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**Subject**

# Program Concrete Block Machine

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بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

*يَرْفَعِ اللَه الَذينَ آمَنُوا مِنكُمْ

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# General introduction

## Automation

Automation, the realm where human ingenuity converges with technological prowess, has become an integral component of modern society. It encompasses a diverse array of disciplines aimed at enhancing efficiency, productivity, and precision across various sectors. Among these, industrial automation stands as a cornerstone, revolutionizing manufacturing processes and shaping the landscape of global industries.

## Industrial automation

Industrial automation epitomizes the fusion of mechanical, electrical, and computer engineering principles to streamline production workflows and optimize output in manufacturing settings. At its core, it leverages advanced control systems, sensors, actuators, and programming algorithms to orchestrate complex tasks with minimal human intervention. From assembly lines to chemical plants, industrial automation permeates diverse sectors, catalyzing advancements in quality, safety, and cost-effectiveness.

Key components of industrial automation include programmable logic controllers (PLCs), supervisory control and data acquisition (SCADA) systems, robotics, and machine vision technologies. PLCs serve as the nerve center, executing programmed instructions to regulate machinery and monitor vital parameters in real-time. SCADA systems provide a centralized interface for operators to oversee entire production processes, facilitating data acquisition, analysis, and decision-making. Robotics, characterized by precision and versatility, perform tasks ranging from material handling to intricate assembly operations, augmenting productivity and flexibility on the factory floor. Machine vision systems harness the power of imaging technology to inspect, identify, and track components with unparalleled speed and accuracy, ensuring adherence to stringent quality standards.

The way things are made in factories has changed a lot because of industrial automation. It's brought in a new era called Industry 4.0. This change means that factories are now smarter. They use connections between machines, data to make decisions, and can even fix problems before they happen. This happens because of things like smart machines, the Internet, and computers working together. They make factories more flexible and efficient.

## Industrial automation in Algeria

In Algeria, industrial automation plays a crucial role in driving economic modernization and industrial growth. As the nation aims to diversify its economy and boost industrial competitiveness, adopting automation technologies becomes increasingly important. Algerian industries, including petrochemicals, automotive, and agro-food processing, are embracing automation to improve efficiency, ensure product quality, and meet changing market demands.

Government initiatives and investments highlight Algeria's commitment to creating an environment conducive to industrial automation. Programs focusing on skills development, technology transfer, research and development promote innovation and capacity-building in the automation sector. Partnerships with international stakeholders and technology providers strengthen Algeria's position in the global automation landscape, fostering knowledge exchange and collaboration.

Nevertheless, challenges persist in the widespread adoption of industrial automation in Algeria. Issues such as infrastructure limitations, workforce skills gaps, and regulatory hurdles require coordinated efforts from both public and private sectors to overcome barriers and fully harness the benefits of automation across industries.

## Industrial automation in Concrete block's making machine

In the ever-evolving landscape of construction and infrastructure development, the need for efficient and innovative solutions has become paramount. One area that has witnessed significant advancements is the automation and programmable control of concrete cutting and processing machinery. This project aims to address the challenges faced by the construction industry by introducing a state-of-the-art programmable concrete cutting machine.

Concrete, a ubiquitous material in modern construction, often requires precise cutting and shaping to meet the demands of intricate architectural designs and structural requirements. Traditional manual cutting methods not only pose safety risks but also lack the precision and consistency needed for high-quality results. Moreover, they are labor-intensive and time-consuming, leading to increased project costs and delays.

The programmable concrete cutting machine presented in this project offers a revolutionary solution by combining advanced programming techniques with robust mechanical engineering. Through intelligent software and control systems, this machine enables precise and automated cutting operations, ensuring unparalleled accuracy and repeatability.

By integrating cutting-edge programming methods, the machine can be seamlessly integrated into modern construction workflows, allowing for efficient planning, execution, and monitoring of concrete cutting tasks. This not only enhances productivity but also reduces the likelihood of human errors, minimizing material waste and rework.

Moreover, the programmable nature of the machine enables highly customizable cutting patterns and profiles, empowering architects and engineers to bring their most ambitious designs to life with uncompromising precision. This versatility opens up new possibilities for innovative and intricate concrete structures, pushing the boundaries of what is achievable in the construction industry.

In addition to its functional capabilities, the programmable concrete cutting machine prioritizes safety and environmental sustainability. By automating hazardous cutting operations, it minimizes the risk of accidents and injuries on construction sites. Furthermore, the machine's efficient operation and precise material utilization contribute to reduced waste and a lower environmental footprint.

## Industrial automation in our project

This project represents a significant leap forward in the integration of advanced programming techniques and automation in the construction industry. It paves the way for a more efficient, precise, and sustainable approach to concrete cutting and processing, revolutionizing the way we build our infrastructure and shaping the future of construction.

# Chapter 1

# Production process overview

## 1.1 General introduction

It's evident that concrete and its technology have evolved considerably since their conception 1.2. Starting with the construction of the Great Pyramids at Giza 1.1 and extending to the integration of smart sensors for monitoring concrete temperature, maturity, and other crucial aspects, the progress has been noteworthy.

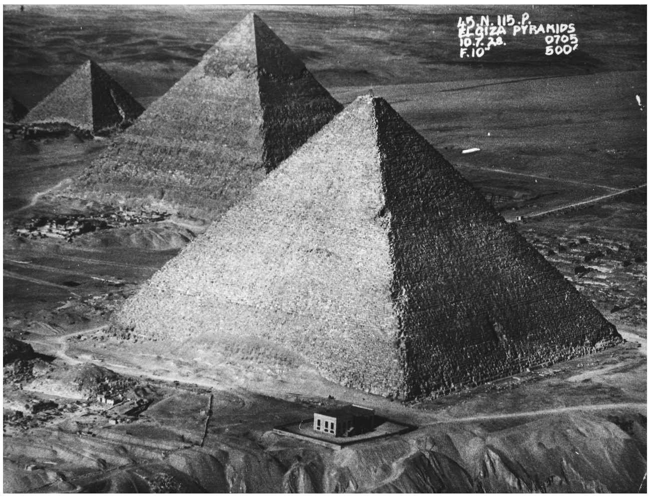


Figure 1.1: The Pyramids Giza Egypt, 1928 - The National Archives

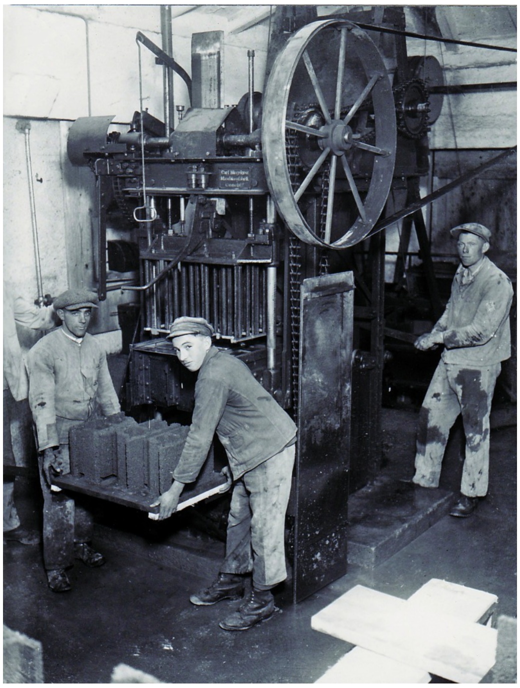


Figure 1.2: Concrete Plant Precast Technology

After Harmon Palmer's 1.3 invention of the first commercially successful concrete block machine in 1900 shown in the picture fig.1.4, the construction industry experienced a rapid expansion, with numerous manufacturers producing blocks featuring a stone-like surface achieved through molds or special aggregates in the concrete mix[21].


Figure 1.3: Harmon Sylvanus Palmer

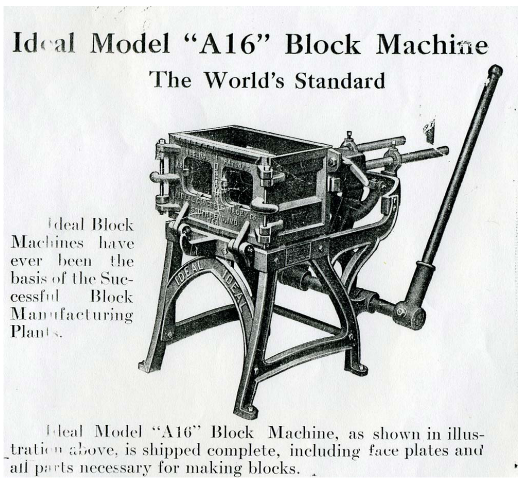



Figure 1.4: First concrete block machine

For centuries, construction relied on materials such as stone and wood, each with inherent limitations. Then emerged concrete, a versatile and durable material that revolutionized building possibilities. However, like any innovation, concrete required refinement, which gave rise to the concrete block machine, a technological marvel transforming raw materials into standardized, efficient building blocks.

In the 21st century, there's a big demand for new and eco-friendly building materials that don't harm the environment much. To keep up with this demand, we need to switch from the old-fashioned ways of making blocks and other building products to new, automated methods [1].

In our fast-paced city lives, we now need machines that can make products without causing pollution. These machines help make eco-friendly materials, keep costs low, speed up manufacturing, and give us good quality items at a reasonable price. That's why there's a growing need for automatic and eco-friendly fly as block-making machines.

Thanks to advancements in technology and automation, there is considerable potential for these fully automatic machines. "CMU" denotes Concrete Masonry Unit, a precast rectangular block standardized for various construction applications. Construction demands materials that are reliable, durable, and cost-effective.

CMUs not only meet these requirements but also offer ease of installation and flexibility in design and construction. In many respects, they represent the ideal material for construction endeavors[9].

## 1.2 Problem Definition

During the second semester of the 2023/2024 academic year, our team had the opportunity to visit the Block Factory. The factory management sought our assistance in addressing a particular task: the need for an automated solution for both the CHINA GUANGYAN BLOCK MACHINE and NOVA51 concrete block-making machines.

The main issue arises from forgetting or failing to remember the password for the PLC program controlling the first machine we mentioned. Additionally, malfunctioning HMI requiring program development.

Our project team has been entrusted with the task of developing the electrical and control components, utilizing a PLC controller.

This collaboration presents an exciting opportunity to innovate and implement cutting-edge solutions that will enhance efficiency and productivity within the factory. We are committed to delivering a robust and effective automated system that meets the unique requirements of the Block Factory.

## 1.3 Factory overview

BRIKCI BLOCK fig.1.5 is a company that specialized in the production of various kinds of concrete blocks designed for building processes.

Figure 1.5: companie logo

Created in 2005 with a surface of 1HA(10000 $m^2$) they relied on manual machines until they adopted automation in 2015.

There are two (2) managers who supervise the production within the production unit, the first one is a production manager and the second is an administrative manager.

There are seven (7) production workers. They gather the necessary materials and equipment, inspect finished products to detect defects, ensuring that quality standards are met.

For the storage there are 2 warehouses for trucks and forklifts, raw materials, and on-site machinery. The on-site machinery includes:

- concrete batching plant shown in the following picture fif.1.6

Figure 1.6: Concrete batching plant

- 2 concrete block machines: the fixed one CHINA GUANGYAN BLOCK MACHINE fig.1.7 (which is the subject of our thesis), and NOVA-51 fig.1.8 the mobile machine which we will use as a comparison with the first one.

Figure 1.7: CHINA GUANGYAN BLOCK MACHINE

Figure 1.8: NOVA-51 machine

## 1.4 What is concrete ?

Concrete as represented in this picture fig.1.9 is a composite material widely used in construction, formed by mixing cement, coarse, fine aggregates, and water, with or without the incorporation of admixtures, additives or fibers, which develops its properties by hydration.

Figure 1.9: Concrete

## 1.5 Principle of Press Machine

A press machine in the context of BLOCK making fig.1.10 refers to a device used to apply pressure to raw materials such as concrete or clay to form blocks of consistent shape and size. The pressing process is a crucial step in block manufacturing, as it ensures the compactness and integrity of the final product.

Figure 1.10: Press machine

Here's an explanation of the pressing process in BLOCK making:

1. Raw Material Processing fig.1.11: Ahead of the pressing process, the raw materials essential for block making fig.1.12, such as clay or concrete, are meticulously mixed and prepared to achieve the desired consistency and composition.

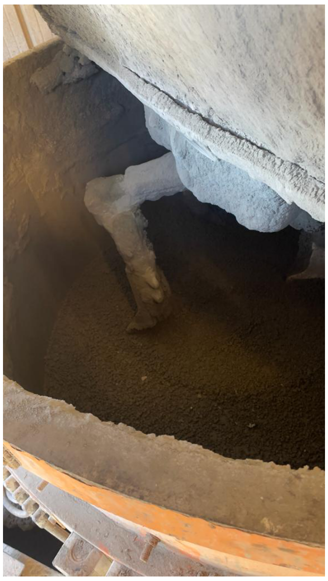


Figure 1.11: Mixing process

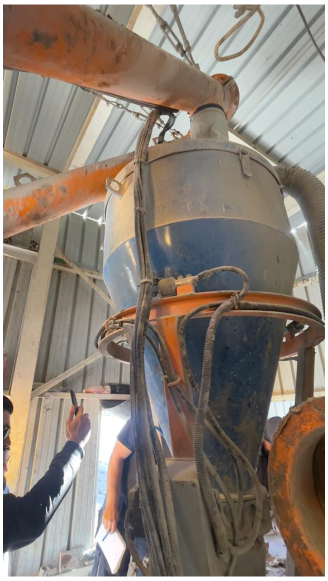


Figure 1.12: Container of the mixture

2. Loading the Press Machine: The prepared raw material mixture is placed into molds fig.1.13 or chambers within the press machine. These molds are often shaped according to the desired dimensions and design of the blocks being produced as we can see in the picture fig.1.14.

Figure 1.13: Mold

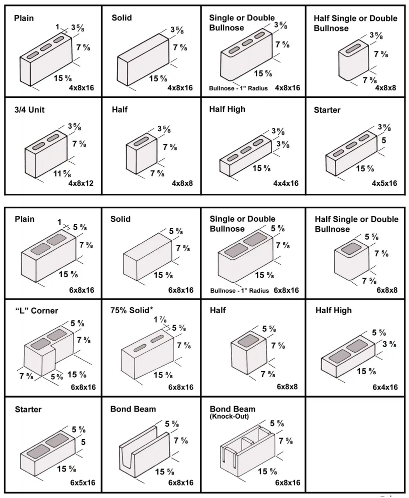




Figure 1.14: Diffrent dimentions and design of blocks

3. Application of Pressure: Once the raw material is loaded into the molds, the press machine applies pressure to compact the material and shape it into blocks fig.1.15. The amount of pressure applied depends on factors such as the type of material used and the desired density and strength of the final product.

Figure 1.15: the machine appliying pressure

4. Release and Removal: After the pressing process is complete, the pressure is released, and the newly formed blocks are removed from the molds. These blocks may then undergo further curing or drying processes fig.1.16, depending on the specific requirements of the manufacturing process.

Figure 1.16: transfer station

5. Quality Control: Throughout the pressing process, quality control measures are often implemented to ensure that the blocks meet the desired standards for strength, size, and appearance. This may involve monitoring the pressure applied, inspecting the finished products for defects, and adjusting the process.

Overall, the pressing process in block-making is a critical step that helps produce durable and uniform blocks suitable for various construction applications. Press machines play a key role in automating and standardizing this process, leading to efficient and consistent BLOCK production [1].

## 1.6 Concrete batching plant

Concrete Plants are the facilities where the raw materials such as gravel, sand, water and cement are balanced and mixed in certain proportions then ready-mix concrete is produced by Contractors.

The mixture produced by these plants is then transported to construction sites where it is used as a building material. [16]

Modern construction greatly benefits from these plants as they significantly save time. Concrete batching plants enable easy production of concrete, allowing for control over the concrete's consistency by adjusting the water content. Additionally, these plants are employed in the molding of block concrete.

## 1.7 Description of concrete batching plant on site (horpre central hormigon P500)

The mixers, automated to ensure consistency, are the heart of production, offering flexibility for various formulations. Its function is to mix all the ingredients that make up the concrete.

The mixing process is carried out for a certain period depending on the desired level of homogeneity.

### 1.7.1 Components of concrete batching plant

- Aggregate Hoppers sown in this picture fig.1.17: It is the area where raw materials such as sand, gravel, aggregate are stocked in ready mixed concrete production. There is a weighing band at the bottom.

Figure 1.17: Aggregate hoppers

- Aggregate dosing or weighing system fig1.18

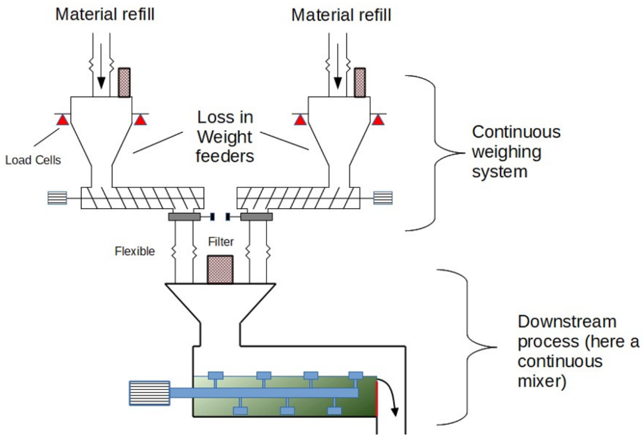



Figure 1.18: Aggregate dosing or weighting system

- Conveyor belt fig1.19 for the transport of aggregates.

Figure 1.19: Conveyor belt

- Cement silos: Cement silos fig.1.20 store cement for concrete preparation. Some plants also store fly ash. Silos come in welded or bolted types, with capacities like 45T or 120T.

Bolted silos are preferred for transport. Basic silos have inlet/outlet pipes, but options include filters and safety hinges. Our company offers silos in various capacities and sizes. Silos include features like filters, pressure relief valves, level indicators, and fluidizers.

Figure 1.20: cement silos

- Endless screw conveyor: The endless screw conveyor fig.1.22 directs cement from the storage silo to the cement weigher, which accurately measures the amount needed for the concrete recipe. After weighing, the cement is discharged into the batching plant's mixer fig.1.21.

Figure 1.21: Endless screw conveyor connected to the mixer

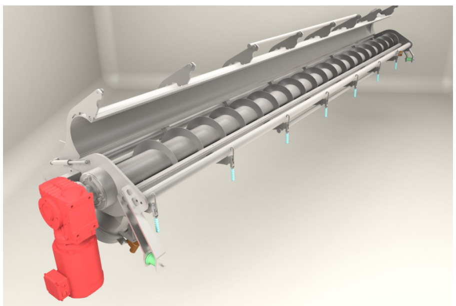


Figure 1.22: Endless screw conveyor structure

- Mixer:The primary function of the concrete mixer as shown in fig.1.23 is to blend all the ingredients of the concrete mixture thoroughly. This mixing process is crucial for achieving the desired level of homogeneity. The duration of the mixing process varies depending on the specific requirements and the desired consistency of the concrete.

Figure 1.23: concrete mixer

There are several types of concrete mixers, the most common are the following:

1. Mixer pan
2. PLANETARY mixer
3. Twin shaft mixer (TWIN SHAFT)
4. Continuous twin-shaft mixers

- Control System: The control system fig.1.24 acts as the central nervous system of the entire concrete plant. Typically, it comprises a fully automated system that, through programmed commands, oversees the precise dosing of aggregates, cement, water, and additives required for the correct mixture.

Figure 1.24: control system

Moreover , it regulates the mixing duration within the concrete mixer and manages the discharge process into concrete mixer trucks. This integrated control ensures the consistency and quality of the concrete produced, optimizing the efficiency of the entire operation.

## 1.8 Block Making Machines and Their Functions

### 1.8.1 Automatic Paver Block Making Machine

An automatic paver block making machine is a specialized piece of equipment used in the construction industry to produce high-quality paver blocks.

#### 1.8.1.1 Function and Purpose

These machines are designed to create paver blocks, which are commonly used for pathways, driveways, pavements, and outdoor flooring.

Paver blocks come in various shapes, sizes, and designs, enhancing the aesthetics of outdoor spaces.

#### 1.8.1.2 Types of Automatic Paver Block Making Machines

Fully Automatic Type: These machines operate with minimal manual intervention.

They handle the entire process, from raw material feeding to block production. Popular models include ABM-3S, ABM-4SE, ABM-6S, ABM-8S, ABM-10S, and ABM-12S.

Semi-Automatic Type: These machines require some manual input but still offer efficient production. Ideal for medium-scale production units.

Concrete Hollow Block Making Machine: Specifically designed for creating concrete and cement bricks.

By changing molds, you can produce bricks with different specifications and shapes

#### 1.8.1.3 Technical Specifications

- Hydraulic Hollow Block Making Machine: Operates using hydraulic transmission. It has features of: low noise, high production output, and compact bricks. Example specifications for the ABM-3S model:
- Hollow Bricks: 390mm × 190mm × 190mm (3 bricks per mold)
- Solid Blocks: 200mm × 100mm × 60mm (10 blocks per mold)
- Interlocking Bricks: 225mm × 112.5mm × 60mm (8 bricks per mold)

  Mechanical Type:
- Simple mechanical structures.
- Some noise during operation but reliable and easy to maintain.

#### 1.8.1.4 Applications

Paver block making machines are essential for large-scale construction projects.
They contribute to efficient and cost-effective block production.

In summary, automatic paver block making machines play a crucial role in modern construction, ensuring the availability of durable and aesthetically pleasing paver blocks for various applications.

### 1.8.2 Manual Block Making Machine

manual block making machine is a valuable tool used in the construction industry for producing concrete blocks [18]. there are some more details about this machine:

#### 1.8.2.1 Description:

Manual block making machines are also known as laying block machines or egg-laying machines.

They are highly professional machines used in construction areas,especially for producing concrete blocks and solid blocks.

Unlike other block-making methods, these machines create blocks directly on the ground without using pallets.

#### 1.8.2.2 Features:

Straight-Line Production: Manual block making machines produce blocks in a straight line on the ground.

Variety of Blocks: They can create different types of blocks, including hollow blocks, solid blocks, asmolen blocks, straphored blocks, and curbstone blocks.

High-Quality Design: Vess manual block making machines are thoughtfully designed for functionality and high-performance output.

Easy Operation: These machines are user-friendly, efficient, and durable.

Customization: They can produce customized concrete blocks according to specific requirements.

#### 1.8.2.3 Specifications

- Model: VESS 3.1
  - Total Engine Power: 3.2 kW
  - Min - Max Product Height: 18-20 cm
  - Daily Capacity (8 hours): 2,250 hollow blocks
  - Designed to Work 24 Hours: High production capacity with fewer employees.
  - Advantages:

1. Easy installation and maintenance.
2. Low noise with silent engine pumps.
3. Smooth surface due to fine aggregate.
4. Can produce various block types.

### 1.8.3 Hollow Block Making Machine

hollow block making machine as represented in this picture fig.1.25 is a remarkable piece of equipment used in the construction industry. It compresses concrete mortar into molds, creating concrete blocks through a combination of pressure and vibration.

These machines are widely employed for mass-producing hollow blocks, which are essential building components. [8]

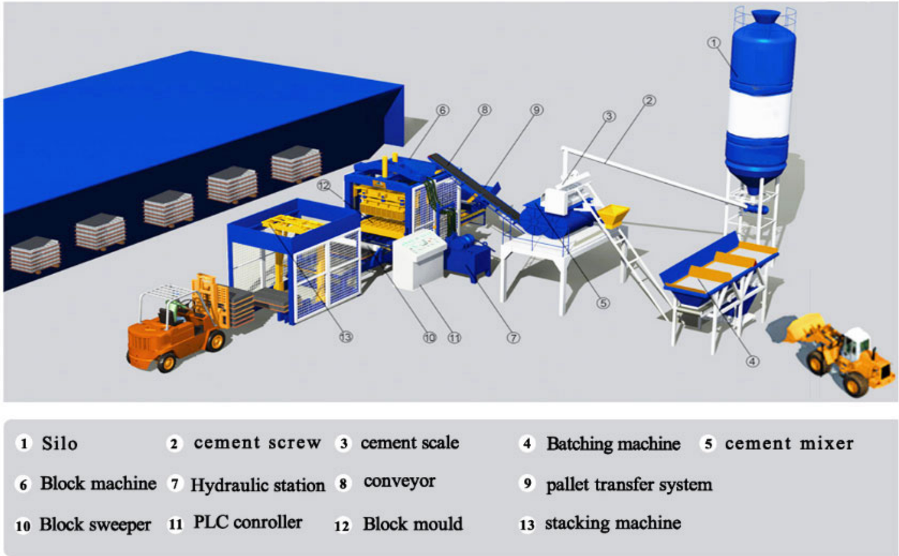



Figure 1.25: hollow block making machine

Here are some key points about hollow block making machines:

#### 1.8.3.1 Types of Hollow Block Machines

1. Fully Automatic Type: These machines operate automatically, producing hollow blocks with minimal manual intervention. Some popular models include ABM-3S, ABM-4SE, ABM-6S, ABM-8S, ABM-10S, and ABM-12S.

2. Semi-Automatic Type: These machines require some manual input but still offer efficient production.

3. Concrete Hollow Block Making Machine: Specifically designed for creating concrete and cement bricks. By changing molds, you can produce bricks with different specifications and shapes.

#### 1.8.3.2 Hydraulic and Mechanical Types

4. Hydraulic Hollow Block Making Machine:

   Operates using hydraulic transmission, resulting in low noise, high production output, and compact bricks.

Here are some specifications for different models:

- ABM-3S:

  Hollow Bricks: 390mm × 190mm × 190mm (3 bricks per mold)

  Solid Blocks: 200mm × 100mm × 60mm (10 blocks per mold)

  Interlocking Bricks: 225mm × 112.5mm × 60mm (8 bricks per mold)

- ABM-4S, ABM-6S, ABM-8S, ABM-10S, ABM-12S: Similar variations with varying capacities.

## 1.9 comparability of machines

### 1.9.1 CHINA GUANGYAN BLOCK MACHINE

GUANGYAN BLOCK MACHINE 1.7 is an automatic hollow block machine, a sophisticated system meticulously designed for the efficient production of concrete blocks.

Showcasing a range of essential elements, such as twin concrete hoppers for material feeding, an electric system ensuring smooth hopper door operation, and dual conveyor belts for material transportation and pallet ejection, this machine embodies precision and reliability.

Its hydraulic pallet distributor ensures swift and automated pallet loading, while a concrete cart, driven by an electric motor, incorporates a mixing system for consistent material distribution. With a dedicated color cart for precise color application and a hydraulic-driven mold for shaping blocks, the machine guarantees uniformity and quality in every block produced.

A hydraulic press ensures optimal compression, while a vibrating table enhances block integrity. Supported by a dependable hydraulic pump and a forklift for material handling, the GUANGYAN BLOCK MACHINE embodies efficiency and innovation.

Its operational process, from pallet placement to block ejection, shows seamless functionality, making it an indispensable asset in the concrete block production industry.

Figure 1.26: CHINA GUANGYAN BLOCK MACHINE

Statement of work

1. Introduction:

This document specifies the requirements for a pressing machine used in concrete block production. The machine's purpose is to efficiently compress and shape concrete mixtures into uniform blocks blocks using hydraulic pression and vibration.

2. Functional Requirements:

- The machine consists of 12 motors: 8 electric motors and 2 hydraulic pump motors, along with 2 hydraulic motors.
- Types of materials: Designed to handle concrete mixtures formed by mixing cement, coarse aggregates, fine aggregates, and water.

Concrete Transportation:

- 1st hopper with endless screw, motor, and contactor to feed concrete onto a conveyor belt.
- Conveyor belt moving by motor to transport the concrete to the 2nd hopper.

Concrete Distribution:

- 2nd hopper with operated door, 2 sensors, contactor, and relay to control concrete flow.
- Cart with 1 hydraulic cylinder, 2 sensors, distributor, and 2 relays to receive and distribute concrete.
- Mixer with motor, contactor, and relay to mix concrete as needed.

Molding:

- Pressing cylinder with 3-level sensors to compact concrete into the mold.
- Vibrating table with 2 hydraulic motors to vibrate and release formed blocks from mold.

Ejection:

Pallet distributor to position pallets to receive ejected blocks 4 colorpalettess to separate different block types/colors.

Pallet Conveyor:

Conveys pallets moving by the motor to handle the pallet with concrete blocks that are ejected by hydraulic cylinder to the transfer station.

Cycle time: 35 seconds for one full cycle.

3. Operation Sequence:

1) Start hydraulic pumps by pushing pump buttons (two pumps).
2) Concrete transported from 1st hopper to 2nd hopper via conveyor.
3) 2nd hopper door opens to load concrete into the cart.
4) Cart distributes concrete into the mold.
5) Pressing cylinder compacts concrete in the mold.
6) The vibrating table activates to release the formed block.
7) Released block is transferred to pallet distribution.
8) Pallet distribution:
   - Call pallet conveyor.
   - The pallet conveyor goes back to the starting position.
   - Pallet conveyor advances to receive block.
   - Block placed on pallet conveyor.
9) Pallet conveyor transports block to end position triggering limit switch.
10) Transfer station receives a block from pallet conveyor.

4. Control System and User Interface:

- Control System Architecture:

- PLC: Siemens S7-200 series.
- HMI: Weintek MT6071iP with 7" TFT color touchscreen display.
- The HMI will serve as the central operator control panel.
- Communication between PLC and HMI via serial connection (RS-232 or RS-485).

User Interface:
- 7" 800x480 resolution TFT color touchscreen display.
- Allows operator to view machine status, alarms, and production data.
- Ability to start/stop the machine, and adjust settings via touchscreen.
- Data logging capabilities for production tracking.

Connectivity:
- USB port on HMI for program uploads/downloads.
- No remote monitoring/control connectivity specified.

### 1.9.2 NOVA-51 machine

NOVA-51 shown previously in this picture fig.1.8 is an automatic concrete block-laying machine

#### 1.9.2.1 Principle of Operation

- Movement of the machine to the laying position.
- Molding with a press and 4 electric vibrators.

#### 1.9.2.2 Description of the electrical equipments

- The electrical equipment automates the movements of the machine.
- The machine is equipped with an electrical cabinet where protection and control elements are located, as well as the programmable controller.
- All control components are powered at 24V AC or 12V DC. Two separate transformers are therefore included in the cabinet, each equipped with its corresponding rectifiers to reduce and rectify the current suitable for each component.
- The operation of the motors is carried out using contactors, and they are all protected by their corresponding thermal-magnetic circuit breakers.
- The latter must be adjusted at the startup of the machine to prevent disconnections in case their setting is too low.

#### 1.9.2.3 Description of the hydraulic equipments

- The electrical power of the motor is converted into hydraulic energy in the pump and then distributed to the work locations through the hydraulic circuit.
- The generating element is the pump, and the receiving elements are cylinders. The distribution system is located between the generator and the receiver.
- The oil tank is integrated into the machine's chassis with a capacity of 140 liters.
- The gear pump is to the right of the tank, connected to the motor by the top of the elastic coupling. Its connection to the tank is made through the suction hose, and the connection to the distributor is done through the hose, with a safety valve set at 180 bars interposed between them.

### 1.9.3 3036 CONCRETE BLOCK MACHINE

In addressing high production demands within budget constraints, the 3036 concrete block machine fig.1.27 represents the pinnacle of modern multi-layered production systems. Its innovative design has made significant strides in recent industrial history.

Figure 1.27: 3036 CONCRETE BLOCK MACHINE

#### 1.9.3.1 Key Features

1. Enhanced Pallet Design: Unlike single-layer machines that rely on pallets susceptible to vibration and moisture damage, the 3036 features robust pallets designed to withstand abrasive conditions without compromising product integrity.

2. Optimized Pressing Process: Before each press, a layer of sand is strategically applied to prevent product adhesion, facilitating seamless stacking and drying on forklift-compatible pallets.

3. Efficient Product Handling: Dried products are easily transferred to shipping pallets using various holders, while emptied production pallets are promptly cycled back into the machine for subsequent casting, streamlining the production process.

#### 1.9.3.2 Benefits

1. Reduced Pallet Requirements: The 3036 necessitates only 10 of the pallets required by single-layer machines, resulting in a remarkable 90 reduction in handling time and effort.

2. Cost-Effective Solution: Considering its unparalleled productivity and modest investment cost, the 3036 stands as the most economically viable option for high-volume projects in the industry.

The 3036's multi-layered production capabilities redefine efficiency and cost-effectiveness, making it a cornerstone solution for meeting demanding production needs without compromising quality[14].

#### 1.9.3.3 Technical specifications

| | |
|---|---|
| Merkon 3036 | full automatic |
| Production time | 20 Sn |
| Pallet size | 1150x1300 |
| Mold (production area) | 1m2/ 1.2m2 |
| Minimum product height | 60 mm |
| Maximum product height | 300 mm |
| Total power | 60 Kv |
| Main hydraulic servo motor | 150 Nm |
| Main hydraulic motor | 7.5 Kw |
| Main vibrator | 2 x18 Kn |
| Top vibrator | 1 x 18 Kn |
| Operating pressure | 180 Bar |
| Vibrator Table control | lazer |
| Pallet dispenser capacity | 10 units |
| rough table body | 1800 x 1600 x 20 mm |
| Thin table body | 800 x 1600 x 20 mm |
| Pallet stacking robot control | sensor |

Table 1.1: Technical spesifications of the 3036 CONCRETE BLOCK MACHINE

norms
Building construction machinery and equipment (ISO 19711-1:2018)

## 1.10 Industrial maintenance

Industrial maintenance ensures the reliability and longevity of equipment, machinery, and facilities in industrial settings. It aims to prevent breakdowns, reduce downtime, optimize performance, and meet safety standards. Essential for operational efficiency and profitability in manufacturing and processing industries [14]

industrial maintenance include:

- **Preventive Maintenance (PM)** Scheduled inspections, lubrication, cleaning, and routine servicing to prevent equipment failures and minimize downtime. Follows manufacturer guidelines and best practices to identify and address potential issues before they escalate.

- **Corrective Maintenance**

  Reactive repairs and troubleshooting performed in response to unexpected equipment failures or malfunctions. Focuses on restoring equipment to operational status as quickly as possible to minimize production disruptions and losses[22].

- **Maintenance Costs**

  Maintenance costs include expenses incurred during equipment downtime, preventive maintenance software and tools, replacement parts, and spare parts inventory management. These costs include production losses, idle labor costs, missed targets, impact on customer satisfaction, investment in preventive maintenance software, expenses for replacement parts, and spare parts inventory management expenses. Efficient management of these costs is crucial for minimizing downtime and ensuring efficient operation.

- **Predictive Maintenance (PdM)**

  Relies on data analysis and condition monitoring techniques to predict when equipment failure is likely to occur. Using sensors, monitoring systems, and predictive analytics to identify early signs of deterioration or abnormalities, allowing for timely intervention before major breakdowns occur[12] .

# Chapter 2

# Process Description and Analysis

This chapter explores the essential components required for the process, including controllers, actuators, feedback systems, and hydraulic motors.

## 2.1 Technical presentation

### 2.1.1 CHINA GUANGYAN BLOCK MACHINE

- Concrete Belt Conveyor ( Conveyor system )

  The concrete conveyor system incorporates a container with a belt conveyor, as shown in figure 2.1, engineered to accommodate a capacity of 2000 kg. Powered by a motor that has 1.7kw and a rotation speed of 1200 RPM connected to an endless screw as shown in figure 2.2, the system ensures the smooth transportation of the concrete mixture.

Figure 2.1: 1st container

Figure 2.2: endless screw

The conveyor's angle is about 20° to allow reaching the second container without colliding with the different in-between obstacles, the belt is 7.7 meters in length and 0.45 meters in width and transfers the prepared concrete mixture to a second container with a capacity of 700 kg This design guaranteeing a consistent transfer of materials.

- Concrete distribution

  Following the discharge of the concrete mixture into the second container as shown in figure 2.3

  the concrete cart initiates the transfer of its contents into the mold. This process is actuated by a motor connecting rod that is used to open and close the container door. The motor's operation is detected by two Inductive Proximity Sensors (PNP) that are directly connected to a contactor, which, in turn, is controlled through a safety relay.

Figure 2.3: Concrete distribution

Furthermore, the movement of the concrete cart is driven by a hydraulic cylinder. This hydraulic system is equipped with two Inductive Proximity Sensors, strategically positioned to ensure efficient and precise movement. To control the flow and direction of the hydraulic system, there are distributors incorporated into the hydraulic control line.

The types that are used are 4/3 (This writing means that this dispenser therefore has 4 ports, and there are 3 solutions to connect them (3 positions) ), and 1/8 solenoid directional valves as shown in figure 2.4.

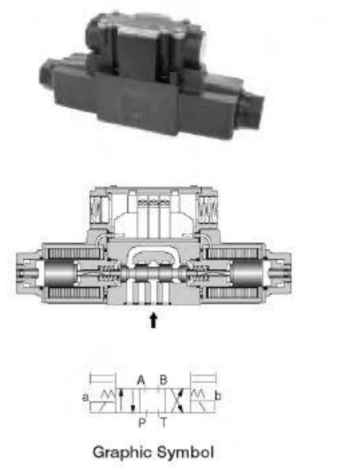



Figure 2.4: Solenoid directional valves

The motor's rotation is transferred through the chain as shown in figure 2.5, which is guided by bearings for smooth operation. As the motor turns, the connecting rod converts this rotational motion into linear motion, propelling within the mixing system, to uniformize concrete distribution in the mold.

Figure 2.5: Timing chain that connects the motor with the mixing cart

- Molding

  Following the concrete cart's transfer of its contents into the mold, two hydraulic motors, actuating with a vibrating table, compress the concrete within the mold. The synchronized operation of the hydraulic motors ensures uniform pressure distribution, while the vibrating table enhances consolidation. This integrated system guarantees effective compaction and superior quality of the concrete product as shown in figure 2.6.

Figure 2.6: Molding process

- Ejection

  The block is positioned on a pallet designed for transporting items between locations, then directed by a distributor and conveyed through a conveyor system.

  A double-acting hydraulic cylinder ejects as shown in figures 2.8 2.7 the block from the pallet, ensuring precise control. Once freed, the block travels to the transfer station

Figure 2.7: hydraulic cylinder

Figure 2.8: hydraulic cylinder

- Transfer station

The transfer station is equipped with two motors and sensors, facilitating the management of up to 12 pallets, with 4 pallets stationed on the iron rack at any given time. Vertically-driven by the motors, each pallet can accommodate 5 blocks. The transfer station operates with linear movement and includes storage for transfer operations shown in figure 2.11.

The conveyor pallet, measuring 2.5 meters in length, is driven by a motor. A limit switch sensor is strategically placed to detect pallet arrival at the conveyor's end as shown in figure 2.10.

Figure 2.9: transfer station

Figure 2.10: limit switch

Figure 2.11: Storage for Transfer Station

### 2.1.2 Electrical Design

### 2.1.3 Electrical and Control Component

This subsection will discuss all the electrical components mentioned before and their general use.

#### 2.1.3.1 Controller (PLC)

A programmable Logic Controller (PLC) is a controller designed for industrial use forautomatede machines because it can be used under harsh environment such as high temperatures and dusty conditions.

The chosen PLC for this project is Siemens PLC S7-200 as shown in figure 2.12


Figure 2.12: PLC

The S7-200 PLC executes its tasks in a scan cycle following these steps:
[19]

- Reading the Inputs

  Digital inputs: The scan cycle begins by reading the current value of digital inputs and writing these values to the process-image input register.

  Analog inputs: Analog inputs from expansion modules are updated during the scan cycle if analog input filtering is enabled.

