DANANG UNIVERSITY

UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING

CAPSTONE PROJECT

PROJECT TITLE

DESIGN DISHWASHERS FOR SMALL BUSINESSES

Supervisor:	**Dr. Dang Phuoc Vinh**	
	Mr. Nguyen Tan Uy (Tan Long Company)	
Reviewer:	**Dr. Vo Nhu Thanh**	
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Class:	**19CDTCLC2**	

Danang, 12/2023

THE UNIVERSITY OF DANANG **Socialist Republic of Vietnam**

UNIVERSITY OF SCIENCE AND TECHNOLOGY Independent – Freedom - Happiness

FACULTY OF MECHANICAL ENGINEERING

CAPSTONE PROJECT

TT	Student's name	Student code	Class	Major
1	Truong Van Vu	101190372	19CDTCLC2	Mechatronics Engineering
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1. *Topic:*

capable of operating continuously throughout the day

Design dishwashers for small businesses.

2. *Initial figures and data:*

   a) *Requirements:*
   - *The machine is capable of operating continuously throughout the day.*
   - *The dishes don't need to be arranged before washing.*
   - *The machine must be reduce time and labor compared to traditional dishwashing.*
   - *Must be saving power, water consumption and environmental friendly divices.*
   - *The machine can be disassembled for easy cleaning.*

   b) *Processing capacity*
   - Dishes: 20 plate / 10 bowl / 15 glasses.
   - Capacity of Standard / HighTemp program: 40 / 15 rack/h.
   - Target of Standard / HighTemp program: 60 / 20 rack/h.

3. *Contents of explanations and calculations:*

a. General part:

TT	Student's name	Contents
1	Truong Van Vu	- Analysis and selection of design options - Explanation - System design - Install the system - Circuit system design
2	Tran Danh Nam	
3	Do Van Tri	

b. Private part:

TT	Student's name	Contents
1	Tran Danh Nam	- Components included in the system - Calculation and selection of mechanical components
2	Do Van Tri	- Machine size design

		- Assembling mechanical components
3	Truong Van Vu	- Machining of electrical circuits - System control programming

4. Drawings, graphs (specify types and sizes of drawings):

a. General part:

TT	Student's name	Contents
1	Truong Van Vu	3D drawing on Fushion
2	Tran Danh Nam	
3	Do Van Tri	

b. Private part:

TT	Student's name	Contents
1	Truong Van Vu	1 Schematic electrical drawings A0 1 Funtion flowchart drawing A0
2	Tran Danh Nam	1 Detailed drawings A0 1 Assembly drawing A0
3	Do Van Tri	1 Algorithm flowchart A0

5. Supervisor: Dr. Dang Phuoc Vinh and Mr. Nguyen Tan Uy (Tan Long Company)

6. Project assignment date: 09/2023

7. Project completion date: 12/2023

	Da Nang,September 6, 2023
Head of Department **Mechatronic Engineering** **Dr. Vo Nhu Thanh**	**Supervisor** **Dr. Dang Phuoc Vinh**

PREFACE

Today, our country's economy is on the path of strong development with an increasing number of people. The need to protect and improve health in life through daily meals is increasing. This is an opportunity but also a challenge for the mechanical industry to serve the commune's festive needs. Another essential requirement is to save time for businesses and free up human labor. To accomplish this, the team researched, designed and manufactured "Design dishwashers for small businesses". Therefore, practitioners are required to master basic concepts of mechanics and electronics.

During the process of working on the project, my group received the help of supervisor is Mr. Nguyen Tan Uy (Tan Long Company) and teachers in the Department of Mechatronics - Faculty of Mechanical Engineering - University of Science and Technology - the University of Danang, and especially Dr. Dang Phuoc Vinh.

In the process of making mistakes, all comments and suggestions from everyone to improve the topic of my group are extremely valuable to me. I sincerely thank you!

PROTEST

The "Dishwashers for small businesses" is a very useful application in today's world, and it is in accordance with the country's modernization trend. This idea was executed in such spirit by our group, which included Truong Van Vu, Tran Danh Nam and Do Van Tri. The concept was based on Dr. Dang Phuoc Vinh and Mr. Nguyen Tan Uy’s knowledge and guidance.

We guarantee that we will execute this project thoroughly under the supervision and assistance of other instructors from the Faculty of Mechanical Engineering.

We thus confirm that the facts and research findings in this study are accurate and have not been plagiarized from a scientific publication.

Danang, November 25, 2023.

Student

Truong Van Vu

Tran Danh Nam

Do Van Tri

TABLE OF CONTENTS

PREFACE ..... **III**

PROTEST ..... **IV**

TABLE OF CONTENTS ..... **V**

LIST OF TABLE ..... **VII**

INTRODUCTION ..... **IX**

CHAPTER 1: OVERVIEW **1**

1.1. Overview of dishwashers **1**
1.1.1. Introduction about dishwasher machine **1**
1.1.2. Domestic and international situation **2**
1.1.3. Some popular dishwasher brands **3**
1.2. The practical needs of dishwashers **6**
1.2.1. For family **6**
1.2.2. For industry **8**
1.3. Operation modes **9**
1.3.1. Standard washing mode **9**
1.3.2. High temperature washing mode **10**
1.4. Operation **10**
1.4.1. Before switching on the machine **10**
1.4.2. Washing **11**
1.5. Servicing and maintenance **12**
1.6. Rinse aid and detergent **14**
1.6.1. Rinse aid **14**
1.6.2. Detergent **14**
1.7. About the topic **16**
1.7.1. Requirements: **16**
1.7.2. Product object **16**
1.7.3. Processing capacity **16**

CHAPTER 2: CALCULATION AND DESIGN OF MECHANICAL SYSTEM **17**

2.1. Given idea **17**
2.2. Group plan **17**
2.3. Principle of operation **18**
2.4. Machanical design **19**
2.4.1. Frame **19**
2.4.2. Lid **20**
2.4.3. Tank **21**
2.4.4. Boiler **22**
2.4.5. Filter **24**
2.4.6. Spray arm **25**

2.4.7. Hold handle 26
2.5. Main parts 27
2.5.1. Wash pump 27
2.5.2. Rinse pump 28
2.6. Assembly 29
CHAPTER 3: CALCULATION AND DESIGN OF CONTROL SYSTEM 31
3.1. Block diagram of the machine 31
3.2. Requirement water supply system 31
3.2.1. Requirements for the on-site inlet water connection 31
3.2.2. Requirements for the on-site water stop cock 32
3.2.3. Connecting the supply hose 32
3.3. Requirement in wash and rinse process 33
3.4. Control system components 33
3.4.1. Microcontroller 33
3.4.2. Circuit breaker 37
3.4.3. Relay Module 38
3.4.4. Emergency button 38
3.4.5. Contactor 39
3.4.6. Temperature safety 40
3.4.7. Heating element of boiler 42
3.4.8. Heating element of tank 42
3.4.9. Solenoid valve RPE 2 VIE 230V 50/60Hz 43
3.4.10. Temperature sensor DS18B20 44
3.4.11. Water level sensor float switch MH83C: 44
3.5. System control diagram 45
3.6. Expense calculation 46
3.7. Circuit design 46
3.8. Flowchart 49
CHAPTER 4: CONCLUSION 51
4.1. Results 51
4.2. Limitation 54
4.3. Direction of development 54
REFERENCES 55
APPENDIX 56

LIST OF TABLE

Table 1.1: Comparison table of dishwasher lines 6
Table 1.2: Required detergent and fresh water 15
Table 3.1: Require about water inlet 31
Table 3.2: Requirement in wash and rinse process 33

LIST OF FIGURE

Chapter 1:

Figure 1.1: The first dishwasher (Source: Internet) 1
Figure 1.2: Global commerical dishwasher market 2022-2026 (Source: Internet) 2
Figure 1.3: Winterhalter P50 (Source: Internet) 3
Figure 1.4: Dolphin DW-5000 (Source: Internet) 4
Figure 1.5: Hobart H600 (Source: Internet) 5
Figure 1.6: Benefit of dishwasher machine for family (Source: Internet) 7
Figure 1.7: Bosh dishwasher machine SMS4HAW48E (Source: Internet) 7
Figure 1.8: Benefit of dishwashers machine for industry (Source: Internet) 8
Figure 1.10: Important note before swiching on the machine (Source: Internet) 11
Figure 1.11: Setup process (Source: Internet) 12
Figure 1.12: Cleaning process (Source: Internet) 12
Figure 1.13: Rinse aid (Source: Internet) 14
Figure 1.14: Detergent (Source: Internet) 15
Figure 1.15: Dishes (Source: Internet) 16

Chapter 2:

Figure 2.1: Block diagram of the machine 17
Figure 2.2: Principle diagram (Source: Internet) 18
Figure 2.3: 2D frame of machine 19
Figure 2.4: 3D frame of machine 20
Figure 2.5: 3D lid of machine 20
Figure 2.6: 2D tank of machine 21
Figure 2.7: 3D tank of machine 21
Figure 2.9: 3D boiler of machine 23
Figure 2.10: 2D filter of machine 24
Figure 2.11: 3D filter of machine 24
Figure 2.12: 2D spray arm of machine 25
Figure 2.13: 2D spray arm of machine 25
Figure 2.14: 3D spray arm of machine 26
Figure 2.17: Wash pump FAGOR (Source: Internet) 28
Figure 2.18: Rinse pump (Source: Internet) 28
Figure 2.19: Image analysis of the details of the model 29
Figure 2.20: Pictures after being assembled (Close lid) 30
Figure 2.21: Pictures after being assembled (Open lid) 30

Chapter 3:

Figure 3.1: Cotrol system of the machine 31
Figure 3.2: Water stop cock (Source: Internet) 32
Figure 3.3: Supply hose (Source: Internet) 32
Figure 3.4: STM32F103C8T6 microcontroller (Source: Internet) 34
Figure 3.5: PLC S7-1200 CPU 1214C (Source: Internet) 35
Figure 3.6: MCCB(Source: Internet) 37
Figure 3.7: Insulated Case Circuit Breaker (Source: Internet) 37
Figure 3.8: Miniature circuit breakers (Source: Internet) 37
Figure 3.9: Relay module (Source: Internet) 38
Figure 3.10: Emergency button (Source: Internet) 39
Figure 3.11: Contactor 220V 63A (Source: Internet) 39
Figure 3.12: Contactor 220V 9A (Source: Internet) 40
Figure 3.13: Table select temperature safety follow power of load (Source: Internet) 41
Figure 3.14: Temperature safety (Source: Internet) 41
Figure 3.15: Boiler heating element (Source: Internet) 42
Figure 3.16: Heating element of tank (Source: Internet) 43
Figure 3.17: Solenoid valve RPE 2 VIE 230V 50/60Hz (Source: Internet) 43
Figure 3.18: Temperature sensor (Source: Internet) 44
Figure 3.19: Water level sensor float switch MH83C (Source: Internet) 44
Figure 3.20: System control diagram 45
Figure 3.21: Electric drawing 47
Figure 3.22: Control circuit 47
Figure 3.23: Main circuit 48
Figure 3.24: Flowchart of setup process 49
Figure 3.25: Washing flowchart 50

Chapter 4:

Figure 4.1: Image of Dishwasher machine in actual 51
Figure 4.2: Press Power button to turn on the machine 52
Figure 4.3: Wait LCD display Ready 52
Figure 4.4: Bring the dishes into the machine 52
Figure 4.6: Select modes 53
Figure 4.7: Press P to start washing 53
Figure 4.5: End program and bring dishes out the machine 53

INTRODUCTION

- **Survey and analysis**
  - "Dishwashers for small businesses" is an essential solution in the food and beverage business. In developed countries, dishwashers have become a common household appliance, in line with the trend of modernization of the country. Therefore, the author group brought up the topic "Design of dishwashers for small businesses".
- **Project's goals**
  - The machine works properly and is controlled microcontroller STM32F103C8T6 based on the process of testing many times to give the desired results.
  - Expected results: Dishwasher passes 3rd party test results.
- **Scope and subject of research**
  - The research goal of the author's group is to calculate, design the mechanical part and control the machine, to program the machine to operate the machine stably to meet the user's needs.
  - Research object: Dishwashers for small businesses.
  - Design research: Calculation and design of machine shell, mechanical components, main controller.
  - Fabrication: The prototype model will then be manufactured based on the calculations and design results.
- **Main contents**
  - Chapter 1: Overview
  - Chapter 2: Calculation and design of mechanical system
  - Chapter 3: Calculation and design of control system
  - Chapter 4: Conclusion

CHAPTER 1: OVERVIEW

1.1. Overview of dishwashers

1.1.1. Introduction about dishwasher machine

The first dishwasher was patented in 1850 by Joel Houghton in America. The operating mechanism of the machine at this time was still simple, this machine used the hand to turn a wheel, causing water to splash onto the dishes to wash (water pumps had not yet been invented at that time). In 1893 Josephine Cochrane, of Indiana, introduced a more successful dishwasher, and founded KitchenAid, a leading company in dishwashers and kitchen appliances.

These first dishwashers were not widely available because the price was too high and the washing time was too long. Dishwashers really took off in the 1950s, when Youngstown Kitchens commercialized dishwashers. By 1999, Bosch Group had developed the world's first fully automatic dishwasher, many features were added to the dishwasher and it was neatly placed under the kitchen like a cabinet.

Today's dishwashers are high-end products mainly imported from Europe. Dishwashers can wash a large number of bowls, cups, and plates in a short period of time with 1/3 less water than washing by hand and the dishes are still clean. In addition, the product is also designed in a luxurious style to make the kitchen space more modern and sophisticated.

A dishwasher can be understood simply as an intelligent and user-friendly robot. Just place dirty dishes and utensils into the machine, add detergent, set the program, and the dishwasher takes care of the rest.

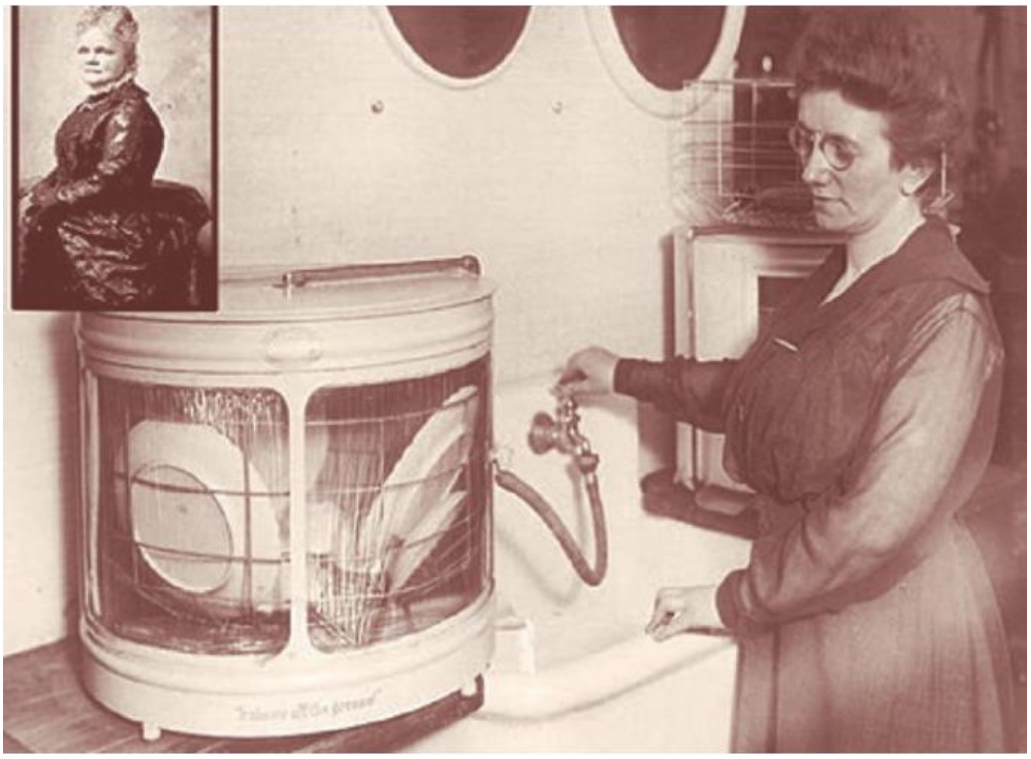

Figure 1.1: The first dishwasher (Source: Internet)

1.1.2. Domestic and international situation

At present, the use of dishwashers in Vietnam is becoming more common, especially in large cities and developed urban areas. Here are some notable points regarding the current situation of dishwashers for the people in Vietnam:

- Enhanced Convenience and Living Standards: With increased income and urban development, dishwashers are becoming a convenient household appliance, saving time and effort in daily chores.
- Lifestyle Shift and Cultural Awareness: There is a transition from manual dishwashing to using dishwashers due to changes in lifestyle and awareness of the convenience and efficiency they offer.
- Diverse Options: The market offers various types of dishwashers, ranging from well-known brands to mid-range and budget-friendly models, providing many choices for consumers.
- Technology Integration: Advanced dishwasher models feature smart functionalities and modern technology, attracting those who want to integrate technology into their daily lives.
- User Demographics: Dishwashers are commonly used in households with medium to high income, where convenience and time-saving are prioritized

For foreign markets: Dishwasher in European and American countries have become very popular. Due to the need to save time and ensure health for the whole family and space, it contributes as a beauty device to a comfortable, clean and beautiful home. Not only at home, dishwashers are also widely used in restaurants, resorts, hotels, event venues, etc. Because of their technical simplicity, fast dishwashing time and its convenience. The user will feel more comfortable when the dishes and utensils will be cleaned quickly, contributing to a well-organized event.

