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Automated Feed Mill Systems and Automation Process

Abhishek Tiwari[1] and Gagan Chawla[2]
1Ph.D Scholar, Animal Nutrition Division,
ICAR–National Dairy Research Institute (NDRI), Karnal–132001, Haryana, India.
2Ph.D Scholar, Animal Physiology Division,
ICAR- National Dairy Research Institute, Karnal 132001, Haryana, India
***Corresponding Author:** drabhishektiwari78@gmail.com
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Abstract:

Automation in feed mill systems has become an essential component of modern animal feed manufacturing due to its ability to improve production efficiency, feed quality, and operational accuracy. Automated feed mills integrate advanced computer hardware, software, programmable logic controllers (PLCs), supervisory control and data acquisition (SCADA) systems, communication networks, and sensor technologies to manage and monitor feed processing operations in real time. Computer-based control systems function as the central control unit of feed plants by coordinating batching, mixing, conveying, monitoring, and data management activities. Modern automation architectures, including Client/Server systems and Distributed Control Systems (DCS), provide improved flexibility, reliability, and process integration. In addition, advanced interfaces such as graphical user interfaces (GUI), barcode systems, and imaging technologies enhance operator interaction, traceability, and intelligent monitoring. Automation in feed mills minimizes manual intervention, reduces operational errors, improves process consistency, and supports regulatory compliance. Therefore, modern computerized feed mill systems play a significant role in achieving efficient, precise, and sustainable feed manufacturing operations.

Introduction:

An automated feed mill is an advanced feed manufacturing facility in which major operations are controlled through automation technologies to achieve higher productivity, consistent feed quality, and reduced manual labor. Computer-based control systems serve as the brain and central nervous system of modern feed plants by coordinating processing operations, monitoring equipment performance, and ensuring process accuracy. With continuous technological advancements, standardized hardware, software, and communication systems have improved operational efficiency, system compatibility, maintenance support, and future scalability.

Modern Computers in Feed Mills: Hardware & Software

Modern feed mills utilize advanced computer hardware, software, communication networks, and sensor technologies to achieve fast, intelligent, and efficient process control. Computer-based control systems act as the brain and nerve center of modern feed manufacturing plants by optimizing equipment operation, monitoring production processes in real time, and maintaining product quality and performance records. Networking systems facilitate information sharing, production planning, and logistics management, while sensors provide rapid real-time responses for accurate process control. User-friendly interfaces such as touchscreen and wireless controls further improve operational convenience and efficiency. Beyond traditional process control, modern computerized systems support flexible, need-based operations, regulatory compliance, and efficient feed mill management

Systems Architecture Hardware:

Early feed mill controls systems mainly consisted of electro-mechanical devices used for basic batching operations. During the early 1970s, computers and programmable logic controllers (PLCs) were gradually introduced into feed manufacturing plants, leading to significant advancements in automation. Modern feed mill automation systems commonly employ an integrated Personal Computer/Programmable Logic Controller (PC/PLC) architecture, although other hardware configurations are also used successfully. In these systems, PCs and PLCs are interconnected through communication networks for efficient plant operation and control.

The PC primarily performs supervisory functions such as production planning, process monitoring, data management, reporting, and communication. In contrast, the PLC executes real-time plant floor operations using ladder logic programming to control machinery, sensors, conveyors, motors, and other processing equipment. This PC/PLC combination provides a reliable, flexible, and scalable automation platform for modern feed mills.

Role of PC and PLC in Feed Mill Automation:

- **Role of PC (Planning and Supervisory Unit):**

  In automated feed mills, the Personal Computer (PC) acts as the central planning and monitoring system. It provides the Human–Machine Interface (HMI) for operators, manages feed formulations and production recipes, handles alarms, reports, and data storage, and facilitates communication with PLCs for coordinated plant operation.

- **Role of PLC (Operational Control Unit):**

  The Programmable Logic Controller (PLC) performs real-time control of feed mill operations through ladder logic programming. It controls motors, conveyors, mixers, sensors, and other processing equipment, ensures safety interlocks, and continuously collects process information through input/output (I/O) systems.

Advantages of the PC/PLC Combination:

The PC/PLC architecture is widely used in modern feed mills because it combines the planning capability of PCs with the rugged operational reliability of PLCs. The system is mature, reliable, easy to maintain, and built with standardized components. PLCs can efficiently operate under harsh industrial conditions, while the overall system remains flexible and scalable for future automation and technological advancements.

System Architecture Software in Feed Mill Automation:

Software technology, development tools, and programming methods in feed mill automation have evolved rapidly with advancements in processor speed, computing power, and data storage capacity. Modern automation software provides improved process control, faster data processing, better communication, and enhanced system reliability. Technologies such as WIN32 application programming interfaces, Component Object Model (COM), and Distributed Component Object Model (DCOM) support integration and communication between different software applications and automation systems.

- **Procedure-Oriented Programming (Traditional Approach):**

  Procedure-oriented programming follows a linear, task-based coding structure in which the entire program is written as a single sequence of instructions. In this approach, data and functions remain separate, making system modifications difficult because changes often require editing the entire program. Additionally, errors in one section may affect the overall system performance.