  The filtered value is updated once per scan cycle if filtering is enabled. Analog inputs AIW0 and AIW2 on the CPU 224XP are updated every scan cycle with the most recent result from the analog-to-digital converter.

- Executing the Program

  The PLC executes the user's program, starting with the first instruction and proceeding to the end instruction. Immediate I/O instructions provide access to inputs and outputs during program execution. Subroutines and interrupt routines are stored as part of the program and executed when called.

  Figure 2.13 [4]depicts the flow of a typical scan including the local memory usage and two interrupt events, one during the program–execution phase and another during the communications phase of the scan cycle

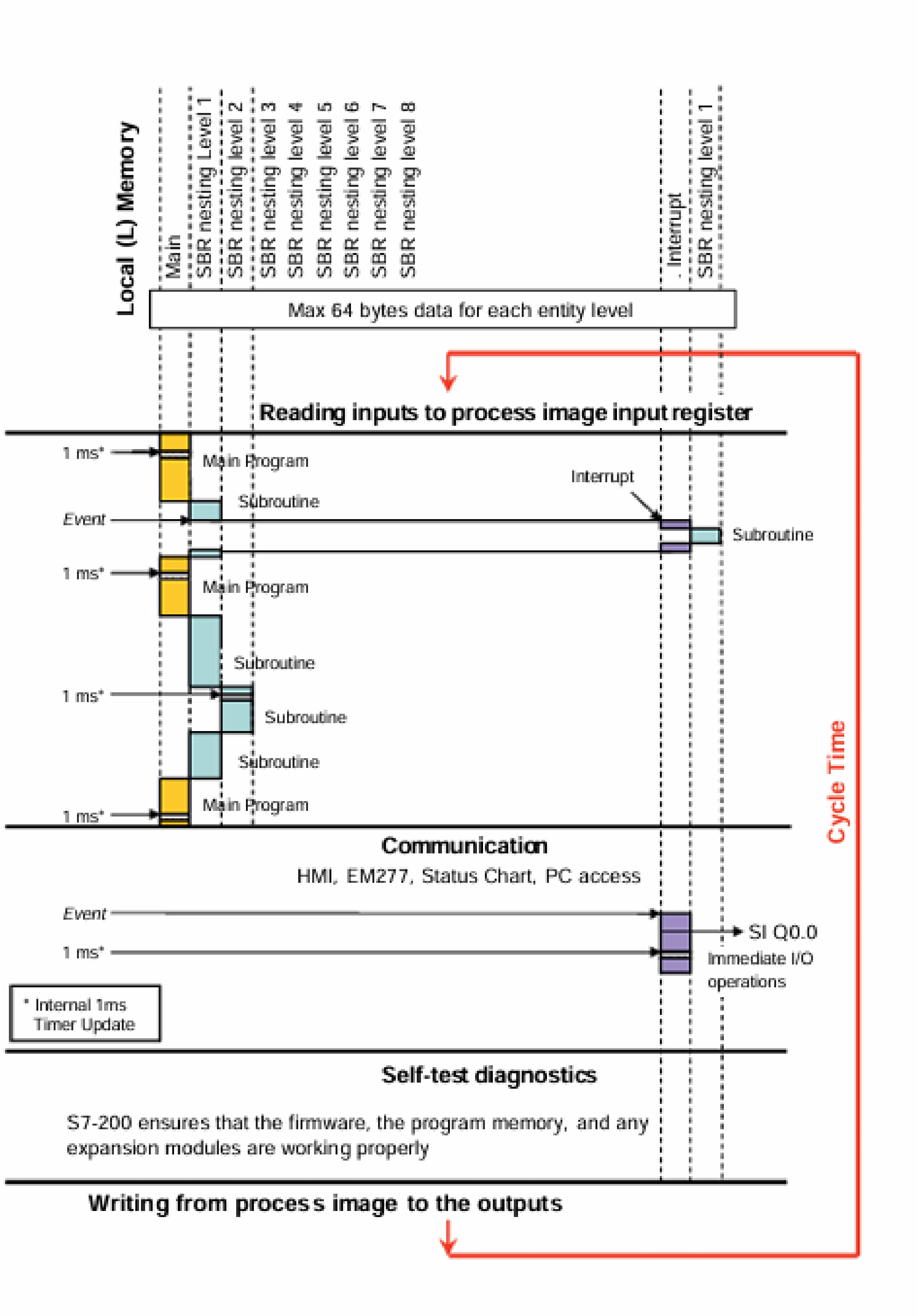



Figure 2.13: Typical scan Flow

- Processing Communications Requests

  The PLC processes any messages received from the communications port or intelligent I/O modules during the message-processing phase of the scan cycle.

- Executing CPU Self-test Diagnostics

  The PLC checks for proper operation of the CPU and the status of any expansion modules during this phase of the scan cycle.

- Writing to the Digital Outputs

  At the end of every scan cycle, the values stored in the process-image output register are written to the digital outputs. Analog outputs are updated immediately and independently from the scan cycle.

**Pulse Width Modulation** (PWM)
PWM is a technique used to adjust the power supplied to an electrical device by rapidly switching the signal on and off at a high frequency. This method allows for variable control of the device's parameters without sacrificing its operating ability. The average voltage of the signal changes as the relative on-time of the signal increases or decreases 2.14.

The cycle time and the pulse width in either microsecond or millisecond increments:

- Cycletime: 2 ms to 65.535 ms or 10 $\mu$s to 65,535 $\mu$s

- Pulsewidth time : 0 ms to 65,535 ms or 0 $\mu$s to 65,535 $\mu$s

- The output voltage Vout = Vmax * duty cycle

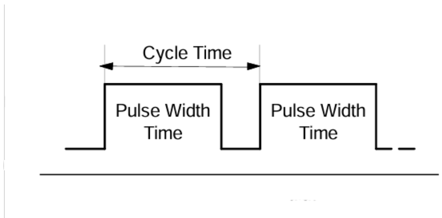



Figure 2.14: Pulse Width Modulation (PWM)

Key parameters of PWM include the frequency of the switching, which depends on the load device's response rate, and the duty cycle, representing the relative amount of time the signal is on expressed as a percentage. The duty cycle dictates the power provided to the load: a higher duty cycle means more power, while a lower duty cycle means less power.

PWM finds applications in various fields such as battery charging for electric vehicles and solar panels, where precise control of power transmission is crucial. In Variable Frequency Drives (VFDs) for 3-phase AC motors, PWM is utilized to control motor speed by varying the frequency of the AC waveform.

Devices capable of generating PWM signals range from standalone controllers with analog inputs to microcontrollers with built-in PWM outputs. Implementation of PWM varies based on the device used and the application's specific requirements. Careful consideration of DC and AC applications, response speed, and power requirements is essential for effective PWM implementation across different load types [5].

#### 2.1.3.2 Human-machine Interface (HMI)

Human-machine interface (HMI) fig.2.15 is a discipline that focuses on designing and developing interfaces that enable effective communication and control between humans and machines, particularly in industrial and automated environments.

Figure 2.15: Human-machine interface (HMI)

In the automation industry, HMI plays a crucial role in facilitating smooth interaction between operators and complex systems, processes, and machinery.

HMI encompasses various components, including physical interfaces (such as control panels, displays, and input devices), software interfaces (like graphical user interfaces and visualization tools), and the overall design principles that govern their integration and usability.

These components are meticulously designed to ensure optimal user experience, efficiency, and safety.

The applications of HMI in the automation industry are far-reaching and diverse. One prominent application is in industrial control systems, where operators use HMI interfaces to monitor and control manufacturing processes, power plants, and other industrial facilities. These interfaces enable operators to issue commands, monitor parameters, and respond promptly to alarms or emergencies.

HMI also plays a crucial role in the design and operation of machinery used in manufacturing, robotics, and other automated processes. Well-designed HMI interfaces, such as control panels and input devices, allow operators to safely and efficiently operate and maintain these machines, ensuring optimal productivity and safety[3].

In the field of robotics and automation, HMI is essential for programming, operating, and maintaining robotic systems and automated production lines.

Effective HMI design facilitates seamless human-robot collaboration, improving overall productivity and safety while reducing the risk of errors. Process visualization and monitoring in industries such as chemical processing, oil and gas, and utilities heavily rely on HMI interfaces. These interfaces provide operators with real-time data and visual representations of complex processes, enabling them to track key parameters, identify issues, and make informed decisions promptly.

Furthermore, HMI interfaces are often designed to support maintenance and troubleshooting activities, providing technicians with access to diagnostic information, system status, and control functions to manage and repair automated systems efficiently.

Effective HMI design in the automation industry involves considering various factors, such as user experience, ergonomics, safety, and compliance with industry standards and regulations. By improving human-machine interaction, HMI contributes to increased productivity, efficiency, and overall system performance while ensuring operator safety and situational awareness[7].

#### 2.1.3.3 Circuit breakers.

A circuit breaker is a safety device designed to protect electrical circuits from damage by overcurrent. Explanation of how circuit breakers work

- Fault Detection: Circuit breakers detect when a fault occurs, such as an overload or short circuit.

- Interrupting Current: Circuit breakers interrupt the flow of electricity to prevent overheating, meltdown and possible fire.

- Arc Quenching: Enables arc quenching methods to extinguish arcs formed during interruptions.

- esettable and Reusable: Unlike fuses, circuit breakers can be reset and reused, making them more sustainable.

- Improved safety: Circuit breakers increase system safety by preventing equipment damage, fire hazards, and power outages[17].

### 2.1.4 Hydraulic system components

- Hydraulic Actuators: Hydraulic actuators convert fluid power into mechanical energy to perform useful work. Linear actuators (such as hydraulic cylinders) provide straight-line motion. Rotary actuators (like hydraulic motors) offer rotational motion. They can apply force, produce continuous rotary motion, or clamp objects [11].

- Hydraulic Pump: The heart of the system, the hydraulic pump, converts mechanical energy into hydraulic energy. Driven by a prime mover (like an electric motor), it creates a partial vacuum at its inlet. Atmospheric pressure forces fluid through the inlet line into the pump. The pump then pushes the fluid throughout the hydraulic circuit.

- Valves and Control: Valves control fluid direction, pressure, and flow rate within the circuit. Direction control valves determine the path of fluid flow (e.g., forward, return, or off). Pressure relief valves prevent excessive pressure buildup. Proper valve selection ensures efficient system operation[24].

- Fluid Reservoir and Filtration: The fluid reservoir stores hydraulic oil or fluid. It acts as a buffer, maintaining a constant supply for the system. Proper filtration is crucial to remove contaminants (dirt, debris, and particles). Clean fluid ensures optimal performance and prolongs component life[15].

## 2.2 HMI PROJECT

#### 2.2.0.1 Setting up communication between PLC AND HMI

PLCs fig.2.16 are industrial computers used to control and automate various processes and machinery in manufacturing, production lines, and other industrial environments. They are programmed to execute specific logic and control sequences based on inputs from sensors and other devices.


Figure 2.16: Programmable Logic Controller

HMIs are typically connected to PLCs fig.2.17 through communication protocols such as Ethernet, Modbus, or other industrial communication standards. This connection allows the HMI to receive real-time data from the PLC, including process variables, alarms, and status information.

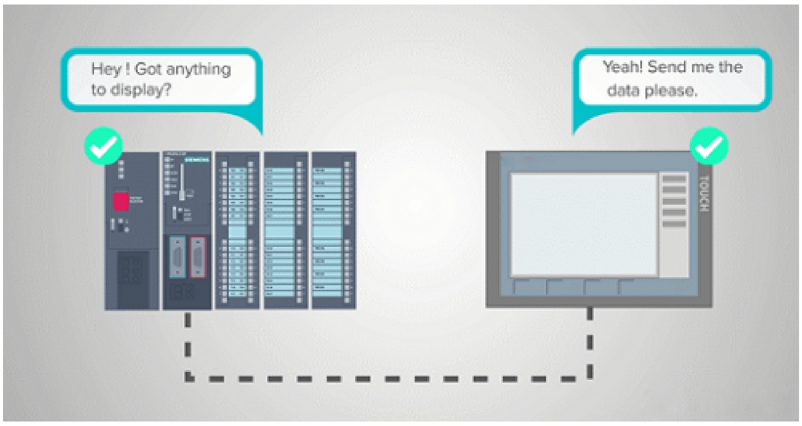



Figure 2.17: Connection between PLC and HMI

Setting Up Communication Between S7-200 PLC and HMI:

1. Power Up the S7-200 CPU:

- Connect the necessary power supply to the S7-200 CPU unit to ensure it is powered up.

2. Establish Communication:

- Use an appropriate communication cable to connect the programming device (e.g., PC) to the S7-200 CPU.

3. HMI Connection:

- Identify and connect the communication port on the S7-200 CPU to the corresponding port on the HMI device.

- Configure the HMI settings (baud rate, parity, etc.) to ensure proper communication with the S7-200.

4. Programming and Configuration:

- Utilize software like Siemens STEP 7 Micro/WIN to develop the program for the S7-200.

- Configure the HMI to display relevant information and map tags between the S7-200 and the HMI.

5. Testing and Troubleshooting:

- Download the program to the S7-200 and observe the HMI's response to test the communication link.

- Address any issues by checking cable connections, communication settings, and program configurations.

6. Pin Configuration:

- Connect the appropriate pins (e.g., RXD, TXD, GND) between the PLC and the computer or HMI using the specified DB9 connectors.

- Ensure resistors (5K-Ohm, 3K-Ohm, 680 Ohm) are included for optimal communication.

7. Software Configuration:

- Use software such as Siemens STEP 7 Micro/WIN to configure communication settings matching between the S7-200 and the HMI.

8. Further Testing and Troubleshooting:

- Test the communication link after connecting the pins and configuring the software.

- Monitor communication status and address any issues that arise promptly.

#### 2.2.0.2 Easy Builder Pro

In our project, we will be using EasyBuilder Pro fig.2.18, a powerful and user-friendly software tool designed specifically for creating Human-Machine Interfaces (HMIs).

Figure 2.18: Easy Builder Pro logo

EasyBuilder Pro is developed by Weintek, a leading provider of industrial automation solutions, and is widely used in various industries for its flexibility and ease of use.

EasyBuilder Pro is a comprehensive HMI development environment that allows us to design and configure intuitive and visually appealing user interfaces for industrial automation systems. With its rich feature set and extensive object libraries, we can create complex HMI applications tailored to our specific project requirements. One of the key advantages of EasyBuilder Pro is its ability to integrate seamlessly with a wide range of Programmable Logic Controllers

(PLCs) and other industrial devices. This integration is facilitated through support for various communication protocols, such as Modbus, Ethernet, and a variety of proprietary protocols, ensuring seamless data exchange between the HMI and the connected devices.

Using EasyBuilder Pro, we can design user interfaces that display real-time process data, alarm notifications, and system status information in a clear and organized manner. The software provides a vast array of graphical objects, including charts, gauges, and animations, which enable us to create visually appealing and informative displays.

Additionally, EasyBuilder Pro offers advanced features like recipe management, data logging, and reporting capabilities. These features are particularly useful in scenarios where we need to track and analyze historical data or manage different production recipes.

Throughout our project, we will leverage the powerful tools and features of EasyBuilder Pro to create an intuitive and efficient HMI that meets our specific requirements. With its user-friendly interface and comprehensive documentation, EasyBuilder Pro will enable us to develop a robust and reliable HMI solution that enhances the overall efficiency and productivity of our industrial automation system.

#### 2.2.0.3 EasyBuilder Pro in our project

EasyBuilder Pro is a fantastic tool for designing HMIs to connect people and industrial automation systems. With its simple interface, rich libraries, and customization abilities, we were able to build our project in a professional way.

first of all there are a more specefic description of this software and how we used it in our work:

1-main page: fig.2.19

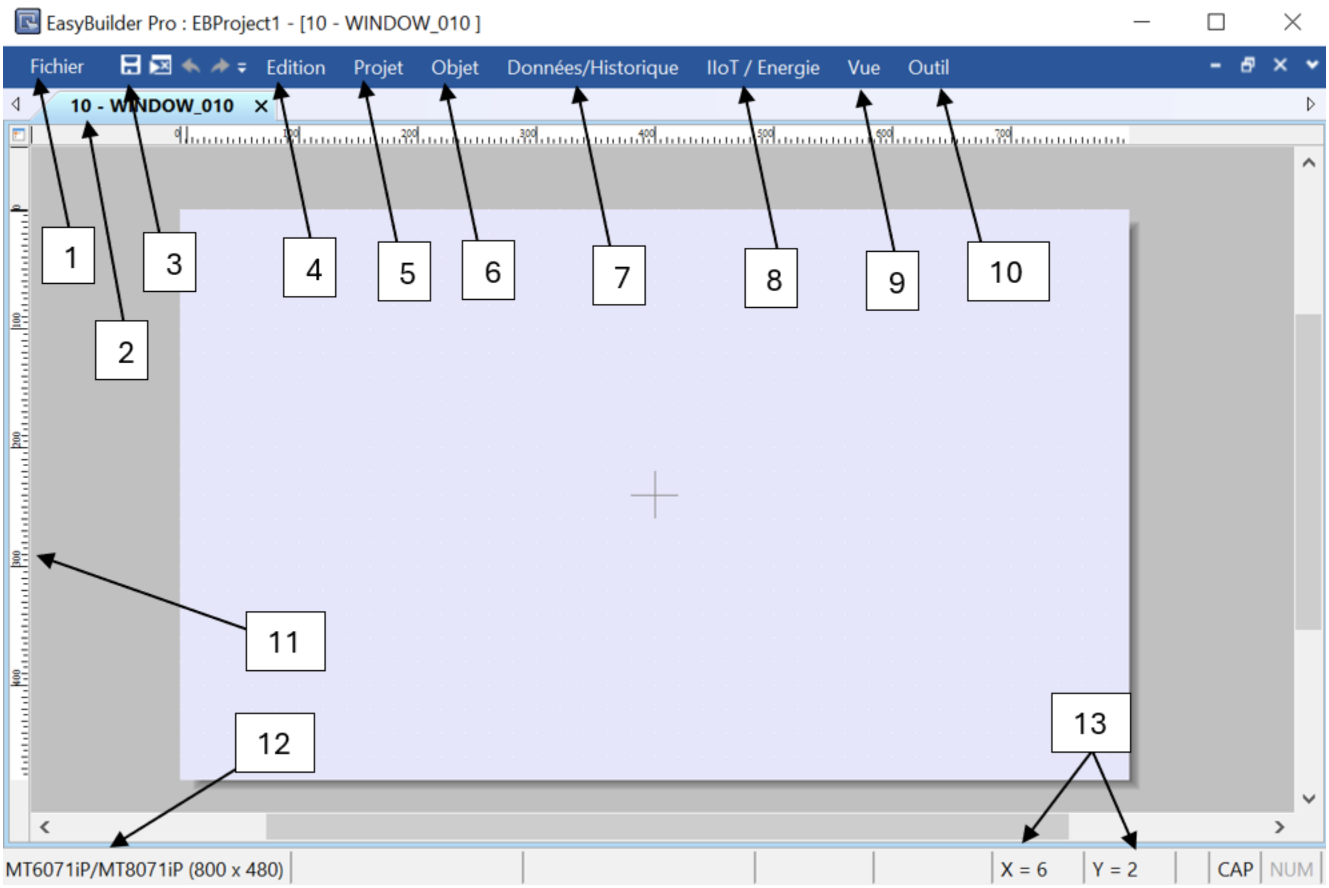



Figure 2.19: Main page in EasyBuilder Pro

1. File button: A button that allows you to open, save, or manage files in a software or application.
2. Main page in the work space.
3. Save button: A button that allows you to save any recent changes in the file.
4. Edit button fig.2.20: It refers to the function or action of modifying or making changes to a page within the software interface.
5. Project button fig.2.21: refers to a specific page or interface within the software where you can view or manage a project. This could include details about the project, its files, settings, or other related information.
6. Object button fig.2.22: It refers to a specific interface or area where you can view and manage individual graphical objects or components that make up the HMI, such as buttons, sliders, indicators, etc.
7. Data/History button fig.2.23: the "data" button provides access to features related to managing or displaying the data used in the HMI, while the "history" button is used to view or manage the history of actions performed in the software.
8. Station/ Energie button fig.2.24: is a feature related to managing or configuring energy-related settings or components in the software.
9. View button fig.**??**: It allows to switch between different viewing modes or perspectives within the software interface.
10. Tool button fig.2.26: It's a feature that provides access to various tools or functionalities within the software for designing or configuring HMIs.
11. Ruler: It's a tool for measuring and aligning objects in the interface, displayed as a horizontal or vertical bar with measurement units.
12. MT6071IP/MT8071I (800x480) : means that we have the option to choose between the MT6071IP model and the MT8071I model of this HMI, both of which have a screen resolution of 800x480 pixels.
13. X and Y: Is the position of the cursor or selected object on the horizontal (X) and vertical (Y) axes within the workspace.

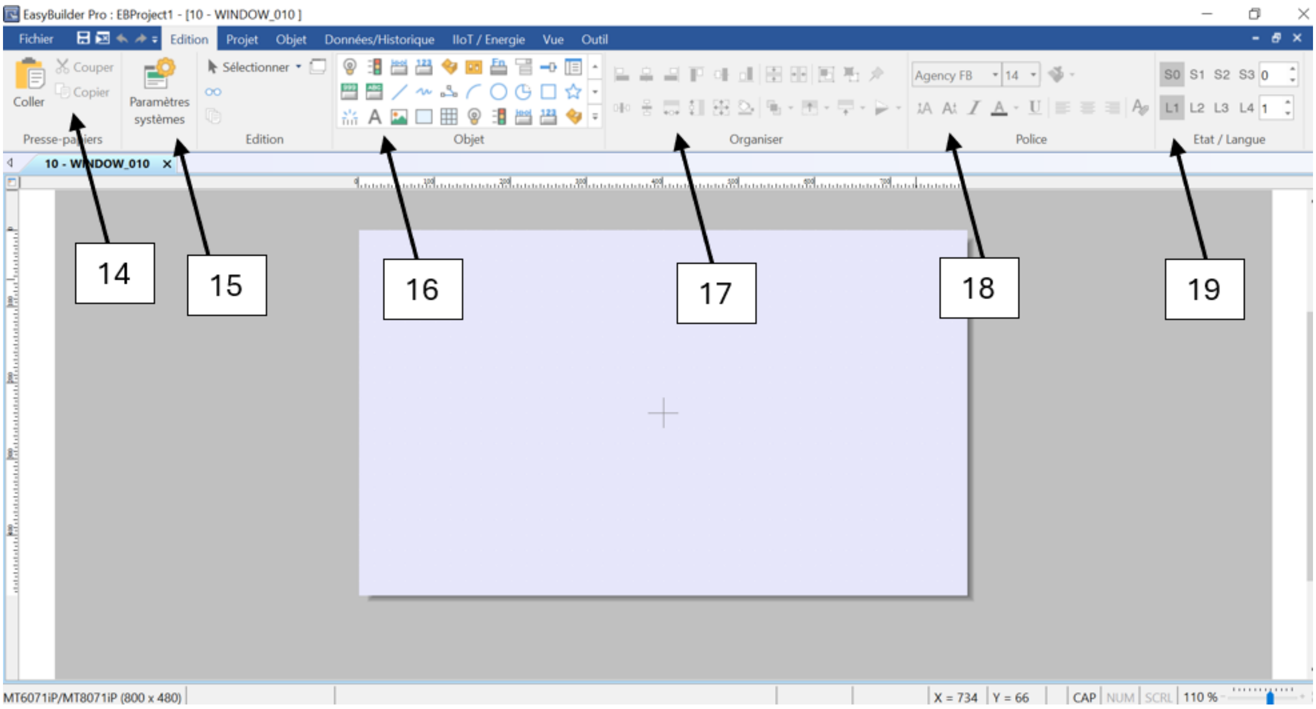



Figure 2.20: Edition page

14. Clipboard tab: refers to a feature that allows to copy, cut, and paste elements from one screen to another or within the same screen. This tab facilitates the management of graphical elements and their movement within the HMI design software.

15. System Parameters button: likely allows to access and configure various system settings related to the HMI device or the project being developed.

16. Object feature: It contains various types of buttons or graphical elements that you can use to build your HMI. These may include:

    -Standard Buttons: Such as push buttons, toggle buttons, radio buttons, etc.

    -Text Elements: Including text boxes, labels, numeric displays, etc.

    -Image Elements: For displaying images or icons.

    -Control Elements: Such as sliders, gauges, progress bars, etc.

    -Specialized Elements: Such as alarm indicators, trend charts, recipe displays, etc.

17. Organise feature: contains tool that allows to arrange and organize elements within the interface. This could include options for aligning objects, distributing them evenly, grouping items together, and managing the layout of your HMI design

18. Font feature: contains tool that allows you to select and customize the font properties for text elements within the interface. This button enables you to choose the font type, size, style, and other formatting options for your text.

19. Language/State feature: Enables to switch between different languages for the user interface or to configure language-specific settings for the HMI project.

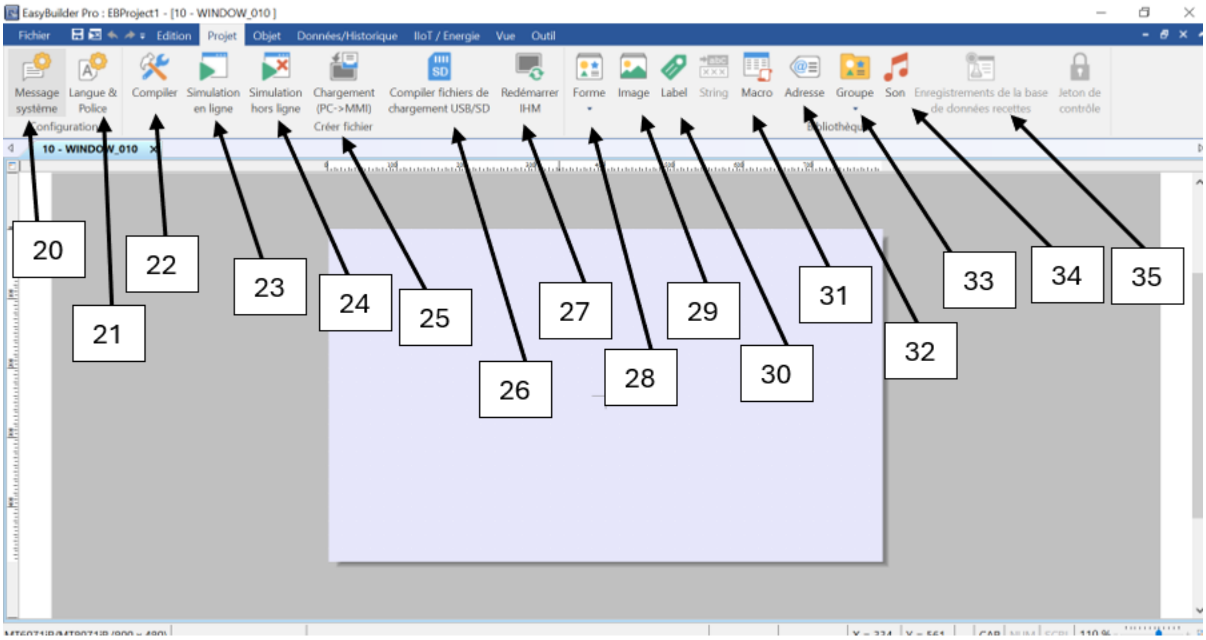



Figure 2.21: Project page

20. System message button: Is used for displaying system messages or notifications during programming. It provides feedback and alerts to the user, aiding in debugging and guiding the programming process.

21. Language and fonts button: It allows users to adjust the language settings of the interface and customize the font style or size for better readability, and enabling them to personalize their software environment according to their preferences.

22. Run button: is typically used to translate the visual programming or configuration created within the software into executable code that can be run on the target hardware.

23. Enline simulation button: allows users to simulate their programmed logic or application online, without using physical hardware, for testing and debugging purposes.

24. Offline simulation: enables users to simulate their programmed logic or application without an internet connection, typically for testing and debugging purposes.

25. UPload button: uploads data from a PC to an HMI.

26. Compile SD/USB loading files button: Is used to generate compiled files that can be loaded onto an SD card or USB drive. These files might include configuration settings, programs, or other data needed for the HMI or other devices to operate.

27. REstart HMI button: allows users to initiate a restart of the HMI device. This action can be useful for applying changes, troubleshooting, or resetting the HMI to its initial state.

28. Shape button: IT allows users to add shapes or graphical elements to their HMI, and enables them to enhance the visual layout of their HMI screens by incorporating shapes such as rectangles, circles, lines, or polygons. These shapes can be used for aesthetic purposes or to organize and highlight information on the interface.

29. Image button: allows users to incorporate graphical images into their HMI.

30. Label Button: allows users to create interactive text elements on their HMI screens. These buttons can display text and may be configured to trigger specific actions or events when clicked or activated, providing users with a way to interact with the interface through textual prompts.

31. Macro button: enables users to generate and execute custom sequences of commands or actions. These macros streamline workflow by automating repetitive tasks or executing complex operations with ease, enhancing productivity in HMI programming.

32. Adresse Button: likely refers to a feature that allows users to assign or configure memory addresses for various components or functions within their HMI.These addresses are crucial for communication and data exchange between different parts of the system, such as PLCs in our case.

33. Group button: a tool for organizing or grouping related elements or components within the user interface.

34. Audio button: allows users to add audio functionality to the HMI.

35. Recording of the recipes database button: save or store recipe data, such as manufacturing parameters or formulas, within a database for future use.( we wont use it in our project)

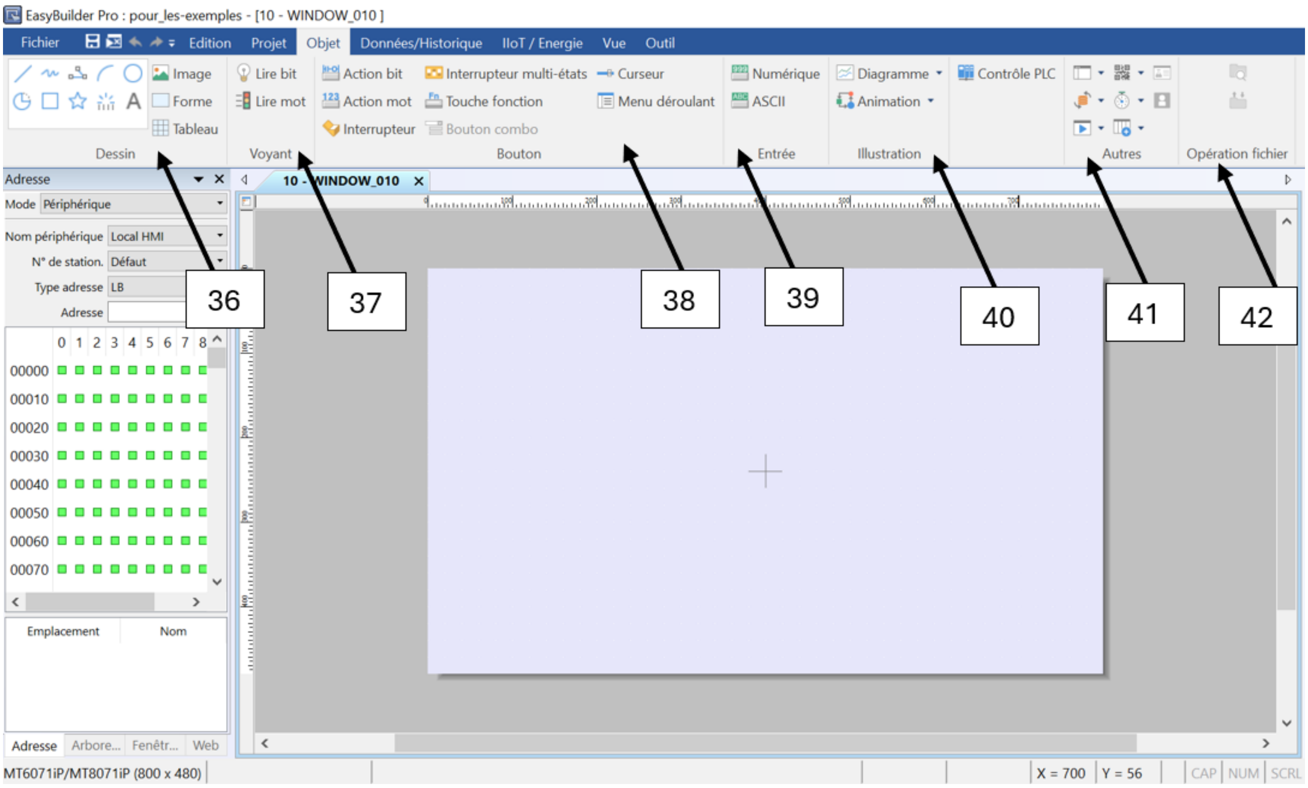



Figure 2.22: Object page

36. Draw button: is used for drawing custom buttons, icons, symbols, tables, or other unique visual elements without the need for external design tools or pre-existing images.

37. Indicator button: Allows to visualize the state of bits or words in an automated system, providing a clear and intuitive visual representation of this data.

38. Button feature: allows to add interactive buttons to the HMI. These buttons can be customized in terms of size, shape, color, text, and actions (such as linking to another page or triggering a specific event). They are commonly used for navigation, calls to action, or any other interactive elements.

39. Entry section: Is used for form submissions or for triggering specific actions when clicked.

40. Illustration section: Allows you to add custom buttons to your website, which can include diagrams and animations for interactive engagement

41. Other section: gives access to other features like inserting barcodes, timestamp, video etc.

42. operation folder: Allows to inport/ export folders.

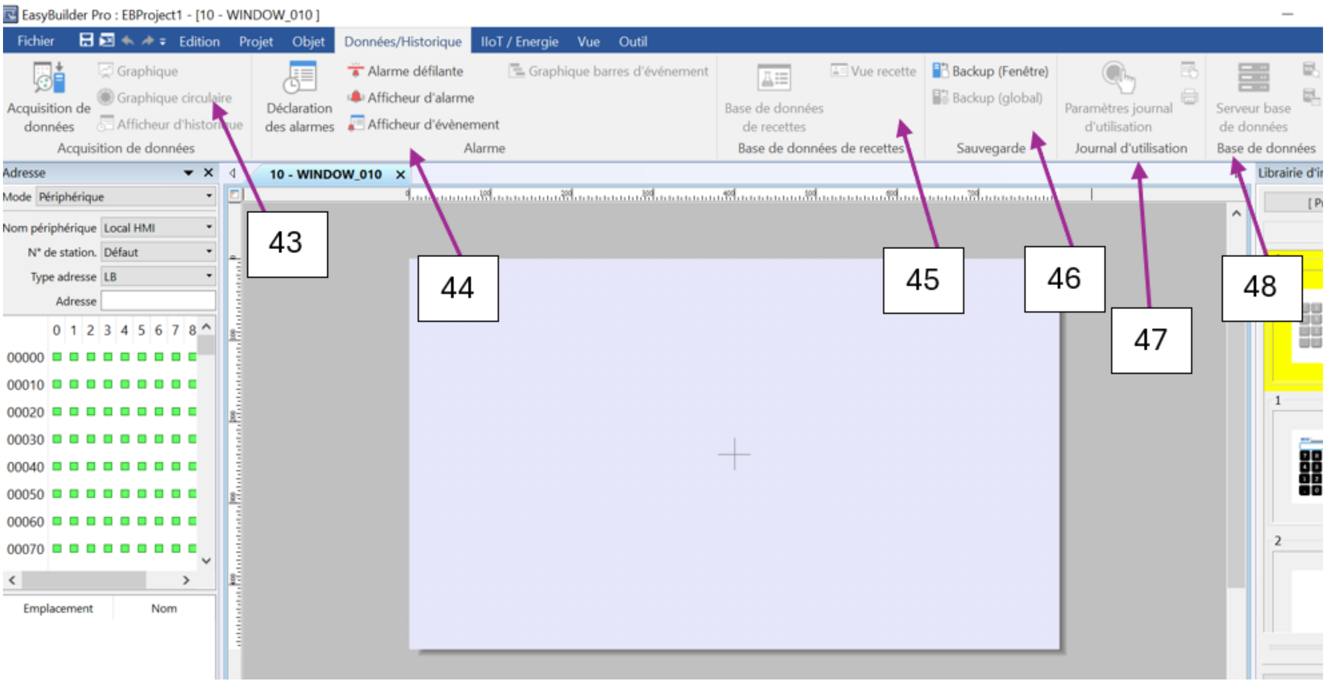



Figure 2.23: History/Data page

43. Data aquisition section: Is used to start or stop the data acquisition process, or trigger a specific action related to data collection.

44. Alarm section: set up and manage alarms to monitor conditions or events and get notified when thresholds are exceeded or conditions are met.

45. Recipe management functionality: Enables to create, organize, and display recipes on the HMI, it includes features like: Recipe Creation, Organization, Search and Filtering, Display, Interaction.

46. Save backup feature: Allows to create backups of the HMI, ensuring that the progress is preserved and protected.it's used regularly to safeguard our work against unexpected events like software crashes or data corruption.

47. Activity Log feature: records and displays user actions, providing a chronological history of project edits for easy reference, error detection, and navigation.

48. database functionality: It allows us to connect the HMI projects to server-based databases for data visualization, logging, and manipulation.

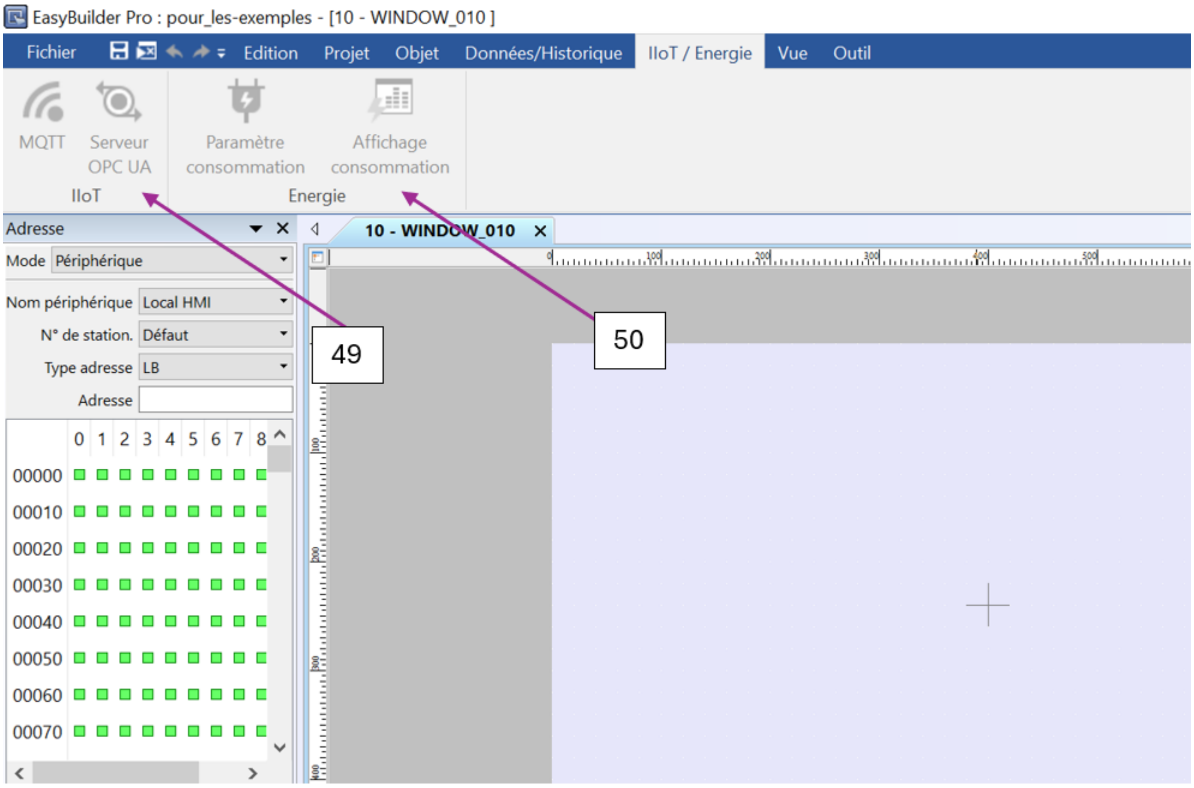



Figure 2.24: Energy Management page

49. - MQTT(Message Queuing Telemetry Transport): is a lightweight messaging protocol used for communication and exchange of data between devices.

