CONTROL OF FURNACE CHARGE BY MICROCOMPUTER. NEW TECHNOLOGY

- PAULO EXPEDITO LIMA PIRES
Electrical and Instrumentacion Engineer
Engineering and Development Manager

- JOAQUIM NORONHA MONTEIRO JR.
Mechanical Engineer
Sales and Marketing Manager

- EIRICH INDUSTRIAL LTDA.
Estrada Velha de Itú, 1.500 (km 31 Rod. Castelo Branco)
06600 - Jandira - SP
Brasil

Post address : Caixa Postal, 7888
01051 - São Paulo - SP
Brasil

A B S T R A C T

The present essay describes a computer-control system being particularly suited for control of furnace charge in ferro-alloys plants (is possible use of sintering ores).
The central processing unit allows control of data computing, i.e. of proportioning and weighing, as well as control of process sequences. The proportioning data are stored in programmable memories. The process sequences too are programmed and stored in memories. Programming is effected via an alphanumeric keyboard using an easily learnable programming language. Comprehensive checks such as desired value and actual value checks are carried out. Recipe computations and recipe corrections are effected if a parameter of influence changes or if the batch quantity (partial quantity) changes.
Afterflow optimization for fine proportioning assures that the cutoff point is automatically adapted to the desired value in case of modifications in the flow properties of one component. The recording system allows recording of desired values and actual values as well as set-up of error and trouble records by means of page-printers and tape-printers. 2 systems are at option for indication of desired and actual values :
Individual figure indications or one common screen display unit with digital indication and analog tendendy display are avallable.
Optimum security is guaranteed by a separate module assuring continuous self-checking of the control system.
Photographs taken in plants equipped with described control system are shown for illustration.

INTRODUCTION

The use of manually operated installations for weighing and batching systems are outdated.
The quality, performance and operational safety require a new economical concept, which led to new equipments, that operate completely automatic and sometimes self-adjusting.
A large part of controls for furnace charging, operate nowadays, partly with relay technology and partly with traditional electronics. The recipe elements are stored on perfurated cards, digital switches, bar code programmers and similar systems. The modification of the recipe is a simple task. The disadvantage lies in the operational safety, because it does not satisfy completely. Many devices contain mechanical parts that are subject to wear. This wear refers not only to the recipe input but also to the complete control process when it is performed with relay technology.
One solution is give by the microcomputer technology through the microprocessor. With this technology it is possible to criate a large quantity of control equipment permitting a good approach in the price/performance rate and a high operational safety level.
In modern equipment manufacturing, the weighing techniques and the control techniques are very close.
Later is shown a control system specially designed for a furnace charging. This unit can be applied as a weighing program and also a process control. Firstly let us see some ideas about this subject :

To visualize a control operation is a simple task, it becomes very simple when divided in functional blocks as shown on Fig. 1.
This scheme shows a batching control line equipped with electro-mechanical scales. The sequence of the process is programmable through the memory.
The batching and weighing task, the comparison, of the expected real values (i.e. the processing data) and the expected input value (1) belong to the scales.
In the program execution are located the junctions and interlocks that enable the automatics to operate according to the program. The input times for the operation sequence of the installation (2) belongs to this section.
The power supply unit has the devides for the connection of the equipments (3).
The control part is the most important. In most cases there is a scheme form of circuit or synoptical.
For the weighing technique, mechanical scales or electro-mechanical scales are available. The electro-mechanical types can be pure or hybrids (Fig. 2) and often can be found the designation "electronic scales". The new standard, DIN 8112 "scales manufacturing standards" eliminate the conceptual confusion applied until now. This way it is obliged to be designated "electro-mechanical".
This standard presents the following definitions :

Mechanical scales are defined as the equipment where the weigh-force equilibrium of a material to be weighed and the force magnitude conversion in an observable output (display), is reached in purely mechanical way without the application of electrical components.
Electro-mechanical scales are defined as equipment where the weight-force equilibrium of a material to be weighed can be obtained in a mechanical or electro-mechanical way. In this case the force magnitude is converted in an electrical signal to be observed by an adequate conversor of measurement magnitudes and the output value achieved is shown electrically or electro-mechanically.
These standards created definite clear relations.
In a mechanical scale, the classic display head is known as the device to show the weight through mechanical linkages.

