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PRACTICAL ASPECTS OF OPERATION OF A GRANULATION PLANT FOR NPK FERTILISERS OF 1000 TM/DAY.

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SUMMARY

Based on experience over the last 20 years as a manufacturer of fertiliser, and on a continual and dynamic application to the study and development of processes, E.R.T. has acquired sufficient technology to allow it to plan and construct granulation plants for NPK fertilisers that have high production output (1000 or greater Tm/day) coupled with regularity of operation, high standard of constancy and quality of product and very high transformation yields.

This report analyses and describes the process of one of the plants constructed with E.R.T. technology, which is operating at the present time and which has served as a basis for the study carried out, and also as a means of testing the model established in order to simulate the operation of this type of installation, serving, therefore, as a base for its design.

The E.R.T. process incorporates and synthesises almost all the modern conventional systems for fertiliser granulation, and gives an excellent constancy of quality and of production output, with a remarkable flexibility in the formulations and equilibria as well as in the utilisation of premanufactured primary materials.

INTRODUCTION AND PURPOSE

The aim of the E.R.T. granulation process is the production of high concentration fertilisers, utilising urea and superphosphates, and phosphoric acids and ammonia in devices like the pug-mill, pipe-cross-reactor and sparger of our own design.

Urea has been used in the manufacture of granulated fertilisers for something more than 20 years, and it plays a limited role in the different processes, serving only to complement other sources of nitrogen such as ammonium sulphate.

In fact, Du Pont, in 1955, published some studies on the combined use of urea and simple superphosphate, though the former was used in the form of ammoniacal solutions. T.V.A., in 1958, published studies on the storage properties of certain U.SSP formulations, postulating and discussed caking mechanisms for the products.

In the same year (1958), I.C.I. took out a patent on the production of fertiliser formulations based on U.SSP mixtures up to maximum proportions of 20% urea and utilising classical means of granulation.

In 1961, the Technical Meeting of I.S.M.A. presented a new contribution to the use of ammoniacal solutions of urea in conjunction with superphosphates. This and other contemporaneous reports demonstrated, with variable degree of comprehension and quantification, that the U.SSP system has adverse adhesion characteristics during the course of granulation and drying. Many of these reports pointed out that the problem is ameliorated if the free-acid content of the superphosphates is either totally or partially netralised.

In another direction, the T.V.A. initiated, in 1964, an important pilot study of the urea-MAP system, the resumé of which we were able to study in the Mixed Technical and Agronomic Meeting od I.S.M.A. in Stressa in 1967.

Gupta and Rao reported laboratory-scale trials on different formulations of NPK fertilisers based on SSP, urea, DAP, CLK (1969). They attribute the adhesive properties of U-SP mixtures to the reduction of the free-acid content of the SSP by the presence of DAP, and registered a loss of water-solubility of the P_2O_5 as a result of the given SSP-DAP reaction.

In 1968, the Fertiberia Company (nowdays, E.R.T.) operated pan for the production of high-grade NPK using MAP and SSP with quantities of urea up to 17%, and achieved outputs of the order of 40,000 Tm of 12-24-12, 12-12-24, and 8-24-15.

An exhaustive review of the British experiences in production of high-grade fertilisers based on urea, ammonium sulphate, SSP and or MAP can be found among the reports of the I.S.M.A./F.A.I. Technical Congress in 1971.

Japan (Ando 1970) has also published reports of industrial-scala manufacture of 17.17.17, 16.16.16., 15.15.15, 10.2o.20, and 20.20.14, based on urea and utilising conventional drum and pan granulators. The primary materials were crystalline or lightly milled, and occasionally melted urea was used and the MAP was added in powdered state. In the same year, T.V.A. announced the construction of a granulation plant using urea and ammonium polyphosphates as basic materials. In the same directior Mitsui Toatsu published the results of their investigations and experiences in a pilot plant, but they used prilling with oil as the granulation system.

We have also examined a study, dated 1972, and presented in the Colloquium of the F.A.I. of the same year, on operation experiences, in India, of production of UAP in plants using the wet process.

The investigations carried out by Fisons on the U-SSP system using lime as a neutralising agent to control the free-acid of superphosphate, were reported by Hemsley in 1972. This report describes the development and experience of an industrial-scala manufacture of high nutrient content fertiliser based on urea and ammonium phosphates.

The I.S.M.A. Congress in 1972 gives importart relevant information. T.V.A. presents a report on the semi-industrial processes of plate granulation. Also, Fisons-Fertiberia present their operational experience in the use of a conventional granulator by the dry process and E.R.T. presents another comparative study of the utilisation of urea in combination with SSP, TSP and MAP in three different installations.

This last publication points out how E.R.T. makes the necessary adaptations and developments for transforming their installations and fitting them to use urea and superphosphates, and contains much important operational experience. The capacities of the plants described in this study were 10, 12 and 22 Tm/hr. , and they consumed quantities of urea up to 45% of weight in some grades. The report describes the experience and operating conditions for obtaining a wide range of products and equilibria in each of the installations described, which had not been designed for such dosifications. In addition, experimental results were obtained that corroborated the theoretical considerations given in the literature on hydrolysis of urea, internal ammoniation of MAP, the balance of ammonia in the granulator, and the levels of soluble P_2O_5 in the water during the process of granulation and drying.

Over recent years, E.R.T. has given much attention to these matters and has obtained sufficient experimental and technological experience to develop its own process applicable to installations of high production capacity. Therefore, in 1977, they built for themselves a plant of 1000 Tm/d having a high degree of technology and wide possibilities, whose exploitation has allowed them to carry out simultaneous trials and adaptations that we shall describe in this report.

Likewise, through an in-depth study of the equipment with a varied range of primary materials, formulations and equilibria of N:P:K, it has been possible to make a simulation model of the installation that is computer controlled and that, independent of its multiple applications for design of plants of this type, permits applications to real working of any installation, starting out from a determined granulation efficiency or given quality requirements of the finishe product.

DESIGN BASES OF THE E.R.T. PROCESS

From the experience obtained from all the installations available to E.R.T. in recent years, in those installations capable of producing the whole range of fertilisers that national or foreign markets might require, and having built-in production capacity of about 1 million tons per year, E.R.T. arrived at the necessary technological basis for the design of plants with a capacity of 1000 Tm/day that may be defined in the following way.

a) The supply of primary materials to the plant must envisage a clear separation of superphosphate and urea; and therefore the design provides for a double supply system.

   On the other hand, the fines for recycling can be fed mixed with urea without the formation of aducts, since they do not contain free acid.

b) We have proved the advantages of granulation in two stages (pug-mill and drum granulator), wich gives a high efficiency, excellent reaction, and consequently a very low recycle (less than 1:1) and good transformation yield.

c) One of the big advantages of the pregranulator is that of being able to neutralise sulphuric acid with ammonia, with the resultant formation of ammonium sulphate, which inhibits the formation of the aduct $4CO(NH_2).Ca(H_2PO_4)_2$, in agreement with reports in the available literature.

d) One feature of the process that will be described is that the energy balance of the drying system is optimised by using recycled heat and by operation at a granulation temper above 80°C, with cosequent low humidity content of the product at the entry to the dryer; in this way hydrolysis of avoided by working at low dryer temperatures (120°C).

