University of Engineering & Technology (UET) Taxila

Electrical Engineering Department

Industrial Automation Lab

Complex Engineering Problem

Statement**: Automating of Cement Making Process System**

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Introduction

Overview

In Pakistan, the cement industry plays a pivotal role in the nation's economy, contributing significantly to construction projects and infrastructure development. Cement manufacturing involves intricate processes that demand precise control and monitoring to ensure optimal efficiency and product quality.

Need for Automation

As Pakistan continues to witness growth in construction activities and urbanization, the demand for cement is on the rise. To meet this demand sustainably, there is a pressing need to enhance productivity while minimizing environmental impact. Automation presents a viable solution by streamlining operations, improving safety standards, reducing energy consumption, and curbing emissions.

Project Objectives

The primary goal of this project is to design an automation system for a cement kiln with a daily production capacity of 1500 tons. This system will leverage advanced sensors and control mechanisms to regulate production levels effectively, ranging from 500 to 1500 tons per day, thereby optimizing operational efficiency and meeting market demand.

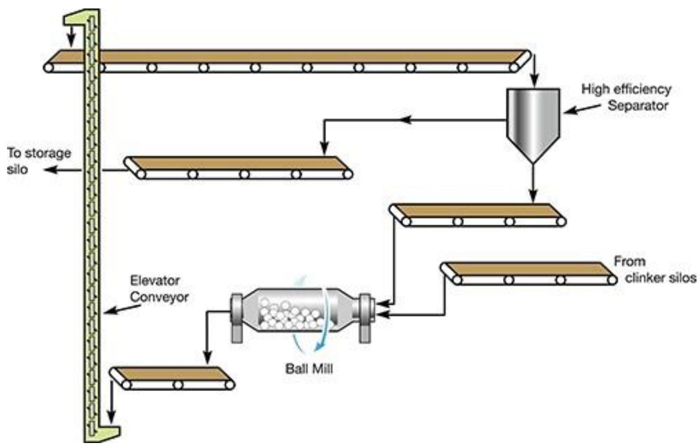
Scope of the Report

This report delves into the comprehensive analysis and design approach for automating the cement manufacturing process in Pakistan. It encompasses the selection of appropriate automation components, system design considerations, PLC programming, and evaluation of environmental impact. Additionally, the report addresses vendor comparison, strategies for reducing CO2 emissions, and insights into project management practices.

Literature Review and Problem Analysis

Existing Automation Systems in Cement Plants

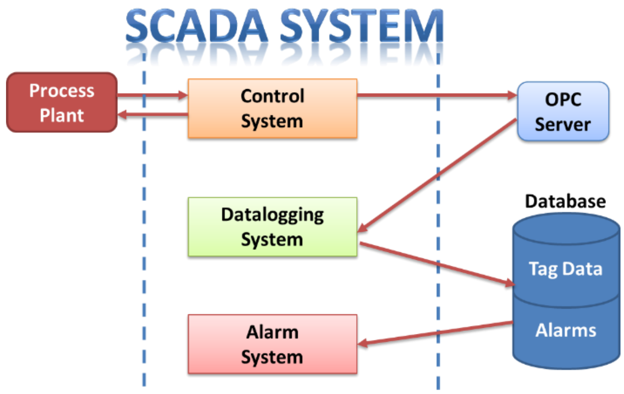
A review of existing literature reveals that automation plays a crucial role in enhancing efficiency and reducing operational costs in cement plants worldwide. Various automation technologies, such as Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) systems, and advanced sensors, are commonly employed to automate different stages of the cement manufacturing process.



Key Components of Existing Systems

PLCs: PLCs are widely used for process control and automation in cement plants due to their reliability, flexibility, and ease of programming. They facilitate the integration of multiple sensors and actuators to monitor and control various aspects of the manufacturing process.

SCADA Systems: SCADA systems provide real-time monitoring and control of plant operations, allowing operators to visualize process data, diagnose issues, and make informed decisions remotely.



Sensors: Advanced sensors, including temperature, pressure, flow, and level sensors, are deployed throughout the plant to collect data on key process parameters. This data is utilized for process optimization, predictive maintenance, and quality control.

Challenges and Opportunities

While automation offers numerous benefits, implementing and maintaining automation systems in cement plants pose several challenges. These include high initial costs, complexity of integration with existing infrastructure, and the need for skilled personnel to operate and maintain the systems.

However, advancements in automation technologies, such as cloud computing, Internet of Things (IoT), and artificial intelligence (AI), present new opportunities for enhancing the efficiency and reliability of cement manufacturing processes.

