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APPLICATION TO BATCH PROCESS: AN AUTOMATED SYSTEM IN A MIX-FEED FACTORY

Satoru Hirabayashi

1. FOREWORD

In the processing, assembly, and other manufacturing industries, automation and systemization of plant facilities is advancing positively and improvement of production efficiency, changes in multiproduct small lot production and the work force due to diversification of market needs (aging, shortage of experienced labor, higher education) and other social changes are being desit with.

Fuji Electric is meeting these needs and developing the high-speed processing, advanced functions programmable controller (PC) MICREX-F100/200 series, man-machine interface equipment PMS-050, and other FA control system components and various process control and factory automation systems, including the super microcomputer FASMIC G500 series that introduced the newest electronics technology, and is sending them to society.

The assorted feed factory management control system, which is one example of a batch process using the FA control system components mentioned above, is introduced here.

2. OVERVIEW OF PLANT

This plant manufactures assorted feed for livestock. Most of the feed produced is for cattle, hogs, and chickens. Since it governs the livestock raising state, occurrence of diseases, etc. the nourishment, balance, taste and appearance (shape, color) of the feed are problems.

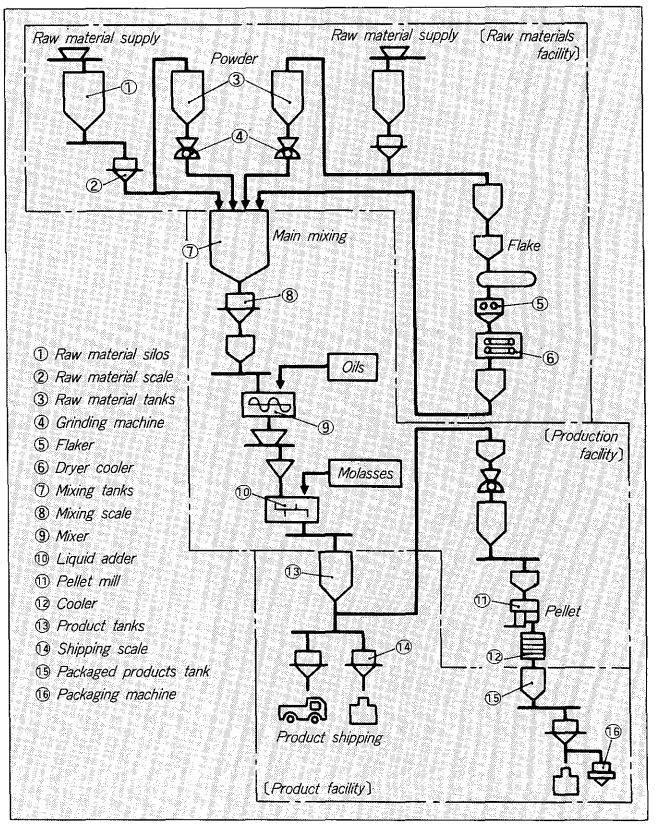
The facilities consist mainly of a raw material facility, production facility, and product facility. They are outlined in Fig. 1.

2.1 Raw material facility

This facility performs the processes from receiving of the raw material to processing (grinding, pelletizing) of the raw material and its transportation to the mixing tank. There are many transporting routes, depending on the kind of raw material and processing method. Many kinds of raw materials are also used and they are carried to the factory by truck, conveyor, ship, railway freight car, etc. and after being weighed by truck scales, hopper scales, etc., they are stored in a silo, tank, or raw material warehouse. Thereafter, when the amount of raw material in the mixing tank is reduced, the necessary stored raw material is processed and supplied to the mixing tank manually or automatically.

Besides conveyor, bucket elevator, cut damper, and other transporting machinery, there is also a magnetic separator, grinding machine, grader, flaker, etc. These equipments are controlled automatically by a PC.