The tubular reactor improves the energy balance of the system even more.

e) The system of double washing of gases, one in the granulator (with recirculation of phosphoric acid) and the other in the tail of the installation, allows recovery when necessary of the ammonia resulting from urea hydrolysis, which could escape in the ammoniation reactions, this being one more reason for working with a tubular reactor.

f) A rotating drum drying system is used with an internal structure based on labyrinths of fins, so that there is a high efficiency of drying with minimum risk of granule breakage or of caking of the product in the head region.

g) E.R.T.'s experience in screening and milling of hot fertilisers of high urea content has suggested the design of equipment based on self-cleaning vibrating screen and mixed mills of chains and rollers of our own design.

h) Bearing in mind that we are dealing with design of a plant of 1000 Tm/day capacity, the first of its type built in Spain and with Spanish technology, E.R.T. felt that it was necessary to give maximum degree of self-control to the process, this being based on instrumentation that will be described later. Although it may seem in principle to be sophisticated, it offers great possibilities for study and subsequent development for future designs.

i) In summary, we are speaking of a techology drawn from experience in operating existing plants.

DESCRIPTION OF THE PROCESS

The process develops in the following way:

The solid raw materials required for each formulation are transported separately from the bulk stores to a rotary distributor that may be sequentially programmed and that feeds each of the hoppers, allowing the system to function empty between each of the raw materials in order to avoid contamination of one with another. The distribution system is controlled from the working site and adapted to the available levels in the hoppers.

Each one of the raw materials, and the recycled fines, is extracted from the hoppers by means of weighers of extensiometric cells, that discharge onto belts which in turn feed the two elevators, that discharge by free fall onto the pug-mill.

In the first granulator the raw materials are intimately mixed with steam and ammonia gas, injected beneath the granulating bed, in order to control the temperature, pH and moisture of granulation. Likewise, sulphuric acid is sprayed into the head of the granulator as an aid in certain formulations of high urea - content.

The partially granulated material is discharged onto a rotary granulator where the process of granulation and of rounding of the granules continues. This second granulator is provided with a system for addition of ammonia, sulphuric acid, steam and water, in order to provide those aids necessary for a greater efficiency of granulation.

In order to avoid soiling of the walls of the rotary drum and maintain a good thermal balace with the least possible losses, the walls of the granulator are covered with self-cleaning panels of flexible rubber and, if necessary, striking hammers, or any other adequate system of cleaning.

The possibilities of this granulation system are notably widened by a tubular reactor of our own design and by the ability to introduce concentrated solutions of urea into the pug-mill,

The granulated product is discharged onto a parallel flow rotary dryer with hot air coming from a combustion chamber.

The hot product is screened to separate the large from the fine particles and the large ones can be recycled again onto the screen after passing through the milling phase.

Both the milled large particles and the fines and the powder from the cyclons system are discharged onto the hopper of fines for recycling.

The product separated on the screen falls directly onto a rotary cooler, where it is cooled in a counter current of air until it reaches the temperature required for good storage.

The sieved fertiliser from the cooler is fed to a regulator hopper whose mission is to supply a constant flow to the weighing belt at the production terminal, which sends a proportional signal to the coating agent and fuel oil weighers that feed the coater drum.

The hot air from the dryer and the cooler is led by means of ventilators, and through their corresponding cyclones, to the scrubber where it is expelled to the atmosphere.

The effluent recuperation system is complemented by a venturi type washer with its corresponding extractor ventilator and a recirculation of hot liquids to the tubular reactor.

FLEXIBILITY OF THE PROCESS

Although the plant is designed to operate with formulations rich in MAP, urea and superphosphate complemented with ammonia and potassium, one of the main feactures of this type of installation is the great versatility in use of raw materials, not only thourgh its double system for dosification for those mate rials that are incompatible, but also because it can use practically any type of solid or liquid product, more specifically, urea can be supplied either solid or melted by a plant situated in the same complex.

In this way, it can use ammonium sulphate, potassium sulphate, simple and triple superphosphates, and borax, magnesium, etc. type micronutrients, in addition ammonia is supplied as a gas from the recovery circuit of the aforementioned urea plant.

When it uses very rich primary materials it can achieve a 60% contribution of nutrients, as in 8-36-16, or elevated concentrations of one of them as in 25-7-14 and 25-5-25 that contain 50% urea.

As for equilibria, the manufactured formulations can range over all those possible for a NPK formulation, those normally manufactured being the following:

1:1:1	1:1:2	1:2:1
1:2:2	1:2:3	1:2:4
1:3:1	1:3:2	1:4:2

Of particular importance in this context is the utilisation of tubular reactors to produce MAP, DAP or PPA substitives in the formulations.

The reactor designed by E.R.T. allows, moreover, with an adequate selection of intervals in the mixing chamber, a variable capacity in the production of pulp, which falls in the range of 4-18 Tm/hr.

REGULATION AND CONTROL OF THE PROCESS

The essential feature of the E.R.T. process in this context lies in having a recycle product hopper that can provide a constant contribution of recycle product to the granulator.

This means that the minimum fluctuation in amplitude of the production wave, which lies at ± 10÷ 15%, can be Kept within the pulsation proper to the plant, with consequent constancy in composition and quality of the product. This question is studied in the available simulation model.

The instrumentation both in the plant and in the control panel provides exact information on the operating conditions and, in an extraordinary manner, on the dosification of raw materials and of the level of accumulation of recycled material in the hopper, which indirectly conditions the thermal balance of the plant. Thus the variables controlled by the operator are minimal

- level or recycling hopper.
- drying temperature.
- granulation temperature.
- pH of granulation.

and therefore the personnel needed to attend the plant is minimal and is required basically for the panel.

We should like to say that once the dose levels are fixed, and the controlled and controlling variables, the plant reaches mass and energy balance (6 hours), with a granulation efficiency of 50-60%, a quality variance coefficient of 3 ÷ 4, and the operation continues with the aforementioned variables controlled and with an autoanalyser system bases on representative samples every 2 hours.

PRACTICAL ASPECTS OF OPERATION OF A GRANULATION PLANT OF 1000 TM/D OF NPK ACCORDING TO THE E.R.T. PROCESS

a) Formulations and equilibrations

As mentioned earlier, a variety of NPK equilibrations can be obtained with a wide range of concentrations of nutrients. Thus we have selected the following fertilisers, for which we possess manufacturing experience.

20-20-20	10-20-20
20-10-10	9-18-27 (*)
18-18-18	9-27-18
(*) 18-11-5 (Mgo)	8-36-16
(*) 15-15-15	8-24-16
13-13-21	3-30-10
(*) 12-24-12	0-20-30
12-24- 8	0-20-25 (S) (*)

for the purposes of the present explanation we consider those marked with an asterisk (*) to be typical fertilisers, because of their representative nature within the commercial range and their different utilisation of primary materials.

b) Operation indices of the plant

We shall use the term work index to describe the relation between the hours of actual working and the total operating hours of the plant.

The operation index is the relation between the operated load in Tm/h. of product, and the load of raw materials for a recycle of 1:1.

We shall go on to quote the indices registered in the actual working for production of some typical grades:

	Work index	Operation index	Recycle
15-15-15	85% min.	90	1:1.25
12-24-12	85-90%	100	1:1
9-18-27	90%	117	1:0.7

c) Dosages

We shall refer to the 5 formulations marked an asterisk in section a).- Data are in Kg/Tm. dry base.