Figure 1.2: Global commerical dishwasher market 2022-2026 (Source: Internet)

1.1.3. Some popular dishwasher brands

1.1.3.1. Winterhalter

Winterhalter is a renowned manufacturer of dishwashing equipment and industrial dishwashers worldwide. Here are some characteristics of the Winterhalter dishwasher brand:

- Specialization in Industrial Dishwashing: Winterhalter focuses on providing professional solutions for dishwashing in industrial environments such as restaurants, hotels, industrial kitchens, and other foodservice establishments.
- High Technology and Performance: Winterhalter is known for integrating advanced technology into its products, ensuring high and reliable dishwashing performance.
- Save operating costs: Winterhalter dishwashers have an energy-saving design, consuming only 2.9 to 3.8 liters of water per wash cycle.
- Diverse Models and Product Lines: The brand offers a variety of choices with different models and product lines, catering to the diverse needs of businesses and organizations.
- Energy and Water Efficiency: Winterhalter often emphasizes the development of products that are energy and water-efficient, aiming to minimize negative environmental impact.
- Support Services: The brand provides customer support services, including maintenance, repairs, and user guidance, ensuring that their products operate efficiently.

Figure 1.3: Winterhalter P50 (Source: Internet)

1.1.3.2. Dolphin

Dolphin Co., Ltd. are a leading commercial Dishwasher manufacturer in Korea for 24 years since 1991.

They market share exceeds 40% over in Korea through 64 local sales agents and sales volume reaches ten thousand units annually.Here are some key points about Hobart dishwashers.

- Efficiency and Energy Saving: Dolphin dishwashers are well-known for their high performance and energy-saving capabilities. Their models are often designed to provide efficiency with low electricity and water consumption.
- Integrity and Durability: Dolphin emphasizes product quality and durability. Their dishwashers are usually constructed with high-quality materials to ensure robustness and stability.
- Special Features and Advanced Utilities: Dolphin frequently incorporates various features and advanced technologies into their dishwashers. This includes special wash programs, the ability to automatically adjust water flow, and smart features such as Wi-Fi connectivity.
- Silent Operation: Dolphin is recognized for producing some of the quietest dishwasher models on the market, making them a popular choice for those living in noise-sensitive environments.
- Positive Consumer Reviews: Dolphin often receives positive reviews from users, being regarded as a reliable brand that delivers high satisfaction.

Figure 1.4: Dolphin DW-5000 (Source: Internet)

1.1.3.3. Hobart

Hobart is one of the leading brands in the production of dishwashing equipment and industrial kitchen appliances. Here are some key points about Hobart dishwashers:

- High Quality: Hobart is renowned for the high quality of its products. Hobart dishwashers are designed and manufactured to high standards to ensure reliable performance in industrial environments.
- Variety of Models and Features: Hobart offers a range of dishwasher models to meet the diverse needs of businesses. Features include special wash programs, water and energy-saving capabilities, as well as smart features like touchscreens and Internet of Things (IoT) connectivity.
- High Performance and Energy Efficiency: Hobart consistently focuses on improving the performance of its dishwashers while emphasizing reduced water and energy consumption to help businesses save operating costs.
- Size and Capacity Diversity: The brand provides dishwashers ranging from small models suitable for small eateries to large-capacity machines catering to large restaurants and hotels.
- Automation and User-Friendly: Hobart dishwashers are often designed for convenient use, with many automated features to reduce manual work and ensure an efficient dishwashing process.

Figure 1.5: Hobart H600 (Source: Internet)

Table 1.1: Comparison table of dishwasher lines

Brand / Specifications	Hobart H600	Winterhalter P50	Dolphin DW-5000
Water consumption /cycles (L)	3	2.4	2.8
Power (rack/h)	50~60	60	60
Price (VND)	65.000.000	85.000.000	50.000.000
Dimension (mm)	636×748×1445	630×720×1460	690×745×1455
Washing temperature (℃)	60	65 - 70	60 - 65
Advantage	- High quality - User-Friendly - Cheap price - Internet connectivity - Intuitive touch screen	- High performance - Save energy - Save water - Easy to use - Good warranty - Friendly environment	- High performance - User-Friendly - Cheap price - easy to order
Disadvantage	- High price - Low warranty period	- High price - Long delivery time - Complicated purchasing procedures	- Low warranty period - No internet connect - Unstable
Suitable for	- Mid-range restaurant - Hotel - Pub…	- Large retaurant - Company - Bar…	- Small hotel - Restaurant - Cafe…

1.2. The practical needs of dishwashers

1.2.1. For family

A dishwasher meets several important practical needs for a family, including:

- Time Saving: Dishwashers significantly reduce the time and effort families spend on handwashing dishes, freeing up time for other activities.
- Hygienic Maintenance: Dishwashers effectively clean plates, utensils, and dishes, helping to maintain a clean and safe kitchen environment for the family.
- Convenience in Busy Lifestyles: In today's fast-paced society where the demand for convenience is high, a dishwasher becomes an indispensable appliance, helping families cope with the daily workload.
- Water and Energy Efficiency: Many modern dishwashers are designed to save water and energy, helping families reduce costs and positively impact the environment.
- Variety and Flexibility: There are various dishwasher models and designs on the market, ranging from compact units suitable for small kitchens to large-capacity machines suitable for larger families.

Figure 1.6: Benefit of dishwasher machine for family (Source: Internet)

- **Product suggestions:**

Figure 1.7: Bosh dishwasher machine SMS4HAW48E (Source: Internet)

❖ **Specification:**

- Model: SMS4HAW48E
- Branch: Bosch
- Serie: 4
- Product size (H × W × D): 845×600×600 mm
- Production site: Germany
- Warranty: 36 month
- Water consumption: 9,5 liters
- Energy efficiency class
- Washing time: 195 min
- Prices: 990 $

1.2.2. For industry

Dishwashers play a crucial role in meeting practical needs within the industrial context, including:

- Efficiency and Productivity: Industrial dishwashers are designed to handle large volumes of dishes efficiently, contributing to increased productivity in commercial kitchens and foodservice establishments.
- Hygiene and Food Safety: Ensuring proper cleaning and sanitization of dishes is paramount in the food industry. Industrial dishwashers meet strict hygiene standards, helping to maintain food safety and regulatory compliance.
- Labor Savings: By automating the dishwashing process, industrial dishwashers reduce the need for manual labor, allowing staff to focus on other critical tasks in a busy commercial kitchen.
- Consistent Cleaning Standards: Industrial dishwashers deliver consistent and reliable cleaning results, ensuring that dishes, utensils, and cookware meet high cleanliness standards in every cycle.
- Energy and Resource Efficiency: Many industrial dishwashers are designed to be energy-efficient and water-saving, contributing to cost savings and aligning with sustainability goals.
- Durability and Reliability: Given the demanding nature of industrial settings, dishwashers for the industry are built to be durable and reliable, withstanding the rigors of frequent use.
- Customization and Adaptability: Industrial dishwashers often offer customization options to adapt to specific needs and requirements of different establishments, whether it be a large restaurant, hotel, or catering service.

Figure 1.8: Benefit of dishwashers machine for industry (Source: Internet)

➢ **Product suggestion:**

Figure 1.9: Winterhalter p50 (Source: Internet)

❖ **Specification:**

- Model: P50
- Branch: Winterhalter
- Product size (W × D): 630 × 720 mm
- Height when closing (opening) the lid: 1,460 (1,890)mm
- Warranty: 36 month
- Number of programmes: 2
- Washing time of Standard / HighTemp mode: 60 / 180s
- Rinse water volume per wash cycle Standard / HighTemp: 2,4 / 3,8 liters
- Theoretical capacity standard / HighTemp: 60 / 20 rack/h
- Energy efficiency class
- Friendly environment
- Prices: 3.460 $

1.3. Operation modes

Controls and types of washing cycles are additional features to increase the value of a dishwasher. Industrial dishwashers usually have 2 basic washing modes, depending on the purpose of use.

1.3.1. Standard washing mode

The normal washing mode is suitable for dishes with normal stains, not too stubborn or sticky. The normal washing mode has the following characteristics:

- Washing time: 1 minute. This is enough time for the detergent to clean the dishes, but not too long to save energy and time.
- Water consumption: 2.4 liters/cycle. This is the optimal amount of water consumed for one wash, ensuring cleanliness and saving water. Compared to the thorough wash mode, the normal wash mode saves 1.4 liters of water per wash.
- Washing water temperature: 70 ℃. This is the standard washing water temperature for both normal and thorough washing modes. This temperature helps increase the effectiveness of cleaning and disinfecting dishes, removing hard-to-remove dirt.
- Rinsing water temperature: 85℃ This is the standard rinsing water temperature for the rinsing process. This temperature helps increase the efficiency of cleaning and disinfecting dishes.

1.3.2. High temperature washing mode

The high temperature wash mode is a mode used for dishes with difficult-to-remove stains, requiring higher temperatures and longer time than the normal wash mode. The thorough washing mode has the following characteristics:

- Washing time: 3 minutes. This is three times longer than normal washing mode, to ensure that stubborn stains such as grease, coffee, tea, milk, eggs, meat... will be completely removed from dishes. Longer washing time also helps enhance the ability to disinfect and kill bacteria on the surface of dishes.
- Water consumption: 3.8 liters/cycle. This is a higher amount of water consumption than normal washing mode, so you need to consider when using thorough washing mode. Higher water consumption helps increase wash water pressure, cleaning difficult-to-remove stains deeper and faster. However, higher water consumption can also waste water and energy, so you should only use the deep rinse mode when absolutely necessary.
- Sink temperature: 75℃ this is a temperature 5℃ higher than the normal washing mode, to increase the effectiveness of cleaning and disinfecting dishes. Higher temperatures help melt stubborn stains and kill bacteria and mold that can be harmful to your health. However, higher temperatures can also damage some heat-sensitive dishes, such as plastic, ceramic, glass... so you should carefully check the material of the dishes before using the mode. wash thoroughly.
- Rinsing water temperature: 80℃ this is the standard rinsing water temperature for the rinsing process. This temperature helps increase the efficiency of cleaning and disinfecting dishes.

1.4. Operation

1.4.1. Before switching on the machine

Recommend: You should follow the below cautions and note for the machine working most stably. Otherwise, the machine's life will decrease faster.

Caution:

- Consider Dish Types: Avoid placing unsafe or easily breakable items in the dishwasher.
- Loading: Arrange dishes evenly in the machine, avoiding overcrowding or excessive covering, to ensure even distribution of water and detergent.
- The pump inlet filter protects the circulating pump. Operate the machine only with the pump inlet filter fitted.
- Water Supply: Ensure an adequate and unobstructed water supply. Inspect water hoses and valves to prevent leaks.
- Select the Right Program: Use the appropriate wash program based on the type of dishes and the level of dirt to save energy and water.

Note:

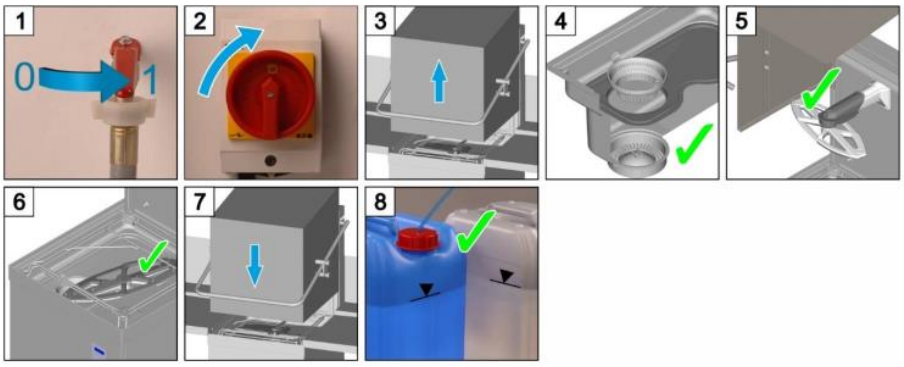

Figure 1.10: Important note before swiching on the machine (Source: Internet)

1. Turn off water stop cock
2. Disconnect the power source
3. Pull up the lid of the machine
4. Check water filter
5. Check the upper spray arms
6. Check the lower spray arms
7. Pull down the lid of the machine
8. Chek detergent and rinse aid

1.4.2. Washing

1.4.2.1. Preparing the dishes for washing

Prepare dishes for washing included:

- Pre-rinse all dishes and pans with cold water.
- Remove food residues and pour out drink residue.
- Soak dried residues.
- Soak cutlery till it is rinsed.
- Light plastic parts may slip or turn when washing. Ensure such parts are weighted down.

1.4.2.2. Washing process

Recommend: You should follow the setup process below for the machine working most stably.Otherwise, the machine's life will decrease faster.

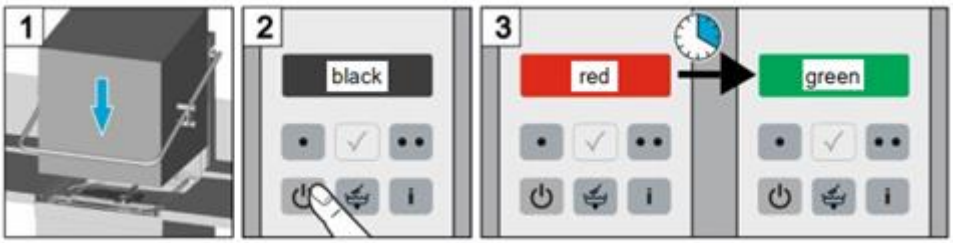

Figure 1.11: Setup process (Source: Internet)

1. Pull down the lid of the machine
2. Select **Mode** and press **Power** button
3. Wait until the LCD display **"Complete"**

1.4.2.3. Switching off

Switch the machine off at the end of the working day using the self-cleaning programme so that it is cleaned and emptied every day.

If you use the On/Off switch, the tank stays filled but will no longer be kept at temperature. If the tank temperature has dropped too much before the machine is switched on again, the tank will be emptied automatically and filled again.

1.5. Servicing and maintenance

Figure 1.12: Cleaning process (Source: Internet)

We recommend that you clean the machine daily to ensure optimum cleaning results

Self-cleaning programme at the end of the working day:

- The machine is equipped with a self-cleaning programme that assists you in cleaning the interior of the machine.

During operation: Remove the filter basket, clean if necessary and re-insert it.

Manual cleaning of the machine interior

- Ensure that there are no rusty foreign objects in the machine which can cause even "rust-free stainless steel" material to start rusting. Rust particles can come from non-rust-free cleaners, damaged wire racks or non-rust-protected water lines.
- The following materials must not be used for cleaning:
  - High-pressure cleaner.
  - Detergents containing chlorine or acid.
  - Cleaning sponge or wire brush containing metal.
  - Abrasives or abrasive cleaners.

➢ Remove dirt with a brush or a cloth.

Cleaning the exterior of the machine

- Clean the operating panel with a damp cloth.
- Clean the external surfaces using a stainless steel cleaner and stainless steel polish.
- Leave the hood open so that the interior can dry. This is important for long-term corrosion protection even in case of stainless steel.

1.6. Rinse aid and detergent

1.6.1. Rinse aid

A rinse aid is necessary to ensure that water on the dishes drains off after washing and dries off after a short while. Rinse aids are automatically supplied from a storage container outside the machine into the boiler of the machine. The rinse aid dosing device is either an in-built or external component of the machine. The authorised service technician sets the dosing amount when commissioning the machine.

Figure 1.13: Rinse aid (Source: Internet)

Information products:

- Price: About 63,1€ /10 L – 10,2 Kg.
- Brand: Winterhalter.
- Product benefits:
  - Universal high concentrate.
  - Excellent wetting of the dishes.
  - Very good water drainage.
  - Spot-free drying.
  - Gorgeous shine.
  - Good beer foam stability.

1.6.2. Detergent

A detergent is necessary to ensure that the leftovers and dirt on the dishes is cleaned. Detergents can be supplied as follows:

- Manually as detergent powder.
- Automatically from an external container using a built-in or an external detergent dosing device.

Manual dosing of detergent powder:

- Pre-dosing
  - Switch on the machine and wait until the display is lit green.

- Adhere to the dosing instructions on the packaging of the detergent. The machine's tank capacity is approx. 28 litres.
- Place approx. 90 g of detergent powder in the machine. This corresponds to a dosing of approx. 3 g/l.
- Then start the wash cycle immediately to mix the detergent powder with the water.

- Post-dosing
  - At each wash cycle fresh water enters the dishwasher. This water must be mixed with detergent powder as follows.

