities, and each button functions as expected, as shown in Figures 26 and 27.

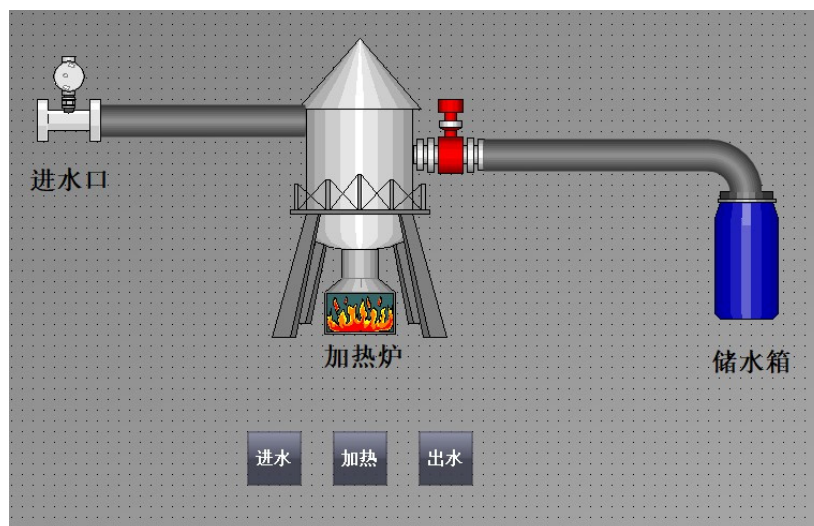


Figure 26. The main interface can successfully implement the required functionalities

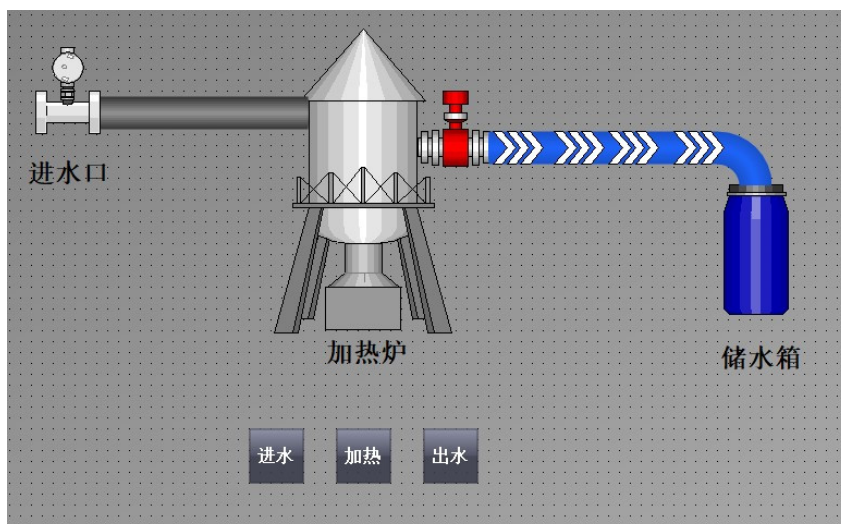


Figure 27. each button functions as expected

In the alarm screen, the controls display the date, time, configured number, error point, and message text. The alarm functionality is operating correctly, as depicted in Figure 28.

