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AUTOMATED BATCH PROCESSING USING PROGRAMMABLE LOGIC CONTROLLER

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Abstract: All Production industry need production batch processing to the machinery. So, the main aim of these project is to control Production batch and maintain every production data to the Factory automation. And when it reaches to our target point automatically every counting data should need to add and when it reaches to our production target all process should stop. For doing this we use conveyer, tank, control valves and fro bottle count, one sensor. when you turn on the input-the motor will run, bottle will sense by the sensor, and in parallel the PLC program count will increase and motor will stop the bottle filling by the valve, once filling is done then other bottle will come and same procedure will repeat and when it reach to target point, we consider that one batch has completed. For doing all other processing we use one Delta PLC with all setup production line and for comparison purpose we use comparator concept in the PLC which automatically counts. And when it reaches to set point it will stop the entire system.

Key Components: Delta PLC, Digital inputs, Communication Cables, Digital outputs, 1Phase motor, Sensor.

1. INTRODUCTION

Every Production industry needs production batch processing in the machinery system, and this projects presents about the Bottle Filling Batch Process using PLC.

PLCs – Programmable Logic Controller in the industrial fields are utilized to control a certain process in order to get better performance and higher accuracy to give more production in industries with an efficient manner.

The bottle filling batch process is an industrial application where bottles are filled with a liquid product such as water, juice, or other beverages.

Switched Mode Power Supply (SMPS) is a linear power supply, and draws input supply from the ac mains, to the DC motor.

A conveyor belt is a mechanical system, typically made of durable materials like rubber, fabric, metal, or plastic. The belt forms a continuous loop over pulleys.

A proximity sensor is a device that can detect or sense the approach or presence of nearby objects.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. Solenoids offer fast and safe switching, high-reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

Automating this process using a Programmable Logic Controller (PLC) enhances precision, efficiency, and reliability. PLCs are robust industrial computers designed for the control of manufacturing processes.

BLOCK DIAGRAM

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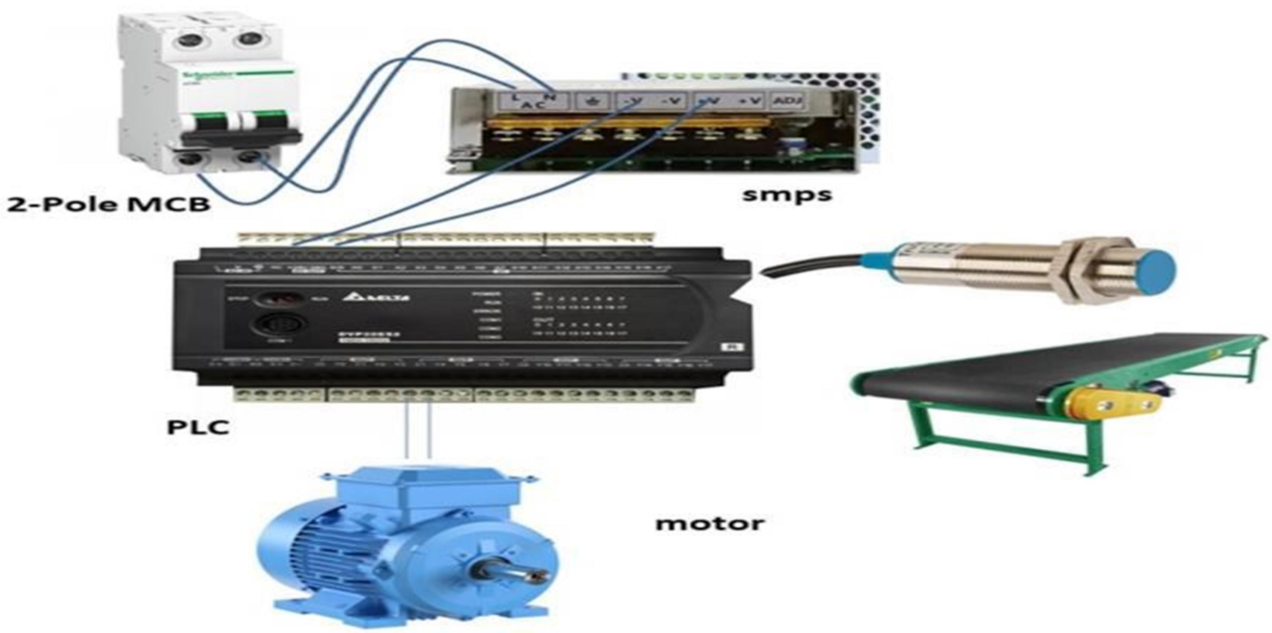

