HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF ELECTRICAL ENGINEERING

PROJECT REPORT

DCS & SCADA

EE4364E

Topic: *"Clean in place control system for beer factory."*

Point	Instructor's comments

Instructor: PhD. Đào Quý Thịnh

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ABSTRACT

The "Clean in Place Control System for Beer Factory" project aims to develop an automated solution for cleaning equipment and pipelines in a beer factory. The project involves designing and implementing a Clean in Place (CIP) control system that uses sensors, actuators, and programmable logic controllers (PLCs) to monitor and control cleaning parameters. The system aims to improve operational efficiency, reduce cleaning time, enhance product quality, and minimize contamination risks. Successful implementation of the CIP control system can serve as a model for other beverage manufacturing industries, promoting automation and standardization in ensuring cleanliness and product quality.

Finally, we would like to express our gratitude to our instructor – Mr. Đào Quý Thịnh, who guided us through this project.

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Chapter 1: Introduction

1.1. Beer Factory

Beer factories are essential components of the beverage industry, responsible for producing and distributing beer globally. These facilities combine traditional brewing techniques with modern technologies to transform raw ingredients into a variety of beer styles.

Figure 1. Beer components

With meticulous attention to detail and adherence to quality standards, beer factories employ advanced equipment and quality control measures to ensure consistent taste, purity, and safety.

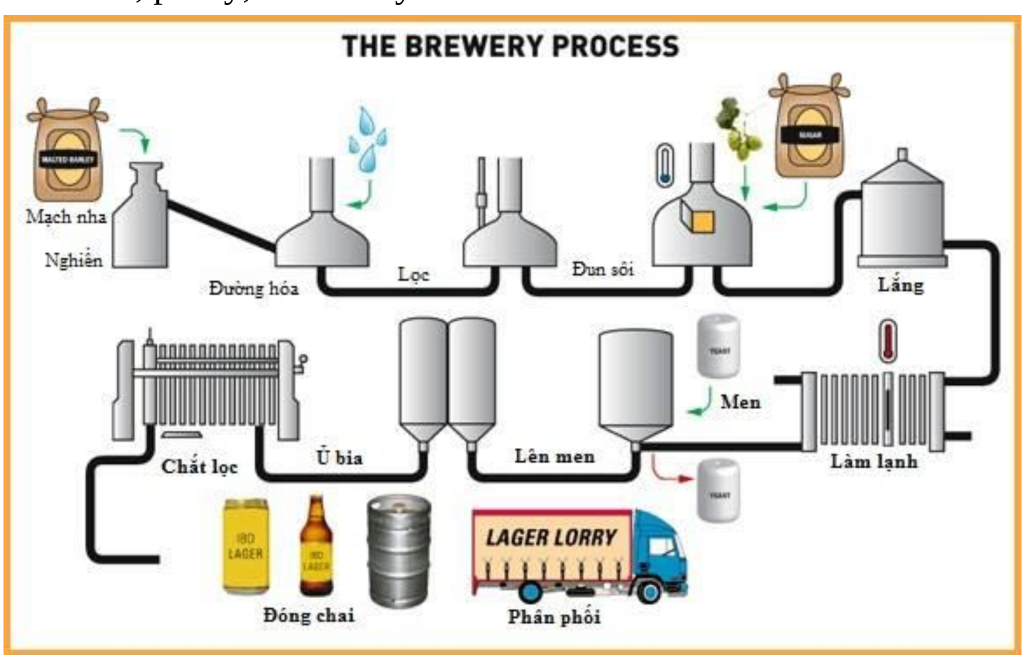


Figure 2. Brewing process

1.2. Clean in Place (CIP) System

Clean in Place (CIP) systems have revolutionized the cleaning processes in various industries, including beer manufacturing. These automated systems eliminate manual labor, reduce downtime, and enhance cleanliness and hygiene standards. By utilizing sensors, actuators, and programmable logic controllers (PLCs), CIP systems monitor and control cleaning parameters, resulting in improved operational efficiency and product quality.

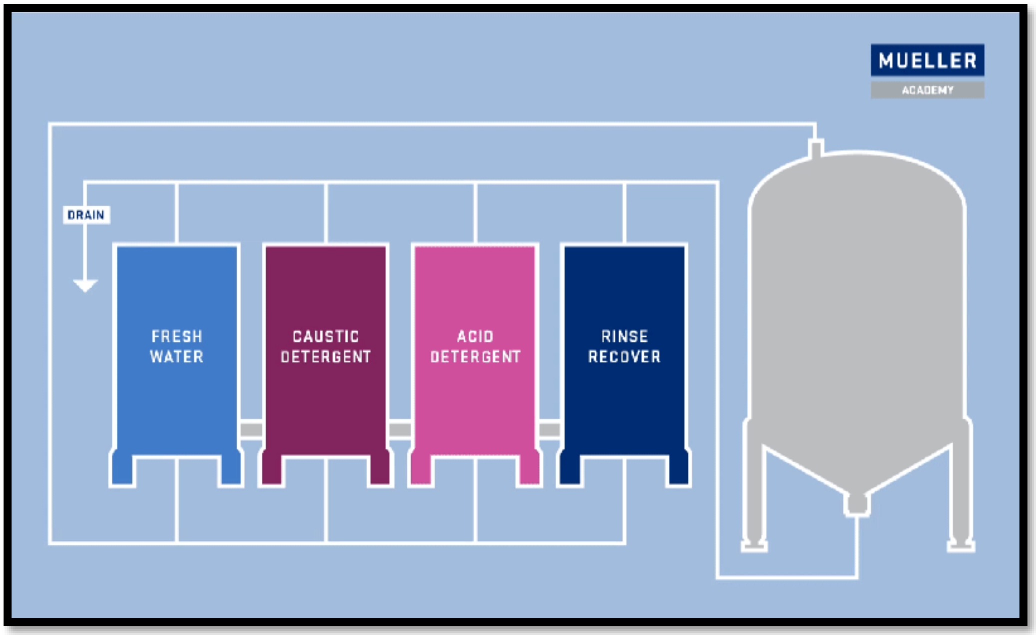


Figure 3. CIP System

Chapter 2: System Design

2.1. Architecture

The system architecture includes 4 layers: supervisory, communication, local control and field (I/O).

Layer structure	Technologies	Architecture			
Supervisory	Scada	Microsoft SQL Server	PC System	GUI	
Communication	ODBC, S7 NET, OPC				
Local Control	PLC, HMI	CPU	HMI		
Field	Sensors, Actuators	Level Sensor	Valves	Pumps	Motor

Figure 4. System Architecture

The supervisory layer includes an SQL server for database management, a GUI application to operate on PC system as a master terminal unit to supervise and control the remote terminal unit. The communication layer includes protocols such as ODBC, S7 NET. The local control includes SIMATIC CPUs, HMIs and modules. The field layer includes level sensors, valves, pumps and motor.

2.2. Instrumentation

(A) Level Sensor

LMT121 is a level sensor manufactured by a company called Endress+Hauser. The LMT121 is part of their Liquiphant series of point level switches. LMT121 offers reliable operation, liquids compatibility, process conditions, easy installation fail-safe operation and hazardous are certification.

(B) Valves

Using a butterfly valve, specifically a DN250 size with a pneumatic actuator AT14, can offer several advantages and considerations when used in a CIP (Clean in Place) system.

Advantages: Flow Control, Quick Operation, Hygienic Design and Compact Size.

Disadvantages: Sizing, Actuator Control, Maintenance and Reliability.

(C) Pumps

Based on research conducted, the SUDMO KRP 50/127-1.510 pump was choose. Advantages:

+ Efficiency: SUDMO pumps are known for their efficient performance, which can help in achieving optimal cleaning results in a CIP system.

+ Hygienic Design: SUDMO pumps are typically designed with hygienic considerations, making them suitable for use in the food and beverage industry and other applications with strict hygiene requirements.

