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Design and Development of PLC Based Chemical Mixing Plant

Nishchitha M H[1]
Department of Mechatronics
Acharya Institute of Technology
Bangalore, India

Darshan R Anvekar[2]
Department of Mechatronics
Acharya Institute of Technology
Bangalore, India.

Charukesh P N[3]
Department of Mechatronics
Acharya Institute of Technology
Bangalore, India.

Lavanya R[4]
Department of Mechatronics
Acharya Institute of Technology
Bangalore, India

Amit G Hegde[5]
Department of Mechatronics
Acharya Institute of Technology
Bangalore, India

Abstract:- This paper introduces an efficient solution for integrating a Programmable Logic Controller (PLC) into chemical industry processes, emphasizing precise mixing of three solutions. Leveraging conventional PLC components and ladder logic, the project employs digital inputs through push buttons to control relay-based outputs. Accurate filling ratios are achieved using a combination of time-based sequencing and user input. Code transmission challenges are addressed with a data integrity buffer and CH 340 drivers. Timing control utilizes the PLC's onboard timer (TON), while open PLC software and Atmel microcontroller libraries ensure smooth operation. This concise project offers a streamlined approach for PLC integration, optimizing chemical industry applications

Keywords:- *Automation, PLC Integration, Chemical Industry, Precision Control, Modularity in Design, Time-Based Proportional Filling, Industrial Efficiency, Continuous Improvement in Automation.*

I. INTRODUCTION

Automation, a concept rooted in the Greek term 'self-dedicated,' is the key to modernization. It is profoundly understood as a pathway to enhance efficiency and boost productivity. The essence of automation lies in having machines follows predetermined sequences of operations, minimizing human labor. This involves employing specialized equipment and devices to control and execute manufacturing processes. Explore the transformative force of automation, unlocking new possibilities for efficiency and productivity in various industries.

In the contemporary landscape of industrial processes, the integration of advanced automation technologies plays a pivotal role in optimizing operational workflows. This project embarks on the incorporation of a Programmable Logic Controller (PLC) into real-time applications, specifically addressing the complexities of chemical industry processes. The focal point of the endeavor is the precise mixing of three solutions, a critical task with wide-ranging applications, including the production of paints and pharmaceuticals.

The project unfolds with the initial phase of 3D design, providing a comprehensive visual representation of the system. Subsequently, conventional PLC functionalities such as basic gates, timers, and counters are harnessed, forming the backbone of the automation logic. Digital inputs are managed through push buttons, triggering relay-based digital outputs that control various aspects of the chemical mixing process.

The industrial application under consideration involves meticulous control over the proportionate filling of three tanks, each equipped with dedicated pumps. The unique aspect lies in the utilization of time- based control, where the pumping duration is determined by user input and specific ratios. This approach draws parallels with industries requiring precision, such as paint and pharmaceutical production.

The ladder logic developed for the PLC is translated into a Python script, and the ensuing challenges in serial transmission at a baud rate of 9600 are addressed by incorporating buffers in the program. Additionally, the integration of CH 340 drivers facilitates the smooth transmission of binary code to the microcontroller.

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Timing precision, a critical aspect in chemical processes, is achieved through the onboard timer of the PLC, specifically utilizing the TON (Timer On-Delay) functionality. The project leverages the Open PLC software, benefiting from standard libraries tailored for Atmel Microcontrollers, ensuring a seamless and efficient operation of the automated system.

In essence, this project not only demonstrates a comprehensive integration of hardware and software elements but also underscores the meticulous approach in addressing challenges inherent in real-world industrial automation. The subsequent sections delve into the specific methodologies employed, challenges encountered, and the successful solutions implemented to achieve the project's overarching objectives.

II. LITERATURE SURVEY

- Nikitha nadgauda [1]described that increase in competition and consumer expectations worldwide, the need for smarter, faster and more powerful technologies has been on the rise. The recent shift towards the utilization of automated systems has necessitated newer and more advanced technologies that can improve efficiency, accuracy and flexibility of processes in the industrial
- environment. Implementation has been carried using Programmable Logic Controller (PLC) – SCADA systems which provides durability, flexibility and ease of programming.
- Dr Csilla Farkas[2] says that since the operators are skilled professionals the protection of programmable logic controllers (PLC's) have not been sufficiently addressed.
- Priyam Parikh[3] gives an in-depth introduction of making programmable logic controllers (PLCs) using the base of Arduino as a prototyping board.
- Muhammad Chattal ,Hina Madiha with all proposes an industrial automation system using FATEK PLC, LabVIEW, and the internet. Their focus on cost-effective automation for mixing limestone powder and hot water aims to reduce risks and accidents. The system ensures controlled water levels and temperatures, providing a safer alternative to manual processes.

