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USE OF PROCESS MANAGEMENT COMPUTER IN SYLVINITE THERMAL TREATMENT AT ALSACE POTASH MINE*

J.P. Rulleau
Mines de Potasse d'Alsace, France

RESUME

La potasse produite en France provient exclusivement du bassin alsacien, qui est exploité par les Mines de Potasse d'Alsace (MDPA) filiale de l'Entreprise Minière et Chimique (EMC), établissement public à caractère industriel et commercial.

Après extraction, le minerai potassique est traité dans des "fabriques" au moyen de procédés de séparation physique afin d'obtenir le chlorure de potassium, KCl. Celui-ci est essentiellement utilisé dans l'industrie des engrais.

Le début de l'extraction de la potasse du sous-sol alsacien remonte à 1910. Les MDPA ont actuellement une capacité d'extraction d'environ 7 000 000 de tonnes de minerai brut, représentant une production après traitement d'environ 1 500 000 tonnes de chlorure de potassium.

L'un des deux centres de production de MDPA, la Mine Marie-Louise, traite par voie thermique plus de la moitié du minerai extrait.

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1. CONTRIBUTION OF DIGITAL INSTRUMENTATION

The main qualities of these industrial systems are the following:

- **Easy adjustment to the specific mining requirements**
- **Easy monitoring by the attendants in the control room**

- The system informs of the events and state of the treatment process in a way that facilitates the analysis of the operation.
- The dialogue operator-system enables such a management that the process is easy to monitor correctly (and difficult to monitor incorrectly).
- In addition, the system can later ensure the digital regulation of new loops.

The digital system enables an easy extension of existing units or the addition of new units.

The system can adapt to modifications without the need to make new cuts in the existing tables and screens, to wait for the delivery of new equipment, to modify the cables or to wait for a long stop (vacations) of the operational sector to carry out the modification.

In those systems, since the set-up is memorized as instructions form and not as cabled materials with wire, the changes are easily and quickly made by modification of the programme.

The system has visualization consoles which give the operator an overall view on sector by sector of the mine. Parameters can be put together logically so that the operator's attention can be drawn on the information which actually reflect the state of good (or bad) operation of the process of manufacture.

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The alarms are displayed as soon as they appear on the screen, whatever the information which the operator is watching. The system keeps in memory all the existing alarms which the operator can consult at any time. Thus, the afternoon shift, for example, knows exactly what abnomaly happened in the morning. The alarms are also printed in chronological order.

These documents are also very useful for those responsible of the mining, for further study, and also very often, to the maintenance service in case of dispute or failure of the equipment: pumps, engines, catchers, etc.

The key to improve the operation is to realize what is working well or not. Relying on the recorded diagrams, or the recollection of any of the control room attendants, to know which alarm started first in an operation incident, or even the information appearing on note books of the control room can often be criticized as incomplete and far from satisfactory.

The chronological recording programmes of a digital system presents the process information on a well displayed and easy to read control panel.

The alarm boards present the incidents comprehensively and accurately. No information is missing, there is no uncertainty concerning the progress of events.

2. PRINCIPLE OF THE SYSTEM ADOPTED AT MDPA

2.1. History

Before 1955, all the operational pieces of equipment were controlled manually, visually by numerous attendants and operators.

In 1955 and until 1970, a few measuring instruments and simple regulation loops were installed. The technology of the equipment was based on electrical then mainly pneumatical systems. Control systems were many and specific to the different sectors of operation.

A big step forward was made in 1972 as the treatment plant of Marie-Louise mine was equipped with a centralized control room with electronic analogue instrumentation. For the first time, all the equipment of the plant could be controlled and monitored from a unique spot allowing a better overall view and a more uniform management.

A Siemens-Teleperm, type AS 230 automation-system was set up in 1983. This system is designed to do some regulation by computer calculation on the basis of parameters coming from sensors connected with the system.

With regard to hardware, the system includes a central unit which contains a real time processor plus the normal peripherals (screens, keyboards, printer and disk drive).

The in/out modules achieve the conversion analogue digitally and vice-versa.