FIG 2.1.1 BLOCK DIAGRAM

2.2 COMPONENTS USING IN BATCH PROCES

Below shows the components using in PLC system

- DELTA PLC
- Pneumatic valve
- Pneumatic cylinder
- Pneumatic piston
- Water tank
- Conveyer with DC motor
- SMPS
- Container
- Proximity sensor

2. LITERATURE SURVEY

In Process Industries, mainly food and beverage industries, proper automation should be maintained to ensure the standard quality of the product. This project converts manual manufacturing into the fully automated one thereby reducing the production time, improving quality, regulating level, temperature, stirrer action, volume of batch and making the plant environmentally safe. In this paper automation is done by using the hardware and software tools like PLC.

An Automatic production process with minimal amount of cost (MAC). The main purpose of this paper is to give an idea about automatic shrink packaging of the final product and sorting technique which reduces the overall packaging and sorting time and also increases productivity. In this project a PLC based low-cost automation cell will be developed for industry. This automation cell combines two different types of work in one frame.

Automation of Batching Plant using PLC, This paper presents the need for effective automation using PLC in the process control, A flexible system that can be controlled by the user at the site with preferred logics without disturbing its external connection. Thus the paper takes an attempt to explain the automated and process industries in general with an example of batching plant system methodology in particular with PLC.

In the proposed work, to manufacture a system involving computers and electro-mechanical components for cooking two of the most widely consumed Indian delicacies Dosa (Pancake) and Idli (Rice cake). Reported work discusses the detailed mechanical fabrication of the device, including the process of automation implemented on Programmable Logic Controller (PLC). A detailed comparison is tabulated comparing the similar product to highlight the working of the proposed system.

One of the important parts of the developing policy for any branch of the industry is automation. This paper focuses on automating a food production process by designing an automated system based on the technologies of the programmable logic controller (PLC) tosolve two problems; the first problem is to control precisely the amount of dough that is filled in a product molds on a conveyor belt which spins in a specific speed.

This research is to design and build an automatic manufacturing for energy drink system by using Programmable Logic Controller (PLC). In this research, Mitsubishi PLC FX2n-20MT was used to control and automate the system. The ladder language was written to program the PLC by GX work-2 software. This research included different two liquids which are filling in one tank with pump. When the photoelectric sensor is detected, liquids are filling the bottle with timer.

3.1 PLC – PROGRAMMABLE LOGIC CONTROLLER

Definition of a PLC:

A programmable logic controller (PLC) is a specialized computer used to control machines and process. It uses a programmable memory to store instructions and specific functions that include On/Off control, timing, counting, sequencing, arithmetic, and data handling.

According to NEEMA (National Electrical and Electronics Manufacturing Association) of US, It is a digitally operating electronic system designed for use in an industrial environment, which uses a programmable memory for the internal storage of instructions for implementing specific functions to control various types of process.

HISTORY OF PLC:

Father of PLC is DICK MORELY. The PLC was introduced in late 1960's. The First Commercial and successfully PLC was Design and developed by launched in 1969 by MODICON as relay replacer for general motor Earlier it was called acronym PC Late 1970's it is greatly controlling device with microprocessor based equipment to control industrial equipment's.

Before PLC there were other industrial controlling's, which are

- MANUAL CONTROLLING
- HARDWARE LOGIC CONTROLLER
- ELECTRONIC CONTROLLING

MANUAL CONTROLLING

In 18th century all industries were controlled by man power, but by using man power we observed few draw backs, those are

- NO safety
- Quality is less
- Less quality
- No accuracy
- Time consuming is high.

HARDWARE LOGIC CONTROLLER

From 1920's onwards hardware controlling has started, If you want to control any device it need to be wired, So the drawbacks observed are

- Space will increase
- Rewiring
- Troubleshooting is not easy
- Time consuming

ELECTRONIC CONTROLLING

For Replacing of relay logic electronic has started in the 1960. In the place of timers, counters we used electronics and From1969 onwards PLC has started working based on micro processer. Lately in 1970's it is greatly controlling device with microprocessor based equipment to control industrial equipment's. And Developed to offer the same functionality as the existing relay logic systems.