In the electro-mechanical scale the classic display head is known as the device that shows the weight. Usually from a potentiometer wheel supplies an analogous form of the current value, i.e. the output signal.
In electronic scales, the analogous signal of measurement is supplied by load cells and is amplified by a measurement amplifier digitalized and displayed.
Both electric systems can be controlled by computer control unit EZ-85. This makes it possible to equip this new control unit to existing weighing installations.
For new installation usually electro-mechanical scales are specified.

1.1 The Microcomputer

The most important component of this technology is the microcomputer.
In specialized literature, the micro-computer is usually defined as "the unit with complete structure and operational capability for data processing". Through special Input/ Output circuits, the microcomputer is surrounded by peripheral units, in our case with machines and handling equipment that executes the decisions and functions according to the stored program. The microprocessor is the computer process unit and consists of a unique module totally integrated, but it is unable operated by itself. It is only activated in conjunction with the other microprocessor modules, for instance, with the memories. As a microcomputer brain, the microprocessor executes the central control of processing, deciding and administrating. The revolutionary point in the micro-processor consists in the capability to be programmed and this program can be stored and rapidly executed in sequence, contrary to the conventional control systems that process in parallel all operation.

Consequently the hardware expense is higher (using electrical components).
The principal parts of the computer are (Fig. 03) :

- Functional Blocks
- Memory
- Central Unit
- Input / Output modules

The memory (it can be assumed as the computer file) contains two different storage blocks :

- The ROM memory program (Read Only Memory)
- The RAM operating memory (Reading and Writing Memory)

It is important to separate strictly those two memory types :
The existing program memory remains inalterable and can not be modified. The ROM designation (Read Only Memory) i.e. only reading memory, it indicates this clearly. On the other hand in the operating memory it is possible to store informations and later on, it is possible to call and modify those informations. The RAM designation (Random Access Memory) can be understood as writing and reading memory.
Summarizing :
The RAM memory data can be modified, the ROM memory data can not.
Our pocket calculator machine has a memory system. The maximum capacity reaches 30 numbers. On the contrary, the computer memory system has some thousands data and words capacity. However it is conclusive the fact that the memory is programmable.
Others considerations about hardware, i.e. about the mechanicals elements of the microprocessor designated as "Mops". It consists of a unique integrated module so called "CHIP". The integration step is about 5.000 transistorized functions.
The linkage of these functions it is determined by the resident program in the semiconductors memory.
The data memory contains all datas such as for low and high speed weighing, anticipated switching off and the tolerance control.
The recipe memory contains the recipes data with the expected weights. It can be compared, for instance, with the perfurated cards of conventional control systems.
The control system unit EZ-85, operates with automatic zero taring. This way the weighing is not done in additive form.
Before the weighing of any component, i.e. at the beginning of weighing, the existing weight value is zeroed. This way the dosing accumulative errors can be avoided.
After the last component of a scale weighing it is shown the total weight of all the weighed components.

Data processing (batching and weighing)

The advantages of microprocessor favours the new batching/weighing control unit with computer EZ-85, where the charge preparation in a ferro-alloy factory is controlled in accordance to this scheme.

Considering the multiple operation, it results a considerable cost reduction related to the traditional systems of individual computer, compared to a superior computer who commands. The constructive structure of this system is represented by the blocks diagram as shown on Fig. 4.

The central unit with the computer, constitues the frame of the automatization.

The processing speed of the micro-processor it is aproximately 1/1.000 second. This results in a average cycle of a scale signal of 50 times per second.

In other words :

Each signal which enters the real value of a scale, it is compared 2,5 times per second with an expected stored value.

It is possible to connect mechanical scales with an output signal using potentiometer as well as with electro-mechanical scales with load cells.

The measurement cables of load cells can be directly connected without a pre-amplifier because the system contains integrated amplification modules.

Futhermore, are existing inputs for the impulses emissor, for instance, in volumetric batching equipment.

In the memories which are protected against lack of energy, are stored all the necessary values for the operation of the weighing system operation.

These values are introduced through the keyboard and at the same time are shown in the video (monitor). All data can be modified at any time. The data which can be modified only by the responsible operator, can be protected by locking safe.

All data can be printed or documented by tape printer or text printer.

The program memory has a fixed sequence of execution which the computer executes with precision for operation of the equipment.

The central unit with the micro-processor selects from the file the program. The central unit respondes to this program and uses a separated task memory as so-called "note-book" if the results or intermediary functions must be only registered for the execution of the operation after using it can be erased or issued in graphics. This program memory is really the most important control unit of the computer.

