IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

PLC BASED MATERIAL TRANSFER OPERATION IN INDUSTRIAL APPLICATIONS

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Abstract: In current days notable improvements in the industrial environment have been made in short time, and there is an increasing need for effectual material transfer approach. Flexibility, precision, and quickness were problems with traditional practice. This calls for the investigation of novel remedies to solve these constraints. The ethicalness of using a PLC-based material transfer system, proposes to close the gap between current trends in the technology and the varying needs of the industrial field. PLC-based hardware design and implementation transfer system that improves accuracy and efficiency in industrial applications is the main purpose. To do this, had created an in-depth problem description that details the shortcomings of existing material transfer techniques and emphasises the demand for automation. Our perspective involves integration logic controller (PLC), providing real-time monitoring and control, into the material transfer plan of actions. Data and samples from industrial facilities have been used to authenticate the successfulness of this perspective. The observed results show remarkable furtherance in material transfer activities, including a considerable reduction in the transfer amount times and a remarkable increase exactly. The two big numbers represent a 30% decrease in transfer time and a 15% reduction in error rate. The interpretation of these results stands out the role of PLCs in streamlining material transport as well as their potential for future application. PLC-based systems help improve the industrial material transfer and adding more chances to increase production and effectiveness.

Keywords – PLC-based. Material Transfer, Industrial Application, Automation, Efficiency, Precision

I. INTRODUCTION

In recent industrial implementation require the efficient and dependable flow of materials make sure productive production processes and greatest possible resource utilization. One of the main technologies that has revolutionized material transfer processes in industrial settings is the Programmable Logic Controller (PLC). PLCs have developed into the core of automation systems because they allow accurate and automated control over material transfer activities. [1]. Specialized computers called PLCs are employed in industrial settings to monitor and control a variety of machinery and operations. Due to its ability to handle sophisticated logic, work with several sensors and actuators, and complete tasks in real-time, it is ideal for controlling material transfer activities. Material transfer refers to the movement of supplies between different locations in an industrial facility, including raw materials, intermediate goods, and finished goods. Items may need to be moved from one conveyor to another, cargo must be loaded and unloaded from trucks or ships, storage facility inventories must be kept current, and material flow through pipelines and valves must be managed. [2]. PLC-based material transfer processes have revolutionized industrial applications because they provide precise, automated, and effective control over material movements. Its ability to adapt, monitor, and optimize activities in industrial settings has significantly increased productivity, increased safety, and reduced operational costs. As technology advances, PLCs will remain crucial in deciding how material transfer processes in industrial applications change. [3]. In many industrial applications, effective material movement is a crucial need that greatly boosts production and reduces costs. The incorporation of Programmable Logic Controllers (PLCs) has recently come to light as a potential strategy for streamlining and improving material transfer operations in industrial settings. This study investigates the usage of PLCs in material transfer applications by delving into recent literature, with a primary focus on the last five years [4]. Despite their extensive use, there are still problems that need to be rectified. For instance, "smart" devices that can perform fundamental control functions by making decisions independently of a central CPU are required by control system architectures Examining these challenges and learning how PLCs may be successfully employed for material transfer activities in industrial settings are the main objectives of this work [5]. Process control and industrial automation require PLCs. They connect with one another via developing protocols and manage a variety of analogue and digital sensors, actuators, and interfaces. PLCs may automate a variety of industrial processes, including the assembly line at a factory, the ore processing plant, and the wastewater treatment plant. They act as the real physical connections between a SCADA or HMI system and the machinery on the factory or plant floor.