- Programmable, reusable and reliable
- Could withstand a harsh industrial environment
- No hard drive, instead battery backup
- Could start in seconds
- Used Ladder Logic for programming.

Programmable logic controllers are used throughout industry to control and monitor a wide range of machines and other movable components and systems. PLC is used to monitor input signals from a variety of inputs (input sensors) which report events and conditions occurring in a controlled process. Programmable logic controllers are typically found in factory type settings.

A plc includes a rack into which plurality of input/output cards may be placed. a rack includes several slots into which a plurality of input/output cards are installed.

Each input/output card has a plurality of I/O points. The I/O modules are typically pluggable into respective slots located on a backplane board in the plc. An i/o bus couples the cards in the slots back to the processor of the programmable logic controller. the slots are coupled together by a main bus which couples any i/o modules plugged onto the slots to a central processing unit (CPU).

4. SMPS

Switched Mode Power Supply (SMPS) is a linear power supply, the switched mode power supply converts the available unregulated ac or dc input voltage to a regulated dc output voltage. However in case of SMPS with input supply drawn from the ac mains, the input voltage is first rectified and filtered using a capacitor at the rectifier output. The unregulated dc voltage across the capacitor is then fed to a high frequency dc-to-dc converter.

Most of the dc-to-dc converters used in SMPS circuits have an intermediate high frequency ac conversion stage to facilitate the use of a high frequency transformer for voltage scaling and isolation. In contrast, in linear power supplies with input voltage drawn from ac mains, the mains voltage is first stepped down (and isolated) to the desired magnitude using a mains frequency transformer, followed by rectification and filtering. The high frequency transformer used in a SMPS circuit is much smaller in size and weight compared to the low frequency transformer of the linear power supply circuit. The 'Switched Mode Power Supply' owes its name to the dc-to-dc switching converter for conversion from unregulated dc input voltage to regulated dc output voltage.

The switch employed is turned 'ON' and 'OFF' (referred as switching) at a high frequency. During 'ON' mode the switch is in saturation mode with negligible voltage drop across the collector and emitter terminals of the switch where as in 'OFF' mode the switch is in cut-off mode with negligible current through the collector and emitter terminals. On the contrary the voltage regulating switch, in a linear regulator circuit, always remains in the active region.

In fact there are several other switched mode dc-to-dc converter circuits that do not use a high frequency transformer. In such SMPS circuits the unregulated input dc voltage is fed to a high frequency voltage chopping circuit such that when the chopping circuit (often called dc to dc chopper) is in ON state, the unregulated voltage is applied to the output circuit that includes the load and some filtering circuit.

5. PLC WIRING

Before going to discuss about plc wiring we need to know about the types of inputs.
Types of inputs coming from field/site/ application

5. Sink (24-)

6. Source (24+)

If 24V- signal coming from one device then it is considered as a sink signal. If 24V + signal coming from one field device then the signal called as source signal. Usually PLC input voltage either 230V AC or 24 DC.

PLC having the option as S/ S means sink /sours. Suppose if your giving 24+ in S/S the we need to give 24- in the input terminals common. Suppose if your giving 24- in S/S the we need to give 24+ in the input terminals common.

Types of Outputs coming from PLC also two Types

8. Transistor (24-)

9. Relay (24+)

If 24V – signal coming from PLC then it consider as a transistor output. If 24V + output signal coming from PLC then it consider as a Relay output.

In our delta PLC we are using transistor outputs. Suppose if we are getting 24 – signal coming from PLC, then we need to connect 24+ in the common terminals of output devices. Suppose if we are getting 24 – signal coming from PLC then we need to connect 24+ in the common terminals of output devices. PLC is transistor output that's why we need to use 24+ as common in the output of PLC.

In inputs (buzzer siren, relay, limit switches, emergency etc) of PLC we have given 24- and we need to give 24+ in the S/S terminal of PLC.

Base these signals coming from PLC then it will turn off and protect the the devices from the critical situations coming from the site.

5.2 SOFTWARE EXECUTION

[2] Open WPL software and go to file option on tool bar and create a new program with ES2 series PLC and assign name for Project.

