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PLC Driven Conveyor and Bottle Filling System

Ms. Gayathri J[1], Mr. Sumanth[2], Mr. Manjunatha Ustamara[3], Mr. Nikhil[4], Mr. Joshwa D Costa[5]

[1]Assistant Professor, Electrical & Electronics Engineering, RYMEC Bellary
[2,3,4,5] Student, Electrical & Electronics Engineering, RYMEC Bellary

Abstract

This project focuses on the design and development of an automated conveyor and bottle filling system, using a Delta PLC DVP14SS2 to manage the entire process. The system is programmed through ladder logic using WPL Soft, with a photoelectric sensor used to detect bottles on the conveyor and accurately initiate the filling process. The ladder logic program is transferred to the PLC via an RS232 connection, which allows smooth communication between the programming software and the hardware. By setting the PLC to control both bottle positioning and the filling mechanism, the system achieves precise timing and reliability, essential for industrial automation tasks.
The hardware setup includes a control panel equipped with a push button, relay module, and bus bars for efficient system operation and control. The conveyor itself is constructed with practical materials, using a wooden board base, bearings, a conveyor sheet, gears, and a timing belt for smooth and reliable movement.

1. Introduction

1.1 Introduction to PLC

A Programmable Logic Controller is an industrial digital computer. It is designed specifically to automate and control manufacturing processes, machinery, and other control systems. It works as the central processing unit of a system that monitors input from various devices, processes this information according to the programmed logic, and produces outputs to control machines or processes effectively.

PLC internal architecture:

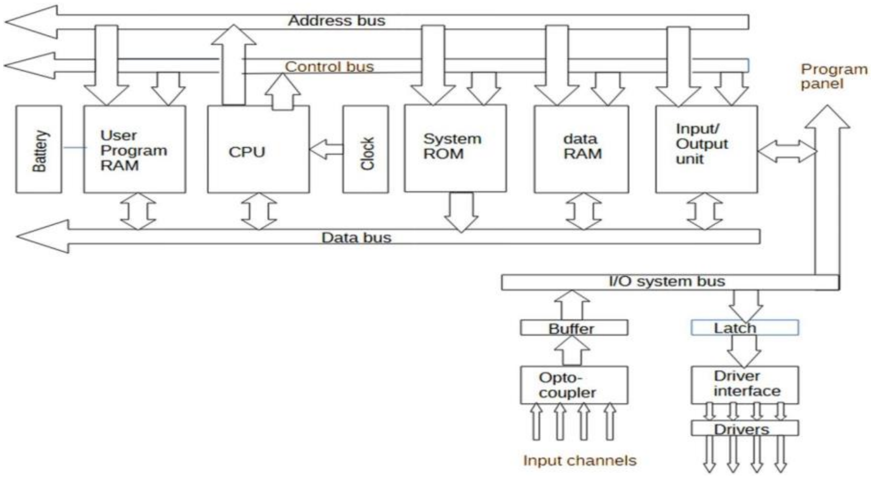

Fig -1 Internal architecture of PLC

The CPU

At the very basic, the internal architecture of a PLC consists of a central processing unit (CPU) containing the system microprocessor, memory and input/output circuitry. The CPU is supplied with a clock which determines the operating speed of the PLC and provides the timing and synchronization for all elements in the system. The information within the PLC is carried by means of digital signals which flow along internal paths called buses.

The internal structure of the CPU depends on the microprocessor concerned. In general, they have:

An arithmetic and logic unit (ALU) which is responsible for data manipulation and carrying out arithmetic operations of addition and subtraction and logic operations of AND, OR, NOT and EXCLUSIVE-OR. Memory, termed registers, located within the microprocessor and used to store information involved in program execution. A control unit which is used to control the timing of operations.

Input output interfaces

An I/O module is a plug-in–type assembly containing circuitry that communicates between a PLC and field devices. These devices could be transmitting and/or accepting digital or analog signals.

Memory system

This is the area in the PLC where all of the sequences of instructions, or programs, are stored and executed by the processor to provide the desired control of field devices. The memory sections that contain the control programs can be reprogrammed to adapt to any changes in process control requirements.

Power supply

The system power supply provides internal DC voltages to the system components (processor, memory, and input/output interfaces). The power supply is characterized by a maximum amount of current that it can provide at a given voltage level, depending on the type of power supply.

The Buses

In a PLC's internal architecture, key buses facilitate efficient data processing and control. The system bus links the CPU and memory for rapid data exchange essential for control programs.

I/O bus connects the CPU to input/output modules, enabling real-time interaction with external devices.

The address bus directs the CPU to specific memory or I/O locations, and the data bus transfers data and instructions between components for bidirectional communication.

Control bus carries signals, such as read, write, and interrupt commands, to synchronize operations and ensure precise control. Together, these buses enable smooth coordination within the PLC system. Automation processes. These buses in combination enable the smooth coordination and control of the entire PLC system.

1.2 Introduction to the project

This project will involve designing an automated PLC-driven conveyor and bottle filling system dedicated to the improvement of bottling processes in terms of efficiency, precision, and repeatability. In the case of food, beverages, and pharmaceuticals, high accuracy and consistency must be ensured to maintain quality standards and meet production targets. The primary objective of this project is to make filling processes as automated as possible in order to minimize interference and reduce errors while hastening production.

The heart of the Delta DVP14SS2 PLC will centrally control all parts. For bottle movement, DC motors will move conveyor belts. Installation of two photoelectric sensors E3F-DS30C4 PNP at the conveyor belt side can give exact controls. These sensors may then send signals to the control panel to let the bottle at critical points monitor to have accurate management in its filling process.

Flexibility is part of its build, so it is simple to adapt according to bottle size or fill levels should the production requirements change. The PLC can carry out a program sequence and interpret data from various sensors; then, control outputs that involve the motor and pump provide a robust and adaptive industrial automation solution.
This project demonstrates how automation can be used to simplify bottling operations using this PLC-driven approach. Therefore, this model setup typifies the accuracy, scalability, and efficiency required in a modern manufacturing system.