Regulation modules with local micro-processor permits continued operation in case of failure of the central unit. In that case, the regulation loops become independent and the control room attendant displays the instructions individually on the different loops as if they were regulated by conventional boards.

In 1989, a supervisor (OS262) was added to complete the control-monitoring. It enables to take care of all the logical controls coupled with the programmable automates.

The structure and the operation of the system do not need any particular electronic or programming knowledge of the operators of the plant. The basic software is mostly built on predesigned software blocks.

It is possible to call on the screens all the software blocks implemented by the user and thus to visualize all the data concerning the process and the set-up (parameters, thresholds, links, instantaneous measured values, etc.).

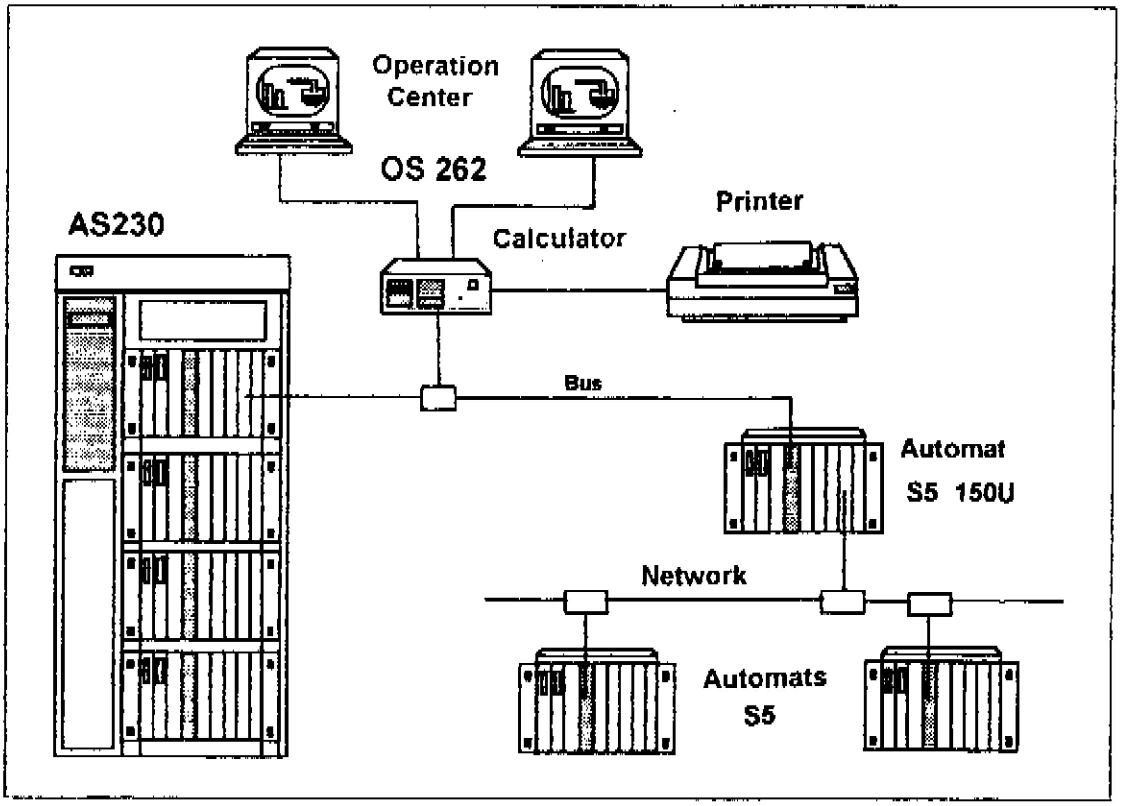

Figure 1 : Present system

A simplified keyboard is associated with the configuration alpha-numerical keyboard, allowing the attendant to visualize on the screen the different views of control and monitoring.

2.2. Measurement sensors

Obviously such a system can be fully efficient only if the sensors connected with the process give a good image of its conditions. But collecting good information depends on different factors:

- Sensors must be set up so that the data obtained are representative. Indeed, a temperature probe, for example, influenced by an environment other than the one under investigation will give an erroneous measurement disturbing the control.