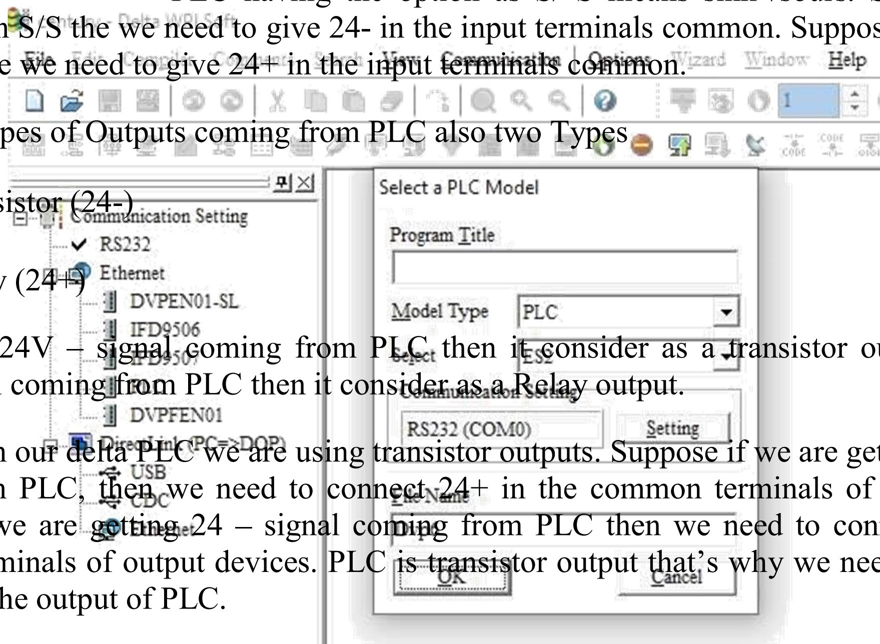

FIG 5.2.1 WPL SOFTWARE

[6] Write a Program according to instructions

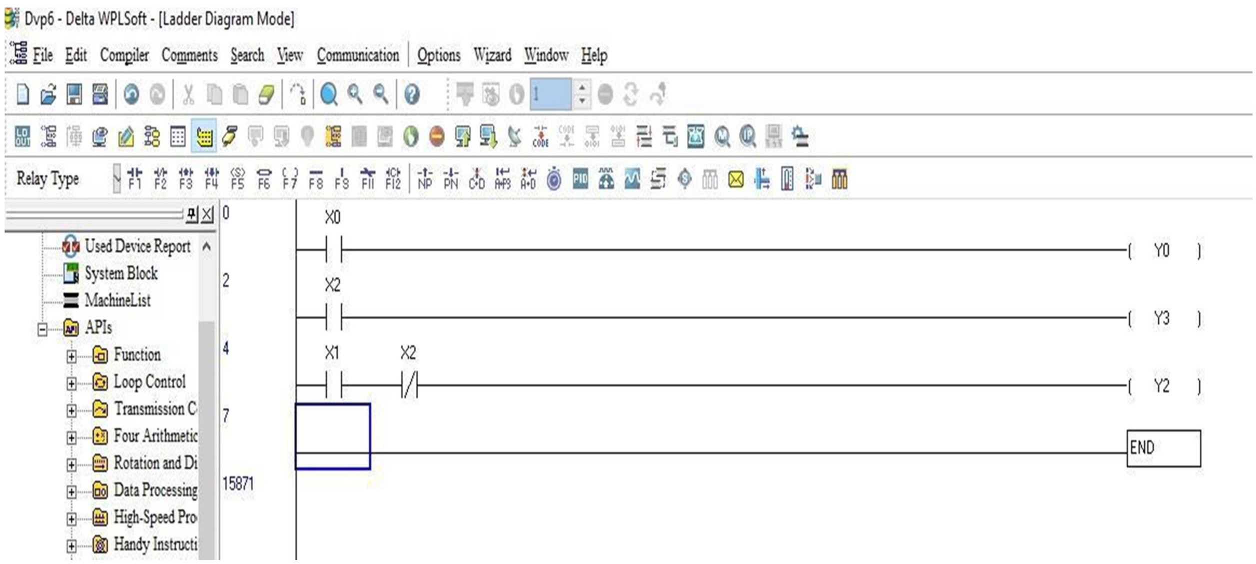

FIG 5.2.2 WPL PROGRAM ACCORDING TO INSTRUCTIONS

- Go to compiler Option and click on ladder instruction option