Table 1.2: Required detergent and fresh water

	Fresh water per wash cycle	Required detergent powder after 5 wash cycles
Standard	2.6 l	40g
HighTemp	3.8 l	60g

Figure 1.14: Detergent (Source: Internet)

Information products:

- Price: About 87€/9,1 L – 12 Kg
- Brand: Winterhalter.
- Product benefits:
  - Odour-neutral high concentrate.
  - Good cleaning.
  - Ensures beer foam stability.
  - Prevents odor formation in glasses particularly well.

1.7. About the topic

Factories are progressively investing in development teams that may help enhance production, thereby improving productivity, profitability, and reducing human labor in this age where everything is driven by the advancement of science and technology. To address these issues, automatic robots have now been created.

About the topic, put a certain amount of pre-washed dishes in the machine. With the aid of the gadget, the dirt and bacteria of dishes will be completely cleaned.

1.7.1. Requirements:

- The machine is capable of operating continuously throughout the day.
- The dishes don't need to be arranged before washing.
- The machine must be reduce time and human labor compared to traditional dishwashing.
- Must be saving power, water consumption and environmental friendly divices.
- The machine can be disassembled for easy cleaning.

1.7.2. Product object

Figure 1.15: Dishes (Source: Internet)

- Name: Dishes, as shown in Figure 1.15.
- Materials: Not plastic.
- Rack size: 500×500 mm.

1.7.3. Processing capacity

- Rack: 20 plate / 10 bowl / 15 glasses.
- Capacity of Standard / HighTemp program: 40 / 15 rack/h.
- Target of Standard / HighTemp program: 60 / 20 rack/h.

CHAPTER 2: CALCULATION AND DESIGN OF MECHANICAL SYSTEM

2.1. Given idea

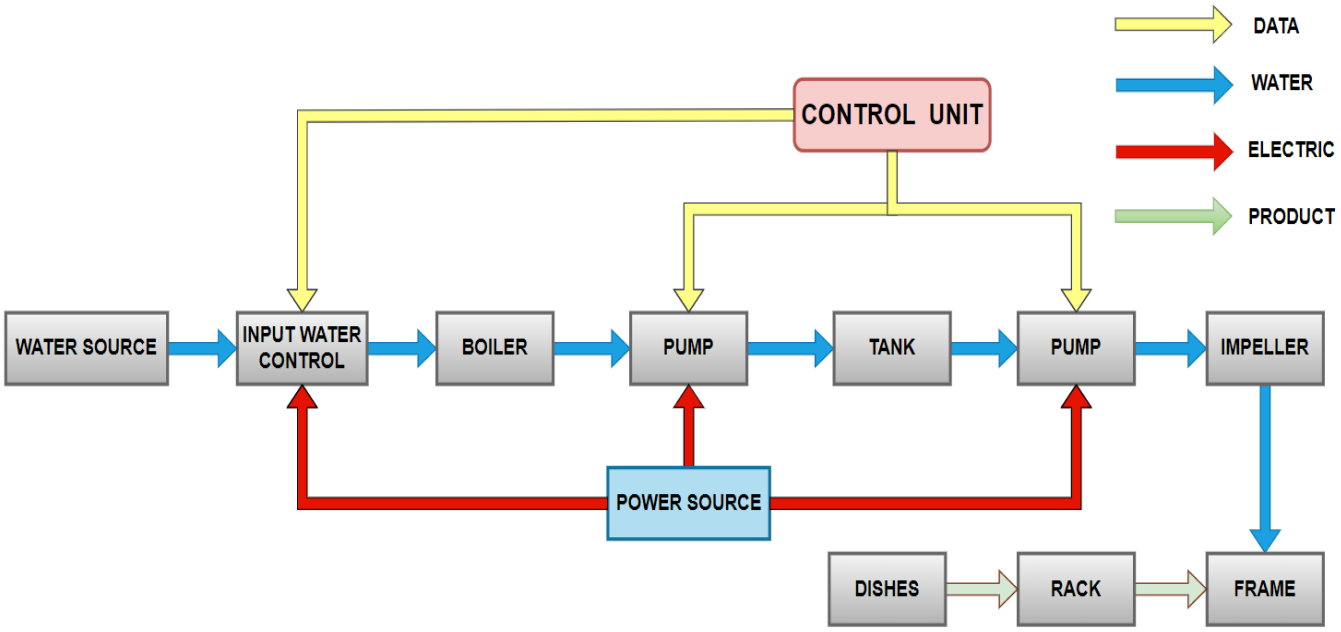

Figure 2.1: Block diagram of the machine

In this option, the machine wil have 2 main part including:

- Mechanical part: Frame, rack, impeller, boiler, tank, pump…
- Control part: Microcontroller, relay, sensor, button, input water control…

Water will be fed into the machine through the input water control, then pumped into the machine through the pump controlled by the controller. Then, the water will pump to the impeller in the machine frame where the dishes are washed.

2.2. Group plan

After consulting many dishwashers with the same purpose and capacity and discussing with Tan Long company, the group decided to choose the above option to build a dishwasher according to the company's model and improve some components to match with the above idea. The external part will be designed by the team and the internal parts including boiler, pump, contactor, solenoid valve, heating element, etc. will be supported by the company. The remaining parts such as temperature safety, LED lights, buttons, sensors, contactors, electrical circuits... the team will carefully consider to choose in accordance with the company's requirements.

2.3. Principle of operation

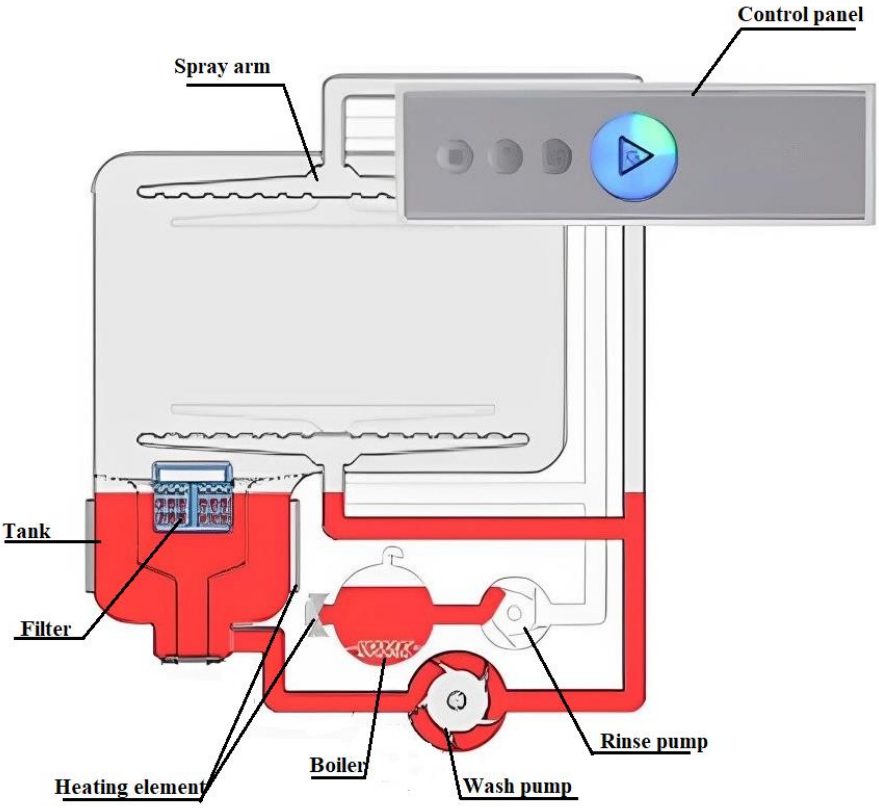

Figure 2.2: Principle diagram (Source: Internet)

Step 1: When the machine is operated → The solenoid valve is controlled by microcontroller through returned signal of water level sensor to bring the water in boiler.

Step 2: When the water in boiler full → The microcontroller will control relay to turn off valve inlet and turn on heating element of boiler, temperature sensor. Once temperature of boiler reaches 70°C then heating element of boiler will turn off and turn on pump rinse to bring the hot water to tank right now the microcontroller will controll external dosing deviece to bring certain amount of detergent in tank. Once the water of tank full, the microcontroller will turn off pump rinse and check continuously temperature of tank and boiler. If temperature of tank smaller than 60°C or temperature of boiler bigger than 80°C then microcontroller will turn on heating element.

Step 3: Once reach the setting temperature then microcontroller will announce to users through lcd and buzzer.

Step 4: When users place dirty dishes in the machine, close door and select programs then the machine will start working.

Step 5: The microcontroller will turn on pump wash to bring hot water combined with detergent to remove dirt of dishes. This process will work in 40s (mode standard) or 120s (mode high temp) then turn of pump wash and delay 5s (mode standard) or 10s (mode high temp) to remove remaining detergent then turn on pump rinse right now the microcontroller will control external dosing devices to bring rinse aid combined with the hot water to rinse

and drying dishes. This process will work in 15s (mode standard) and 50s (mode high temp). End cycle of wash the microcontroller will return step 1.

2.4. Machanical design

After agreeing with the company, the design of the machine will be based on the sample product provided by the company and upgrade and edit some inappropriate details. The main material of the frame is stainless steel. Color of the machine is silver white.

2.4.1. Frame

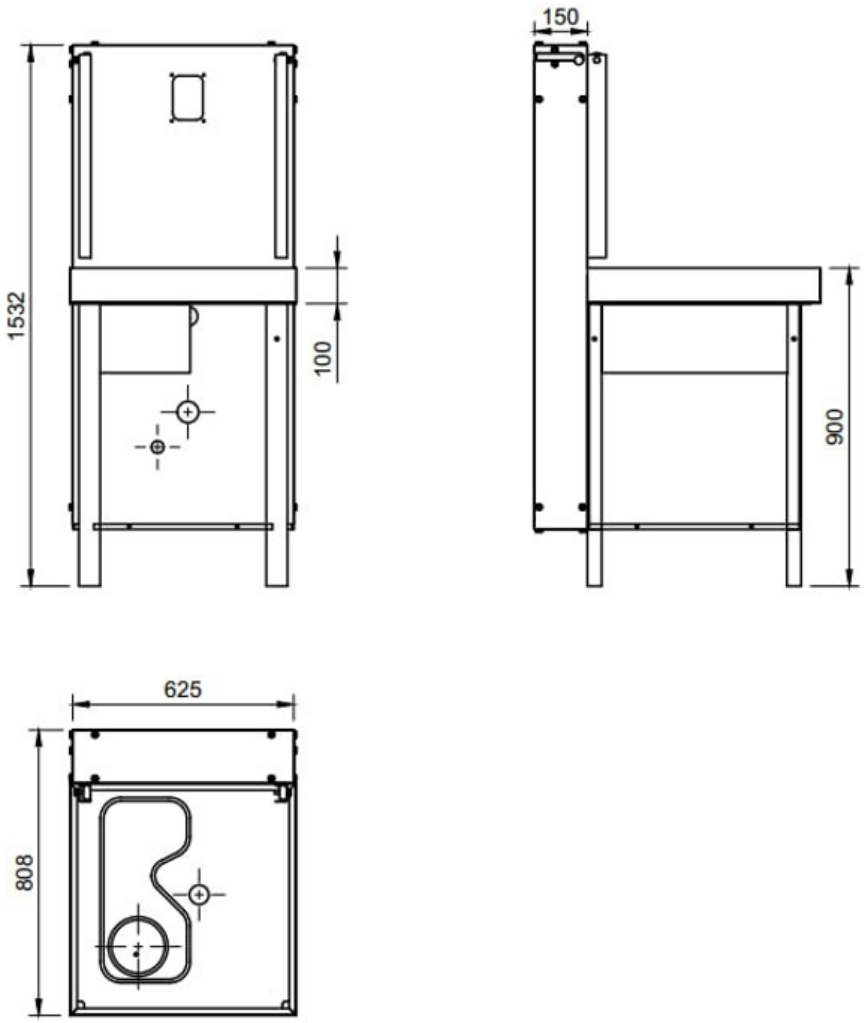

Figure 2.3: 2D frame of machine

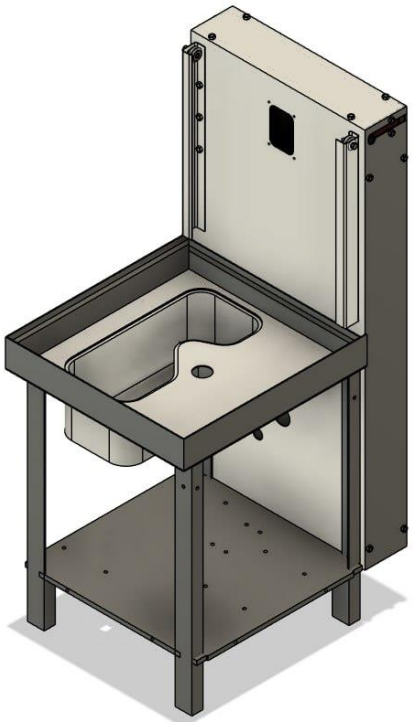

Figure 2.4: 3D frame of machine

- Requirement of company: One cycles can wash 20 plate/10 bowl/15 glasses
- After researching the market, the group chose a rack with dimensions: 500×500 mm, capacity of 20 plates/10 bowls/15 cups and after assembling the components into the machine, the group calculated the size (H×W×D) is 1532×625×808mm.
- Dimensions are optimized to provide enough space and save costs to suit small businesses.
- Material: 2mm thick stainless stell, silver white color. The frame holds all the parts of the machine. Therefore, it needs 2mm thickness to hold everything without shaking.

2.4.2. Lid

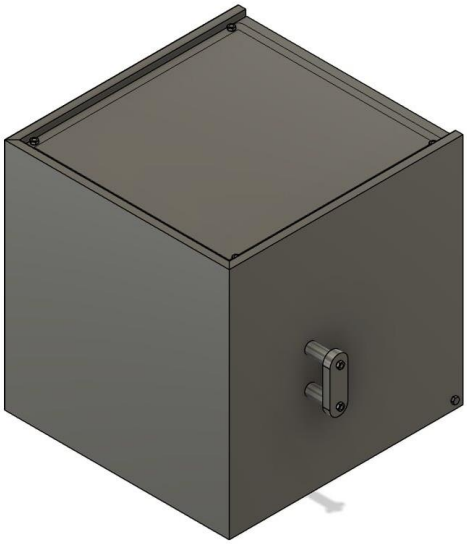

Figure 2.5: 3D lid of machine

- The lid of machine is used as a signal to start or end the program, preventing insects flying inside the machine, protecting users by hot water in washing process
- Dimension (H ×W ×D): 650×625×650 mm.
- Material: Inox.

2.4.3. Tank

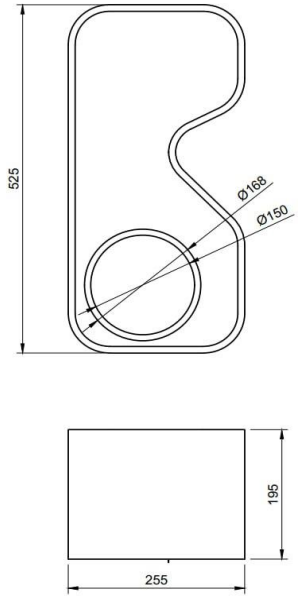

Figure 2.6: 2D tank of machine

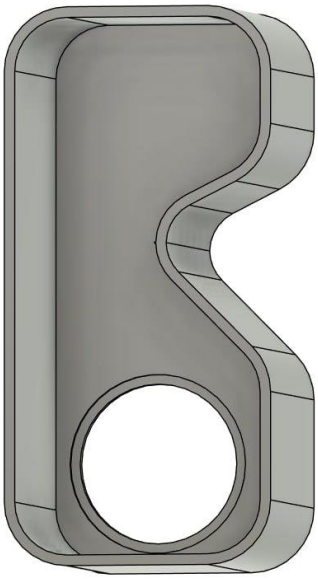

Figure 2.7: 3D tank of machine

- Tank of the machine is used to contains the water of washing process
- Following the requirement of company is: In one cycle of the system, the machine need to washing 20 plate / 10 bowl / 15 glasses.
- Many tests have proven that the same amount of dishes for a regular meal with different dirt such as oil and grease, if washed by hand, would require about 20 liters of water to be completely cleaned. . However, with different types of dishwashers

such as Bosch, Siemens dishwashers... They prove to be much more economical by only using about 5 to 12 liters of water but washing time of dishwasher for famiy at least about 20 min.

- However, for hotels, restaurants small business. They have to serve hundreds of customers every day, so washing time of at least 20 minutes and water consumption of 5 - 12 liters at a time of a family dishwasher is not feasible.
- Realizing that, the group researched and came up with a solution to reduce the time and water consumption.

➢ After consulting with the company, the design of the tank will be based on the sample product provided by the company and has the following parameters:

- Water capacity: 28 liters.
- Water consumption on 1 cylces: 3 liters.
- Dimension (H×W×D): 195×255×525 mm.
- Material: Inox.