II. FLOW DIAGRAM OF PLC BASED MATERIAL TRANSFER

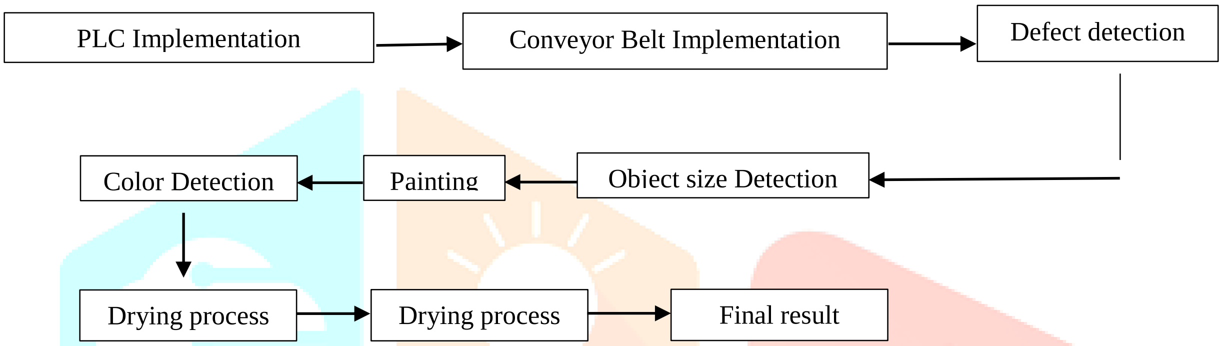

Fig. 1: Flow diagram of the proposed PLC based material transfer

The detailed schematic representation of the proposed material transfer operation using PLC system in industrial applications in Figure 1 [8]. The proposed material transfer operation, which has a advantages of reducing man work increasing the efficiency of the industry it mainly reduces the errors made by the humans and fasters the production of the industry

III. PROPOSED METHODOLOGY

A. Objective:

The intension of the project "PLC based material transfer operation in industrial application" is to outline, execute, and enhance a reliable and efficient material transfer system using Programmable Logic Controllers (PLCs) in an industrial setting. This project aims to achieve the following specific goals, Automation, Safety Enhancement, Efficiency Improvement, Scalability, Remote Monitoring and Control, Integration with Existing Systems, Cost-Benefit Analysis

B. Advantages of ladder logic programming in material transfer application:

PLCs' capacity to carry out repeatable, exact control sequences ensures accurate placement and timing throughout material transfer processes. With this level of precision, waste is reduced, product quality is increased, and resource use is maximized. [8]. Flexibility and Adaptability: PLC programs may be swiftly changed and modified to changing production demands because they are so versatile. In dynamic industrial environments where processes and output requirements alter over time, this adaptability is crucial. [7]. Greater Efficiency: Automating material transfer procedures with PLCs makes them simpler, requiring less manual labor and downtime. As a result, productivity and overall effectiveness both Significantly rises [5].

C.Applications of PLC in Material Transfer Function:

Conveyor Systems: Conveyor belts are typically managed by PLCs in industrial buildings, distribution centres, and warehouses. They manage the start, stop, pace, and direction of the conveyors, allowing for smooth and effective material flow [6]. Bulk Material Handling: PLCs are used in bulk material handling systems in industries like mining and agriculture. They run the equipment that moves enormous quantities of goods, including hoppers, conveyor belts, and other devices [7].

D. Advantages of HMI with PLC in Material Transfer Function:

A "human machine interface," or HMI, is a user interface that allows a human operator to interact with a machine or process. HMI is frequently used in industrial settings to enable operators to monitor and manage activities, such as those in a factory or power plant. An HMI is frequently attached to a programmable logic controller (PLC), which controls the process using data from the HMI and field sensors. Only information and commands can be entered by the operator using the HMI; these commands are then sent to the PLC for execution. Some advantages of combining HMI and PLC for material transfer operations include the following: Alarms/Warnings: When a process goes wrong, HMI can give the operator alarms and warnings. Reliable Messaging: The operator can receive correct information about the status of the process through the HMI. Easier Overall Plant Management: HMI can make it easier for the operator to run the complete plant by providing a user-friendly graphical interface.