    - OPC UA (Open Platform Communications Unified Architecture): is a standard communication protocol commonly used in industrial automation for exchanging data between various devices and software applications.

50. -consumption parameters: It refers to settings related to monitoring and managing energy consumption within industrial systems.

    -Consumption display:Is the display or visualization of energy consumption data within the HMI interface.

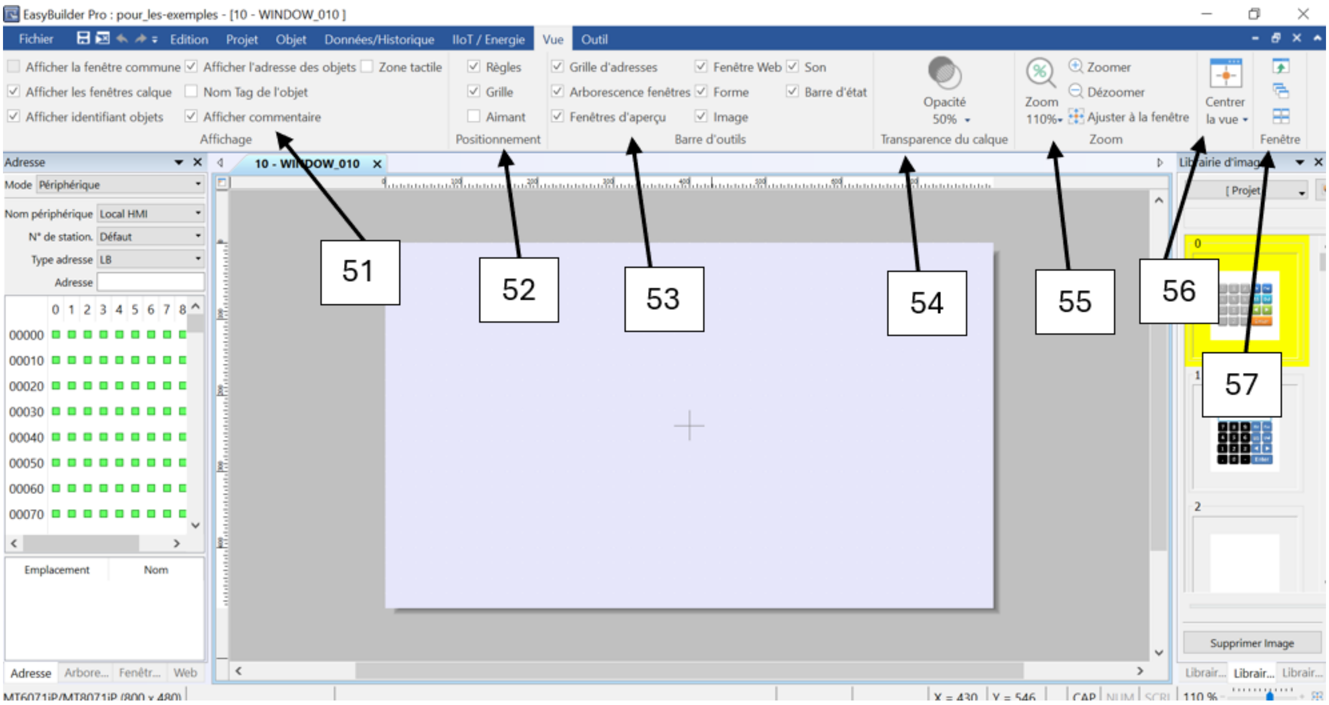



Figure 2.25: View page

51. Display feature: in EasyBuilder Pro encompasses tools and functionalities for designing and configuring the visual interface of HMI. This includes creating layouts, incorporating interactive elements, visualizing real-time data, customizing appearances, and ensuring smooth navigation for operators.

52. positioning and alignment of objects within the HMI, precisely place and arrange elements such as buttons, text, images, and other controls on the display screen.

53. toolbar functionality: Gives access to commonly used tools and commands, that allows for efficient navigation and workflow while designing HMI.It contains icons or buttons representing various actions such as adding components, configuring settings, and more.

54. allows users to adjust the transparency or opacity of layers within the HMI project.

55. zoom feature: Enables to magnify or reduce the display size of the HMI projects for easier editing and viewing. This functionality allows designers to focus on specific details or get an overview of the entire interface, enhancing precision and efficiency during the design process.

56. Center the view feature: Allows us to center the view within the HMI project workspace. This functionality is useful for quickly repositioning the viewport to the center of the design canvas, making it easier to focus on specific elements or navigate around the project.

57. Window feature: Allows us to open, close, resize, arrange, and switch between different windows or views within the application.

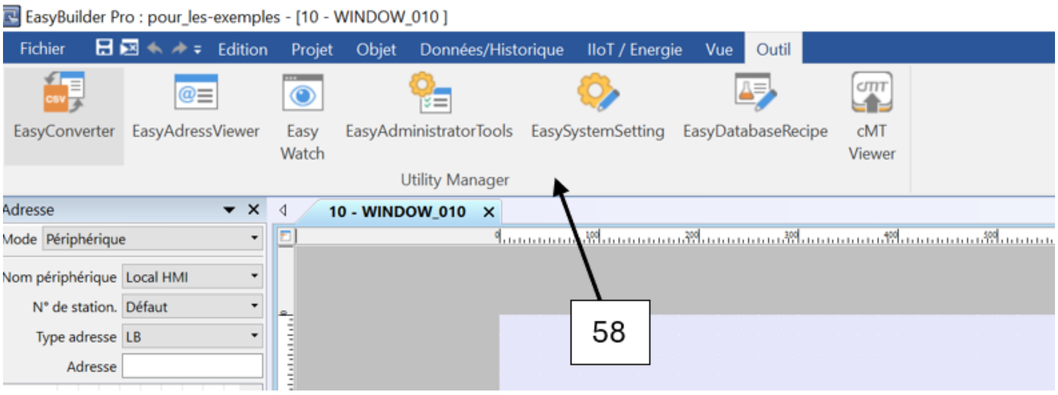



Figure 2.26: Outil page

58. Utility manager feature: Allows us to manage various utilities or auxiliary functions related to the HMI, like configuring communication settings, managing project files, handling backups, setting up security options, and performing other administrative tasks.

#### 2.2.0.4 HMI PROJECT

In this part we'll talk about the key features and functionalities of our HMI system, explore and explain its design principles and considerations, demonstrate its functionality through demonstrations, and discuss the benefits it brings to our organization.

this picture below fig.2.27 represents the main page of our HMI.

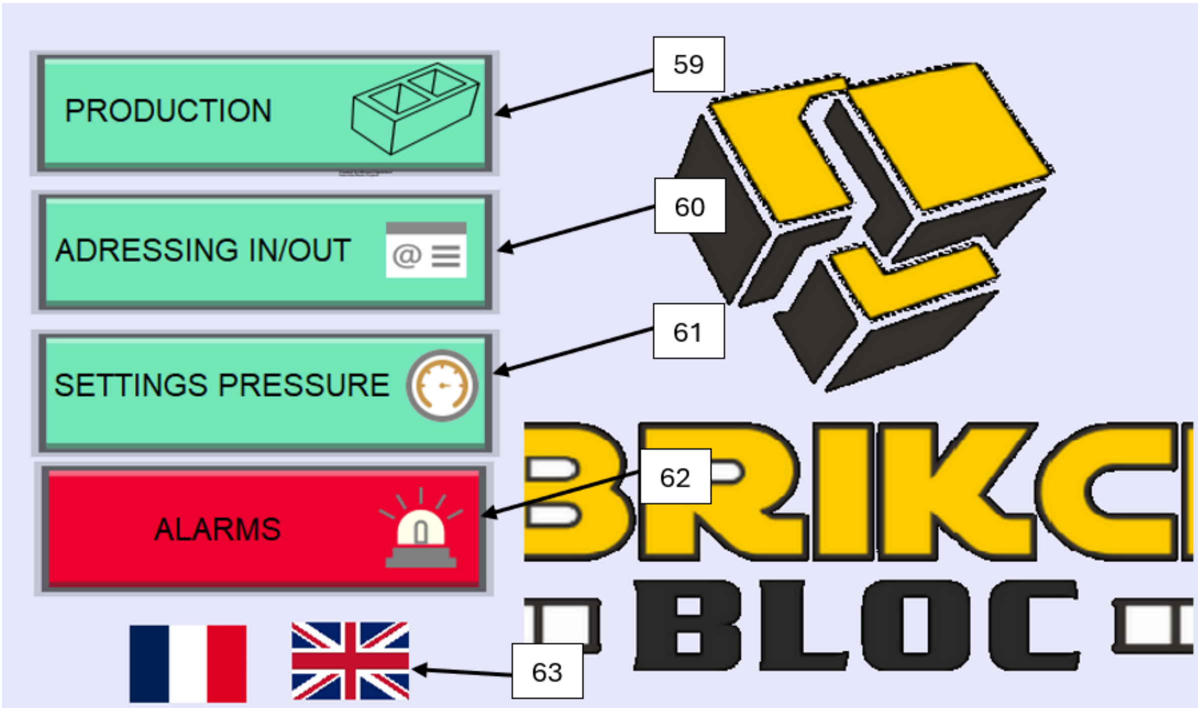



Figure 2.27: MAIN PAGE OF THE HMI

59. PRODUCTION fig.2.30: this button allows us to access the production process.

60. ADRESSING IN/OUT fig.2.37: this button allows us to access sensors, control pannel, inputs and outputs.

61. SETTINGS PRESSURE fig.2.43: this button allows us to access the pressure settings menu on the HMI screen for Adjusting Pressure Parameters, Calibration and more.

62. ALARMS : this button gives us access to Alarm Configuration, Viewing Alarm Status,Acknowledging, silencing Alarms. Check the Alarm History, configuring Alarm Parameters and more.

63. LANGUAGE BUTTONS : these buttons give us the abiliy to select a language by choice.In this project we made 2 languages (French and English)

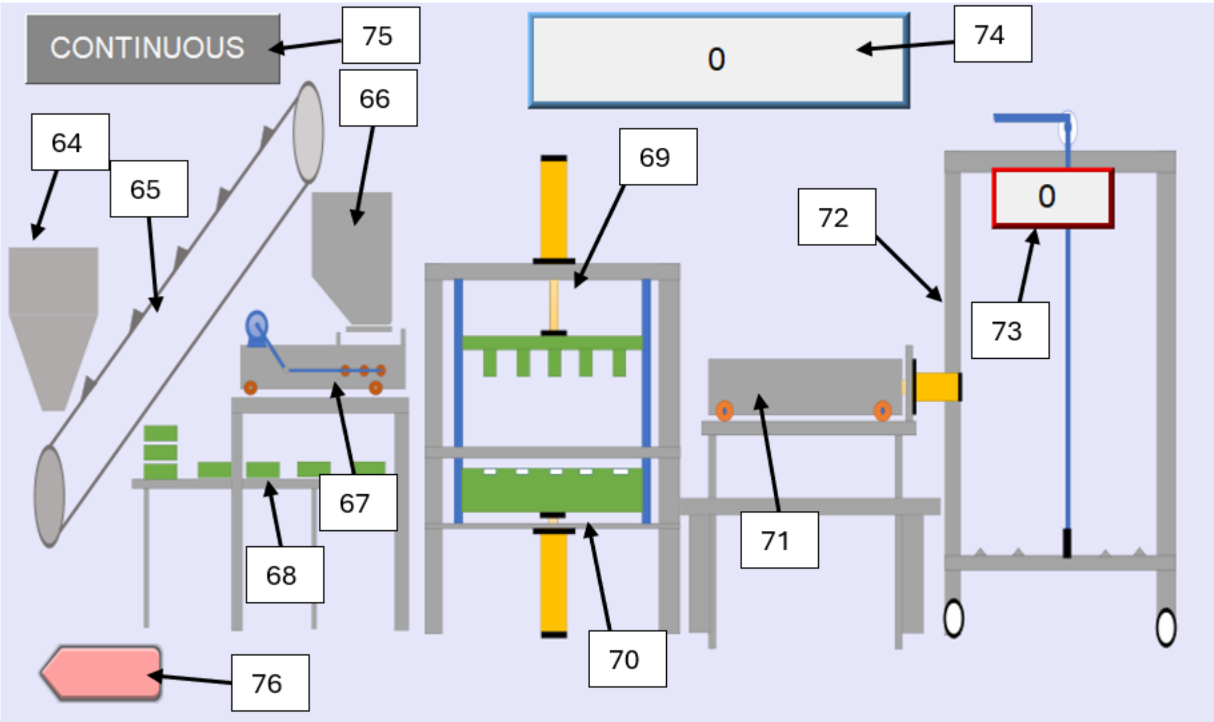



Figure 2.28: PRODUCTION menu of the GUANGYAN BLOCK MACHINE

The picture above represents a model of the GUANGYAN BLOCK MACHINE process. and we are going to explain the components below:

64. Container

65. Conveyor

66. Bucket

67. Concrete cart

68. Palet dispenser

69. press

70. Mold

71. Color cart

72. Stacker

73. Display button of the stacker

74. Display button of the counter

75. Push button: allows us to choose between continuous and discontinuous operating mode. fig.2.29

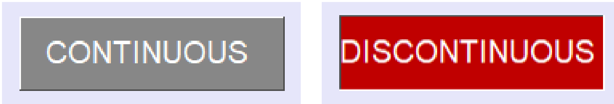



Figure 2.29: CONTINUOUS OR DISCONTINUOUS operating mode

76. Back button: it takes us the the previous window (main page).

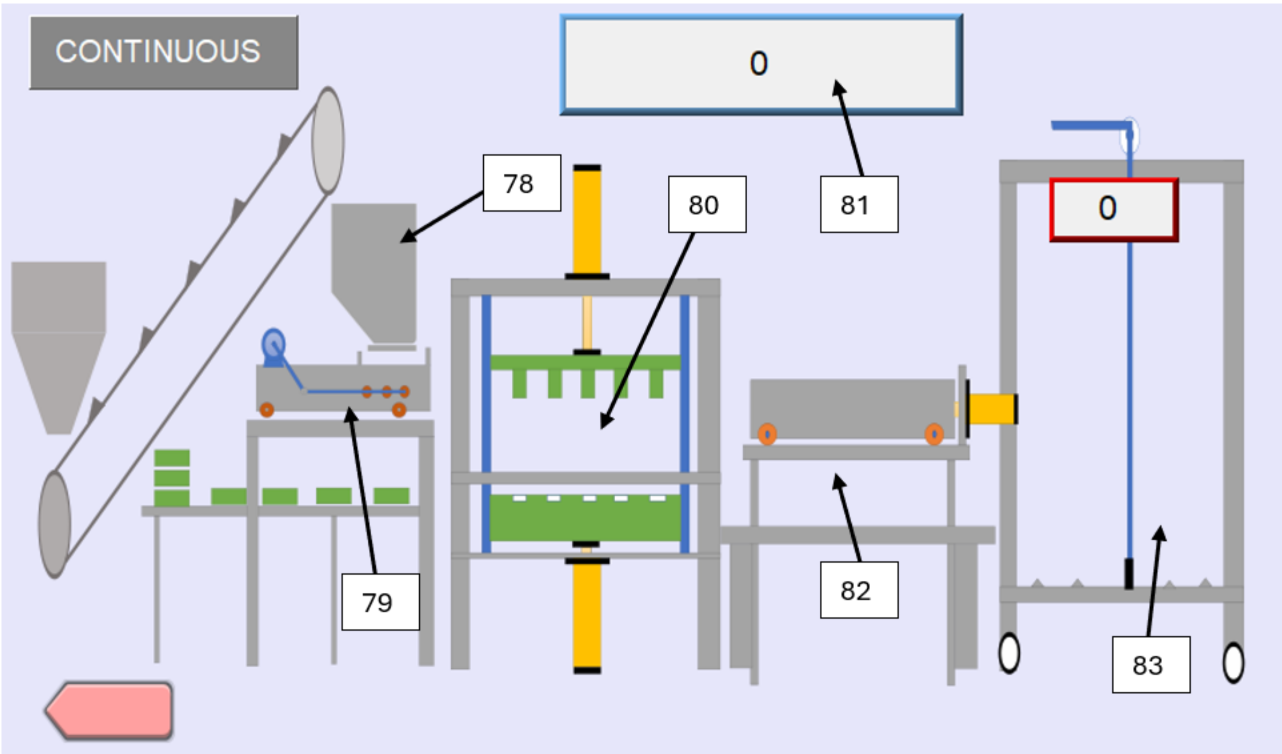



Figure 2.30: CLICKABLE AREA

This explains and shows different clickable areas, each area gives us access to different regulations windows according to the user.

78. Concrete bucket and conveyor fig.2.31
79. Concrete cart fig.2.32
80. Press fig.2.33
81. Counter fig.2.36
82. Color cart fig.2.34
83. Stacker fig.2.35

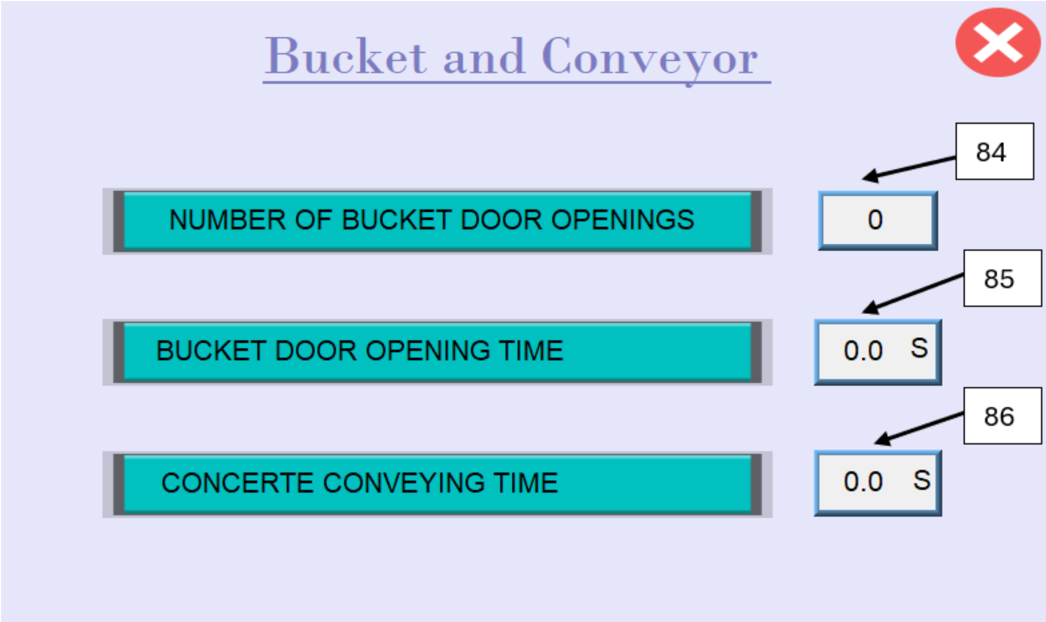



Figure 2.31: Bucket and Conveyor settings

84. This button function gives us the ability to compose a digit to determine the number of times the bucket's door has to open.

85. This button function gives us the ability to compose a digit to determine the bucket's door opening time.

86. This button function gives us the ability to compose a digit to determine the concerete conveying time.

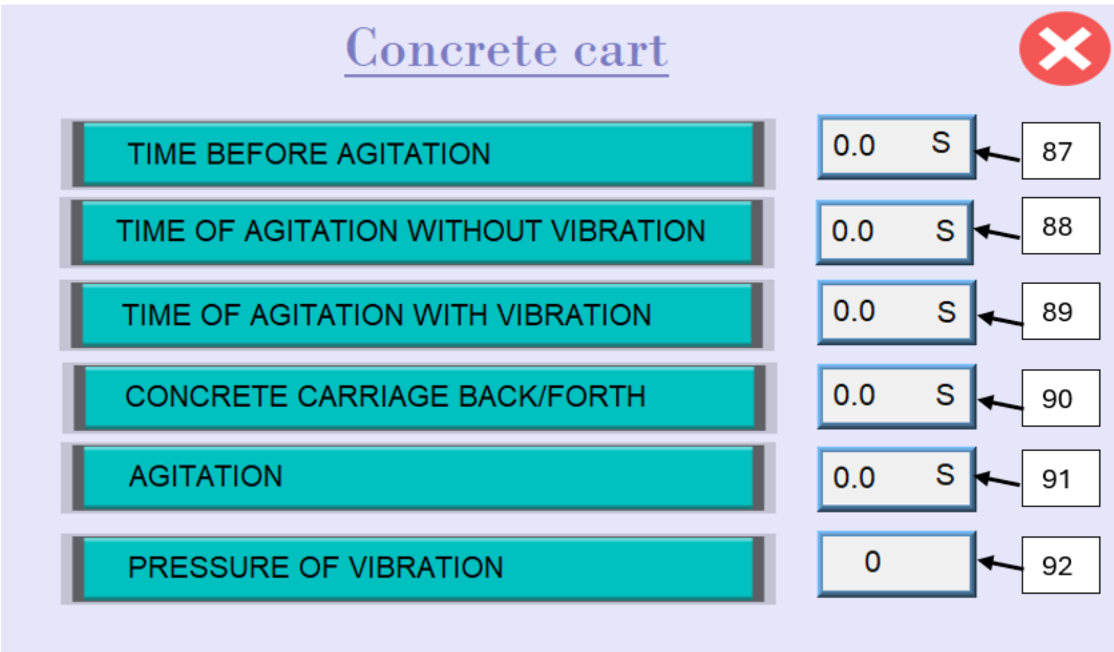



Figure 2.32: Concrete cart settings

87. This button function gives us the ability to compose a digit to determine the period of time before concrete's agitation.

88. This button function gives us the ability to compose a digit to determine the period of time of concrete's agitation without adding vibration.

89. This button function gives us the ability to compose a digit to determine the period of time of concrete's agitation with vibration.

90. This button function gives us the ability to compose a digit to determine the period of time of concrete carriage going back and forth.

91. This button function gives us the ability to compose a digit to determine the period of time of agitation.

92. This button function gives us the ability to compose a digit to determine the pressure of vibration.


Figure 2.33: Press settings

93. This button function gives us the ability to compose a digit to determine press descent's time.

94. This button function gives us the ability to compose a digit to determine the period of time for the press to go up slightly.

95. Use this button to set the duration for the concrete carriage's vibrating period.

96. Use this button to configure the delay time following the vibration of the concrete carriage.

97. This button function allows us to input a value to determine the pressure when the concrete carriage goes down.

98. This button function allows us to input a value to determine the pressure when the concrete carriage goes up.

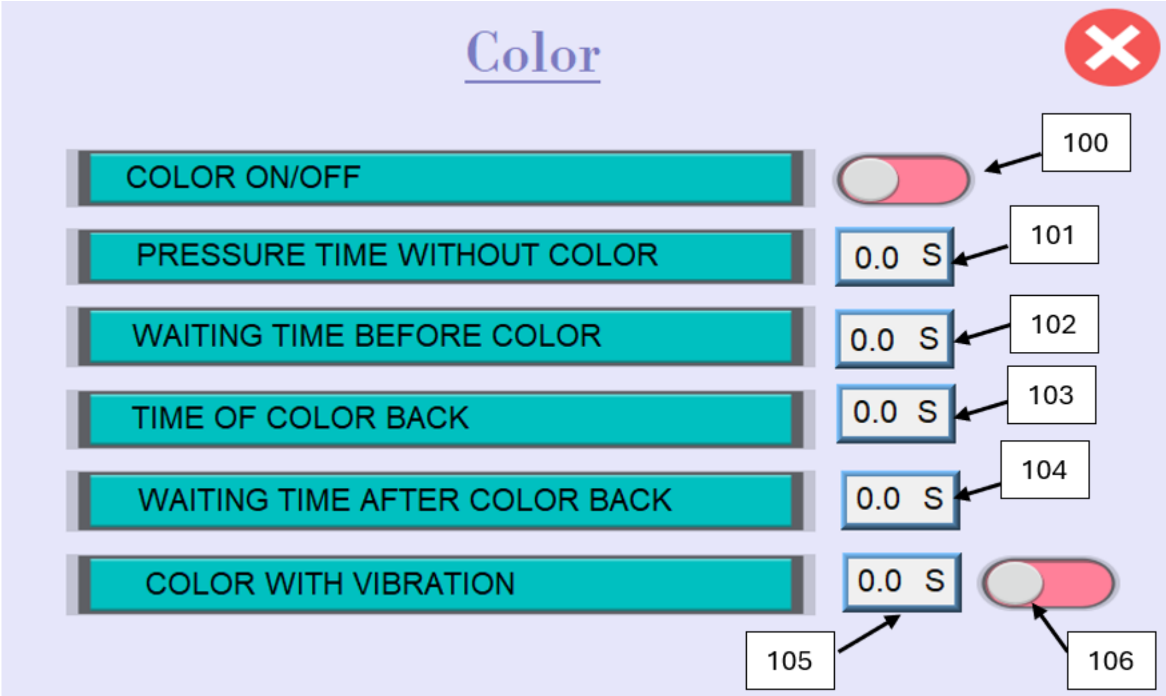



Figure 2.34: Color settings

100. This switch gives us the ability to start or stop the coloring process.

101. This button function gives us the ability to compose a digit to determine the pressure time without color.

102. This button function gives us the ability to compose a digit to determine the period of waiting before coloration.

103. This button function gives us the ability to compose a digit to determine the duration for the color cartridge in the rear position.

104. This button function gives us the ability to compose a digit to determine the duration for the color cartridge after the rear position.

105. This switch gives us the ability to start or stop the vibration that comes with the coloring process, and another button function that gives us the ability to compose a digit to determine the amount of time this vibration is going to be on.

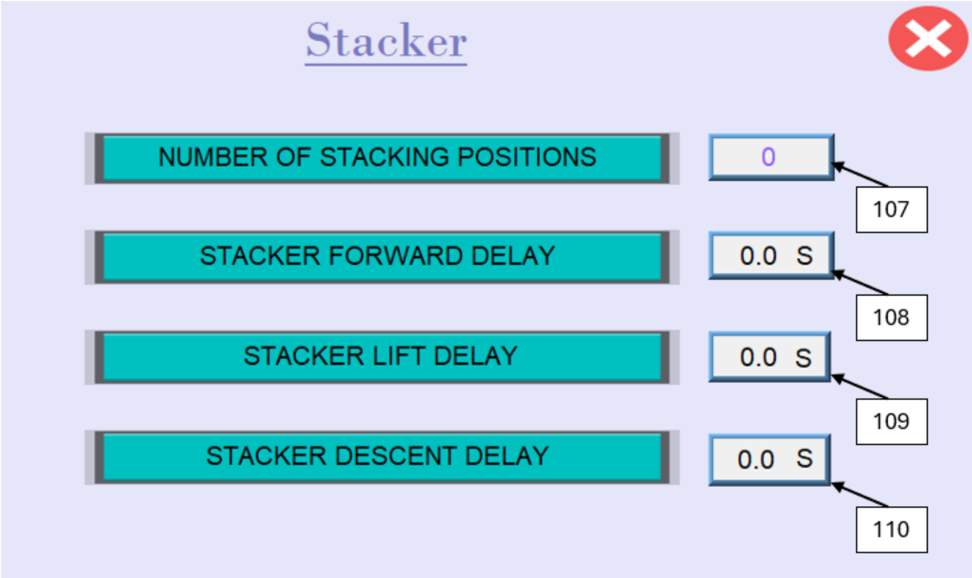



Figure 2.35: Stacker settings

107. This button function gives us the ability to compose a digit to determine the number of stacking positions.

108. This button function gives us the ability to compose a digit to determine the stacker's forward delay.

109. This button function gives us the ability to compose a digit to determine the stacker's lift delay.

110. This button function gives us the ability to compose a digit to determine the stacker's descent delay.

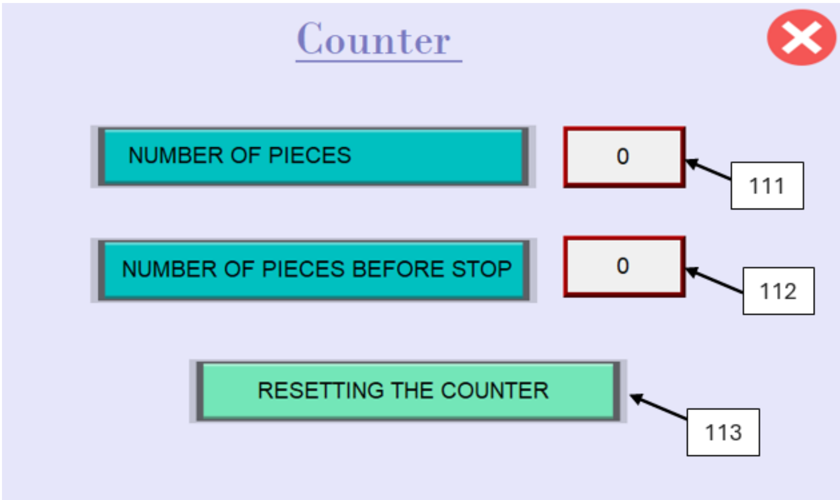



Figure 2.36: Counter

111. This button function gives us the ability to compose a digit to determine the number of peaces that we want.

112. This button function gives us the ability to compose a digit to determine the number of peaces number of pieces obtained before the stop.

113. This button function gives us the ability to reset the counter.

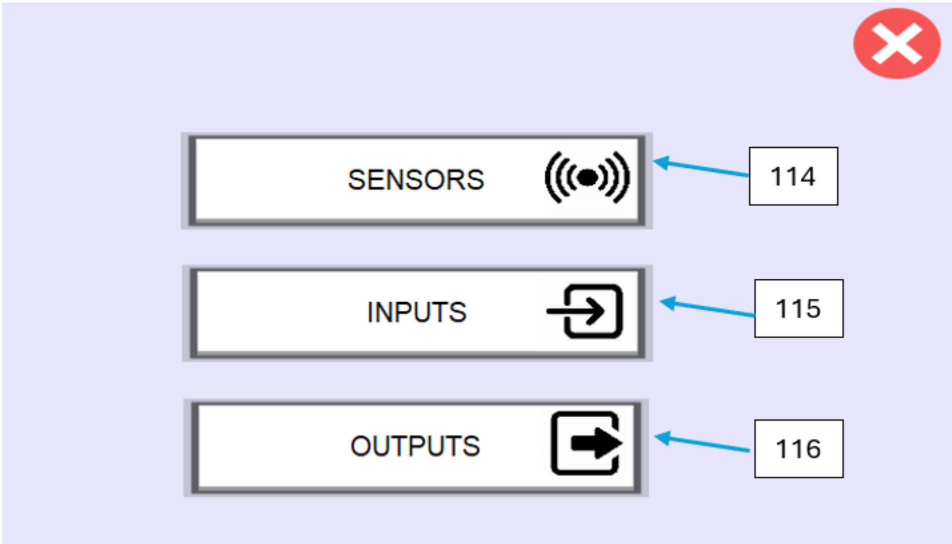



Figure 2.37: Adressing

This picture above represents the window that gives us access to all inputs, outputs, command window and sensors.

114. SENSOR button fig.2.38: gives us access to informations about all sensors and their adresses.

115. INPUTS button fig.2.40: gives us access to the command window, plus informations about all inputs and their adresses.

116. OUTPUT button: gives us access to informations about all outputs and their adresses.

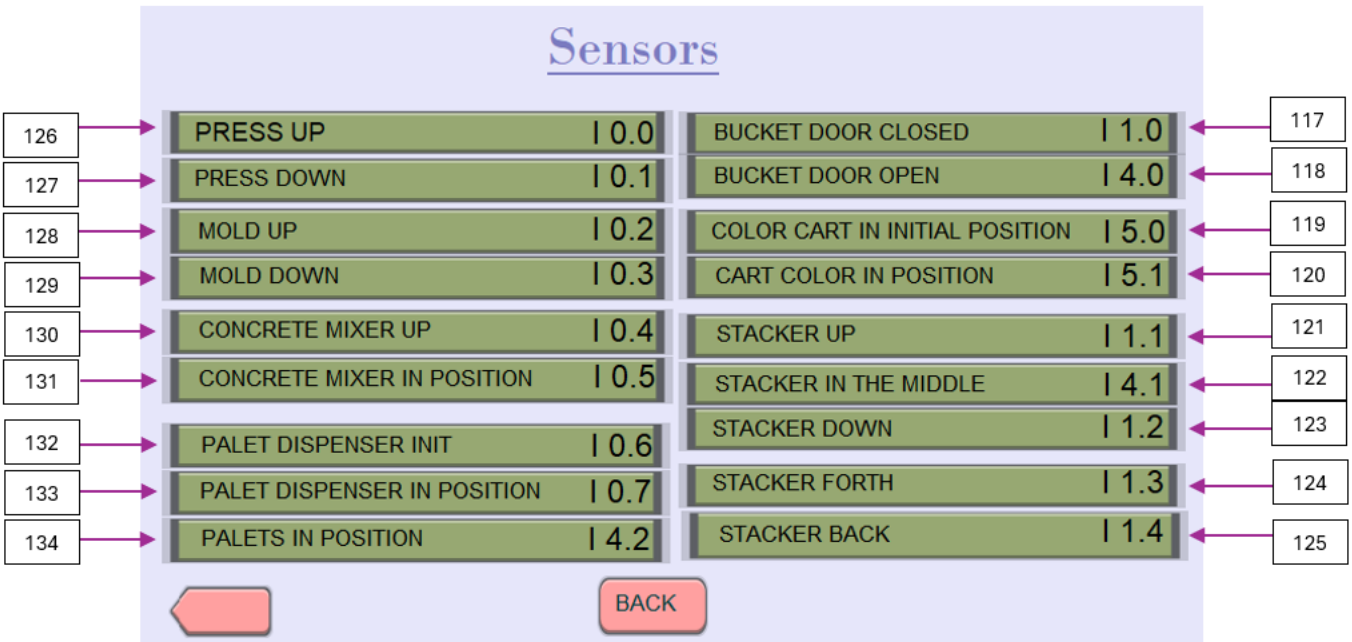



Figure 2.38: Sensors

117. This indicator allows reading the state of the sensor adressed as I1.0 from the HMI. It has been given a label "BUCKET DOOR CLOSED" that will facilitate its calling.
118. This indicator allows reading the state of the sensor adressed as I4.0 from the HMI. It has been given a label "BUCKET DOOR OPEN" that will facilitate its calling.
119. This indicator allows reading the state of the sensor adressed as I5.0 from the HMI. It has been given a label "COLOR CART IN INITIAL POSITION" that will facilitate its calling.
120. This indicator allows reading the state of the sensor adressed as I5.1 from the HMI. It has been given a label "CART COLOR IN POSITION" that will facilitate its calling.
121. This indicator allows reading the state of the sensor adressed as I1.1 from the HMI. It has been given a label "STACKER UP" that will facilitate its calling.
122. This indicator allows reading the state of the sensor adressed as I4.1 from the HMI. It has been given a label "STACKER IN THE MIDDLE" that will facilitate its calling.
123. This indicator allows reading the state of the sensor adressed as I1.2 from the HMI. It has been given a label "STACKER DOWN" that will facilitate its calling.
124. This indicator allows reading the state of the sensor adressed as I1.3 from the HMI. It has been given a label "STACKER FORTH" that will facilitate its calling.
125. This indicator allows reading the state of the sensor adressed as I1.4 from the HMI. It has been given a label "STACKER BACK" that will facilitate its calling.
126. This indicator allows reading the state of the sensor adressed as I0.0 from the HMI. It has been given a label "PRESS UP" that will facilitate its calling.
127. This indicator allows reading the state of the sensor adressed as I0.1 from the HMI. It has been given a label "PRESS DOWN" that will facilitate its calling.
128. This indicator allows reading the state of the sensor adressed as I0.2 from the HMI. It has been given a label "MOLD UP" that will facilitate its calling.
129. This indicator allows reading the state of the sensor adressed as I0.3 from the HMI. It has been given a label "MOLD DOWN" that will facilitate its calling.
130. This indicator allows reading the state of the sensor adressed as I0.4 from the HMI. It has been given a label "CONCRETE MIXER UP" that will facilitate its calling.
131. This indicator allows reading the state of the sensor adressed as I0.5 from the HMI. It has been given a label "CONCRETE MIXER IN POSITION" that will facilitate its calling.
132. This indicator allows reading the state of the sensor adressed as I0.6 from the HMI. It has been given a label "PALET DISPENSER INIT" that will facilitate its calling.
133. This indicator allows reading the state of the sensor adressed as I0.7 from the HMI. It has been given a label "PALET DISPENSER IN POSITION" that will facilitate its calling.
134. This indicator allows reading the state of the sensor adressed as I4.2 from the HMI. It has been given a label "PALETS IN POSITION" that will facilitate its calling.

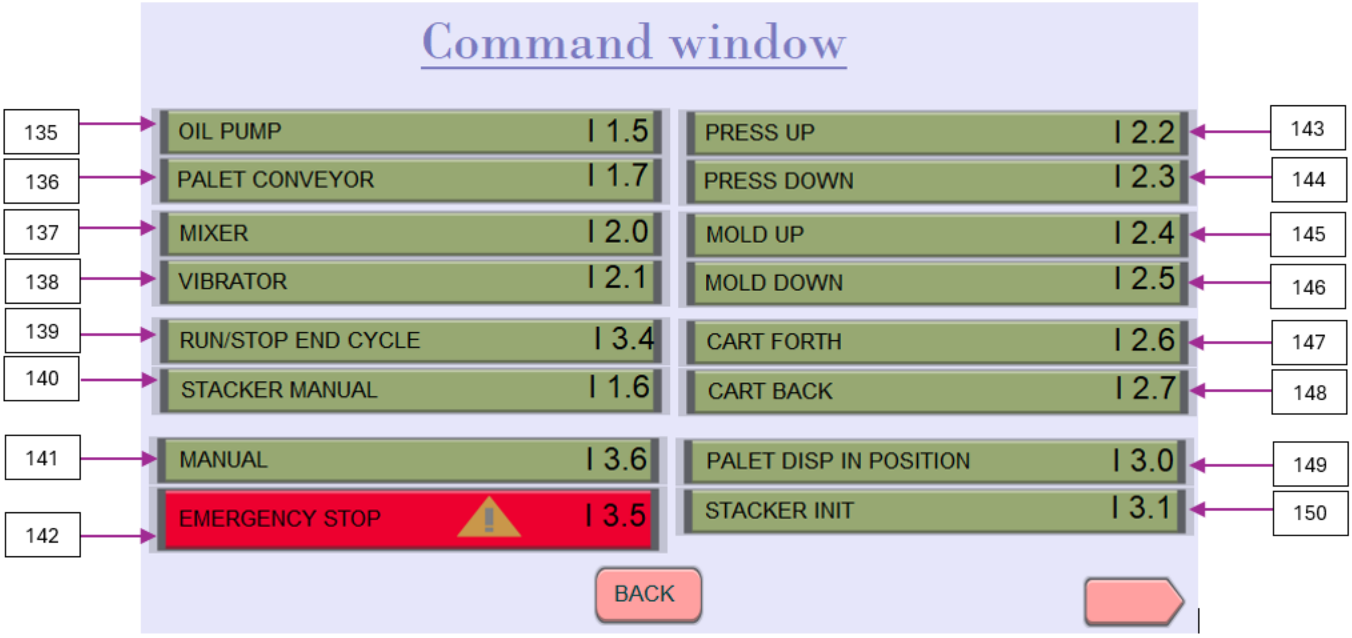



Figure 2.39: Commande window( inputs)

135. This indicator allows reading the state the push button adressed as I1.5 from the HMI. It has been given a label "OIL PUMP" that will facilitate its calling.