	18-11-5 (Mg)	15-15-15	12-24-12	9-18-27	0-20-25 (S)
Urea	318	250	111	76	-
Ammonia	38	25	42	33	-
MAP	118	211	370	294	-
SSP	255	193	208	100	-
TSP	-	-	-	-	434
Sulphuric acid	22	48	-	-	-
Inert Substances	140	20	63	35	30
Potassium chloride	85	254	203	457	-
Potassium sulphate	-	-	-	-	508
Magnesite	29	-	-	-	-
Coatings	13	13	13	13	13

d) Working conditions

In accord with the operating possibilities of the installation and its regulation on the basis of fixed recycling the parameters that define the working conditions are the following:

	18-11-5 (Mg)	15-15-15	12-24-12	9-18-27	0-20-25 (S)
Granulator					
Temperature °C.	70-75	70-75	80-85	75-80	78-82
pH	6.0-6.5	4.8-5.2	6.0-6.5	6.5	3.0
Speed (rpm)	10	10	12	9	12
Dryer (°C)					
Entry temperature of gases	130	120-130	210-220	160-180	320
Exit temperature of product	73-75	75	80-85	78-83	85-90
Exit temperature of gases	70	70-80	75-80	70-75	90-100

e) Transformation yields

According to the figures given in dosifications of raw materials (section c) the yields consolidated can be quoted as:

Total nitrogen	94.2	-	95.1
Available phosphorus	98.0	-	98.6
Soluble potassium	98	-	98.5

For nitrogen, it has been shown that the efficiency of transformation of ammonia in the pug-mill-granulator unit is of the order of 97% , the hydrolysis of urea in the dryer representing approximately 2% of non-recuperated losses.

Nevertheless, when operating with a tubular reactor to produce MAP substitive,the transformation efficiencies of ammonia do not fall off, owing to the recovery effected in the venturi washer. The influence of this piece of equipment on the hydrolysis of urea in the drum granulator itself has not been verified.

f) Quality of the products

The coefficient of variance of the plant (3÷ 4) permits guarantee of the granulated NPK under the following conditions:

% N or P or K guaranteed	Maximum deviations		
	N	P_2O_5	K_2O
< 10	0.5	0.6	0.7
11-15	0.6	0.7	0.9
> 15	0.7	0.7	1.1

and in any case N + P_2O_5 + K_2O does not surpass 3/5 of the total maximum admissable deviation.

As for physical quality, manufactured products have above 85% of granules of size between 1 and 4 mm. and in no instance do the fractions outside these limits surpass 10% of the total.

As already mentioned, the plant has an automatic system of sampling of the total production (3"/10' <> 40 Kg/h > 3 Kg/2h.)and a completely automated analytical control with five channels (NH_4^+ - NH_2^- - P_2O_5 av - P_2O_5 ws - K_2O). This permits the application of statiscal systems of correction, e.g. accumulated sums of deviations, with decision intervals in function of the mean lengths of the series.

Other characteristics of the manufactured products are:

- Conversion P_2O_5 tot/ P_2O_5 w.s.	90-95%
- Conversion P_2O_5 tot/ P_2O_5 av.	99% (MAP)
- Conversion P_2O_5 tot/ P_2O_5 av.	90-95% (SP)
- pH (10% Sol.) (dep. on NPK)	4.5-6.5
- Apparent density	0.900-0.950
- Angle of repose	30°
- Moisture (Karl Fisher)	< 1.5% max.

The critical relative humidity of the products varies between 55 and 60, which suggests good storage qualities taking into account that the products are not held loose and that they are bagged and palletted as thet are produced.

g) Effluents

The capture of dust in the dryer and cooler circuits is made by independent batteries of cyclones with a final common wash with sea water without recirculation.

The efficiency of cyclones can be guaranteed up to 98% particles of 50 μ, with a maximum dust content in the exit gases of 200 mg/m^3 , and these are subsequently captured by the washing system.

The final sea-water effluent from the plant shows the following content: (for a fertiliser of equilibrium 1 : 1 : 1).

Total nitrogen	2000 ppm	max.
P_2O_5 total	500 "	"
K_2O total	300 "	"

the quantity discharged being from 60-100 m^3/h., depending on the formulations.

h) Consumption of services and personnel requirements

Following are the mean figures for consumption per Tm of finished product:

Energy	21 kw h
Sea water	2 m^3
Raw water	0.3 m^3 (max.)
Steam (3-5 kg/cm^2)	10 Kg.
Fuel-oil	13 Kg.
Coatings	10 Kg.
Personnel	0,2 Man-hours
Supervisor	0,03 Man-hours

USE OF MATHEMATICAL SIMULATION MODELS

As said earlier, the E.R.T. process for large capacity plants for fertiliser granulation, has been based on experience of operation and on exhaustive study of the most influential variables for the efficiency of granulation by the conventional pug-mill and drum, with optimised consumption of services and personnel, and moreover, guarantees a very high quality of the products.

All this has depended on the agility and the possibilities offered by the computer-processable mathematical models which, even when representing only a transitory running of the plant allows easy performances of mass and energy balances in the different loops of the plant, and, more importantly, allows preparation of complete test programmes for the study of the permanent (dynamic) running.

When an analytical study of the dynamics of a granulation plant is undertaken, a practically unresolvable system of integral and differential equations is inevitably reached. This is due to the fact that the mathematical treatment of the solids cannot exist in practice but only in statistical studies. Moreover, in all the known models of granulation kinetics it is not possible to relate the most significant variables which fall into two classes:

a) Controlled variables (Temperature and humidity in the granulator) (Quantity recycled and granulometric distribution)

b) Manipulated variables (relation of solids/liquids to the granulator, quantity of ammonia, quantity of sulphuric acid, drum velocity, quantity and temperature of air in the dryer etc.)

and have a high level of interrelationship among themselves.

As a result, the problem of dynamics and control of a granulation plant requires three degrees of analysis.

A) Knowledge of the dynamics of the process

B) Selection of the manipulated and controlled variables and pairing of each of them or, what is the same thing: decision of how to close the control loop.

c) Study of which are the interactions between the loops and decision whether we can use interactive structure (loops with little coupling) or discopulative uncoupling structure (loops with a high level of interaction among themselves).

Obviously, in practice, plants are not constructed with adequate control loops, and therefore the points B and C are not easily achieved. Nevertheless, knowledge of the dynamics of the process holds a great interest from a double viewpoint:

1. It is essential before reaching the points B and C.

2. In isolation, and on its own, it is able to explain the behaviour of a plant in actual operation and forsee the answer to certain problems introduced into the system.

This has been the path chosen for our studies, and, among the divers types of process-identification trials, we have selected as valid in order of economy of time, facility in realisation and greatest significance of results, the one known as Pulsional Trial.

The method consists of exciting the system with an entry signal u (t) and subsequent examination and analysis of the exit signal y (t). For the trial to be relevant, apart from fulfilling certain mathematical requisites, it is essential that all the manipulated variables remain constant throughout.

The nethod had the advantage of requiring a single trial for each manipulated variable and, moreover, allows study of the variation of all the controlled variables simultaneously.

In the plant we are dealing with, the excitation of the system can be achieved by means of, for example, opening one of the valves of the liquids fed to the pug-mill, or also, altering the dosage of any solid material (in a way that does not affect the desired composition of the final product).