E. Scope of the project:

Despite their extensive use, there are still problems that need to be rectified. For instance, "smart" devices that can perform fundamental control functions by making decisions independently of a central CPU are required by control system architectures. Examining these challenges and learning how PLCs may be successfully employed for material transfer activities in industrial settings are the main objectives of this work. The objective of this study is to give a comprehensive understanding of PLC-based material transfer functions, including their advantages and potential growth areas. It will also explain how these systems could be improved for greater efficacy and efficiency. System analysis and design: identifying the requirements for material transfer and assessing the present manual or only partially automated processes. enhancing material handling by developing a trustworthy, efficient automated system. PLC programming is the process of creating PLC programmes that define the logic and behaviour of the material transfer operation. In order to do this, programming languages compatible with the specific PLC model, such as ladder logic, must be developed. Sensor Integration: Tracking the movement of items during the transfer process by integrating a variety of sensors, such as proximity sensors, sample detection sensors, conveyor belt controllers, and objects-in-motion monitors. Safety Measures: Putting in place safety procedures to ensure the safe transportation of goods, such as emergency stop buttons, safety interlocks, and motion detection to avoid crashes. Human-Machine Interface (HMI): Developing an HMI that provides users with an easy way to show alarms, adjust system settings, and control the material transfer procedure. Automation and Efficiency: PLCs are often used in industrial automation because of their ability to accurately and quickly control complicated operations. By decreasing manual intervention and the likelihood of human error, using a PLC-based material transfer programme can increase transfer efficiency. Cost-effectiveness: Using PLCs to automate material transfer processes is a good way to cut costs. Once set up, the system can function with little help from people, reducing labour costs and increasing resource efficiency. Integration with Existing Systems: PLC-based control systems are now utilised for a variety of objectives across a wide range of industries. Studying PLC-based material transfer solutions can help integrate material handling with existing systems, resulting in a smooth and well-coordinated industrial operation. Real-time monitoring and control of material transfer parameters, such as speed, position, and amount, are made possible by PLCs. Operators can then discover bottlenecks, maximise transfer process efficiency, and make data-driven decisions.

F. Working methodology:

The siemens s7-1200 trainer kit is added to the small-scale industrial equipment's to improve the material transfer operation the industry. The first application is based on the conveyor belt application the conveyor belt is connected to the defect detection system. The product produced from the initial step gets moved through conveyor belt to defect detection process. In the defect detection process the size of the material produced is measured if there any abnormalities observed the material is moved to another conveyor belt for the recycling process the dimension of the material is observed by the Infrared sensors consider if the object length is about 15 to 20 centimeter the infrared sensor are placed accordingly to the size of the object, if the length of the object more or less than the normal size the object is rejected to go into the next process it is moved to the recycling step. If the object crossed the first defect detection step, then it's moved to Second step coloring, after coloring the object is moved to the color detection step if the color of the product miss matches with the requirement color the object is moved to the paint stripper process which removes the paint in the object and the object is move to the painting process this process continues until the product matches with the required color. In the coloring process the color of the product is identified by using photo electric sensors which is used to detect the color of the object. After the completion of the coloring process, the material is moved to the drying step in this step the object is placed for some time in the drying machine in that the colored paint gets dried and the object is moved to next process. The temperature of the drying machine is monitored by Resistant Temperature Detection sensor it can withstand up to -200 degree Celsius to 600 degrees Celsius. If the temperature of the drying machine varies by using Resistant Temperature Detection sensor can able to identify the variation and can able to rectify it. The objects are placed in the dryer for a particular time and it is measured by Timer components in the Siemens PLC. The next process is packaging. The dried products are moved to the packaging area. In packaging area by using counters the products are moved to different packaging sections, the counters are implemented in the process by the help of proximity sensor. If the proximity sensor detects the object. Counter gets increased to one. By the way material transfer function using PLC system works. In these steps the main component emergency switch is placed in all steps if there is any emergency the total process gets stopped by pressing the emergency stop button.

G. Proposed work modules:

System Design and Requirements Analysis:

Define the detailed system requirements based on industrial application needs. Develop a comprehensive system architecture and block diagrams. Conduct stakeholder interviews to gather specific requirements for material transfer, safety, and automation. Create a detailed system requirements document, including performance specifications and safety criteria. Develop a system architecture design, outlining the hardware and software components, their interconnections, and communication protocols.

Hardware Procurement and Installation:

Procure and install the necessary hardware components for the PLC-based material transfer system. Prepare a procurement plan and select vendors for PLCs, sensors, actuators, safety devices, and communication equipment. Procure the hardware components according to the plan and ensure compatibility. Install and configure hardware components, following manufacturer's guidelines and safety standards.