III. PROPOSED DESIGN

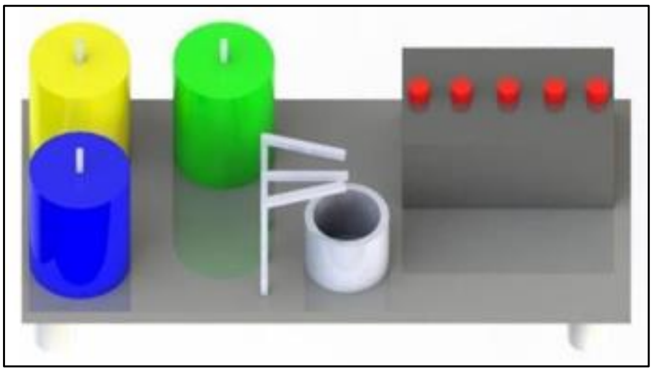

Fig 1 Mixing plant

Our proposed design for the integration of a Programmable Logic Controller (PLC) into the chemical mixing process aims to enhance precision and reliability, crucial aspects in the industrial setting. The system architecture is designed with modularity and scalability in mind, allowing for easy adaptation to diverse chemical mixing requirements. By employing basic gates, timers, counters, and specialized function blocks, the PLC serves as the central control unit, orchestrating the intricate chemical mixing operations.

Digital input commands are facilitated through user-friendly push buttons, offering an intuitive interface for operators. The corresponding digital output, controlled by relays, ensures a responsive and accurate execution of the mixing process. Our design specifically addresses the needs of the chemical industry by emphasizing the mixing of three solutions in predefined proportions. This involves strategically placing three containers, each housing a distinct solution, on a plank within the system.

Fluid transfer is accomplished through peristaltic pumps, providing a controlled and precise method for drawing solutions from the containers. The quantity of the mixture drawn by the pump is intricately determined by the PLC ladder logic program. This ladder logic is developed to enable time-based proportional filling, where each tank, equipped with an individual pump, is activated based on user-defined proportions selected via push buttons on the input modules.

The integration of code conversion is a critical aspect of our proposed design. The ladder logic is translated into Python script and hex code, allowing for seamless execution. Challenges encountered during serial transmission at a baud rate of 9600 are adeptly addressed through buffer additions, ensuring the smooth flow of binary code transmission to the microcontroller. Timing precision, fundamental for the mixing process, is achieved through the PLC's onboard TON timer. This timer ensures accurate control over the output relay, maintaining synchronization within the system.

A key element of our design lies in the integration of open PLC software, leveraging standard libraries dedicated to Atmel microcontrollers. This integration significantly enhances the stability and responsiveness of the system. In summary, our proposed design offers a comprehensive solution to optimize chemical mixing processes in the industrial domain. Through precise control, efficient automation, and adaptability, our design stands as a robust solution for enhancing chemical mixing operations.

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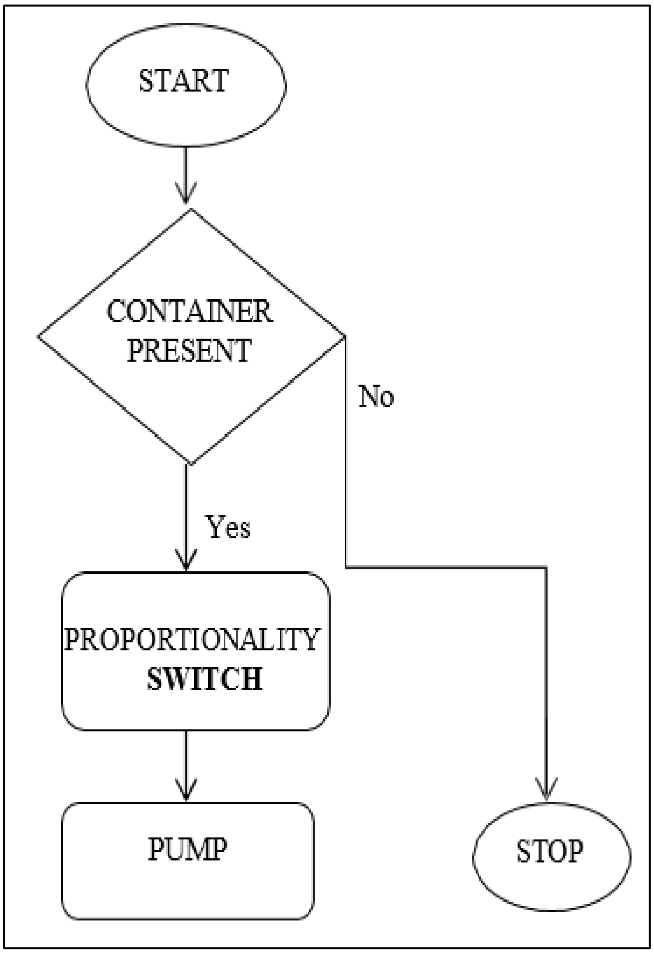

Fig 2 Working Flow Chart

The figure 2 shows the flow of execution,Upon confirming the presence of the mixing jar, the systemactivates a proportionality switch, a mechanism tasked with regulating the ratio of different chemicals or liquids to be pumped into the mixing container. This step signifies the system's readiness to initiate the mixing process in accordance with the predefined proportions established by the proportionality switch.