136. This indicator allows reading the state the push button adressed as I1.7 from the HMI. It has been given a label "PALET CONVEYOR" that will facilitate its calling.

137. This indicator allows reading the state the push button adressed as I2.0 from the HMI. It has been given a label "MIXER" that will facilitate its calling.

138. This indicator allows reading the state the push button adressed as I2.1 from the HMI. It has been given a label "VIBRATOR" that will facilitate its calling.

139. This indicator allows reading the state the push button adressed as I3.4 from the HMI. It has been given a label "RUN/STOP END CYCLE" that will facilitate its calling.

140. This indicator allows reading the state the push button adressed as I1.6 from the HMI. It has been given a label "STACKER MANUAL " that will facilitate its calling.

141. This indicator allows reading the state the push button adressed as I3.6 from the HMI. It has been given a label "MANUAL " that will facilitate its calling.

142. This indicator allows reading the state the push button adressed as I3.6 from the HMI. It has been given a label "EMERGENCY STOP" that will facilitate its calling.

143. This indicator allows reading the state the push button adressed as I2.2 from the HMI. It has been given a label "PRESS UP" that will facilitate its calling.

144. This indicator allows reading the state the push button adressed as I2.3 from the HMI. It has been given a label "PRESS DOWN" that will facilitate its calling.

145. This indicator allows reading the state the push button adressed as I2.4 from the HMI. It has been given a label "MOLD UP" that will facilitate its calling.

146. This indicator allows reading the state the push button adressed as I2.5 from the HMI. It has been given a label "MOLD DOWN" that will facilitate its calling.

147. This indicator allows reading the state the push button adressed as I2.6 from the HMI. It has been given a label "CART FORTH" that will facilitate its calling.

148. This indicator allows reading the state the push button adressed as I2.7 from the HMI. It has been given a label "CART BACK" that will facilitate its calling.

149. This indicator allows reading the state the push button adressed as I3.0 from the HMI. It has been given a label "PALET DISP IN POSION" that will facilitate its calling.

150. This indicator allows reading the state the push button adressed as I3.1 from the HMI. It has been given a label "STACKER INIT" that will facilitate its calling.

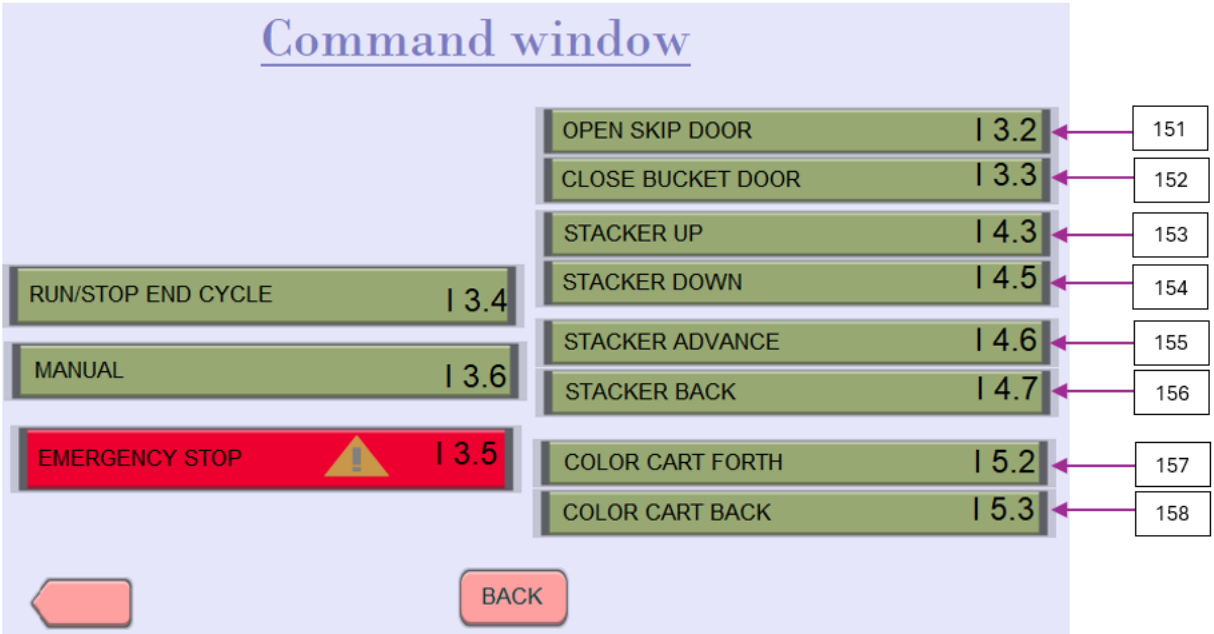



Figure 2.40: 2ND Commande window (inputs)

151. This indicator allows reading the state the push button adressed as I3.2 from the HMI. It has been given a label "OPEN DOOR SKIP" that will facilitate its calling.

152. This indicator allows reading the state the push button adressed as I3.3 from the HMI. It has been given a label "CLOSE BUCKET DOOR" that will facilitate its calling.

153. This indicator allows reading the state the push button adressed as I4.3 from the HMI. It has been given a label "STACKER UP" that will facilitate its calling.

154. This indicator allows reading the state the push button adressed as I4.5 from the HMI. It has been given a label "STACKER DOWN" that will facilitate its calling.

155. This indicator allows reading the state the push button adressed as I4.6 from the HMI. It has been given a label "STACKER ADVANCE" that will facilitate its calling.

156. This indicator allows reading the state the push button adressed as I5.2 from the HMI. It has been given a label "COLOR CART BACK" that will facilitate its calling.

157. This indicator allows reading the state the push button adressed as I5.2 from the HMI. It has been given a label "COLOR CART FORTH" that will facilitate its calling.

158. This indicator allows reading the state the push button adressed as I5.3 from the HMI. It has been given a label "COLOR CART BACK" that will facilitate its calling.

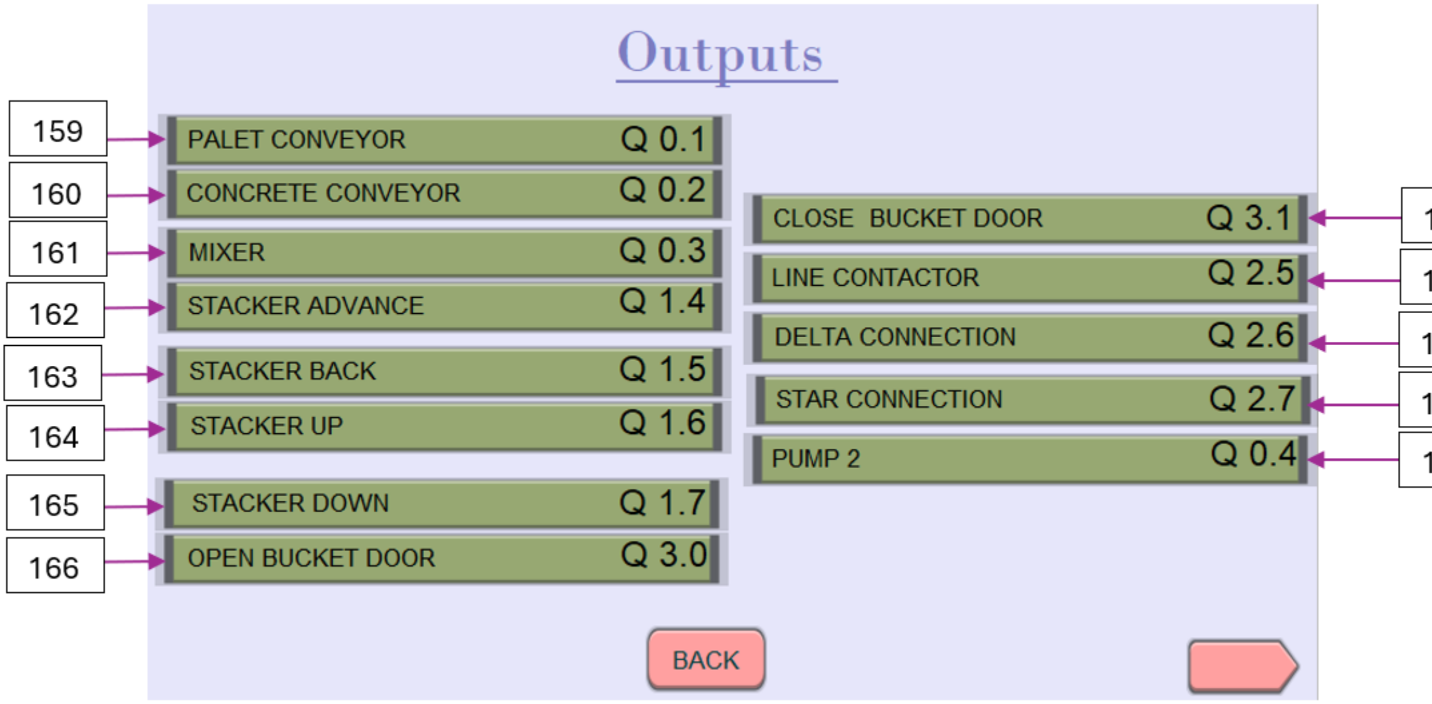



Figure 2.41: 1st page of outputs

159. This indicator allows reading the state the relay K5 adressed as I0.1 from the HMI. It has been given a label "PALET CONVEYOR" that will facilitate its calling.

160. This indicator allows reading the state the relay K13/K14 adressed as IO.2 from the HMI. It has been given a label "CONCRETE CONVEYOR" that will facilitate its calling.

161. This indicator allows reading the state the relay K6 adressed as I0.3 from the HMI. It has been given a label "MIXER" that will facilitate its calling.

162. This indicator allows reading the state the relay K7 adressed as I1.4 from the HMI. It has been given a label "STACKER ADVANCE" that will facilitate its calling.

163. This indicator allows reading the state the relay K8 adressed as I1.5 from the HMI. It has been given a label "STACKER BACK" that will facilitate its calling.

164. This indicator allows reading the state the relay K9 adressed as I1.6 from the HMI. It has been given a label "STACKER UP" that will facilitate its calling.

165. This indicator allows reading the state the relay K10 adressed as I1.7 from the HMI. It has been given a label "STACKER DOWN" that will facilitate its calling.

166. This indicator allows reading the state the relay K12 adressed as I3.0 from the HMI. It has been given a label "OPEN BUCKET DOOR" that will facilitate its calling.

167. This indicator allows reading the state the relay K11 adressed as I3.1 from the HMI. It has been given a label "CLOSE BUCKET DOOR" that will facilitate its calling.

168. This indicator allows reading the state the relay K1 adressed as I2.5 from the HMI. It has been given a label "LINE CONTACTOR" that will facilitate its calling.

169. This indicator allows reading the state the relay K2 adressed as I2.6 from the HMI. It has been given a label "DELTA CONNECTION" that will facilitate its calling.

170. This indicator allows reading the state the relay K3 adressed as I2.7 from the HMI. It has been given a label "STAR CONNECTION" that will facilitate its calling.

171. This indicator allows reading the state the relay K4 adressed as I0.4 from the HMI. It has been given a label "PUMP 2" that will facilitate its calling.

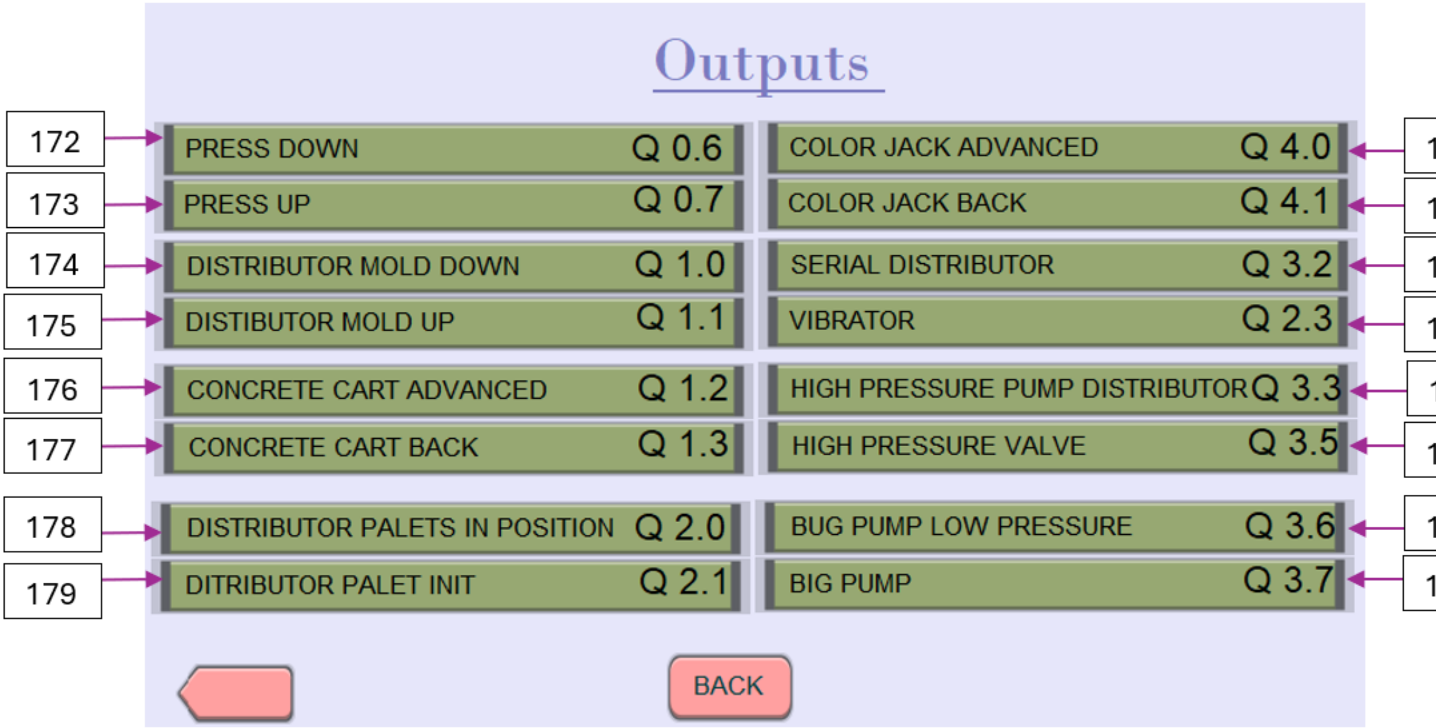



Figure 2.42: 2nd page of outputs

172. This indicator allows reading the state the relay K15 adressed as I0.6 from the HMI. It has been given a label "PRESS DOWN" that will facilitate its calling.

173. This indicator allows reading the state the relay K16 adressed as I0.7 from the HMI. It has been given a label "PRESS UP" that will facilitate its calling.

174. This indicator allows reading the state the relay K17 adressed as I1.0 from the HMI. It has been given a label "DISTRIBUTOR MOLD DOWN" that will facilitate its calling.

175. This indicator allows reading the state the relay K18 adressed as I1.1 from the HMI. It has been given a label "DISTRIBUTOR MOLD UP" that will facilitate its calling.

176. This indicator allows reading the state the relay K19 adressed as I1.2 from the HMI. It has been given a label "CONCRETE CART ADVANCED" that will facilitate its calling.

177. This indicator allows reading the state the relay K20 adressed as I1.3 from the HMI. It has been given a label "CONCRETE CART BACK" that will facilitate its calling.

178. This indicator allows reading the state the relay K21 adressed as I2.0 from the HMI. It has been given a label "DISTRIBUTOR PALETS IN POSITION " that will facilitate its calling.

179. This indicator allows reading the state the relay K22 adressed as I2.1 from the HMI. It has been given a label "DISTRIBUTOR PALET INIT" that will facilitate its calling.

180. This indicator allows reading the state the relay K23 adressed as I2.3 from the HMI. It has been given a label "COLOR JACK ADVANCED " that will facilitate its calling.

181. This indicator allows reading the state the relay K28 adressed as I4.0 from the HMI. It has been given a label "COLOR JACK BACK" that will facilitate its calling.

182. This indicator allows reading the state the relay K29 adressed as I4.1 from the HMI. It has been given a label "SERIAL DISTRIBUTOR " that will facilitate its calling.

183. This indicator allows reading the state the relay K24 adressed as I3.2 from the HMI. It has been given a label "VIBRATOR" that will facilitate its calling.

184. This indicator allows reading the state the relay K adressed as I3.3 from the HMI. It has been given a label "HIGH PRESSURE PUMP DISTRIBUTOR " that will facilitate its calling.

185. This indicator allows reading the state the relay K25 adressed as I3.5 from the HMI. It has been given a label "HIGH PRESSURE VALVE " that will facilitate its calling.

186. This indicator allows reading the state the relay K26 adressed as I3.6 from the HMI. It has been given a label "BIG PUMP LOW PRESSURE " that will facilitate its calling.

187. This indicator allows reading the state the relay K26 adressed as I3.7 from the HMI. It has been given a label "BIG PUMP " that will facilitate its calling.

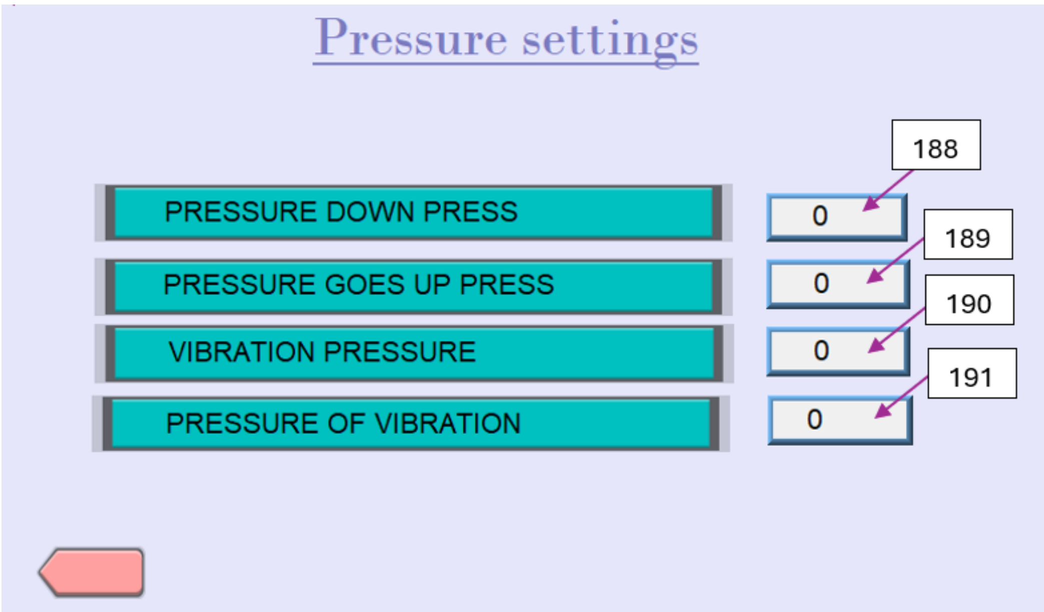


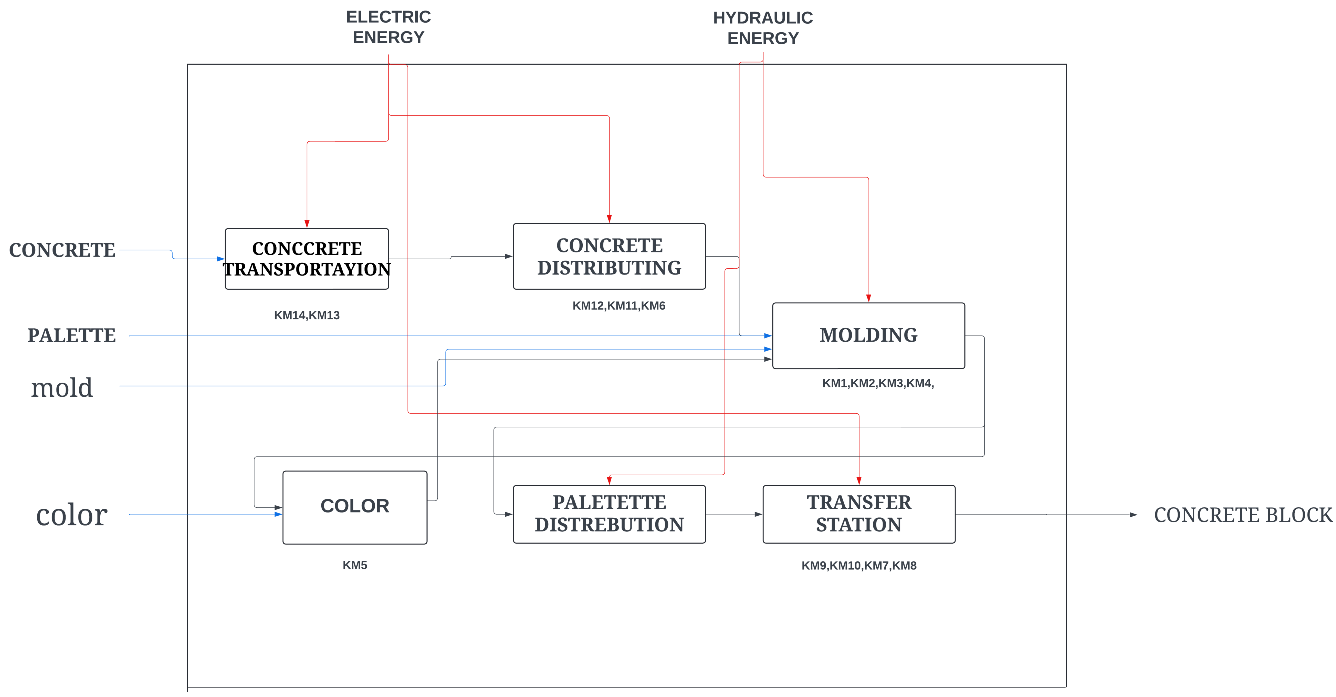

Figure 2.43: Pressure settings

172.

## 2.3 Structured Analysis and Design Technique (SADT)

SADT: is a methodology used in software engineering and systems analysis to model and analyze complex processes or systems. It involves breaking down the system into a hierarchical set of diagrams, each representing a specific level of detail.

SADT GENERAL




### 2.3.1 Functional Requirements

The operating process of the machine proceeds as follows:

1. acquittal and initialization:

   The operator must press the acquittal button located on the HMI in the ALARM panel. This prepares the machine to its initial state after each restart or in case of pressing the emergency stop button.

2. Setting the operating part to initial state or manual mode:

   Once the machine is ready for use (operating part in initial state), the operator has the choice to switch between automatic or manual mode by turning the AUTO/MAN switch to either position.

   If manual mode is chosen, the operator can perform operations in any order.

3. Preparation for automatic operation:

   Once automatic mode is selected, the machine needs to be prepared under the following initial conditions:

   - Activation of the hydraulic pump (star-delta start) if required.
   - Raising the press until it reaches the high position sensor.

- Closing the second concrete feeding bucket.
- Placing the color carriage in the initial position indicated by the color carriage position sensor.
- Activation of the pallet ejection conveyor.
- Placing the concrete carriage in the initial position until it reaches its initial position sensor.
- Raising the mold until it reaches the high position sensor of the mold.

4. Normal operation:

   Once the ON/OFF button is engaged, the process proceeds as follows:

   - Lowering the mold to the initial position.
   - Advancing the concrete carriage over the mold, adjusting its position using the mixer, until it reaches the front sensor of the concrete carriage. It then retracts slightly before returning over the mold to ensure proper distribution of concrete. Once filled, the carriage returns to its initial position.
   - Filling the concrete carriage from the second bucket, then being fed by the first bucket via the concrete conveyor belt.
   - Product molding: lowering the press until it reaches the low-level sensor while vibrating the mold to compact the product.
   - After molding and compacting, the mold and press return to their initial position.
   - Retracting the pallet distributor cylinder to hook an empty pallet. When the pallet distributor cylinder advances again, the full pallet is ejected from the vibrating table.
   - The full pallet is then retrieved by the pallet conveyor for transportation to the transfer station.

5. Emergency stop management:

   In case of pressing the emergency stop button, all ongoing processes are immediately halted. When the emergency stop button is released, the machine needs to be reset following the procedure described above.

6. Transfer station:

   When four aligned pallets are detected and the transfer station's end-of-travel switch is engaged:

   - The forks of the transfer station rise until they reach the high-position sensor.
   - The station moves to a unloading position indicated by the front sensor.
   - The forks descend to the low-level position to unload the full pallets onto the unloading support.

### 2.3.2 Sequential Function Charts (SFC)

Sequential Function Chart is a visual programming language designed for coordinating the sequential execution of program steps and transitions. It is beneficial for implementing state machines and handling scenarios that require defined sequences or parallel execution paths. SFC provides a clear, structured representation of program flows, making it advantageous for documentation and troubleshooting.

While SFC excels at describing sequences directly, it can integrate with other programming languages like Ladder Diagram and Structured Text to call actions within the sequential steps. SFC is based on the GRAFCET standard and is specified in the IEC 61131-3 industrial automation standard. When developing larger applications, it is recommended to separate the core sequence logic in the SFC program from supporting sub-functions like I/O handling or data processing, which can be implemented in complementary program modules[2].

#### 2.3.2.1 FluidSIM

FluidSIM is a comprehensive software solution designed for automating and visualizing industrial processes, with a particular emphasis on pneumatic and hydraulic systems. One of its core strengths lies in its powerful pneumatic schematization tools, which allow users to create detailed diagrams and simulations of pneumatic circuits and components.

The software provides a vast library of pneumatic components, including cylinders, valves, air compressors, and various control elements. Users can drag and drop these components onto a virtual workspace and connect them to construct complex pneumatic circuits. This visual representation enables a clear understanding of the system's layout, component interactions, and overall functionality.

Furthermore, FluidSIM's pneumatic schematization tools offer advanced simulation capabilities. Users can simulate the behavior of their designed pneumatic circuits, observe the flow of air, and analyze the operation of individual components. This feature is invaluable for testing and debugging pneumatic systems before physical implementation, reducing the risk of errors and optimizing system performance.

In addition to its pneumatic capabilities, FluidSIM also excels in the realm of programming and control. One of its standout features is the support for Sequential Function Chart (SFC) programming, also known as GRAFCET. This graphical programming language represents control logic as a series of steps and transitions, making it easier to understand and maintain complex sequential processes.

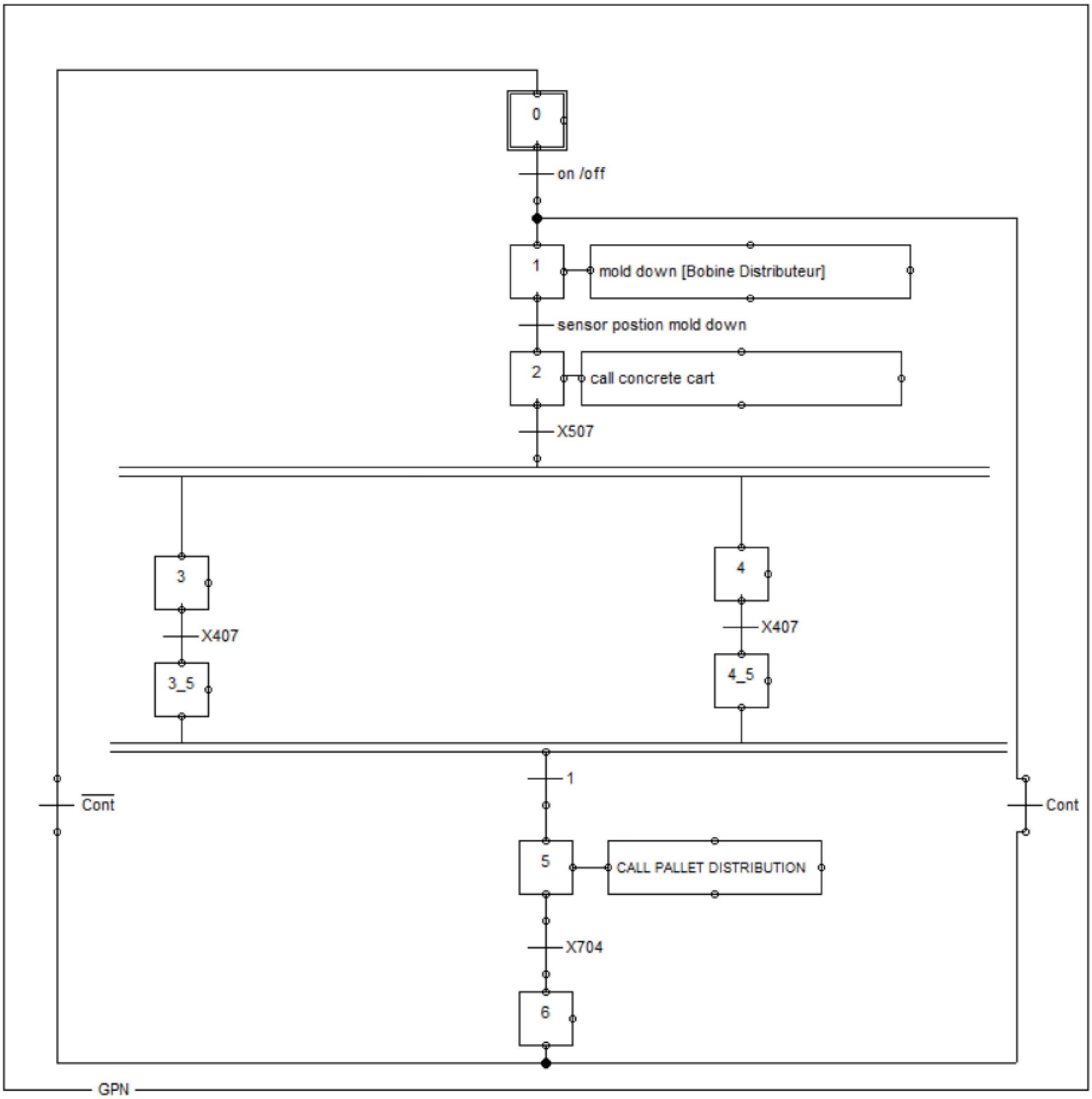
FluidSIM's GRAFCET editor allows users to create detailed GRAFCET charts by defining steps, transitions, actions, and transitions between steps. Each step represents a specific state or condition in the process, while transitions define the criteria for moving from one step to the next. Actions can be associated with steps or transitions, enabling the execution of specific control commands or operations.

For our project, while we did not directly utilize FluidSIM's pneumatic schematization tools, we heavily relied on its GRAFCET programming capabilities. By leveraging the visual nature of the SFC language, we were able to effectively model and represent the sequential processes involved in the operation of the CHINA GUANGYAN BLOCK MACHINE.

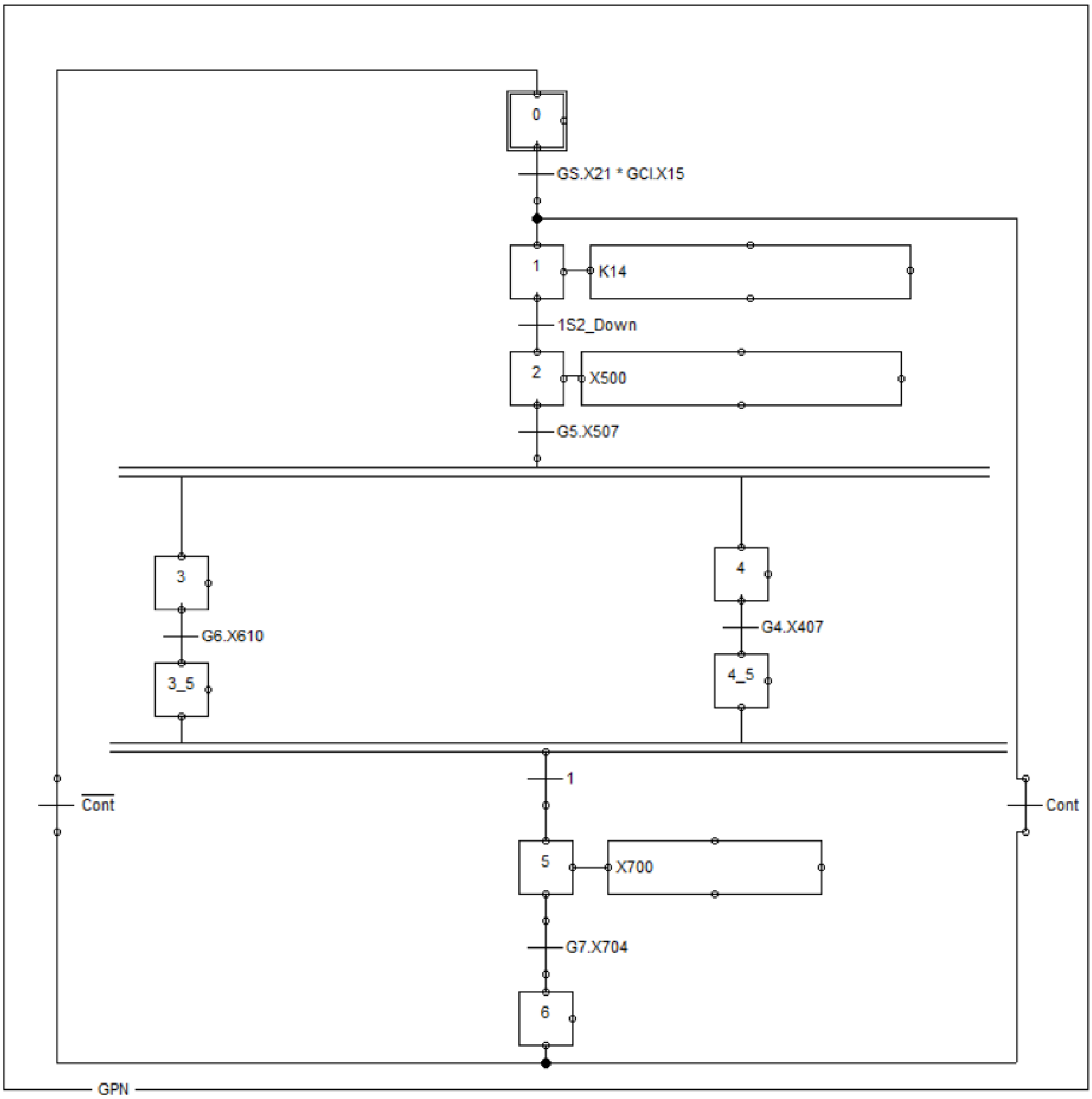
As our goal was to generate the initial SFC-based control program, which was subsequently translated into ladder logic for compatibility with the existing Siemens S7-200 PLC controlling the machine. The GRAFCET chart we developed in FluidSIM provided a clear and intuitive representation of the production steps, transitions between steps, and associated actions required for controlling the machine.

