PLC Based Batch Process Control System at Cattle Feed Plant

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Abstract
Compound cattle feed is an important constituent of ration, considering the fact that dairy animals in India have limited access to cultivated green fodder and grasses. Most of the macro and micro nutrients requirement of animals are provided by compound feed, especially on crop residue based diets. It is possible to formulate balanced rations of ingredients using PLC based batch process control system for growing and lactating animals only if the feed used conforms to the laid down specifications for energy, protein, minerals, vitamins etc. In this paper study was carried out to develop PLC based batch process programming control system at cattle feed plant. Using programmable control systems for controlling a feed production line increases productivity, save energy and cost. It is preferred to use the programmable control system with multimedia interface to control feed production.

Keywords: **Batch Process Control, PLC (Programmable Logic Controller), CFP (Cattle Feed Plant), Product Recopies.**

1. INTRODUCTION

Batching is considered to be one of the most critical and essential operations in feed manufacturing. Lack of proper batching can lead to reduced diet uniformity, affecting not only animal performance but regulatory compliance as well. A process that manufactures a finite quantity of material by subjecting measured quantities of raw materials in a sequential order of processing actions using one or more pieces of equipment is called as Batch Process. The batch process control system consists of a PLC processor and I/O programmed for the specific application that controls the process devices with sequential logic and loops based on information from the product recipe. Specific relay ladder logic subroutines (libraries) in the PLC processor to perform the actions required of each unit to produce a product.

2. SYSTEM COMPONENTS

The batch process control system consists of several software and hardware components. Figure 1. Shows the batch process products and the process equipment in the cattle feed plant.

Cattle Feed Plant uses plant computer for creating recipes, scheduling production, tracking batches and controlling inventory. On a network, the plant computer can communicate with multiple process control stations as well as with the business systems.
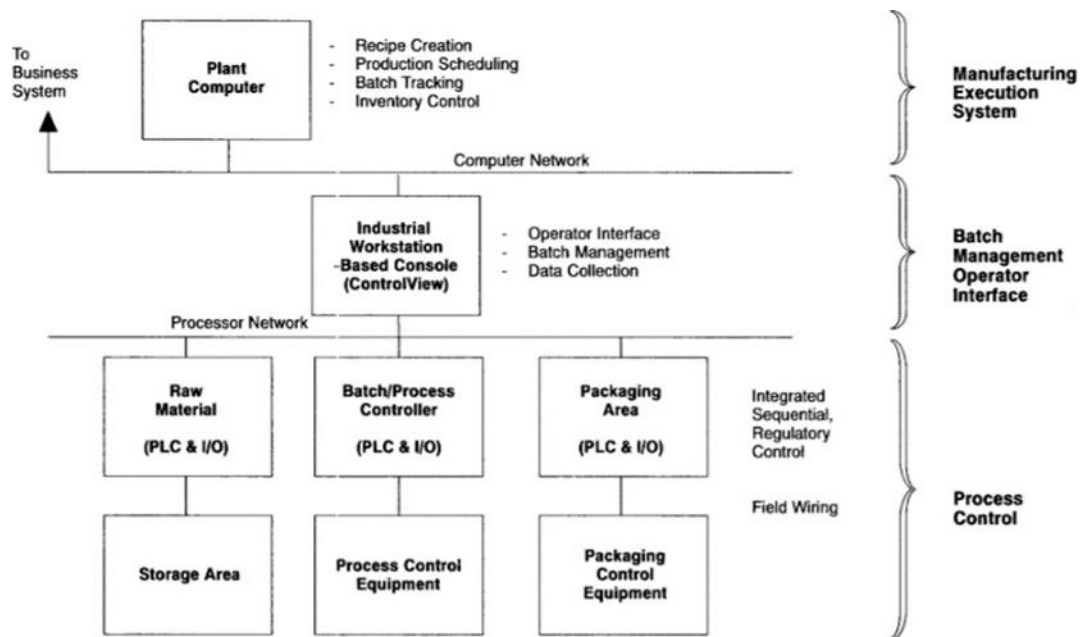
Figure 1. Batch Process Control Components

An industrial workstation and a PLC processor share the responsibilities of controlling the process equipment. The computer performs all file management and data processing functions (supervisory operator interface). The PLC processor performs all the control operation logic including input/output interface functions.

A.   *Product Reciepies*
The batch process control is based on managing the process as dictated by recipes. This allows to define the control by product requirements, without the engineering-intensive programming normally required in a PLC-based batch system. Using Recipe Builder software, recipes are created from procedure, formula and operation files.
The procedure file contains the specific sequence of operations necessary to produce a particular product. This file specifies the way a product will be manufactured. Operations are major processing activities (subsets of the total procedure) executed during the batch. Every operation is a group of one or more control activities referred to as phases or steps. The formula file contains the specific values for all variables required by each operation for the product. These variables can be amounts of ingredients, times, temperatures, pressures, and so on.