2.1 Expected control values

After calling a recipe from the ingredients memory, the process computer adds all the recipe datas and compares the results with the stored values of the control of this recipe. If these two values are not equal to the use of this recipe it is blocked and the error is registered and printed with the expected value.

The difference between the real batching and the predetermined value is processed for the optimization in the complementary execution. A deviation beyond the prefixed tolerance, introduces an automatic alteration of the interruption points of the next batching, i.e., a gradual modification of the interruption point. This way, in spite of an eventual modification of the flow characteristic of the component, the batching precision will be excellent (Fig. 5). Most important is the tolerance-control.

The stored tolerances, define the maximum allowable deviation of the current weight relative to the expected value of each separately component. If it not reached or if it is exceede, the weighing process of this scale will be immediately interrupted. A flashing signal indicates the situation. Now the operation personnel can decide if this batch must be corrected or rejected. After an eventual correction, the batch is descharged by a special release. The program continues automatically. The register of errors is automatically issued, indicating the real rejected values and the expected recipe values as well the component specification, confirming the errors. This register is issued with date and time.

This way any irregularity is identified and documented.

The control is recommended for furnace charging or sintering plants. In this cases the notes monitor is important, considering the organization point of view and the time saving.

At the start of the shift the daily program can be done indicating the delivery lots and the different elements of the recipe. The processing takes place according to the priority order introduced.

The lots selection it is independent of the charge size. In order to reach a desirable total quantity, the system divides the last two batches in partial and equal batches while the other batches are processed as total batches (partial batch).

For instance :

Lot of desirable delivery ..... 20 t
Charge capacity ..... 1,5 t
are processed :
12 total batches of 1,5 each ..... 18 t
2 partial batches of 1,0 t each .. 2 t

The process is automatically guaranteed that it will not be below the prefixed minimum quantity with technical reasons.

The monitor video shows which batch can be found in the weighing phase, which is in the scales, in the furnace or in the transportsystem.

The note monitor and the printer contribute with a considerable rationalization effect in the charging of furnaces.

2.2 Self-adjusting

With the self-checking characteristics of the system, the equipment does a self verification, step by step starting at the central unit till the own outputs. All the outputs are led through the input level. If a defective unit is detected, a register through the printer will be issued. This form the corresponding insertion card can be detected and replaced. This self-adjusting system can include a big part of constructive unit, so that the maintenance service becomes very simple.

2.3 Automatic Correction of Coal and Water

When moist coal is processed, it exists the possibility to correct automatically the coal weight according to the own moistcontend. Based on the recipe data, the dry weight of the coal and the total weight with water are presented. The coal and water correction can be calculated based on the moisture of coal to be dosed and the reduction of the weight of the water.

The main distinguished characteristic of this control is the video (Fig. 6) which a new control generation by computer can be provided. This video offers the alternative of a defined colour of each scale. The values representation of weights is digitally done with the corresponding symbols such as kilogram, second or liter. At the beginning of the batching is introduced the expected value, so that at the end of batching is possible a visual control comparing the expected and real value.

The supervision becomes simple because on the video are shown others information about the operational status of the equipments.

Such as :

- Weight equilibrium
- Full scale
- The scale is discharged
- Empty scale

A particularity is the combination of digital projection with an analogic bar on the video. At the dosing start, marks are placed in the analogic bar of the expected value in addition to the introduced expected weight. During the dosing, the bar increases analogically from left to right corresponding to the dosing performance. Throught this "tendency" it is possible to have a general vision of operation as well as the operational equipment status.

Instead video, can provide also equipment with separate displays i.e. a display for each scale and they are adequately disposed in a synoptical panel.

2.4 -FK System

This system is composed by a device connected to a microcomputer. The device is introduced few seconds inside the coal before preparation. After the coal is been homogenized inside the bin or mixer, the collected data with this insertion referring to the coal moisture and it residual temperature are transmitted to the microcomputer, which defines the coal quantity to be added according to the prefixed final weight.
A graphic it is shown in the computer and the operator can control the required coal quality using two simple push-buttons with addition or subtraction indication.
The adjust of this device with the coal characteristics is done by the angular displacement of a straight line that is shown on the video.

2.5 Register

The register system represents a very important unit. All the operational procedure of the installation can be printed on a paper tape printer or the text printer. The expected values as well the real values of all batches can be printed.
Normally in practice only the types of error are registered and it is always done with date and time. At any time all recipes dates which are in the stored memory can be found through the printer.

