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Automatic Bottle Filling Machine Using PLC

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Abstract: *In today's fast industrial environment, automation of production processes has become essential for maintaining high productivity and ensuring product quality. One critical area where automation plays a significant role is in the bottle filling process, especially in the beverage, pharmaceutical, and chemical industries. Manual filling methods are prone to errors such as inconsistent filling levels, and slower production rates.*

This research presents the design and development of an Automatic Bottle Filling System using a LOGO Siemens Programmable Logic Controller (PLC). The system is designed to detect bottles automatically using sensors, control the movement of a circular conveyor belt, and manage the filling operation through precise timing and valve control. The Siemens 6ED1052-1HB08-0BA1PLC Logo PLC is programmed using the LOGOSOFT software with ladder logic to achieve synchronized control of all components.

The developed system can consistently fill bottles to the desired level with minimal human intervention, ensuring accuracy, reducing product wastage, and improving production speed. Testing of the system showed a filling accuracy of 98% and a cycle time of approximately 1.2 seconds per bottle. The system is also flexible enough to adjust for different bottle sizes and filling volumes through simple modifications in the PLC program. Overall, the proposed automatic filling system provides a cost- effective and reliable solution suitable for small, medium, and large-scale industrial applications. Future improvements include integrating a weight sensor for even higher accuracy and using advanced monitoring systems for remote operation and maintenance.

Keywords: Automatic Bottle Filling System

I. INTRODUCTION

Automation has transformed the manufacturing industry by enhancing efficiency, accuracy, and productivity. One critical application of automation is in the bottle filling process, where precision and speed are important to meet production demands. Traditionally, bottle filling has been a manual process involving significant human labor, which has issues such as inconsistent filling levels, spillage, contamination, and slower production rates. These challenges create the need for a reliable and automated solution that can perform the task consistently with minimal human involvement. A Programmable Logic Controller (PLC) is a digital computer designed specifically for industrial automation. PLCs are highly flexible, reliable, and suitable for harsh working environments. They offer real-time control and can be programmed easily to automate a wide range of processes. This project focuses on the development of an Automatic Bottle Filling System using a Siemens LOGO PLC. The system is designed to detect empty bottles arriving on a conveyor, accurately fill them to the desired level using a controlled valve system, and then move the filled bottles forward for packaging. Sensors are used to detect bottle presence, while a solenoid valve is used to control the flow of the liquid. The PLC coordinates the entire sequence of operations based on sensor inputs and programmed logic. The main goals of the project are: To increase the speed of the filling process.To improve the accuracy of filling volumes. To reduce human errors and minimize wastage. To enhance safety by reducing manual handling of liquids.

By implementing automated system, industries can achieve higher production efficiency, better quality control, and lower operational costs. Furthermore, the flexibility of the PLC-based system allows easy adjustments for different bottle sizes, types of liquids, and varying production rates. This paper presents the detailed design, working principle, and performance analysis of the automatic bottle filling system using Siemens LOGO PLC, showcasing its effectiveness and potential for industrial application.

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II. LITRATURE REVIEW

Several researchers have explored the automation of bottle filling systems using different technologies, with a focus on increasing production speed, accuracy, and reducing human intervention. This project developed an automated bottle filling system using an Siemens LOGO PLC. Their project successfully utilized a circular conveyor belt, proximity sensors, and a solenoid valve controlled by the PLC to automate the process. They achieved around 90% accuracy in filling operations and reduced human errors. However, their system had limitations, such as being suitable only for fixed bottle sizes, and required manual adjustments for different product types.

These systems showed significant improvements in accuracy and efficiency compared to manual methods. However, many earlier designs were limited to handling only one type or size of bottle and required manual adjustments when switching products.