- Sensors must be selected for their reliability according to the environment in which they operate.

- Sensors must be carefully and regularly maintained. This implies periodical dismantling to control the measuring device and replace it if necessary.

To some extent, the system enables, through cross-checking and calculations, to make up for failures of the sensors.

A number of analyses previously carried out by the laboratory are done continuously with different means (flame photometry, selective electrodes, gammametry, ...).

3. PRACTICAL APPLICATION OF THE DIGITAL SYSTEM CONTROL

3.1. Treatment process

Potash ore processed in the Marie-Louise plant contains about 24% KCl, 58% NaCl and 18% insolubles.

The treatment process used is leaching or selective dissolution. It is based on the solubility of the two salts present, KCl and NaCl, at 30°C and 100°C. For that reason, it is called thermal process

Principle (See Figure 2)

The thermal process is based on the possibility of separation of KCl from NaCl and the insoluble by dissolving KCl only when the potash ore is mixed with a required amount of mother liquor at 100°C. Mother liquor means the aqueous solution containing already KCl and NaCl at concentrations corresponding to the double saturation of the two salts at 30°C. Required amount means the amount of mother liquor able to dissolve at 100°C entirely and at saturation the amount of KCl present in the sylvinite processed. The solution obtained at 100°C by dissolution of KCl at saturation is called brine.

The "dissolution" is achieved in cylindrical tanks, displayed horizontally in which the crude salt and the hot mother liquor flow countercurrently, a mechanical mixing promoting the dissolution of KCl contained in the crude salt. Out of the dissolution tanks, there is a brine on the one hand and solid residues on the other, made of NaCl primarily (about 80%) and insoluble clay materials.

After residue removal and brine clarification, the latter flows to crystallization where it is cooled from 100°C to 30°C by partial evaporation at a reduced pressure. The slurry obtained is made of mother liquor and solid KCl which is separated to obtain the standard KCl containing 60% K_2O or 95% KCl.