PLC Programming and Control Logic Development:

Develop PLC programs to control material transfer, implement safety features, and handle error conditions. Choose the appropriate PLC programming language (e.g., ladder logic, structured text). Develop control logic for material handling, including conveyor control, material routing, and motion control. Implement safety interlocks, emergency stop procedures, and fault detection routines. Create error handling and recovery mechanisms to minimize downtime.

HMI and SCADA Development:

Design and implement a user-friendly Human-Machine Interface (HMI) or Supervisory Control and Data Acquisition (SCADA) system. Design the HMI/SCADA interface with a focus on user-friendly navigation and real-time data visualization. Develop screens and dashboards for monitoring material transfer status, safety alerts, and system diagnostics. Enable remote access and control capabilities through secure network connections.

Testing and Simulation:

Validate the functionality and safety of the PLC-based material transfer system through rigorous testing and simulation. Perform functional testing to ensure all system components operate as intended. Conduct safety testing, including emergency stop tests and collision avoidance simulations. Simulate various error scenarios to test the system's fault tolerance and recovery capabilities.

Integration with Existing System:

Integrate the PLC-based material transfer system with existing industrial automation systems, if applicable. Identify integration points with other automation systems or Manufacturing Execution Systems (MES). Implement communication protocols and data exchange mechanisms to ensure seamless interoperability.

Training and Documentation:

Ensure that personnel are trained to operate and maintain the system safely and effectively. Develop comprehensive operation manuals and maintenance guides for the PLC system. Provide training sessions to operators and maintenance staff on system operation, troubleshooting, and safety procedures.

Deployment and Optimization:

Deploy the PLC-based material transfer system in the industrial environment and optimize it for efficiency. Install the system in the designated industrial setting, ensuring all components are properly calibrated and aligned. Continuously monitor system performance and optimize material transfer operations to minimize cycle times and energy consumption.

Safety Compliance and Quality Assurance:

Ensure that the system complies with safety standards and meets quality assurance criteria. Verify compliance with relevant safety standards and regulations, such as ISO 13849 or SIL. Conduct quality assurance checks to ensure that material transfer operations meet predefined quality standards.

Project Evaluation and Reporting:

Evaluate the success of the project based on predefined objectives and generate regular reports on system performance. Evaluate the achievement of project objectives, including automation efficiency, safety enhancements, error reduction, and energy savings. Generate periodic reports summarizing system performance, safety incidents, and energy consumption for management and compliance purposes.

Maintenance and Support:

Establishing a maintenance schedule and provide ongoing support to address system issues and changing requirements. Develop a proactive maintenance schedule to ensure system reliability. Provide ongoing support to address any issues or modifications required during the system's operational life.

Scalability and Future Enhancements:

Plan for scalability and identify opportunities for future enhancements. Design the system to accommodate future expansions or the addition of new material transfer units. Continuously assess opportunities for system enhancements, efficiency improvements, and technological advancements.