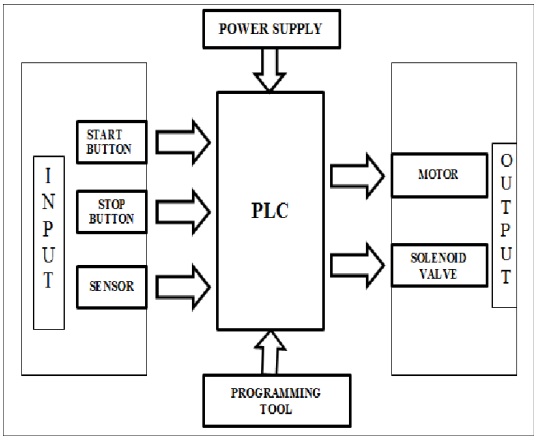
Programmable Logic Controllers (PLCs) have been preferred in industrial environments due to their flexibility, robustness, and ability to handle complex tasks. Among various brands, Siemens PLCs have gained popularity because of their durable hardware, fast processing speeds, and easy programming through software like LOGOSOFT. Systems built with Siemens PLCs also offer better integration with Human Machine Interfaces (HMI) and other industrial networks, providing real-time monitoring and control, which is essential in modern production lines.

The role of sensors is also critical in automated bottle filling systems. Technologies such as proximity sensors, level sensors, and photoelectric sensors have been integrated with control units to improve the reliability and consistency of filling operations. The use of real-time feedback from sensors allows precise bottle positioning, accurate filling, and immediate fault detection, minimizing liquid wastage and production downtime.

From the review of existing systems, it is evident that PLC- based bottle filling automation, particularly with Siemens controllers, offers significant advantages over manual and microcontroller-based methods. Despite many advancements, gaps remain in achieving maximum flexibility, easy scalability, and minimal maintenance requirements in existing systems. Therefore, there is a strong need for a more robust and adaptable bottle filling system designed using a Siemens PLC, which this project aims to develop and present. In addition to PLC control, modern bottle filling systems have increasingly integrated various types of sensors to further enhance reliability and efficiency. Proximity sensors are used to detect the arrival of bottles at the filling station, while photoelectric sensors are employed to detect bottles at high speeds with minimal delay. Level sensors and flow meters are sometimes used to measure the quantity of liquid filled into each bottle, ensuring precision and reducing wastage. Real- time feedback from these sensors allows the PLC to make intelligent decisions, such as pausing the conveyor if a bottle is missing, adjusting filling times, or alerting operators if any faults occur in the system.

III. METHODOLOGY

Block Diagram:



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1. Power Supply

The power supply is the source of electrical energy that makes the entire PLC system work. Just like any electrical device needs power to operate, the PLC also needs electricity to function. The power supply provides this energy in either AC (like 220V from a wall socket) or DC (like 24V used in many control systems). It powers not only the PLC but also the input and output devices connected to it. Without this power supply, the PLC cannot perform any operations, and the connected machines will not start.

2. Input Section

The input section includes all the devices that send signals to the PLC. These devices can be simple buttons or advanced sensors. For example, a start button is pressed by a human to tell the PLC to begin a process. A stop button is used to stop the process. These buttons act like switches that open or close electrical circuits. Another important input device is a sensor, which can automatically detect things like the presence of an object, temperature, pressure, or motion. These input devices give real- time data to the PLC so it knows what's happening in the system.

3. Programmable Logic Controller (PLC)

The PLC is the heart or brain of the entire system. It is a special type of computer used in industries to control machines and processes. The PLC receives information from the input section, checks that information using a program, and then decides what actions to take. It then sends commands to the output devices. The program inside the PLC contains logic rules (for example, "If the start button is pressed and a sensor detects an object, then turn on the motor"). PLCs are highly reliable, very fast, and can run continuously for years in factories.

4. Programming Tool

The programming tool is usually a computer or a device that is used to write and upload the program into the PLC. In this project Siemense LOGO PLC is a special software to write the control logic in programming languages like Ladder Logic. The programming tool is connected to the PLC using a cable or such as (Ethernet). Once the program is uploaded, the PLC follows it to control the system. If there is any need to change the system's behavior, it can update the program using the same tool. This makes PLCs very flexible and easy to use.