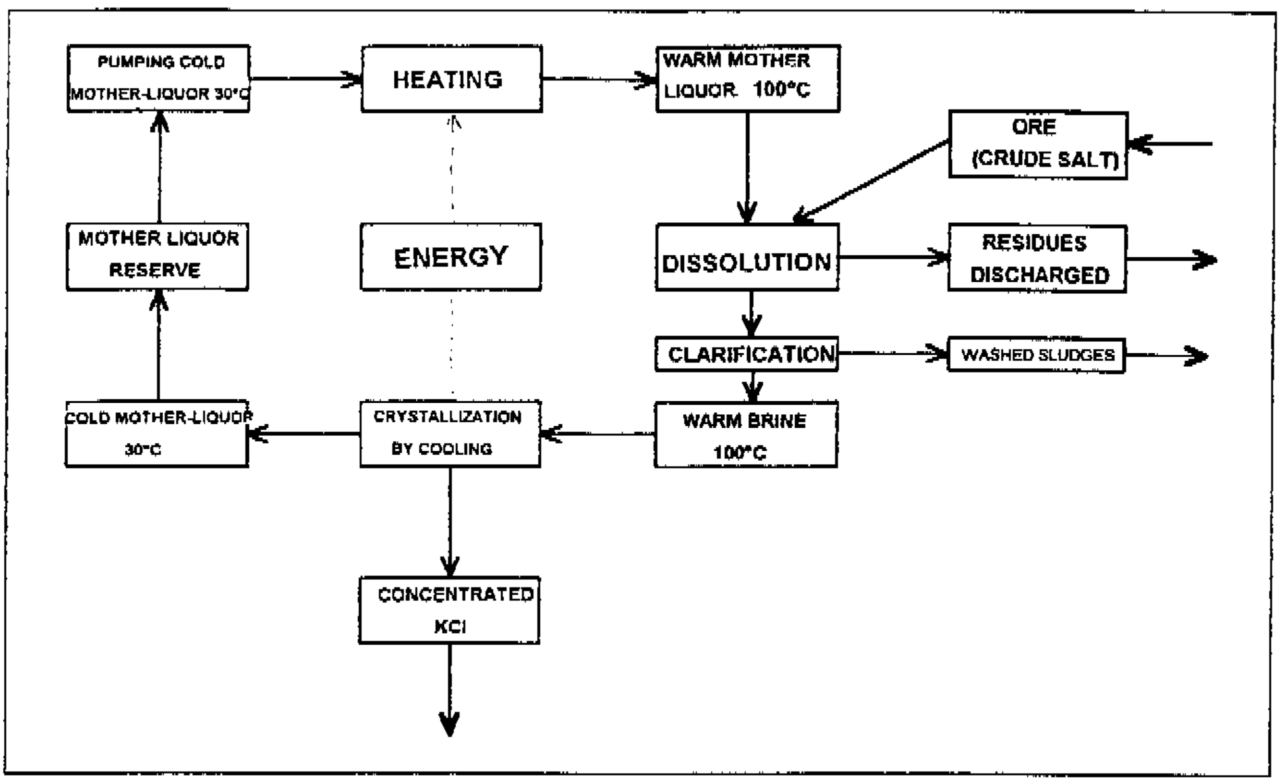

Figure 2 : Manufacture cycle of KCl by the thermal process

The collected mother liquor is then available to start a new treatment cycle. Crystallization under vacuum enables to recover much of the energy contained in the brine to heat up the mother liquor before dissolution. An energy make up, supplied as steam is, however, necessary.

The processing capacity of the plant is 20 000 t/d ore. The production of standard chloride obtained with an efficiency exceeding 92.5% is about 5 000 t/d.

3.2. Objectives of plant management

These objectives are essentially:

- to process a maximum hourly tonnage
- to achieve the best production efficiency (and, consequently, the lowest possible losses through residues)
- to obtain the concentrate produced with a minimum range of content relative to the commercial standard.

The factors which enable to reach these objectives are interrelated: there is a problem of optimization which could be solved by the use of a computer to manage the process.

On the other hand, it is not necessary to integrate all the existing regulation loops. Optimization concerns a number of sectors dealt with in priority:

The computer enables to act at two levels:

- at the regulation level, the calculator enables to get closer to the limits set by the equipment. It contributes to improve the daily output and the efficiency
- at the process optimization level, the power of the calculator enables to modify easily the regulation diagram and to study the methods of application. The theoretical models of the process are thus quickly checked and improved.

3.3. Sectors of the plant taken over by the system

The operation sectors taken over by the system are the following:

- dissolution
- crude salt supply
- distribution of mother liquor and brine
- management of the stock of mother liquor and the use of available water
- regulation of the chloride content, 60% standard K_2O
- spin drying and drying of the standard chloride
- control of samplers for continuous photometry analysis
- production plant of snow clearing salt

3.3.1. Dissolution

Dissolution is essential for the smooth operation of a treatment plant for several reasons:

- the production efficiency largely depends on the quality of the brine, in view of the direct influence of the latter on the KCl losses in solid residues
- the maximum capacity of the equipment to remove solid residues with a chain and bucket elevator without stuffing hazards would directly influence the possible treatment level of the dissolver. Obviously, the tonnage of solid residues depends on the KCl content of the crude salt.
- the maximum treatment capacity of the brine by the vacuum crystallization lines can also limit the level of treatment in the case of a high KCl content of the crude salt.

The purpose of the regulation of the two dissolvers is to obtain a brine with an optimum saturation rate. This optimum results from a compromise between the required quality of the brine under crystallization and the exhaustion of the residue.