On the other hand, we have shown that it is more useful to manipulate the valves directly than to vary the fixed points of the flow loops which regulate the opening of these valves, given that, although these loops are very rapid, the transitory that they cause makes difficult the mathematical analysis of the results.

The trial is repeated for each of the possible manipulated variables, and in each trial all the controlled variables are studied. The duration of each trial and the magnitude of the excitation given to the system, depend on the rigorousness of the mathematical analysis that is required.

A HP-21MX calculator and a programme of dynamic simulation of processes in suitably modified Fortran IV language was used.

The model is a sum of elements, one corresponding to each basic piece of equipment of the plant, with due interconnenctions between them. These interconnections are of two types:

- dead time between pieces of equipment.
- data on exit of one element that serve for the entry of another or others (temperatures, quantities, granulometric distributions, nutrient content, humidities, etc.).

Type of regimen

We have considered two types of regimens: transitory and permanent. This is reasonable, since, in some pieces of equipment the transitory is important (large times of residence and response), while in others the opposite is true.

Balance equations

Balances of mass have been made in all the elements of the model and of energy only in those in which appreciable heat transfer occurs.

Empirical data. Efficiencies

We have opted for the use of empirical graphs that define very well the efficiencies of the different pieces of equipment and the achievement of the exit data, and compare very well with the actual results of operation.

Inputs

We refer to the inputs or the plant, using the exit data from one element of the model serving as inputs for others. These data are:

- referring to primary materials
- referring to the quantity and conditions of the air entering the dryer and the cooler.

Outputs

These data refer not only to the outputs from the plant (finished product, emissions) but to any other operational parameter of the plant, since the developed programme allows the exit of any desired intermediate, e.g. global efficiency of sieving, loss of weight in cyclones tec...

Global structure of model

- A main programme of dynamic simulation with various sub-routines for storing of data, numerical integration, impression of exit data, etc..
- A sub-routine with the mathematical model that is called from the main programme and that in turn calls the different sub-routines with those elements of the model corresponding to each piece of equipment, establishing the precise interconnections between them.
- Some sub-routines for calculation and intermediate storage that are activated from any sub-routine linked to the main programme.

Diagram of developed model

Accompanying this description is an explanatory diagram with legend, where the interconnection data between the different elements of the model appear.

As for this diagram, it is necessary to bear in mind the following points in order to interpret it with ease:

- RT or RP indicates whether or not differential equations (accumulations) appear and refer to one regimen or another according to whether or not the time of the transitory regimen is negligible.
- The other notations that appear within each block (piece of equipment) indicate the equations considered. The efficiencies have been obtained empirically through actual trial in the plant.
- The notations appearing on the flow lines indicate the results obtained by the model.
- The data that are proceded by a key are the initial data.

Results

The developed model functions well, and for each series of entry data, provides results of the following order (e.g., for 15:15:15):

a) Efficiencies

Dryer cyclones	99.4%
Cooler cyclones	99.0"
Primary screen	79.0"
Secondary screen	81.2"
Mills	30.0"

b) Load losses (maximum values)

Dryer cyclones	96.0 mm.C.A.
Cooler cyclones	97.0 mm.C.A.

c) Emissions

Dust cyclones from dryer	14 Kg./h.
Dust cyclones from cooler	5 Kg./h.

d) Global yields

Total nitrogen	98.1%
Available phosphorus	97.3"
Potassium	99.2"

e) The model is able to provide information on the variability in the levels of these three nutrients and throughout the actual time incurred.

Applications

Obviously, the possibilities and versatility of the plant are increased by these techniques of process programming and simulation, and E.R.T. hopes that it will serve to facilitate the design of new plants.

FUTURE DEVELOPMENTS OF THE ERT PROCESS NPK-1000

The activities of investigation and technological development of the Fertilisers Division of E.R.T. in this field are centred basically on the on-the-spot preparation of ammonium phosphates by means of tubular reactors of home design, using sulphuric acid, phosphoric acid, ammonia and melted urea as reagents.

On the other hand, the use of simulation models with verification of results in actual working of the plant, offers enormous possibilities both for the design of the other units and for the optimising of existing plants.

CONCLUSIONS

We have tried in this paper to illustrate how a company with basically manufacturing activities in the field of fertilisiers has managed, through operating experience and the necessary investigations, to acquire the information necessary for designing and constructing a large capacity plant for granulation of NPK fertilisers, with the additional possibility of arriving at new designs in the line of really optimised returns and quality.