2. LITERATURE REVIEW

2.1 Introduction to automation in industrial process

In any industry having automation work have many devices which are interconnected through wires and making all of them work together and handling their features collectively is the work of PLC (Programmable logic Controller). They are most forwardly used as they are simplest forms of control structures that are now taking over the hard-wired Relays. PLCs which are computer-based controllers are the exceptional for handling systems, which requires excessive care and accuracy like small and medium scale industries for input and Output processes. Leaning a little in the direction the utilization of Automation in Industries will only give a beneficiary performance, flexibility, accuracy, least or null engagement of human interference. And for controlling and tracking of the large- scale industries where PLCs are not enough, SCADA (Supervisory Control and Data Acquisition Systems) are used as they are more efficient, and can be handled without difficulty from the main control room/office which is remotely located at other place or at far area. One of critical function of PLC is that its input and output elements can be prolonged according to the requirement or motive. They are very easy to operate for those who are having even a basic Information. [2]
A PLC is a ruggedized computer specially designed to operate reliably under harsh industrial environments such as extreme temperatures, wet, dry, and/or dusty conditions. It is used to automate industrial processes machine function or even entire production line such as a manufacturing plant's assembly line, an ore processing plant, or a wastewater treatment plant. PLC plays a crucial role in the field of automation, using larger SCADA systems. A PLC can be programmed based on the operational requirement of the process. In the manufacturing industry, there will be a need for reprogramming at any stage due to the change in the nature of production. To overcome this difficulty, PLC based control systems were proposed. [3]

2.2 Role of PLCs in automation

A programmable logic controller (PLC) plays a significant role in every era, whether it is in the field of automation, industry, or educational purposes. As the demand for automation grows exponentially, control systems need to be easy to program, flexible, reliable, and cost-effective. PLC is a unique type of microprocessor-based controller. It comprises a programmable memory to accumulate instructions and

execute tasks like timing, logic, arithmetic, counting, and sequencing [4]
PLCs are designed and used by engineers to process and control machines with narrow information of computer1 programming. The same PLC unit can be used to control different systems after each scan. The programmable logic controller can be regarded as a special computer for industrial use. It is not influenced by vibration, noise, heat, and moisture. It can be simply automatic by easy encoding language, which mainly involves logic and switch operations. The PLC contains hardware and software systems for standard input/output or multiple input/output systems. PLC is also used in analog or digital control systems [5]

3. PROJECT DESIGN

3.1 Block diagram

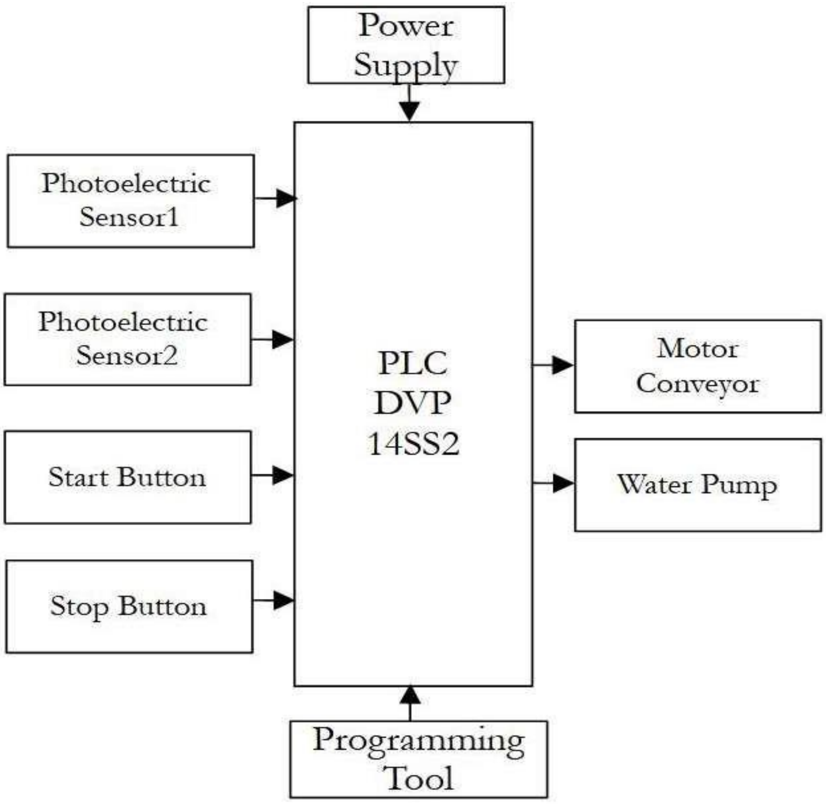

Fig -2 block diagram bottle filling system

The block diagram for this PLC-driven conveyor and bottle filling system illustrates the connections and roles of the key components, including the input and output devices controlled by the Delta DVP14SS2 PLC.

3.1.1 Inputs to the PLC

Start Push Button: This push button initiates the process. When pressed, it sends a signal to the PLC to start the conveyor and prepare the system for bottle filling operations.
Stop Push Button: This button is used to stop the entire system manually. When activated, it sends a signal to the PLC to halt both the conveyor and pump operations, providing a safety feature and allowing for manual control.

Photoelectric Sensor 1: Positioned along the conveyor, this sensor detects the presence of a bottle as it moves into the filling position. When triggered, it sends a signal to the PLC, instructing it to stop the conveyor and activate the filling pump.
Photoelectric Sensor 2: Located at the end of the conveyor, this sensor detects when a filled bottle reaches the end of the line. When activated, it sends a signal to the PLC to stop the conveyor until the next cycle begins, ensuring proper control over bottle handling.

3.1.2 Outputs from the PLC

DC Motor (for Conveyor): The PLC controls the DC motor, which drives the conveyor. When the start button is pressed, the PLC activates the motor, setting the conveyor in motion to transport bottles through the system. The motor stops when Photoelectric Sensor 1 or 2 is triggered, ensuring precise control over bottle movement.
Pump: The PLC controls the pump responsible for filling the bottles. When Photoelectric Sensor 1 detects a bottle, the PLC sends a signal to turn on the pump for a predefined time, filling the bottle to the desired level. After the fill cycle, the pump stops, and the conveyor resumes movement

3.2 Equipment and analysis

3.2.1 PLC (Delta DVP 14SS2)

Fig -3 Delta DVP 14SS2 PLC

The Delta DVP14SS2 PLC is a compact, versatile Programmable Logic Controller designed by Delta Electronics, often used in automation applications for controlling machinery, processes, and equipment in industries. This PLC is particularly popular for small to medium automation tasks because of its reliable performance, flexibility, and cost-effectiveness.
Compact Design: The DVP14SS2 has a small footprint, making it ideal for installations with limited space. It’s designed for mounting inside control panels or on DIN rails, which is standard in industrial automation setups.

I/O Configuration: Digital Inputs: It has 8 digital input points from X0 to X7, allowing it to receive

signals from devices like sensors, push buttons, and other input devices.
Digital Outputs: The PLC has 6 digital output points (Y0 to Y5) to control equipment such as motors, pumps, relays, and indicator lights.

High-Speed Processing: This PLC features a fast CPU with a processing speed of 0.64 µs per basic instruction, making it highly responsive for real-time control tasks, including conveyor operations and bottle filling applications where timing is critical.
Built-in Functions: The DVP14SS2 supports various built-in functions such as timers, counters, and arithmetic operations. These features are essential for creating complex control sequences and for applications that require precision and timing.