The driving of these dissolvers was achieved by two distinct analogue loops **(See Figure 3)**:

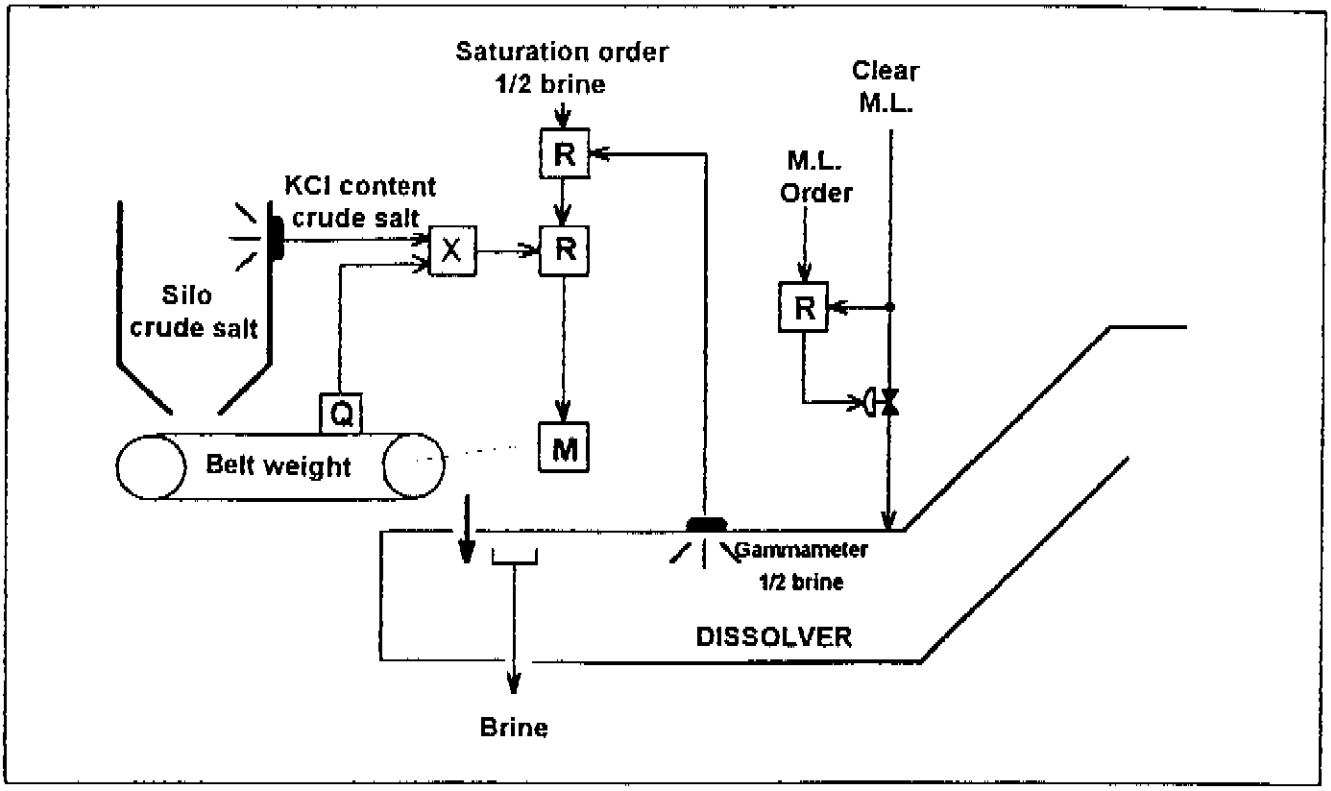

Figure 3: Monitoring of a dissolver before installation of an automatization system

- one assuring a constant mother liquor flow following the instruction displayed by the attendant
- the other including two regulators installed a cascade, the first recovering an instruction of saturation displayed by the attendants. This regulator, according to the actual concentration of the brine measured by gammametry in one spot of the dissolver, works out a KCl output instruction, which is applied to the second regulator. The latter receives as a measure the actual KCl output obtained by the product "KCl content x crude salt output" carried out by a Hall effect analogue multiplier. The output of this regulator controls the speed of the belt weigher supplying crude salt to the dissolver.

The control room attendant thus displayed the saturation instruction and sets the treatment level by controlling the mother liquor flow. Informed by the dissolver attendant on the load level of the residue elevators, he modified the instructions according to the KCl content of the treated ore. But there was no optimization.

