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PLC Based Automated Mixing System in a Tank

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Abstract: *Liquid mixing processes are automated in modern industrial applications for bett r productivity and consistency. The project here is a PLC-based automated mixing system to mix two different liquids within a tank efficiently. Various components such as level sensors, solenoid valves, and an agitator motor are integrated into the system and controlled through a PLC programmed with ladder logic.*
The Delta PLC model DVP14SS211R is an 8-input, 6-output controller used in many industrial automation applications. It works on a 24VDC power supply. This controller is programmed using WPL Soft software. Using the WPL Soft, one can easily design and develop ladder logic diagrams efficiently. On activation, the two liquids are filled into the tank in sequence by opening appropriate inlet valves based on feedback from level sensors. At the required levels, an agitator motor is actuated to mix the liquid for a specified time after which the mixed product will be drained out of the tank through an outlet valve. Other safety features in the form of low-level detection are added to make the operation complete.
This automated mixing system minimizes human intervention, enhances process accuracy, and reduces operational errors. It is an excellent solution for industries with liquid mixture requirements. This project will thus demonstrate the effectiveness of PLC technology in the streamlining of industrial processes and how this c n optimize overall efficiency in handling liquids.

Keywords*:* PLC, Industrial Process Automation, Agitator Motor, Timing Control, Solenoid Valve Control

I. INTRODUCTION

PLC-Based Automated Mixing System in a Tank automates the mixing of two different liquids from separate tanks, using controlled actions to ensure an efficient and accurate mixing process. The Delta PLC model DVP14SS211R uses a 24V DC power supply to operate. The operation in filling, mixing, as well as draining stages is carried out fully automatically, very ideal for applications that do need to have precise liquid handling efficiency such as manufacture chemical and food processing. The PLC model can be programmed through the use of WPL Soft thus offering efficient design and the development of ladder logic diagrams.

The system begins by filling the tank through solenoid valves, which regulate each liquid's flow. The PLC then activates the mixing motor to mix the liquids comprehensively for a given period of time. Mixing is carried out with great precision. Customization of the time allows mixing to be done properly for different operati nal needs, ensuring that the mixture is always consistent. The entire process is monitored by confirming the presence of liquids and the completion of mixing, making it safer and more efficient with the PLC.

Once mixing has been done, the PLC will then trigger the outlet valve of the tank to drain. This, in turn, exhibits the flexibility and impact of PLCs in controlling complicated systems requiring precise timing, coordination, and adaptability. This project shows the contribution of automation in industrial setup as it demonstrates how PLC like Delta DVP14SS211R improves consistency, reliability, and control in liquid mixing and handling applications in industrial fields.

PROBLEM STATEMENT

In many industrial processes such as chemical processing, food and beverage production, pharmaceuticals, and water treatment, liquid mixing is a critical operation. Conventional mixing systems are often operated manually, which can lead to inconsistent mixing quality, human error, excessive manpower requirement, and reduced process efficiency. Manual control also makes it difficult to maintain precise timing, accurate level control, and repeatability of the mixing process.

II. LITERATURE REVIEW

Panchal explored a PLC-based system that controls conveyor, mixing, and filling sections, enabling accurate liquid mixing proportions while minimizing waste. This system, controlled by a Delta PLC, offers higher production speeds and reduced operational costs relative to manual processes.

Baladhandabany developed a PLC-based system that can handle multiple containers simultaneously. The user can set specific volume levels, and the PLC manages input scanning and control without requiring an external pump, reducing human intervention

Kulkarni and Elango integrated a PLC for monitoring parameters such as liquid level and flow. The combination of PLC and SCADA provided superior monitoring and error reduction by enabling start-stop control through SCADA. Biswa implemented a high-speed colour-mixing process, utilizing SCADA and PLC ladder logic for error reduction and precise mixing. Their system supports flexible mixing for different liquids, achieving operational efficiency through timers that control the mixing cycles.

III. METHODOLOGY

Requirement Analysis

Identify process requirements such as mixing sequence, liquid levels, mixing time, and automation needs.

System Design

Select PLC, sensors, valves, mixer motor, and define the control sequence and safety interlocks.

I/O Mapping

Assign PLC input and output addresses for sensors, switches, valves, and motor.

PLC Programming

Develop ladder logic to control filling, mixing, and discharge using timers and interlocks.

Simulation and Testing

Simulate the program and test all operating conditions for correct sequencing and safety.

Hardware Implementation

Connect field devices to PLC, download the program, and perform I/O checks.

Commissioning and Evaluation

Run the system, adjust parameters, and verify performance and reliability.

IV. WORKING

WORKING PRINCIPLE

As soon as the system is energized, the Low-Level Sensor (LLS) located near the bottom of the tank confirms the required minimum level. If the tank is empty, the PLC will open the Inlet Valve for Material A and its flow into the tank continues until a preset level is reached by the Material A Level Sensor. This sensor is mounted at the particular height where the level of Material A is needed, which sends a signal to the PLC to close the inlet valve when the target level has been reached. At the desired level, the PLC opens the Inlet Valve for Material B. This comes into the tank and mixes with Material A. This continues until the High-Level Sensor determines that the tank has reached full level. The PLC closes the Inlet Valve for Material B to prevent overflow. This high-level sensor, therefore, indicates that the tank is ready for the mixing stage, where two materials have been accurately measured and placed within the tank.