Fig. 1 Mix-feed factory facilities



2.2 Mixing facility

This facility performs the processes from mixing of the weighed raw materials in the mixing tank to its entry into the product tank. Secondary grinding and pelletizing

after weighing and mixing may also be performed. The kinds and mixing ratio of the raw materials differ with the product name, etc. Because of the relationship between raw material shape, mixing accuracy, and mixing state, to produce one product, weighing and mixing are performed in three processes of standby mixing, main mixing, and liquid addition. Weighing and mixing are performed in batch units and the state of movement of the material is constantly tracked by PC and the signals that open and close each gate are controlled automatically so that the material weighed for one batch is not mixed without another batch by mistake. The part which performs this weighing and mixing is the most important part of the feed factory and setting of the weighing value, supply of small amounts of raw material, etc. must be performed manually.

2.3 Product facility

This facility ships the products stored in the product tanks. After the material in the tank is weighed by a scales, it may be loaded onto a truck, railway freight car, etc. and shipped or packed in paper bags, TB (trans-bag), or other bags and stored in a product warehouse before being shipped.

3. SYSTEM CONFIGURATION

Recently, a control system designed to save labor by concentrating the supervisor and control functions distributed about the factory at a central control room and controlling the factory centrally has become the mainstream.

A configuration example of such a system is shown in Fig. 2. A microcomputer FASMIC G500 is used for data management and the system is configured by installing advanced functions PC MICREX-F205 at each system and connecting them by data line LAN (Local Area Network).

3.1 Functions load sharing and distribution

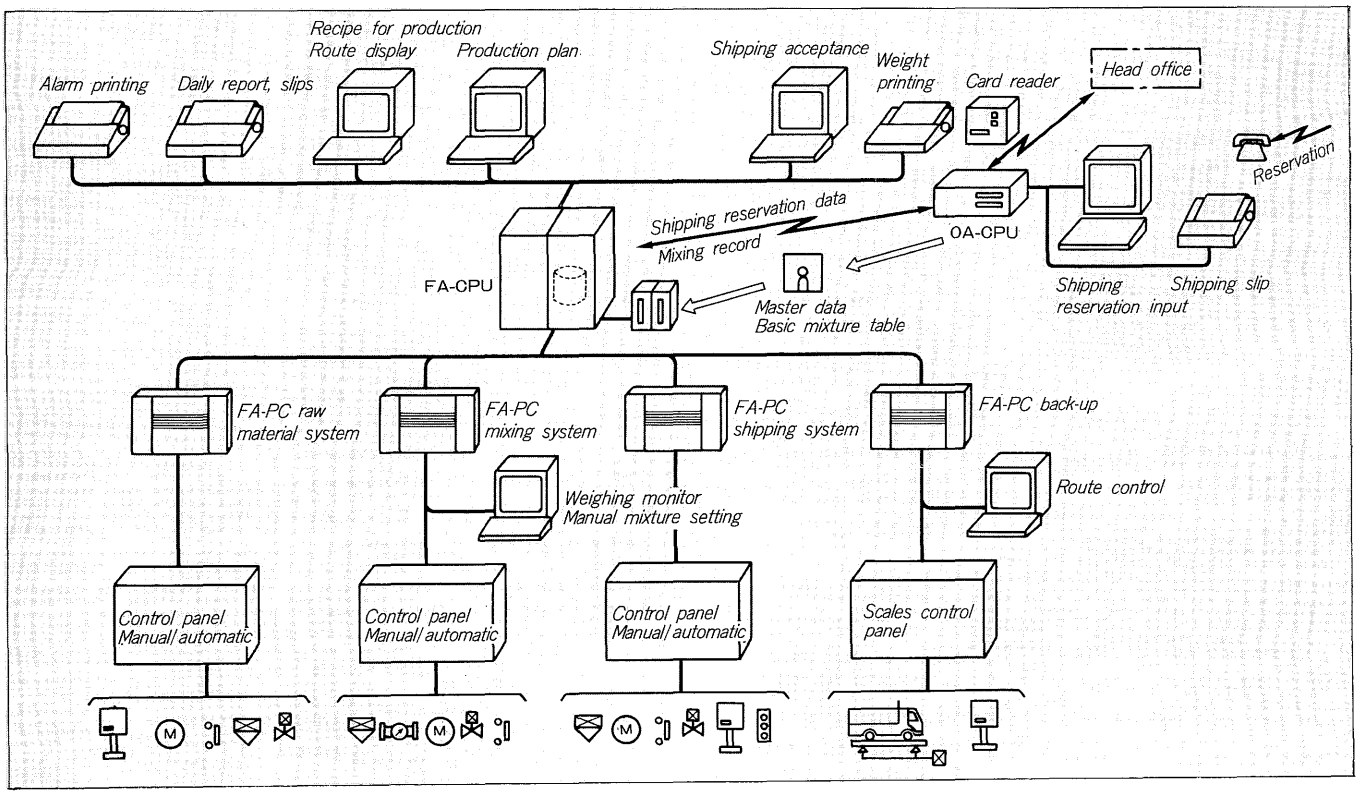
Since this facility produces livestock feed, the interruption of shipment for a long time is not allowed. Therefore, the system configuration is made a hierarchical configuration, distributed control system and consideration is given so that trouble at one controller does not have a wave effect on other parts.