+ Reliability: SUDMO is a reputable manufacturer known for producing reliable and high-quality pumps, which can contribute to the overall reliability and uptime of the CIP system.

+ Product Range: SUDMO offers a wide range of pumps, allowing for flexibility in selecting a model that suits the specific flow rate, pressure, and requirements of the CIP system.

There are also disadvantages:

+ Cost: Depending on the specific model and features, SUDMO pumps may be relatively more expensive compared to some other pump brands available in the market.

+ Specific Application Considerations: The suitability of the SUDMO KRP 50/127-1.510 for the CIP system would depend on the specific application requirements, such as flow rate, pressure, and compatibility with the cleaning solution.

(D) Motor

When selecting a 3-phase gear motor for a CIP (Clean in Place) system, there are several factors to consider.

Power and Torque: 3-phase gear motors can deliver high power and torque, which is beneficial for driving pumps, agitators, or other equipment in a CIP system.

Speed Control: 3-phase motors offer flexibility of speed control, allowing you to adjust the motor's speed to meet specific cleaning requirements or optimize the process.

2.3. CIP control system

The choice of a CPU (Central Processing Unit) for a CIP (Clean in Place) control system depends on various factors: performance and processing power, networking capabilities, scalability and flexibility, robustness and reliability, integrated safety features, programming environment.

(A) S7 – 1500 1512C-1 PN

The S7-1500 series CPUs are known for their high-performance capabilities, offering fast processing speeds, efficient program execution, and advanced diagnostics. The "PN" in the model number indicates that the CPU supports PROFINET, a widely used industrial communication protocol. This allows for seamless integration with other PROFINET-compatible devices in the CIP system, such as I/O modules, HMIs (Human Machine Interfaces), and other controllers, enabling efficient data exchange and system coordination. The S7-1500 1512C-1 PN CPU also supports OPC UA (Unified Architecture), which is a widely adopted industrial communication protocol for interoperability and data exchange between different automation devices.

Figure 5. CPU S7 – 1500 1512C-1 PN

Product type designation	CPU 1512C-1 PN
Firmware version	V2.8
Engineering with	STEP 7 TIA Portal
Supply voltage	24 V DC
Power	10 w
Work memory integrated (program)	250 kbyte
Work memory integrated (data)	Mbyte
CPU processing times for bit	48 ns
CPU processing times for word	58 ns
Number of distributed IO systems	32

Clock synchronization	supported
Interface types	RJ 45 (Ethernet)
Web server	HTTPS
OPC UA	Runtime license required
RAM	1 MB
ROM	non-volatile

(B) TP1200 comfort

The TP1200 Comfort is a Siemens HMI panel designed for CIP control systems. It features a large touchscreen display, user-friendly interface, flexible connectivity options, robust construction, advanced functionality, security features, and remote access capabilities. It provides an intuitive and reliable interface for monitoring and controlling CIP processes in industrial environments.

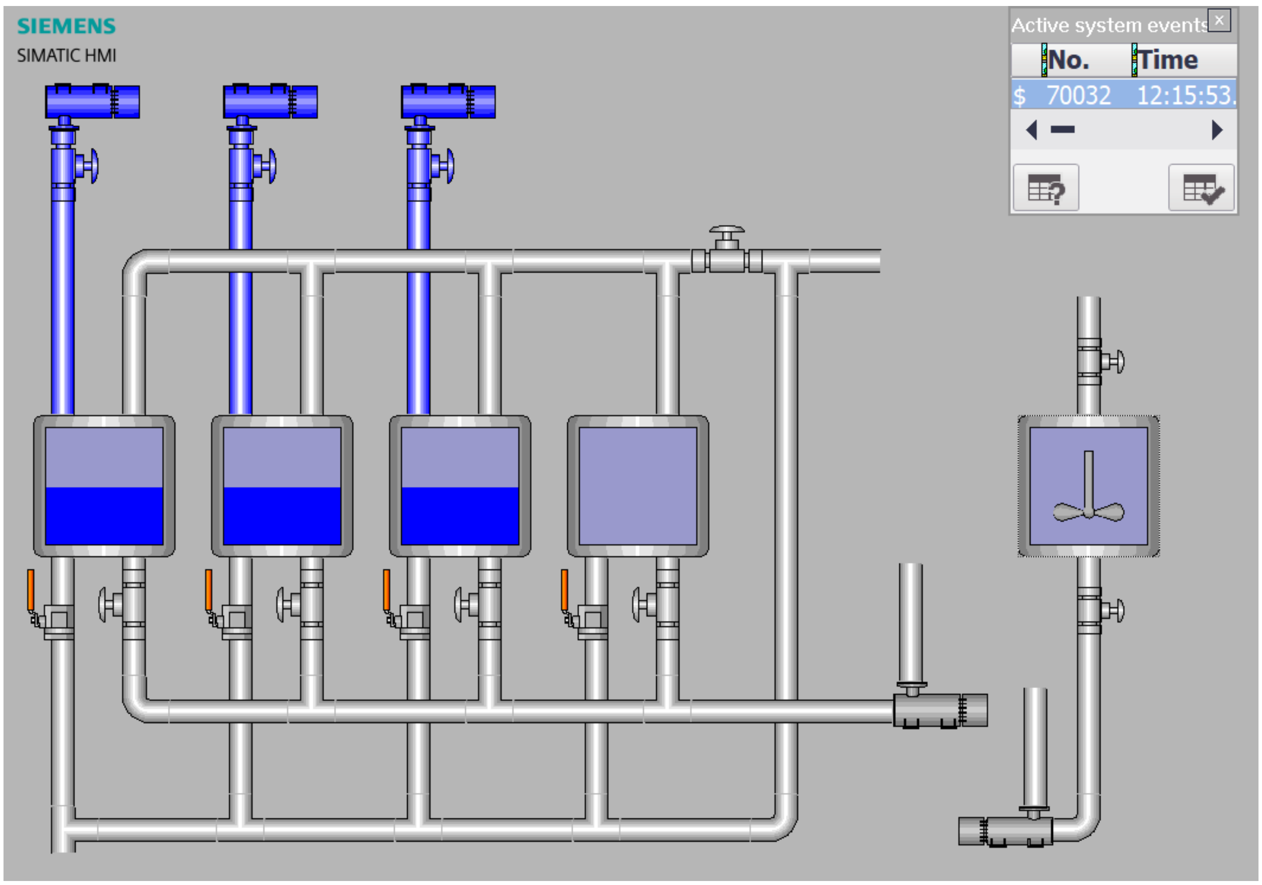


Figure 6. TP1200 simulated using WinCC RT Professional

(C) WinForms C#

WinForms in C# can be used to develop the user interface (UI) components of a CIP (Clean in Place) control system. With its drag-and-drop interface, event-driven programming model, data binding capabilities, and customization options, WinForms enables the creation of intuitive and visually appealing UIs for interacting with the CIP system. It seamlessly integrates with the backend logic written in C#, allowing for data processing, device communication, and control algorithm implementation. WinForms also supports error handling, data validation, reporting, and visualization, making it a versatile framework for building CIP control systems.

Figure 7. WinForms C# Splash art

In WinForms C# development for industrial automation, several libraries are commonly utilized:

- S7Net: S7Net is a C# library facilitating communication with Siemens S7 PLCs. It enables establishing connections, reading/writing data, and monitoring PLC variables.
- SymbolFactoryDotNet: SymbolFactoryDotNet is a C# library for creating graphical symbols and controls used in industrial automation UIs. It offers a range of customizable pre-built symbols for intuitive visualization.
- SQL: The SQL library enables C# applications to connect to and interact with databases such as Microsoft SQL Server, MySQL, or Oracle. It supports tasks like querying data, updating records, and executing stored procedures.
- PLC Libraries: PLC libraries include C# libraries developed by manufacturers or third-party developers to simplify PLC integration. These libraries provide features like data access, alarm handling, recipe management, and event logging for specific PLC models.
- OPC Libraries: OPC libraries are used to establish communication with OPC servers and devices. They enable C# applications to

read/write data, subscribe to real-time updates, and handle alarms/events in OPC-enabled systems.