E. R. T. PROCESS N. P. K. 1.000

FLOW DIAGRAM

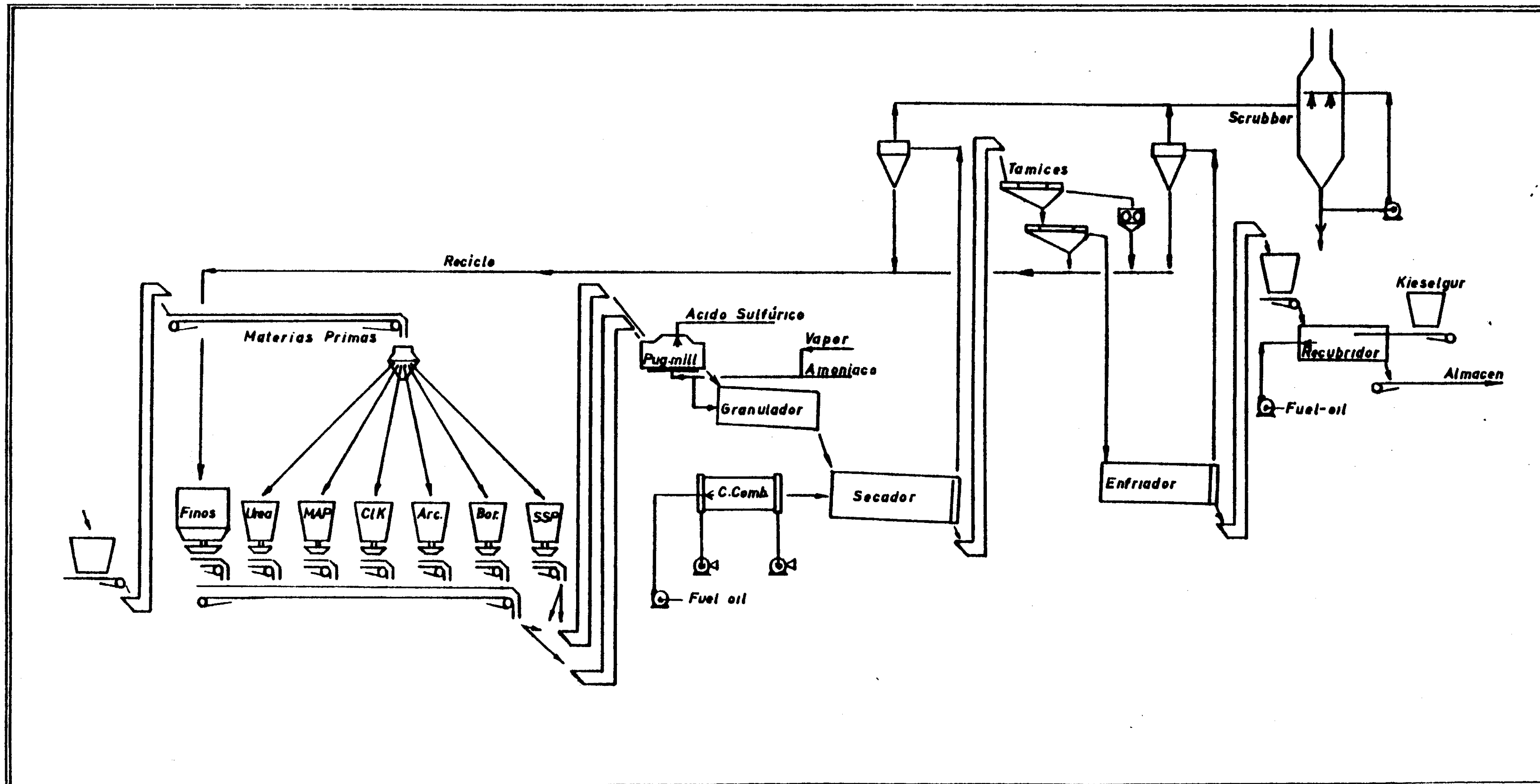

Fig. 1

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E.R.T. PROCESS N.P.K. 1.000