Conversely, if the IR sensor fails to detect the mixing jar, the system enters a halted state. In this state, all operations come to a standstill, ensuring that the mixing process is only initiated when the necessary mixing jar is present. This deliberate pause in operation acts as a safety measure, preventing unintended actions in the absence of the requisite mixing container.

IV. IMPLEMENTATION

➢ *Hardware Setup*

PLC Installation: Begin by installing the Programmable Logic Controller (PLC) in the designated control panel. Ensure proper power supply and connections.

Input Modules and Push Buttons: Connect the input modules to the PLC, and wire the user-friendly push buttons for selecting proportions. Ensure a secure and reliable connection to the PLC's digital input ports.

Output Modules and Relays: Connect the output modules to the PLC and wire the relays. The relays control the peristaltic pumps responsible for fluid transfer. Verify proper connections to the digital output ports.

Containers and Plank Setup: Arrange the three containers on the plank according to the system design. Ensure each container contains the designated solution and is equipped with a peristaltic pump.

Peristaltic Pumps: Connect the peristaltic pumps to the corresponding relays. Verify the connections to ensure accurate and controlled fluid transfer from the containers.

➢ *Software Development and PLC Programming Ladder Logic Programming:*

Develop and download the ladder logic program into the PLC. Ensure the program incorporates time-based proportional filling logic, user input handling through push buttons, and proper control over the peristaltic pumps.Code Conversion and Transmission: Translate the ladder logic into Python script and hex code. Implement buffers in the program to address challenges in serial transmission at a baud rate of 9600. Verify the smooth transmission of binary code to the microcontroller. Onboard Timer (TON) Configuration: Configure the onboard TON timer of the PLC to achieve precise timing control. This timer should synchronize the activation and deactivation of the peristaltic pumps according to the specified proportions.

V. RESULT

The implementation of the PLC-based chemical mixing plant, as outlined in the design and development process, yields a reliable and efficient system for precision mixing of three solutions in the chemical industry. The system showcases precise control over the proportionate filling of three tanks through the integration of time-based proportional filling logic and user-friendly push buttons, ensuring accurate mixing ratios based on user input. Controlled fluid transfer from containers to the mixing area is facilitated by peristaltic pumps, while the onboard TON timer of the PLC ensures timing precision for synchronized pump activation and deactivation. Challenges in code transmission are effectively addressed with buffer additions and CH 340 drivers, resulting in smooth binary code transmission to the microcontroller. The integration of open PLC software and Atmel microcontroller libraries enhances system stability and responsiveness during regular production runs. Comprehensive documentation and training materials support maintenance and operation, while continuous improvement processes ensure adaptability to diverse chemical mixing requirements. In essence, this implementation signifies a significant advancement in leveraging automation for optimizing industrial chemical mixing processes, promoting increased efficiency and safety. Regular monitoring and continuous improvement efforts contribute to the sustained success of the system.

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The design and development of the plc-based chemical mixing plant present a comprehensive solution for enhancing precision and efficiency in the chemical industry. by incorporating advanced automation technologies, specifically the programmable logic controller, the system achieves precise control over the mixing of three solutions, a critical process with broad applications.

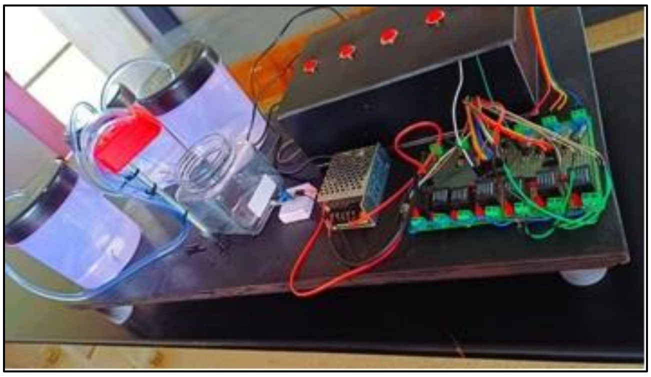

Fig 3 Our Prototype

The implemented design, featuring modularity and scalability, offers adaptability to various chemical mixing requirements. The integration of basic gates, timers, counters, and specialized function blocks in the ladder logic programming, along with user-friendly interfaces and peristaltic pumps, ensures a reliable and accurate mixing process. Challenges related to code transmission at a baud rate of 9600 are effectively addressed through buffer additions and the incorporation of CH 340 drivers, contributing to the overall robustness of the system.

VI. CONCLUSION

In conclusion, this project provides an effective, streamlined method for integrating a PLC into chemical processes, with a particular focus on achieving accurate, time-controlled mixing of solutions. Through the use of ladder logic, relay-based controls, and user-defined time sequencing, this approach ensures precise filling ratios. Challenges related to code transmission and timing control were effectively addressed using data integrity buffers, CH 340 drivers, and the PLC's onboard timer. The use of open-source software and Atmel microcontroller libraries further enhances compatibility and ease of implementation. This solution offers a practical, reliable framework for optimizing chemical process automation, with potential applications across various industry settings.

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