By incorporating S7Net, SymbolFactoryDotNet, SQL, PLC, and OPC libraries into WinForms C# applications, developers can create powerful and user-friendly interfaces for controlling and monitoring industrial automation systems, integrating with PLCs, databases, and OPC-enabled devices.

(D) Microsoft SQL Server

In a CIP (Clean in Place) control system, Microsoft SQL Server 2019 can be utilized for data storage and management, while integrating with other technologies such as the S7-1500 PLC, WinForms in C#, and OPC (OLE for Process Control).

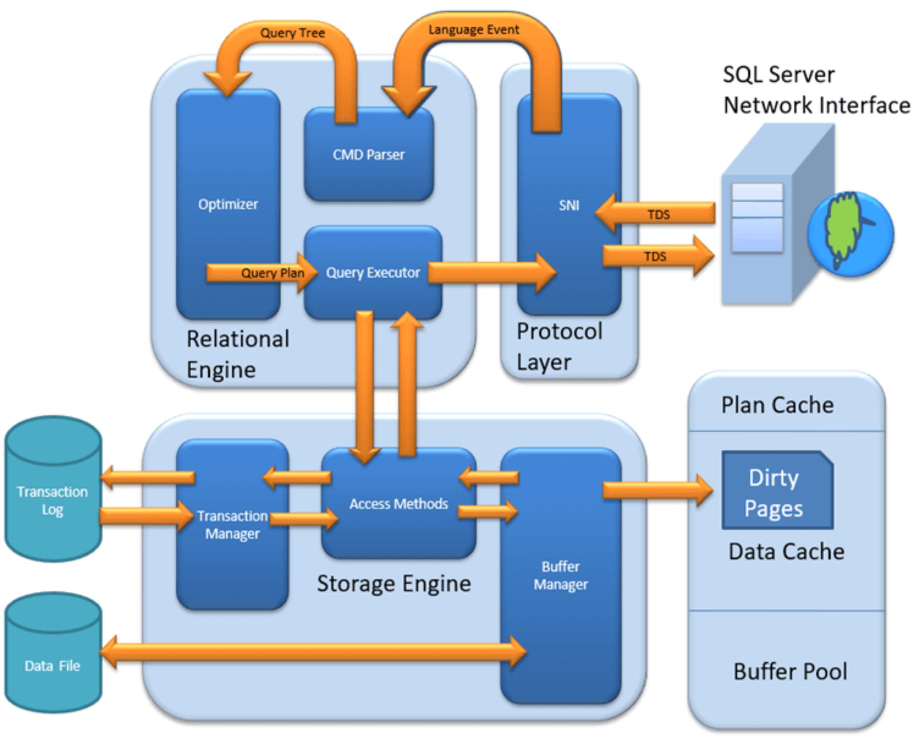


Figure 8. SQL Server structure

SQL Server 2019 is a robust relational database management system (RDBMS) provided by Microsoft. It offers a comprehensive suite of tools and features for storing, managing, and retrieving data. SQL Server can be used to store CIP process data, configuration settings, alarm/event logs, and other relevant information for the control system.

By combining Microsoft SQL Server 2019, S7-1500 PLC integration, WinForms in C#, and OPC libraries, a comprehensive CIP control system that leverages the power of a robust database for data storage and management, communicates with the PLC for process control, and provides a user-friendly interface for operators to monitor and interact with the system. OPC integration ensures seamless communication with OPC-enabled devices, enabling efficient data exchange and control within the CIP processes can be created.

2.4. I/O Variables

Current CIP LOW	Bool	%I10.0	Sensors
Current CIP HIGH	Bool	%I10.1	Sensors
Caustic LOW	Bool	%I10.2	Sensors
Caustic HIGH	Bool	%I10.3	Sensors
Acid LOW	Bool	%I10.4	Sensors
Acid HIGH	Bool	%I10.5	Sensors
Water Low	Bool	%I10.6	Sensors
Water High	Bool	%I10.7	Sensors
Rinse Low	Bool	%I11.0	Sensors
Rinse High	Bool	%I11.1	Sensors

Figure 9. Inputs for CPU

CIP Valve DRAIN	Bool	%Q4.0	Actuators
CIP Valve SUPPLY	Bool	%Q4.1	Actuators
CIP MOTOR	Bool	%Q4.2	Actuators
Pump RECOVERY	Bool	%Q4.3	Actuators
Pump SUPPLY	Bool	%Q4.4	Actuators
Caustic Valve Source	Bool	%Q4.5	Actuators
Caustic Valve Drain	Bool	%Q4.6	Actuators
Caustic Valve Recovery	Bool	%Q4.7	Actuators
Caustic Valve Supply	Bool	%Q5.0	Actuators
Acid Valve Source	Bool	%Q5.1	Actuators
Acid Valve Drain	Bool	%Q5.2	Actuators
Acid Valve Recovery	Bool	%Q5.3	Actuators
Acid Valve Supply	Bool	%Q5.4	Actuators
Pump Caustic	Bool	%Q5.5	Actuators
Pump Acid	Bool	%Q5.6	Actuators
Pump Water	Bool	%Q5.7	Actuators

Figure 10. Outputs for CPU part 1

Water Valve Source	Bool	%Q6.0	Actuators
Water Valve Drain	Bool	%Q6.1	Actuators
Water Valve Recovery	Bool	%Q6.2	Actuators
Water Valve Supply	Bool	%Q6.3	Actuators
Rinse Valve Drain	Bool	%Q6.4	Actuators
Rinse Valve Recovery	Bool	%Q6.5	Actuators
Rinse Valve Supply	Bool	%Q6.6	Actuators
Line Supply Valve	Bool	%Q6.7	Actuators
Line Recovery Valve	Bool	%Q7.0	Actuators
Valve Ricec	Bool	%Q7.1	Actuators
Valve Malt	Bool	%Q7.2	Actuators
Valve Filter	Bool	%Q7.3	Actuators
Valve Hops	Bool	%Q7.4	Actuators
Valve Settling	Bool	%Q7.5	Actuators