Moreover, the data management and processing functions performed by computer and the control functions of the devices performed by PC are clearly separated and the data needed in control is downloaded to the PC in real-time so that operation can be continued even if trouble should occur in the computer.

3.2 Facilities expandability

Since the product demand trend, raw material procurement state, etc. must be dealt with quickly, facility modifications are frequent. Because renovation or expansion of existing facilities is accompanied by restrictions from various standpoints, a study at the system design

Fig. 2 System configuration



stage is an important point.

Because the independence of the computer and each PC is maintained with this system by using a high-speed LAN, its overall functions can be exhibited. Therefore, modifications can be made independently at each equipment. A PC is installed at each system so that expansion and renovation work can be performed at each system. A PC I/O section and power panel are installed at each site so that local renovation is possible.

3.3 System maintainability

Few factories have resident engineers who specialize in computers and other control equipment. In many cases, the factory facilities are maintained and managed by a number of persons in charge. Mechanization and systemization are performed with promotion of rationalization and various machines and controllers are introduced. On the other hand, the equipment itself is made more advanced and complex and, therefore, its handling, installation, and adjustment are more complex and a special knowledge is necessary.

Equipment repair is the responsibility of the manufacturer and rounding out of the service network is planned, but emergency countermeasures until the arrival of the service man at the site must be taken by the person responsible for maintenance of the factory.

Therefore, the system configuration is simplified so that detection of faulty parts and countermeasures can be performed easily. Moreover, equipment with RAS functions is used and unification of types is planned and load distribution is performed and an easy-to-use microcomputer for FA is used.

3.4 System economy

The dust from the raw materials and products accumulates or floats in the air around the machinery and facilities. If this dust enters and builds up in the controllers, overheating, insulation degradation, faulty contact of contacts, and other accidents may occur. Therefore, the installation of controllers at the site is undesirable.

However, there are such merits as (1) facility construction cost is low (electric room is unnecessary or is noticeably small, cable between center and site is small), (2) work and field adjustment period can be shortened, (3) when trouble occurs in the facility, it can be processed and checked at the site, etc. With this system, the PC I/O section and power panel are installed near the machinery and facilities. Complete dustproofing countermeasures were planned by implementing the following:

(1) The site panel was made dustproof with a drain.
(2) Contactless and sealed devices were used at the PC I/O section and wherever else possible.
(3) Relays difficult to make contactless were equipped with an operation display.

3.5 Back-up operability

Local stopping of the system is associated with a reduction of system functions. To maintain operation, operation different from normal is necessary and becomes a load on the operator. Usually, a large gap with the operation method at operation leads to erroneous operation. With a hierarchical system, since trouble at a high level device has a large effect, the back-up operation method at that time is a problem.