2.4.4. Boiler

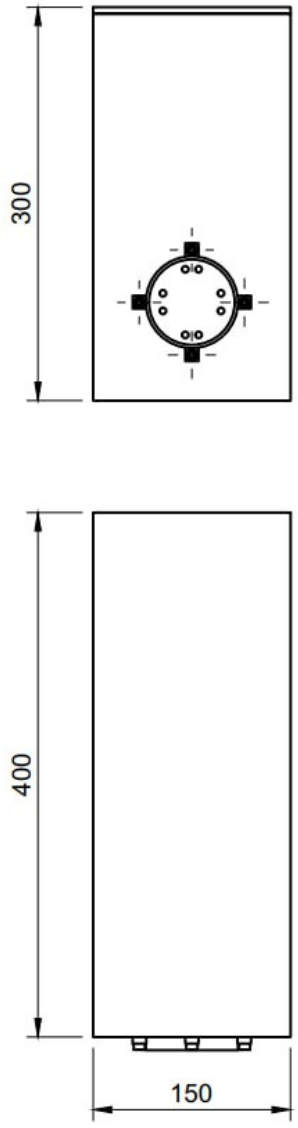

Figure 2.8: 2D boiler of machine

Figure 2.9: 3D boiler of machine

- Boiler of the machine is used to contains the water of rinsing process and where to heating water for washing and rinsing process.
- According to the documents received from the guide company, the selection of boilers for dishwashers must follow the following procedures:
    - Determine the operating power of the machine.
    - Determine the volume of water in the boiler. This volume is the amount of water needed to heat the water leading through to wash.
    - Determine the heating capacity of the combustion resistance to choose accordingly.

  ➢ After consulting many dishwashers with the same purpose and capacity and discussing with Tan Long company, the group chose:
- Boiler capacity: 8 liters.
- Dimension (H ×W ×D): 295×150×400 mm.
- Material: Steel.

2.4.5. Filter

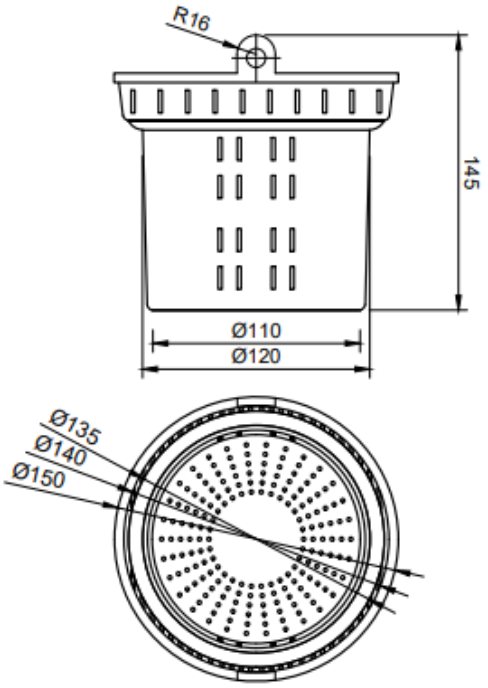

Figure 2.10: 2D filter of machine

Figure 2.11: 3D filter of machine

- Its function is to filter residual dirt during the washing process and prevent dirt from entering the engine.
- Material: Plastic.

2.4.6. Spray arm

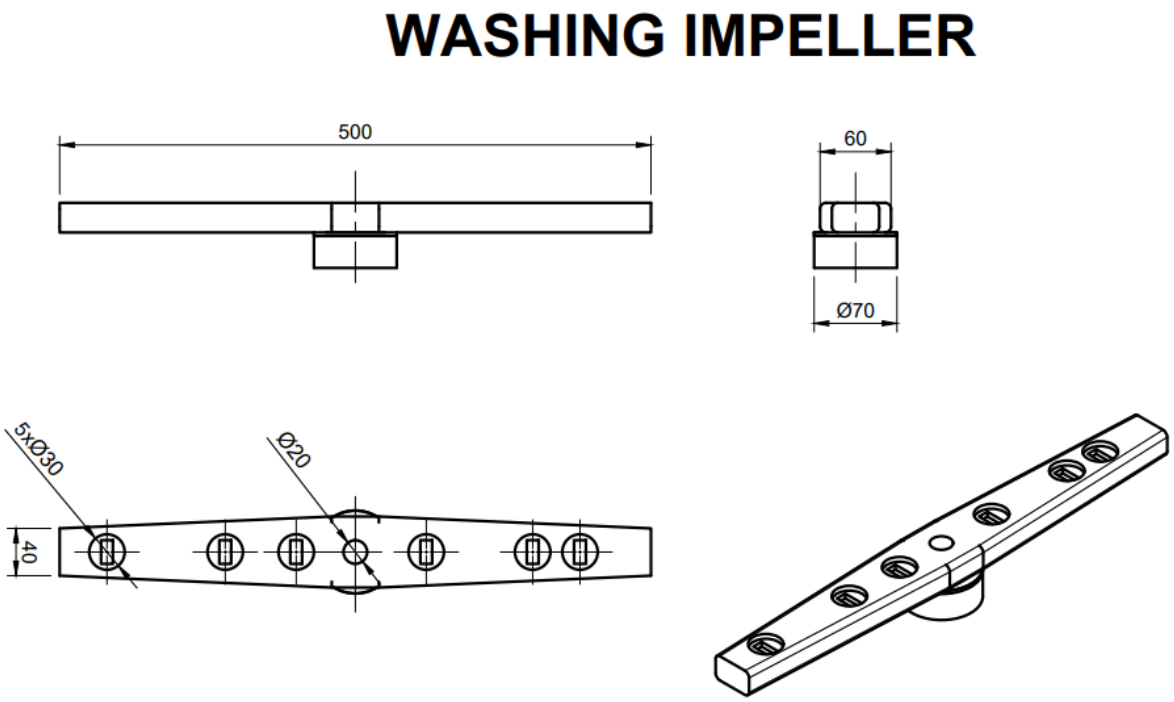

Figure 2.12: 2D spray arm of machine

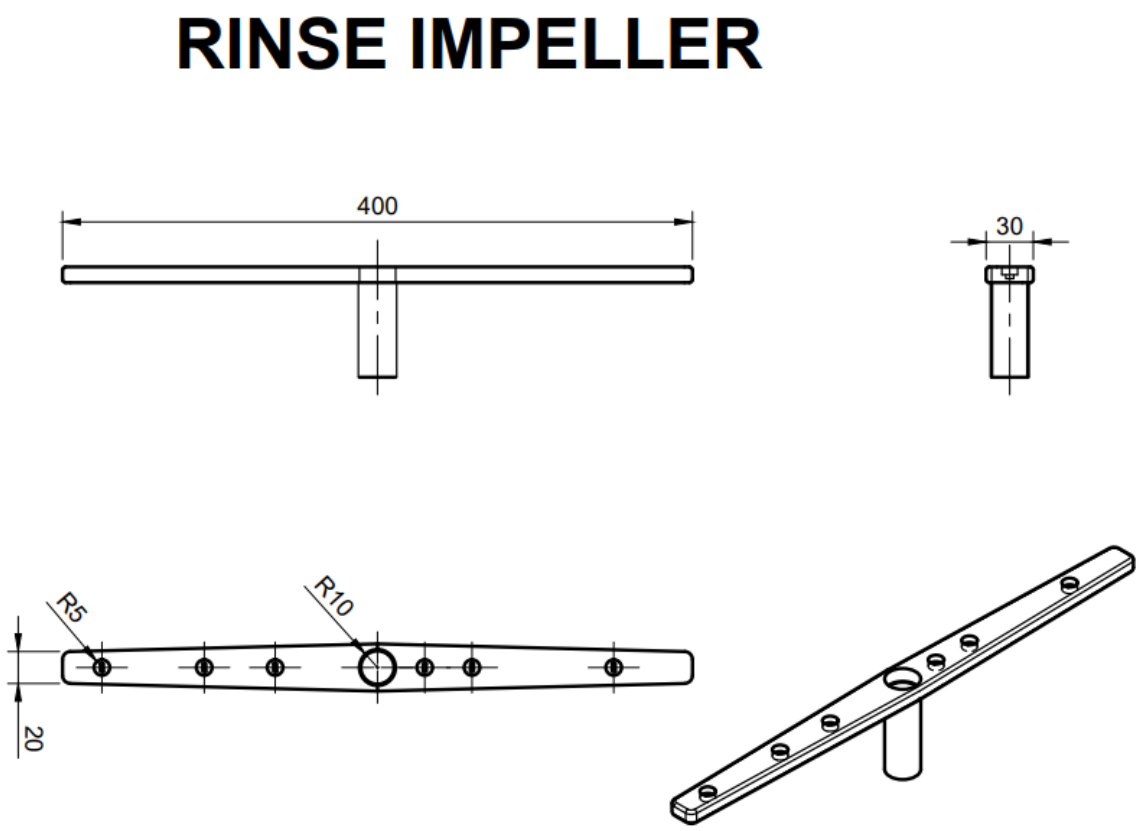

Figure 2.13: 2D spray arm of machine

Figure 2.14: 3D spray arm of machine

- Its function is to bring the water from tank and boiler to everywhere inside the sink to remove dirt.
- The spray arm operates based on the pressure difference at the nozzles. Because these nozzles are arranged at an offset, when water pressure passes through, it will create a difference and cause it to rotate.
- Material: Plastic.

2.4.7. Hold handle

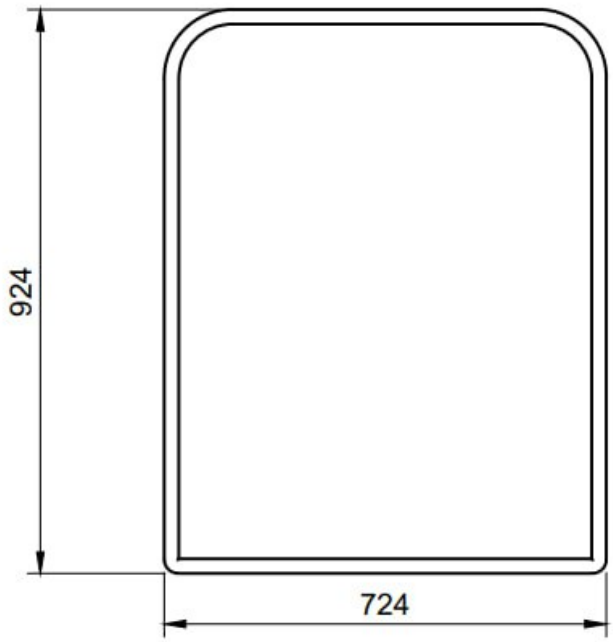

Figure 2.15: 2D hold handle of machine

Figure 2.16: 3D hold handle of machine

- Hold handle is designed to open and close the dishwasher lid. Additional, it is designed to withstand the forces involved in opening and closing the door reliably without causing damage or wear.
- Dimension (W×D): 724×924 mm.
- Material: Inox.

2.5. Main parts

2.5.1. Wash pump

- When selecting a water pump for a dishwashing machine, it must meet certain criteria to ensure stability during operation, effective cleaning of utensils, and cost efficiency in terms of water and energy consumption.
- To calculate the selected power of a water pump, the following formula can be uesd for calculation: Pp = P/ Efficiency of the motor (Usually, choose efficiency of the motor = 0,43) and P is calculated:

$$P = \frac{S \times v \times H \times D}{102 \times N}$$

- P: Power of the pump (kW),
- Q: Flow rate (m^3/s),
- H: Head (height) of the water column being pumped (m),
- D: Density of water (1000kg/ m^3),
- N: Efficiency of the pump (0,8 – 0,9).
- S: the cross-sectional area of the pipe (m^2),
- v: the velocity of the water (m/s), v = 0,15-1,52(m/s).

Choose v = 1 (m/s):

$$Q = S \times v = \pi \times 0.025^2 \times 1 = 0{,}002\ (m^3/s)$$

$$\Rightarrow \quad P = \frac{Q \times H \times D}{102 \times N} = \frac{0{,}002 \times 10 \times 1000}{102 \times 0{,}8} = 0{,}245\ (kW)$$

$$\Rightarrow \quad Pp = \frac{0{,}245}{0{,}43} = 0{,}569\ (kW)$$

With $Pp = 0{,}569$ (kW), the group chose circulating pump has power $Pp = 0{,}59$ (kW)

➢ **Wash pump FAGOR 220-240V 60Hz 590 W**

Figure 2.17: Wash pump FAGOR (Source: Internet)

❖ **Specifications:**

- Voltage: 220-240 VAC
- Frequency: 60 Hz.
- Power: 0.59 kW.
- Inlet Diameter(Ø): 38 mm.
- Outlet Diameter(Ø): 39 mm.
- Motor Capacitor: 10 µF.
- Rate of flow :38 l / min.
- Max temperature: 90°C.

2.5.2. Rinse pump

Similar to circulating pump, we have:

Choose v = 1,5 (m/s):

$$Q = S \times v = \pi \times 0{,}0125^2 \times 1{,}5 = 0{,}0008\ (m^3/s)$$

$$\Rightarrow P = \frac{Q \times H \times D}{102 \times N} = \frac{0{,}0008 \times 10 \times 1000}{102 \times 0{,}8} = 0{,}098\ (kW)$$

$$\Rightarrow Pp = \frac{0{,}098}{0{,}43} = 0{,}228(kW)$$

With $Pp = 0{,}228(kW)$, we chose rinse pump has power $Pp = 0{,}27(kW)$

➢ **RINSE BOOSTER PUMP 220-240V 50Hz 0.27Kw**

Figure 2.18: Rinse pump (Source: Internet)

❖ **Specifications:**

- Inlet Diameter: 28mm.
- Outlet Diameter: 26mm.
- Type: UP60-184.
- Voltage: 230 VAC.
- Frequency: 50Hz.
- Phases: 1 Phase.
- Power: 0.27kW.
- Length: 190mm.
- Rotation Direction: Left.
- Capacitor: 5µF.
- Producer: HANNING.
- Max Pressure: 0.77 bar.
- Max temperature: 100°C.

2.6. Assembly

After completing the parts of the machine, we proceed to assemble according to the previously designed drawings.

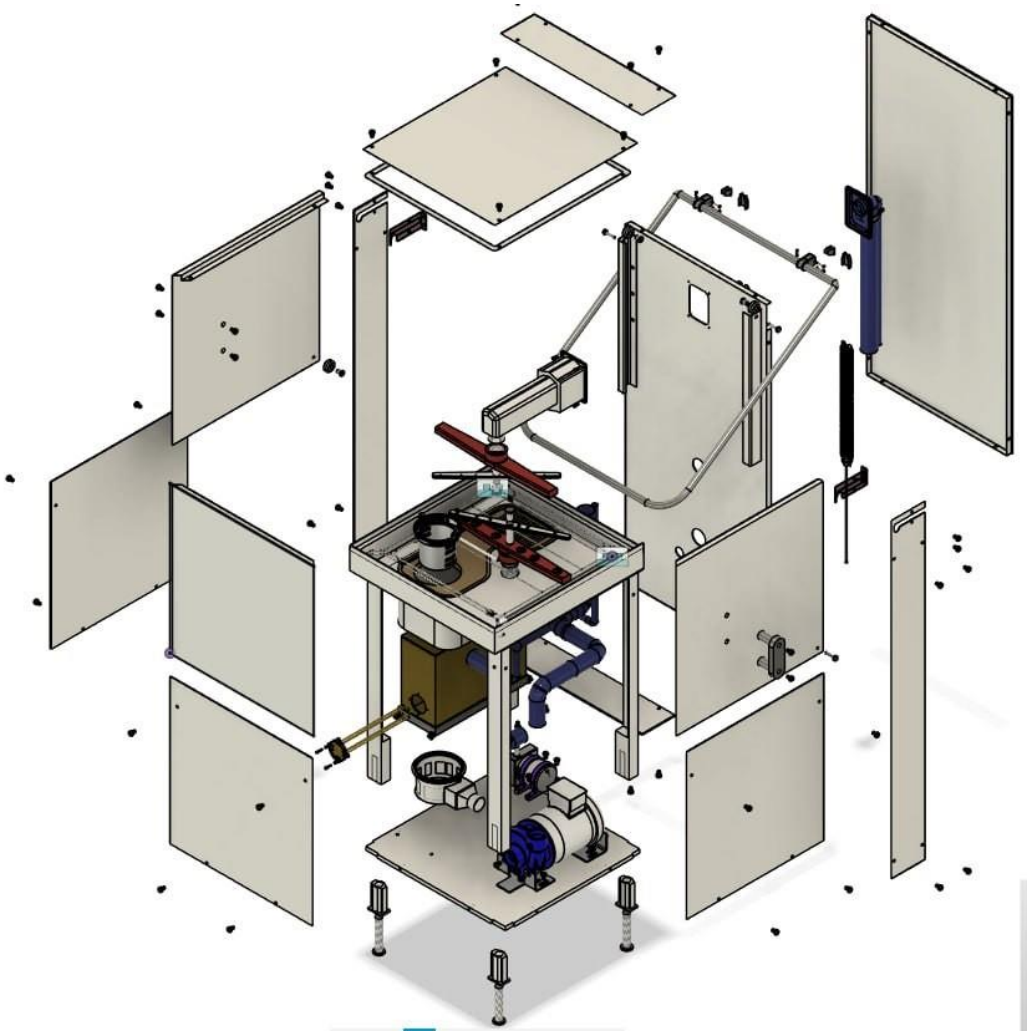

Figure 2.19: Image analysis of the details of the model

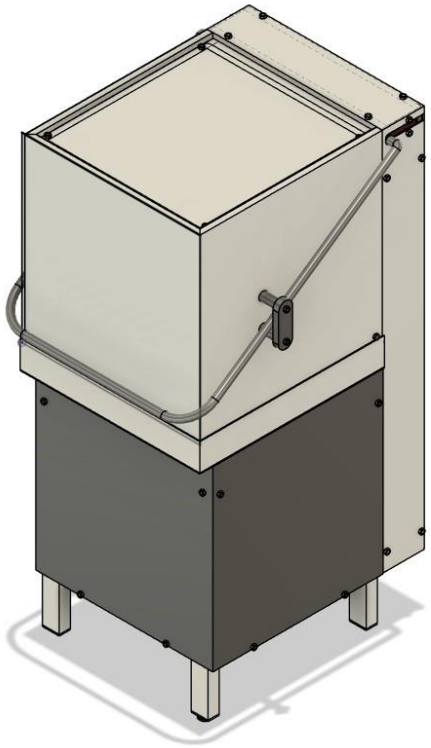

Figure 2.20: Pictures after being assembled (Close lid)