Figure 11. Outputs for CPU part 2

2.5. Wiring Diagram

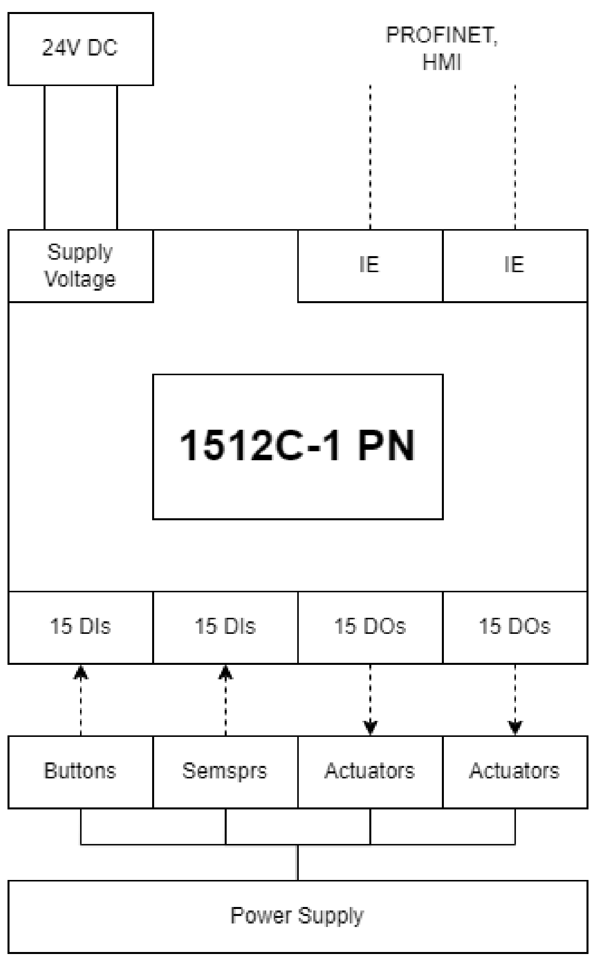


Figure 12. Wiring Diagram

2.6. Control sequence

(A) User Login

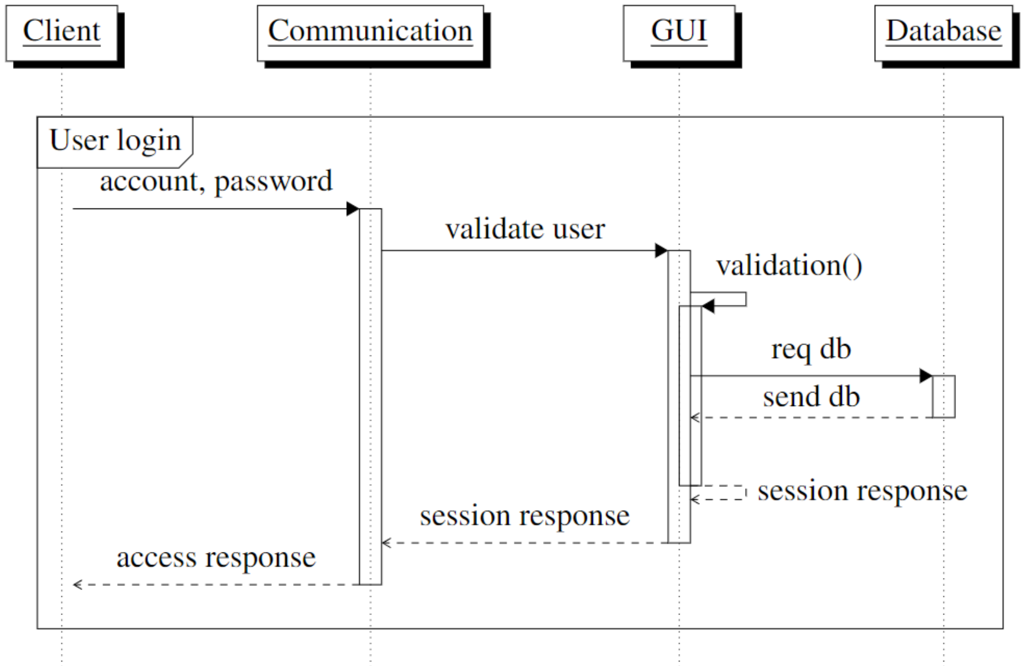


Figure 13. User login control sequence

(B) Mode selection

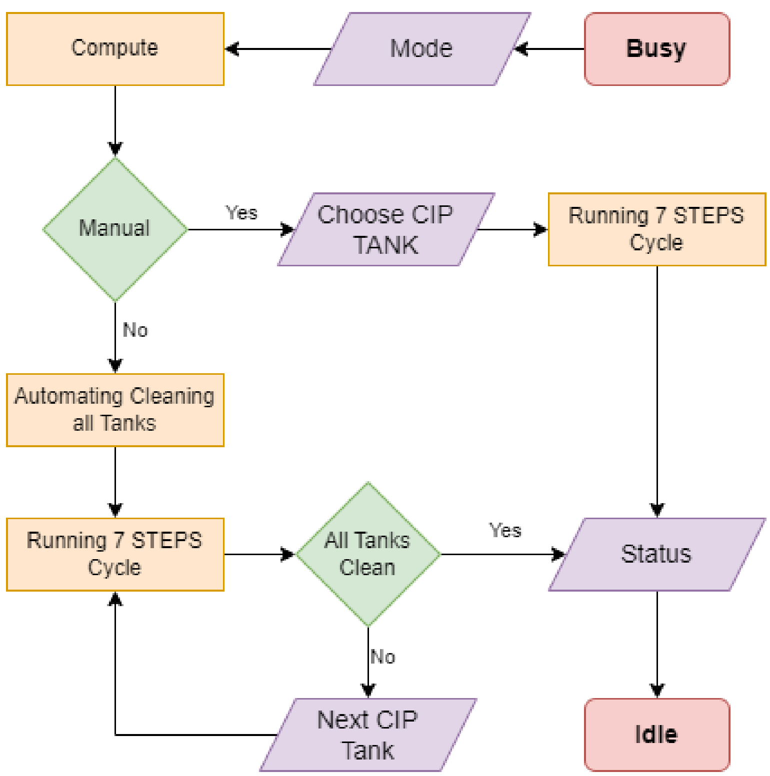


Figure 14. Mode control algorithm flowchart

(C) Step 1: Pre-empty

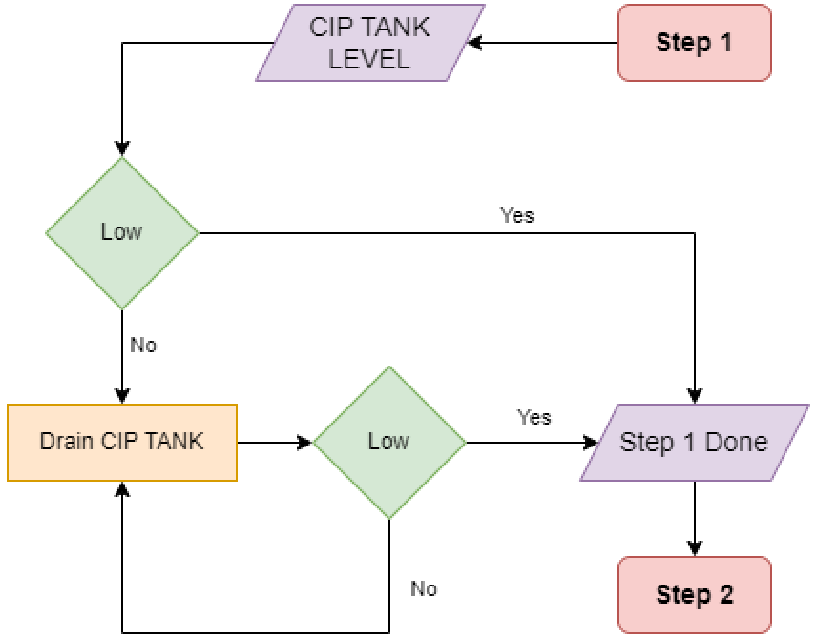


Figure 15. Step 1 control algorithm flowchart

(D) Step 2: Re-supply

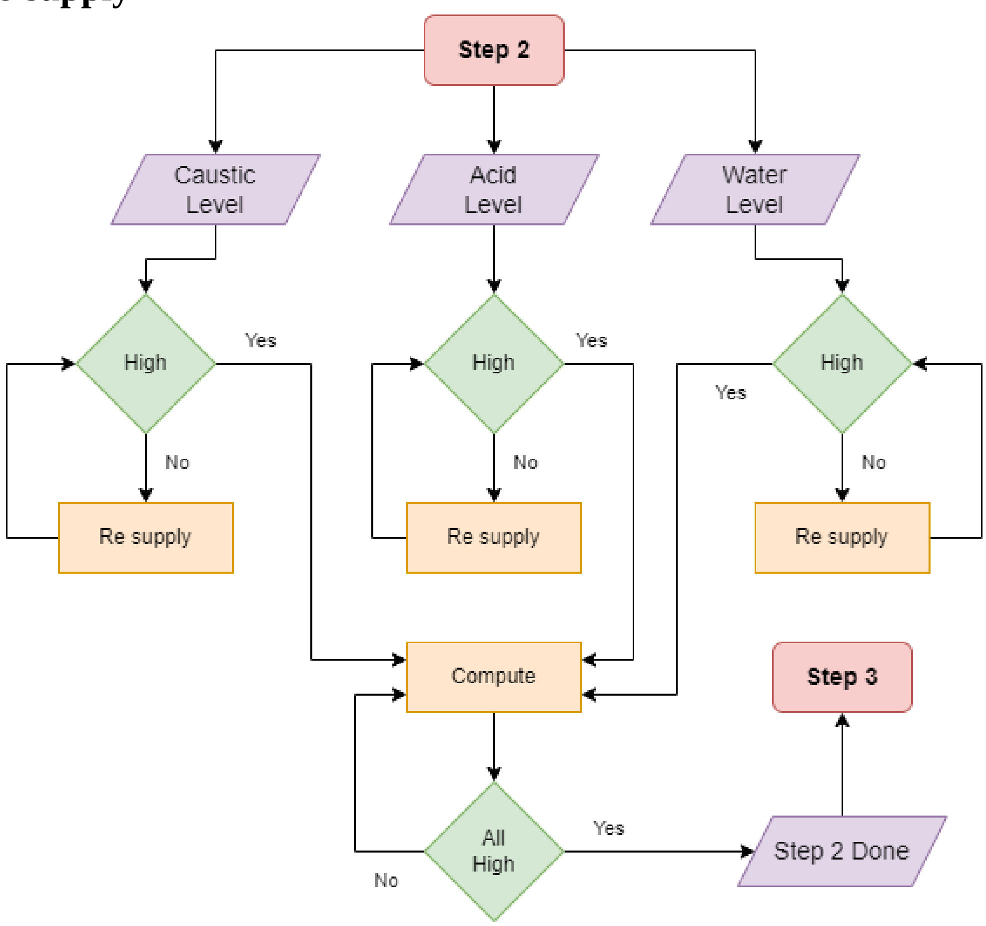