#### 2.3.2.2 SFC program

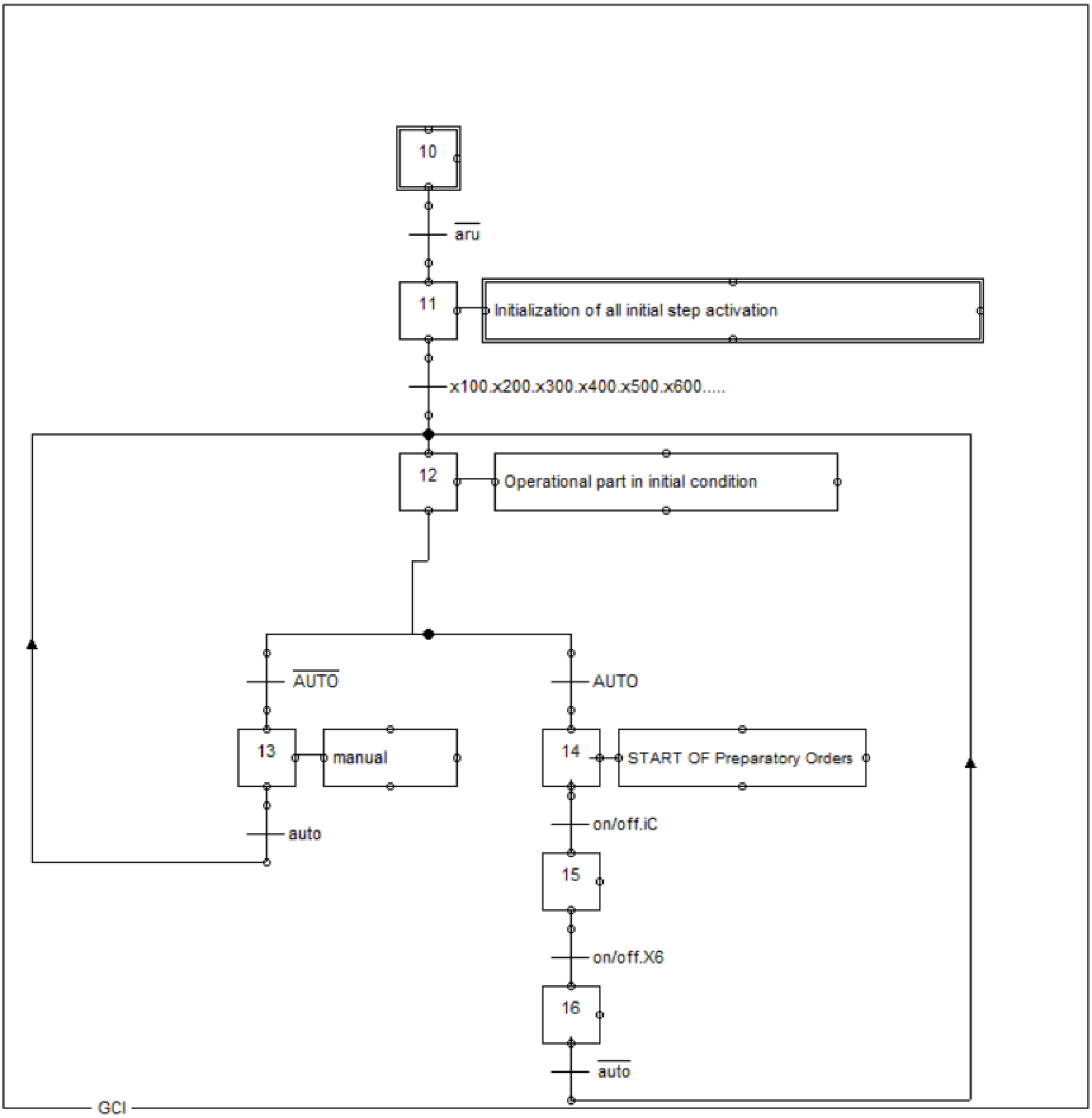
GPN (description part)



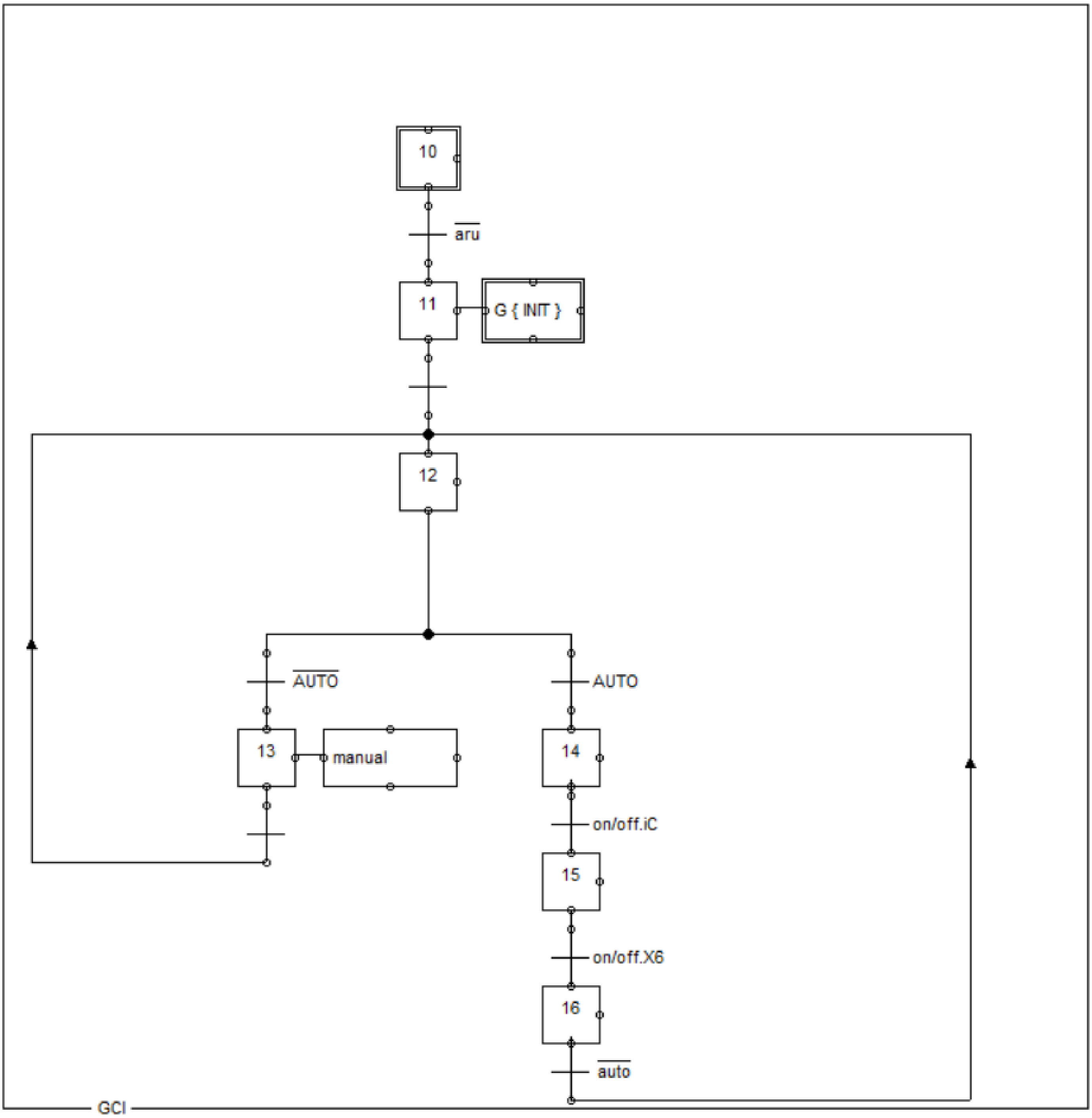
GPN (control part)



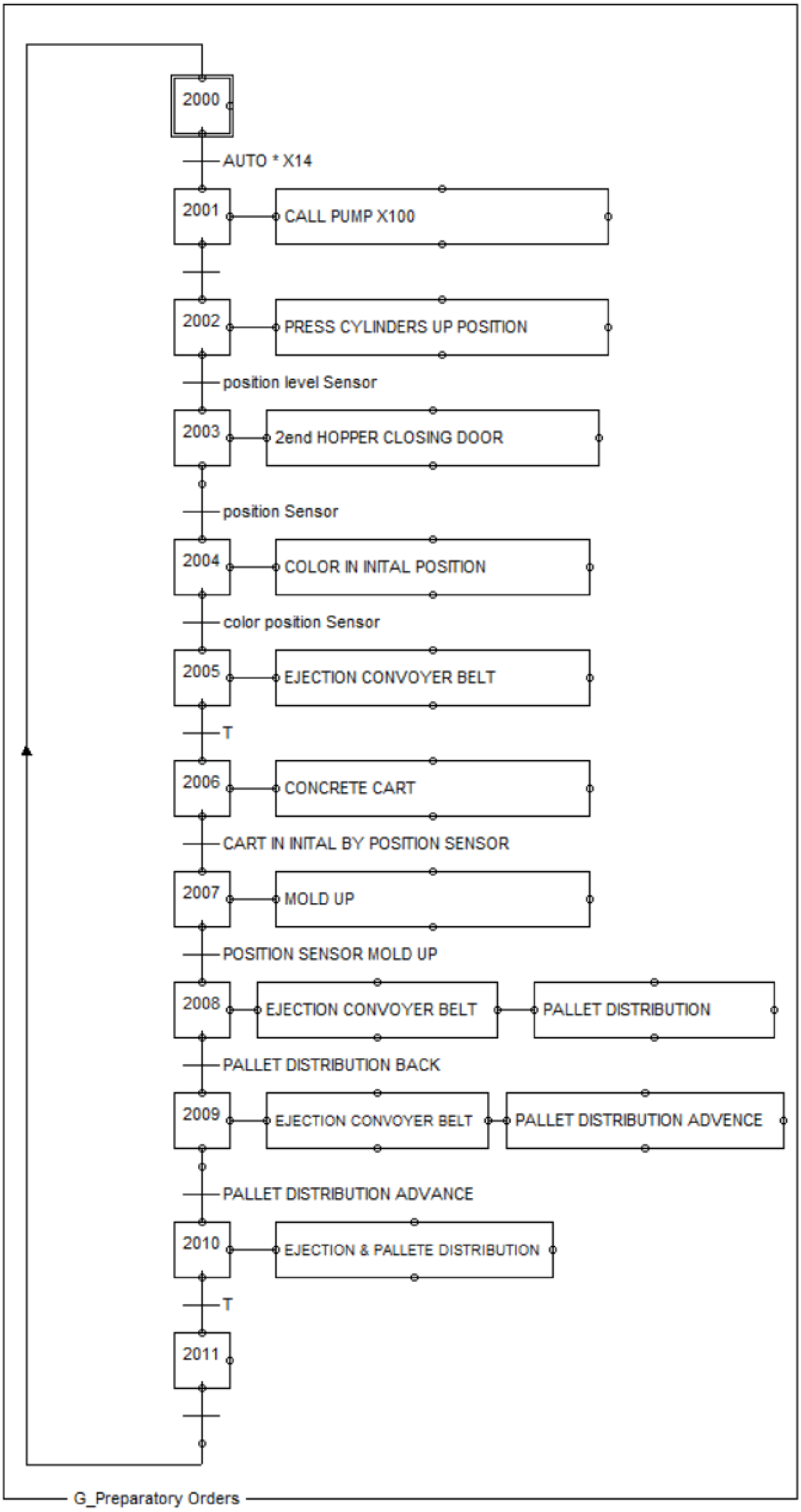
GCI (description part)



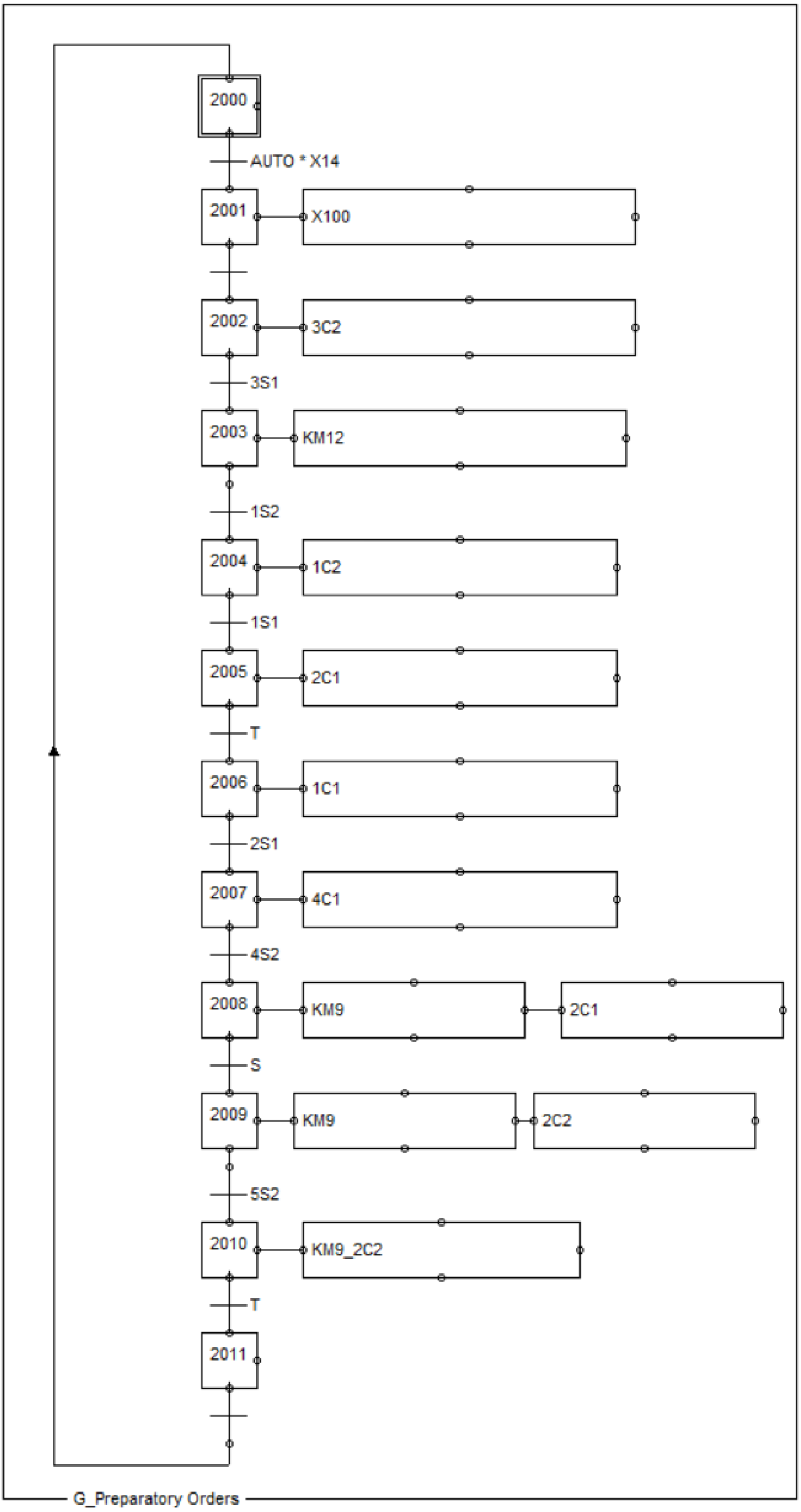
GCI (control part)



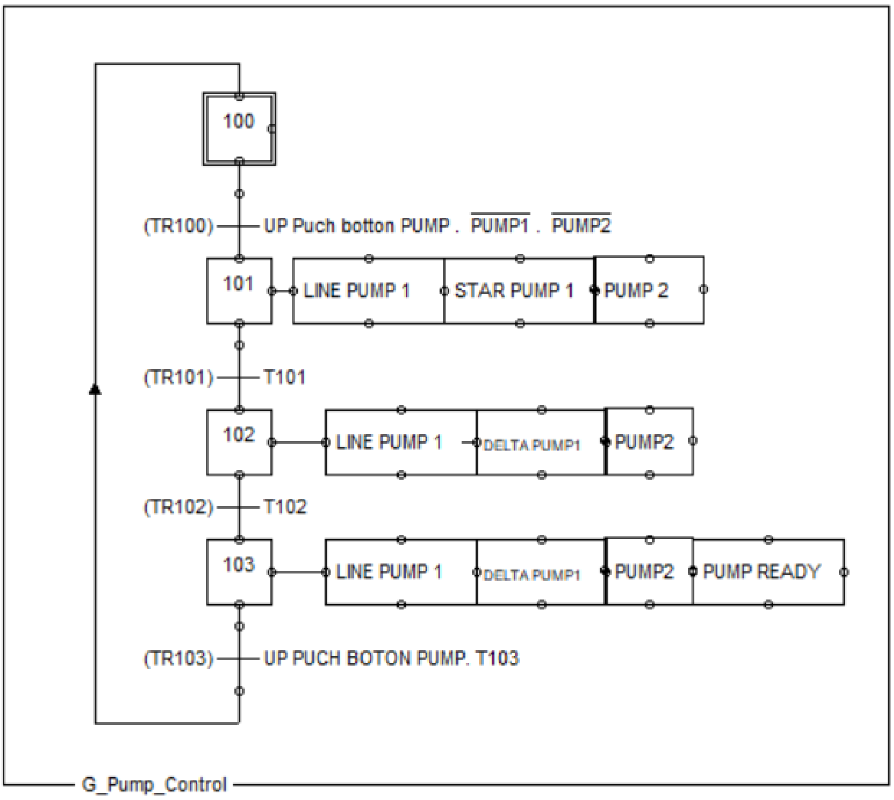
PREPARATORY ORDERS (description part)



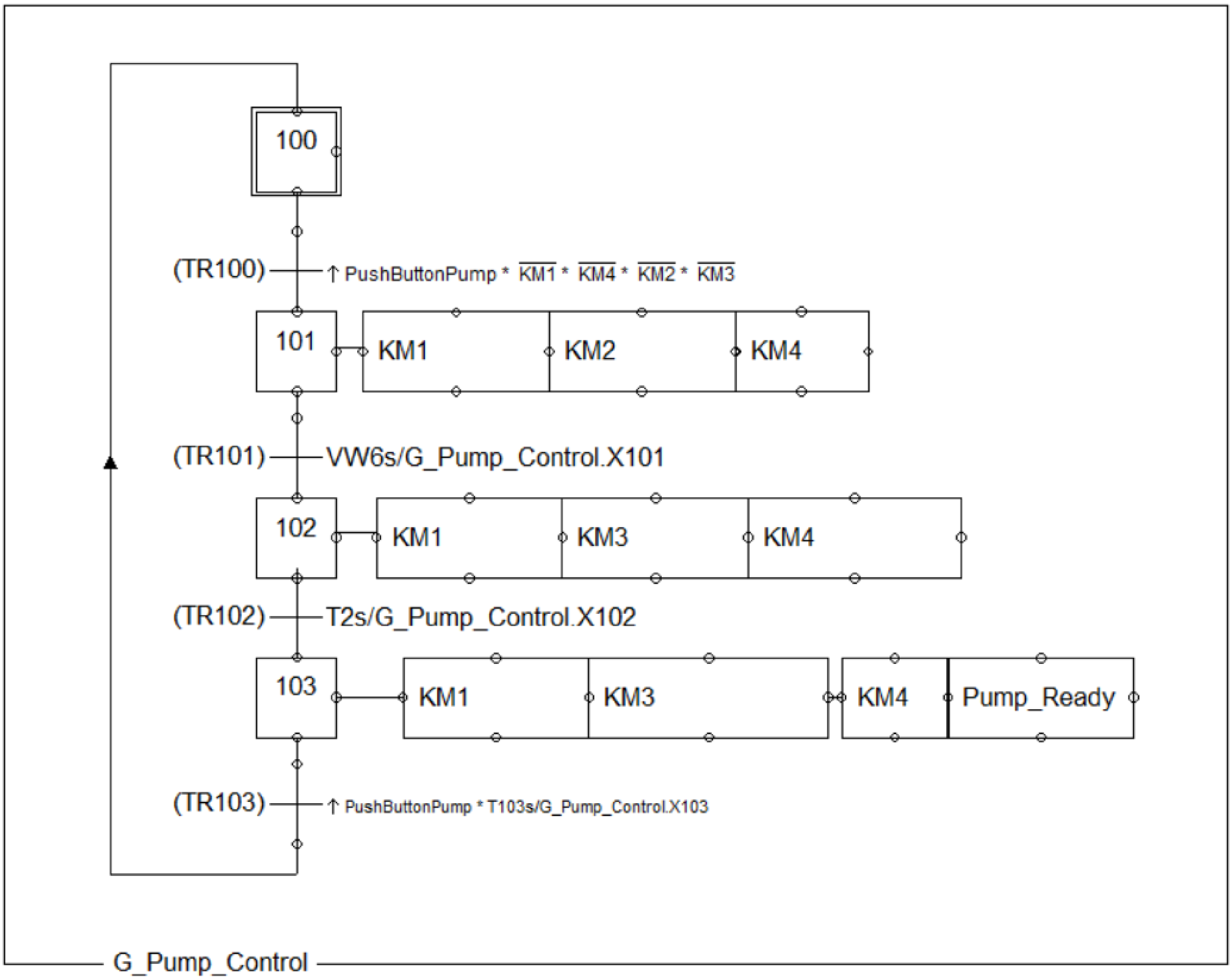
PREPARATORY ORDERS (control part)

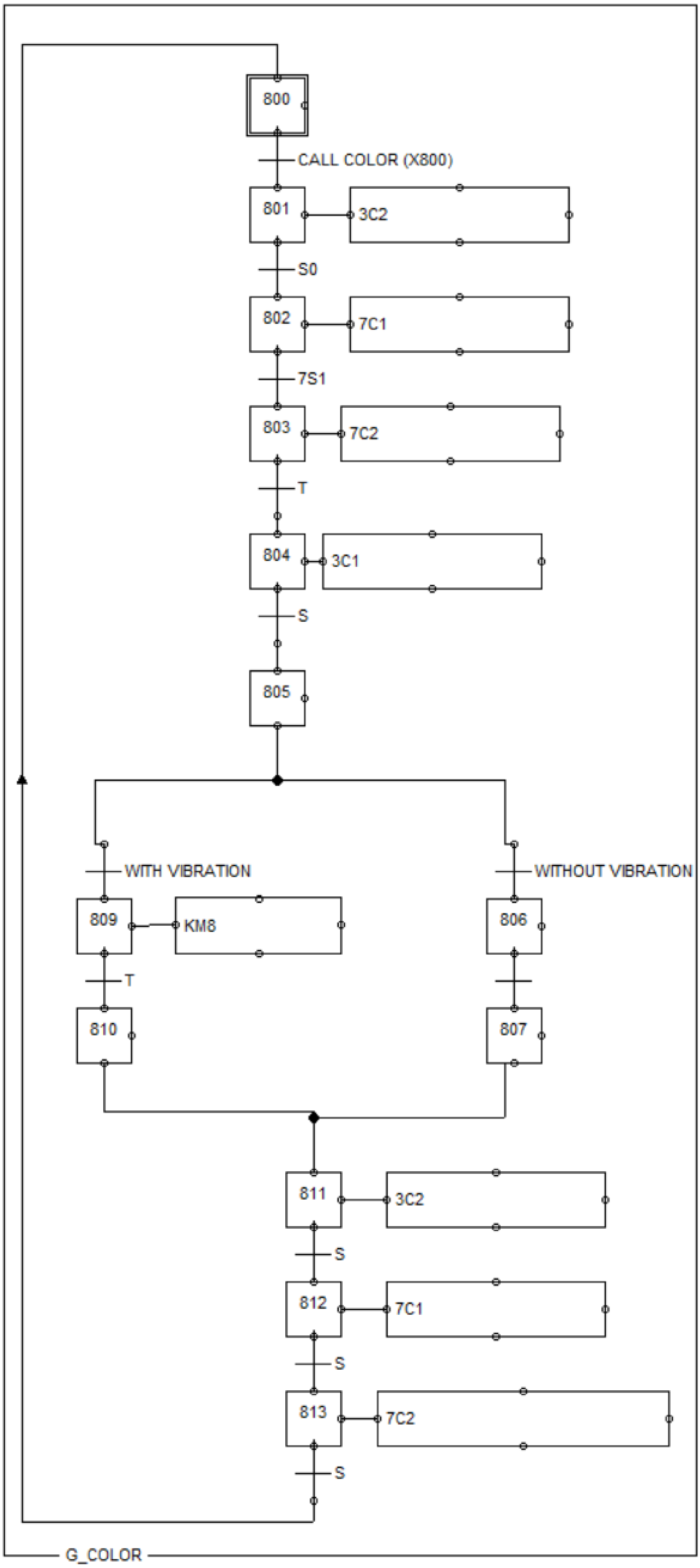


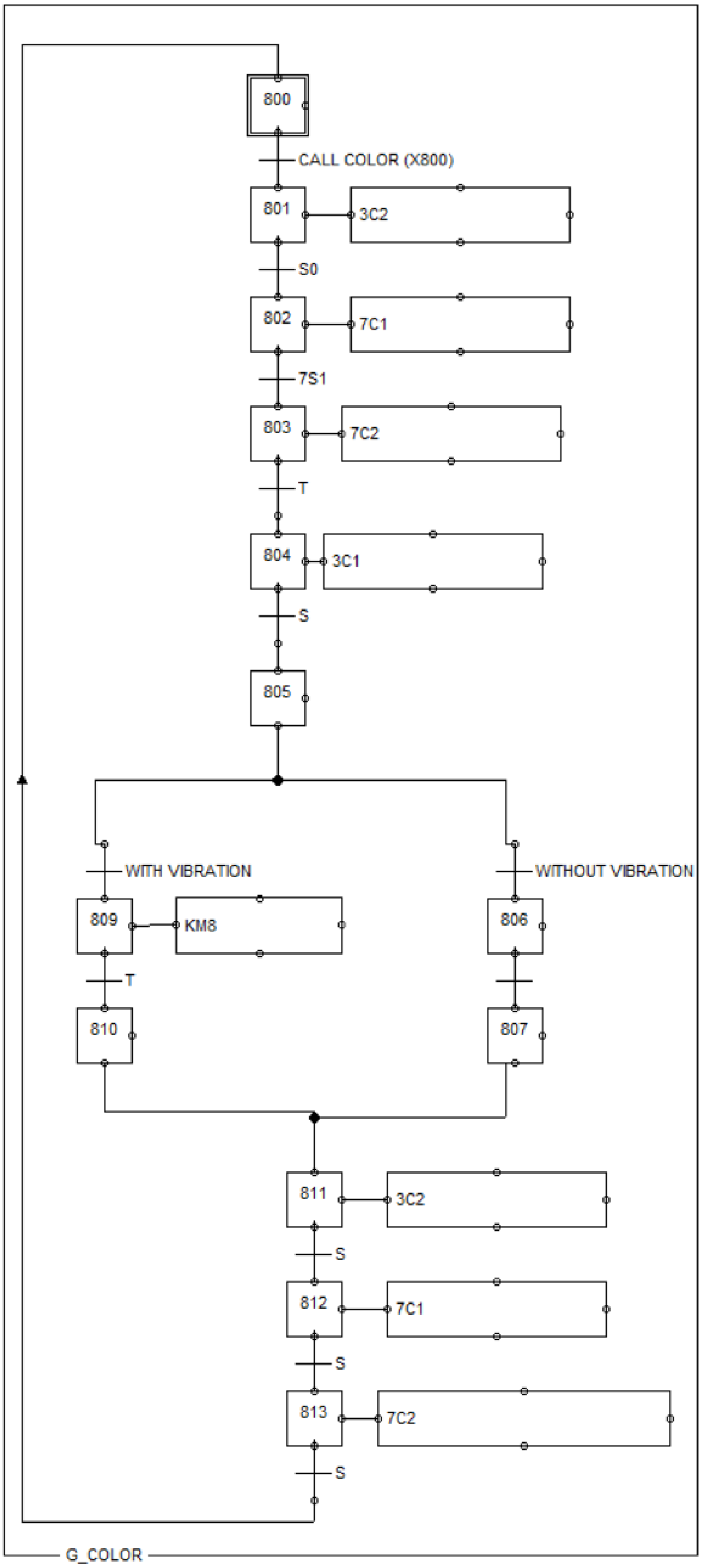
pump (description part)



pump (control part)




800
CALL COLOR (X800)
801
3C2
S0
802
7C1
7S1
803
7C2
T
804
3C1
S
805
WITH VIBRATION
WITHOUT VIBRATION
809
KM8
806
T
810
807
811
3C2
S
812
7C1
S
813
7C2
S
G_COLOR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CALL COLOR (X800)
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3C2
S0
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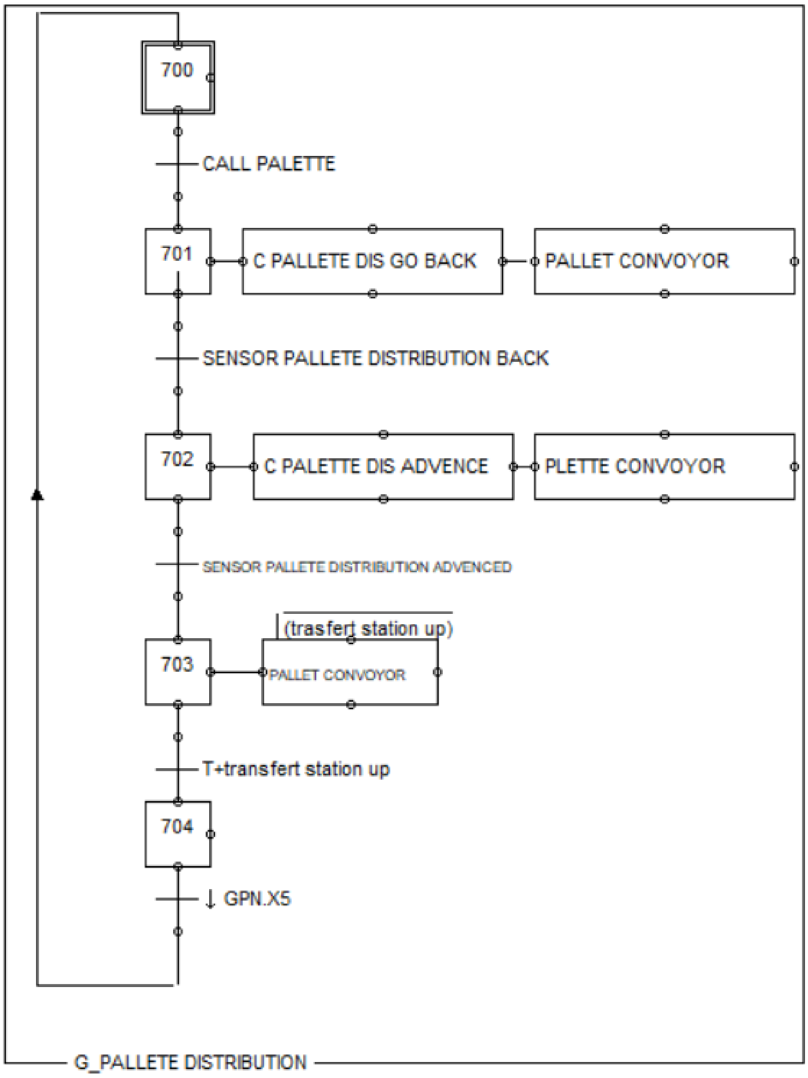
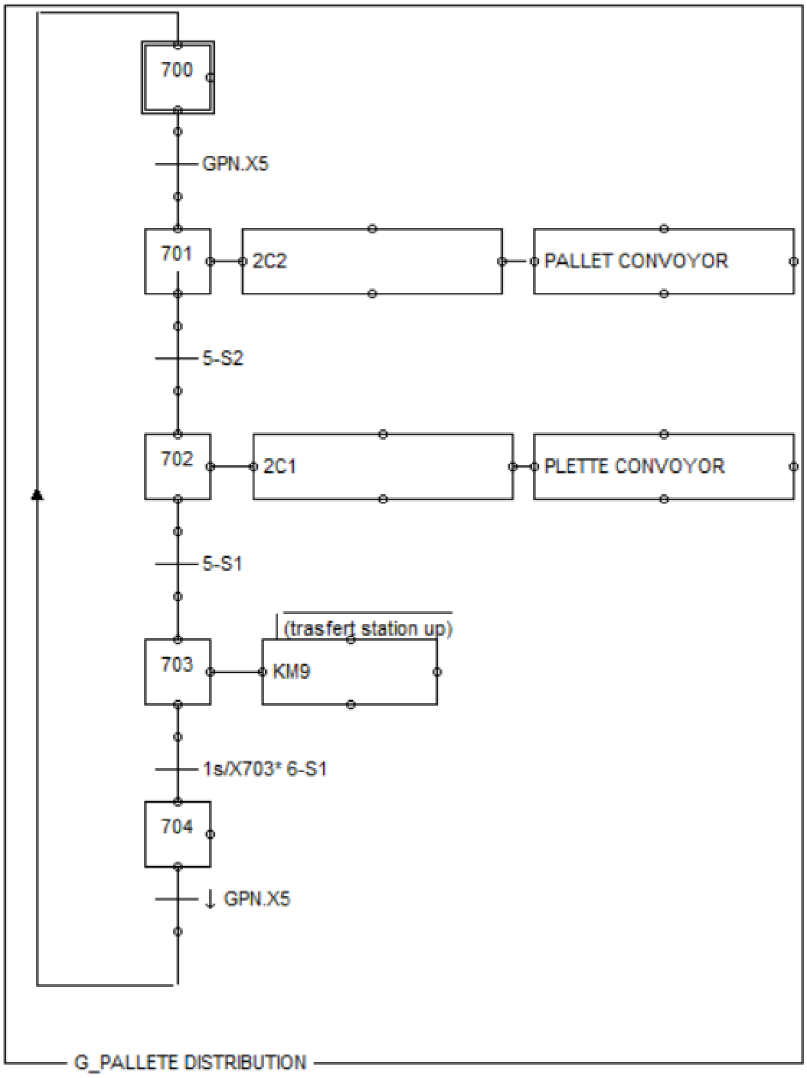
7C1
7S1
803
7C2
T
804
3C1
S
805
WITH VIBRATION
WITHOUT VIBRATION
809
KM8
T
806
810
807
811
3C2
S
812
7C1
S
813
7C2
S
G_COLOR

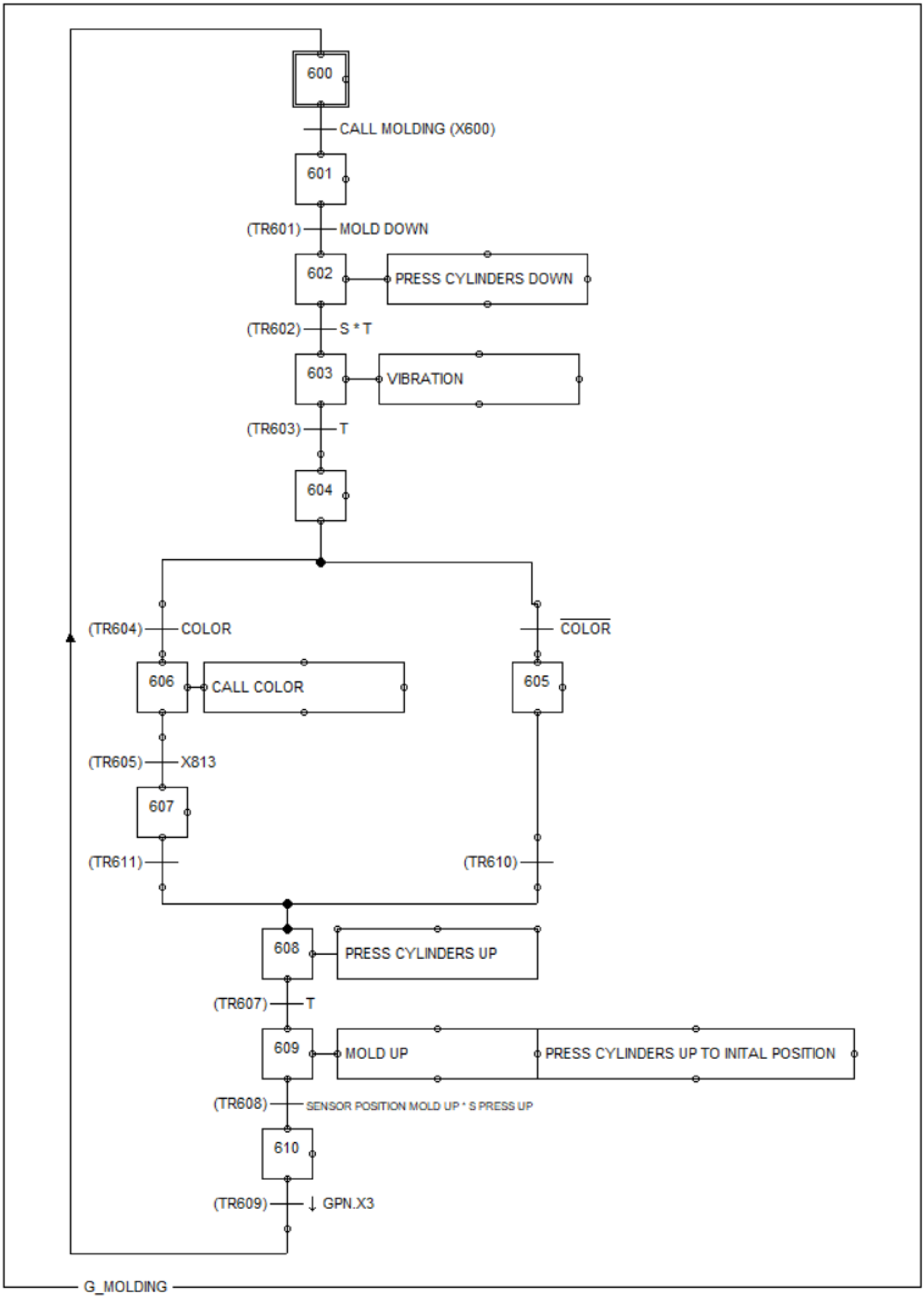
pal(description part)



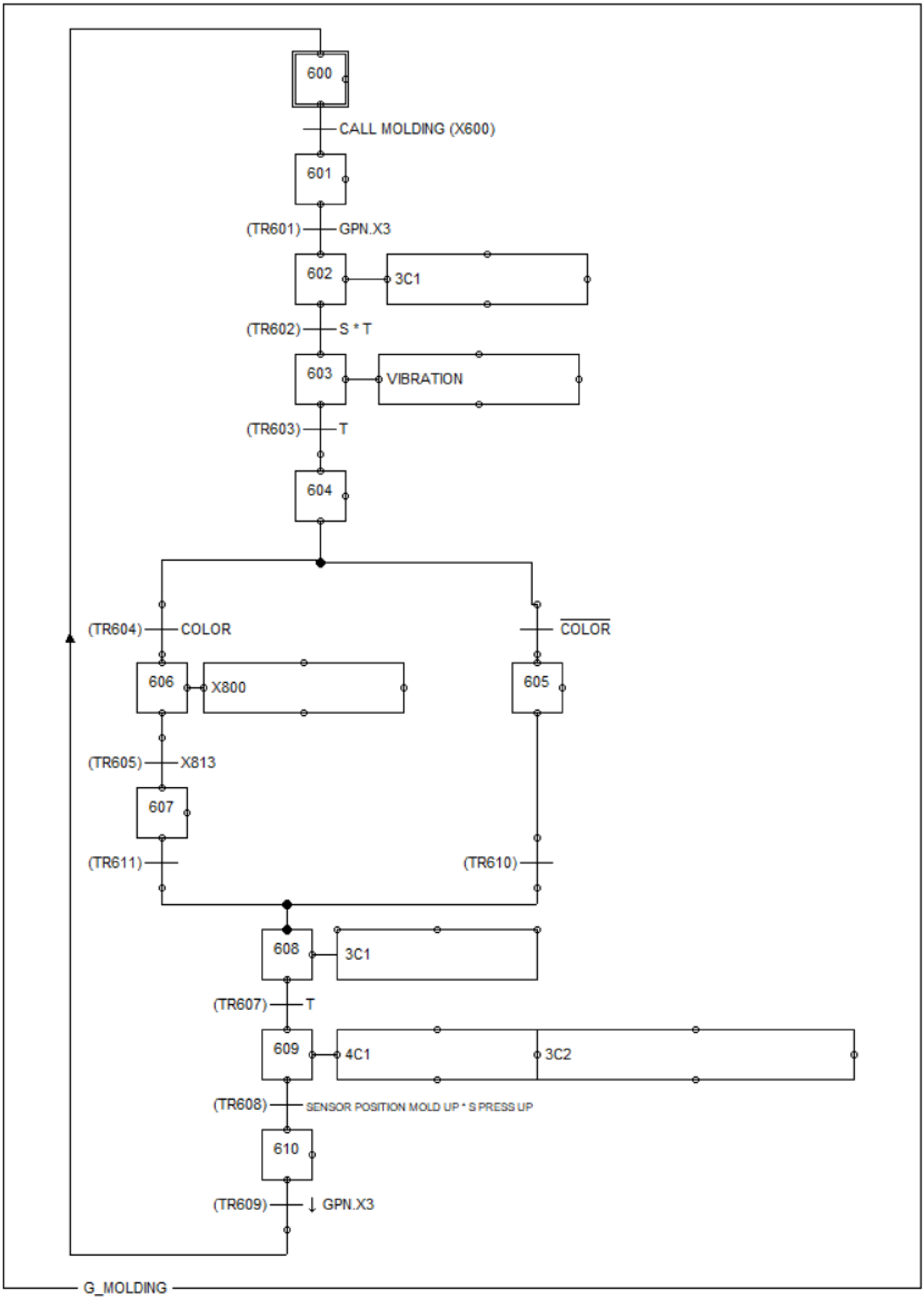
PREPARATORY ORDERS (control part)



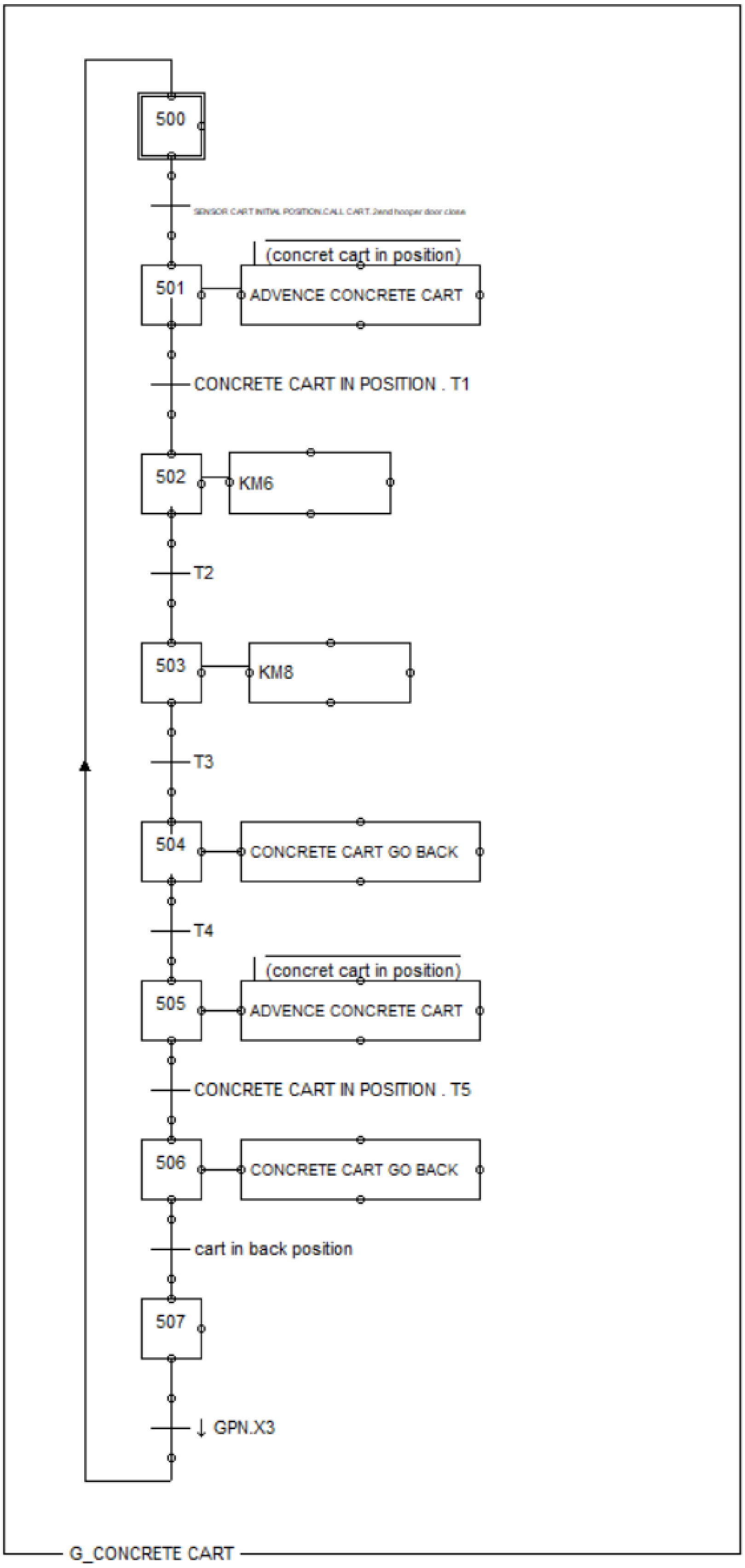
MOLDING (description part)