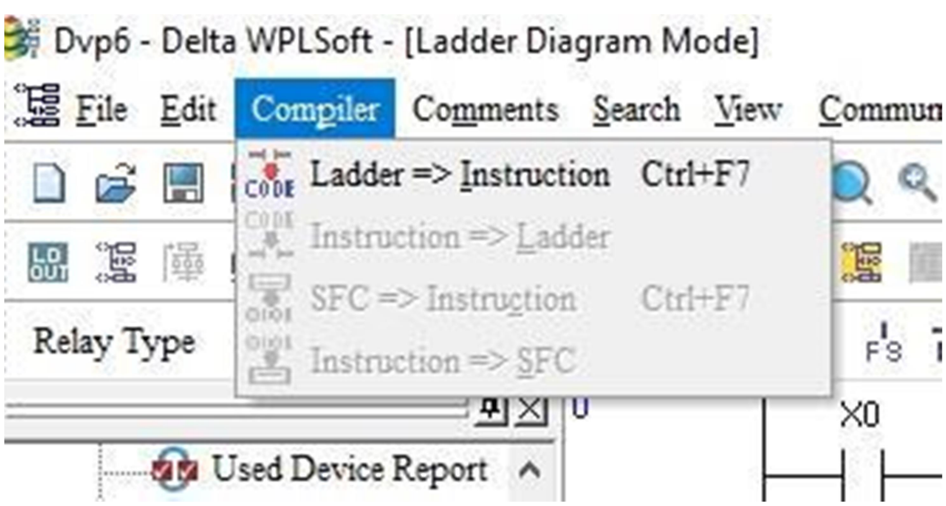

FIG 5.2.3 COMPILER COMMAND

- Click on simulator Option

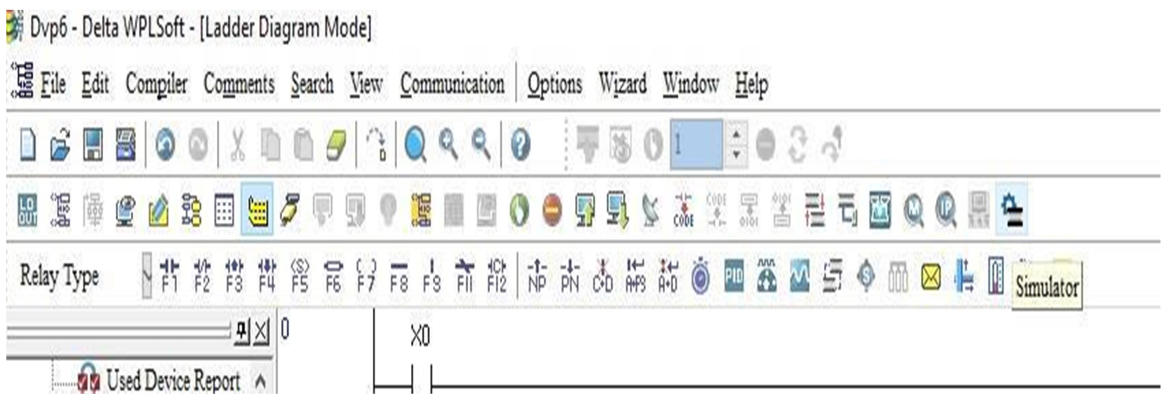

FIG 5.2.4 SIMULATION

- Click on Online mode and next click on run mode for offline execution not on the kit
- Set on/off inputs and check your Program.