Since the installation of a Teleperm automation system, the optimization of the operation of dissolvers takes place at two levels **(See Figure 4)**:

- the level of treatment
- the quality of the brine and of the residues

Level of treatment

The level of treatment is limited first by the maximum capacity of solid residues disposal, second by the maximum flow of brine to be treated downstream. To obtain an optimum level of treatment, one should be permanently at the level of one of the limits.

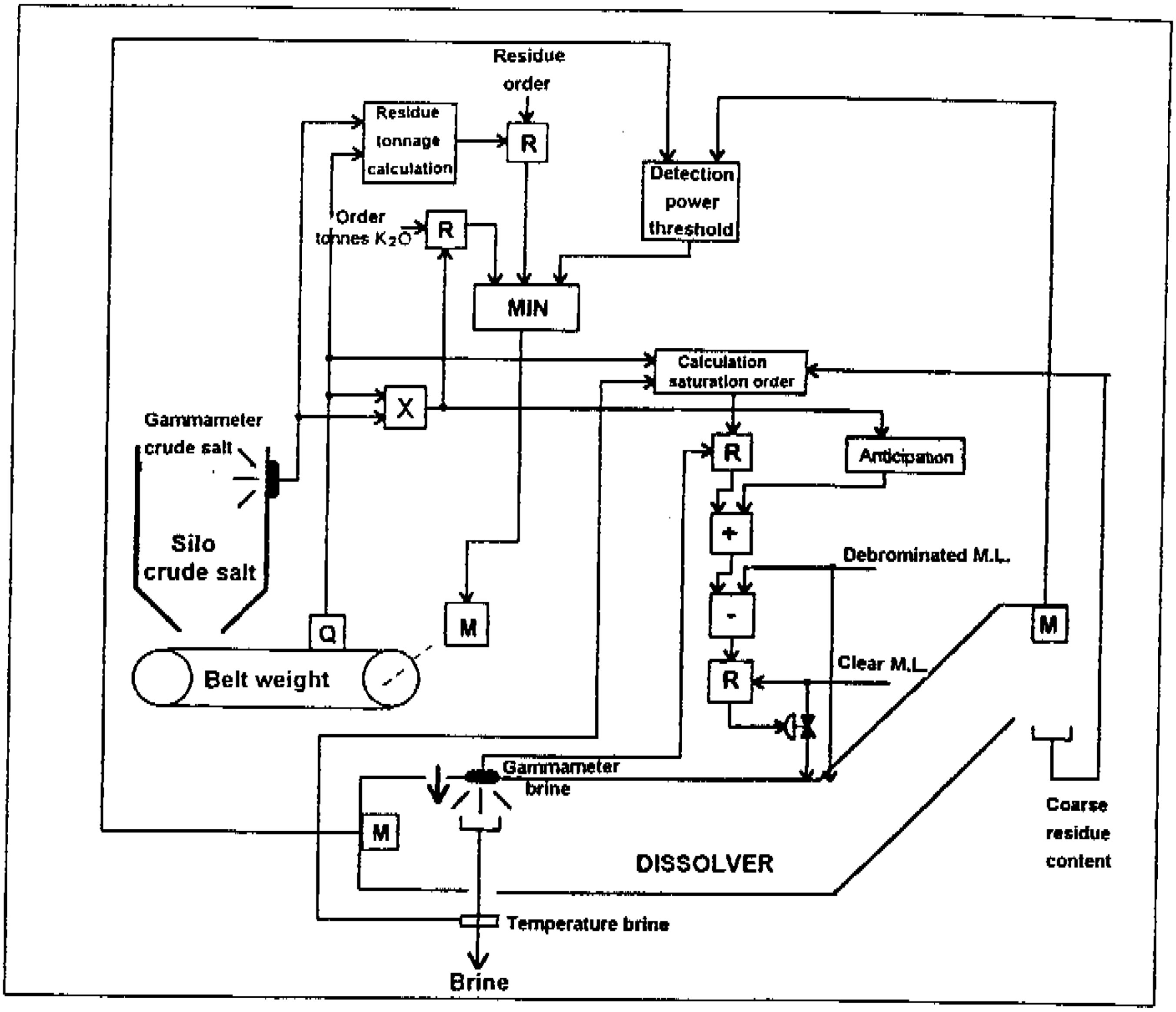

Figure 4: Monitoring of a dissolver after installation of the automatization system

The two physical limits are materialized by two different regulators, one receiving KCl tonnage instructions and the other the output of disposal of solid residues. Any time, the lower output is valid and controls the belt weighter.