Figure 16. Step 2 control algorithm flowchart

(E) Step 3+5+7: Pre-rinse / Intermediate rinse / Final rinse

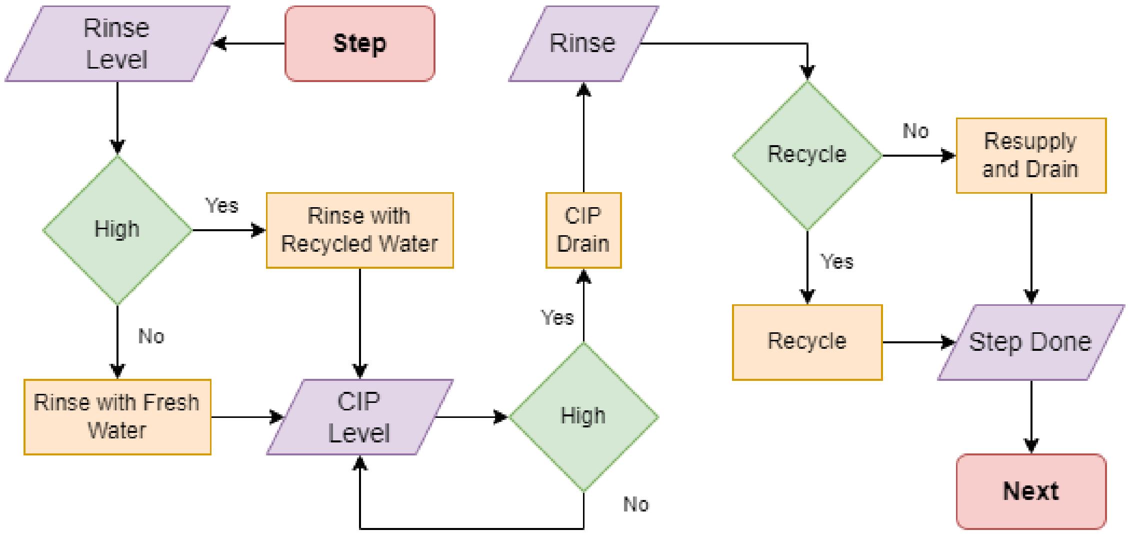


Figure 17. Rinse step control algorithm flowchart

(F) Step 4+6: Caustic wash / Acid wash

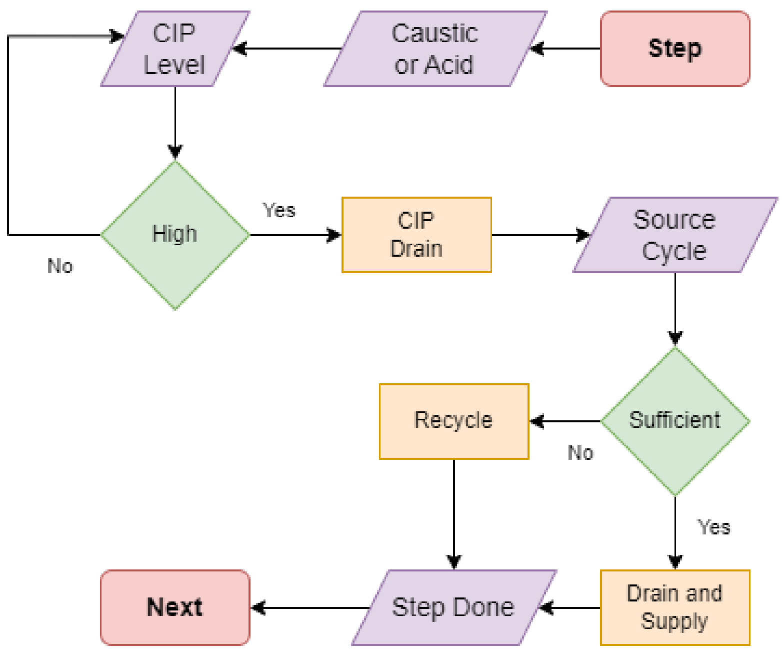


Figure 18. Caustic / Acid wash control algorithm flowchart

2.7. Authorization Distribution

The access authorization is divided into 3 levels: admin (can field, read report and setting for user); operator (can field report and access on HMI for operating); guest (can remotely read reports).