The Recipe builder software creates and maintains confidential recipes at a level that best meets operational requirements for cattle feed. After the recipe is created, the file (product recipe) can be loaded onto the batch operator interface terminals. The recipe is created as a binary file which adds another level of security to recipes since it cannot be modified on the plant floor, without proper security software.

B.   *Batch Process Control*
The batch process controller consists of a PLC processor and I/O programmed for the application controls process devices with sequential logic and regulatory loops based on information from the product recipe. The batch application can be simplified and achieve a high degree of batch flexibility by segmenting the batch process into identifiable, independent batch process control units.
Then specific relay ladder logic subroutines (libraries) are created in the PLC processor to perform the actions required to produce a product. Such subroutines can,
(i)   add ingredients to the tank
(ii)   mixing ingredients in the tank for certain period of time.
(iii) outleting the product through outlet valve.
   This establishes the base from which we can build the batch process control system. Figure 2. shows the

operation of batch process control system. This system has been divided into five process units. Two preweigh tanks (process unit 1, process unit 2) weigh out several ingredients and then dump the ingredients into the mixing tank (process unit 3). The mixing tank also weighs out an ingredient, agitates the mixture, undergoes a heat cycle, and dumps out the finished product which is then stored in storage tank no. 1 or no. 2. Once the units are defined it is a simple step to establish the control required for operation subroutines. Unit 1 (preweigh tank 1) could have operations such as adding ingredients, mixing ingredients, transferring ingredients. These can be phases of a single operation. Units 2 and 3 would follow the same approach.
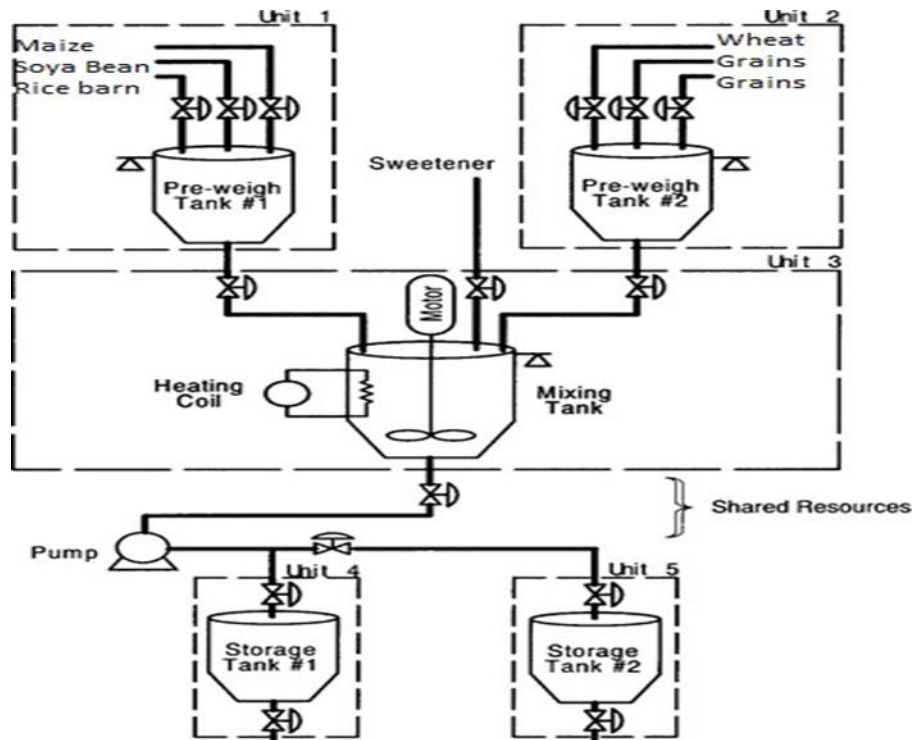

Figure 2. Batch Process Control operation

The Batch Process Control system stores only basic operation logic (subroutines) in PLC processor memory. This is of significant advantage because it substantially reduces the amount of controller code necessary to run batches by eliminating most of the control operations. It also provides more flexibility for the operator to interact during batch operation.

To produce a batch the recipe library is accessed through a local hard disk or remote file server and select a product recipe using the operator screens, assign it to a particular batch by adding the batch name and then start the batch.

While batches are running, the operator interface software provides system status information and a window to the control, which is displayed on the operator interface screen at the operator's console to keep operators informed and enable them to fine-tune the process. In addition, the operator interface provides alarm monitoring and logging functions.