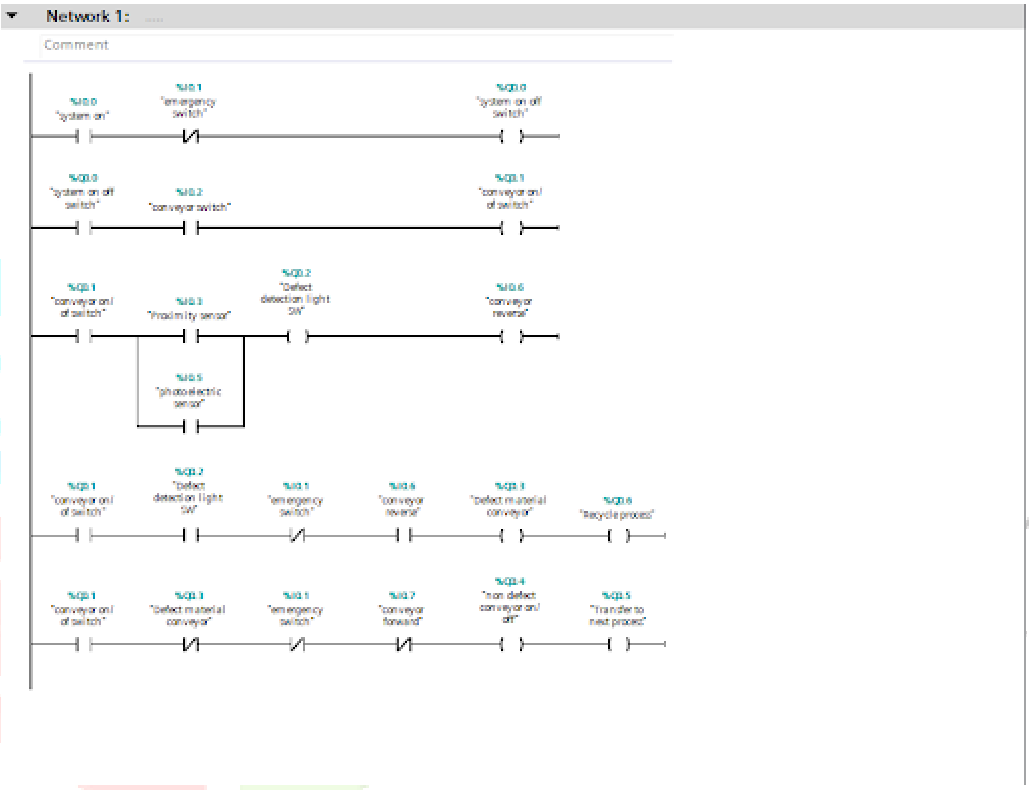

Fig. 4: Plc Ladder logic used for material transfer function

Tags | User constants | System constants

PLC tags

	Name	Tag table	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
1	system on	Default tag table	Bool	%I0.0	☐	☑	☑	☑	
2	emergency switch	Default tag table	Bool	%I0.1	☐	☑	☑	☑	
3	system on off switch	Default tag table	Bool	%Q0.0	☐	☑	☑	☑	
4	conveyor switch	Default tag table	Bool	%I0.2	☐	☑	☑	☑	
5	conveyor on/of switch	Default tag table	Bool	%Q0.1	☐	☑	☑	☑	
6	Proximity sensor	Default tag table	Bool	%I0.3	☐	☑	☑	☑	
7	Defect detection light SW	Default tag table	Bool	%Q0.2	☐	☑	☑	☑	
8	Defect material conveyor	Default tag table	Bool	%Q0.3	☐	☑	☑	☑	
9	non defect conveyor SW	Default tag table	Bool	%I0.4	☐	☑	☑	☑	
10	non defect conveyor on/off	Default tag table	Bool	%Q0.4	☐	☑	☑	☑	
11	photo electric sensor	Default tag table	Bool	%I0.5	☐	☑	☑	☑	
12	Transfer to next process	Default tag table	Bool	%Q0.5	☐	☑	☑	☑	
13	conveyor reverse	Default tag table	Bool	%I0.6	☐	☑	☑	☑	
14	conveyor forward	Default tag table	Bool	%I0.7	☐	☑	☑	☑	
15	Recycle process	Default tag table	Bool	%Q0.6	☐	☑	☑	☑	
16	<Add new>				☐	☑	☑	☑	

Fig. 4: Tags used in the Material transfer function

IV. RESULTS AND DISCUSSION

PLC Programming and Implementation:

Material Transfer Precision: The system demonstrated high precision in transferring materials from one point to another. This precision met the specified tolerances required by the application, ensuring consistent and accurate material handling. Efficient Material Flow: The PLC-controlled conveyor system efficiently transported materials at the desired speed and capacity. This resulted in improved production throughput and reduced material handling times. Safety Features: Safety features, such as emergency stop mechanisms and safety interlocks, were integrated into the system design. These safety measures effectively responded to potential hazards, ensuring the protection of personnel and equipment. In conclusion, a well-designed ladder logic diagram can greatly benefit a PLC-based material transfer operation in an industrial application. It can enhance accuracy, efficiency, safety, and reliability. However, it is important to note that the success of this approach relies on careful planning, design, and implementation of the ladder logic diagram. In the project, successfully designed and implemented a Programmable Logic Controller (PLC) system for material transfer operations in industrial applications. The PLC program was developed using ladder logic, and it effectively controlled the material transfer process. The following key results were observed. Smooth Material Transfer: The PLC-controlled system demonstrated smooth and precise material transfer between different sections of the industrial facility. This was achieved through the precise control of conveyor belts, robotic arms, and other relevant equipment. Reduced Downtime: One of the primary objectives of this project was to minimize downtime during material transfer operations. With the PLC in place, downtime due to manual interventions and errors was significantly reduced, leading to increased overall production efficiency. Error Handling: The PLC system was programmed to detect and handle errors in real-time. It could identify issues such as jams in the conveyor system or equipment malfunctions and respond appropriately, either by initiating troubleshooting procedures or by shutting down the system to prevent further damage.