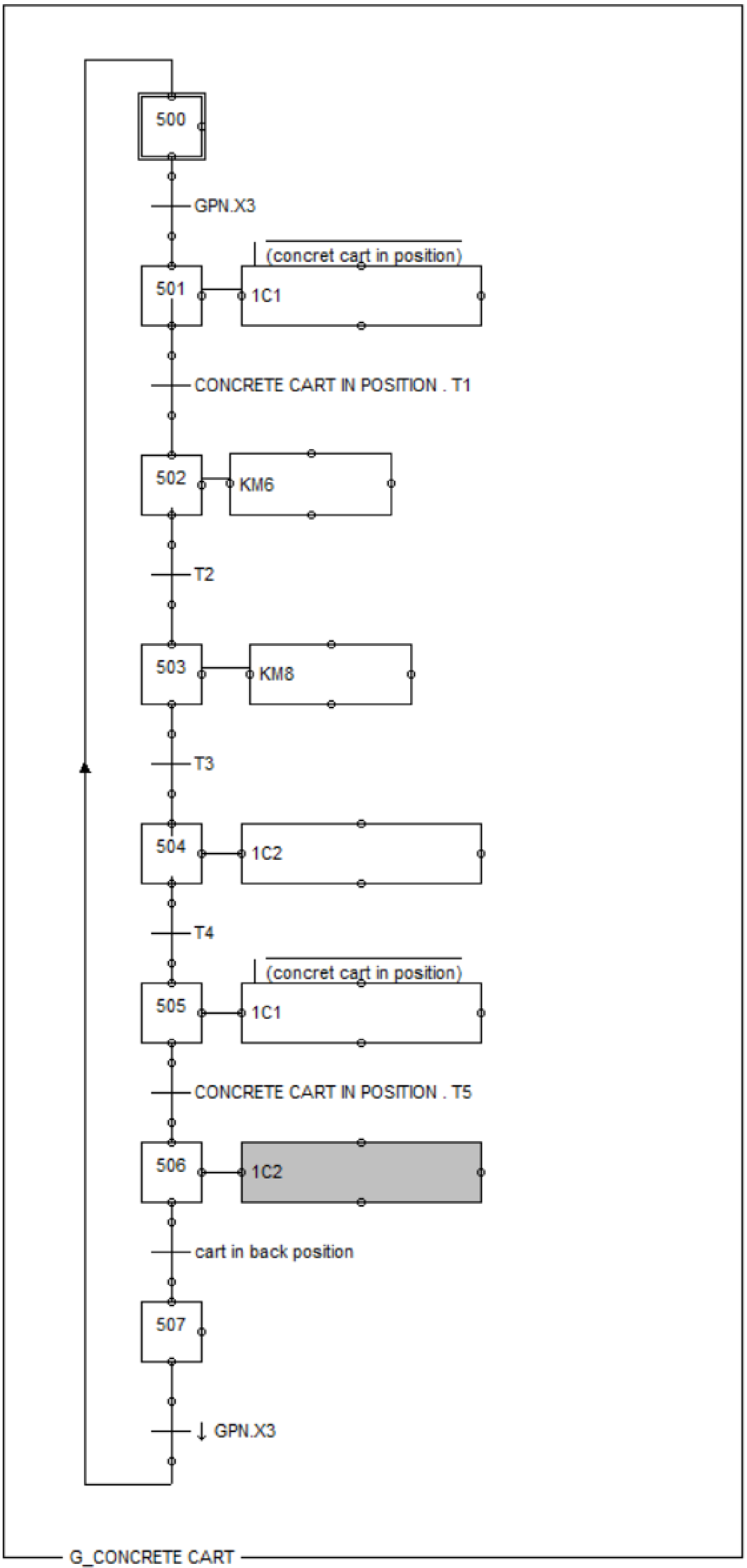
MOLDING (control part)



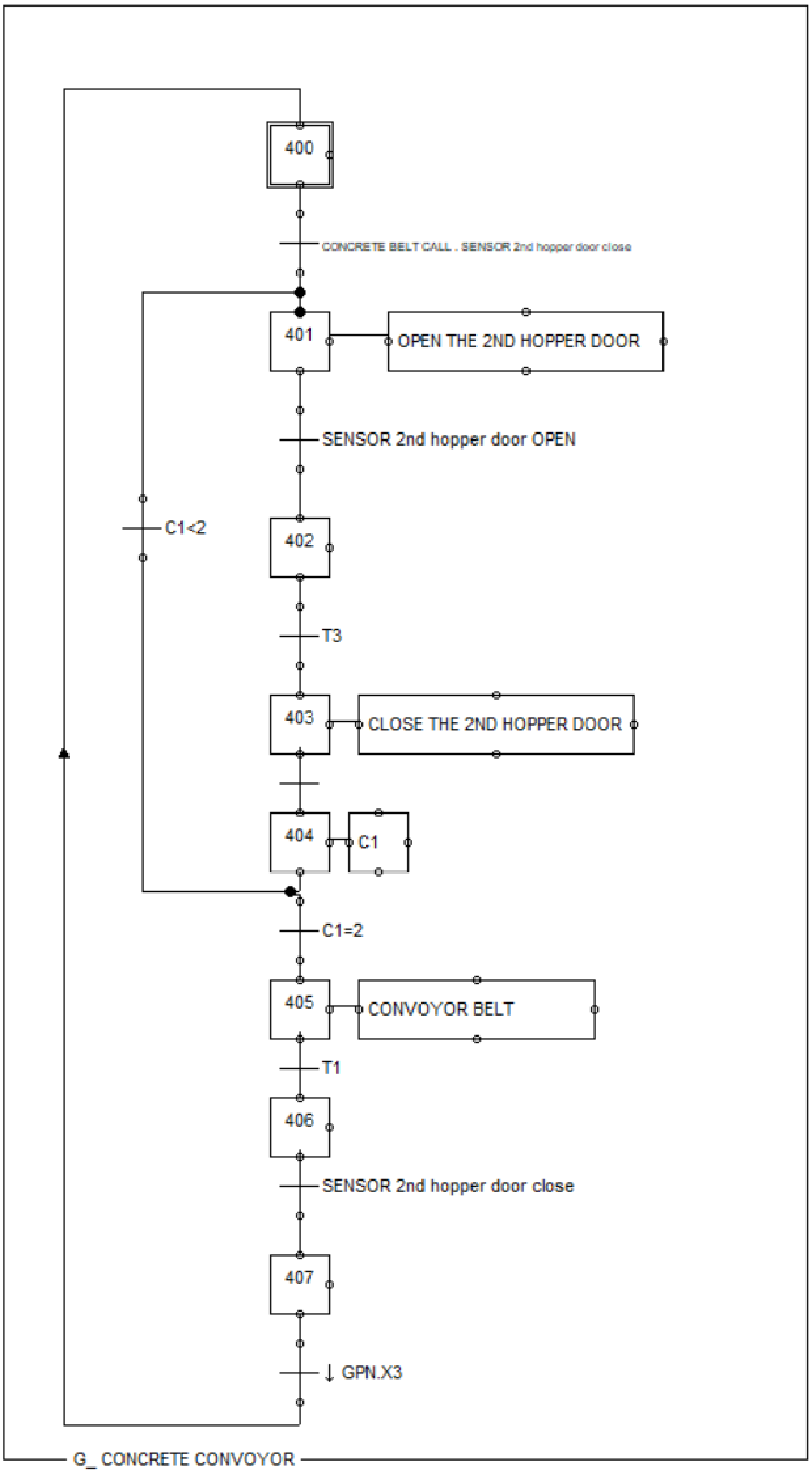
CART (description part)



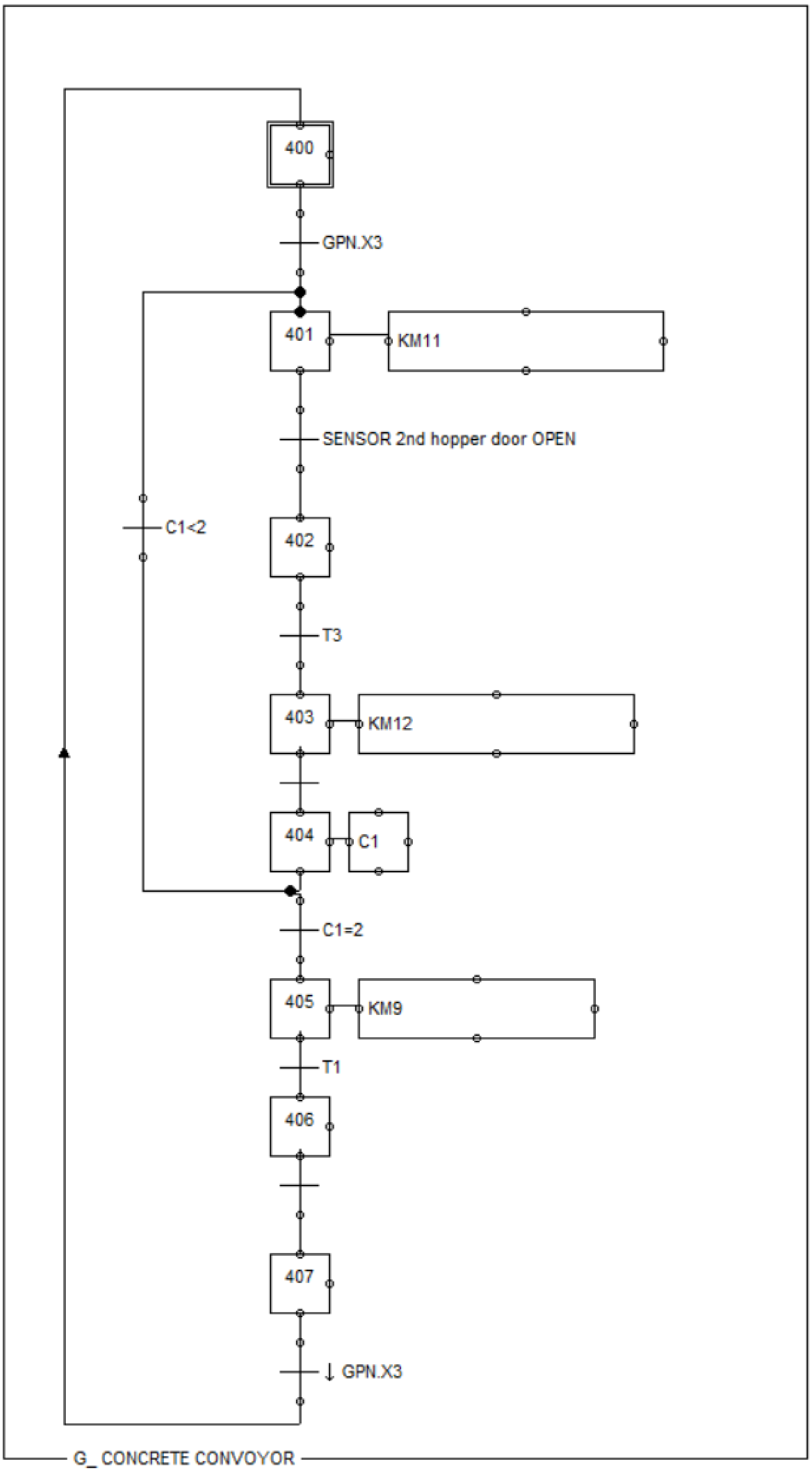
CART (control part)



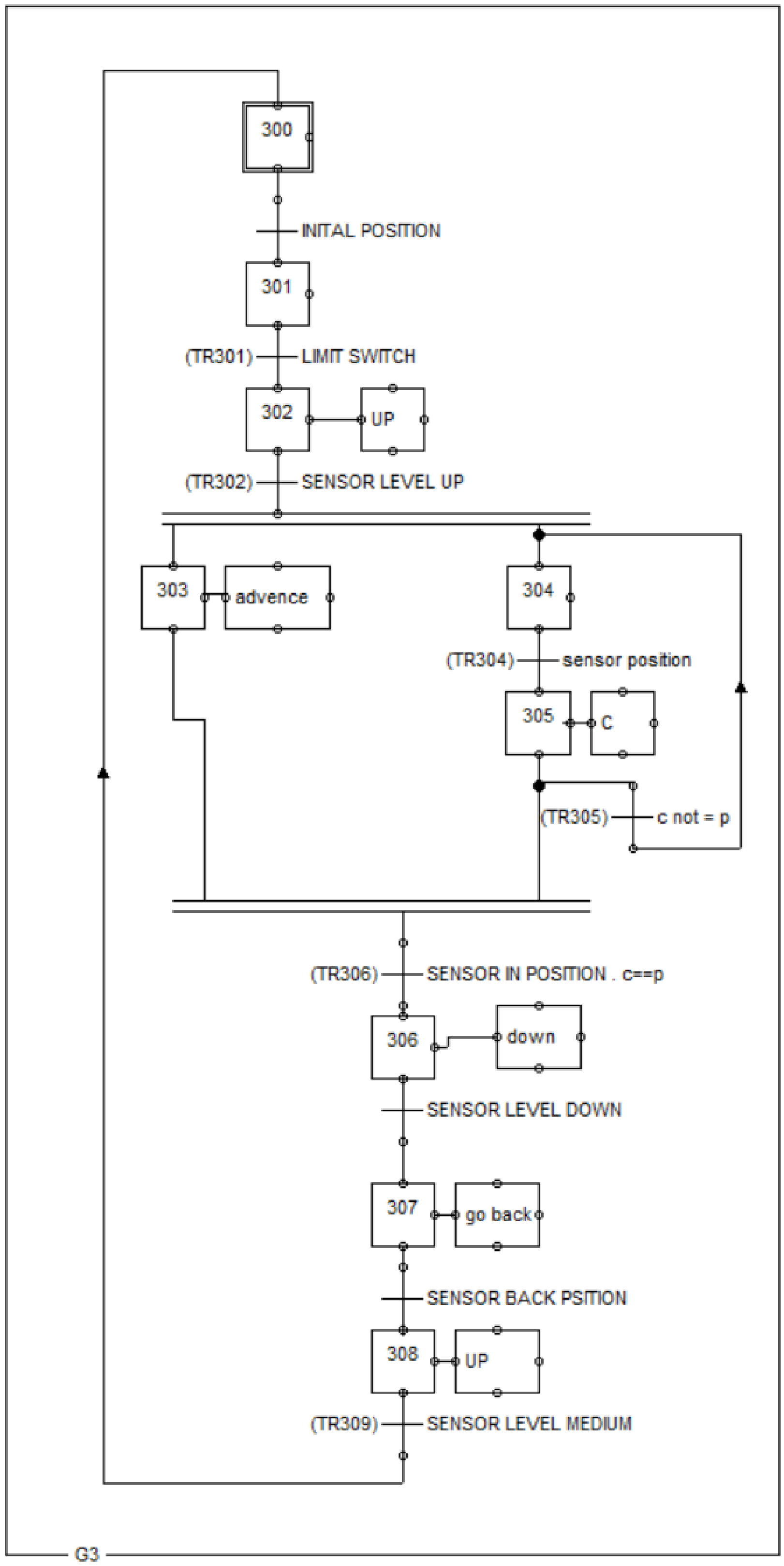
CONCRETE CONVEYOR (description part)

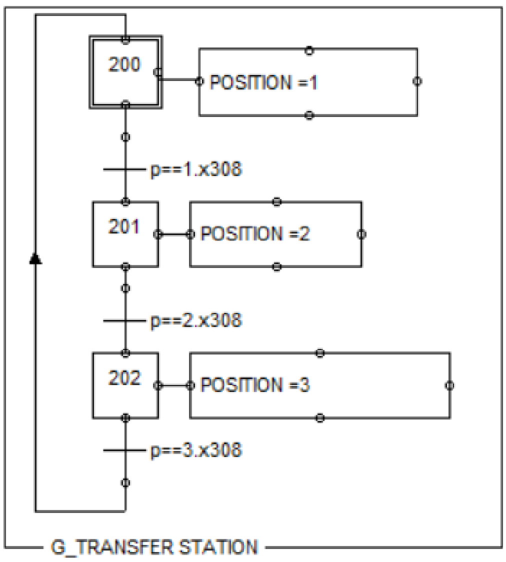


CONCRETE CONVEYOR (control part)

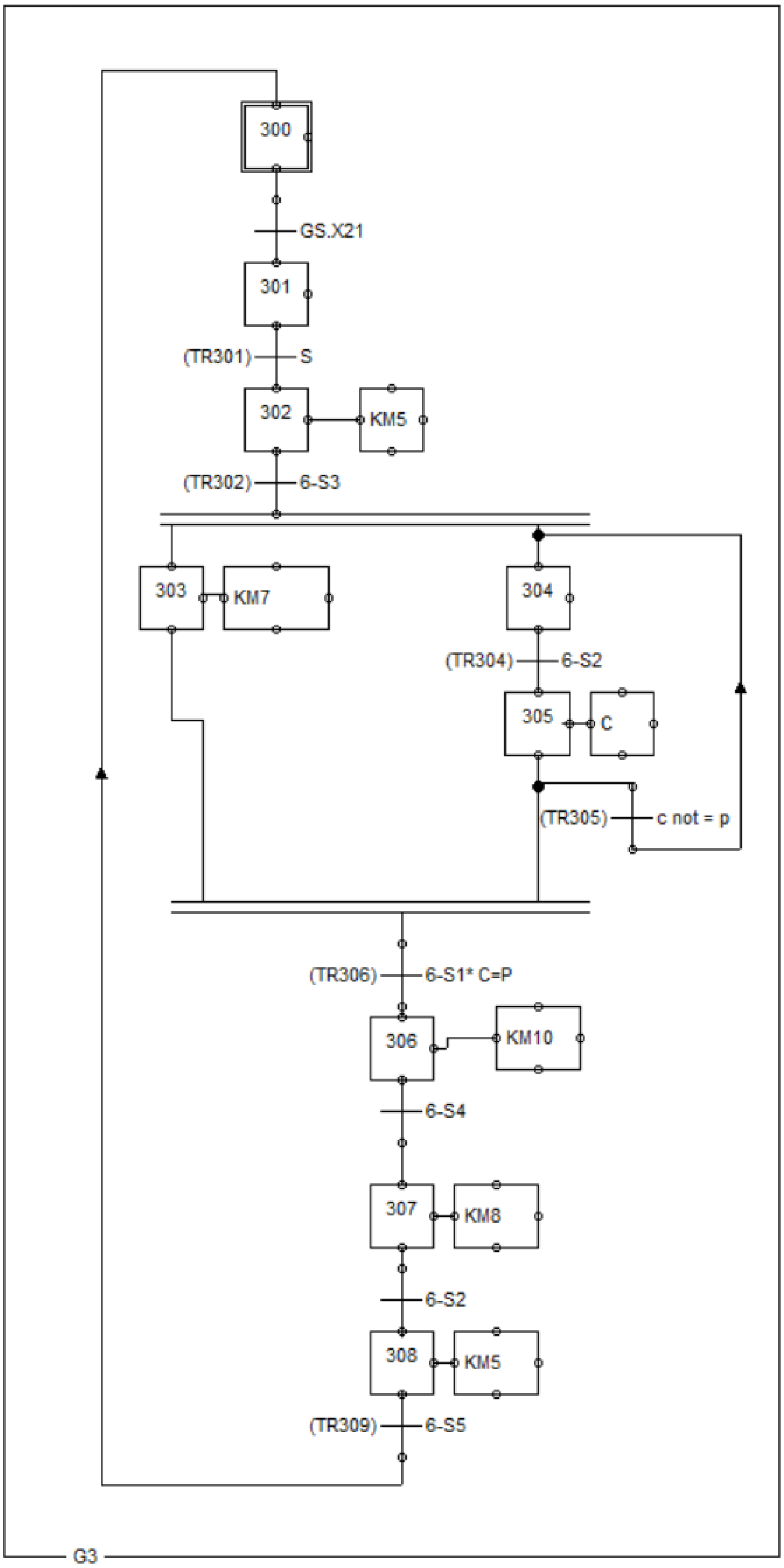


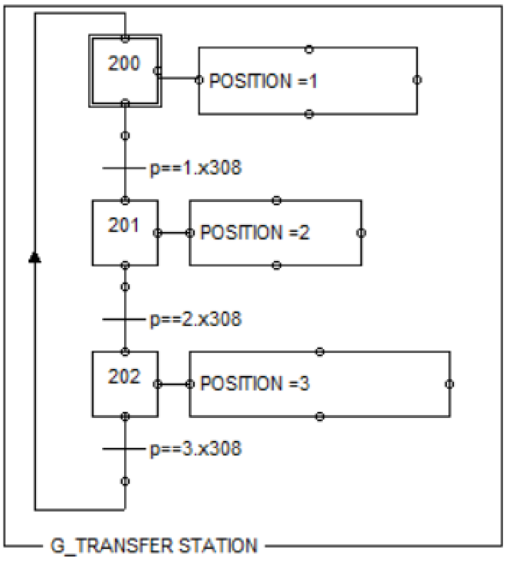
TRANSFER STATION (description part)



TRANSFER STATION (control part)



### 2.3.3 Table of variables

The tables below tab.2.1 and tab.2.2 presents a comprehensive listing of the various effectors, actuators, contactors, and relays involved in our automated concrete block making process, along with their corresponding sensors. Each row represents a specific component, categorized by its type and function within the overall system.

The effectors and actuators are responsible for executing physical actions or movements, such as operating machinery, opening/closing valves, or positioning components. Contactors and relays, on the other hand, serve as electrically controlled switches, enabling or disabling power flow to various circuits or components. Alongside these components, the table includes the associated sensors, which provide feedback on the state or condition of the effectors, actuators, contactors, and relays.

This structured representation facilitates a clear understanding of the system's physical components, their interconnections, and their corresponding sensing mechanisms. By consolidating this information in a single table, it becomes easier to comprehend the interplay between the control logic, the physical components, and the feedback loops, aiding in programming, troubleshooting, and maintenance efforts.

| | Effector | Actuator | Contactors | Relay | sensors |
|---|---|---|---|---|---|
| palet transfer | convoyeur belt | motor | KV1 | K21 | ADVANCE |
| | | | KV2 | K22 | BACK |
| Cylender of the cart | Cart | selenoid valve | KV3 | K19 | ADVANCE |
| | | | KV4 | K20 | BACK |
| Cylender of the Press | Press | motor | KV5 | K16 | UP |
| | | | KV6 | K15 | DOWN |
| Cylender of the Mold | Mold | motor | KV7 | K18 | UP |
| | | | KV8 | K17 | DOWN |
| Cylender color cart | Cart | motor | KV9 | K28 | ADVANCE |
| | | | KV10 | K29 | BACK |
| motor Vibration | vibrator | motor | KV11 | K21 | / |

Table 2.1: First Variable table

| Process | Effector | Actuator | Contactor | Relay | Sensors |
| --- | --- | --- | --- | --- | --- |
| Pump 1<br>High pressure | Pump | motor | KM1 | K1 | / |
| | | | KM2 | K2 | |
| | | | KM3 | K3 | |
| Pump 2<br>Low pressure | Pump | motor | KM4 | K4 | / |
| ejection conveyor belt | Belt | Electrical Motor | KM5 | K5 | / |
| Conveyor belt of concrete | Blet | Electrical Motor | KM14 | K13 | / |
| | | | KM13 | K13/K14 | |
| Mixing | Mixer | Electrical Motor | KM6 | K6 | / |
| door of hopper | Door | motor | KM12 | K12 | Door open |
| | | | KM11 | K11 | Door closed |
| Transfer station<br>UP/DOWN | Stacker | Electrical Motor | KM9 | K9 | UP |
| | | | KM10 | K10 | DOWN |
| Transfer station ADVANCE/ BACK | Stacker | Electrical motor | KM7 | K7 | Initial position |
| | | | KM8 | K8 | Advance |
| Endless screw | Screw | Endless screw | KM | K | / |

Table 2.2: Second Variable table

## 2.4 GEMMA

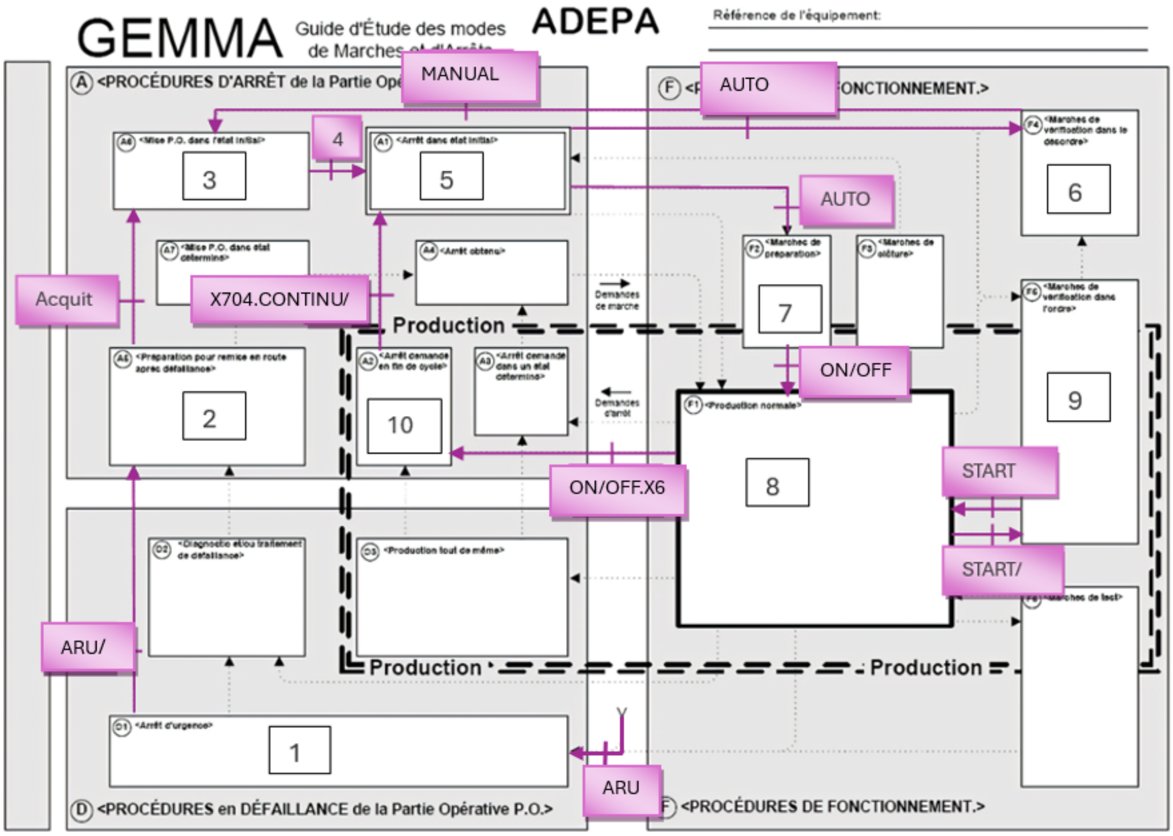



Figure 2.44: GEMMA

1. X20
2. X21
3. X100*X200*X300*X400*X500*X600*X700*X800*X900*X2000
4. X100*X200*X300*X400*X500*X600*X700*X800*X900*X2000
5. X2002*X3000
6. X2003
7. X2004
8. X2005
9. X2006
10. X22*X0

# Chapter 3

# Result and programming

## 3.1 Introduction

This chapter explores the programming and control systems employed in modern production environments. Emphasis is placed on the S7-WINCC software suite from Siemens, which enables logical control programming and visualization for their S7 series programmable logic controllers (PLCs).

By combining programming techniques, control system architectures, and hardware schematics, this chapter equips readers with a comprehensive understanding of the automation systems driving efficient production operations. Real-world examples and best practices are provided to bridge the gap between theory and practical implementation.

### 3.1.1 STEP7-MicroWin

The Step 7 MicroWIN fig.3.1 is a software tool used for programming Siemens SIMATIC S7-200 micro programmable logic controllers (PLCs). It provides a user-friendly environment for writing, editing, and downloading programs onto these compact PLCs.


Figure 3.1: STEP 7 MicroWIN

One of the standout features of MicroWIN is its intuitive and user-friendly interface. It uses a ladder logic programming environment fig.3.1, which is a graphical language commonly used for PLC programming. Ladder logic allows us to create programs using graphical representation well-suited for sequential process control. Detailed electrical and hydraulic schematics are also covered, providing insights into the integration of control logic with physical components like motors, valves, and sensors, making it easier for those familiar with electrical control diagrams to transition to PLC programming.

In addition to ladder logic, MicroWIN also supports other programming languages like Statement List (STL), which is a low-level language that provides more control over the program execution. This flexibility allows us to choose the programming method that best suits our needs and skill level.

One key feature of MicroWIN is its built-in simulator,allows us to test and debug their PLC programs on a virtual S7-200 PLC running on their computer before downloading to the actual hardware. This simulation capability is invaluable for verifying program logic, checking for errors, and ensuring proper operation without risking damage to the real PLC system.

Within the simulator, we can set up a virtual PLC configuration matching their hardware setup. They can simulate digital inputs by forcing them on or off and can monitor how the program responds by watching the simulated output states. Analog values can also be adjusted to test the program's reaction.

The simulation is dynamic, allowing the us to single-step through the program, set breakpoints, and watch variable values in real-time. This makes it easier to pinpoint issues and understand how the program flow executes under different input conditions.

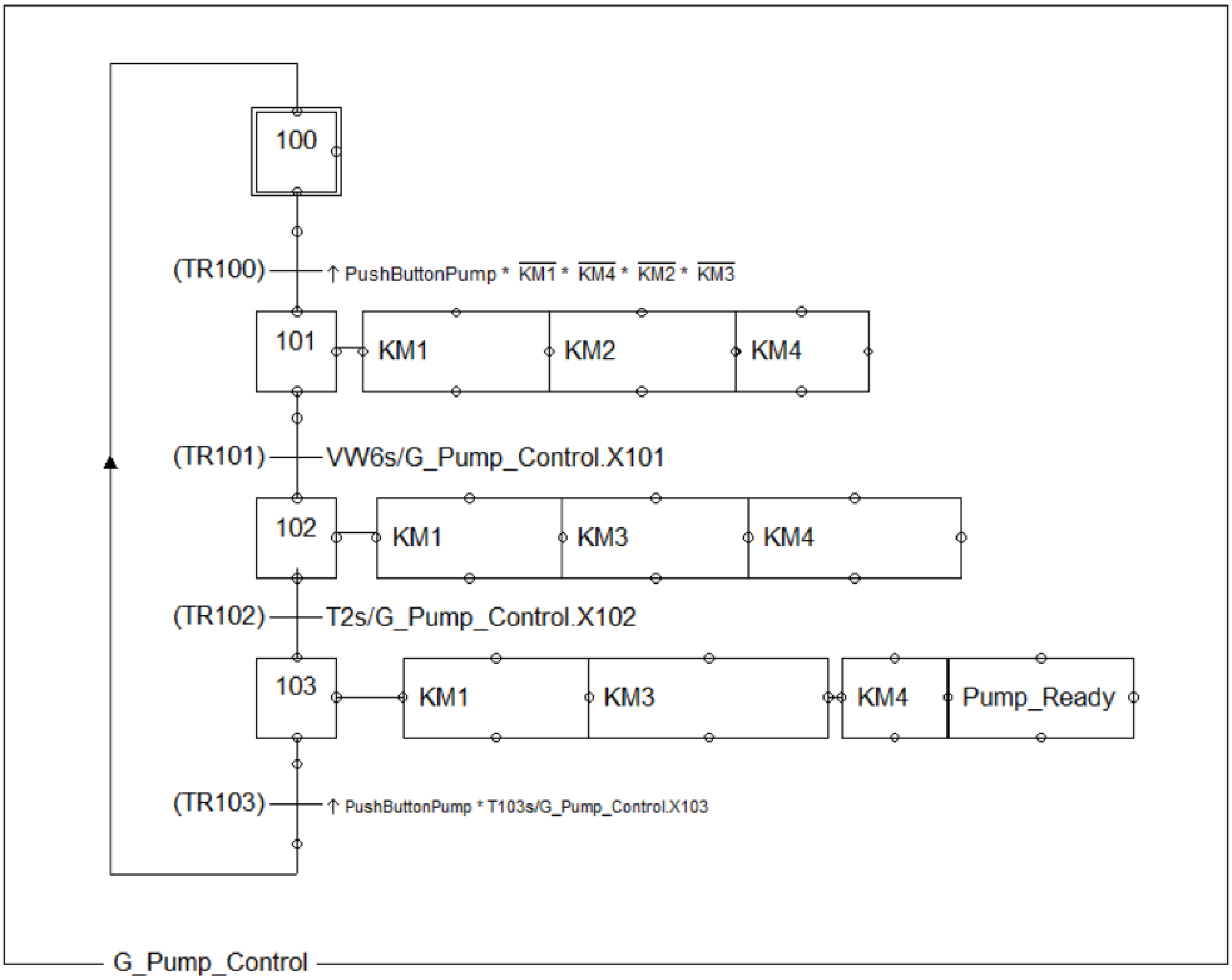
Overall, the Step 7 MicroWIN simulator provides an invaluable testing environment that helps minimize downtime, reduces debugging effort on live equipment, and allows more thorough validation before deployment. Its integration with the MicroWIN programming interface makes it a seamless part of the development workflow for S7-200 PLC applications.

### 3.1.2 Ladder program

Moving forward, we will explore the ladder logic program that drives the control system for our manufacturing process.

The ladder logic implementation follows a diagram-based approach, with each "rung" representing a specific condition or set of conditions that trigger associated outputs or actions when evaluated as true. This visual representation mirrors the architecture of relay logic circuits, making it an intuitive choice for engineers and technicians well-versed in electrical control systems.

Our ladder program is designed to be modular and scalable, with the overall control requirements broken down into individual rungs and subroutines. This approach promotes code maintainability, simplifies debugging efforts, and facilitates future modifications or expansions to the system.




After writing our program in the SFC programming language, we can convert it to a Ladder Diagram using the equation:

*Equation Breakdown*

$$X_{(N)} = TR_{(N-1)} + \overline{TR_{(N)}}.X_N$$

Where:

. X: Represents the current step

. TR(N-1): The condition or signal that activates the step (ACTIVATION).

. NOT(TR): The negation of the transition condition, indicating the step should remain active if the transition condition is not met (DISACTIVATION).

. +: Logical OR operation.

. ×: Logical AND operation.

### 3.1.3 Solidworks

#### 3.1.3.1 SolidWorks Electrical

SolidWorks is a powerful 3D computer-aided design (CAD) and computer-aided engineering (CAE) software suite developed by Dassault Systèmes fig.3.2.

It is widely used by engineers, designers, and manufacturers across a wide range of industries for creating, simulating, and documenting product designs.[20]

Figure 3.2: SolidWorks Electrical

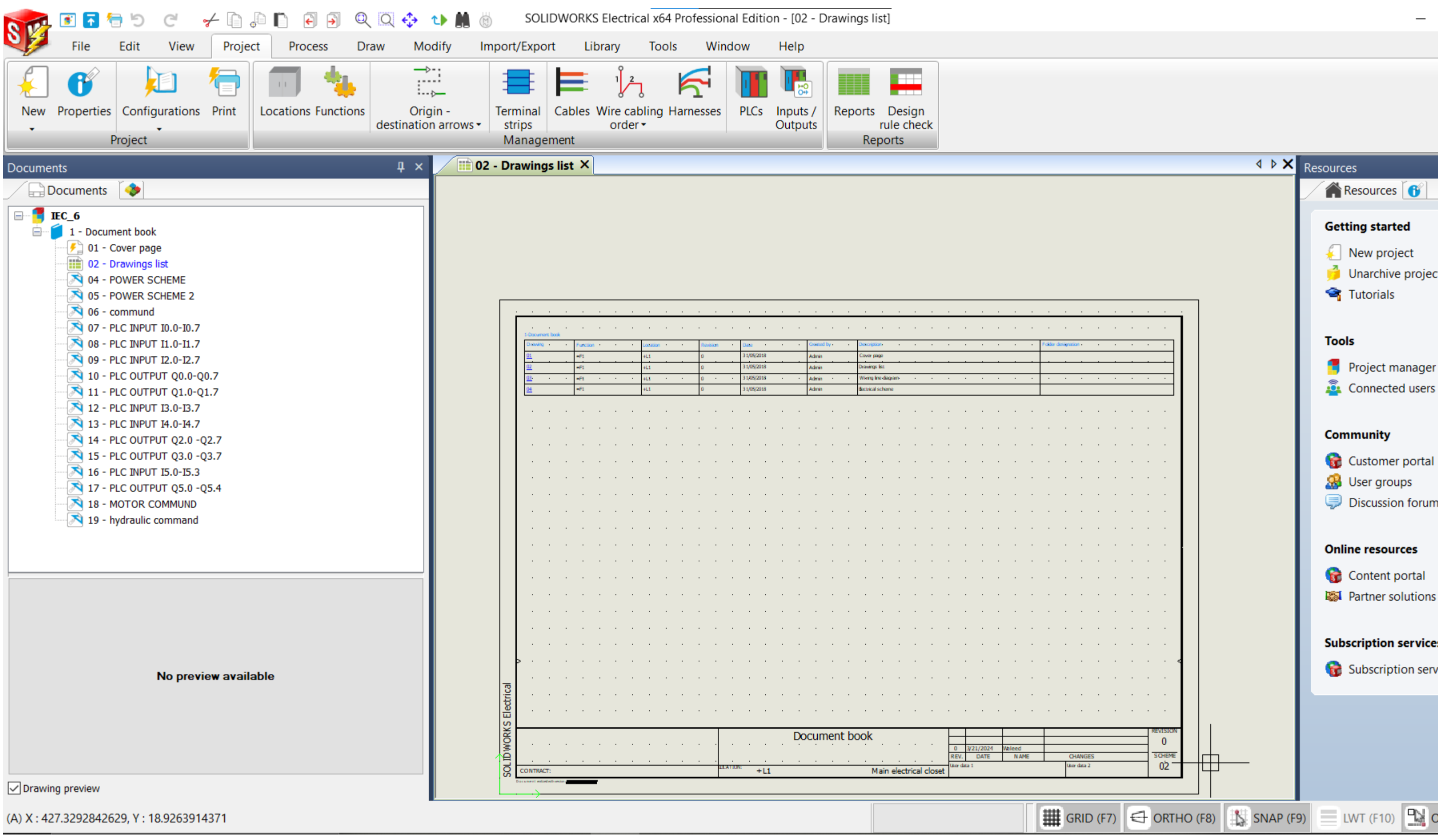



Figure 3.3: SolidWorks Electrical main page

At its core, SolidWorks is a parametric solid modeling software that enables us to create and manipulate three-dimensional (3D) solid models of parts and assemblies.