Quality of the brine and residues

The instruction of brine concentration is a dynamic variable depending on various measured parameters:

- temperature of the brine leaving the dissolvers
- flow of crude salt entering the dissolvers
- KCl content of coarse residues leaving the dissolvers

Whatever the level of treatment, the amount of mother liquor introduced in the dissolver must allow to obtain a brine of that quality.

The operation of the equipment becomes very simple since the attendant can only act on the KCl flow and residue tonnage instructions. However, he can recover the control at any time to act directly on other parameters if need be.

3.3.2. Other applications

3.3.2.1. Crude salt supply of dissolvers

The system controls the rotation speed of the two extractors getting the crude salt to under flow from the homogenisation bin in relation to the feeding rate of the two dissolvers. The regulation diagram adopted enabled to improve the stability of the loop in spite of an important slack period and the low capacity of the silo feeding the dissolvers.

3.3.2.2. Distribution of mother liquors and brine

The purpose of the regulation is to keep constant the levels of the warm mother liquor tank feeding the dissolution and the brine tank in spite of important variations of the flow due to the regulation of the dissolution put in operation. The calculator works out the instructions of cold mother liquor flow of each crystallization line in relation to the total warm mother liquor requirements of the dissolution. In addition, its calculates the corresponding brine flows to comply as much as possible with the M.L./brine ratio on each crystallization line.

3.3.2.3. Management of the mother liquor stock

The purpose of this regulation is to maintain to the level required of the mother liquor stock by controlling the flow of waste washing water.

The total M.L. volume is estimated by measuring the levels of the tanks.

The parameters controlling the wash flows are:

- the difference of the volume of M.L. stock desired and existing
- the tonnage of residues disposed of.

This management enables to control the evolution of M.L. stock, to find out the anomalies and to obtain a rational and regular usage of wash water.

3.3.2.4. Adjustment of the content of the concentrate produced

The adjustment of the content of the concentrate produced is obtained by water injection in the crystallization sector. On our three crystallization lines, the amount required is calculated as exactly as possible considering:

- the temperature differential between the inlet and the outlet of crystallization lines
- the KCl content of the brine
- the flow of the brine

In addition, water injections in the Lurgi crystallization line are achieved in a sequential way in the empty tanks. The cycle was arranged so as to control as efficiently as possible encrusting.

3.3.2.5. Snow clearing salt production plant

This plant, which started up in 1989, was entirely taken over by OS262 with programmable automates. The start and stop sequences, the operation control are monitored from the centralized control room. This automatized operation can work without staff.

5. RESULTS AND CONCLUSIONS

The digital system of control-monitoring is an efficient tool which was well integrated in the existing control room (compatibility with the existing equipment). It enabled to improve quantitatively and qualitatively the treatment of our ore.

The average treatment level of the plant was noticeably increased without modification of the existing installations. All things equal, the increase of the level is 15%, of which 10% is due directly to the system. The remainder is due indirectly to it owing to the improvement of the knowledge of the plant resulting from its implementation.

After reaching 20,000 t/d for the first time in 1984, the average level of treatment even now exceeds 23,000 t/d crude salt, 16% K_2O.

The processing efficiency increased by 2 points owing to:

- the improvement of the residues coming out of the dissolvers, the KCl content of which now varies from 1.2 to 1.4% instead of about 1.8-2% formerly.
- the rational use of the available water amount within the mother liquor cycle
- the regularity of operation of the plant and the consistency of the operation of the various sectors of the installation.

This system resulted in very positive results for a total investment of about 2 million francs. In addition, we devoted much time in investigations for the adjustments done in close co-operation between the operation and regulation control services. It also requires a very strict maintenance of all the equipment connected with the system, in particular the sensors.