3. SOFTWARE PRODUCTS

Batch process control software consists of the following modular products:
(i) Process Configuration and Operation software.
(ii) Batch Management software.
(iii) Control view software.

(i) Process Configuration and Operation software - The Process Configuration and Operation software is PLC- based code that is the foundation on which batch process control system is build. It includes an extensive set of controller logic, extended regulatory loops, device drivers, and communications services to the operator interface and other intelligent I/O devices. The software loaded into the PLC processor using

standard PLC programming software and it is configured by filling the needed data using the PLC programming software or configuration interface screens on Control view.

(ii) Batch Management software - Batch Management software provides effective management of batch execution based on the selected product recipes. Using this software batch process control system can run multiple batches using multiple batch controllers and process units, easily change the production procedure or products, and automatically monitor and collect batch production data. Batch Management software includes:

(a)   System Summary — summary of all batches scheduled and current status.

(b)   Batch Detail — a detailed look at the sequence of operations for a batch and the current status.

(c)   Formula Detail — a screen that enables the modification of a recipe formula.

(d)   Unit Summary — provides an overview of all batch units and their status.

(e)   Operator Action — a listing of information and actions an operator may need for running a batch.

These screens are used in conjunction with Control view custom graphics created using the mouse graphics package to provide a single window into the process.

(iii) Control view software – Control view software is the industrial workstation based component that provides a multitasking, multi-windowed, graphics-oriented environment that integrates data collection, real-time operator interface, and supervisory control of a batch process control system.

3.   HARDWARE PRODUCTS

Batch Process Control hardware consists of following modular products.

(i)   Batch Master Batch Process Controller.

(ii)   Batch Process Control Keyboard.

(iii) Batch view Console.

(iii)   Batch view Operator Workstation.

(i)   Batch Master Batch Process Controller - The Batch Master Batch Process Controller consists of enclosure suitable for use in industrial environment and includes the following components:

(a) PLC programmable controller

(b) I/O chassis

(c) power supply

(d) field terminal blocks

(e) standard enclosure items such as lights and locks, etc.

(ii)   Batch Process Control Keyboard - The Batch Process Control Keyboard is an industrially hardened operator's keyboard designed to simplify operator's efforts. The keyboard allows rapid access to process equipment displays, alarm reports, etc. It also includes an integrated section that can be connected to PLC processor to provide special functions. The Batch Process Control Keyboard can be used on a desktop or permanently mounted to an operator's console or batch controller.

(iii) Batch view Console –The Batch View Operator Console is a desk enclosure complete with industrial computer and Batch Process Control keyboard.

(iv) Batch view Operator Workstation - combines the industrial workstation and the Batch Process Control Keyboard. The workstation includes pre-configured software and is factory tested.

Software includes: Process Control software for the PLC processor, Control view software, Batch Management software.

5.   BATCH PROCESS CONTROL OPERATIONS

Batch Management software has a hierarchical display screen structure to help operator to monitor and adjust the batch process control. Menu screens are provided to guide you through the displays. Figure 3.

Shows Batch Management menus and custom screens are organized. These screens highlight only a few of the features available. Along with the accessibility to the data, these screens establish a consistent way of interacting with batch process control system. This reduces the engineering time required by a system integrator to build system. A consistent approach makes it easier for operators to move from line to line since each system interface is similar.
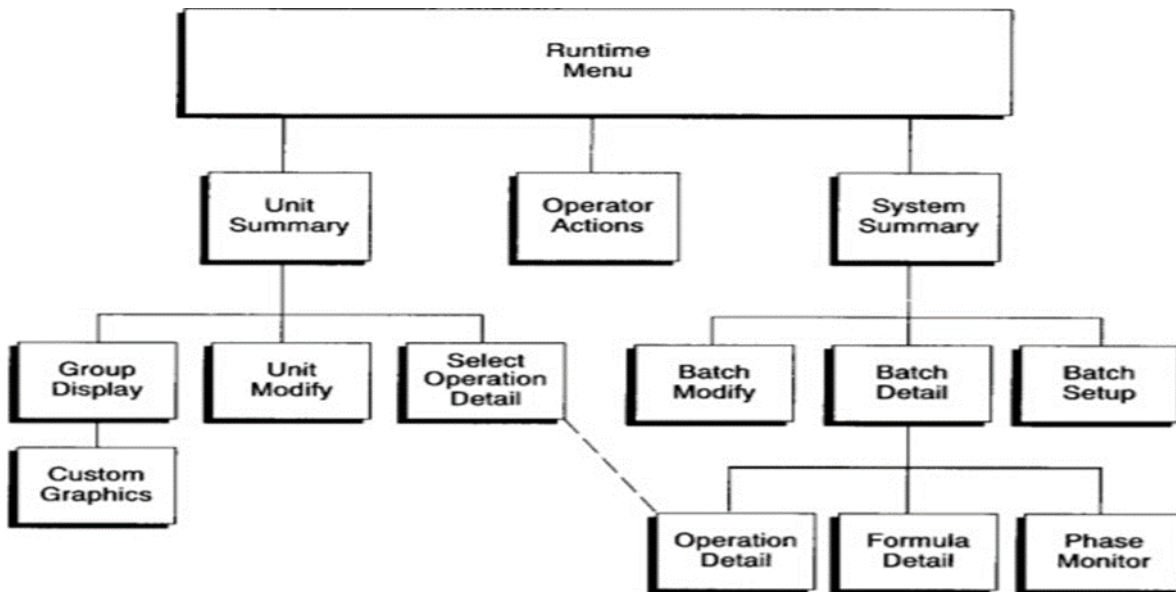