Communication Capabilities: It has a built-in RS-232 and RS-485 communication port, which allows for connection to other devices like HMIs (Human-Machine Interfaces) or other PLCs for more advanced control and monitoring.

Fig -4 RS232

3.2.2 Photo electric sensor

Fig -5 E3F DS30C4 Photo electric sensor

These sensors are widely used in industrial automation for detecting the presence or absence of objects, such as bottles on a conveyor.

Specifications:

Type: Photoelectric Sensor Detection Method: Diffuse reflection

Sensing Distance: Up to 30 cm (depending on the target size and reflectivity) Output Type: PNP (sourcing), NPN (sinking) options available

Supply Voltage: 10 to 30V DC

Current Consumption: Maximum 30 mA Response Time: 1 ms

Wiring Configuration for E3F-DS30C4:

Brown Wire (Positive Voltage Supply):

This wire is used to supply power to the sensor.

Connect to the positive terminal of the power supply (usually +24V DC). Blue Wire (Ground):

This wire serves as the ground connection for the sensor. Connect to the ground (0V) of the power supply.

Black Wire (Output):

This wire outputs the sensor's detection signal.

PNP (Sourcing): The output will be +V (24V) when an object is detected. In this project PNP sensor is used.

Working:

The E3F-DS30C4 works based on the principle of light reflection:

Emission: The sensor emits a beam of infrared light (LED) towards a target object (like a bottle).

Detection: When the beam strikes the object, some of the light is reflected back to the sensor.

Signal Output: If the reflected light intensity exceeds a certain threshold (based on sensitivity settings), the sensor triggers its output (either turning ON or OFF the PNP or NPN output signal). This output signal is then used by the PLC to control downstream operations, such as stopping the conveyor or activating a filling pump.

Fig -6 Gear motor

3.2.3 Gear Motor

The 12V, 30 RPM DC motor is mounted to the gear which is connecter to the shaft through timing belt, which allows it to turn the conveyor belt efficiently. This setup ensures that as the motor spins, it drives the shaft, causing the belt to move. The motor's steady speed of 30 RPM provides a smooth and controlled motion for transporting items along the conveyor. By using this type of motor, we can effectively move products from one point to another in various applications, such as packaging or assembly lines.

General Specifications:
Voltage: 12V DC
Rated Speed: 30 RPM (Revolutions Per Minute)

Working:
The DC gear motor is powered by a direct current (DC) source, DC power supply.is given. When voltage is applied, it energizes the motor.
Motor Operation:
The motor has two main components: the stator (the stationary part) and the rotor (the rotating part). When electricity flows through the motor, it creates a magnetic field that causes the rotor to spin.
Gear Reduction:
The rotor is connected to a gear system. The gear arrangement reduces the speed of the motor while increasing the torque (the turning force).
Output Shaft:
The output shaft of the gear motor transfers the motion to the application, such as a conveyor belt or robotic arm. This output is slower but stronger due to the gear reduction.

3.2.4 Water pump

Fig -7 water pump

Working of a 12V DC Pump

Power Supply: The pump operates on a 12V DC power source, supplied by DC power supplies.
Motor Function: Inside the pump, there is a small DC motor that spins when powered. This motor is similar to a regular DC motor, converting electrical energy into mechanical energy.
Impeller: Attached to the motor is an impeller (a rotating component). As the motor spins, the impeller rotates, creating a centrifugal force that draws fluid into the pump.

Fluid Movement: The rotation of the impeller forces the fluid outward and pushes it through the pump's outlet. This creates a flow of fluid, which can be directed to where it's needed (like in a garden, aquarium, or cooling system).
Sealing and Housing: The pump is sealed to prevent leakage and is usually housed in a plastic or metal casing to protect the internal components.
Control: The pump can be controlled using a switch or relay to start and stop the flow. Speed can also be regulated by varying the voltage supplied to the motor.

3.2.5 Relay

Fig -8 Relay module

A relay is an electrically operated switch that allows a low-power signal to control a larger load. A 24V relay operates specifically on a 24V DC power supply.
Relay consists
Coil: An electromagnetic coil that generates a magnetic field when energized.
Armature: A movable iron lever that is attracted to the coil when the coil is energized.
Contacts: Metal terminals that open or close to control the circuit. There are typically two types of contacts:
Normally Open (NO): These contacts are open when the relay is not energized and close when the relay is activated.
Normally Closed (NC): These contacts are closed when the relay is not energized and open when the relay is activated.
Activation: When a 24V DC voltage is applied to the relay coil, it creates a magnetic field. This can be done using a switch or a control circuit that supplies the required voltage.
The magnetic field pulls the armature towards the coil, which causes the contacts to change state.
Deactivation: When the voltage is removed from the coil.

Purpose of relay in this project
In this project, the relay serves as a crucial component to bridge the low-power control signals from the PLC to the higher-power devices, such as the DC motor driving the conveyor and the pump used for bottle filling. Since the PLC outputs limited power, it cannot directly operate these devices; therefore, the relay allows the PLC to control them indirectly by acting as an electrically controlled switch. When the PLC sends a signal, the relay closes its contacts, allowing power to flow to the motor or pump. This setup ensures the PLC is isolated from any high-power surges or fluctuations that could damage its sensitive electronics. Additionally, the relay enables precise, automated control over the start and stop actions for both the conveyor and filling system, enhancing safety by providing a quick disconnect option in case of

faults. Overall, the relay is essential for achieving safe, efficient, and automated control of the system.