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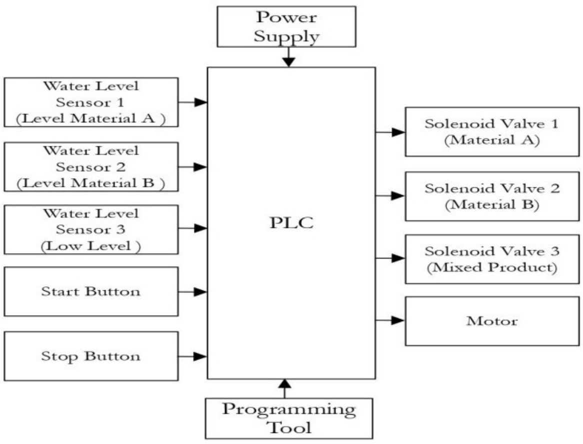
The agitator motor is energized at this stage. Above the tank, this motor drives a shaft into the tank where the two materials are stirred up to give a uniform mixture. The mixing period is controlled by an ON timer set in the PLC. A typical mixing time cycle set is 20 seconds. This ensures uniformity in the final product, since all materials have been well mixed. Once this period has elapsed, the agitator motor will cut off automatically, thus putting a stop to the mixing stage.

After the mixing, the PLC opens the outlet valve for the discharge of mixed solution from the tank. This outlet valve is open and allows the mixture to come out until the low-level sensor detects the fact that the tank is empty. When the low-level sensor gets activated, it signals to the PLC to close the outlet valve, and that will be the end.

During this cycle, relay modules in the PLC permit a precise control of every single process element through feedback of the sensor. The PLC is always running; its task is to monitor input from the sensor according to each stage process, with the procedure being followed along the sequence. The third component of the control panel consists of a Stop Push Button override-this is the point that instantly stops the system for specific requirements on safety and controls.

BLOCK DIAGRAM



COMPONENTS USED

- PLC (Delta DVP 14SS2R)
- XKCY26NPN
- Liquid level Sensor
- Agitator Motor
- Solenoid valve
- Relay module

COMPONENTS DESCRIPTION

Delta PLC (Model No: DVP14SS211R)

The DVP-S series of Delta PLCs offer a wide variety of hardware configurations, communication, power and computing capabilities to meet the most diverse needs in industrial automation. Whether the automation project is large or small, the DVPS Series PLCs are the right choice at the right price.

Water Level Sensor (Model No: XKC Y26 NPN)

The non-contact liquid level sensor is applicable to non-metallic containers without direct contact with the liquid, not affected by scale or other impurities. It can detect liquid levels of various toxic substances, acid, alkali, and all kinds of liquid in high pressure airtight containers. It can penetrate and detect the liquid water level in various non-metallic containers and pipelines, such as plastic, glass, ceramic and other containers.

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Agitator Motor

Agitators are equipment that induces flow and shear to a fluid or material, which causes the fluid to homogenize. Mixers are used to blend two or more components rapidly. Agitators ensure homogeneity and equilibrium in an existing mixture.

Solenoid Valve

A solenoid valve is an electrically controlled valve used to allow or prevent the flow of media through it. A solenoid valve works by having a plunger move up and down based on the magnetic field generated from the electrical solenoid. The plunger either opens or closes the orifice that the media flows through. Since they electrically controlled, they can be controlled remotely and automatically. They are commonly found in water treatment, automative, food processing, and many other industrial applications.

Relay Module

Relay modules are widely used in automation systems, industrial machinery, automotive electronics, and home automation. They provide a convenient and efficient way to control devices like motors, lights, and appliances from low-power control signals generated by microcontrollers or other digital systems.

The primary function of a relay module is to switch electrical devices or systems on and off. It also serves to isolate control circuits, ensuring that low-power devices, such as microcontrollers, can safely control higher voltages and currents

ADVANTAGES

- Automation and Precision: Ensures accurate mixing ratios and timing, improving product quality and consistency.
- Real-Time Monitoring and Control: PLCs allow real-time feedback and control over mixing speed, temperature, flow rate, etc.
- Reduced Human Error: Minimizes manual intervention, decreasing errors and safety risks.
- Flexibility and Programmability: Easily reprogrammed for different mixing recipes or process changes.
- Improved Safety: Integrated safety interlocks and alarms protect operators and equipment

LIMITATIONS

System performance depends heavily on accurate level sensors; sensor failure can affect operation. PLC hardware, sensors, and control components increase the initial setup cost.System operation stops during power failure unless backup power is provided.

V. CONCLUSION

The PLC-Based Automated Mixing System successfully demonstrated the advantages of automation in achieving accurate, consistent, and efficient mixing processes. It was possible to operate the system without interruption from material intake to discharge, with minimal manual intervention, due to the integration of a PLC with sensors, an agitator motor, and control valves. Material measurements and dispensation accuracy was ensured through level sensors. Also, a timer was in place for agitator motor to ensure perfect mix of every batch in all the reactors.

The live sight through the transparent acrylic tank enhances control in this project. The PLC and relay system ensures that the system responds promptly to sensor inputs both accurately and swiftly and assures a smooth workflow with safe operation. In addition, the system proved to be user-friendly, as it provided easy controls on the panel for start and stop operations and had an easy maintenance layout.

FUTURE SCOPE

Future enhancements for the PLC-Based Automated Mixing System focus on improving control, p ecision, and user interaction. SCADA integration would enable remote monitoring, real-time data visualization, alarms, and analytics, boosting system reliability and efficient resource management. Incorporating an HMI (Human-Machine Interface) display would enhance usability by providing clear visuals of material levels, valve statuses, and mixing times, making it easy for operators to adjust parameters directly.

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