The parametric modeling approach allows for easy modification of designs by changing the underlying parameters or dimensions, automatically updating the model accordingly.

One of the key strengths of SolidWorks is its intuitive and user-friendly interface, which facilitates efficient design workflows. Users can create complex geometries using a variety of modeling tools, such as extrudes, revolves, sweeps, and lofts, as well as advanced surfacing tools for creating organic shapes.

SolidWorks is not just limited to part modeling; it also offers robust assembly modeling capabilities. Users can create intricate assemblies by mating and positioning individual components, enabling them to visualize and analyze the complete product design. This feature is particularly valuable for identifying potential interferences, clearance issues, or design flaws before physical prototyping.

In addition to its core modeling capabilities, SolidWorks includes a suite of integrated tools and modules that extend its functionality across various engineering disciplines. Some of these tools and modules include:

- Simulation: SolidWorks Simulation allows us to perform finite element analysis (FEA) on their designs to analyze structural performance, stress, deformation, and other physical properties without needing physical prototyping.

- Motion Analysis: SolidWorks Motion enables us to simulate and analyze the motion of assemblies, including kinematics, dynamics, and interaction between components.

- Computational Fluid Dynamics (CFD): SolidWorks Flow Simulation allows users to analyze fluid flow, heat transfer, and related phenomena, which is crucial for designing products involving fluid systems or thermal management.

- Electrical Design:

  SolidWorks Electrical enables users to develop and manage electrical schematics for control and power circuits, enabling them to effectively streamline their electrical design processes.

SolidWorks also integrates with other Dassault Systemes products, such as ENOVIA for product data management and 3DEXPERIENCE for collaborative product lifecycle management, enabling seamless data exchange and collaboration across various engineering disciplines and teams.

In addition to its design and engineering capabilities, SolidWorks plays a crucial role in manufacturing processes. It supports the generation of detailed manufacturing drawings, bills of materials (BOMs), and other documentation required for production. SolidWorks models can also be directly exported to computer-aided manufacturing (CAM) software for generating toolpaths and programming computer numerical control (CNC) machines.

Overall, SolidWorks is a comprehensive and versatile CAD/CAE solution that streamlines the product development process from conceptual design to manufacturing.

Its powerful modeling, simulation, and visualization tools and integration capabilities make it a valuable asset for engineers, designers, and manufacturers across diverse industries, including automotive, aerospace, consumer products, and many others.[23]

In the following pictures we will show and explain everything concerning the electrical schematics of the CHINA GUANGYAN BLOCK MACHINE:

### 3.1.4 Mnemonic Tables

#### 3.1.4.1 Mnemonic tables of sensors, command console and outputs (Actuators)

The tables below present a mnemonic listing of the various inputs, outputs, and sensors integrated into our automated process. Mnemonics provide a concise and structured way to label and reference these components using abbreviated codes. Each row corresponds to a specific input signal, output action, or sensor reading instrumental to the system's operation.

The mnemonic codes serve as symbolic representations, offering a systematic naming convention that aids in programming, documentation, and troubleshooting efforts. Alongside the mnemonics, the corresponding memory addresses are provided, enabling the control program to interface with the physical inputs, outputs, and sensors by accessing the appropriate memory locations. This structured representation facilitates a clear understanding of the system's interface with the real-world components, streamlining programming efforts and ensuring proper communication between the control logic and the physical devices.

This first table tab.3.1 lists all SENSORS along with their respective addresses as shown below.

| Sensors | Symbol | address |
|---|---|---|
| PRESS UP | 3S1 | I0.0 |
| PRESS DOWN | 3S2 | I0.1 |
| MOLD UP | 4S2 | I0.2 |
| MOLD DOWN | 4S1 | I0.3 |
| CONCRETE CART BACK | 2S1 | I0.4 |
| CONCRETE CART ADVANCE | 2S2 | I0.7 |
| HOPPER DOOR CLOSED | 9S2 | I1.0 |
| HOPPER DOOR OPEN | 9S1 | I4.0 |
| STACKER UP | 6S3 | I1.1 |
| STACKER MIDDLE | 6S5 | I4.1 |
| STACKER DOWN | 6S4 | I1.2 |
| STACKER ADVANCE | 6S1 | I1.3 |
| STACKER BACK | 6S2 | I1.4 |
| LIMIT SWITCH | 5S | I4.2 |
| COLOR CART ADVANCE | 7S2 | I5.1 |
| COLOR CART BACK | 7S1 | I5.0 |

Table 3.1: List of sensors

This 2nd table tab.3.2 lists the first part of inputs in the CONTROL CONSOLE along with their respective addresses as shown below.

| Control console | address |
|---|---|
| PUMP1 | I1.5 |
| AUTO/MANUAL | I1.6 |
| CONVEYOR PALET | I1.7 |
| MIXER | I2.0 |
| VIBRATION | I2.1 |
| MANUAL PRESS UP | I2.2 |
| MANUAL PRESS DOWN | I2.3 |
| MOLD UP | I2.4 |
| MOLD DOWN | I2.5 |
| CART ADVANCE | I2.6 |
| CART BACK | I2.7 |
| PALET DISTRIBUTOR ADVANCE | I3.0 |
| PALET DISTRIBUTOR BACK | I3.1 |
| OPEN DOOR HOPPER | I3.2 |
| CLOSE DOOR HOPPER | I3.3 |
| ON/OFF | I3.4 |
| ON/OFF COLOR | I7.2 |
| EMERGENCY STOP | I3.5 |
| AUTO/MANUAL | I3.6 |
| STACKER UP | I4.3 |
| STACKER DOWN | I4.5 |
| STACKER ADVANCE | I4.6 |
| STACKER BACK | I4.7 |
| COLOR CART ADVANCE | I5.2 |
| COLOR CART BACK | I5.3 |

Table 3.2: List of inputs of the first control console

This 3rd table tab.3.3 lists the second part of inputs in the CONTROL CONSOLE along with their respective addresses as shown below.

| Actuators | Symbol | address |
|---|---|---|
| PWM DIFFERENTIAL VALVE | / | Q0.0 |
| KM PALET CONVEYOR | KM5 | Q0.1 |
| KM CONCRETE CONVEYOR | KM13/KM14 | Q0.2 |
| KM MIXER | KM6 | Q0.3 |
| KM 2ND PUMP | KM4 | Q0.4 |
| KV PRESS DOWN | 3C1 | Q0.6 |
| KV PRES UP | 3C2 | Q0.7 |
| KV MOLD DOWN | 4C2 | Q1.0 |
| KV MOLD UP | 4C1 | Q1.1 |
| KV CONCRETE CART ADVANCE | 1C1 | Q1.2 |
| KV CONCRETE CART BACK | 1C2 | Q1.3 |
| KM STACKER ADVANCE | KM7 | Q1.4 |
| KM STACKER BACK | KM8 | Q1.5 |
| KM STACKER UP | KM9 | Q1.6 |
| KM STACKER DOWN | KM10 | Q1.7 |
| KV PALET DISTRIBUTOR ADVANCE | 2C1 | Q2.0 |
| KV PALET DISTRIBUTOR BACK | 2C2 | Q2.1 |
| KV VIBRATOR | KV12 | Q2.3 |
| LAMP PB DCY | / | Q2.4 |
| KM PUMP1 | KM1 | Q2.5 |
| KM DELTA CONNECTION PUMP1 | KM2 | Q2.6 |
| KM STAR CONNECTION PUMP1 | KM3 | Q2.7 |
| KM OPEN HOPPER DOOR | KM12 | Q3.0 |
| KM CLOSE HOPPER DOOR | KM11 | Q3.1 |
| KV COLOR CART ADVANCE | 7C1 | Q4.0 |
| KV COLOR CART BACK | 7C2 | Q4.1 |

Table 3.3: List of inputs of the second control console

#### 3.1.4.2 Mnemonic tables of the GRAFCET program

The tables below lists the steps and transitions of the control sequence GRAFCET program, along with their respective addresses. The steps, represented by "X", indicate the stable states or actions taken. The transitions, shown by "TR", are the conditions required to move from one step to the next. The addresses provided correspond to the memory locations associated with each step and transition in the control program.

This first table tab.3.4 lists the steps and transitions of the GPN GRAFCET (Grafcet for Normal Production)(X0), along with their respective addresses as shown below.

| | |
|---|---|
| X0 | M9.6 |
| X1 | M9.7 |
| X2 | M3.0 |
| X3 | M3.1 |
| X4 | M3.2 |
| X5 | M3.3 |
| X6 | M3.4 |
| X3-5 | M3.5 |
| X4-5 | M3.6 |

| | |
|---|---|
| TR0 | M31.0 |
| TR1 | M31.1 |
| TR2 | M31.2 |
| TR3 | M31.3 |
| TR4 | M31.4 |
| TR5 | M31.5 |
| TR6 | M31.6 |
| TR7 | M31.7 |
| TRATT | M5.1 |

Table 3.4: List of GPN grafcet's steps and transitions with their addresses

This 2nd table tab.3.5 lists the steps and transitions of the GCI GRAFCET (Independent Conduct Grafcet)(X10), along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X10 | M12.3 |
| X11 | M12.4 |
| X12 | M12.5 |
| X13 | M12.6 |
| X14 | M12.7 |
| X15 | M13.0 |
| X16 | M13.1 |

| Transitions | address |
|---|---|
| TR10 | M23.3 |
| TR11 | M22.4 |
| TR12 | M22.5 |
| TR13 | M22.6 |
| TR14 | M22.7 |
| TR15 | M23.0 |
| TR16 | M23.1 |
| TR17 | M23.2 |

Table 3.5: List of GCI grafcet's steps and transitions with their addresses

This 3rd table tab.3.6 lists the steps and transitions of the GS GRAFCET (Sequence Grafcet)(X20), along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X20 | M10.0 |
| X21 | M10.1 |
| X22 | M10.2 |

| Transition | address |
|---|---|
| TR20 | M20.0 |
| TR21 | M20.1 |
| TR22 | M20.2 |

Table 3.6: List of GS grafcet's steps and transitions with their addresses

This 4th table tab.3.7 lists the steps and transitions of the SFC GRAFCET (Sequential Function Chart)(X100) who's responsable for starting the hydraulic pump, along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X100 | M10.3 |
| X101 | M10.4 |
| X102 | M10.5 |
| X103 | M10.6 |

| Transition | address |
|---|---|
| TR100 | M20.3 |
| TR101 | M20.4 |
| TR102 | M20.5 |
| TR103 | M20.6 |

Table 3.7: List of SFC (starting the hydraulic pump) grafcet's steps and transitions with their addresses

This 5th table tab.3.8 lists the steps and transitions of the first TRANSFER STATION's GRAFCET (X200), along with their respective addresses as shown below.

| | |
|---|---|
| X200 | M19.2 |
| X201 | M19.3 |
| X202 | M19.4 |

| | |
|---|---|
| TR200 | M29.3 |
| TR201 | M29.4 |
| TR202 | M29.5 |

Table 3.8: List of transfer station grafcet's steps and transitions with their addresses

This 6th table tab.3.9 lists the steps and transitions of the second TRANSFER STATION's GRAFCET (X300), along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X300 | M19.5 |
| X301 | M19.6 |
| X302 | M19.7 |
| X303 | M19.8 |
| X304 | M9.0 |
| X305 | M9.1 |
| X306 | M9.2 |
| X307 | M9.3 |
| X308 | M9.4 |

| Transition | address |
|---|---|
| TR300 | M29.6 |
| TR301 | M29.7 |
| TR302 | M30.0 |
| TR303 | M30.1 |
| TR304 | M30.2 |
| TR305 | M30.3 |
| TR306 | M30.4 |
| TR307 | M30.5 |
| TR308 | M30.6 |
| TR309 | M30.7 |

Table 3.9: List of SFC (starting the hydraulic pump) grafcet's steps and transitions with their addresses

This 7th table tab.3.10 lists the steps and transitions of SFC GRAFCET (Sequential Function Chart) of the concrete conveyor (X400), along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X400 | M16.6 |
| X401 | M16.7 |
| X402 | M17.0 |
| X403 | M17.1 |
| X404 | M17.2 |
| X405 | M17.3 |
| X406 | M17.4 |

| Transition | address |
|---|---|
| TR400 | M26.6 |
| TR401 | M26.7 |
| TR402 | M27.0 |
| TR403 | M27.1 |
| TR404 | M27.2 |
| TR405 | M27.3 |
| TR406 | M27.4 |
| TR407 | M27.5 |

Table 3.10: List of SFC (concrete conveyor) grafcet's steps and transitions with their addresses

This 8th table tab.3.11 lists the steps and transitions of CONCRETE CART's GRAFCET (X500), along with their respective addresses as shown below.

| | |
|---|---|
| X500 | M18.2 |
| X501 | M18.3 |
| X502 | M18.4 |
| X503 | M18.5 |
| X504 | M18.6 |
| X505 | M18.7 |
| X506 | M19.0 |
| X507 | M19.1 |

| | |
|---|---|
| TR500 | M28.3 |
| TR501 | M28.4 |
| TR502 | M28.5 |
| TR503 | M28.6 |
| TR504 | M28.7 |
| TR505 | M29.0 |
| TR506 | M29.1 |
| TR507 | M29.2 |

Table 3.11: List of CONCRETE CART grafcet's steps and transitions with their addresses

This 9th table tab.3.12 lists the steps and transitions of MOLDING's GRAFCET (X600), along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X600 | M15.3 |
| X601 | M15.4 |
| X602 | M15.5 |
| X603 | M15.6 |
| X604 | M15.7 |
| X605 | M16.0 |
| X606 | M16.1 |
| X607 | M16.2 |
| X608 | M16.3 |
| X609 | M16.4 |
| X610 | M16.5 |

| Transitions | address |
|---|---|
| TR600 | M25.2 |
| TR601 | M25.3 |
| TR602 | M25.4 |
| TR603 | M25.5 |
| TR604 | M25.6 |
| TR605 | M25.7 |
| TR606 | M26.1 |
| TR607 | M26.3 |
| TR608 | M26.4 |
| TR609 | M26.5 |
| TR610 | M26.2 |
| TR611 | M26.0 |

Table 3.12: List of MOLDING grafcet's steps and transitions with their addresses

This 10th table tab.3.13 lists the steps and transitions of PALETS DISTRIBUTION's GRAFCET (X700), along with their respective addresses as shown below.

| | | | |
|---|---|---|---|
| X700 | M17.5 | TR700 | M27.6 |
| X701 | M17.6 | TR701 | M27.7 |
| X702 | M17.7 | TR702 | M28.0 |
| X703 | M18.0 | TR703 | M28.1 |
| X704 | M18.1 | TR704 | M28.2 |

Table 3.13: List of PALETS DITRIBUTION grafcet's steps and transitions with their addresses

This 11th table tab.3.14 lists the steps and transitions of COLOR's GRAFCET (X800), along with their respective addresses as shown below.

| STEPS | address | Transitions | address |
|---|---|---|---|
| X800 | M13.2 | TR800 | M23.4 |
| X801 | M13.3 | TR801 | M23.5 |
| X802 | M13.4 | TR802 | M23.6 |
| X803 | M13.5 | TR803 | M23.7 |
| X804 | M13.6 | TR804 | M24.0 |
| X805 | M13.7 | TR805 | M24.1 |
| X806 | M14.0 | TR806 | M24.2 |
| X807 | M14.1 | TR807 | M24.3 |
| X808 | M14.3 | TR808 | M24.4 |
| X809 | M14.4 | TR809 | M24.5 |
| X810 | M15.0 | TR810 | M24.6 |
| X811 | M15.1 | TR811 | M24.7 |
| X812 | M15.2 | TR812 | M25.0 |
| | | TR813 | M5.0 |

Table 3.14: List of COLOR's steps and transitions with their addresses

This 12th table tab.3.15 lists the steps and transitions of PREPARATORY ORDERS's GRAFCET (X2000), along with their respective addresses as shown below.

| STEPS | address |
|---|---|
| X2000 | M10.7 |
| X2001 | M11.0 |
| X2002 | M11.1 |
| X2003 | M11.2 |
| X2004 | M11.3 |
| X2005 | M11.4 |
| X2006 | M11.5 |
| X2007 | M11.6 |
| X2008 | M11.7 |
| X2009 | M12.0 |
| X2010 | M12.1 |
| X2011 | M12.2 |

| Transition | address |
|---|---|
| TR2000 | M20.7 |
| TR2001 | M21.0 |
| TR2002 | M21.1 |
| TR2003 | M21.2 |
| TR2004 | M21.3 |
| TR2005 | M21.4 |
| TR2006 | M21.5 |
| TR2007 | M21.6 |
| TR2008 | M21.7 |
| TR2009 | M22.0 |
| TR2010 | M22.1 |
| TR2011 | M22.2 |

Table 3.15: List of PREPARATORY ORDERS's steps and transitions with their addresses

#### 3.1.4.3 Mnemonic table of Mementos

This table tab.3.16 lists mementos, along with their respective addresses as shown below.

| MEMENTO | address |
|---|---|
| AQUIT | M4.1 |
| INIT | M0.1 |
| MUMP READY | M0.2 |
| CALL PWM | M0.3 |
| CONTINU | M1.1 |
| ON/OFF COLOR | M0.5 |
| COLOR ON WITH VIBRATION | M0.7 |
| P | MW6 |

Table 3.16: List of MEMENTOS with their addresses

#### 3.1.4.4 POU table

This table tab.3.17 lists POU symbols, along with their respective addresses as shown below.

| POU Symbols | Address |
|---|---|
| SFC SECURITY | SBR0 |
| SFC STARTING HYDRAULIC PUMP | SBR1 |
| TRANSFER STATION | SBR2 |
| CONCRETE CONVEYOR | SBR3 |
| CONCRETE CART | SBR4 |
| RUN PMW0 | SBR5 |
| MOLDING | SBR6 |
| PALET DIRTRIBUTION | SBR7 |
| COLOR | SBR8 |
| PREPARATORY ORDERS | SBR9 |
| GPN | SBR10 |
| GCI | SBR11 |
| VALVES | SBR12 |
| PROGRAM BLOCK | OB1 |

Table 3.17: POU table

## PALETTE DISTRIBUTION

1. TRANSITIONS:
2. STEPS :
3. OUTPUTS :

$$2C2 = x_{701} + x_{13}.PALETDISADVANCE$$

$$2C1 = x_{702} + x_{13}.PALETDISG0BACK$$

$$kM_9 = \overline{6S3}.(x_{701} + x_{702}x_{703}) + x_{13}.CONVOYORPALET$$

# Conclusion

The primary objective of this final year project was to optimize the control and automation system of the CHINA GUANGYAN BLOCK MACHINE used for the production of concrete blocks. Initially, the integrated Siemens S7-200 Programmable Logic Controller (PLC) in the machine had only a ladder logic program, which limited the possibilities for evolution and maintenance of the control system.

To address this issue, an innovative approach was adopted, involving the development of a control program based on the Sequential Function Chart (SFC) language, followed by its translation into ladder logic for compatibility with the existing PLC. This methodology allowed leveraging the advantages of SFC, notably a clear visual representation of the production steps and transitions between these steps, facilitating the understanding and maintenance of the control program.

First, an in-depth analysis of the machine and its production process was carried out, from the mixing of raw materials to the obtainment of the final product, the concrete blocks. This step enabled a detailed understanding of the machine's operation and the constraints associated with its automation.

Next, the Human-Machine Interface (HMI) was developed using the Easy Builder Pro software, ensuring a seamless connection between the machine and the Siemens S7-200 PLC. This HMI provides a user-friendly platform for monitoring and controlling the production operations.

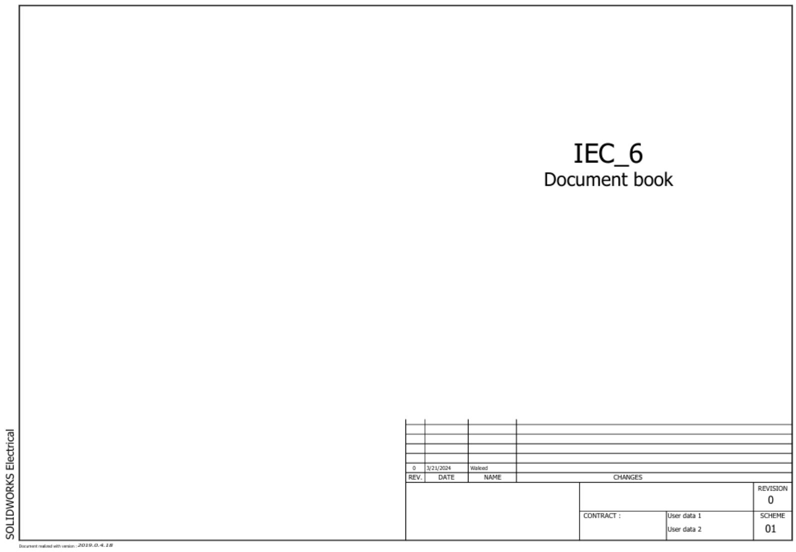
The SFC control program was elaborated using the FluidSIM software, allowing for a visual modeling of the production steps and associated transitions. This program was then converted into ladder logic using Siemens Step 7 software, ensuring compatibility with the existing S7-200 PLC. The simulation of the ladder code was performed using the integrated simulation module in Step 7, enabling validation of the program's proper functioning before deployment on the actual machine.

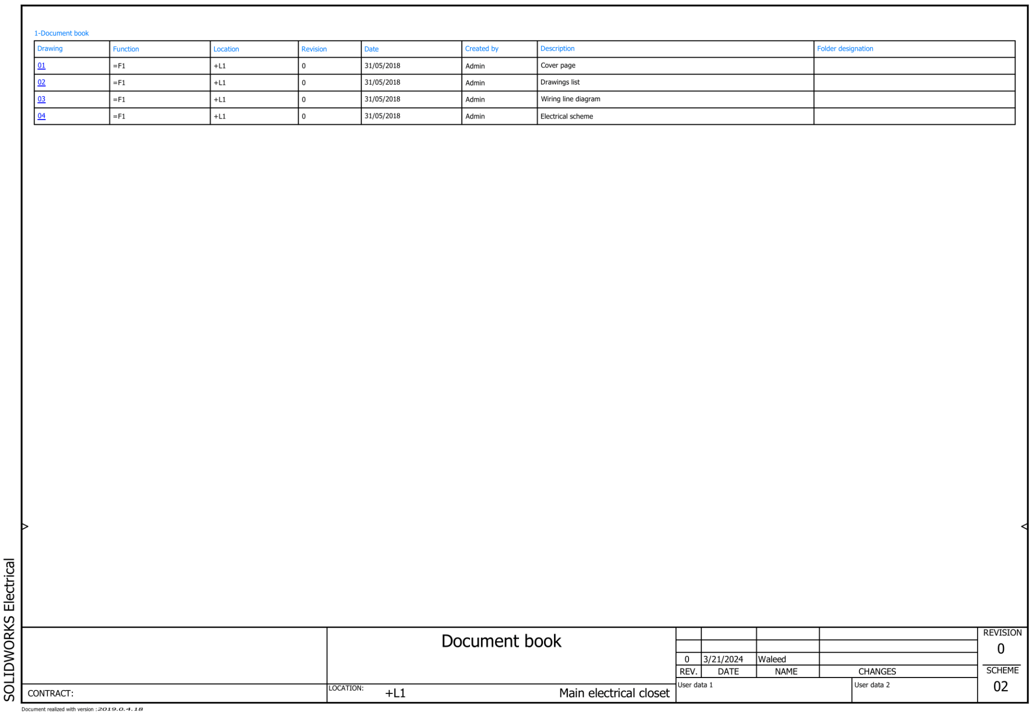
Finally, the electrical schematics of the production process were designed using the SolidWorks software, ensuring complete and accurate documentation of the electrical systems involved in controlling the machine.

In conclusion, this project successfully modernized and optimized the control system of the CHINA GUANGYAN BLOCK MACHINE through the implementation of an SFC-based control program, offering improved flexibility, maintainability, and efficiency in the production of concrete blocks. The adopted approach, combining various software tools and programming techniques, successfully addressed the challenges associated with automating this complex industrial machine.

# Appendix

# Appendix A: electrical scheme



1-Document book

| Drawing | Function | Location | Revision | Date | Created by | Description | Folder designation |
|---|---|---|---|---|---|---|---|
| 01 | =F1 | +L1 | 0 | 31/05/2018 | Admin | Cover page | |
| 02 | =F1 | +L1 | 0 | 31/05/2018 | Admin | Drawings list | |
| 03 | =F1 | +L1 | 0 | 31/05/2018 | Admin | Wiring line diagram | |
| 04 | =F1 | +L1 | 0 | 31/05/2018 | Admin | Electrical scheme | |

Document book

| | | | | |
|---|---|---|---|---|
| 0 | 3/21/2024 | Waleed | | REVISION 0 |
| REV. | DATE | NAME | CHANGES | SCHEME 02 |

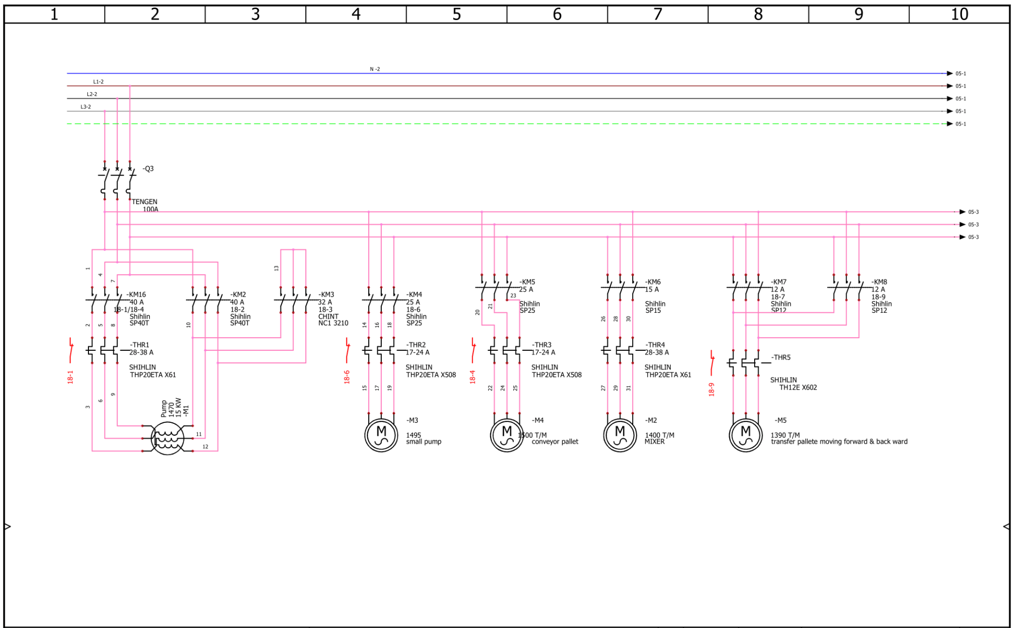
CONTRACT:

LOCATION: +L1 Main electrical closet

User data 1

User data 2

SOLIDWORKS Electrical

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|---|---|---|---|---|---|
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| | | 0 | 4/11/2024 | Waleed | |
| | | REV. | DATE | NAME | CHANGES |
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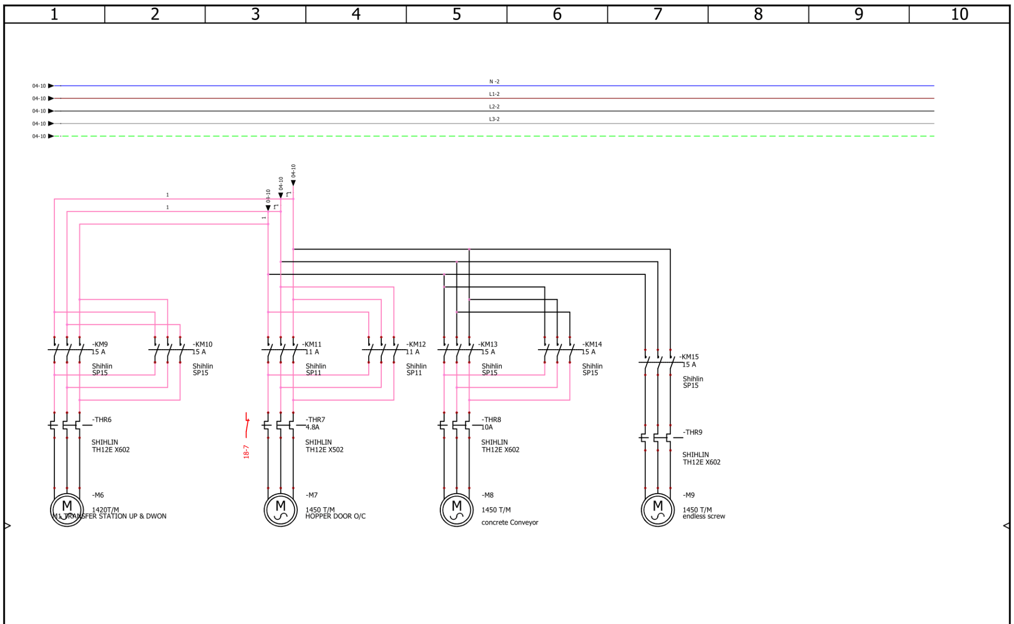
SOLIDWORKS Electrical

Document realized with version :2019.0.4.18

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| | Document book | | | | REVISION 0 |
| | | 0 | 3/21/2024 | Waleed | |
| | | REV. | DATE | NAME | CHANGES |
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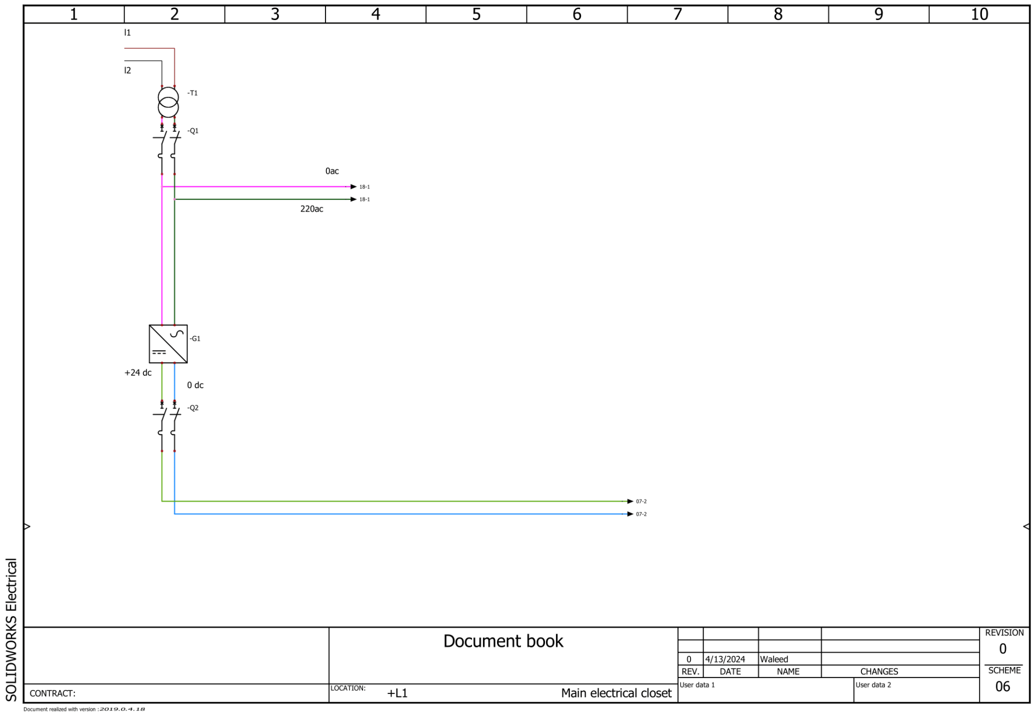
SOLIDWORKS Electrical

Document realized with version :2019.0.4.18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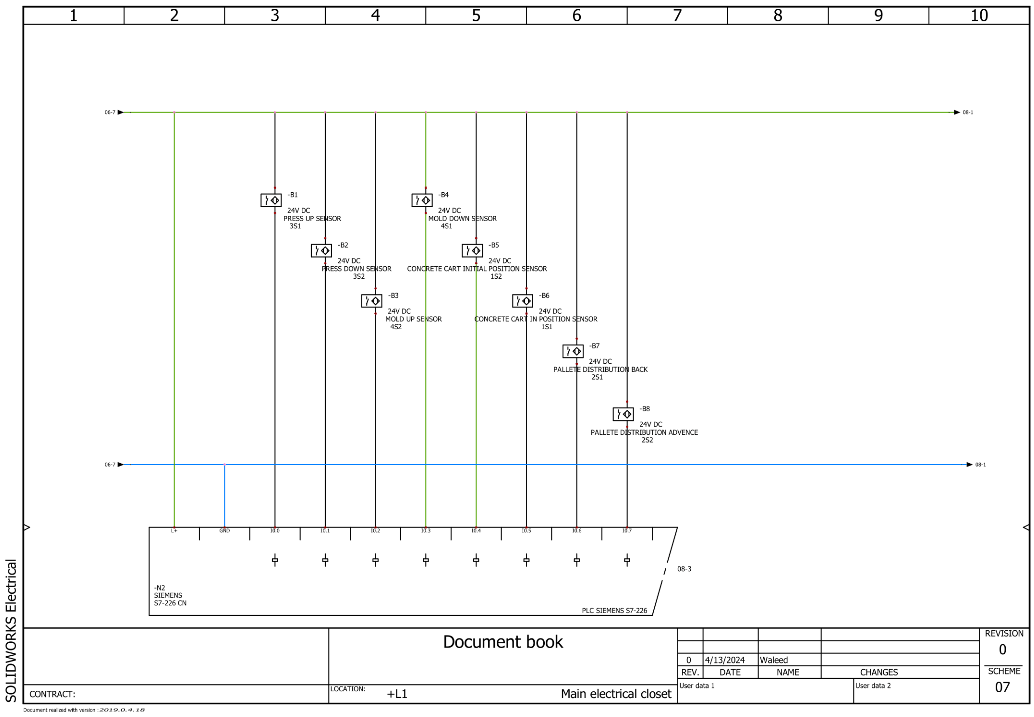
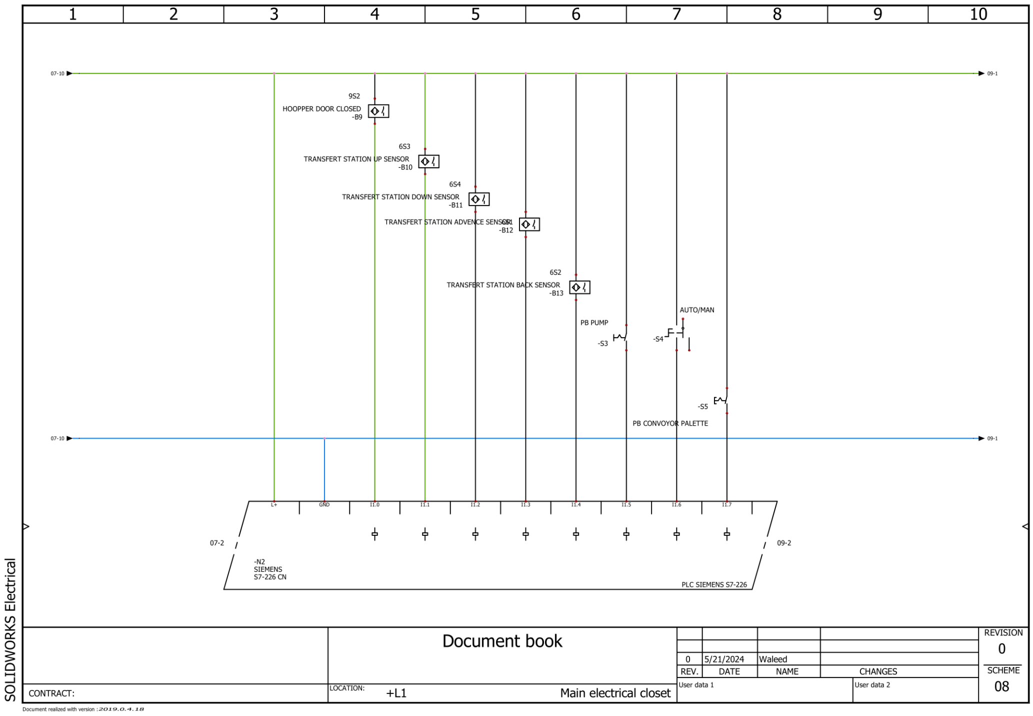
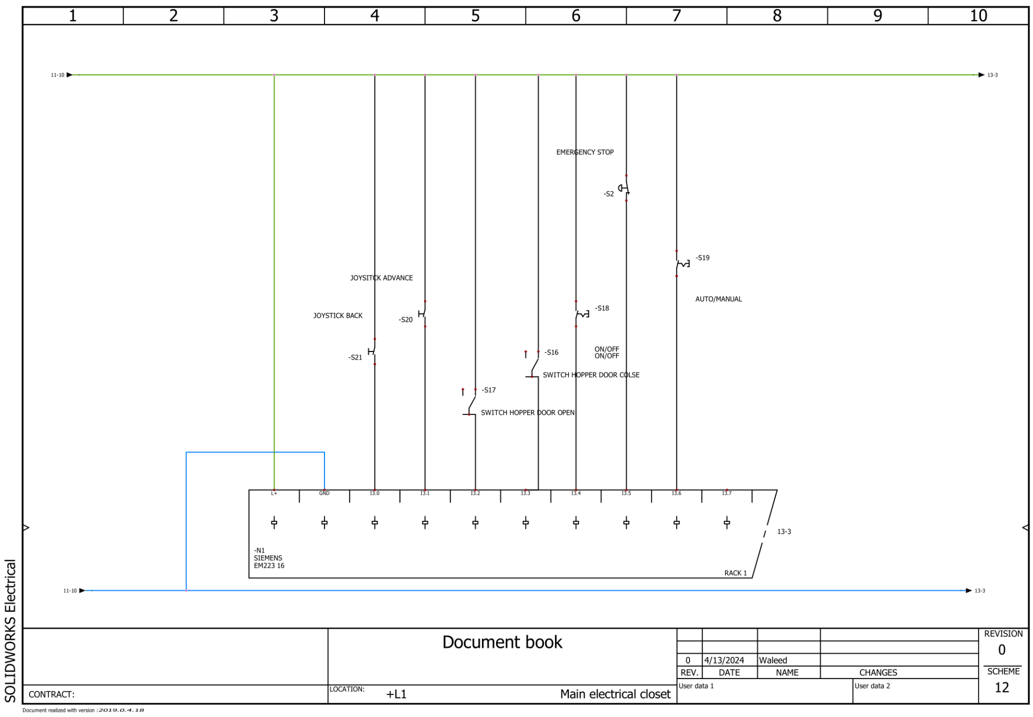
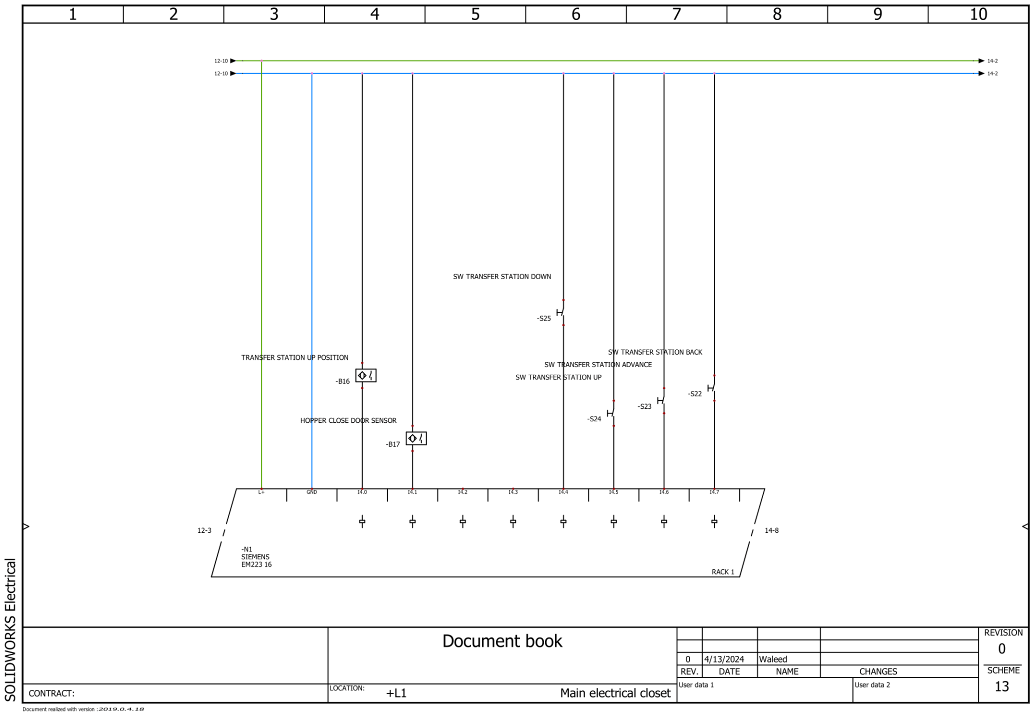
I1
I2
-T1
-Q1
0ac
220ac
18-1
18-1
-G1
+24 dc
0 dc
-Q2
07-2
07-2
SOLIDWORKS Electrical
Document book
0 4/13/2024 Waleed
REV. DATE NAME CHANGES
REVISION 0
SCHEME 06
User data 1
User data 2
CONTRACT:
LOCATION: +L1 Main electrical closet
Document realized with version :2019.0.4.18