4. HARDWARE IMPLEMENTATIION

4.1 Physical structure design

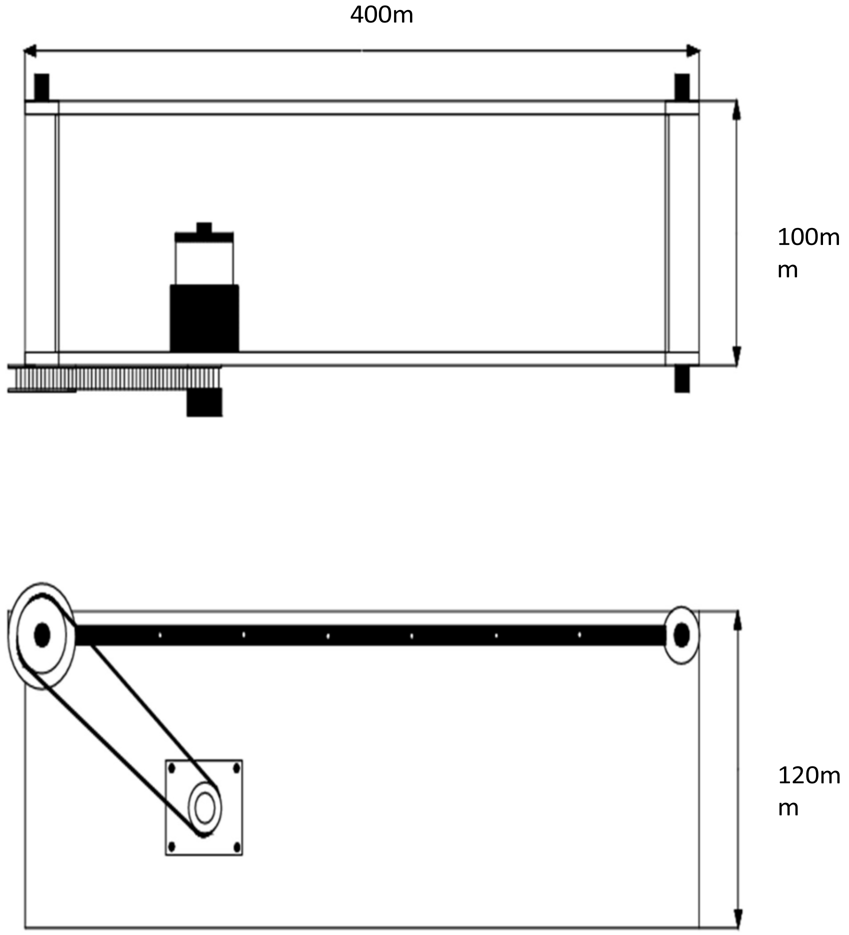

Fig 9 design of prototype

The hardware implementation of this project involves the assembly and integration of various physical and mechanical components to create a functional conveyor and bottle filling system. The setup begins with constructing the conveyor structure using a sturdy wooden board as the base, providing stability for all components. Bearings are mounted on either side of the board to support the shafts that guide the conveyor sheet, enabling smooth rotation and minimizing friction.4.2 Final construction

4.2 Panel board

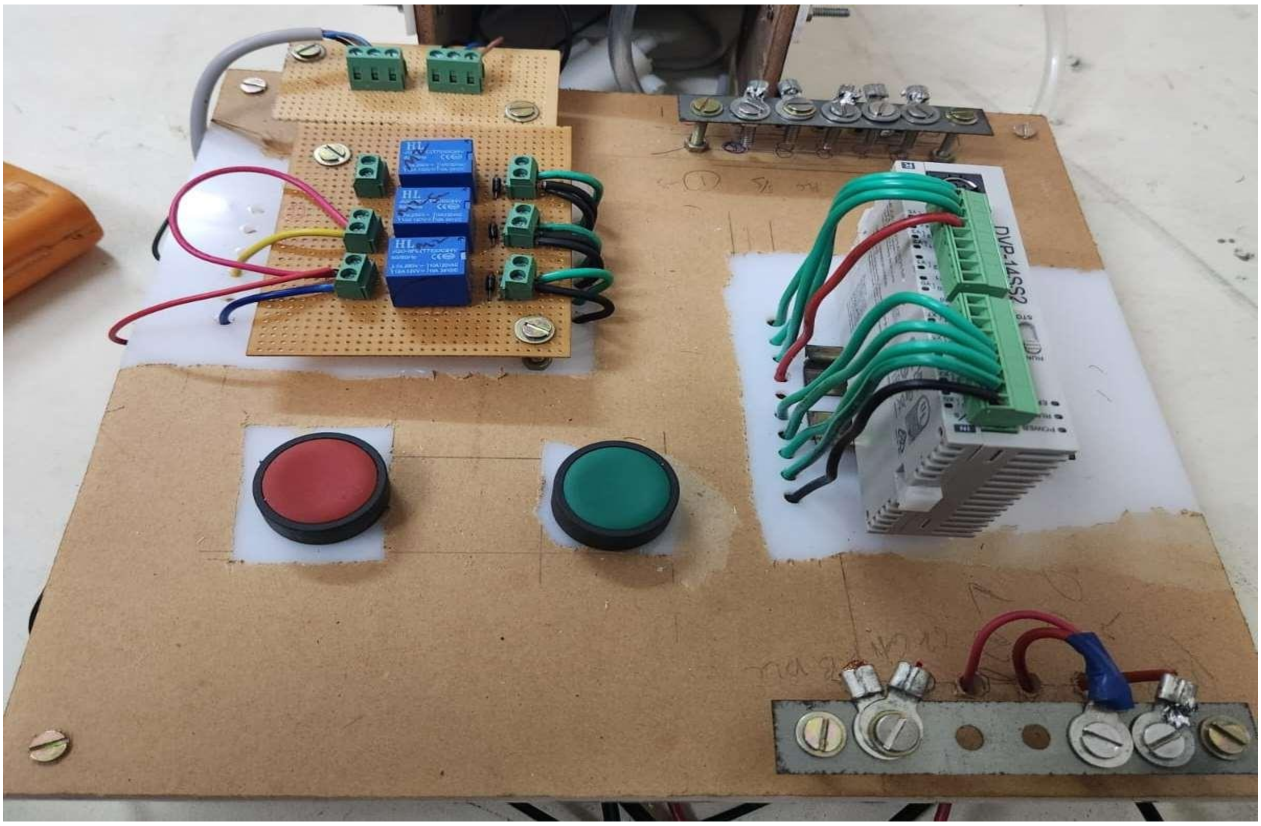

Fig -10 panel board

The panel board serves as a central control unit for the conveyor and bottle filling system, which includes components such as

PLC (Programmable Logic Controller): The PLC is the brain of the system, controlling the operation of the conveyor and pump based on input from sensors and the push button. It processes the signals and executes the automation logic to ensure smooth operation.

Push Button: This component is used to start and stop the system. When pressed, it sends a signal to the PLC or relay module to activate the conveyor and pump.

Relay Module: This module acts as a switch that controls the power supply to the DC motor and pump. It allows the low-power signal from the PLC or push button to safely control the higher-power devices.

Positive and Negative Bus Bars: These bus bars distribute power throughout the system, with the positive bus bar connecting to the power supply and the negative bus bar serving as the return path. They simplify wiring and enhance safety.

Connections: All components are interconnected through clearly defined wiring, ensuring the relay module receives signals from the PLC and push button and effectively powers the motor and pump.

4.3 COMPONENTS USED FOR HARDWARE SETUP

4.3.1 Bearing

Fig -11 Bearing

Bearings are used to support the rotating shafts of the conveyor, allowing them to turn smoothly and with minimal friction. Positioned on either side of the conveyor structure, they help keep the conveyor sheet stable and aligned, ensuring bottles move smoothly along the conveyor path. By reducing friction, the bearings protect parts from wear and allow the motor to drive the conveyor efficiently, which extends the system's lifespan and improves overall performance.

4.3.2 Pulleys and timing belt

Pulleys and a timing belt are essential components for transferring power from the DC motor to the conveyor. The pulleys are mounted on the motor shaft and the conveyor shaft, allowing the timing belt to connect them.