PIPE-REACTOR SYSTEM

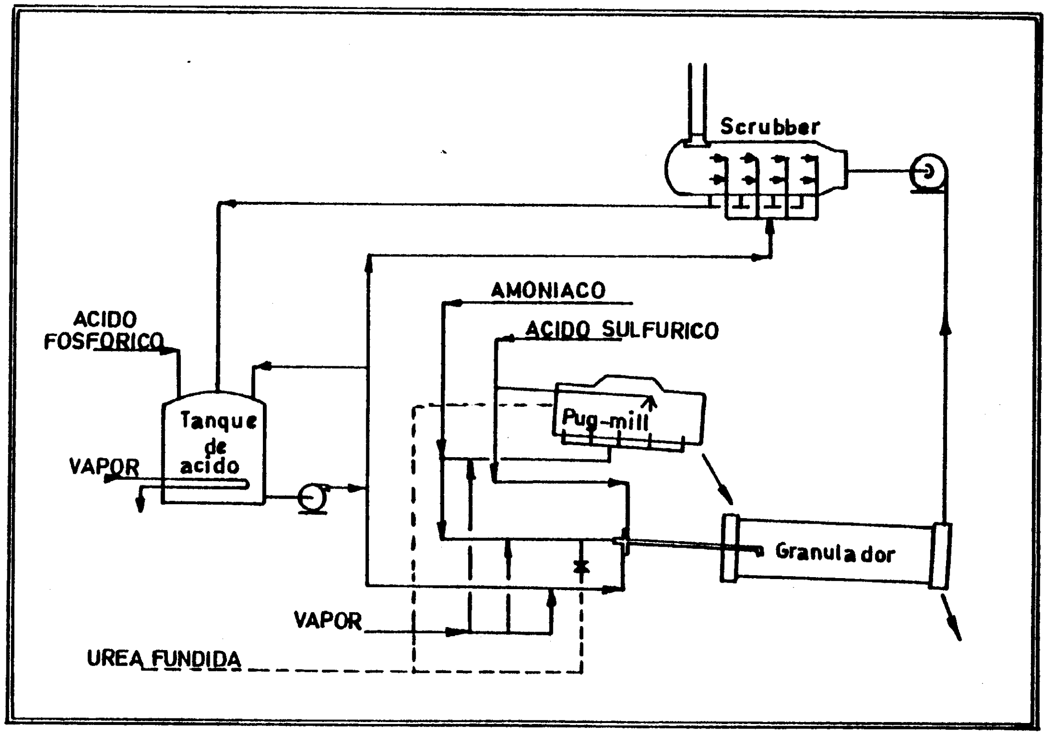
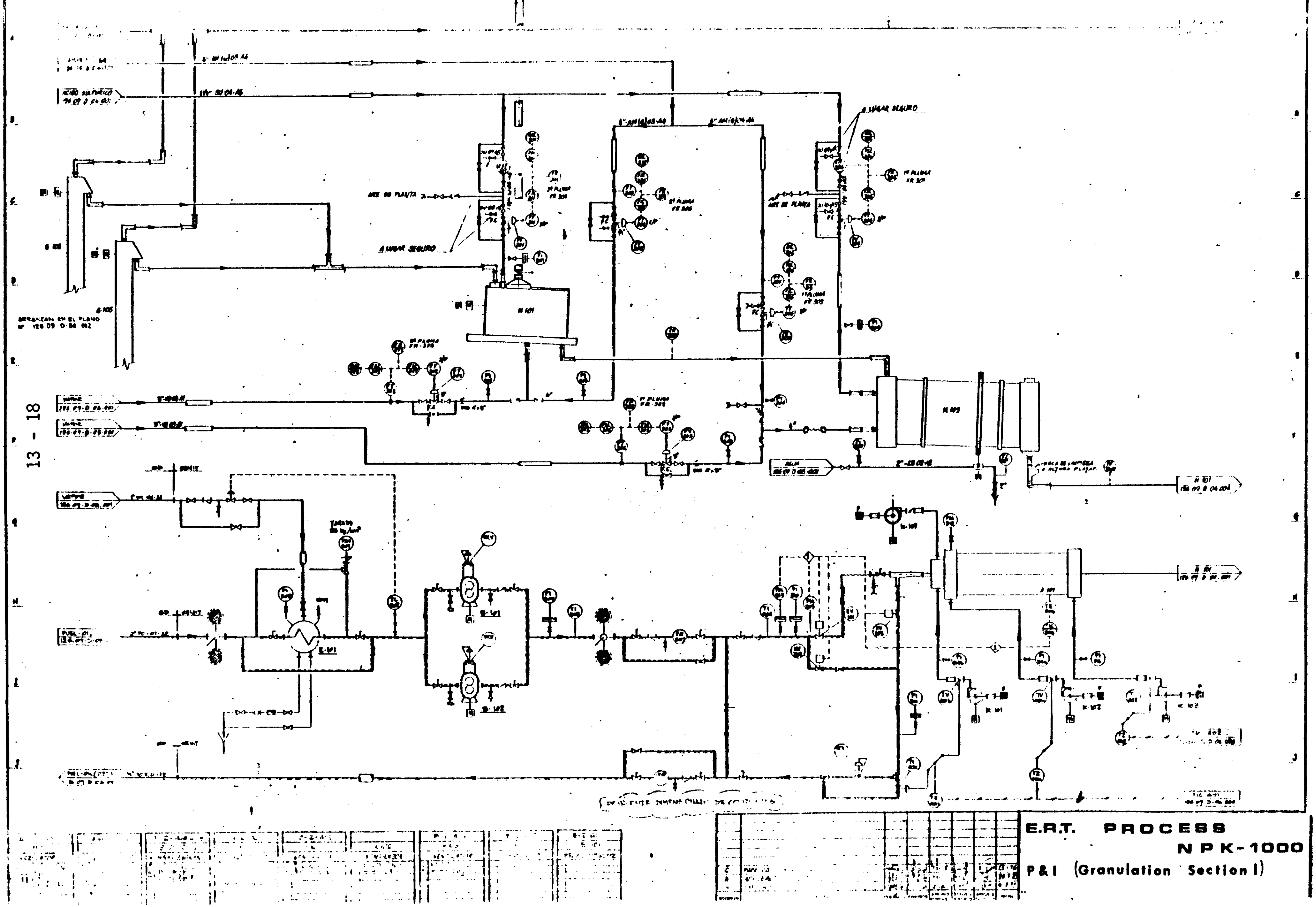
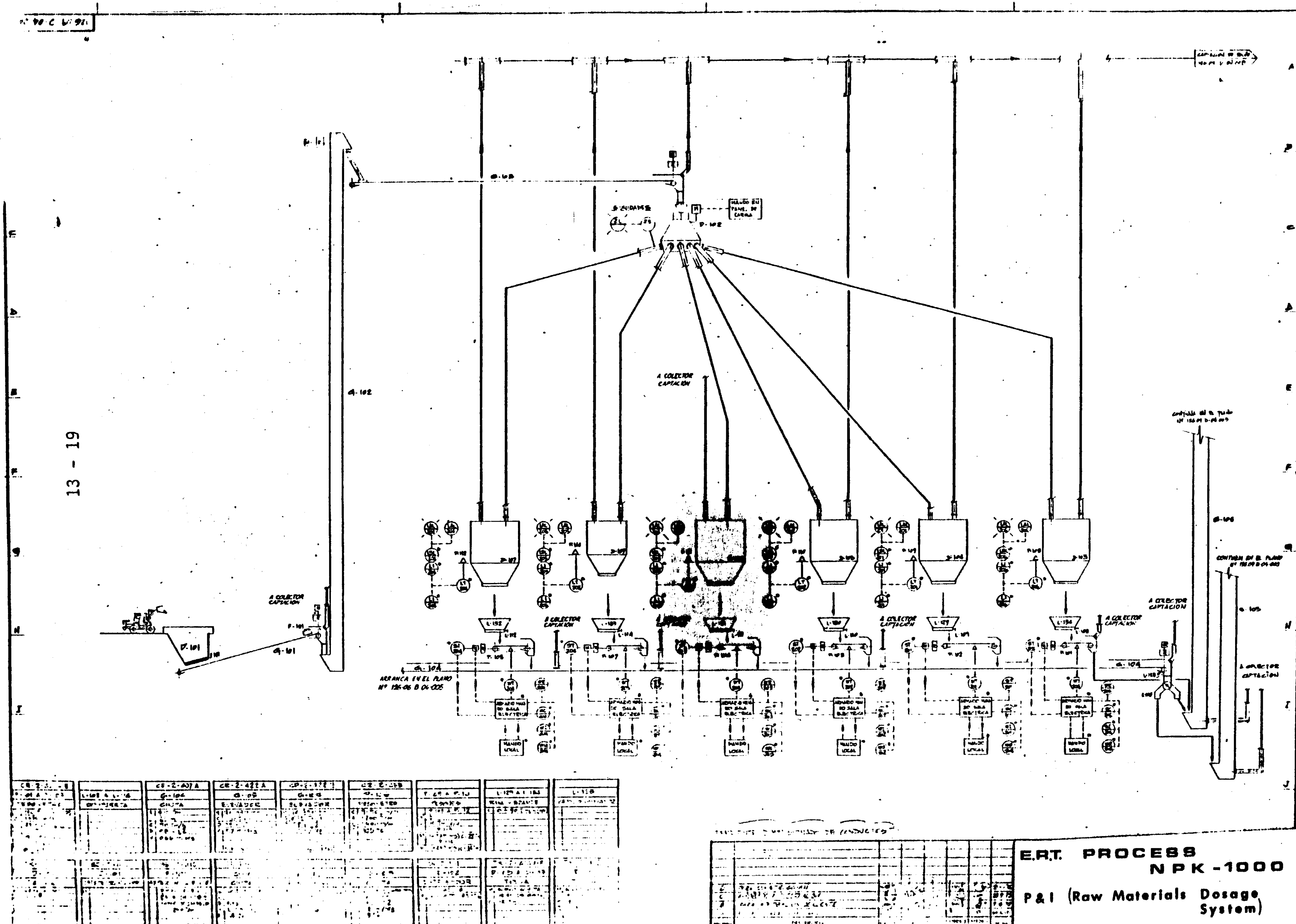
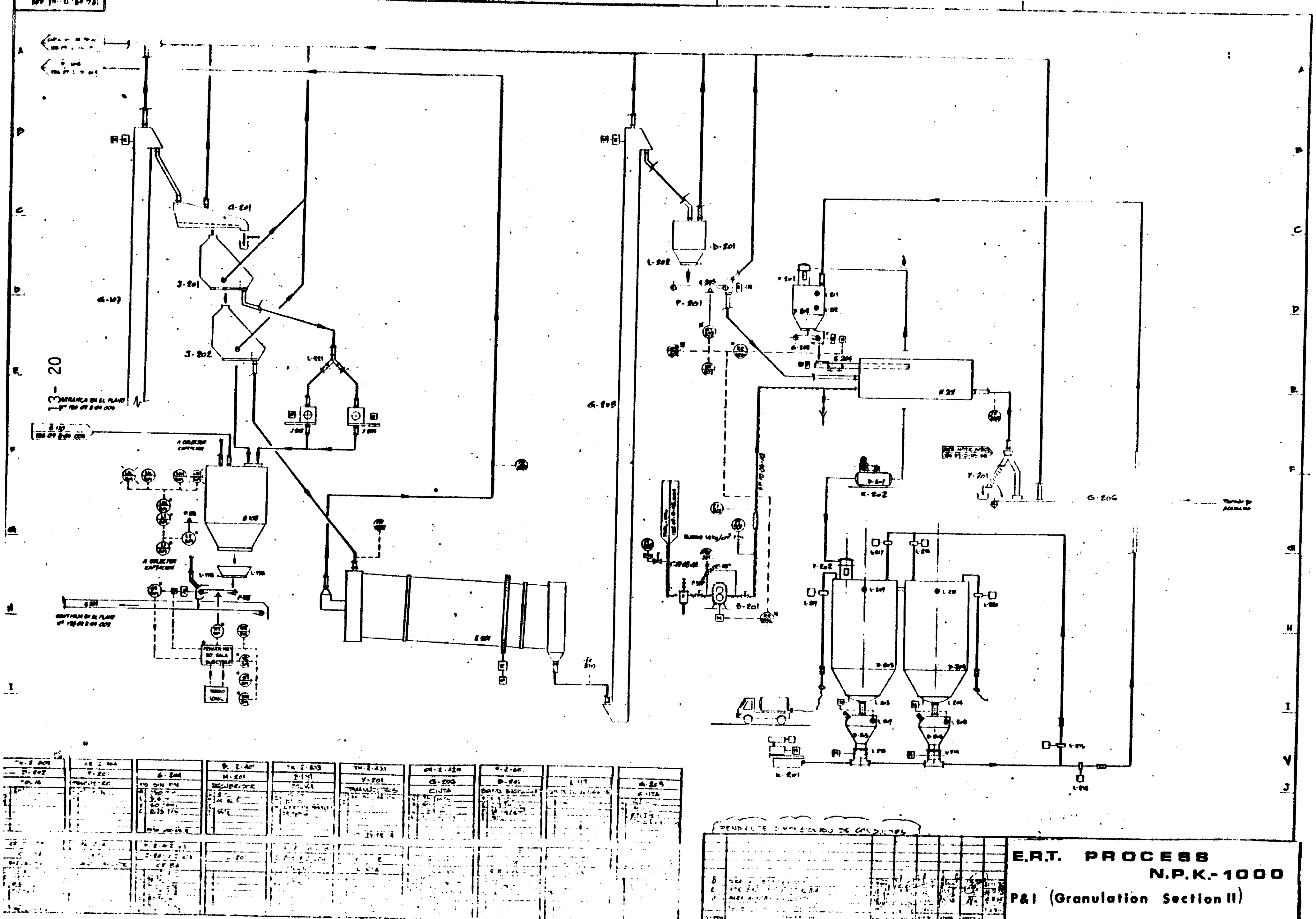