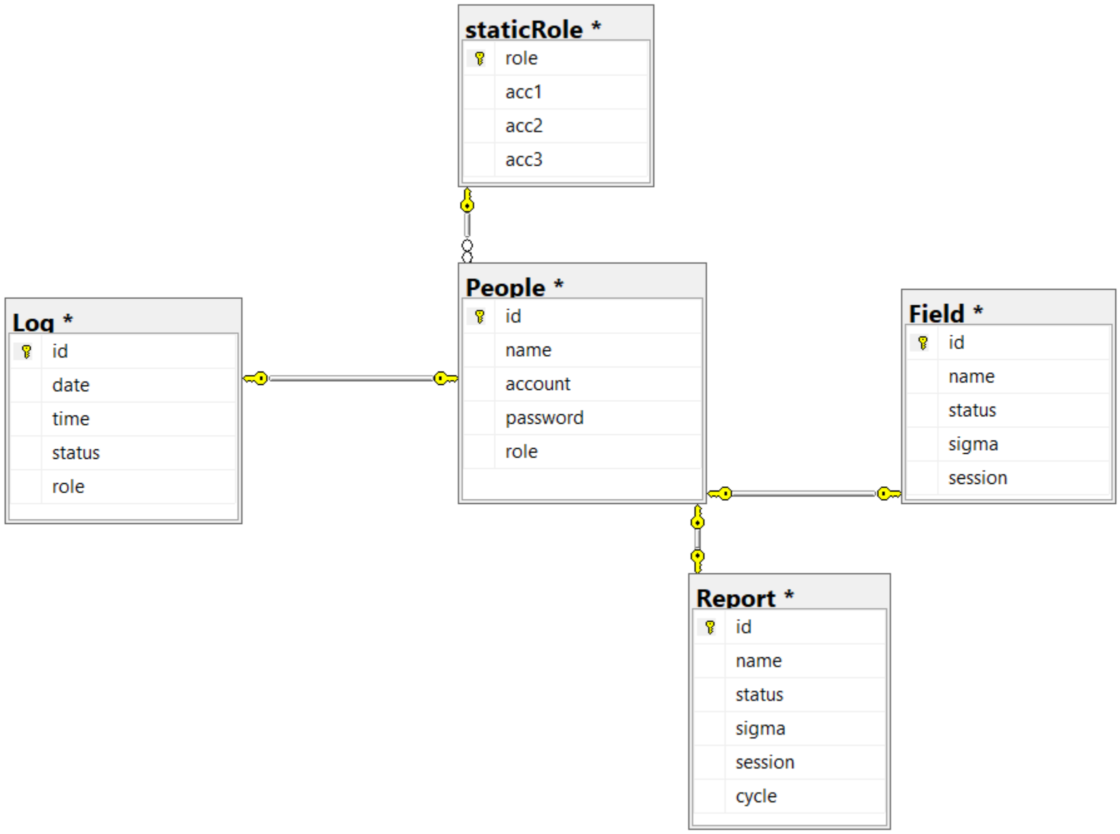


Figure 19. User, log and report database relationship

Chapter 3: Simulation

3.1. User Login

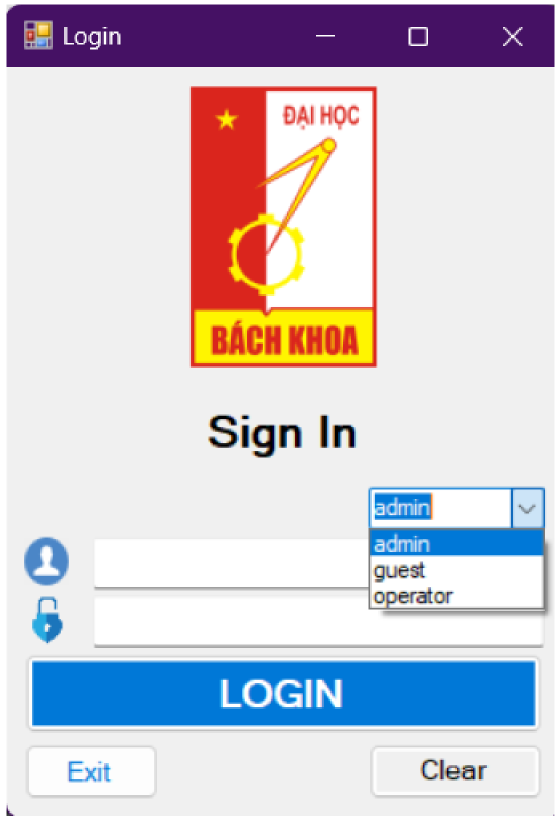


Figure 20. User login form

3.2. Admin forms

(A) Setting

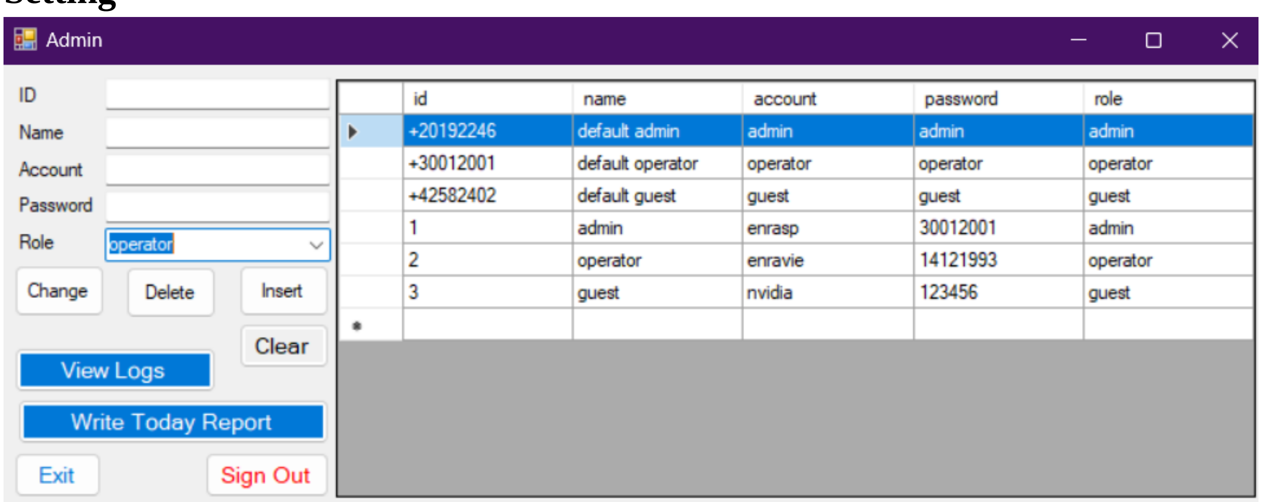
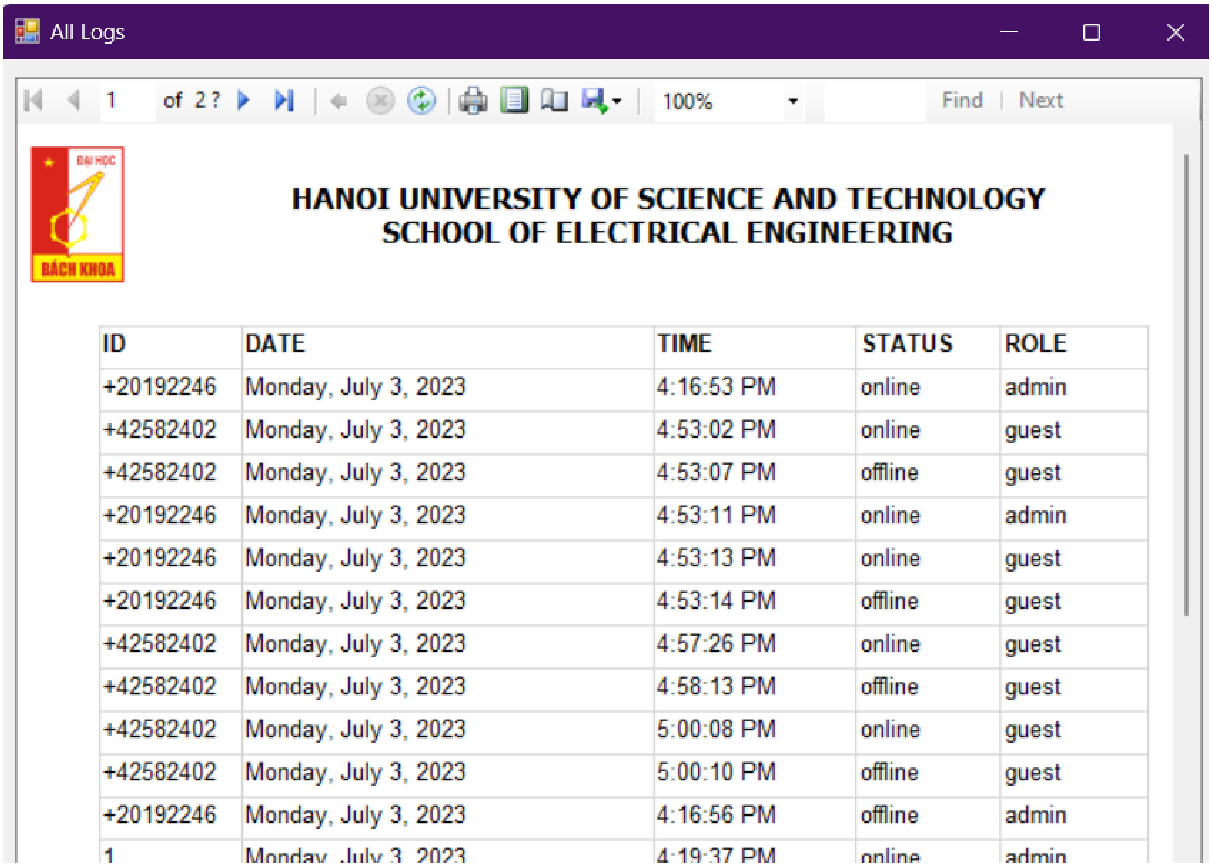