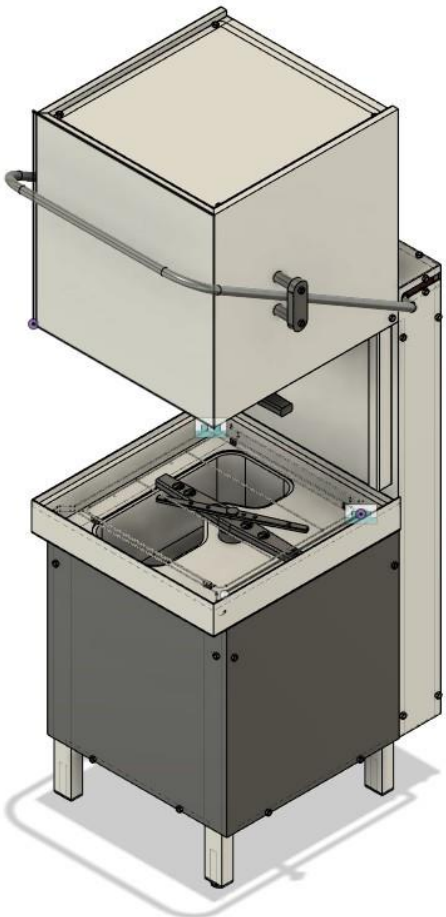

Figure 2.21: Pictures after being assembled (Open lid)

CHAPTER 3: CALCULATION AND DESIGN OF CONTROL SYSTEM

3.1. Block diagram of the machine

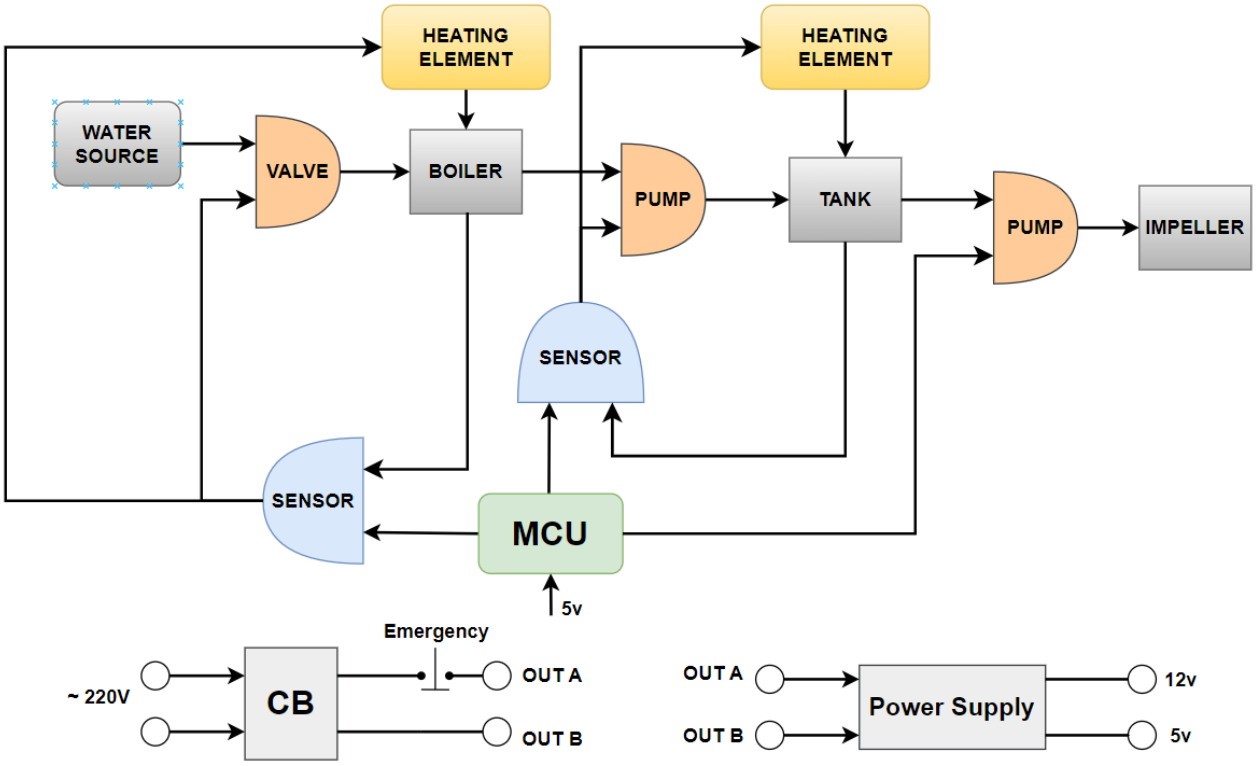

Figure 3.1: Cotrol system of the machine

This image describe control system of the machine. The current supplied from the AC 220V source goes through the circuit breaker, continues through the the emergency button then one part goes to NO of relay to control devieces such as: Valve, heating element, pump,… and one part goes to Power circuit to create 5VDC to control MCU, sensor, lcd, button… and 12VDC to turn on, off relay.

3.2. Requirement water supply system

3.2.1. Requirements for the on-site inlet water connection

Table 3.1: Require about water inlet

Water quality	The inlet water must in microbiological aspects have the quality of drinking water
Water inlet temperature	max 60 °C
Minimum flow pressure	100 kPa (1.0 bar)
Maximum inlet pressure	1000 kPa (10.0 bar)
Rate of flow	at least 4 l/min

3.2.2. Requirements for the on-site water stop cock

- Easily accessible.
- Not behind the machine.
- 3/4" connector.

Figure 3.1: Water stop cock (Source: Internet)

3.2.3. Connecting the supply hose

❖ Note:

- The hose may not be shortened or damaged.
- Old existing hoses may not be re-used.
- Do not bend the hose when laying it.
- The supply hose and dirt trap (special equipment) are located in the machine.
- The dirt trap prevents particles from the water supply line entering the machine thus preventing extraneous rust on the cutlery and in the machine.

Figure 3.2: Supply hose (Source: Internet)

- Connect the supply hose to the machine.
- Connect the dirt trap to the on-site water stop cock.
- Connect the supply hose to the dirt trap.
- Open the water stop cock and test whether the connections are tight.

3.3. Requirement in wash and rinse process

Table 3.2: Requirement in wash and rinse process

Number of programmes	2
Theoretical capacity Standard / Hightemp	60/20 rack/h
Rack dimensions	500×500 mm
Water consumption	
Tank capacity	28 l
Boiler capacity	8 l
Rinse water volume per wash cycle Standard / Hightemp	2.4 / 3.8 l
Temperatures	
Tank temperature standard / Hightemp	65°C
Rinse temperature	85°C
Max water inlet temperature	60°C
Time	
Time Wash – Delay – Rinse of Standard	45 – 5 – 10 s
Time Wash – Delay – Rinse of Hightemp	120 – 10 – 50 s

3.4. Control system components

3.4.1. Microcontroller

3.4.1.1. STM32F103C8T6

The STM32F103C8T6 is a microcontroller from the STM32F1 series by STMicroelectronics. It is a medium-density performance line microcontroller with 64 Kbytes of Flash memory, 72 MHz CPU, motor control, USB and CAN interfaces, and various peripherals.

Here are some of the key features of the STM32F103C8T6 microcontroller:

- Arm® 32-bit Cortex®-M3 CPU core: The microcontroller has a maximum frequency of 72 MHz and can perform up to 1.25 DMIPS/MHz performance at 0 wait state memory access. It also has single-cycle multiplication and hardware division capabilities.
- Memories: The microcontroller has 64 or 128 Kbytes of Flash memory and 20 Kbytes of SRAM.
- Clock, reset and supply management: The microcontroller operates from a 2.0 to 3.6 VDC power supply and has a POR, PDR, and programmable voltage detector (PVD). It also has a 4 to 16 MHz crystal oscillator, an internal 8 MHz factory-trimmed RC, an internal 40 kHz RC, a PLL for CPU clock, and a 32 kHz oscillator for RTC with calibration. It also has low-power Sleep, Stop, and Standby modes and a V BAT supply for RTC and backup registers.

- Dual-sample and hold capability: The microcontroller has 32-bit, 1 µs A/D converters (up to 16 channels) with a conversion range of 0 to 3.6 VDC. It also has a temperature sensor and a DMA 7-channel DMA controller.
- Peripherals: The microcontroller has up to 80 fast I/O ports and 26/37/51/80 I/Os, all mappable on 16 external interrupt vectors and almost all 5 V-tolerant. It also has three general-purpose 16-bit timers plus one PWM timer, two I2Cs and SPIs, three USARTs, a USB, and a CAN.

The STM32F103C8T6 microcontroller is suitable for a wide range of applications such as motor drives, application control, medical and handheld equipment, PC and gaming peripherals, GPS platforms, industrial applications, inverters, printers, scanners, alarm systems, video intercoms, and HVACs 1.

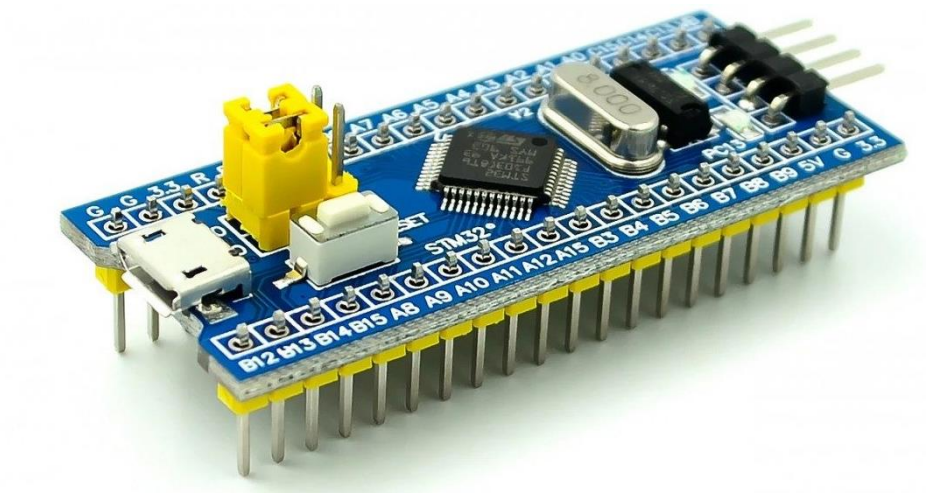

Figure 3.3: STM32F103C8T6 microcontroller (Source: Internet)

❖ **Specifications:**

- Microcontroller: STM32F103C8T6.
- Operating voltage: 5 VDC.
- Operating frequency: 6 MHz.
- Consumption current: 30 mA.
- Analog pin: 2.
- Timer pin: 4.
- Maximum current per I/O pin: 40 mA.
- Maximum output current 5V: 500 mA.
- Maximum output current 3.3V: 50 mA.
- Flash Memory: 64

3.4.1.2. PLC S7-1200 CPU 1214C

2009, Siemens launched the S7-1200 product line to gradually replace the S7-200. Compared to the S7-200, the S7-1200 has outstanding features:

The S7-1200 is a line of programmable logic controllers (PLCs) that can control a variety of automation applications. Compact design, low cost, and a powerful instruction set make us the perfect solution for applications used with the S7-1200.

The S7-1200 includes a microprocessor, an integrated power supply, and inputs/outputs (DI/DO).

Several security features help protect access to both the CPU and firmware:

- ✓ All CPUs provide password protection against access to the PLC
- ✓ "Know-how protection" feature to protect your special blocks

The S7-1200 provides a PROFINET port, supporting Ethernet and TCP/IP standards. In addition, you can use expansion communication modules connected by RS485 or RS232.

The software used to program the S7-1200 is Step7 Basic. Step7 Basic supports three programming languages: FBD, LAD and SCL. This software is integrated into Siemens' TIA Portal 11.

So to do a project with the S7-1200, just install TIA Portal because this software includes a programming environment for PLC and HMI interface design.

Figure 3.5: PLC S7-1200 CPU 1214C (Source: Internet)

❖ **Specifications:**

- Dimensions: 110 ×100 ×75
- User memory:
  - Working memory: 50 Kb
  - Storage memory: 2 Mb
  - Retentive memory: 2 Kb
- Digital input and output: 14 In/10 Out
- Analog I/O: 2 in
- Bit access memory area (M): 4096 Byte
- Expansion signal module: 8
- Communication signal board:1
- Communication module: 3

Table 3.3: Compare between STM32F103C8T6 and PLC S7-1200

Microcontroller / Specification	STM32F103C8T6	PLC S7-1200 CPU 1214C
CPU	32-bit ARM Cortex-M3	32-bit RISC
Clock speed	72 MHz	100 MHz
Memory	64 KB flash 20 KB SRAM	100 KB work memory 4 MB load memory
I/O ports	37 GPIO, 2 I2C, 3 USART, 2 SPI, 1 CAN, 1 USB	14 digital inputs, 10 digital outputs, 2 analog inputs, 2 analog outputs
Dimension	36×55 mm	110×100×75 mm
Communication	UART, I2C, SPI, CAN, USB	Ethernet, PROFINET, PROFIBUS, AS-i, Modbus TCP, Modbus RTU
Power supply	2.0 - 3.6 VDC	20.4 - 28.8 VDC
Price	$2.5	$500
Program language	- C - C++ - Assembly languages	- Ladder Logic - Function Block Diagram - Structured Text languages
Advantage	- Low prices - Compact - Many IO - More flexible and customizable	- Faster clock speed - More memory - Many communication protocols - High stability
Disadvantage	- Low stability - Difficult program - No warranty	- High prices - Complicated connection - Big size
Suitable for	Small project, low budget, little complexity…	Big project, industrial project, …

- After the team researched and calculated the needs for peripherals for the project, the team decided to choose STM32F103C8T6 as the microcontroller for this project as well as let the team learn about the 32bit chip line.

3.4.2. Circuit breaker

A circuit breaker is an electrical safety device, a switch that automatically interrupts the current of an overloaded electric circuit, ground faults, or short circuits. Circuit breakers "trip", shut off, current flow after protective relays detect a fault. Unlike fuses that were used previously, circuit breakers are not usually damaged so they can be reset as opposed to being replaced. Circuit breakers are used in residential and in industrial applications.

❖ Types of circuit breaker: 4 categories

Figure 3.6: MCCB(Source: Internet)

Figure 3.7: Insulated Case Circuit Breaker (Source: Internet)

Figure 3.8: Miniature circuit breakers (Source: Internet)

- Molded Case Circuit breakers (MCCB):
  - 15 – 1200A
  - Use in residential to industrial
- Insulated Case Circuit Breakers
  - 800 – 4000A
  - Electrically operated breaker
  - Commercial to Light Industrial - office buildings, schools, shopping malls
  - Air power circuit breakers
  - 250 – 6000A
  - Heavy industrial application - can involve switchgear
  - Optimal reliability - Hospitals, Data Centers
- Miniature Circuit Breakers (MCB)

- Less than 100A
- Used for low-energy requirements, like home wiring, offices, or small
- electronic circuits
- MCBs are equipped with two tripping mechanisms: the delayed thermal
- tripping mechanism for overload protection and the magnetic tripping
- mechanism for short circuit protection

➢ In this project, since the estimated current consumption is less than 100 A, the authors choose the MCB type.

3.4.3. Relay Module

To control 4 high-voltage devices such as pump, heating element, and valve… users can use multiple relay modules. However, there is a simpler way to use a 4-channel relay module. It is a combination of 4 relays on a single board.

Figure 3.9: Relay module (Source: Internet)

❖ **Specifications:**

- Supply voltage: 3.75 to 6 VDC.
- Trigger current: 5mA.
- Current when the relay is turned on: 70mA (single), 300mA (all four).
- Relay maximum contact voltage – 250VAC, 30VDC.