Operator Interface and Monitoring

The Human-Machine Interface (HMI) is a critical component in industrial applications that involve the transfer of materials and rely on Programmable Logic Controllers (PLCs). Its main function is to establish a connection between operators and the PLC system, enabling them to effectively monitor and control the transfer process. Here is a comprehensive overview of the HMI in relation to your project: Purpose of HMI: The primary objective of the HMI in this project is to provide operators with an intuitive interface that facilitates their interaction with the PLC system responsible for material transfer operations. It allows operators to monitor real-time data, control equipment, and quickly resolve any issues that may arise. Key Features: Real-time Monitoring: The HMI displays up-to-date information related to the material transfer process. This includes details such as conveyor speed, material flow rates, temperature, pressure, as well as any alarms or alerts. Control Functions: Operators can utilize the HMI to initiate, cease, pause, or adjust the transfer process as required. They may also set parameters and configure the system. Alarms and Alerts: In the event of abnormal conditions, such as equipment malfunctions or deviations from set parameters, the HMI is capable of generating alarms and alerts. Data Logging: It has the ability to record and store historical data for the purpose of analysis and quality control. User Authentication: For security purposes, the HMI may implement user authentication to prevent unauthorized access and modifications to system settings. Remote Access: Some HMIs offer remote access capabilities, enabling operators or engineers to monitor and control the system from a remote location.

HMI Hardware:

The hardware components of the HMI generally consist of a touchscreen display, input buttons, and indicator lights. The selection of screen size and resolution should be based on the complexity of the system and the information that needs to be displayed. The software running on the HMI should be user-friendly and customizable. It is often developed using HMI development software, which allows for the creation of graphical interfaces with drag-and-drop elements for buttons, data displays, and trends.

Integration with PLC:

The HMI communicates with the PLC through a communication protocol such as Modbus, OPC (OLE for Process Control), or Ethernet/IP. This integration ensures that the HMI can transmit control commands to the PLC and receive real-time data from it. Maintenance and Upgrades Regular maintenance of the HMI system is crucial to ensure its reliability. Furthermore, as technology continues to advance, it may be necessary to upgrade the HMI software or hardware in order to keep the system up to date and secure

V. CONCLUTION

In conclusion, the HMI plays a crucial role in PLC-based material transfer operations in industrial applications by serving as a vital interface between operators and the control system. It provides real-time data visualization, control capabilities, and a means for operators to efficiently and safely interact with and manage the material transfer process. Proper design, integration, and maintenance of the HMI system are essential for the success of the project. The project also included the development of a user-friendly operator interface, which allowed operators to monitor and control the material transfer process. Key findings related to the operator interface are as follows Real-time Monitoring: Operators could monitor the entire material transfer process in real-time, including the status of conveyors, sensors, and equipment. This real-time feedback enabled prompt decision-making and troubleshooting A PLC-based system for material transfer was successfully constructed and put into use in the research, demonstrating the system's efficacy in automating and managing material handling procedures. According to the study, the PLC system greatly increased the reliability and efficiency of material transfer processes, which resulted in less downtime and higher output in industrial settings. The PLC-controlled material transfer function demonstrated a high degree of accuracy and consistency in regulating material flow, minimizing mistakes and waste in the process, according to data analysis. The research results also highlighted the PLC system's versatility, demonstrating its capacity to easily integrate with current factory setups and adapt to changing operating requirements.

VI. ACKNOWLEDGEMENT

This is a great pleasure and immense satisfaction to express my deepest sense of gratitude and thanks to everyone who has directly or indirectly helped me in completing our paper work successfully. I express my gratitude towards guide Mr. S. Arun Jayakar who guided and encouraged me in completing the work in scheduled time.

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