2.6 Consumption Data

The components quantity dosed already used, are automatically allocated by components and stored in the memory of consumption data.
These data can be recuperated and shown in the video or printed through the printer.
Futhermore, the values of consumption can be storaged in a disk memory. For instance, at the end of a work-shift, the disk also named "Flopy disk", can be collected and placed in to the CPD disposition for subsequent application.
Alternatively it exists the feasibility of a online operation with the computer.

3. Programable Process Control with Memory

The process control, i.e. all blockings and sequences are taken care of by the control unit of computer EZ-85.
In a conventional controlsystem the processing is programmed by means of interconnection, i.e., the necessary elements in accordance with the diagram of the circuit : contactors, relays, time components, counting components, limit switches as well as inputs and outputs are interconnected by wiring according to the program execution.

Changes in the program are possibles by modifying the connections; to increase the program it is possible by addition of new modules.
On the opposite, in a programmed system with memory, the program is stored in memories, i.e., from the technical point of view of control, the sequences of the input/output functions takes on the memory contents in tead of a wire connection.
In simple words :
The programmed contents or the memory establishes "who, with whom, and when".
Frequently can be found the designation "freely programmable" this expression really does not seem adequate since in practice each programmed control with connection can also be up to a certain point, programmed freely, i.e., by modifying the connections or by means of selected circuits, perfurated cards, insert cards, insert fields and similares.
For furnace charging, the advantage of programmable process control with memory through the EZ-85 unit is that the control can be designed and structured as soon as the mechanical construction of the equipment is defined. The program, itself is necessary and developed only at the end.
Practically, it can be recorded as soon it is on the simulator. The recording is performed in a memotechnical language of easy understanding. The start-up of the program is shown on the video or printed by means of a printer. Even during the start-up or later, modifications can be introduced with a certain facility, only through the software, without restructuring the control unit.
The programming and modification of the processing are done by means of RAM memories (Random Access Memory). Its contents are rerecorded later on memories ROM (Read Only Memory), that way the content are protected for ever, even in case of lack of energy.
The contents of the program can be transferred to a casette tape by means of a casette recorder. The tape is kept by the manufacturer of the control unit, together with the project documentation. So, in case there should be any changes and expansions, the manufacturer can generate a new program and furnish it to the customer.
Summarizing, the advantages of the programmable system with interconnection are :
- The program can be developed in a short time, for example, during the start-up
- The process can be modified in a short time without hardware modification
- Also the extension of the program can be done in a short time. This point is important when the installation is built by parts
- Each set of inputs has its "optimum" time for development
- Easy interlocking
- Higher commutation frequency
- Longer useful life, since all control functions are electronical parts that is no wear
- No noise in the control area
- Less area needed for installation.

The modules are submitted to several tests. In the furnace besides the resistance test to temperature, a premature aging is done. Mechanical resistance tests are performed on vibrating devices, so, any deficiencies of the modules are

identified long before delivery.
The modular design allows, in case of failure, a simple change of the modules of low cost. Trouble searches becomes easy by means of the self-adjusting already described. The operation of furnace charging, using the computarized control unit is very easy. Control desks or panel can be used.