3.4.4. Emergency button

Emergency stop buttons, also known as E-Stops or kill switches, are used to reduce the risk of injury by stopping machinery quickly.

Emergency stop buttons are fitted for easy access in any emergency. E-Stops are red and must feature a yellow background, bezel, or housing for attention

Figure 3.10: Emergency button (Source: Internet)

3.4.5. Contactor

Is used to control the high capacity equipment: Heating element boiler, wash pump…

To calculate and select contactor for heating element boiler with Power = 9KW, the following formula can be used for calculation:

$$P = U \times I_{dm} \times \cos\emptyset \rightarrow I_{dm} = \frac{P}{U \times \cos\emptyset} = \frac{9000}{220 \times 0.8} = 51.1A$$

$$\rightarrow I_{tt} = I_{dm} \times 1{,}2 = 51{,}1 \times 1{,}2 = 61.32\ A$$

- P: Engine capacity (W)
- U: Voltage used is measured between 2 phases (V)
- I_{dm}: Rated current(A)
- Cos Φ: Power factor (0.8)
- I_{tt}: Actual current (A)

With $I_{tt} = 61.32\ A$, we chose contactor has power I = 63 A

Figure 3.11: Contactor 220V 63A (Source: Internet)

❖ **Specifications:**
- Model: BCH8-63
- Voltage: 210-240 VAC.
- Resistive load: 63A.
- Load capacity: 9 kW
- Maximum working temperature: 70°C
- Auxiliary contacts: 2NO

Similar, to calculate and select contactor for wash pump with Power = 590 W,the following formula can be used for calculation:

$$P = U \times I_{dm} \times \cos\emptyset \rightarrow I_{dm} = \frac{P}{U \times \cos\emptyset} = \frac{590}{220 \times 0.8} = 3.35\ A$$

$$\rightarrow I_{tt} = I_{dm} \times 1{,}2 = 3.35 \times 1{,}4 = 4.69\ A$$

With $I_{tt} = 4.69\ A$, we chose contactor has power I = 9 A

Figure 3.12: Contactor 220V 9A (Source: Internet)

❖ **Specifications:**
- Model: MC-9a AC220V LS
- Voltage: 210-240 VAC.
- Resistive load: 9 A.
- Load capacity: 590 W
- Auxiliary contacts: 1NO
- Warranty: 12 month
- Manufacturer: LS – Korea

3.4.6. Temperature safety

To select temperature safety for machine. It is necessary to base on the below image and suitable for the contactor selected above.

With power of heating element P=9 kW and selected contactor is Contactor 220VAC 63A BCH8-63. So, the group decide to select temperature safety 30A.

200 ~ 220VAC		380 ~ 400VAC		NGƯỠNG TÁC ĐỘNG
KW	HP	KW	HP	Relay Nhiệt
0.2	0.25	0.4	0.5	0.7 ~ 1.1A
0.3	0.4	0.75	1	1.3 ~ 2.1A
0.4	0.5	1.1	1.5	1.6 ~ 2.6A
0.75	1	1.5	2	2.5 ~ 4.1A
1.1	1.5	2.2	3	3.4 ~ 5.4A
1.5	2	3	4	5.0 ~ 8.0A
2.2	3	3.7	5	7.0 ~ 11A
3	4	5.5	7.5	9.0 ~ 13A
3.7	5	7.5	10	12 ~ 18A
5.5	7.5	12	15	17 ~ 24A
7.5	10	15	20	22 ~ 34A
9	12.5	19	25	28 ~ 38A
11	15	22	30	32 ~ 48A
15	20	30	40	43 ~ 65A
19	25	37	50	54 ~ 80A
22	30	45	60	60 ~ 100A
25	35	55	75	80 ~ 130A
30	40	65	85	80 ~ 130A
37	50	75	100	100 ~ 160A
45	60	90	125	120 ~ 200A
55	75	110	150	150 ~ 250A
65	85	132	180	200 ~ 320A
75	100	150	200	200 ~ 320A
90	125	160	220	260 ~ 440A
110	150	220	300	400 ~ 600A
		315	420	400 ~ 600A

Figure 3.13: Table select temperature safety follow power of load (Source: Internet)

Figure 3.14: Temperature safety (Source: Internet)

❖ **Specifications:**

- Model: NXR-38 30A-38A
- Voltage: 210 - 240 VAC.
- Resistive load: 30 – 38 A.
- Auxiliary contacts: 1NO + 1NC
- Warranty: 12 month
- Manufacturer: China
- Rated voltage: 6000V

3.4.7. Heating element of boiler

To calculate the selected power of a heating element, the following formula can be uesd for calculation:

$$Pt = (M \times L \times T) \div t$$

- Pt is the power used to heat the water(kWh)
- L is the number of liters of water that is being heated (liters)
- T is difference in temperature from started temperature to desired temperature (°C)
- M is Mass of the water = 4,186 J/kg·°C
- t is time need to heating (s)

So, we want to heating 8 liters in boiler from 20 – 85°C in 5 minuture:

$$Pt = (M \times L \times T) \div 300 = \frac{(4{,}186 \times 8 \times (85 - 20))}{300} = 7{,}255 \text{ (kW)}$$

With Pt = 7,255 kwh; we chose heating element has power Pt = 9 kWh

- **Boiler heating element 9Kw**

Figure 3.15: Boiler heating element (Source: Internet)

❖ **Specifications:**

- Power: 9000 W.
- Voltage: 230 VAC.
- Length: 430 mm.
- Width: 36 mm.
- Heigh: 52 mm.
- Weight : 0.613 kg.

3.4.8. Heating element of tank

Similar to circulating heating element, we want to heating 28 liters in boiler from 65 – 70°C in 5 minuture:

$$Pt = (M \times L \times T) \div 300 = \frac{(4{,}186 \times 28 \times (70 - 65))}{300} = 1.95(\text{kW})$$

With Pt = 1.95 kwh; the group chose heating element has power Pt = 2.5 kW

- **Heating element of tank 2500w**

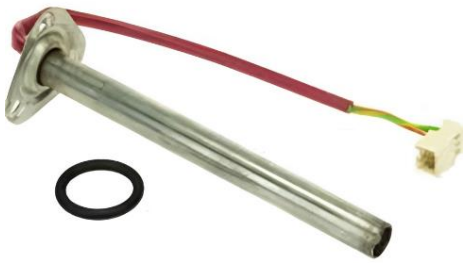

Figure 3.16: Heating element of tank (Source: Internet)

❖ **Specifications:**
- Power: 2500 W.
- Voltage: 230 VAC.
- Length: 215 mm.
- Width: 20 mm.
- Wieght : 0.425 kg.

3.4.9. Solenoid valve RPE 2 VIE 230V 50/60Hz

During the test run of the machine, the water is passed from outside the machine and kept until the temperature is 30 degrees Celsius. The authors measured the operating pressure of the machine as approximately 3 bar, so choose a solenoid valve RPE 2 VIE 230VAC 50/60Hz with discharge pressure from 0.1-12 bar.

Figure 3.17: Solenoid valve RPE 2 VIE 230V 50/60Hz (Source: Internet)

❖ **Specifications:**
- Material: Plastic.
- Branch: RPE.
- Max. Temperature: 60°C.
- Voltage: 230 VAC.

3.4.10. Temperature sensor DS18B20

During the test run of the machine, the hot water changes temperature continuously from 20 -100°C. So, the team decided to choose a temperature sensor with a temperature measurement range of more than 20-100 and a protective cover.

Figure 3.18: Temperature sensor (Source: Internet)

❖ **Specifications:**

- Voltage: 3-5.5 VDC
- Temperature range: -55 – 125 °C
- Error : + - 0.5°C
- Length: 3 m
- Pin: 3 (VCC – GND – DATA)

3.4.11. Water level sensor float switch MH83C:

The MH83C float switch is used to measure the water level in a container and boiler. The output of the switch can be used to turn on the pump rinse,pump wash and close valve inlet or any other I/O device.

The sensor uses a magnetic mechanism for switching, including a magnet and a magnetic switch.

Figure 3.19: Water level sensor float switch MH83C (Source: Internet)

❖ **Specifications:**

- Cable length: 37.5 cm.
- Max Fault Voltage: 220 VDC.
- Maximum switching current: 0.5 A.
- Maximum load current: 1.0 A.
- Maximum contact resistance: 10 mΩ.
- Installation way: top or bottom vertically.
- Use medium: water, oil, medium pressure environment.
- Pressure range: 0.2 Mpa.

3.5. System control diagram

The below image describes the system control diagram of the system after the group calculates and selected as follows: The current supplied from the AC 220V source goes through the circuit breaker, continues through the emergency button then goes through relay to control devieces: valve solenoid, heating element, pump through contactor, temperature safety and they is controlled by STM32F103C8T6 microcontroller through return signal of temperature sensor and water level sensor.

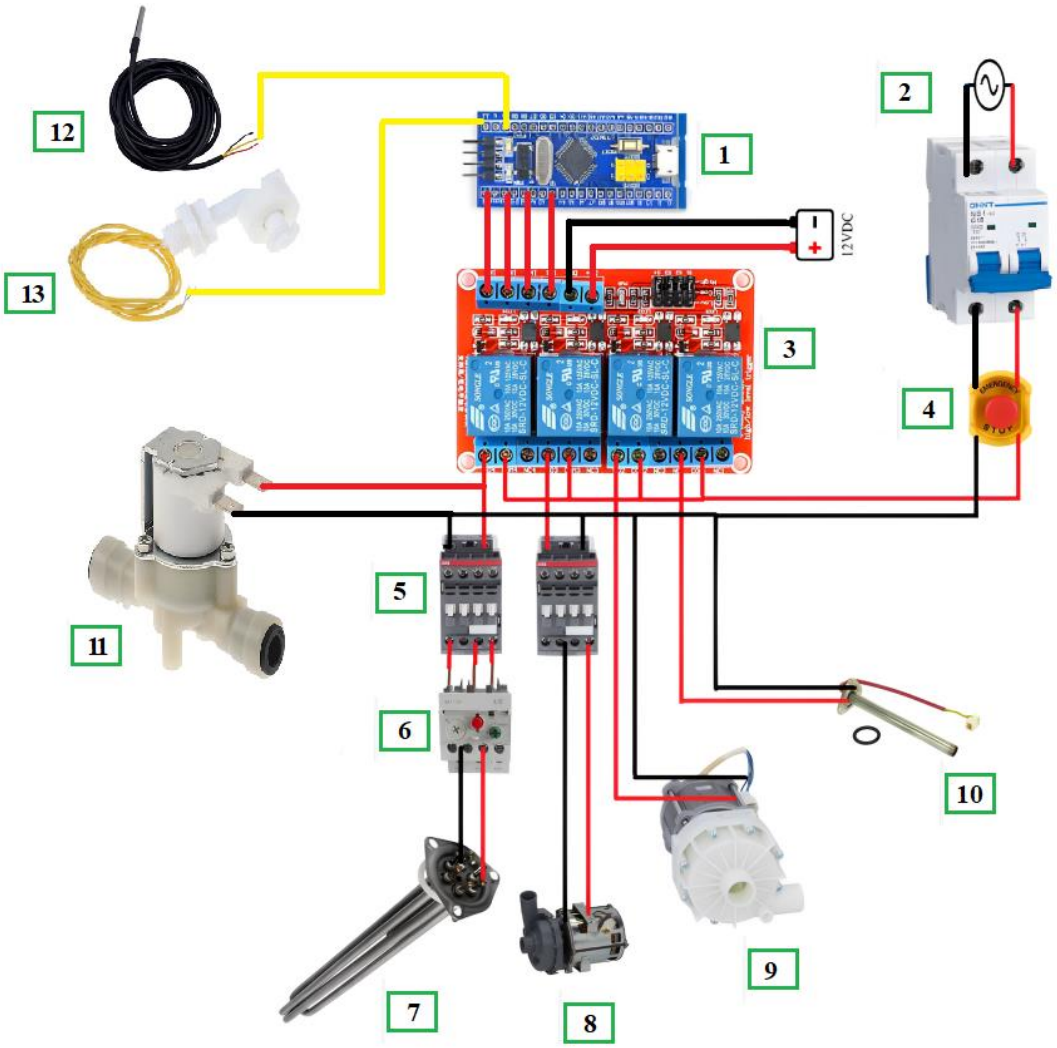

Figure 3.20: System control diagram

1- STM32F103C8T6 Microcontroller 2- Circuit breaker 3- Module relay

4- Emergency button 5- Contactor 6- Temperature safety

7- Heating element boiler 8- Wash pump 9- Rinse pump

10- Heating element tank 12- Temperature sensor

13- Water level sensor

3.6. Expense calculation

Table 3.4: Expense calculation

Number	Name	Quantity	Price (VND)
1	Stm32F103C8T6	1	50.000
2	MCB	1	150.000
3	Relay module	1	18.000
4	Emergency button	1	65.000
5	Contactor	2	190.000
6	Temperature safety	1	120.000
7	Heating element boiler	1	1000.000
8	Wash pump	1	5.000.000
9	Rinse pump	1	3.850.000
10	Heating element tank	1	650.000
11	Solenoid valve	1	300.000
12	Temperature sensor DS18B20	1	25.000
13	Water Level Sensor Float Switch	2	35.000
	Total		11.453.000

3.7. Circuit design

With requirements from company, the main circuit needs to have:

- The circuit draws power directly from the 220 VAC power source.
- Control panel: LCD, button, led and buzzer…
- Relays to control solenoid valve, pump, heating element…

The circuit is controlled by an STM32F103C8T6. The circuit uses directly from 220VAC power, so there will be a transformer to get 12 VDC power supply for relay and 12VDC power will be a transformer 5 VDC to supply for microcontroller. The circuit has 6 buttons one button to start the machine, two button to select washing mode, one button to confirm washing machine and start washing, one button to reset chip and final button to clean myself. The circuit has 6 relays and use them to turn on the pump, valve inlet and heating element and one relay for preventive.The circuit uses PC817 to get the signal from the microcontroller and activates a 12 VDC relay to reduce noise to the chip. At the same

time, the circuit uses the power supply to isolate the main power supply from the chip to reduce interference.