Figure 21. Administration settings

(B) Logs



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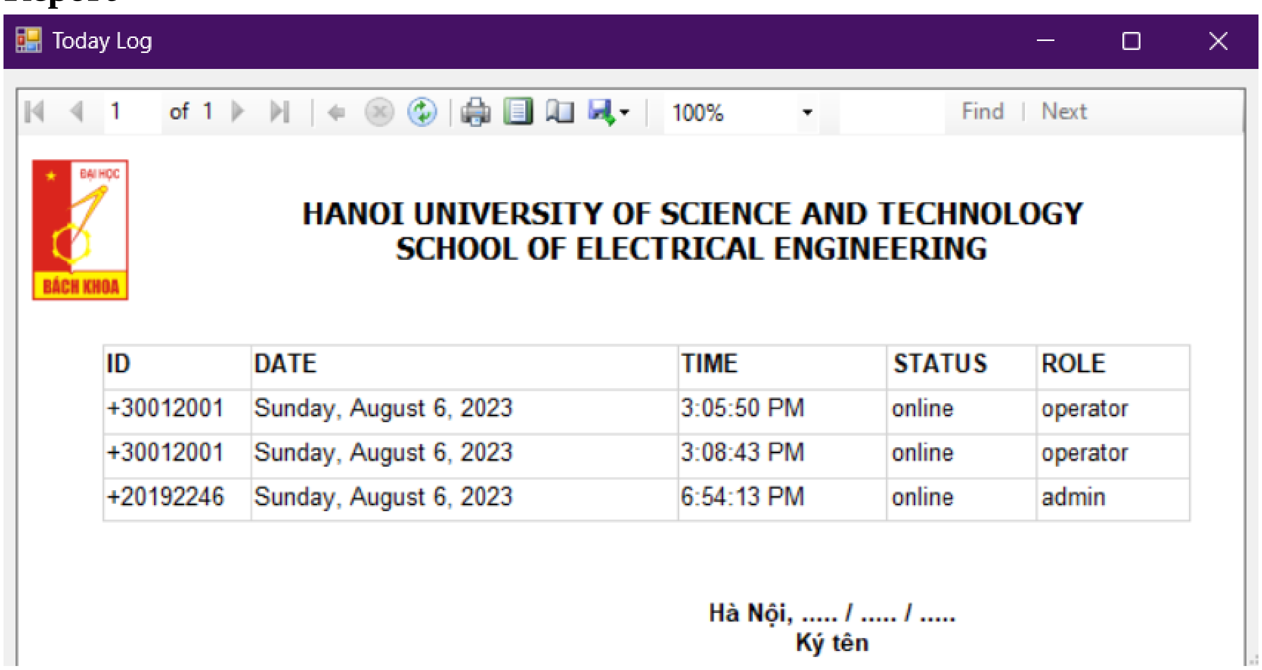
ID	DATE	TIME	STATUS	ROLE
+20192246	Monday, July 3, 2023	4:16:53 PM	online	admin
+42582402	Monday, July 3, 2023	4:53:02 PM	online	guest
+42582402	Monday, July 3, 2023	4:53:07 PM	offline	guest
+20192246	Monday, July 3, 2023	4:53:11 PM	online	admin
+20192246	Monday, July 3, 2023	4:53:13 PM	online	guest
+20192246	Monday, July 3, 2023	4:53:14 PM	offline	guest
+42582402	Monday, July 3, 2023	4:57:26 PM	online	guest
+42582402	Monday, July 3, 2023	4:58:13 PM	offline	guest
+42582402	Monday, July 3, 2023	5:00:08 PM	online	guest
+42582402	Monday, July 3, 2023	5:00:10 PM	offline	guest
+20192246	Monday, July 3, 2023	4:16:56 PM	offline	admin
1	Monday, July 3, 2023	4:19:37 PM	online	admin

Figure 22. User logs

(C) Report



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ID	DATE	TIME	STATUS	ROLE
+30012001	Sunday, August 6, 2023	3:05:50 PM	online	operator
+30012001	Sunday, August 6, 2023	3:08:43 PM	online	operator
+20192246	Sunday, August 6, 2023	6:54:13 PM	online	admin

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Figure 23. Reports

3.3. Operator forms

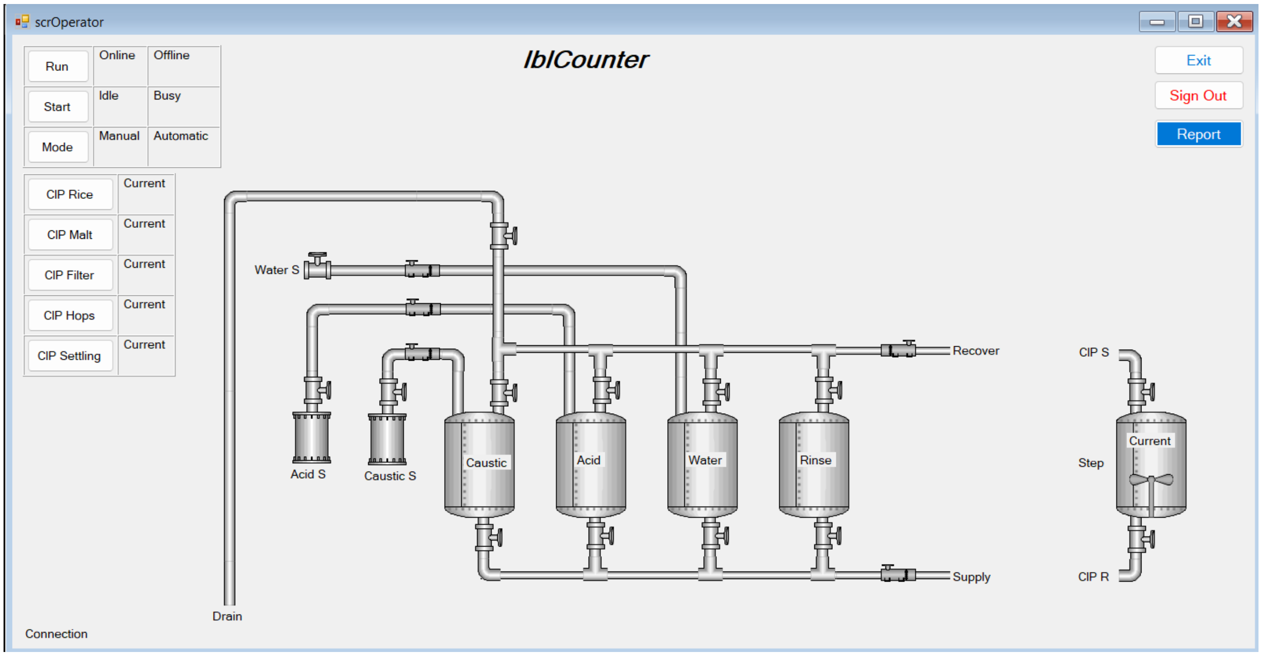
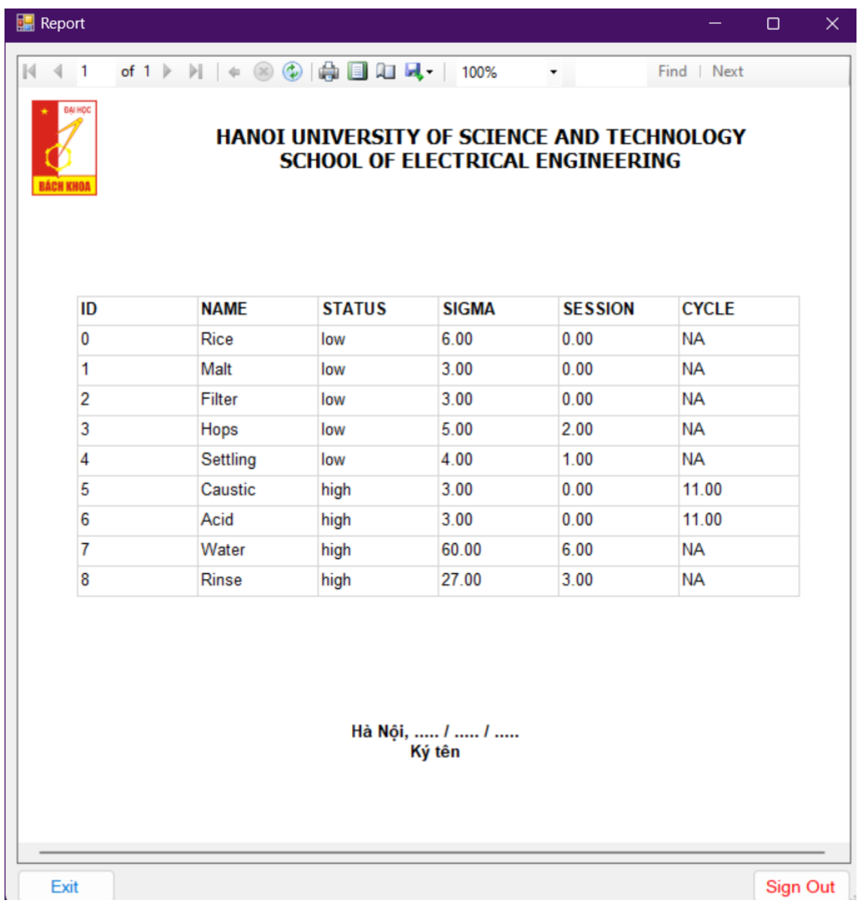