5. Output Section

The output section contains devices that do the actual work in the system based on the PLC's instructions. These can be motors, solenoid valves, lights, alarms, or any other machine parts. For example, a motor might be used to move a conveyor belt or operate a fan. A solenoid valve might open or close to allow air, gas, or liquid to flow. The PLC sends electrical signals to these devices to turn them ON or OFF. These outputs are controlled exactly according to the logic defined in the PLC program, allowing machines to work automatically without human help.

IV. WORKING

An automatic water bottle filling system using a Programmable Logic Controller (PLC) is designed to efficiently fill bottles with precise amounts of water using sensors and programmed logic. The process begins when empty bottles are placed on a moving conveyor belt. As the bottles move, a proximity sensor detects the arrival of a bottle at the filling station. This sensor sends a signal to the PLC. Once the PLC receives the signal, it pauses the conveyor by turning off the motor to keep the bottle in the correct position. Then, it activates a solenoid valve connected to the water tank to allow water to flow into the bottle. The filling can be controlled by setting a specific timer in the PLC program (to open the valve for a fixed time). After the filling is complete, the PLC closes the valve, restarts the conveyor, and the filled bottle moves forward. The process then repeats for the next bottle. The PLC ensures the entire process is automatic, accurate, and can be adjusted easily for different bottle sizes or filling speeds by simply changing the program.

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The working of a PLC (Programmable Logic Controller) system begins when the power supply is turned on. The power supply provides the necessary electricity to the PLC unit and all the connected input and output devices. Once the PLC receives power, it becomes active and begins its process of monitoring and controlling the system. The very first task of the PLC is to read the status of all input devices, such as push buttons and sensors. For example, if a worker presses the start button, or if a sensor detects the presence of an object, those signals are sent to the PLC's input terminals.

After collecting input signals, the PLC moves on to the next stage, which is processing the logic stored inside it. This logic is a program written by an engineer, and it tells the PLC how to respond to certain input conditions. The program may include simple instructions like: "If the start button is pressed and an object is detected, then turn on the motor." The PLC checks each condition one by one, using the logic programmed into it. If the input conditions match the rules, the PLC makes a decision on what action should happen next.

Once the decision is made, the PLC sends output signals to the connected output devices such as motors, solenoid valves, or indicator lights. For example, if the logic tells the PLC to start the motor, it will send a signal to the motor's control system, which then turns it on. This step is known as the output operation, where the physical action is carried out based on the result of the logic. While the system is running, the PLC continuously monitors the input signals to see if anything changes. It does this very quickly.

If the situation changes — for example, if the stop button is pressed or a sensor no longer detects an object — the PLC will immediately re-process the logic and send new output commands. This might mean stopping the motor or closing a valve. This real-time response helps in keeping the system safe and efficient. Finally, when the stop button is pressed or a fault occurs, the PLC stops the system by turning off all outputs. It will stay in this stopped state until the next command is given. In this way, the PLC keeps reading inputs, applying the program, and controlling outputs — all in a fast, continuous cycle — making automatic control of machines and processes possible.

V. OBJECTIVES

The main objective of an automatic water bottle filling system using a PLC is to automate the bottle filling process to improve speed, accuracy, and efficiency. This system aims to reduce human effort and labor costs by performing the task with minimal supervision. It ensures that each bottle is filled with the correct amount of water, avoiding spillage or underfilling, which helps maintain product quality and reduce wastage. Another key objective is to increase production output by allowing continuous and consistent operation, especially useful in industries that require large-scale filling. The system also focuses on flexibility, allowing easy changes in the filling time or quantity through simple reprogramming of the PLC. Overall, it supports hygienic, fast, and reliable bottling operations in water packaging plants.