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Analysis of the Given Engineering Problem: Automating the Cement Making Process

The given engineering problem involves automating a kiln with a daily production capacity of 1500 tons in a cement plant. The objective is to utilize a suite of sensors to regulate production levels within the range of 500 to 1500 tons per day efficiently. This requires the development of a robust automation system capable of monitoring key process parameters, controlling equipment operations, and optimizing production efficiency while adhering to industry standards and environmental regulations.

Key Considerations

- Selection of appropriate sensors and actuators to monitor and control critical process variables, such as temperature, pressure, and flow rates.
- Development of a reliable control strategy using PLC programming to ensure seamless operation and responsiveness to changing production demands.
- Integration of safety systems to mitigate operational risks and ensure the well-being of plant personnel.
- Evaluation of environmental impact, including CO_2 emissions, and implementation of strategies to minimize environmental footprint in line with sustainability goals.

Design Specifications

Automation Objectives

- Maintain kiln production between 500 to 1500 tons/day.
- Optimize efficiency and quality while reducing energy usage.
- Ensure real-time monitoring and safety for plant personnel.

Components and Sensors

- Use temperature, pressure, flow, and level sensors.
- Employ actuators for precise control of material flow.

Control Logic

- Implement PID control algorithms.
- Allow manual/automatic setpoint adjustment.
- Configure alarms and safety interlocks.

System Integration

- Utilize PLC platform with SCADA integration.
- Develop user-friendly HMI interface.
- Enable remote access for authorized personnel.

Environmental Considerations

- Minimize CO2 emissions through optimized processes.
- Install environmental monitoring systems.

Compliance and Standards

- Ensure IEC/ANSI/UL certification.
- Adhere to industry standards for cement manufacturing.

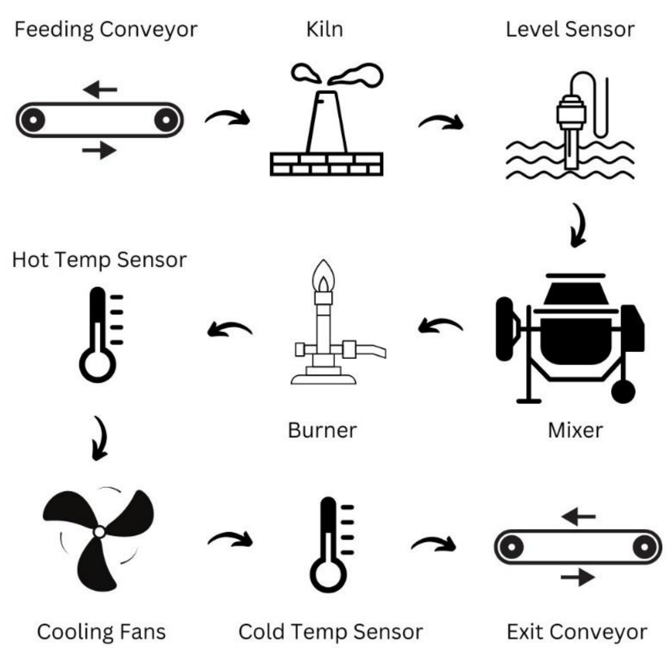
Scalability and Flexibility

- Design for future expansion or modifications.

Documentation and Training

- Provide comprehensive manuals and training for personnel.

P&I Diagram



Material Feeding

- Activate conveyors for raw materials based on production needs.
- Monitor material levels with sensors and replenish as needed.

Kiln Firing

- Activate kiln burner and control fuel flow based on temperature setpoints.
- Adjust burner intensity using PID control to maintain desired temperature.

Clinker Cooling

- Activate clinker cooler fans and control air flow rate.
- Regulate cooling process with PID control based on clinker temperature.

Cement Exit Process

- Initiate conveyor belt operation to transport cement from kiln to storage/packaging.

System Design

PLC (Programmable Logic Controller)

Acts as the central control unit, processing input signals from sensors and generating output signals to control actuators.

Sensors

- **Level sensors:** for monitoring material levels in storage bins.
- **Temperature sensors:** for measuring kiln temperature and clinker temperature.
- **Flow sensors:** for monitoring material flow rates in conveyors.

Actuators

- **Conveyor motors:** for activating conveyors to transport raw materials and cement.
- **Kiln burner:** for controlling fuel flow and burner intensity.
- **Clinker cooler fans:** for regulating air flow rate during the cooling process.

Human-Machine Interface (HMI):

- Interface for operators to monitor and control the automation system.
- Displays real-time data, alarms, and allows manual override if necessary.