Fig -12 pulleys and timing belt

The timing belt, which features teeth that fit into the grooves of the pulleys, ensures a secure grip and precise movement. This design allows for efficient torque transfer, enabling the conveyor to operate smoothly at the desired speed. The use of pulleys and a timing belt also minimizes slippage, ensuring consistent motion and
improving the overall reliability of the conveyor system. Together, these components help maintain the efficiency of the system while reducing wear on the motor.

4.3.3 Wooden boards

Fig -13 Plywood boards

Wooden boards serve as the primary structure for the conveyor system. They provide a stable and sturdy base to mount and support components like the motor, shafts, bearings, and conveyor sheet. The boards help ensure that all parts are securely positioned, allowing for smooth operation and preventing vibrations that could affect performance. This setup gives the entire conveyor system a solid foundation, enhancing durability and reliability

4.3.4 Conveyor sheet

Fig -14 conveyor sheet

A conveyor sheet is fitted over the shafts, creating a continuous surface for transporting bottles. This sheet is securely attached and tensioned to ensure even movement. Power is transferred from the DC motor to the conveyor using gears and a timing belt, which work together to provide the necessary torque and control the conveyor's speed.

5. SOFTWARE IMPLEMENTATIION

5.1 WPL Soft

Fig -15 WPL delta software

PLCs (Programmable Logic Controllers) operate by executing programmed logic that controls various industrial processes and machinery. This programming is typically done using Ladder Logic, a graphical programming language that resembles electrical relay circuits.

5.1.1 PLC Work with Ladder Logic

Ladder Logic Basics: Ladder Logic consists of rungs that represent logical operations. Each rung resembles an electrical circuit, with inputs on the left and outputs on the right. The main components of Ladder Logic include:

Contacts: Represent inputs, such as switches or sensors. They can be normally open (NO) or normally closed (NC).

Coils: Represent outputs, such as motors or relays. When the logic conditions are met, the coil is energized, activating the output.

Program Execution: The PLC continuously scans the Ladder Logic program in a loop, evaluating the state of all inputs and determining the appropriate outputs. The process generally follows these steps:

Input Scanning: The PLC reads the current status of all input devices (e.g., sensors, push buttons).

Logic Evaluation: The PLC evaluates each rung of the Ladder Logic from top to bottom. If the logic conditions in a rung are true (i.e., the relevant contacts are closed), the output coil in that rung is energized.

Output Control: Based on the evaluated logic, the PLC sends signals to the outputs (e.g., turning on motors, activating pumps) accordingly.

Timers and Counters: Ladder Logic can also incorporate timers and counters to handle more complex operations, such as controlling how long the pump runs after a bottle is detected. This allows for precise control of processes.

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5.2 ladder diagram of the project

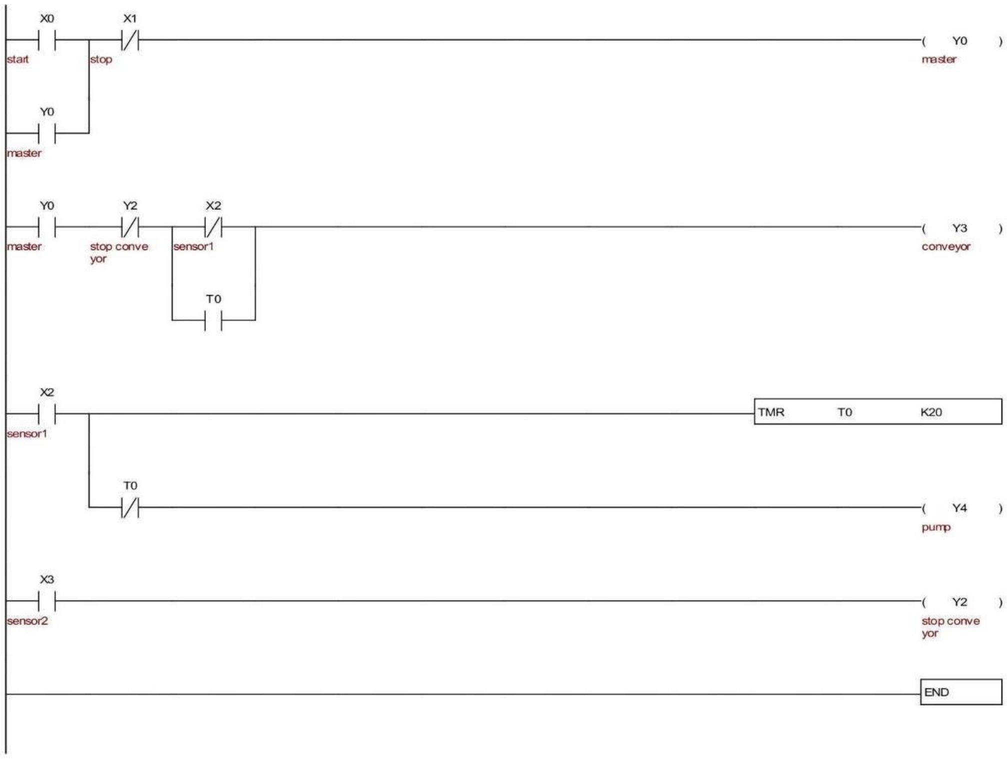

Fig -16 Ladder diagram

Working of ladder diagram

In Rung 1: which includes Start push Button, stop push Button, and Master Coil

When the Start Push Button is pressed, it closes, allowing current to flow and activating the Master Coil.

The Stop Push Button is wired in series. If pressed, it opens the circuit, deactivating the Master Coil and stopping the process.

The Master Coil is latched, meaning it stays activated after the start button is released, maintaining power until the stop button is pressed.

In Rung 2: which includes Master Coil, NC Sensor 2 output, NC Sensor 1, NO Timer 0, Motor Output

When the master coil is activates in rung 1, which starts the conveyor motor in rung 2.

In Rung 3: which includes Sensor 1, Timer 0, Pump Output

Whenever sensor 1 is activated which stops the conveyor, starts timer and water pump. Run the pump till the predetermined time.

In Rung 4: sensor 2 and output coil

When the sensor 2 activates, activates the output coil, which is normally opened in rung 2, so that conveyor stops.

5.3 Algorithm of ladder diagram

STEP 1 :	Press the start Push Button.
STEP 2 :	Then the motor starts and the conveyor moves forward.
STEP 3 :	If the proximity sensor1 detects the presence of bottle, then the conveyor will stop and water pump activates.
STEP 4 :	Water pump fills the bottle for predetermined amount of time.
STEP 5 :	After fill of bottle water pump turns OFF and conveyor turn ON again.
STEP 6:	If the proximity sensor2 (placed at the end of conveyor) detects the presence of bottle, conveyor stops.
STEP 7 :	Repeat the procedure.