The primary objective of an automatic water bottle filling system using PLC is to automate the repetitive and time-consuming task of filling bottles with water in a fast, efficient, and accurate manner. By using a PLC, the system can precisely control the timing, valve operation, and bottle movement, ensuring each bottle is filled with the exact quantity required without manual intervention. This reduces human error, improves productivity, and ensures consistency in the filling process. Another important objective is to maintain hygiene and reduce contamination, which is essential in the food and beverage industry. Since the system is closed and automated, it minimizes direct human contact with the bottles and water. Additionally, the system is designed to be flexible and scalable; changes can be made easily through the PLC program to handle different bottle sizes or filling speeds, making it suitable for various production needs. It also helps in reducing operational costs over time by minimizing water wastage and labor requirements. Overall, the system aims to deliver a reliable, safe, and cost-effective solution for high-speed bottling in industrial environments.

VI. APPLICATIONS

An Automatic Bottle Filling Machine using PLC (Programmable Logic Controller) is a system designed to automate the process of filling bottles with liquids, improving efficiency and accuracy in industries like beverage production, pharmaceuticals, and chemicals. The PLC controls various aspects of the machine, such as bottle detection, filling accuracy, and speed. Sensors detect if the bottles are in place, and once positioned, the PLC activates the filling process by controlling solenoid valves to regulate the flow of liquid. The system ensures that each bottle is filled to the correct

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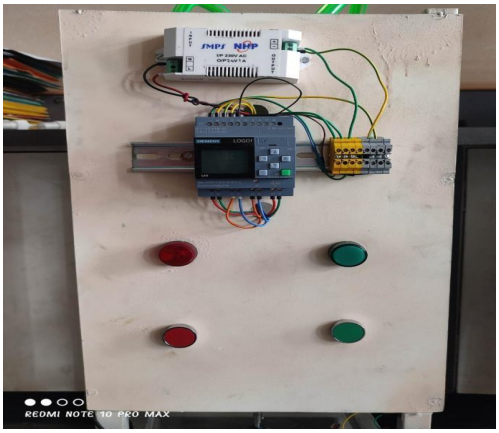
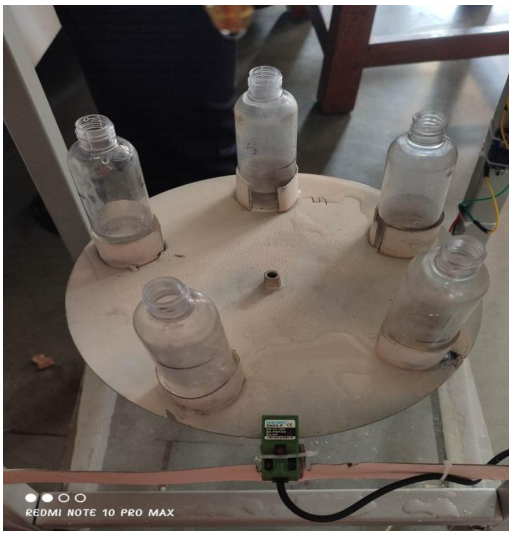
level and stops automatically if there's an overflow or any malfunction. PLCs also enable multi-station automation, allowing for seamless integration with other processes like capping and labeling. Additionally, they provide real-time error detection, data logging, and reporting, which helps maintain production efficiency and ensure consistent product quality. This automation not only reduces human intervention but also improves the reliability and speed of the bottling process.

1. Beverage Industry – Fills water, juice, and soft drinks automatically.
2. Pharmaceutical Industry – Fills medicines and purified water with high accuracy.
3. Food Industry – Fills flavored water and syrups hygienically.
4. Chemical Industry – Safely fills chemicals into bottles.
5. Packaging Industry – Works with sealing and labeling for full automation.
6. Mineral Water Plants – Fully automates rinsing, filling, and capping of bottles.