Working Principle

Material Feeding

- Upon initialization, the system activates the conveyor motors corresponding to the required raw materials (limestone, iron ore, bauxite, laterite, and fluorspar) based on production needs.
- Level sensors monitor the material levels in storage bins or hoppers. If the level of any raw material falls below a predefined threshold, the respective conveyor motor is activated to replenish the material.
- Once all required raw materials are available, the feeding process is complete.

Kiln Firing

- The system activates the kiln burner and controls the fuel flow based on temperature setpoints.
- Temperature sensors continuously monitor the kiln temperature. The PID control algorithm adjusts the burner intensity to maintain the desired temperature profile for efficient clinker formation.

Clinker Cooling

- After the clinker formation process, the system activates the clinker cooler fans and controls the air flow rate.
- Temperature sensors monitor the clinker temperature. The PID control algorithm regulates the cooling process to achieve the desired clinker temperature suitable for storage or further processing.

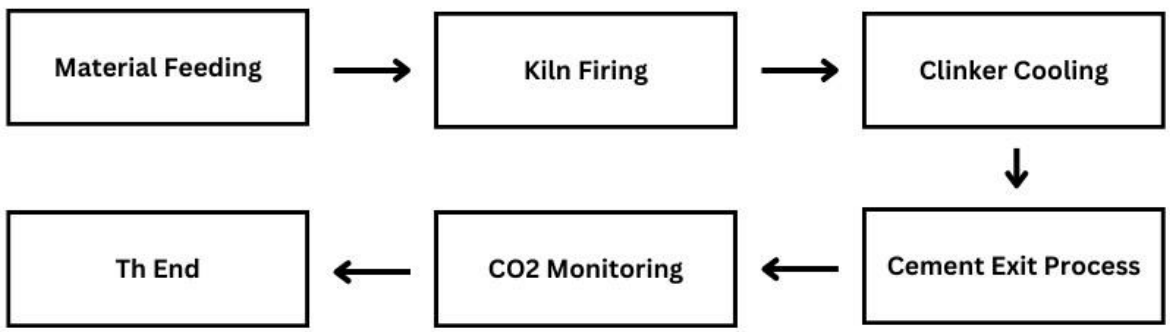
Cement Exit Process

- Upon completion of the clinker cooling process, the system initiates the conveyor belt operation to transport cement from the kiln to storage or packaging.
- The conveyor motor dedicated to cement exit is activated, allowing the cement to be transported out of the kiln area for storage or packaging.