5.4 Flow chart

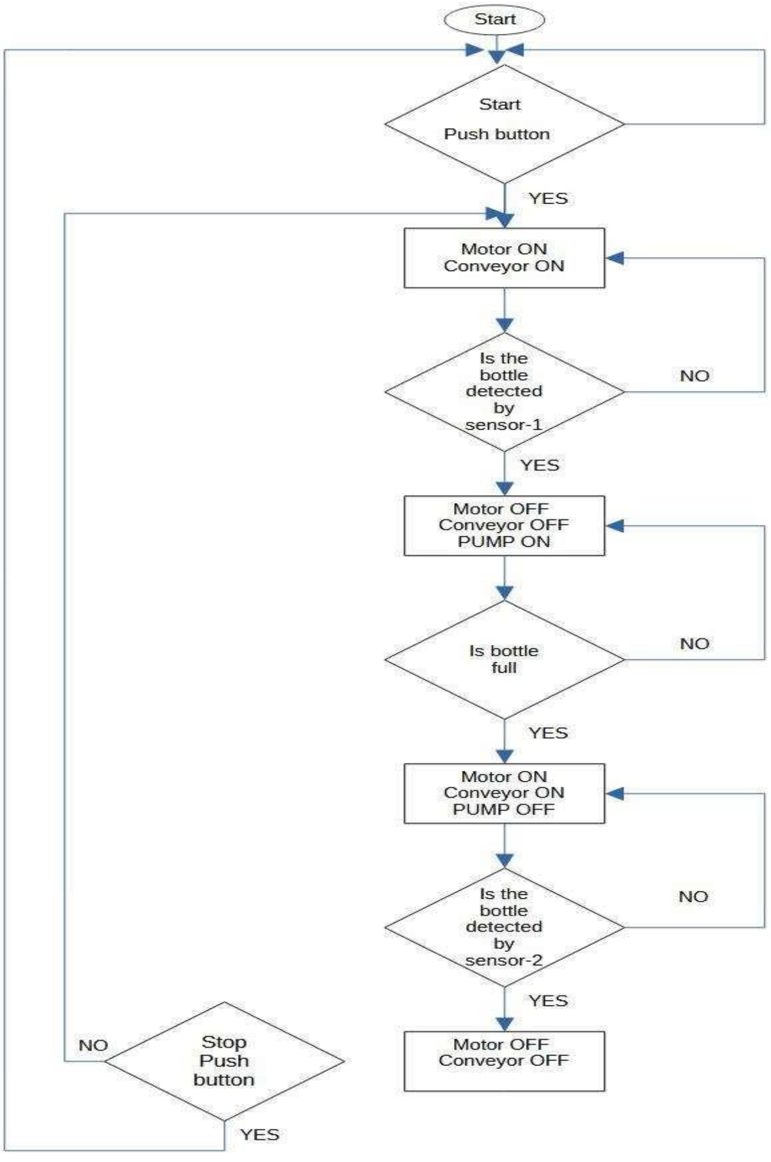

Fig -17 flow chart of ladder diagram

5.5 Dumping ladder diagram to PLC kit

Design the Ladder Diagram in WPLSoft: Use WPLSoft to create the ladder diagram according to the desired automation logic. Ensure that all elements, such as inputs, outputs, and timers, are correctly configured.

Connect the PLC to the PC: Use an RS232 cable to establish a connection between the PLC and computer. Set the PLC to Stop mode before beginning the upload.

Compile the Ladder Diagram: In WPLSoft, as shown in the above figure go to the Compiler option and select Ladder Instructions to compile the ladder logic, check for any errors before transferring it to the PLC.

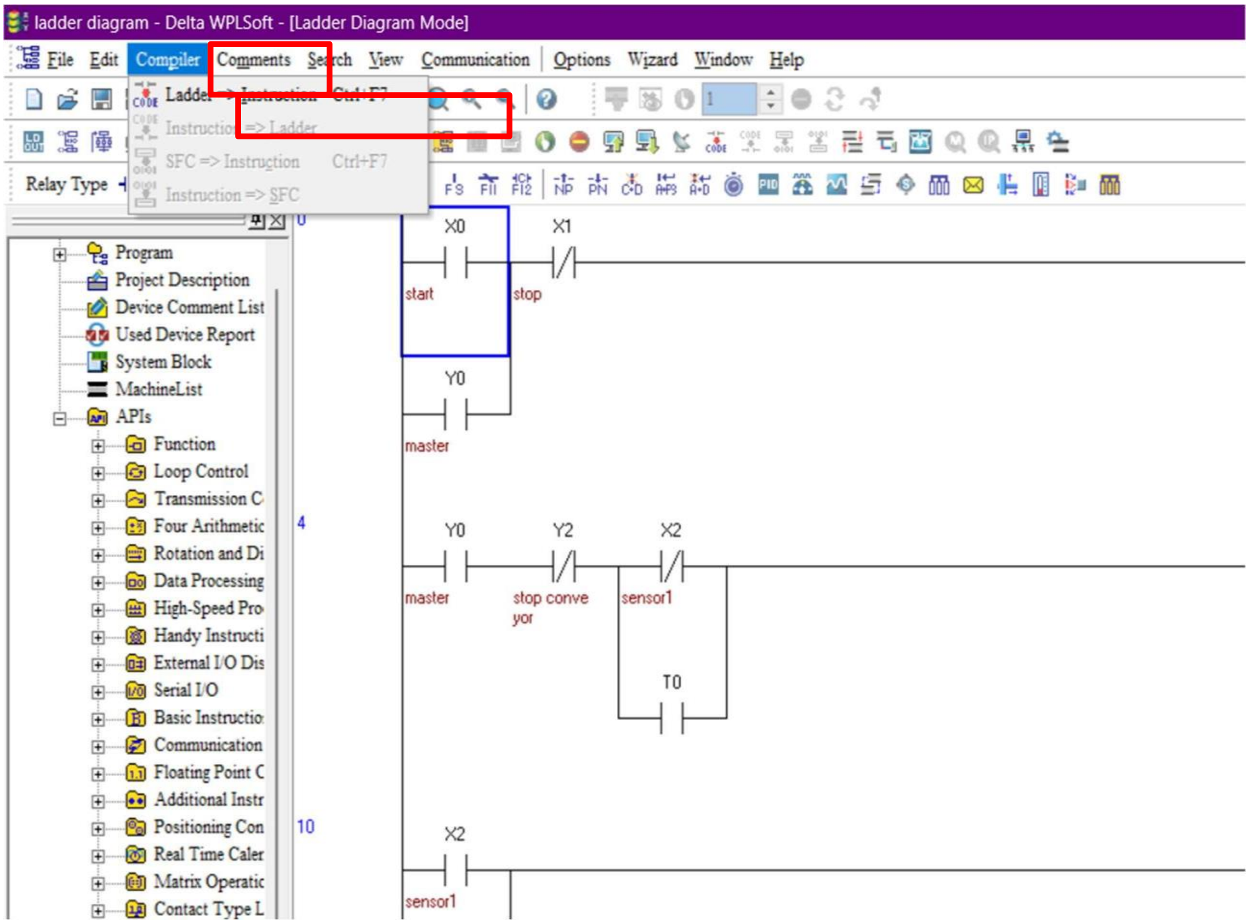

Fig -18 Software window

Set Communication Settings: Open Options as shown in the below figure and select Communication Settings. Use the Auto Detect feature to allow WPLSoft to detect the PLC and set the necessary communication parameters. And click on ok.