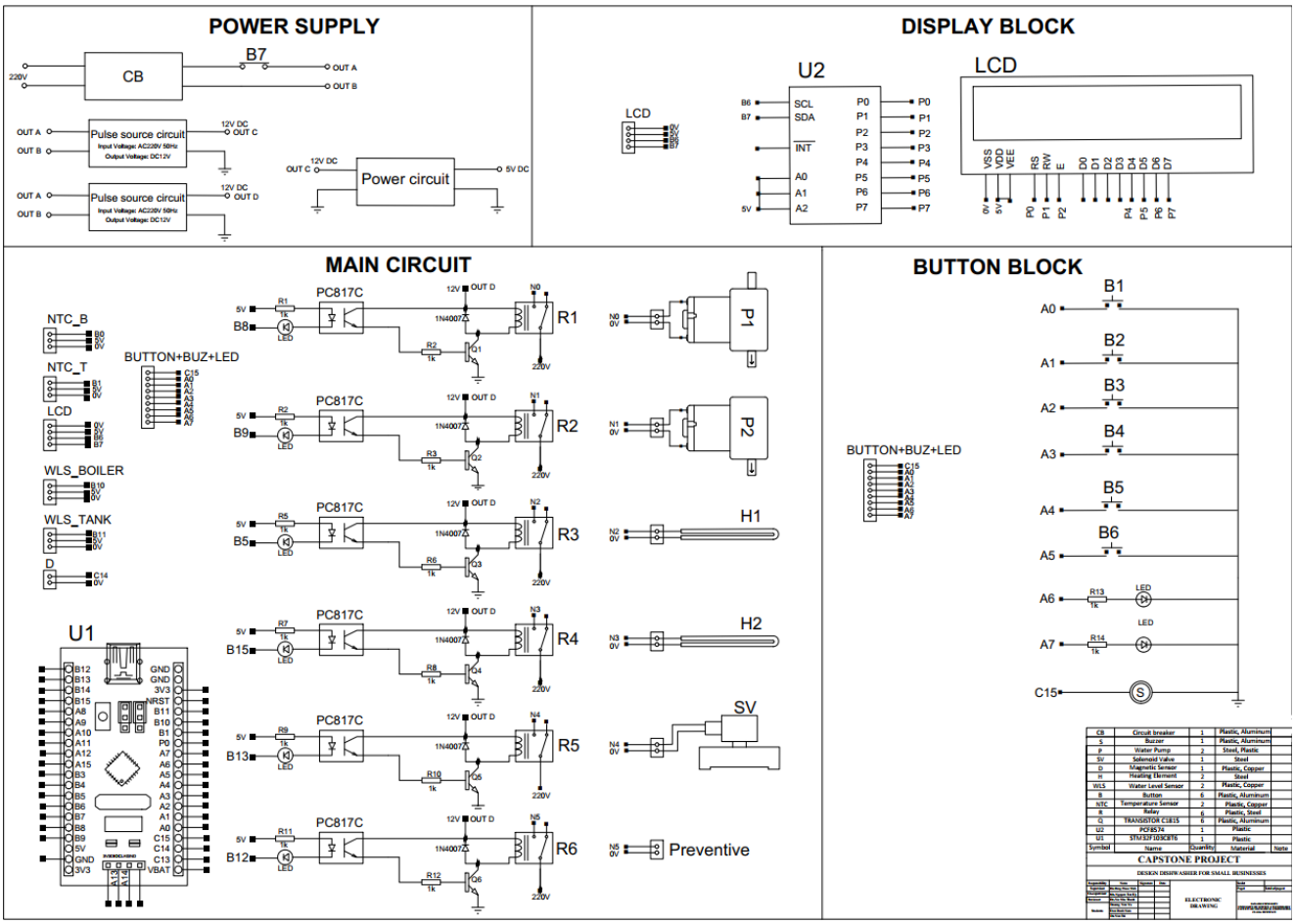

Figure 3.21: Electric drawing

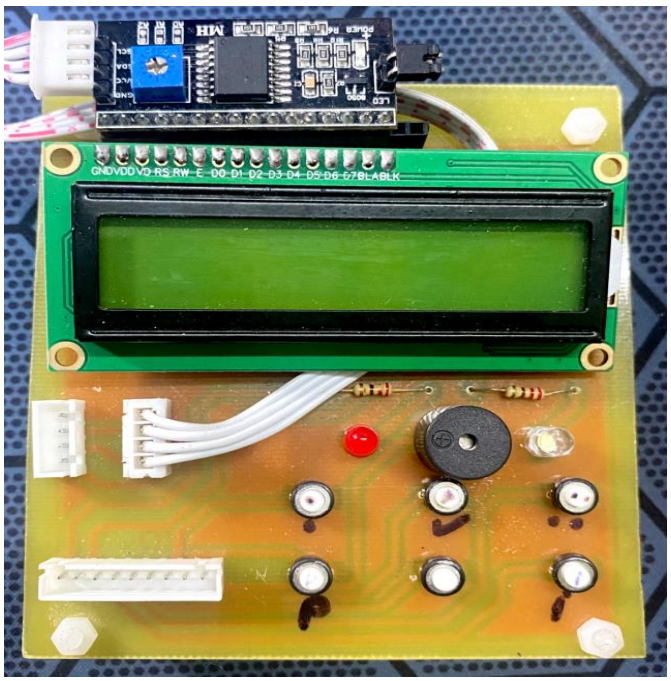

Figure 3.22: Control circuit

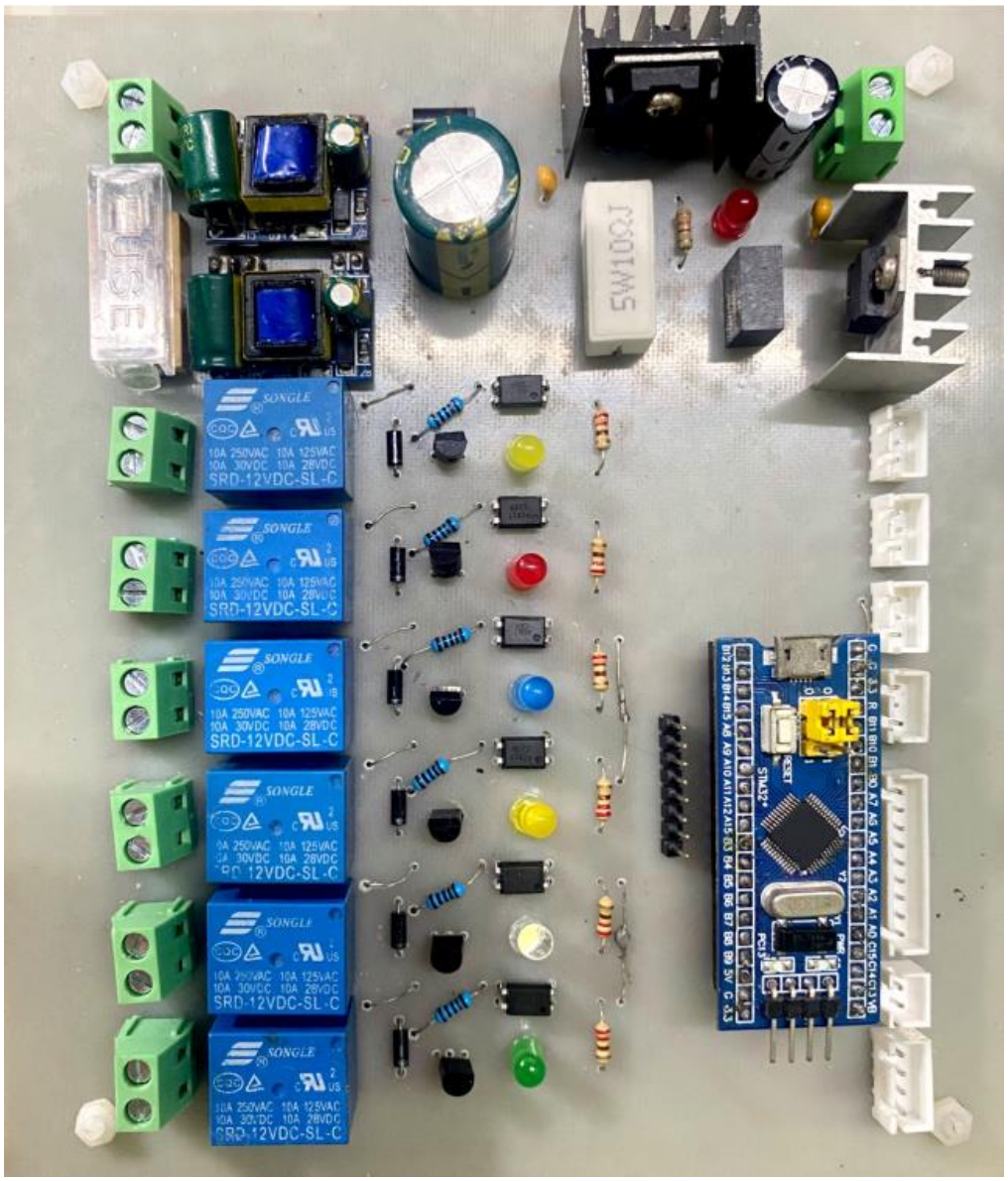

Figure 3.23: Main circuit

After purchasing the necessary components, the group proceeded to make printed circuits at home .

The circuit works well with test mode including main functions such as filling water when the tank and boiler is empty, measure temperature and transmit and receive good signals between 2 electrical circuits.

3.8. Flowchart

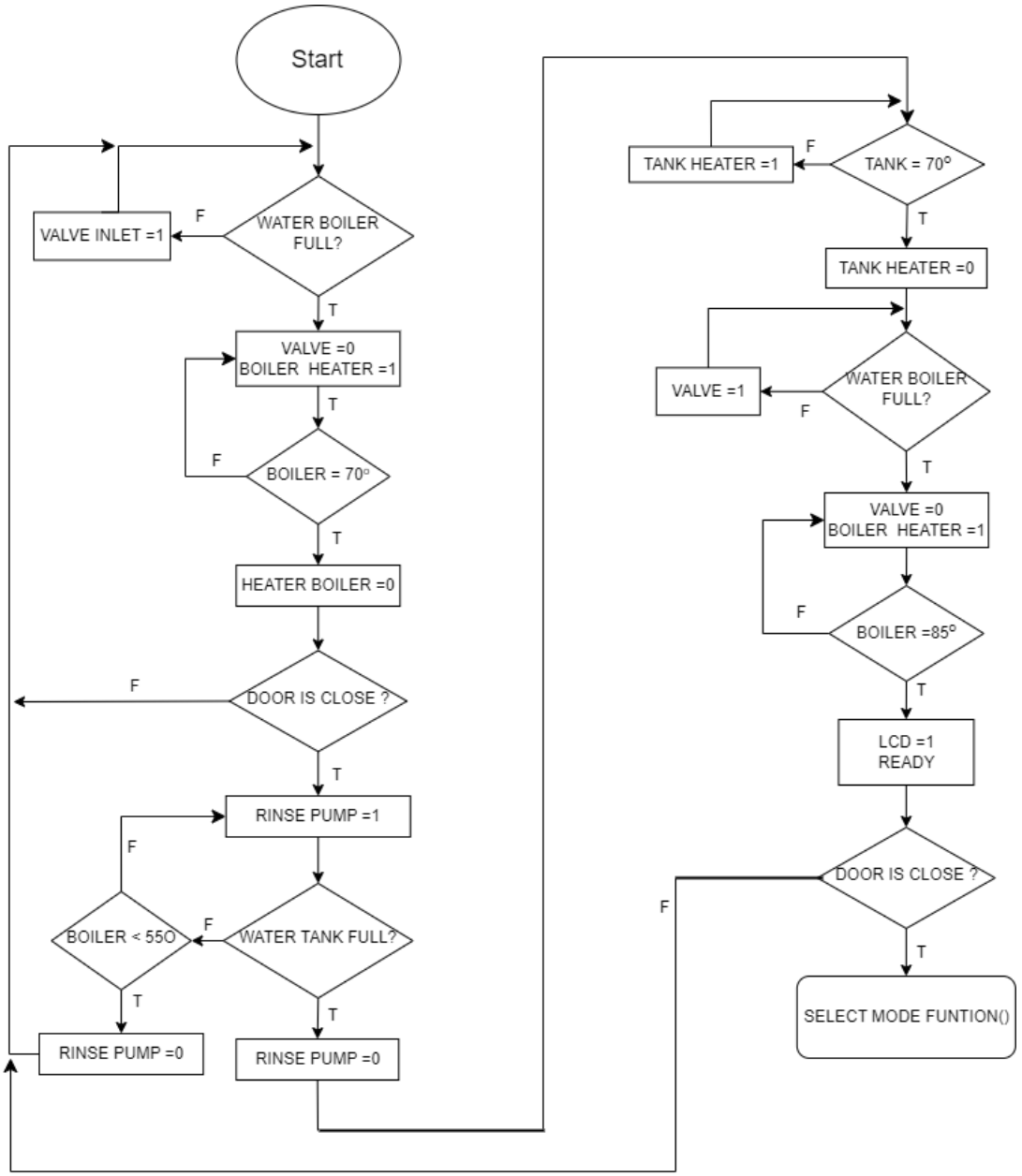

Figure 3.24: Flowchart of setup process

When the system start working. The first, the system will check boiler is full and reaches the setting temperature. Otherwise, will open valve inlet and heating element boiler. Then the system will check tank is full and reaches the setting temperature, if no will check the door is closed or not before pump the hot water into tank. After water level and temperature of tank enough, will check again temperature and water level of boiler is reaches for rinse process or not. After satisfying the above conditions, the system will announce to users through LCD and buzzer. Before moving to the washing process, if the temperature of tank or boiler drops more than 5 degrees. The system will check again from the beginning.

STANDARD AND HIGHTEMP WASHING PROGRAM

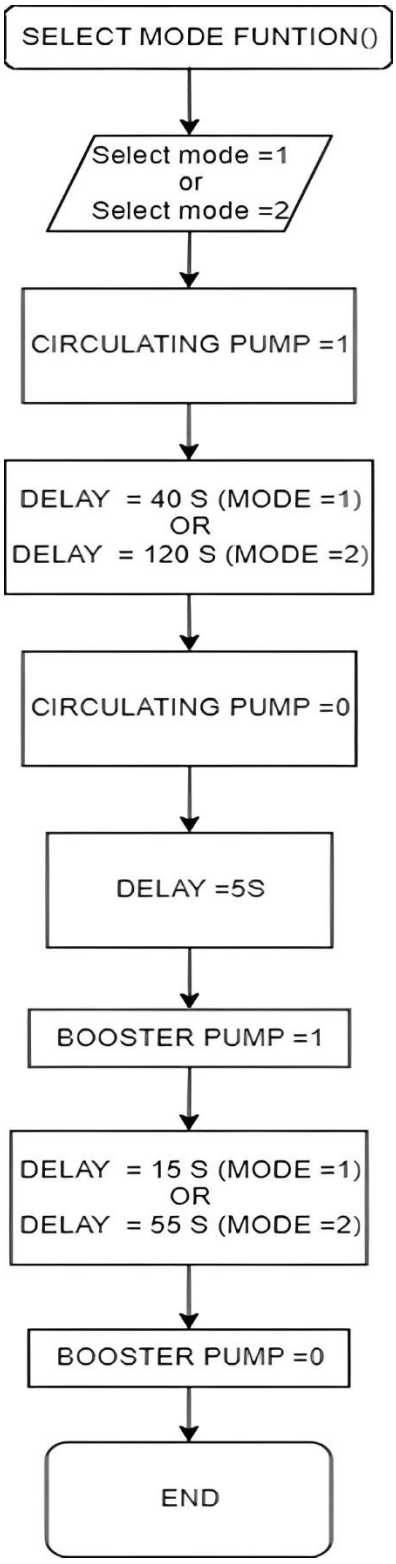

Figure 3.25: Washing flowchart

When the users select washing mode, the system will start working. The first, the system will wash dishes by turn on wash pump. After a certain period of time depends on selected mode, will turn off wash pump and delay 5 – 10s depends on selected mode to the chemicals wash away. Then turn on the rinse pump in certain time depends on selected mode to completely clean and end of 1 cycle.

CHAPTER 4: CONCLUSION

4.1. Results

In the process of implementation, the team tried and made efforts to achieve the set goal. After discuss with company and research market, the team decides to select the machine frame for this project is product of Hafele brand. Because the machine is cheap but still meets all team's requirements.

Figure 4.1: Image of Dishwasher machine in actual

❖ **Technology specification:**

- Module: Hafele HDW – T50A.
- Water pressure: 0.04 - 1Mpa.
- Frequency: 50 Hz.
- Power source: 220 – 250 VAC.
- Dimension (H ×W ×D): 438x550x500 mm.
- Weight: 50 Kg.
- Material: Steel, plastic.
- Color: White and gray.
- Button:
  - Power: To turn on the machine.
  - Mode: To select washing modes of machine.
  - Confirm: To confirm washing modes and start washing.
  - Reset: Reset the machine to back initial status.

❖ **Results:**

- Can wash the dishes conveniently.
- Reduce time washing and water consumption.
- Reduce human labor.

The process is done as follows:

- Step 1: Press the **Power** button to turn on the machine.

Figure 4.2: Press Power button to turn on the machine

- Step 2: Wait for setup process to complete and **LCD** screen will display **"Ready"**.

Figure 4.3: Wait LCD display Ready

- Step 3: Bring the dishes into the machine and close door.

Figure 4.4: Bring the dishes into the machine

- Step 4: Select **Washing Modes** and press **Confirm** button to start washing.

Figure 4.6: Select modes

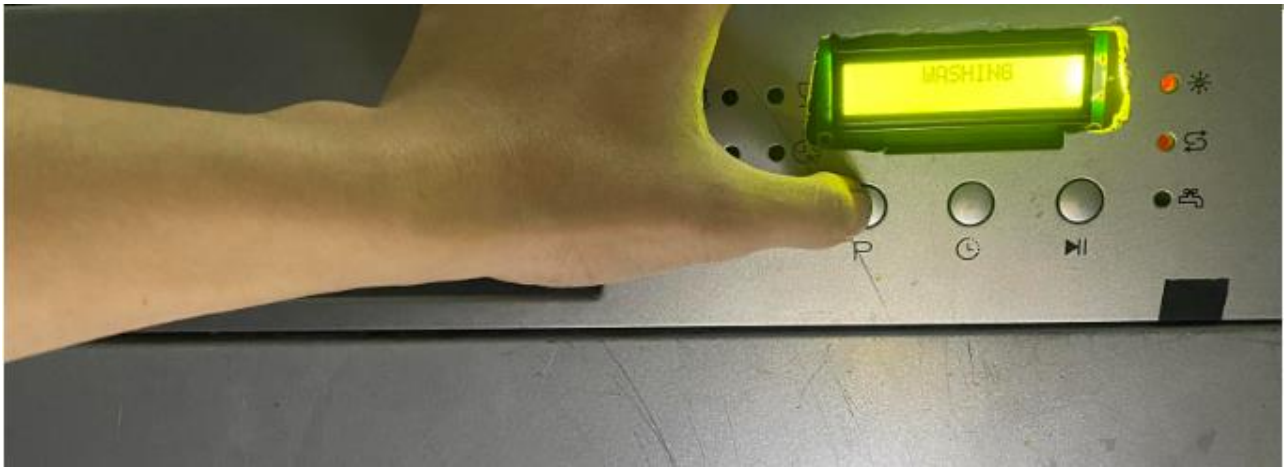

Figure 4.7: Press P to start washing

- Step 5: Wait for the machine to complete washing program

Figure 4.5: End program and bring dishes out the machine

4.2. Limitation

Because of limited time, not deep knowledge and requirements from businesses, the topic still has some limitations:

- The stability of the machine has not reached a high level of stability.
- There is no control software.
- No machine frame according initial design.

4.3. Direction of development

- Using PID algorithm for optimization and stabilize the temperature in the boiler.
- Use drying equipment instead of rinse aid.
- Adding management and control system.