Fig. 2



13 - 18
A LUGAR SEGURO
AIRE DE PLANTA
ACIDO SULFURICO
H 101
H 102
E 101
B 101
B 102
E.R.T. PROCESS
N P K - 1000
P & I (Granulation Section I)

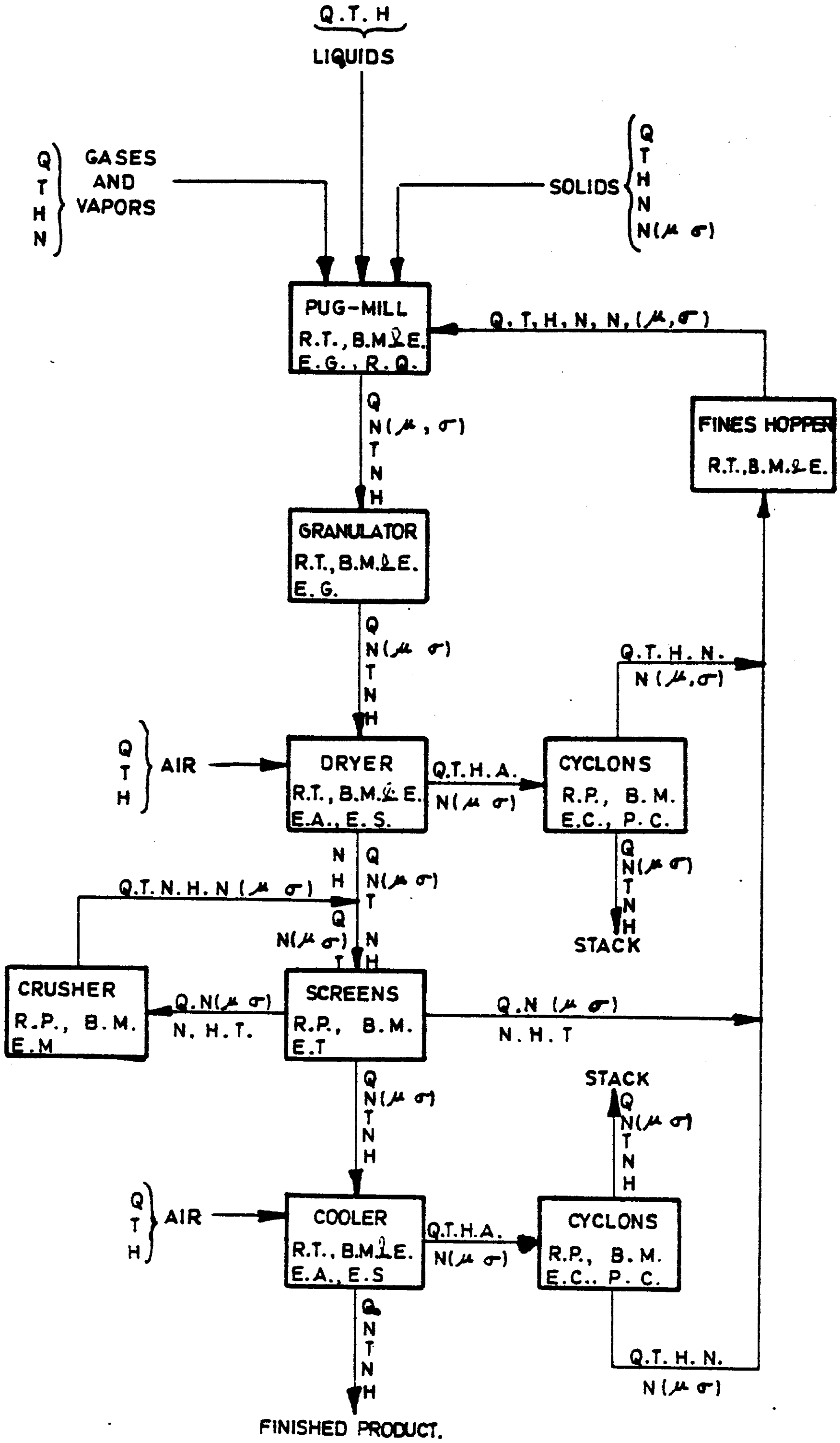

A COLECTOR CAPTACION
ARRANCA EN EL PLANO Nº 126-06 B 04-005
MANDO LOCAL
E.R.T. PROCESS
NPK-1000
P & I (Raw Materials Dosage System)



E.R.T. PROCESS
N.P.K.-1000
P&I (Granulation Section II)

MATHEMATICAL MODEL FOR E.R.T. NPK-1000 PLANT

GENERAL SISTEMATIC.



LEGEND

Q — FLOW.
T — TEMPERATURE.
H — MOISTURE.
N — NUTRIENTS.
RT — TRANSITORIAL REGIME.
RP — PERMANENT REGIME.
BM — MASS BALANCE.
BE — ENERGY BALANCE.
EG — GRANULATION EFFICIENCY.
RQ — CHEMICAL REACTION.
N(μ σ) SIZE DISTRIBUTION.
A — CARRY DOWN.
EA — CARRY DOWN EFFICIENCY.
ES — EQUATION OF DRYING.
EC — CYCLONS EFFICIENCY.
PC — PRESSURE DROP.
ET — SCREENING EFFICIENCY
EM — GRINDING EFFICIENCY.

TA/80/13 Practical aspects of operation of a granulation plant for NPK fertilisers of 1000 tm/day by J. Olivares del Valle, J.L. Lopez Nino, J. Casillas Revilla, U.E.R.T., Spain

DISCUSSION : (Rapporteur F.G. Membrillera, S.A. Cros, Spain)

Q - Mr. T.P. HIGNETT, International Fertiliser Development Center, USA

All of the NPK formulations listed on page 8 of your paper contain phosphate from two sources, MAP and SSP. Ordinarily, one would think that using a single source of phosphorus would be more economical. Are there some special circumstances that make it economical to use two phosphates? Or do you have some other reasons, such as improvement in granulation, improvement of quality of granules, or agronomic considerations? If so, what reasons?

A - I agree, it is more economical to use only a single source of phosphorus generally speaking, but in Spain and in many other countries, the price of P_2O_5 from SSP is lower than from MAP. That is the reason why we produce based on SSP and only add MAP when necessary. In any case the E.R.T. process runs with SSP and the whole MAP used via pipe-reactor.

Nevertheless we accept that granulation performance is better without using SSP, but as said before our process allows the economic optimization of all the formulations allowing the use of SSP.

Q - Would you advise a developing country that wishes to make urea-based NPK compound fertilisers to use similar formulations rather than the more concentrated ones that could be made without SSP?