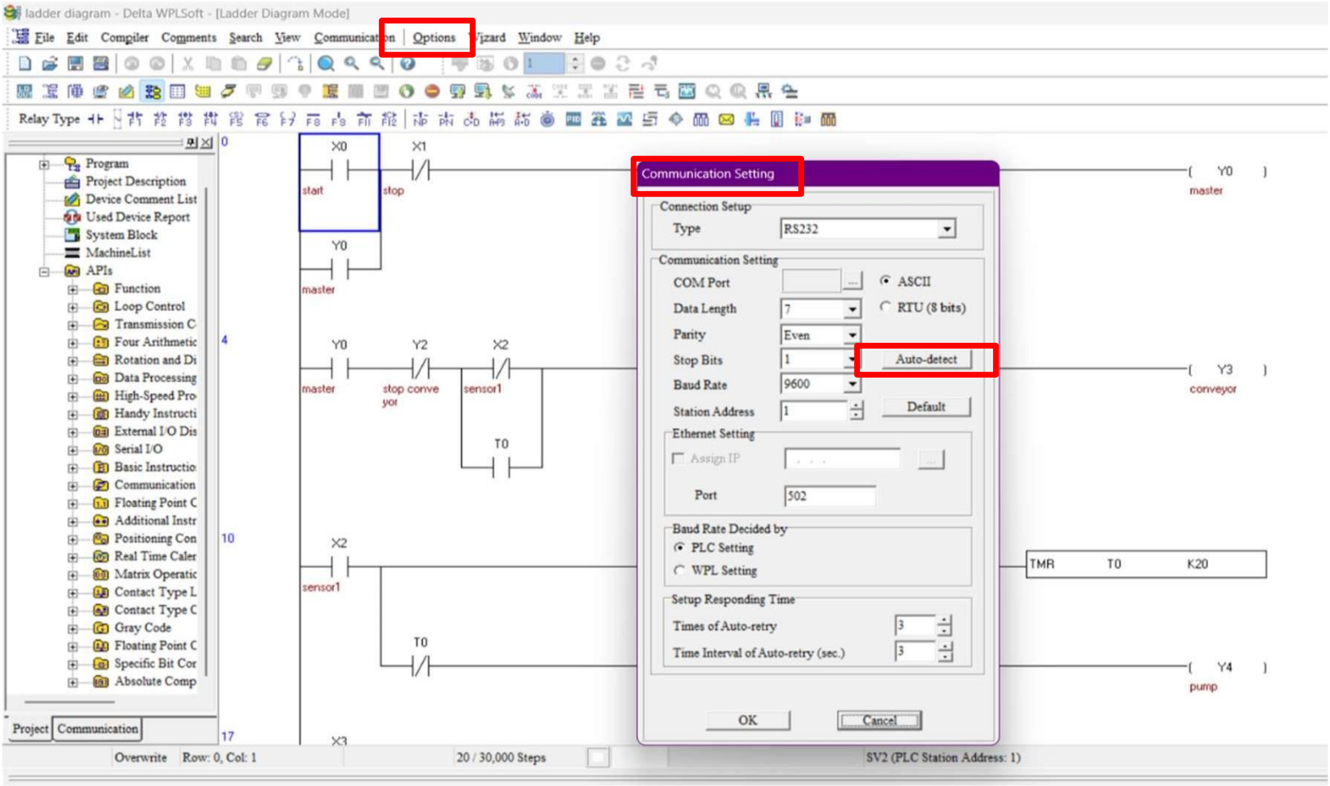

Fig -19 Software window

Write to PLC: Once communication is established, select Write as shown in the below figure to PLC to transfer the ladder diagram to the PLC. Confirm by clicking OK after the transfer completes.

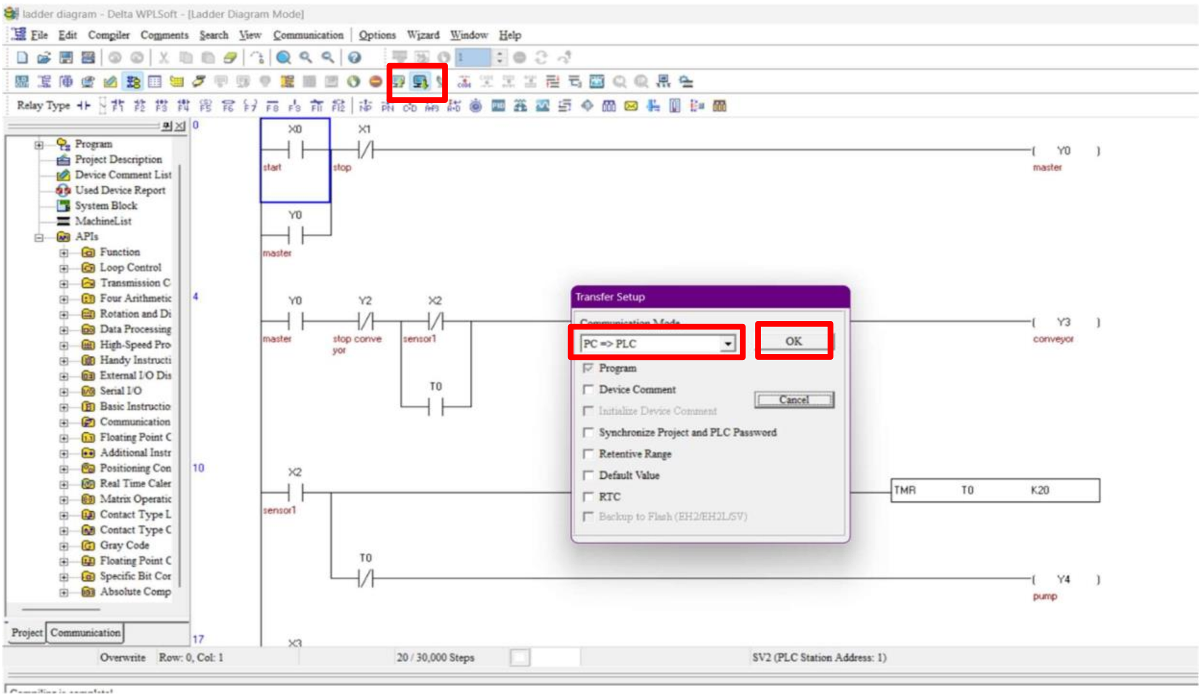

Fig- 20 Software window

Run the PLC: Switch the PLC to Run mode to start executing the uploaded ladder diagram. This will initiate the programmed operations on the PLC kit, allowing to observe the automation process in real-time.