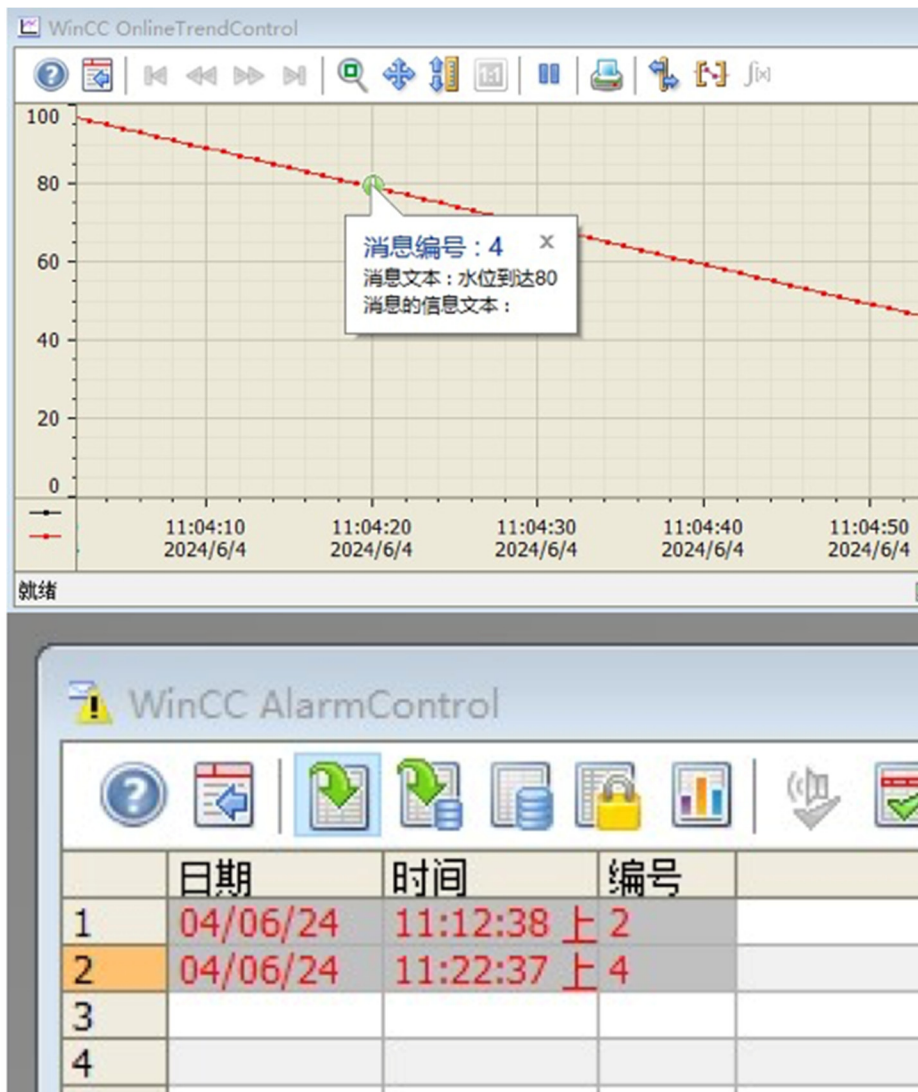


Figure 28. The alarm functionality is operating correctly

11. SUMMARY AND DISCUSSION

11.1. Summary

The heating system designed for the water heater aims to efficiently regulate water temperature through precise control mechanisms. Utilizing sensors and actuators, the system monitors and adjusts temperature levels within predefined limits. The integration of a graphical user interface facilitates user interaction, allowing for easy monitoring and control of heating operations. The system ensures safety and reliability by incorporating alarm functions to alert users of potential anomalies. Overall, the heating system optimizes energy usage and enhances user convenience by maintaining consistent water temperatures suitable for various applications.

11.2. Discussion

The implemented heating system represents a robust solution for maintaining water temperature in the water heater. By leveraging temperature sensors and actuators, the system achieves accurate and responsive control, ensuring that water remains within specified temperature ranges. This capability

is crucial for applications requiring precise water temperatures, such as residential and commercial hot water systems.

The graphical user interface plays a pivotal role in enhancing user experience and system management. Through the graphical user interface, users can easily monitor temperature readings, adjust heating settings, and receive real-time feedback on system status. This interface not only simplifies operation but also contributes to overall system efficiency by promoting proactive management of heating cycles.

Furthermore, the inclusion of alarm functions adds a layer of safety and reliability to the system. Alerts for temperature deviations or system malfunctions enable prompt intervention, preventing potential damage and ensuring uninterrupted operation. This proactive approach to monitoring and alerting underscores the system's reliability and user-centric design.

In conclusion, the heating system for the water heater exemplifies effective integration of control technology to optimize heating processes. Its combination of precise temperature control, intuitive interface, and robust safety features positions it as a reliable choice for applications demanding efficient and dependable water heating solutions.

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