PROGRAM EXECUTION IN SOFTWARE

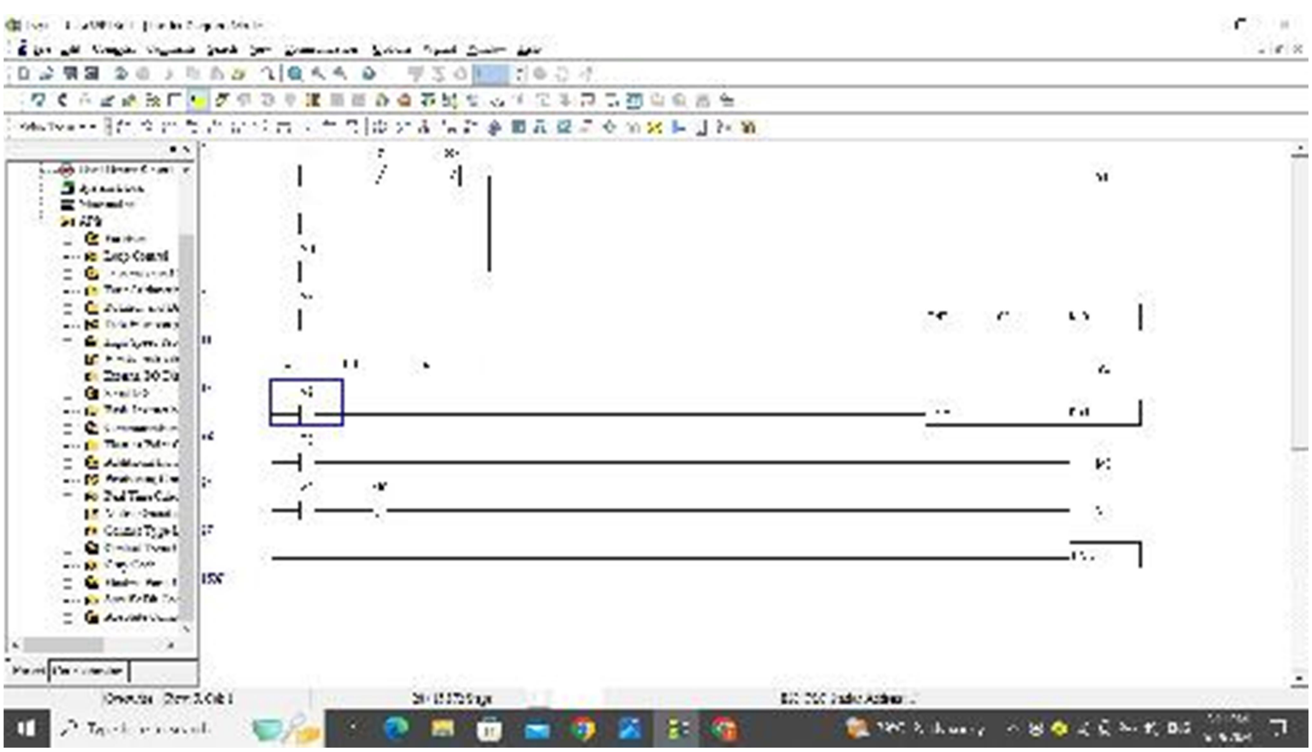

FIG 5.2.5 PROGRAM EXECUTION IN SOFTWARE

APPLICATION

Batch processing using Programmable Logic Controllers (PLCs) is widely used in various industries to automate and control complex processes that involve a sequence of operations. Here are some common applications

- **Chemical and Pharmaceutical Manufacturing:**

Chemical Reactions: PLCs control the mixing, heating, cooling, and reaction times of chemicals to ensure precise formulations.
Pharmaceutical Production: Used for mixing active ingredients, controlling fermentation processes, and managing packaging lines.

- **Food and Beverage Industry:**

Brewing: PLCs manage the brewing process, including mashing, fermentation, and packaging.
Dairy Processing: Automated control of pasteurization, homogenization, and packaging of dairy products.

- **Water and Wastewater Treatment:**

Water Treatment: PLCs control the sequential processes of coagulation, sedimentation, filtration, and disinfection.
Wastewater Treatment: Manage the aeration, sedimentation, and sludge treatment processes.

- **Oil and Gas Industry:**

Refining: PLCs control the fractional distillation, cracking, and reforming processes in refineries.
Pipeline Monitoring: Automate the pumping, pressure regulation, and leak detection in pipelines.

- **Automotive Manufacturing:**

Paint Shops: Control the sequence of operations for cleaning, priming, painting, and drying of vehicle bodies.
Engine Assembly: Manage the precise assembly of engine components, ensuring correct torque and alignment.

- **Textile Industry:**

Dyeing and Finishing: PLCs control the sequence of dyeing, rinsing, and finishing processes.
Fabric Manufacturing: Automate the weaving, knitting, and fabric processing operations

- **Cement and Building Materials:**

Cement Production: Control the mixing, heating, and cooling processes in cement kilns.
Batching Plants: Manage the mixing and delivery of concrete in batch processing plants.

- **Paper and Pulp Industry:**

Pulp Processing: Control the chemical and mechanical pulping processes.
Paper Manufacturing: Automate the paper-making process, including forming, pressing, drying, and cutting.