VII. PROJECT MODEL





In this project, a circular conveyor belt is used to move the bottles. As the bottles rotate along the belt, a sensor detects when a bottle reaches the filling position. The PLC then sends a signal to stop the bottle at the fixture point. The fixture holds the bottle firmly in place to avoid movement. Once the bottle is fixed, the PLC activates the filling valve to pour

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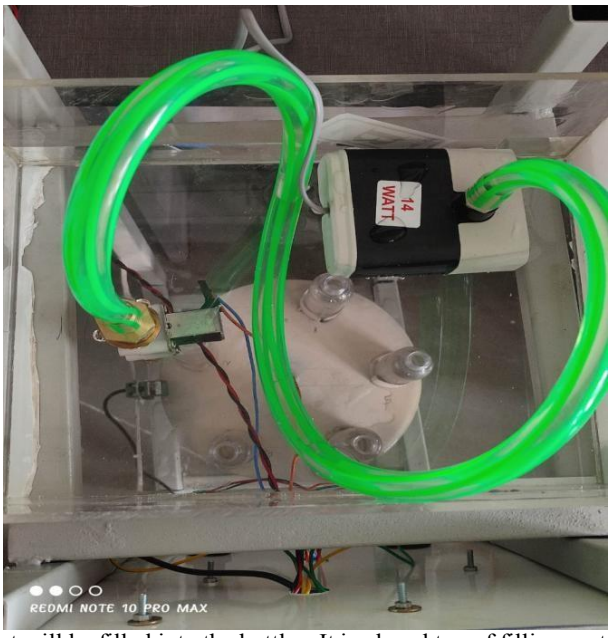
the correct amount of liquid. After filling is complete, the valve closes, and the bottle is released to continue rotating on the conveyor to the next station, like capping or sealing.



The water tank stores the water that will be filled into the bottles. It is placed top of filling system. The tank is connected to the filling valve through pipes. When the PLC gives a signal to open the valve, water flows from the tank into the bottle. This setup helps maintain a constant water supply for smooth and automatic filling.

VIII. CONCLUSION & FUTURE SCOPE

In conclusion, the automatic water bottle filling system using a PLC is a highly efficient and reliable solution for modern bottling operations. It simplifies the entire filling process by using sensors and programmed logic to ensure accuracy, speed, and hygiene. The system reduces manual labor, minimizes errors, and increases productivity, making it ideal for industries that require large-scale water bottling. With its flexible programming, the system can be easily modified to handle different bottle sizes and filling requirements. Looking into the future, this system can be further improved by integrating advanced technologies such as Human Machine Interface (HMI) for easier control, Internet of Things (IoT) for remote monitoring, and Artificial Intelligence (AI) for predictive maintenance and optimization. Energy-efficient components and environmentally friendly materials can also be used to make the system more sustainable. Therefore, the PLC-based bottle filling system not only meets current industry needs but also has great potential for future advancements. The future scope of an automatic water bottle filling system using PLC is very promising, especially with the continuous advancement in automation and smart manufacturing technologies. In the coming years, the system can be enhanced by integrating a Human Machine Interface (HMI), which will allow operators to easily monitor and control the process using a touchscreen. This makes the system more user-friendly and reduces the chances of error. Additionally, Internet of Things (IoT) technology can be used to connect the filling system to a central network, enabling remote monitoring and control through smartphones or computers. This is particularly useful in large factories where multiple machines are running at once. Artificial Intelligence (AI) and machine learning algorithms can be used to analyze data from sensors and predict maintenance needs, helping reduce downtime and improving efficiency. The system can also be upgraded to automatically detect and reject faulty bottles or misaligned containers using vision sensors or cameras. Moreover, future designs may focus on using energy-efficient components and sustainable materials to reduce environmental impact. With these improvements, the PLC-based filling system can become smarter, more efficient, and environmentally friendly, making it suitable for advanced industrial applications in the future.

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