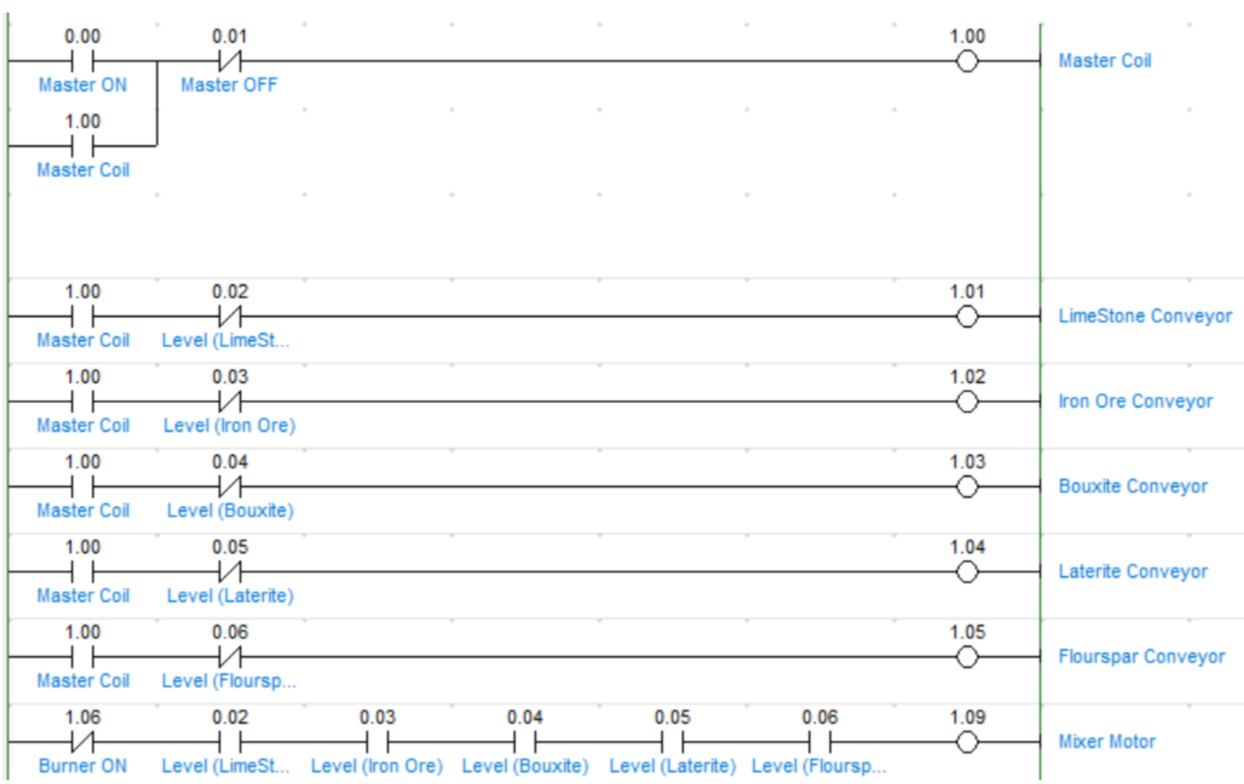
CO2 Monitoring

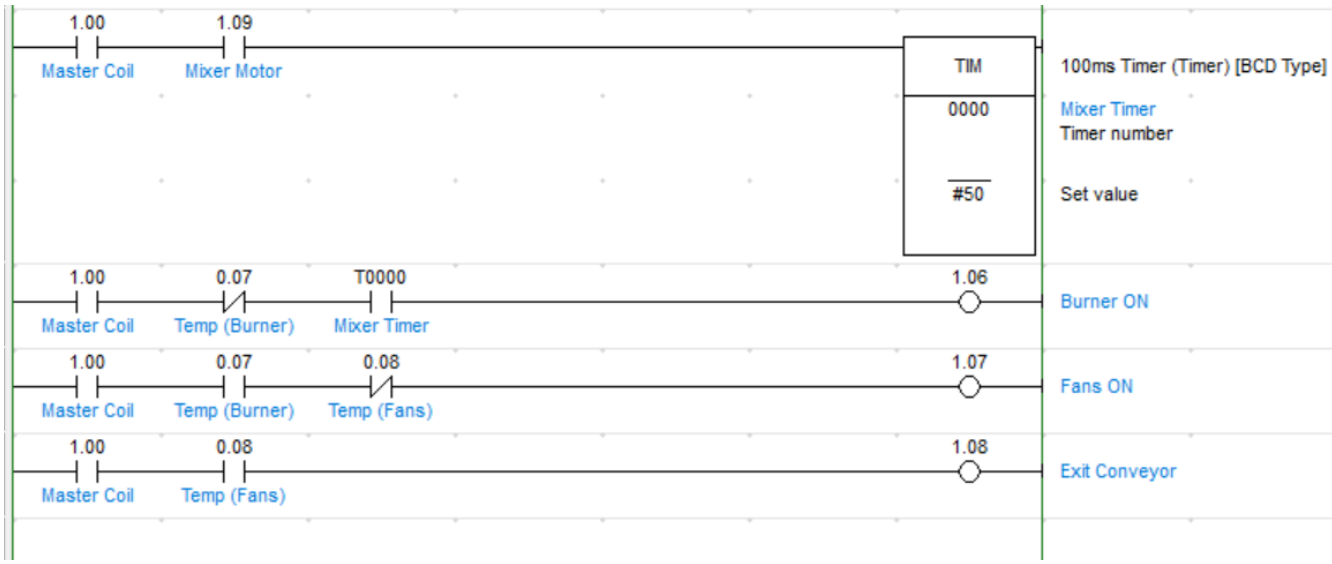
- Monitor CO2 emission for certain level.