- **Object-Oriented Programming (Modern Approach):**

  Object-oriented programming (OOP) is a modern software design approach in which programs are organized around objects that combine data and functions together. This structure improves modularity, flexibility, and system reliability. Modifications and upgrades can be performed more easily without affecting the entire system, while errors generally remain confined to specific objects, resulting in more robust and maintainable automation software for modern feed mill operations.

Software Organization in Feed Mill Automation:

Modern feed mill automation software is generally designed using two major organizational architectures: the Client/Server System and the Distributed Control System (DCS). In many cases, modern automation platforms combine features of both systems to improve flexibility, reliability, and process efficiency.

- **Client/Server System:**

  In the Client/Server architecture, the client represents the user side, such as operator computers or workstations, while the server manages databases, system rules, transactions, and process applications. The server also acts as a communication gateway for sharing information with

other software applications, including least-cost feed formulation programs and inventory management systems.

A related approach is the Peer-to-Peer system, in which multiple networked nodes share equal responsibility and communicate directly with one another without relying on a single central server.

- **Distributed Control System (DCS):**

  In a Distributed Control System, process control tasks are distributed among multiple controllers rather than being managed by a single central unit. Each controller or node supervises a specific section of the feed mill, while all nodes communicate through a network for coordinated plant operation. This structure improves system reliability, flexibility, and operational efficiency.

- **Supervisory Control and Data Acquisition (SCADA):**

  SCADA is a supervisory software system that operates above PLCs and other control devices. It provides functions such as real-time monitoring, alarm management, data logging, report generation, and Human–Machine Interface (HMI) support. SCADA systems can be integrated with Client/Server, DCS, and PLC-based automation architectures for centralized process supervision and control.

- **Dedicated Control Systems:**

  Dedicated control systems are vendor-specific automation units designed for specialized equipment such as liquid applicators, packaging machines, expanders, and smart weighing systems. These systems commonly use ladder logic or low-level programming for equipment operation and function as subordinate units that exchange operational data and process requirements with the main automation system.

System Interface in Feed Mill Automation:

A system interface is a shared hardware or software boundary that enables communication between the automation system, users, and processing equipment within a feed mill. Interfaces play an essential role in data exchange, process monitoring, and operational control. In feed mill automation, interfaces are generally classified into three major categories: operator interfaces, process interfaces, and specialized interfaces.

- **Operator Interface:**

  The operator interface connects the automation system with plant operators and allows user interaction with the feed mill control system. Its primary functions include data entry, command execution, alarm handling, and displaying process status and production results. Earlier systems mainly used text-based displays, whereas modern systems employ Graphical User Interfaces (GUI) that combine graphics with numerical process information

for easier monitoring and operation. User interaction is commonly achieved through keyboards, mouse devices, touchscreens, and, in some cases, wireless mobile control systems. Software tools such as Visual Basic (VB) are often used for GUI development because of their flexibility, scalability, and ease of integration.

- **Process Interface:**

  The process interface enables communication between the automation system and feed mill machinery through input/output (I/O) devices. These interfaces collect operational data and transmit control signals to processing equipment.

  - **Types of Input/Output (I/O) Systems:**
    - ***Discrete (Digital) I/O:*** Used for ON/OFF operations such as motor start/stop functions, switch status, and relay controls.
    - ***Analog I/O:*** Used for continuous process variables such as temperature, pressure, speed, and flow measurements.

- **Specialized Interface:**

  Specialized interfaces are designed for advanced communication and data exchange requirements beyond conventional GUI and I/O systems. These interfaces support specialized manufacturing tasks and intelligent monitoring systems within modern feed mills.

Bar Code Readers:

Bar code systems are used for ingredient tracking, vehicle identification, inventory management, and bin allocation to improve traceability and operational accuracy.

Vision and Imaging Devices:

Advanced imaging technologies enable automation systems to visually detect, analyze, and interpret images dynamically. These systems support quality inspection, material identification, and intelligent monitoring applications in modern feed manufacturing plants.

Conclusion:

Automated feed mill systems have transformed conventional feed manufacturing into a highly efficient, reliable, and intelligent industrial process. The integration of computer-based control systems, PLCs, SCADA, advanced software architectures, and modern interface technologies has significantly improved operational accuracy, process monitoring, product consistency, and production efficiency. PC/PLC-based automation systems provide flexible and scalable solutions capable of operating under demanding industrial conditions while minimizing human intervention and operational errors. Furthermore, modern software systems, communication networks, and intelligent interfaces support real-time data exchange, inventory management, traceability, and regulatory compliance. Although automation

requires substantial initial investment and technical expertise, its long-term benefits in terms of productivity, quality assurance, and cost-effectiveness make it an essential component of modern feed manufacturing industries. Future developments in smart sensors, artificial intelligence, and industrial networking are expected to further enhance the efficiency and sustainability of automated feed mill operations.

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