- **Pharmaceuticals:**

Tablet Manufacturing: Control the granulation, drying, and tablet pressing processes.

Liquid Formulations: Manage the mixing, heating, and bottling processes for liquid medications.

- **Energy Sector:**

Battery Manufacturing: PLCs control the mixing, coating, and assembly of battery cells.
Solar Panel Production: Automate the sequence of cell manufacturing, module assembly, and quality testing.

ADVANTAGES:

Batch processing using Programmable Logic Controllers (PLCs) offers numerous advantages in industrial and manufacturing environments.

- **Efficiency and Speed:**

Automation: PLCs automate batch processes, reducing the need for manual intervention and minimizing human error.
Consistency: Ensures that each batch is processed in the same way, improving product consistency and quality.
Faster Processing: PLCs can handle complex tasks quickly, speeding up the overall batch processing time.

- **Flexibility:**

Programmability: PLCs can be easily reprogrammed to accommodate changes in the process or product specifications, making them adaptable to different batch processes.
Scalability: Systems can be scaled up or down based on production needs without significant changes to the hardware.

- **Improved Quality Control:**

Real-Time Monitoring: Continuous monitoring and control of process variables such as temperature, pressure, and flow rate ensure that the process stays within specified parameters.
Data Logging: PLCs can log data for each batch, facilitating traceability and quality assurance

- **Cost-Effectiveness:**

Reduced Labor Costs: Automation reduces the need for manual labor, lowering operational costs.
Energy Efficiency: Optimized control of processes can lead to better energy utilization, reducing energy costs.
Enhanced Safety:
Fault Detection: PLCs can detect and respond to faults or irregular conditions quickly, preventing accidents and ensuring operator safety.
Interlocks and Safety Protocols: Built-in safety protocols and interlocks can prevent dangerous conditions and ensure safe operation of equipment.

- **Ease of Integration**:

Compatibility: PLCs can easily integrate with existing systems and equipment, making it easier to upgrade or expand current processes.
Standardization: Use of standardized communication protocols facilitates integration with other control systems and devices.

- **Maintenance and Diagnostics**:

Predictive Maintenance: PLCs can monitor equipment performance and predict maintenance needs, reducing downtime and extending the lifespan of equipment.

Ease of Troubleshooting: Built-in diagnostic tools and error logs help in quick identification and resolution of issues.

- **Customization:**

Tailored Solutions: PLCs can be programmed to meet specific process requirements, allowing for highly customized solutions tailored to the unique needs of each batch processing application.

- **Regulatory Compliance**:

Documentation and Reporting: Automated data collection and reporting make it easier to comply with industry regulations and standards.

Process Validation: Ensures that processes meet required standards and guidelines, facilitating compliance with regulatory requirements

- **Remote Access and Control**:

Remote Monitoring: Operators can monitor and control processes remotely, improving oversight and management of operations.

Remote Troubleshooting: Technicians can diagnose and fix issues from remote locations, reducing the need for on-site interventions.

DISADVANTAGES:

Batch processing using a Programmable Logic Controller (PLC) in industrial and manufacturing settings can bring many advantages, such as automation, precision, and efficiency. However, there are also several disadvantages associated with this approach

- **High Initial Costs:**

Equipment Costs: PLCs and associated hardware (sensors, actuators, and communication modules) can be expensive**.**

Software Costs: Specialized software for programming and monitoring PLCs often requires licenses, which can add to the overall expense.

Installation and Setup: The initial setup and configuration of a PLC system for batch processing can be time-consuming and costly, involving detailed planning and engineering work.

- **Complex Programming and Maintenance:**

Programming Complexity: Developing and debugging the control logic for batch processes can be complex, requiring skilled programmers who are familiar with PLC languages such as ladder logic, structured text, or function block diagrams.

Maintenance and Troubleshooting: Maintenance of PLC systems can be challenging. Diagnosing issues in the control logic or in the physical connections requires expertise, which may not be readily available in all organizations.

- **Limited Flexibility:**

Process Changes: Modifying the batch process often requires changes to the PLC program. This can be difficult and time-consuming, especially if the original programmer is not available or if the documentation is inadequate.

Scalability Issues: Scaling a PLC-controlled batch process up or down can be problematic. Adding new sensors or expanding the system may require significant reprogramming and hardware changes.