Block Diagram

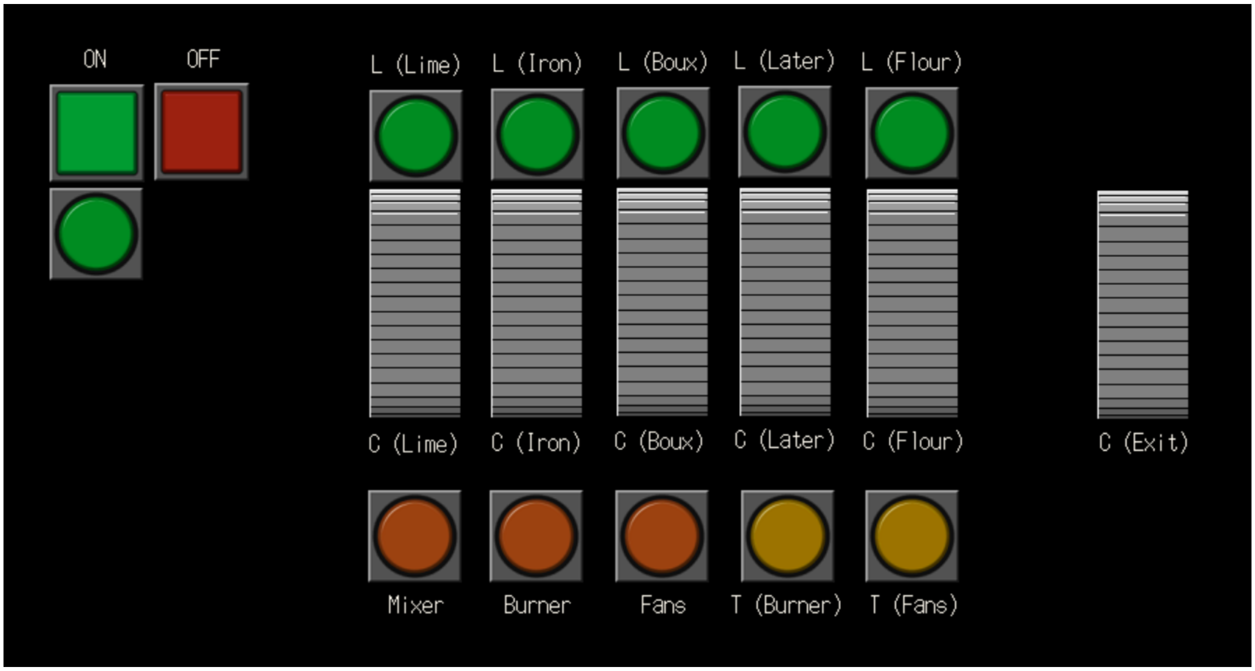


PLC Program in CX-Programmer and CX-Designer





INPUT	Address	OUTPUT	Address
Master (ON)	0.00	Master Coil	1.00
Master (OFF)	0.01	Conveyor (Limestone)	1.01
Level (Limestone)	0.02	Conveyor (Iron Ore)	1.02
Level (Iron Ore)	0.03	Conveyor (Bauxite)	1.03
Level (Bauxite)	0.04	Conveyor (Laterite)	1.04
Level (Laterite)	0.05	Conveyor (Fluorspar)	1.05
Level (Fluorspar)	0.06	Burner	1.06
Temp (Burner)	0.07	Fans	1.07
Temp (Fans)	0.08	Conveyor (Exit)	1.08
-	-	Mixer	1.09



Vendor Comparison

TechPro Automation Solutions

- **Product Features:** Offers a wide range of automation components including PLCs, sensors, and actuators suitable for cement kiln automation.
- **Certifications:** All major components are IEC/ANSI/UL certified, ensuring compliance with international standards for electrical safety and reliability.
- **Reliability:** Known for providing reliable and robust automation solutions with a proven track record of successful implementations.
- **Environmental Considerations:** TechPro emphasizes environmental sustainability and offers energy-efficient components to minimize CO2 emissions.

Innovatech Engineering Solutions

Product Features: Specializes in customized automation solutions tailored to specific industrial applications, including cement manufacturing.

Certifications: All components are IEC/ANSI/UL certified, guaranteeing adherence to stringent quality and safety standards.

Reliability: Innovatech is renowned for its high-quality products and after-sales support, ensuring reliable operation and minimal downtime.

Environmental Considerations: Offers eco-friendly automation solutions designed to reduce energy consumption and environmental impact.

CO_2 Emissions Consideration

Minimization Strategy

- The automation system minimizes CO_2 emissions by optimizing combustion processes, reducing energy consumption, and maximizing fuel efficiency through advanced sensors and control mechanisms.
- Real-time monitoring and PID control algorithms ensure proactive adjustments to kiln operations, maintaining compliance with emission targets and environmental regulations.
- Energy-efficient technologies and alternative fuels further reduce CO_2 emissions and environmental impact.

Conclusion

In conclusion, the automated cement kiln system represents a significant step towards enhancing efficiency and sustainability in cement manufacturing. By integrating advanced automation technologies and adhering to strict standards, we have developed a reliable system that optimizes production, minimizes CO_2 emissions, and ensures compliance with industry regulations. Through careful vendor selection and project management, we have laid the groundwork for future advancements in industrial automation, reaffirming our commitment to innovation and environmental stewardship.

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