Figure 3. Batch Management menus and screens

Batch Management software provides a variety of menus and screens that let operator easily access all batch functions. These screens are used in conjunction with the custom screens developed using the Control view software and the process control screens provided by the Process Control and Operation software. Using these operator interface packages, operator can perform many tasks such as loading recipes from storage, controlling the miscellaneous devices and control loops in process, and monitoring alarms, loops, tags and devices. The tools available to operate and interact with a batch process control system are,

(i) Managing recipes.
(ii)Setting up batches.
(iii)Modifying batches.
(iv)Monitoring batches.
(v)Monitoring units.
(vi)Controlling batches.

(i) Managing recipes - All batches require a master product recipe. This is created using the recipe creation package and load it into the batch system. A batch from a master recipe, called the working recipe is run. This working recipe becomes the recipe that can be modified by the operator at the operator interface level. This protects the original so that each batch starts from the same data. Modification may be needed to make a change in the raw material or the product. Therefore, the Batch Management software has utilities that plant floor operator can easily use to change and save recipes. These functions include,

> Load recipes from the recipe library.
> Save modified recipes with a new filename.
> Delete recipes not linked to a batch.

Using Recipe Builder software on a personal computer, or the Batch View Operator's Console when it is off-line, operator can also create new recipes and add them to the batch database.

(ii) Setting Up Batches - The act of selecting a recipe and scheduling it to run, is called set up. This is done by giving the batch a name, selecting a specific recipe, and establishing a schedule. The system then displays the Batch Name, State, Recipe, Schedule, and assigns a unique ID number. To set up a batch operator select

the Batch Setup window from the System Summary screen and respond to prompts which appear on the screen.

(iii) Modifying batches - Once a batch is set up, operator may need to modify the batch mode, the schedule or one of the formula values contained in the recipe. To modify a batch mode or schedule operator access the Batch Modify screen from the System Summary screen. Operator can then modify the batch approval mode and the batch sequencing mode. Operator can also access other screens that alter details of the batch. For example, if operator want to modify the ingredients or mixing times in a formula of a particular batch, operator access the formula detail screen. Operator can change the working value of the formula between the specified minimum and maximum values. (iv)Monitoring batches - Once a batch is started, operator can monitor the execution of the procedure, operations and even phases that comprise the batch. From this screen information pertaining to the state of the selected batch is available. It also provides information about the procedure contained in the recipe such as, which units are assigned to run the operations and the selected mode. This screen allows the operator, with the proper security level, to select some batch oriented functions that may be executed (such as aborting or modifying an operation).

(iv)Monitoring units -Once the batch process has been segmented into process units, a method to view or monitor each unit is needed. The Unit Summary screen carries the unit concept from the design to the operator, and allow users to monitor the status of all configured units and the activities occurring within each. Operator can access the Unit Summary screen from the Runtime menu or directly from the batch process control keyboard. The Unit Summary screen displays configured process units and the status of activities occurring within them.

(v) Controlling batches - The PLC processor controls the actual batch process equipment. Operator enter control into the PLC processor as ladder code. This code is segmented into subroutines which correspond to either operations or phases. Since Control view uses recipes to provide both the order of execution for these subroutines and the formula data, it can be used to manage the batch execution and provide data for operators to interact with the system. It also controls and coordinates the data flow between the industrial workstation and the PLC processors.

Batch Management, combined with Control view and Process Configuration and Operation software, provides all the functions needed for batch processing including recipe execution, log creation and management, and unit management and control of the process. The actual control of a batch is functionally partitioned into the PLC code. Therefore, process interfaces and specific control requirements need to be incorporated into the PLC processor, and any special operation interfaces need to be developed for panel view or control view.

CONCLUSION

PLC based batch process control helps in getting balanced chemical composition of cattle feed used in the diet. This provides animals with the necessary nutrients to meet their requirements for maintenance, growth, pregnancy and production of milk.

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