5.6 Working of the project

System Start:

The process begins when the Start Push Button is pressed, activating the Master Coil and latching the system on. The conveyor starts moving, driven by the DC motor, carrying empty bottles along the conveyor path.

Bottle Detection and Stopping:

Sensor 1, positioned at the filling station, detects the presence of a bottle on the conveyor. When a bottle reaches this position, the sensor sends a signal to the PLC, which triggers Timer 0.

As soon as Sensor 1 is activated, the conveyor stops, allowing the bottle to remain in place for filling.

Bottle Filling:

While the conveyor is stopped, Timer 0 begins its countdown. During this time, the Pump is activated, filling the bottle. The duration for which the pump remains active is controlled by the timer, ensuring a precise fill.

Once Timer 0 completes, the Normally Closed (NC) contact in the pump's circuit opens, stopping the pump and completing the filling process.

Conveyor Restart and Final Bottle Detection:

After the bottle is filled, the conveyor restarts, moving the filled bottle towards the end of the conveyor.

At the end of the conveyor, Sensor 2 detects the filled bottle. This sensor's signal stops the conveyor, holding the filled bottle at the unloading position and allowing it to be removed from the conveyor.

System Stop:

The system will continue this automated cycle until the Stop Push Button is pressed, which deactivates the Master Coil and stops the entire process.

6. RESULTS & DISCUSSION

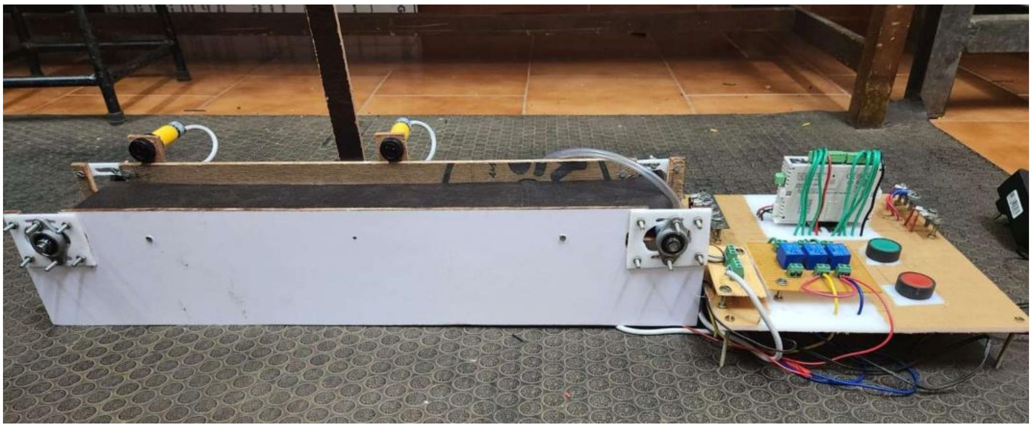

Fig – 21 Final Construction of Prototype

6.1 Results

The designed PLC-driven conveyor and bottle-filling system was successfully implemented and tested.
The conveyor operated automatically through PLC control, ensuring smooth and continuous bottle movement.
The filling process was accurately controlled using sensors and solenoid valves, ensuring consistent liquid levels in each bottle.
The system achieved reliable synchronization between the conveyor and filling unit.
Manual intervention was minimized, and the process efficiency improved significantly.
The HMI interface (if used) displayed real-time system status such as bottle count, motor status, and filling progress.

6.2 Discussion

The project demonstrated how Programmable Logic Controllers (PLCs) can automate industrial processes like bottle filling with high reliability and precision.
The use of sensors reduced human error and improved process accuracy.
The modular design allows for future scalability — such as adding a capping or labeling section.
Minor delays observed during conveyor start-stop transitions were due to sensor lag, which can be reduced by using faster proximity sensors or better conveyor motor control.
Overall, the system performed efficiently under test conditions and can be integrated into small-scale industrial bottling lines.
The project successfully met its objectives — to design, program, and implement an automated, efficient, and cost-effective bottle-filling process using PLC control.

6.3 Advantages

1) This system significantly Increases operational Efficiency by automating repetitive tasks and reducing manual effort.
2) It ensures high precision and consistency in performance, minimizing errors and improving product quality.
3) The solution is cost-effective in the long run by reducing labor costs, energy consumption, and downtime.
4) It allows for easier troubleshooting through real-time diagnostics and clear fault indication systems.
5) The setup enhances safety by reducing human intervention in hazardous areas and ensuring controlled operations.

6.4 Applications

1) The system is widely used in the food and beverage industry for precise filling, packaging, and quality control to maintain hygiene and consistency.
2) In the pharmaceutical industry, it helps ensure accurate dosing, labeling, and compliance with safety and regulatory standards.
3) The technology is applied in the chemical industry for safe handling, mixing, and monitoring of hazardous materials with high precision.
4) It supports small and medium manufacturing units by improving production speed, reducing manual errors, and optimizing resource usage.

7. CONCLUSIONS

7.1 Conclusion

In conclusion, this project has successfully developed an automated bottle filling machine with the capability to handle bottle sizes between 250 ml and 500 ml.

The system fills a 200 ml bottle in some seconds, providing consistent and accurate fills that enhance efficiency in small-scale production environments.

This automated time-based control system offers several advantages over traditional filling methods, including cost-effectiveness, reduced human intervention, and increased operational efficiency. Its compact design and reliable performance make it ideal for use in small-scale filling environments, such as coffee shops, juice bars, and small beverage production facilities. By streamlining the filling process, this machine not only saves time and labor but also maintains consistency and precision in filling, providing a viable solution for businesses looking to optimize their operations.

7.2 Future Scope

This machine has promising potential for further development. By integrating additional features such as variable-speed controls and more advanced sensors, it could accommodate a wider range of bottle sizes and liquid types, including more viscous liquids.

Enhancing the system with a SCADA interface could also allow for real-time monitoring and remote adjustments, which would improve efficiency and diagnostic capabilities. In addition, future versions could be scaled to support medium and large-scale filling operations, potentially expanding its applicability to larger production facilities.

Overall, this project illustrates the value of automation in streamlining production tasks, and the potential future enhancements could make this system even more versatile and impactful within the beverage industry.

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