A - We should advise to use our process and use as much as possible MAP and SSP in this order but considering also the relative price of the P_2O_5 of both sources.

Q - When using solid urea do you use whole prills or do you crush them?

A - In the E.R.T. process, it is not necessary to crush the urea prills.

Q - Mr. V.V. RAO, Dharamsi Morarji Chemical Co Ltd., India

Can the formulations described by you on page 8 use SSP coming straight from the den without curing?

A - It is possible to make it but not convenient.

Q - Mr. R. MONALDI, Montedison SpA, Italy

Your company has a wide knowledge in the field of fertilisers containing urea, but in your paper there is no report about products such as 26-13-13 which can be obtained without the use of superphosphate. Do you produce this type of products?

If you do, can you tell us the granulation operating conditions? (Temperature, moisture, pH, recycle ratio, gas temperature drier inlet, % plant use).

A - We have no experience with the production of 26-13-13 but we have produced a similar one, 20-10-10 with good results.

The normal recycle ratio for 20-20-0 is 1 : 1 ; 1 : 1.15 for 20-10-10 and 1 : 2 for 24-24-0.

Q - Mr. J.D. CRERAR, Fisons Ltd, United Kingdom

On page 4, reference is made to a rotary drum drier with a labyrinth of fins, could you describe it more fully?

A - The rotary drum drier is divided in four longitudinal sectors, with series of buckets specially located to get the maximum residence time, to make the most of the section of the drum, with the minimum P and without caking problems. The rotary drier is provided with a system of hammers to maintain it clean. Also, at the product outlet the drier has been provided with a "lump" removal system.

Q - Why does ERT use a rotary cooler for product size material, rather than a fluidized bed cooler?

A - Our experience does not advise the installation of a fluidized bed cooler to cool the product size, above all in the design of plants that are going to operate in wet and hot climates.

Q - Mr. A. SINTE MAARTENSDIJK, UKF, Netherlands

Only the exhaust gases from the granulator are scrubbed with phosphoric acid, the gases from the drier and cooler are scrubbed with water. Why are these combined gases not scrubbed with phosphoric acid to reduce process losses to a minimum?

A - The economical losses could be at the pug-mill granulation system and with our process we are able to recover them almost completely. The cyclones we have installed are highly efficient and the amount of liquid necessary to remove dust is high. The use of phosphoric acid would not be economical.

Q - What is the N/P ratio, the P_2O_5 concentrations and temperature, in the phosphoric acid scrubbing liquor, for instance when producing 18-11-5?

A - The ratio NH_3/P_2O_5 in the scrubbing liquor is 0.1 maximum. The concentration of the acid is normally between 45-46% P_2O_5 and the temperature of 40-60° C depending on grades.

Q - Which materials of construction are used for the scrubbing liquor pumps? Has any corrosion been observed on these pumps when using KCl as a raw material?

A - The materials are PP and PTFE. There is no corrosion due to the presence of chlorides.

Q - Over what period of time have the operation indices of the plant, as shown on page 8, been calculated?

A - The normal production cycles in our plant are of minimum 5000 T of continuous production.

A - Of course, but the deviations indicated in the paper are the ones officially allowed in Spain.

Q - Mr. T. LOEWY, Israel Chemicals Ltd., Israel

Are all urea containing products coated?

A - Yes, all products produced with our process and in our plant are coated whether urea is used as raw materials or not.

Q - Mr. B. RAISTRICK, Cremer & Warner, United Kingdom

Could we please be told how the E.R.T. process behaves when making, say, 15-15-15 from urea, SSP + TSP, KCl and no MAP is available?

A - The 15-15-15 without MAP can be produced with E.R.T. process and we have already made it, the recycle ratio is a little higher of course but with an excellent granulation performance.

Q - Mr. P. SUPPANEN, Kemira Oy, Finland

What is the moisture content in pug-mill granulator, in drum granulator? Are there big differences between different grades?

A - The moisture depends on the raw materials employed and on the grade produced.

Normally, the water content at the outlet of the pug-mill is between 1 and 2.5% (i.e. 15-15-15 and 12-24-12) and between 1.7 and 4.5% at the outlet of the drum granulator. When the pipe reactor is used the difference in moisture between pug-mill and drum granulator increases.

Q - Mr. F.T. NIELSSON, IMC, USA

In 1953 when I left TVA, my first granulation plant for Royster Co. used a pug-mill followed by a granulating drum. We removed the pug-mill one year after commissioning. You show a pug-mill followed by a drum in your plant. How many maintenance problems does the pug-mill cause?

A - Surely the pug-mill employed in our process has been built more properly than yours. We have no special problems for the maintenance of this equipment.

Q - Mr. J.E. REYNOLDS, W.R. Grace, USA

Could you please describe the design of the pug-mill?
RPM of shafts? Size?

A - Our pug-mill was designed for a capacity of 90 M T/hr. It has two shafts of blades with a total length of 4 meters at a speed of 55 r.p.m. The width is approximately 1.5 m and the height 1.3 m.

Q - If you produce phosphoric acid, why not use the acid direct into the granulation of NPK's rather than making MAP first?

A - The phosphoric acid is fed as a rule to the pipe reactor but it is possible to feed the acid to the granulator too. It depends on the water balance.

Q - Mr. B. AVENBERG, Supra, Sweden

According to your experience of process identification trials, have you developed dynamic models for oversize, product and undersize, and do you use them for control of the plant?

A - No, unfortunately we have not developed such a model yet.

Q - Mr. M. BARLOY, Cermi, France

Have you produced the 18-18-18 with urea? If so, what is the recycle and what about the granulation efficiency?

A - Yes, we have produced the 18-18-18 with urea, MAP and KCl without granulation problems and with a recycle of 1 : 1.25 or smaller using urea crystal.

Q - Mr. J. FROCHEN, Cofaz, France

What is the reason to preheat the phosphoric acid to the scrubbing system? Does it not increase the ammonia losses?

A - The phosphoric acid only is preheated when the concentration is low. Moreover it is convenient to maintain the liquid in recirculation at a certain temperature to evaporate water. At those conditions there are no ammonia losses.

Q - Mr. P. AALTO, Kemira Oy, Finland

In your paper you write that the recycle product hopper is an essential feature of your process. The recycle product in the hopper is hot and, therefore, one of the possible drawbacks of this thing is the caking of the recycle product in the hopper, specially during production stops. Have you got any problems like that and how are they solved?

A - Indeed the recycle hopper is an essential feature of E.R.T. process and contains hot fines but with a negligible amount of dust. The design of this hopper was made in such a way that the total capacity is 30% higher that the maximum capacity of the circuit. This hopper is always operated at minimum level. The plant is shut down with the hopper empty.

Q - In your process, the urea is not dissolved before it is fed to the plant. What is the screen analysis of urea? Does it have an effect on the quality of the final product?

A - Our process is able to use and uses urea prills, crystals or melt. When the urea prill is used, the granule size is 85% between 1 and 2 mm and 8% between 0.5-1.0 mm. The urea crystal is smaller.

Generally speaking, the urea is incorporated very well in all the grades and, in any case, the urea cannot be identified in the final product.

Q - Mr. P. MORAILLON, Générale des Engrais, France

Could you explain the principle of the auto-cleaning screens?

A - The auto-cleaning screens are vibrating screens with a sequential programmer that changes the frequency and amplitude with the time and depending on the grade in production.