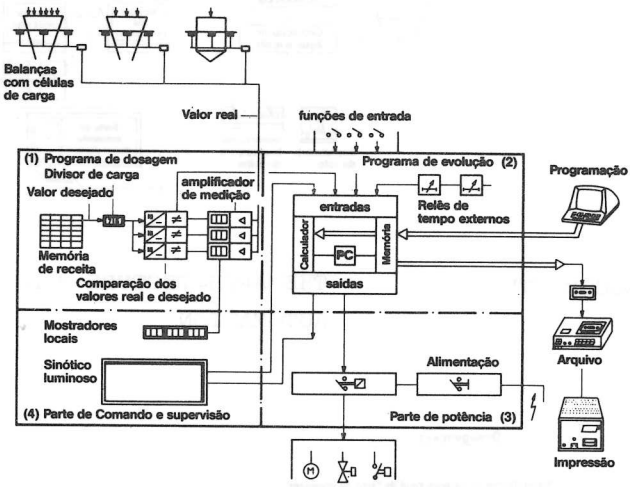

Fig. 1

FIG. 1 - DIAGRAM OF A WEIGHING INSTALLATION

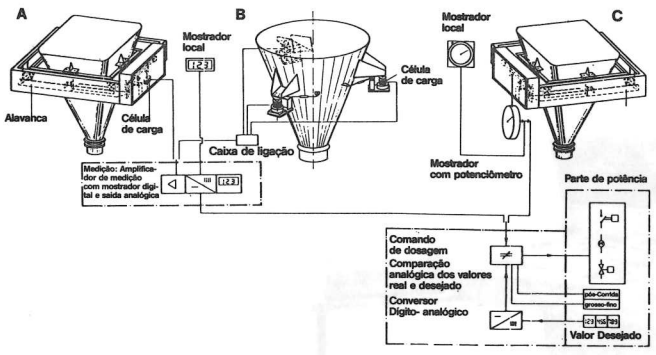

Fig. 2

FIG. 2 - SCHEMATIC REPRESENTATION OF MECHANICAL AND ELECTRO-MECHANICAL WEIGHING TECHNIQUES

Fig. 3

BLOCK -DIAGRAM OF A MICROCOMPUTER

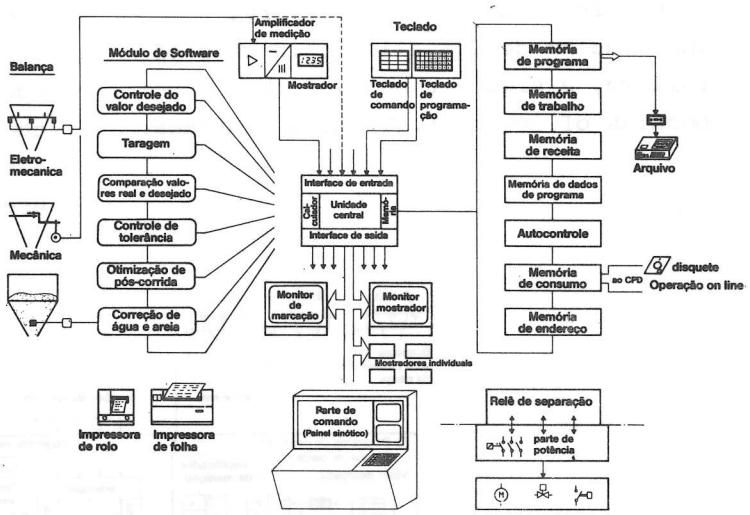

Fig. 4

THE ARCHITECTURE MADE BY COMPUTER OF AUTOMATION

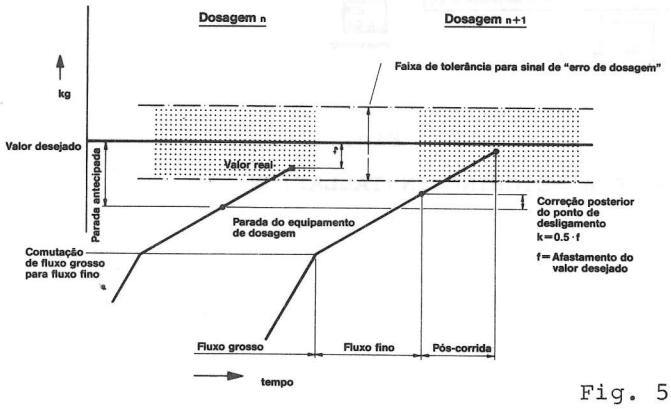

Fig. 5

TOLERANCE CONTROL WITH OPTIMIZATION OF THE COMPENSATION OF FREE FALL MATERIAL

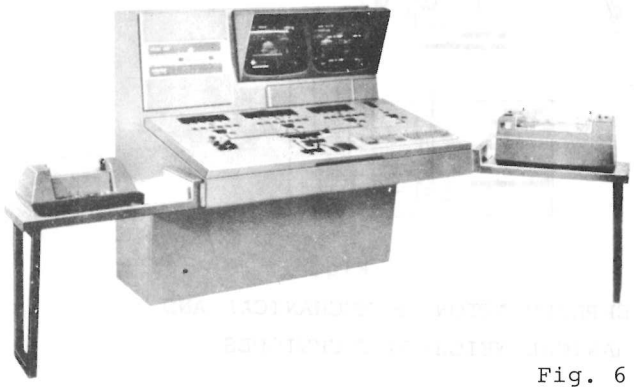

Fig. 6 CONTROLES WITH VIDEO AND PRINTER