Security Concerns:

Cybersecurity Risks: PLCs are often networked and can be targets for cyber attacks. Ensuring the security of the PLC network against unauthorized access, malware, and other threats is critical but can be complex and costly.

Physical Security: Protecting the physical hardware from tampering or damage is also important, especially in industries where the batch process is critical to safety or production.

6. CONCLUSION

The implementation of batch processing using Programmable Logic Controllers (PLC) has proven to be a significant advancement in industrial automation. This project has demonstrated the feasibility, efficiency, and reliability of using PLCs to control and manage batch processes across various applications.

- **Challenges and Solutions**

  During the project, several challenges were encountered, including initial system integration issues and the need for training personnel to handle the new technology. These challenges were addressed through:

  - Comprehensive testing and debugging phases to ensure system reliability before full-scale implementation.
  - Conducting training sessions and providing detailed documentation to equip operators and maintenance staff with the necessary skills.

Throughout the project, we designed, programmed, and implemented a PLC-based control system for batch processing, emphasizing efficiency, precision, and reliability. The key outcomes and learnings from the project:

- **Enhanced Automation and Control**:

  The use of PLCs enabled precise control over the batch processing operations. This automation reduced human error, increased accuracy, and ensured consistency in the production process.
- **Scalability and Flexibility:**

  The PLC system designed with WPL can be easily scaled to accommodate different batch sizes and types of products. Its flexibility allows for modifications and updates without significant downtime or cost, making it adaptable to various industrial applications.
- **Improved Efficiency and Productivity:**

  Automation through PLCs significantly improved the efficiency of the batch processing system. The streamlined processes reduced cycle times, minimized wastage, and optimized resource utilization, leading to enhanced productivity.
- **Data Collection and Monitoring**:

  The PLC system facilitated real-time data collection and monitoring. This capability allows for better process oversight, immediate troubleshooting, and continuous improvement based on data-driven insights.

- **Safety and Reliability**:

  Implementing PLCs improved the safety and reliability of the batch processing system. The built-in safety features and robust design of PLCs minimize the risk of accidents and ensure stable operation even in demanding industrial environments.
- **Skills Development**:

  The project provided an excellent opportunity for team members to develop and enhance their skills in PLC programming, specifically using WPL. The hands-on experience with designing and implementing the system enriched our understanding of industrial automation.

7. FUTURE SCOPE

Batch processing using PLC (Programmable Logic Controllers) has a significant future scope across various industries due to the increasing demand for automation, efficiency, and precision in manufacturing and production processes. Here are some key areas where batch processing using PLC is expected to have a substantial impact:

- **Industry 4.0 and Smart Manufacturing**
  Integration with IOT: PLCs can be integrated with IOT devices to collect and analyze data in real-time, leading to more intelligent and adaptive manufacturing systems.
  Predictive Maintenance: Advanced data analytics can predict equipment failures before they occur, reducing downtime and maintenance costs.
- **Pharmaceuticals and Biotechnology**
  Precise Control: Batch processing in pharmaceuticals requires precise control of various parameters (temperature, pH, mixing speeds), which PLCs can manage effectively.
  Regulatory Compliance: PLCs can help ensure that production processes comply with stringent regulatory standards by maintaining accurate records and ensuring consistent batch quality.
- **Automotive and Aerospace**
  Complex Assembly Processes: Batch processing using PLCs can manage complex assembly lines with high precision, ensuring high-quality outputs.
  Customization and Flexibility: Enables customized manufacturing processes to meet specific client requirements without significant downtime
- **Advanced Manufacturing Techniques**
  Additive Manufacturing: PLCs can control additive manufacturing processes such as 3D printing, ensuring precision in layer deposition and material handling.
  Robotics Integration: Seamless integration of PLCs with robotic systems for tasks requiring high precision and repeatability.

Future Trends and Technologies

- **Artificial Intelligence and Machine Learning**: Combining AI and ML with PLCs to predict and optimize batch processes dynamically.
- **Cybersecurity**: Enhancing the security of PLC systems against cyber threats as they become more connected in industrial networks.
- **Cloud Computing**: Leveraging cloud platforms for data storage, processing, and remote control of PLC systems.

The future scope for batch processing using PLCs is vast and promising, driven by advancements in technology and the growing need for efficient, automated, and precise manufacturing processes across various industries. The integration of emerging technologies will further enhance the capabilities and applications of PLC-based batch processing systems.

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