Figure 24. Operator forms



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ID	NAME	STATUS	SIGMA	SESSION	CYCLE
0	Rice	low	6.00	0.00	NA
1	Malt	low	3.00	0.00	NA
2	Filter	low	3.00	0.00	NA
3	Hops	low	5.00	2.00	NA
4	Settling	low	4.00	1.00	NA
5	Caustic	high	3.00	0.00	11.00
6	Acid	high	3.00	0.00	11.00
7	Water	high	60.00	6.00	NA
8	Rinse	high	27.00	3.00	NA

Hà Nội, ... / ..... / .....
Ký tên

Figure 25. Operator report

3.4. Guest view

+20192246	Monday, July 3, 2023	4:16:56 PM	offline	admin
1	Monday, July 3, 2023	4:19:37 PM	online	admin
1	Monday, July 3, 2023	4:19:53 PM	offline	admin
+30012001	Monday, July 3, 2023	4:25:14 PM	online	operator
+30012001	Monday, July 3, 2023	4:26:45 PM	offline	operator
2	Monday, July 3, 2023	4:27:00 PM	online	operator
2	Monday, July 3, 2023	4:27:03 PM	offline	operator
+42582402	Monday, July 3, 2023	4:46:39 PM	online	guest
+42582402	Monday, July 3, 2023	4:46:47 PM	offline	guest

Figure 26. Guest views

3.5. HMI for operator

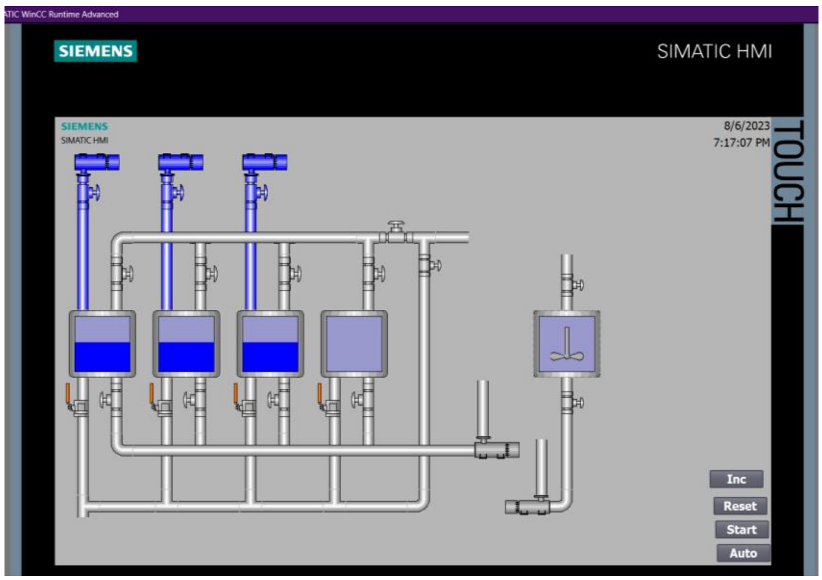

Figure 27. Resupply process

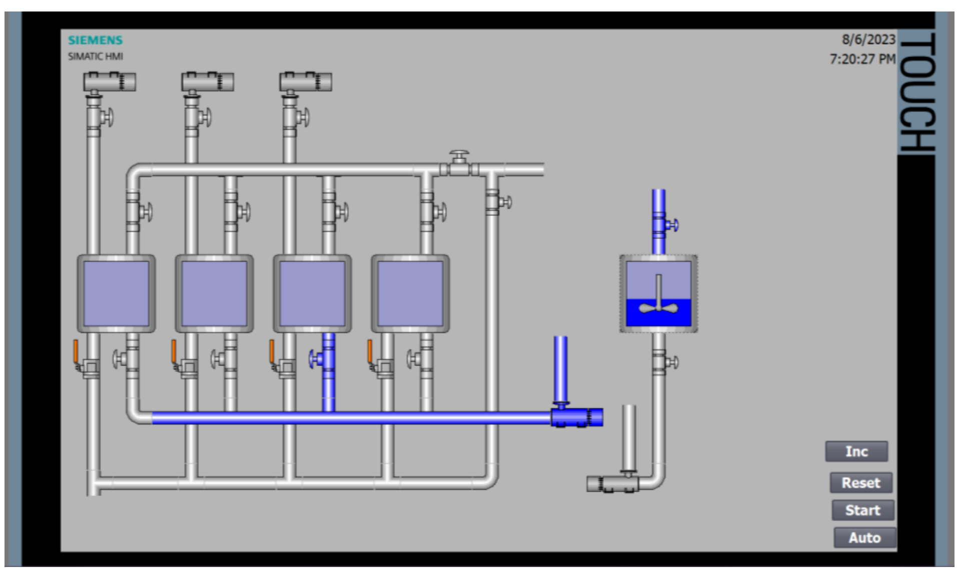

Figure 28. Pre rinse process

Chapter 4: Conclusion

After a period of active and efficient work during the recent semester, the project has essentially been completed on time and has met the required specifications and criteria. However, due to the team's limited practical experience and insufficient domain knowledge, there are still some areas of the project that have not been optimized and require improvement for practical application in the real work environment. We are very grateful to the instructor for their support and attentiveness to the challenges we faced during the project's execution. We hope to receive more feedback and suggestions to enhance the practicality of the project in the future.

Further inspection and adjusting will need to be done through more and more experiments.

Files and data of this project will be uploaded to drive:

https://tinyurl.com/192246DCS-SCADAG220