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APPENDIX

Appendix A: Main program code

```
#include "main.h"
#include "i2c-lcd.h"
#include "stdio.h"
#include "Funtion.h"
/* Private typedef -----------------------------------------------------------*/
I2C_HandleTypeDef hi2c1;
TIM_HandleTypeDef htim1;
TIM_HandleTypeDef htim2;
TIM_HandleTypeDef htim3;
/* USER CODE BEGIN PV */
uint8_t              power_press =0;
float      volatile  Temperature_boiler;
float      volatile  Temperature_tank = 0;
uint8_t    volatile  Presence = 0;
uint8_t    volatile  Temp_byte1, Temp_byte2;
uint16_t volatile  TEMP;
uint8_t    volatile  BOILER_FULL=0;
uint8_t    volatile  TANK_FULL=0;
uint8_t    volatile  DOOR =1;
uint8_t    volatile  MODE =0;
uint8_t    const     Temp_Std_Wash =70;
uint8_t    const     Temp_Std_Rinse =85;
uint8_t    const     Temperature_max =100;
/* Private function prototypes -----------------------------------------------*/
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
static void MX_I2C1_Init(void);
static void MX_TIM1_Init(void);
static void MX_TIM2_Init(void);
static void MX_TIM3_Init(void);
int main(void)
{
  HAL_Init();
```

```
 SystemClock_Config();
 MX_GPIO_Init();
 MX_I2C1_Init();
 MX_TIM1_Init();
 MX_TIM2_Init();
 MX_TIM3_Init();
 /* USER CODE BEGIN 2 */
        HAL_TIM_Base_Start(&htim1);
        HAL_TIM_Base_Start(&htim2);
        DISPLAY_LCD();
 while (1)
 {
CHECK_PRESS_POWER_BUTTON();
SET_BUZZER();
INSPECT_WATER_LEVEL_OF_BOILER();
INSPECT_TEMPORATURE_OF_BOILER(Temp_Std_Wash);
CLOSE_DOOR_TO_FILL(Temp_Std_Wash);
INSPECT_WATER_LEVEL_OF_TANK(Temp_Std_Wash);
INSPECT_TEMPORATURE_OF_TANK(Temp_Std_Wash);
INSPECT_WATER_LEVEL_OF_BOILER();
INSPECT_TEMPORATURE_OF_BOILER(Temp_Std_Rinse);
READY();
CLOSE_DOOR_TO_WASH(Temp_Std_Rinse,Temp_Std_Wash);
SELECT_MODE(Temp_Std_Rinse,Temp_Std_Wash);
 }
}
```

Appendix B: Funtion program code

```
#include "stdio.h"
#include "i2c-lcd.h"
#include "main.h"
#include "Funtion.h"
extern    TIM_HandleTypeDef htim2;
extern    TIM_HandleTypeDef htim1;
extern    TIM_HandleTypeDef htim3;
extern    uint8_t   power_press ;
```

```
extern    uint8_t   Temperature_max ;
extern    float     Temperature_boiler;
extern    float     Temperature_tank ;
extern    uint8_t   Presence ;
extern    uint8_t   Temp_byte1, Temp_byte2;
extern    uint16_t  TEMP;
extern    uint8_t   BOILER_FULL;
extern    uint8_t   TANK_FULL;
extern    uint8_t   DOOR ;
extern    uint8_t   b;
extern    uint8_t   MODE ;
extern    uint8_t   const Temp_Std_Wash;
extern    uint8_t   const Temp_Std_Rinse;

/*FUNTION DISPLAY TIME (US)*/
void DELAY_US(uint32_t time)
{
        __HAL_TIM_SET_COUNTER(&htim1, 0);
        while ((__HAL_TIM_GET_COUNTER(&htim1))<time);
}
/*FUNTION DISPLAY TIME (MS)*/
void DELAY_MS(uint32_t time){
        __HAL_TIM_SET_COUNTER(&htim2, 0);
        while ((__HAL_TIM_GET_COUNTER(&htim2))<time){
        UPDATE_TEMPERATURE();
/*FUNTION DISPLAY LCD*/
void DISPLAY_LCD(){
        lcd_init ();
        lcd_send_string ("CAPTONE PROJECT");
        lcd_put_cur(1, 0);
        lcd_send_string("DISHWASHER MACHINE");
        HAL_Delay(3000);
        lcd_clear ();
        HAL_Delay(500);
```

```
	lcd_put_cur(0, 0);
	lcd_send_string("PRESS P TO START");
}
/*FUNTION READY FOR WASH*/
void READY(){
	lcd_clear();
	lcd_put_cur(0, 5);
	lcd_send_string("READY");
	SET_BUZZER();
}
/*FUTION SET PIN INPUT*/
void Set_Pin_Output(GPIO_TypeDef *GPIOx, uint16_t GPIO_Pin)
{
	GPIO_InitTypeDef GPIO_InitStruct = {0};
	GPIO_InitStruct.Pin = GPIO_Pin;
	GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
	GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
	HAL_GPIO_Init(GPIOx, &GPIO_InitStruct);
}
/*FUTION SET PIN INPUT*/
void Set_Pin_Input(GPIO_TypeDef *GPIOx, uint16_t GPIO_Pin)
{
	GPIO_InitTypeDef GPIO_InitStruct = {0};
	GPIO_InitStruct.Pin = GPIO_Pin;
	GPIO_InitStruct.Mode = GPIO_MODE_INPUT;
	GPIO_InitStruct.Pull = GPIO_PULLUP;
	HAL_GPIO_Init(GPIOx, &GPIO_InitStruct);
}
 //DS18B20 BOILER FUNCTIONS
uint8_t DS18B20_BOILER_Start (void)
{
	uint8_t Response = 0;
	Set_Pin_Output(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);   // set the pin as output
	HAL_GPIO_WritePin (DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin, 0);  // pull the pin low
```

```
        DELAY_US(480);   // delay according to datasheet
        Set_Pin_Input(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);    // set the pin as input
        DELAY_US (80);    // delay according to datasheet
        if (!(HAL_GPIO_ReadPin (DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin))) Response = 1;
        else Response = 2;
        DELAY_US(400); // 480 us delay totally.
        return Response;
}
void DS18B20_BOILER_Write(uint8_t data)
{
Set_Pin_Output(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);  // set as output
for (int i=0; i<8; i++){
        if ((data & (1<<i))!=0)  // if the bit is high{
        Set_Pin_Output(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);  // set as output
        HAL_GPIO_WritePin (DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin, 0);  // pull the pin LOW
        DELAY_US(1);  // wait for 1 us
        Set_Pin_Input(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);  // set as input
        DELAY_US(50);  // wait for 60 us
        }
        else{  // if the bit is low write 0
        Set_Pin_Output(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);
        HAL_GPIO_WritePin (DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin, 0);  // pull the pin LOW
        DELAY_US(50);  // wait for 50 us
        Set_Pin_Input(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);}}}
```

```
uint8_t DS18B20_BOILER_Read(void)
{       uint8_t value=0;
        Set_Pin_Input(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);
        for (int i=0;i<8;i++)
        {
        Set_Pin_Output(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);   // set as output
        HAL_GPIO_WritePin (DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin, 0);
        DELAY_US(1);  // wait for > 1us
        Set_Pin_Input(DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin);  // set as input
        if (HAL_GPIO_ReadPin (DS18B20_BOILER_GPIO_Port, DS18B20_BOILER_Pin)){  // if the pin is HIGH
        value |= 1<<i;  // read = 1
        }
        DELAY_US(50);  // wait for 50 us
        }
        return value;
}
```

/*FUNTION TEMPORATURE OF BOILER*/

```
float TEMPORATURE_OF_BOILER(){
Presence = DS18B20_BOILER_Start();
if(Presence == 2) {
        STOP();
        lcd_clear();
        lcd_put_cur(0,5);
        lcd_send_string("ERROR 1");
        while(HAL_GPIO_ReadPin(RESET_GPIO_Port,RESET_Pin)==1){
        lcd_put_cur(1,0);
        lcd_send_string("PRESS R TO START");}}
        else {
        HAL_Delay (1);
         DS18B20_BOILER_Write (0xCC);  // skip ROM
         DS18B20_BOILER_Write (0x44);  // convert t
         HAL_Delay (800);
          Presence = DS18B20_BOILER_Start ();
        HAL_Delay(1);
```

```
        DS18B20_BOILER_Write (0xCC);  // skip ROM
        DS18B20_BOILER_Write (0xBE);  // Read Scratch-pad
        Temp_byte1 = DS18B20_BOILER_Read();
        Temp_byte2 = DS18B20_BOILER_Read();
         TEMP = (Temp_byte2<<8)|Temp_byte1;}
        return  (float)TEMP/16;
}
/*FUNTION INSPECT TEMPORATURE OF BOILER*/
void INSPECT_TEMPORATURE_OF_BOILER(uint8_t Tem_std){
        if(Temperature_boiler < Tem_std ){
        OPEN_BOILER_HEATER();
        while(Temperature_boiler < Tem_std){
        UPDATE_TEMPERATURE();}}
        CLOSE_BOILER_HEATER();
}
/*FUNTION INSPECT WATER LEVEL OF BOILER*/
void INSPECT_WATER_LEVEL_OF_BOILER(){
        HAL_TIM_Base_Start_IT(&htim3);
        HAL_NVIC_EnableIRQ(EXTI0_IRQn);
        if(HAL_GPIO_ReadPin(WATER_LEVEL_BOILER_GPIO_Port,WATER_LEVEL_BOILER_Pin)=
        OPEN_VALVE();
        while(BOILER_FULL ==0){
        UPDATE_TEMPERATURE();}}
/*FUNTION OPEN VALVE*/
void OPEN_VALVE(){
        HAL_GPIO_WritePin(VALVE_INLET_GPIO_Port,VALVE_INLET_Pin,RESET);
        lcd_clear();
        lcd_put_cur(0,1);
        lcd_send_string("FILLING BOILER");
}
/*FUNTION CLOSE VALVE*/
void CLOSE_VALVE(){
        HAL_GPIO_WritePin(VALVE_INLET_GPIO_Port,VALVE_INLET_Pin,SET);
}
```

```
/*FUNTION OPEN PUMP RINSE*/
void OPEN_PUMP_RINSE(){
        lcd_put_cur(0,2);
        lcd_send_string(" DRAIN PUMP ");
        HAL_GPIO_WritePin(PUMP_RINSE_GPIO_Port,PUMP_RINSE_Pin,RESET);
}
        BOILER_FULL =0;
        }
/*FUNTION CLOSE PUMP RINSE*/
void CLOSE_PUMP_RINSE(){
        HAL_GPIO_WritePin(PUMP_RINSE_GPIO_Port,PUMP_RINSE_Pin,SET);
        HAL_GPIO_WritePin(MECHICAL_WASH_GPIO_Port,MECHICAL_WASH_Pin,RESET);
        HAL_NVIC_DisableIRQ(EXTI1_IRQn);
}
/*FUNTION OPEN PUMP WASH*/
void OPEN_PUMP_WASH(){
        UPDATE_TEMPERATURE();
        HAL_GPIO_WritePin(PUMP_WASH_GPIO_Port,PUMP_WASH_Pin,RESET);
}
/*FUNTION CLOSE PUMP WASH*/
void CLOSE_PUMP_WASH(){
        HAL_GPIO_WritePin(PUMP_WASH_GPIO_Port,PUMP_WASH_Pin,SET);
}
/*FUNTION OPEN BOILER HEATER*/
void OPEN_BOILER_HEATER(){
        lcd_clear();
        lcd_put_cur(0,1);
        lcd_send_string("HEATING BOILER");
        HAL_GPIO_WritePin(BOILER_HEATER_GPIO_Port,BOILER_HEATER_Pin,RESET);
}
/*FUNTION CLOSE BOILER HEATER*/
void CLOSE_BOILER_HEATER(){
        HAL_GPIO_WritePin(BOILER_HEATER_GPIO_Port,BOILER_HEATER_Pin,SET);
}
```

```
/*FUNTION OPEN TANK HEATER*/
void OPEN_TANK_HEATER(){
	lcd_clear();
	lcd_put_cur(0,2);
	lcd_send_string("HEATING TANK");
	HAL_GPIO_WritePin(TANK_HEATER_GPIO_Port,TANK_HEATER_Pin,RESET);
}
/*FUNTION CLOSE TANK HEATER*/
void CLOSE_TANK_HEATER(){
	HAL_GPIO_WritePin(TANK_HEATER_GPIO_Port,TANK_HEATER_Pin,SET);
}
/*FUNTION DISPLAY_TEMPORATURE OF BOILER*/
void DISPLAY_TEMPORATURE_BOILER(float Temp){
	char str[20] = {0};
	lcd_put_cur(1, 0);
	sprintf (str, "B:%.1f", Temp);
	lcd_send_string(str);
	lcd_send_data('C');
}
/*FUNTION DISPLAY_TEMPORATURE OF TANK*/
void DISPLAY_TEMPORATURE_TANK(float Temp){
	char str[20] = {0};
	lcd_put_cur(1,9);
	sprintf (str, "T:%.1f", Temp);
	lcd_send_string(str);
	lcd_send_data('C');
}
/*PRESS POWER BUTTON*/
void CHECK_PRESS_POWER_BUTTON(){
	lcd_put_cur(0, 0);
	lcd_send_string("PRESS P TO START");
	while(power_press ==0 ){
		UPDATE_TEMPERATURE();
	if(HAL_GPIO_ReadPin(POWER_GPIO_Port,POWER_Pin)==0){
```

```
            HAL_Delay(10);
        if(HAL_GPIO_ReadPin(POWER_GPIO_Port,POWER_Pin)==0 && power_press ==0){
            power_press=1;
}}}}
```

/*UPDATE TEMPERATURE OF BOILER AND TANK*/

```
void UPDATE_TEMPERATURE(){
        float a,b;
        a =TEMPORATURE_OF_BOILER();
        b =TEMPORATURE_OF_BOILER();
        if(a<150 && b <150){
            Temperature_boiler = a;
            Temperature_tank = b;
            DISPLAY_TEMPORATURE_BOILER(Temperature_boiler);
            DISPLAY_TEMPORATURE_TANK(Temperature_tank);}}
```

/*FUNTION CHECK WATER LEVEL BOILER AND TANK AND DOOR*/

```
void HAL_GPIO_EXTI_Callback(uint16_t GPIO_Pin){
        if(GPIO_Pin == WATER_LEVEL_BOILER_Pin){
        if(HAL_GPIO_ReadPin(WATER_LEVEL_BOILER_GPIO_Port,WATER_LEVEL_BOILER_Pin)==0){
            HAL_Delay(20);
        if(HAL_GPIO_ReadPin(WATER_LEVEL_BOILER_GPIO_Port,WATER_LEVEL_BOILER_Pin)==0
        && BOILER_FULL==0  ){
            CLOSE_VALVE();
            BOILER_FULL =1;}}}
        else if(GPIO_Pin == WATER_LEVEL_TANK_Pin){
        if(HAL_GPIO_ReadPin(WATER_LEVEL_TANK_GPIO_Port,WATER_LEVEL_TANK_Pin)==0){
            HAL_Delay(20);
        if(HAL_GPIO_ReadPin(WATER_LEVEL_TANK_GPIO_Port,WATER_LEVEL_TANK_Pin)==0     &&
        TANK_FULL ==0){
            lcd_clear();
            lcd_put_cur(0,4);
            lcd_send_string("TANK FULL");
            CLOSE_PUMP_RINSE();
            TANK_FULL =1;
            HAL_Delay(1000);}}}
        else if(GPIO_Pin == DOOR_Pin){
```

```
            DOOR =0;}
        else if(GPIO_Pin == RESET_Pin){
            resetSTM32();}
        else if(GPIO_Pin == MODE_STD_Pin){
            if(HAL_GPIO_ReadPin(MODE_STD_GPIO_Port, MODE_STD_Pin)==0){
                HAL_Delay(20);
                if(HAL_GPIO_ReadPin(MODE_STD_GPIO_Port, MODE_STD_Pin)==0){
                MODE =1;
                lcd_clear();
                lcd_put_cur(0,4);
                lcd_send_string("MODE STD");
            }}}
        else if(GPIO_Pin == MODE_HIGH_TEMP_Pin){
            if(HAL_GPIO_ReadPin(MODE_HIGH_TEMP_GPIO_Port, MODE_HIGH_TEMP_Pin)==0){
                HAL_Delay(20);
            if(HAL_GPIO_ReadPin(MODE_HIGH_TEMP_GPIO_Port,MODE_HIGH_TEMP_Pin)==0 ){
                MODE =2;
                lcd_clear();
                lcd_put_cur(0,4);
                lcd_send_string("MODE HIGH");
}}}}
/*FUNTION BUZZER*/
void SET_BUZZER(){
        HAL_GPIO_WritePin(BUZZER_GPIO_Port, BUZZER_Pin, SET);
        HAL_Delay(500);
        HAL_GPIO_WritePin(BUZZER_GPIO_Port, BUZZER_Pin, RESET);
```