With this system, a special CRT man-machine interface for when the computer is stopped is installed so that similar type back-up operation can be performed without using the computer terminal. A simple graphic panel is also installed so that the operating status of the entire plant can be grasped at a glance and operation is easy.

4. SYSTEM FUNCTIONS

To save labor, automation of processing an weighing equipment and automation of the entire factory with integrated production plan, shipping plan, etc. are demanded. Its main functions are described here.

4.1 Raw material acceptance

A card system is used in accepting the raw materials brought in by truck and sent directly to tanks so that work can be performed by the operator only. At raw material delivery, a card on which the raw material was registered at a receiving CRT terminal is inserted into a card reader at the raw material hopper yard and the necessary conveyors and gates are operated and the route is automatically configured. As an interlock function, the receiving amount is checked at raw material registration at acceptance and whether or not reception is possible is judged and card lock is performed to prevent mixing of difference raw materials at the raw material tanks.

The raw material carried in by conveyor is automatically received at the silo or tank by receiving reservation at the central control room CRT terminal.

4.2 Schedule operation

The production plan for the day can be preregistered at a CRT terminal. The registered items are product code, number of production batches, product lot order, etc. The raw materials recipe and product storage tank are selected automatically and schedule operation is performed in accordance with the registered data. Before the start of operation of a lot, used materials inventory check and production order check are performed.

4.3 Automatic generation of recipe for production

The recipe of raw materials by product is unified at each company and within the company. However, since the facilities are different at each factory, when producing a product, it must be remade to a form suited to the facilities. The necessary mechanical constants are stored in a computer beforehand and are converted automatically by using the interactive screen of a CRT. Since the recipe changed each month, two generation management is per-

formed for old and new conversion.

4.4 Automatic operation of raw materials system

The amount of raw material in the mixing tank is monitored constantly by PC and the powder route is operated automatically according to the insufficient amount so that there is no raw material insufficiency. When there are several raw material tanks for the same product, the tanks are rotated and selected so that the raw material does not become unbalanced at a specific tank.

4.5 Automatic adjustment of mixture weighing error

The raw materials used in feed changes with the product produced and raw materials procurement conditions. When the raw material in the mixing tank changes, the weighing scales must be readjusted. However, normally, a control function is provided so that the weighing record is monitored and error becomes small automatically.

4.6 Shipment of loose product

For improved user service (holiday and night shipment) and rationalization, shipments can be made by card. For reserved products, the reservation contents and shipping dock are checked by dedicated acceptance counter and the products are supplied from the product tank and weighed and shipped automatically by dedicated user card at the specified shipping dock.

When several products are mixed, the shipping dock is selected automatically by computer so that truck movement is minimized so that several trucks are not concentrated at one place.

4.7 Facilities supervision and control

Three operation modes, normal operation, back-up operation, and independent operation, are provided. Except for the independent mode, remote operation is performed from the central control room. Data setting and registration are performed by CRT terminal interactive screen and system starting and stopping are performed by control desk switch. The operating status of the facoty facilities is graphically displayed by CRT.

Equipment trouble is displayed on a CRT and printed out.

4.8 Slip printing

Daily report and slip printing is performed for factory management and recording. The main items are:

(1) Master data printing
(2) Mixing weighing record
(3) Raw materials consumption forecast table
(4) Raw materials and product stock-in and stock-out daily report
(5) Product shipment daily report

5. CONCLUSION

With factory facilities, there are grading proportion control at raw material grinding, prevention of irregularities at liquid addition, warehouse location management, available percentage countermeasures, improvement of product uniformity and many other topics and a mountain of problems. There are also problems which can be dealt with by control system. However, the majority of these are sensor, machinery, work implementation, and similar problems. The guidance and cooperation of machine manufactures and industrialists, including users, is obtained and new technology and knowledge is incorporated and a system with more complex management and control functions is built.

Finally, the authors which to thank all those concerned for their guidance and cooperation in the development of mix-feed factory systems and devices in the past and ask for their continued support in the future.