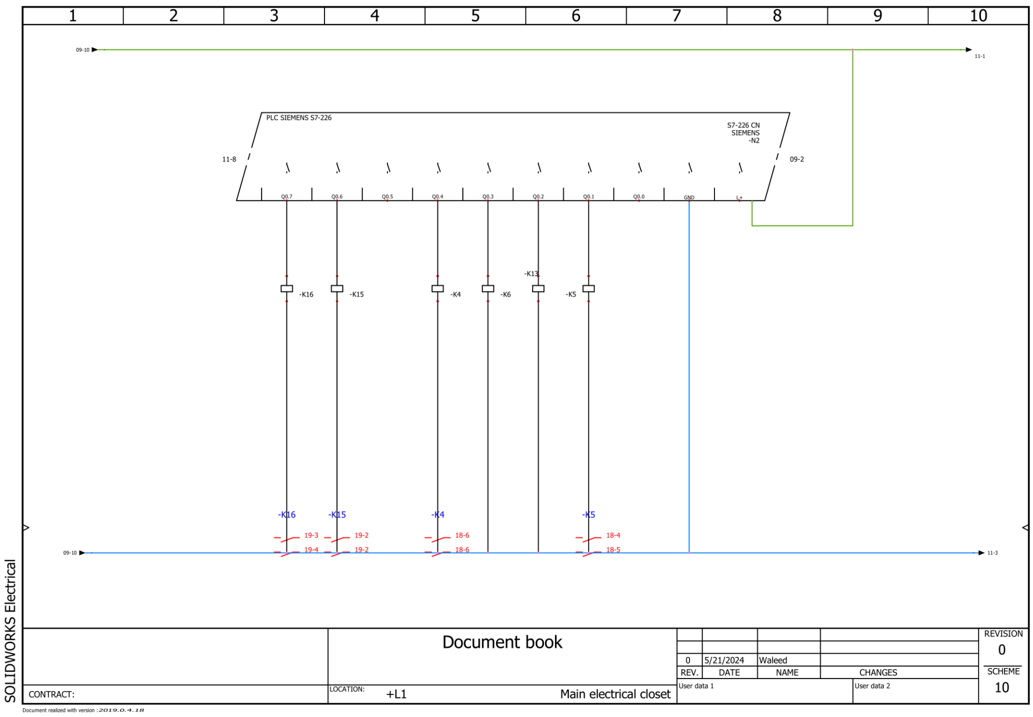

1 2 3 4 5 6 7 8 9 10
06-7
08-1
-B1
24V DC
PRESS UP SENSOR
3S1
-B2
24V DC
PRESS DOWN SENSOR
3S2
-B3
24V DC
MOLD UP SENSOR
4S2
-B4
24V DC
MOLD DOWN SENSOR
4S1
-B5
24V DC
CONCRETE CART INITIAL POSITION SENSOR
1S2
-B6
24V DC
CONCRETE CART IN POSITION SENSOR
1S1
-B7
24V DC
PALLETE DISTRIBUTION BACK
2S1
-B8
24V DC
PALLETE DISTRIBUTION ADVENCE
2S2
06-7
08-1
L+
GND
I0.0
I0.1
I0.2
I0.3
I0.4
I0.5
I0.6
I0.7
08-3
-N2
SIEMENS
S7-226 CN
PLC SIEMENS S7-226
SOLIDWORKS Electrical
Document book
0 4/13/2024 Waleed
REV. DATE NAME CHANGES
REVISION 0
SCHEME 07
User data 1
User data 2
CONTRACT:
LOCATION: +L1 Main electrical closet
Document realized with version :2019.0.4.18


HOOPPER DOOR CLOSED
-B9
TRANSFERT STATION UP SENSOR
-B10
TRANSFERT STATION DOWN SENSOR
-B11
TRANSFERT STATION ADVENCE SENSOR
-B12
TRANSFERT STATION BACK SENSOR
-B13
PB PUMP
-S3
AUTO/MAN
-S4
-S5
PB CONVOYOR PALETTE
-N2
SIEMENS
S7-226 CN
PLC SIEMENS S7-226
Document book
CONTRACT:
LOCATION: +L1 Main electrical closet
0 5/21/2024 Waleed
REV. DATE NAME CHANGES
User data 1
User data 2
REVISION 0
SCHEME 08
SOLIDWORKS Electrical


EMERGENCY STOP
-S2
-S19
AUTO/MANUAL
JOYSITCK ADVANCE
JOYSTICK BACK
-S20
-S18
-S21
-S16
ON/OFF
ON/OFF
SWITCH HOPPER DOOR COLSE
-S17
SWITCH HOPPER DOOR OPEN
-N1
SIEMENS
EM223 16
RACK 1
Document book
CONTRACT:
LOCATION: +L1 Main electrical closet
0 4/13/2024 Waleed
REV. DATE NAME CHANGES
User data 1
User data 2
REVISION 0
SCHEME 12
SOLIDWORKS Electrical



SW TRANSFER STATION DOWN
-S25
TRANSFER STATION UP POSITION
-B16
SW TRANSFER STATION BACK
SW TRANSFER STATION ADVANCE
SW TRANSFER STATION UP
-S22
-S23
-S24
HOPPER CLOSE DOOR SENSOR
-B17
12-3
14-8
-N1
SIEMENS
EM223 16
RACK 1
Document book
0
4/13/2024
Waleed
REV.
DATE
NAME
CHANGES
REVISION
0
SCHEME
13
CONTRACT:
LOCATION:
+L1
Main electrical closet
User data 1
User data 2
SOLIDWORKS Electrical

PLC SIEMENS S7-226
S7-226 CN
SIEMENS
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11-8
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-K16
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-K6
-K11
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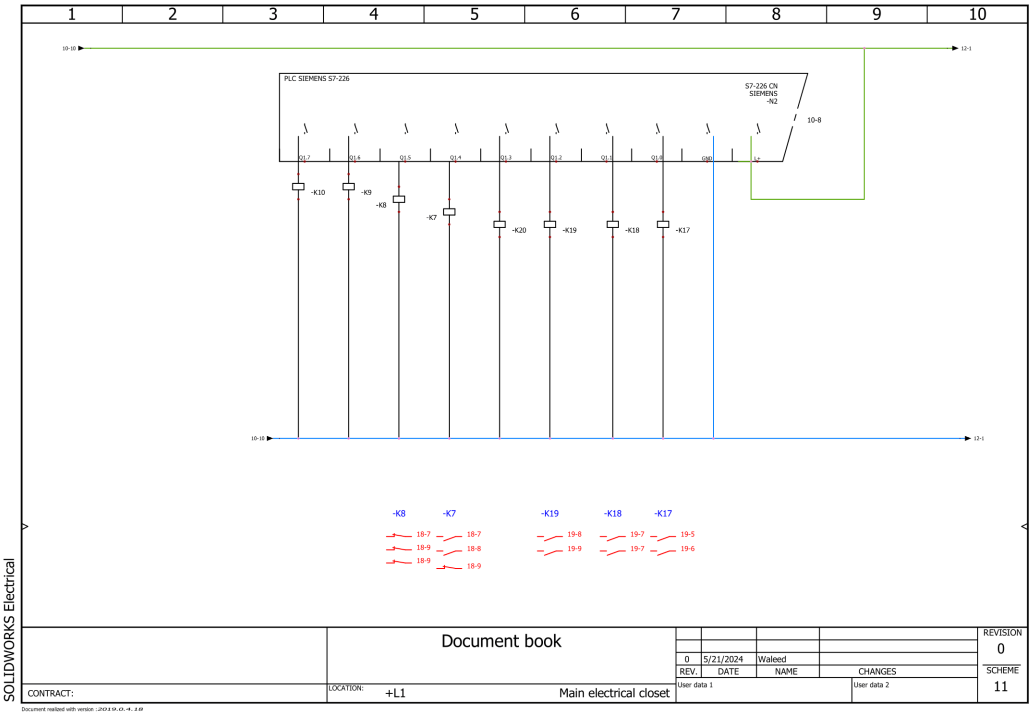
Main electrical closet
User data 1
User data 2
SOLIDWORKS Electrical


PLC SIEMENS S7-226
S7-226 CN
SIEMENS
-N2
-K10
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-K8
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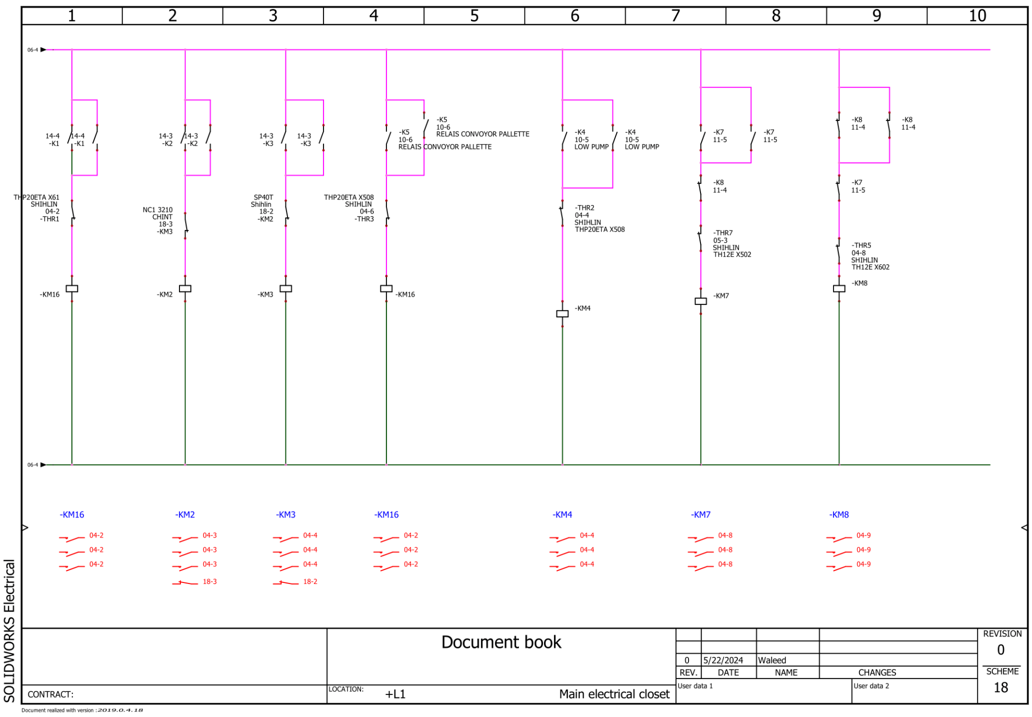
-K5
RELAIS CONVOYOR PALLETTE
-K4
LOW PUMP
-KM16
-KM2
-KM3
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-KM7
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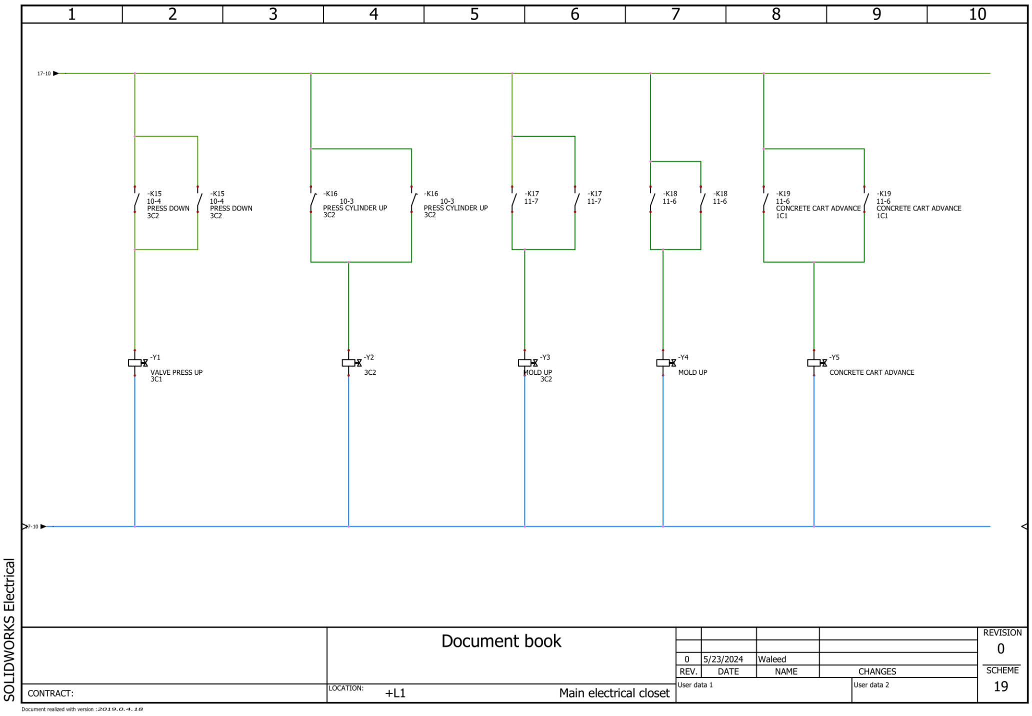
1
2
3
4
5
6
7
8
9
10
-K15
10-4
PRESS DOWN
3C2
-K16
10-3
PRESS CYLINDER UP
3C2
-K17
11-7
-K18
11-6
-K19
11-6
CONCRETE CART ADVANCE
1C1
-Y1
VALVE PRESS UP
3C1
-Y2
3C2
-Y3
MOLD UP
3C2
-Y4
MOLD UP
-Y5
CONCRETE CART ADVANCE
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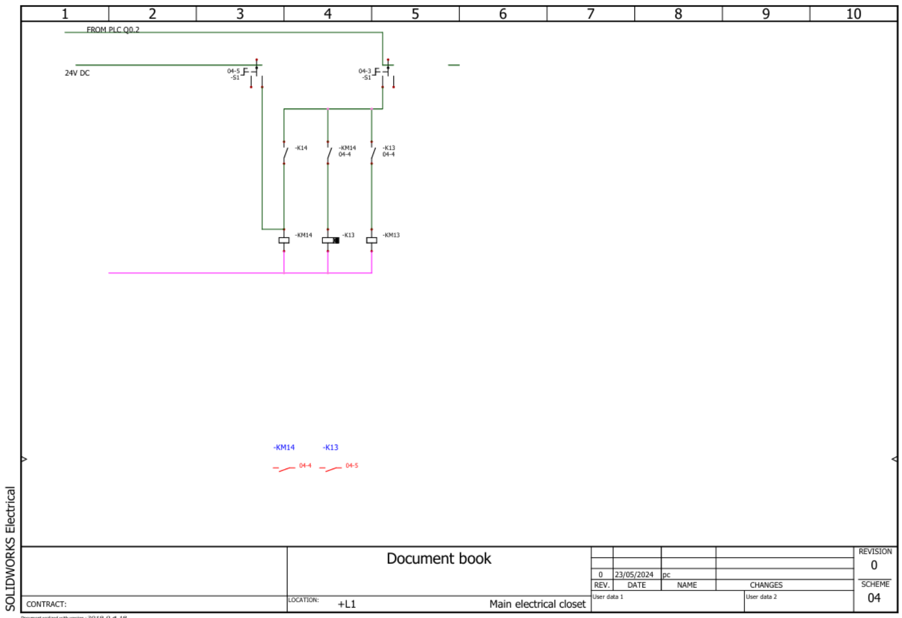
1
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10
FROM PLC Q0.2
24V DC
04-5
-S1
04-3
-S1
-K14
-KM14
04-4
-K13
04-4
-KM14
-K13
-KM13
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Main electrical closet
User data 1
User data 2
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# Appendix B: STEP7-MicroWin program ladder equations

## GPN

STEPS:

$$X_{(0)} = TR_{(6)} + X_{(21)} + (\overline{TR_{(0)}} \cdot X_0)$$
$$X_{(1)} = TR_{(0)} + TR_{(7)} + (\overline{TR_{(1)}} \cdot X_1)$$
$$X_{(2)} = TR_{(1)} + (\overline{TR_{(2)}} \cdot X_2)$$
$$X_{(3)} = TR_{(2)} + (\overline{TR_{(3)}} \cdot X_3)$$
$$X_{(4)} = TR_{(2)} + (\overline{TR_{(4)}} \cdot X_4)$$
$$X_{(3_5)} = TR_{(3)} + (\overline{TRATT \cdot X_{3_5})}$$
$$X_{(4_5)} = TR_{(4)} + (\overline{TRATT \cdot X_{4_5})}$$
$$X_{(5)} = TRATT + (\overline{TR_{(5)}} \cdot X_5)$$
$$X_{(6)} = TR_{(5)} + (\overline{TR_3} + \overline{TR_{(7)}} \cdot X_6)$$

TRANSITIONS:

$$TR_{(0)} = ONOFF \cdot X_0)$$
$$TR_{(1)} = 4S2 \cdot X_1)$$
$$TR_{(2)} = X_{507} \cdot X_2)$$
$$TR_{(3)} = X_{406} \cdot X_3)$$
$$TR_{(4)} = X_{507} \cdot X_4)$$
$$TRATT = X_{3_5} \cdot X_{4_5})$$
$$TR_{(5)} = X_{704} \cdot X_5)$$
$$TR_{(7)} = X_6 \cdot CONTINU$$
$$TR_{(6)} = \overline{CONTINU \cdot X_6}$$

## SFC SECURITY

STEPS: TRANSITIONS:

$$TR_{(20)} = \overline{ES} \cdot I6.0 \cdot X_{20}$$
$$TR_{(21)} = X_{21}$$
$$TR_{(22)} = \overline{ES} \cdot X_{22}$$

## PUMP CONTROL EQUATIONS

STEPS :

$$X_{(100)} = TR_{(103)} + \overline{TR_{(101)}} \cdot X_{100} + X_{(21)}$$
$$X_{(101)} = TR_{(100)} + \overline{TR_{(101)}}.X_{101}$$
$$X_{(102)} = TR_{(101)} + \overline{TR_{(102)}}.X_{102}$$
$$X_{(103)} = TR_{(102)} + \overline{TR_{(103)}}.X_{103}$$

TRANSITIONS:

$$TR_{(101)} = T101 \cdot X_{101}$$
$$TR_{(102)} = T102 \cdot X_{102}$$
$$TR_{(103)} = PB \cdot T103 \cdot X_{103}$$

## CONCRETE CART EQUATIONS

STEPS :

$$X_{(500)} = TR_{(508)} + \overline{TR_{(500)}} \cdot X_{500}$$
$$X_{(501)} = TR_{(500)} + \overline{TR_{(501)}} \cdot X_{501}$$
$$X_{(502)} = TR_{(501)} + \overline{TR_{(502)}} \cdot X_{502}$$
$$X_{(503)} = TR_{(502)} + \overline{TR_{(503)}} \cdot X_{503}$$
$$X_{(504)} = TR_{(503)} + \overline{TR_{(504)}} \cdot X_{504}$$
$$X_{(505)} = TR_{(504)} + \overline{TR_{(506)}} \cdot X_{505}$$
$$X_{(506)} = TR_{(506)} + \overline{TR_{(507)}} \cdot X_{506}$$
$$X_{(507)} = TR_{(507)} + \overline{TR_{(508)}} \cdot X_{507}$$

TRANSITIONS:

$$TR_{(500)} = 1S1 \cdot T62 \cdot X_{501}$$
$$TR_{(502)} = 1S1 \cdot T59$$
$$TR_{(503)} = T58 \cdot X_{503}$$
$$TR_{(504)} = T57 \cdot X_{504}$$
$$TR_{(505)} = T56 \cdot 1S1 \cdot X_{505}$$
$$TR_{(506)} = 1S2 \cdot X_{506}$$
$$TR_{(507)} = \overline{X_{506}} \cdot X_{506}$$

## MOLDING EQUATIONS

STEPS:

$$X_{(600)} = TR_{(610)} + \overline{TR_{(600)}} \cdot X_{600}$$

$$X_{(601)} = TR_{(600)} + \overline{TR_{(602)}} \cdot X_{602}$$

$$X_{(602)} = TR_{(601)} + \overline{TR_{(603)}} \cdot X_{603}$$

$$X_{(603)} = TR_{(602)} + \overline{TR_{(603)}} \cdot X_{604}$$

$$X_{(604)} = TR_{(603)} + \overline{TR_{(604)}} \cdot X_{604} + \overline{TR_{(606)}} \cdot X_{604}$$

$$X_{(605)} = TR_{(606)} + \overline{TR_{(610)}} \cdot X_{605}$$

$$X_{(606)} = TR_{(604)} + \overline{TR_{(605)}} \cdot X_{606}$$

$$X_{(607)} = TR_{(605)} + \overline{TR_{(611)}} \cdot X_{607}$$

$$X_{(608)} = TR_{(611)} + TR_{(610)} + \overline{TR_{(607)}} \cdot X_{608}$$

$$X_{(609)} = TR_{(607)} + \overline{TR_{(608)}} \cdot X_{609}$$

$$X_{(610)} = TR_{(608)} + \overline{TR_{(609)}} \cdot X_{610}$$

TRANSITIONS:

$$TR_{(601)} = I0.3 \cdot X_{601}$$

$$TR_{(602)} = TIMER53 \cdot X_{602}$$

$$TR_{(603)} = [TIMER52 + I0.1] \cdot X_{603} + I0.1$$

$$TR_{(604)} = COLOR(I702) \cdot X_{604}$$

$$TR_{(605)} = X_{812} \cdot X_{606}$$

$$TR_{(606)} = \overline{COLOR(I702)} \cdot X_{604}$$

$$TR_{(607)} = TIMER54X_{608}$$

$$TR_{(608)} = I0.2 \cdot I0.0 \cdot X_{609}$$

$$TR_{(609)} = \overline{X_4} \cdot X_{610}$$

$$TR_{(610)} = X_{605}$$

$$TR_{(611)} = TIMER54X_{607}$$

## COLORING EQUATIONS

STEPS:

$$X_{(800)} = TR_{(813)} + \overline{TR_{(800)}} \cdot X_{800}$$

$$X_{(801)} = TR_{(800)} + \overline{TR_{(801)}} \cdot X_{801}$$

$$X_{(802)} = TR_{(801)} + \overline{TR_{(802)}} \cdot X_{802}$$

$$X_{(803)} = TR_{(802)} + \overline{TR_{(803)}} \cdot X_{803}$$

$$X_{(804)} = TR_{(803)} + \overline{TR_{(804)}} \cdot X_{804}$$

$$X_{(805)} = TR_{(804)} + \overline{TR_{(805)}} \cdot X_{805} + \overline{TR_{(808)}} \cdot X_{805}$$

$$X_{(806)} = TR_{(805)} + \overline{TR_{(806)}} \cdot X_{806}$$

$$X_{(807)} = TR_{(808)} + \overline{TR_{(805)}} \cdot X_{805}$$

$$X_{(809)} = TR_{(808)} + \overline{TR_{(809)}} \cdot X_{809}$$

$$X_{(810)} = TR_{(809)} + \overline{TR_{(810)}} \cdot X_{810}$$
$$X_{(811)} = TR_{(810)} + TR_{(807)} + \overline{TR_{(811)}} \cdot X_{811}$$
$$X_{(812)} = TR_{(811)} + \overline{TR_{(812)}} \cdot X_{812}$$
$$X_{(813)} = TR_{(812)} + \overline{TR_{(813)}} \cdot X_{813}$$

TRANSITIONS:

$$TR_{(800)} = X_{(606)} = \cdot X_{800}$$
$$TR_{(801)} = 3S1 \cdot X_{801}$$
$$TR_{(802)} = 7S \cdot X_{802}$$
$$TR_{(803)} = 7S2 \cdot X_{803}$$
$$TR_{(804)} = 3S2 \cdot X_{804}$$
$$TR_{(804)} = 3S2 \cdot X_{804}$$
$$TR_{(806)} = X_{806}$$
$$TR_{(813)} = M0.7 \cdot X_{805}$$
$$TR_{(807)} = T51 \cdot X_{807}$$
$$TR_{(808)} = X_{808}$$
$$TR_{(809)} = 3S1 \cdot X_{809}$$
$$TR_{(810)} = 7S2 \cdot X_{810}$$
$$TR_{(811)} = 7S1 \cdot X_{811}$$
$$TR_{(812)} = X_{812}$$

OUTPUTS: COLOR CART ADVANCE:

$$7C1 = 3S1 \cdot (X_{802} + X_{810})$$

COLOR BACK:

$$7C2 = 3S1 \cdot (X_{803} + X_{811})$$

## pallet DISTRIBUTION EQUATIONS

STEPS:

$$X_{(700)} = TR_{(704)} + \overline{TR_{(700)}} \cdot X_{700}$$
$$X_{(701)} = TR_{(700)} + \overline{TR_{(701)}} \cdot X_{701}$$
$$X_{(702)} = TR_{(701)} + \overline{TR_{(702)}} \cdot X_{702}$$
$$X_{(703)} = TR_{(702)} + \overline{TR_{(703)}} \cdot X_{703}$$
$$X_{(704)} = TR_{(703)} + \overline{TR_{(704)}} \cdot X_{704}$$

TRANSITIONS:

$$TR_{(700)} = X_{(5)} \cdot X_{700}$$
$$TR_{(701)} = S_PALLETE \cdot X_{701}$$
$$TR_{(702)} = S_PALLETE_ADV \cdot X_{702}$$
$$TR_{(704)} = \overline{X_{(5)} \cdot .X_{704}}$$

OUTPUTS(PALLET CONVEYOR) OUTPUTS :

$$2C2 = x_{701} + x_{13}.(palletDISADVANCE)$$
$$2C1 = x_{702} + x_{13}.(palletDISG0BACK)$$
$$kM_9 = \overline{6S3}.(x_{701} + x_{702}x_{703}) + x_{13}.(CONVEYORpallet)$$

## PREPARATORY ORDERS EQUATIONS

STEPS:

$$X_{(2000)} = INIT \cdot TR_{(2011)} + \overline{TR_{(2000)}} \cdot X_{2000}$$

$$X_{(2001)} = TR_{(2000)} + \overline{TR_{(2001)}} \cdot X_{2001}$$

$$X_{(2002)} = TR_{(2001)} + \overline{TR_{(2002)}} \cdot X_{2002}$$

$$X_{(2003)} = TR_{(2002)} + \overline{TR_{(2003)}} \cdot X_{2003}$$

$$X_{(2004)} = TR_{(2003)} + \overline{TR_{(2004)}} \cdot X_{2004}$$

$$X_{(2005)} = TR_{(2004)} + \overline{TR_{(2005)}} \cdot X_{2005}$$

$$X_{(2006)} = TR_{(2005)} + \overline{TR_{(2006)}} \cdot X_{2006}$$

$$X_{(2008)} = TR_{(2007)} + \overline{TR_{(2008)}} \cdot X_{2008}$$

$$X_{(2009)} = TR_{(2008)} + \overline{TR_{(2009)}} \cdot X_{2009}$$

$$X_{(2010)} = TR_{(2009)} + \overline{TR_{(2010)}} \cdot X_{2010}$$

$$X_{(2011)} = TR_{(2010)} + \overline{TR_{(2011)}} \cdot X_{2011}$$

TRANSITIONS:

$$TR_{(2000)} = AUTO \cdot X_{(14)} \cdot X_{2000}$$

$$TR_{(2001)} = X_{(2001)} \cdot X_{103}$$

$$TR_{(2002)} = 3S1 \cdot X_{2002}$$

$$TR_{(2003)} = 9S2 \cdot X_{2003}$$

$$TR_{(2004)} = 7S1 \cdot X_{2004}$$

$$TR_{(2005)} = TIMER56 \cdot X_{2005}$$

$$TR_{(2006)} = 1S2 \cdot X_{2006}$$

$$TR_{(2007)} = 4S2 \cdot X_{2007}$$

$$TR_{(2008)} = 2S1 \cdot X_{2008}$$

$$TR_{(2009)} = 2S2 \cdot X_{2009}$$

$$TR_{(2010)} = TIMER55 \cdot X_{2010}$$

$$TR_{(2011)} = X_{2011}$$

## TRANSFER STATION EQUATIONS

STEPS PART 1:

$$X_{(200)} = TR_{(202)} + \overline{TR_{(200)}} \cdot X_{200} + X_{(21)}$$

$$X_{(201)} = TR_{(200)} + \overline{TR_{(201)}} \cdot X_{201}$$

$$X_{(202)} = TR_{(201)} + \overline{TR_{(202)}} \cdot X_{202}$$

STEPS PART 2:

$$X_{(300)} = INIT \cdot TR_{(309)} + \overline{TR_{(300)}} \cdot X_{300}$$

$$X_{(301)} = TR_{(300)} + \overline{TR_{(301)}} \cdot X_{301}$$

$$X_{(302)} = TR_{(301)} + \overline{TR_{(302)}} \cdot X_{302}$$

$$X_{(303)} = TR_{(302)} + \overline{TR_{(303)}} \cdot X_{303}$$

$$X_{(304)} = TR_{(303)} + \overline{TR_{(304)}} \cdot X_{304}$$

$$X_{(305)} = TR_{(304)} + \overline{TR_{(305)}} \cdot X_{305}$$

$$X_{(306)} = TR_{(305)} + \overline{TR_{(306)}} \cdot X_{306}$$

$$X_{(307)} = TR_{(306)} + \overline{TR_{(307)}} \cdot X_{307}$$

$$X_{(308)} = TR_{(307)} + \overline{TR_{(308)}} \cdot X_{308}$$

$$X_{(309)} = TR_{(308)} + \overline{TR_{(309)}} \cdot X_{309}$$

TRANSITIONS PART 1:

$$TR_{(200)} = X_{200} \cdot PMW6_1$$

$$TR_{(201)} = X_{201} \cdot PMW6_2$$

$$TR_{(202)} = X_{202} \cdot PMW6_3$$

TRANSITIONS PART 2:

$$TR_{(300)} = 6S2 \cdot X_{300}$$

$$TR_{(301)} = X_{301} \cdot LIMIT_SWITCH$$

$$TR_{(302)} = 6S3 \cdot X_{302}$$

$$TR_{(303)} = X_{304}$$

$$TR_{(307)} = X_{306} \cdot 6S4$$

$$TR_{(308)} = 6S2 \cdot X_{307}$$

$$TR_{(309)} = 6S5 \cdot STM$$

## SFC CONCRETE CONVEYOR EQUATIONS

STEPS:

$$X_{(400)} = TR_{(406)} + \overline{TR_{(400)}} \cdot X_{400} + X_{(11)}$$

$$X_{(401)} = TR_{(400)} + \overline{TR_{(400)}} \cdot X_{401} + TR_{(407)}$$

$$X_{(402)} = TR_{(402)} + \overline{TR_{(403)}} \cdot X_{403}$$

$$X_{(404)} = TR_{(403)} + \overline{TR_{(404)}}.\overline{TR_{(407)}} \cdot X_{404}$$

$$X_{(405)} = TR_{(404)} + \overline{TR_{(405)}} \cdot X_{405}$$

$$X_{(406)} = TR_{(405)} + \overline{TR_{(406)}} \cdot X_{406}$$

TRANSITIONS:

$$TR_{(400)} = X_3 \cdot 9S2 \cdot X_{400}$$

$$TR_{(401)} = 6S3 \cdot X_{401}$$

$$TR_{(402)} = T104 \cdot X_{402}$$

$$TR_{(403)} = 9S2 \cdot X_{403}$$

$$TR_{(404)} = C1 \cdot X_{404}$$

$$TR_{(405)} = T105 \cdot X_{405}$$

$$TR_{(406)} = \overline{X_3} \cdot X_{406}$$

$$TR_{(408)} = \overline{C1} \cdot X_{404}$$

OUTPUT PRESS UP:

$$Q0.7 = X_{602} + (I0.0 \cdot X_{602}) + X_{801} + X_{809}$$

OUTPUT VIBRATION:

$$Q2.3 = X_{(603)} + X_{(807)}$$

OUTPUT PRESS DOWN:

$$Q0.6 = I1.3 \cdot I5.0 \cdot [X_{602} \cdot X_{804}]$$

OUTPUT MOLD UP:

$$(Q1.1) = \overline{3S1} \cdot X_{609}$$

OUTPUT MOLD DOWN:

$$Q1.0 = X_{(1)}$$

VALVES:

$$Q3.2 = 4C2 + 7C2 + 7C + 3C2 + 1C2 + 1C1 + 4C1$$

$$Q3.3 = 7C1 + 3C1 + 1C1 + 4C1$$

$$Q3.4 = 4C2 + 7C2 + 7C1 + 3C2 + 1C2 + 1C1$$

$$Q3.5 = 4C2 + 7C2 + 3C2 + 1C2 + 1C1 + 4C1$$

$$Q3.7 = 4C2 + 7C1 + 3C1 + 3C2 + 1C2 + 1C1 + 4C1$$

OUTPUTS :

$$2C2 = X_{701}$$

$$2C1 = X_{702}$$

$$4C1 = \overline{4S2} \cdot X_{609}$$

$$4C2 = X_1$$

$$3C1 = 7S1 \cdot 1S1 \cdot (X_{602} + X_{804})$$

$$3C2 = X_{608} + (3S1 \cdot X_{609}) + X_{801} + X_{80}$$

$$kM_1 = x_{101} + x_{102} + x_{103}$$

$$kM_2 = x_{101}$$

$$kM_3 = x_{102} + x_{103}$$

$$kM_4 = x_{101} + x_{102} + x_{103}$$

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**ABSTRACT**

This thesis aims to optimize the control and automation system of the CHINA GUANGYAN BLOCK MACHINE used for concrete block production. The existing Siemens S7-200 Programmable Logic Controller (PLC), programmed in ladder logic, lacks flexibility and maintainability. An innovative approach will be implemented involving Sequential Function Chart (SFC) programming in FluidSIM, translated to ladder logic via Step 7 after simulation. A comprehensive analysis of machine operations will be conducted. A user-friendly HMI integrated with the PLC will be developed in Easy Builder Pro, while detailed electrical schematics will be designed in SolidWorks. The SFC-based control program and an intuitive HMI and electrical documentation will enhance system flexibility, maintainability, and production efficiency, modernizing the machine's control architecture through tailored software solutions.

**Key words:** batching plant, PLC, HMI, SADT, ladder, fluidsim, easybuilder pro, step7, solidworks, TRANSFERT STATION, cylender, PWM, SFC

**RESUME**

Cette étude s'attache à améliorer le système de contrôle et d'automatisation de la MACHINE À BLOCS CHINA GUANGYAN, dédiée à la fabrication de blocs de béton. Le contrôleur logique programmable (PLC) Siemens S7-200, programmé en langage ladder (language graphique), présente des lacunes en termes de flexibilité et de facilité de maintenance. Pour remédier à cela, Une approche novatrice sera mise en œuvre basée sur la programmation en Graphes d'États Séquentiels (SFC) dans FluidSIM, qui sera ensuite traduite en langage ladder via Step 7 après simulation. Une analyse approfondie des opérations de la machine sera réalisée. Par ailleurs, une interface homme-machine (IHM) conviviale sera intégrée au PLC grâce au logiciel Easy Builder Pro, tandis que des schémas électriques détaillés seront élaborés dans SolidWorks. Cette solution, fondée sur les graphes d'états séquentiels et couplée à une IHM intuitive ainsi qu'à une documentation électrique détaillée, permettra d'accroître la flexibilité du système, sa facilité de maintenance et son rendement de production. Elle contribuera à moderniser l'architecture de contrôle de la machine en recourant à des solutions logicielles personnalisées.

**Mots clés:** centrale à béton, PLC, HMI, SADT, ladder, fluidsim, easybuilder pro, step7, solidworks, STATION DE TRANSFERT, cylindre, PWM, SFC

# ملخص


تهدف هذه الرسالة إلى تحسين نظام التحكم والأتمتة لآلة إنتاج كتل الخرسانة CHINA GUANGYAN BLOCK MACHINE. يفتقر المتحكم المنطقي القابل للبرمجة Siemens S7-200 الحالي، الذي يعمل بلغة السلم (Ladder)، إلى المرونة والصيانة. سيتم تنفيذ نهج مبتكر يتضمن برمجة Sequential Function Chart (SFC) في برنامج FluidSIM، وتحويله إلى لغة السلم المتدرج (Ladder Logic) عبربرنامج step7 microwin بعد المحاكاة. سيتم إجراء تحليل شامل لعمليات الآلة.

سيتم تبديل وتطوير واجهة المستخدم (HMI) لجعلها سهلة الاستخدام متكاملة مع المتحكم المنطقي (PLC) باستخدام برنامج Easy Builder Pro، بينما سيتم تصميم مخططات التوصيل الكهربائية التفصيلية باستخدام برنامج SolidWorks.



الكلمات المفتاحية : محطة خلط الخرسانة (Batching plant)، المتحكم المنطقي المبرمج (PLC)، واجهة واجهة المستخدم (HMI)، أداة تصميم الأتمتة الآمنة (SADT)، منطق السلم (Ladder Logic)، برنامج (Fluidsim)، برنامج ( EasyBuilder Pro)، برنامج step7 microwin ، برنامج (SolidWorks)، محطة نقل الكتل الخرسانية (Transfer Station)، أسطوانة (Cylinder)، تعديل عرض النبضة (PWM)، ومخطط الوظائف المتتالية (SFC).