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History of a continuous improvement increasing the capacity from 1000 t/d to 2000 t/d

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INTRODUCTION

The development of the SAEPA 1 DAP plant at GABES has been exemplary in two ways :

1. The users, to whom an already existing manufacturing plant with its merits and shortcomings was handed over in 1980, have been able to master its shortcomings, exploit its merits and increase its production capacity by 20% gradually over less than three years. This improvement phase is described in the first chapter of this article.

2. Two companies, SAEPA and AZF, have been able to collaborate effectively in making the most of the new process developed by AZF : the process employing two tubular reactors.

This collaboration took place in two stages: the first in 1983, which consisted in installing a tubular reactor in the dryer, and the second, currently in progress, will lead to the installation of a tubular reactor in the granulator and to the replacement of a part of the gas-scrubbing equipment. Chapters 2 and 3 of this article deal with these last two stages.

1. COMMISSIONING OF THE PLANT AND IMPROVEMENTS

The DAP plant built at SAEPA factory 1 at Gabes was designed by Heurtey Industries for the manufacture of granulated DAP 18-46-0 and 16-48-0 according to the TVA process (Figure 1).

This unit which started up in 1979 consists of :

- a preneutralizer of capacity : 75 m^3
- a granulator Ø 3.8 m, L = 8 m
- a dryer Ø 4 m, L = 30 m
- a sifting bank
- a scrubbing section consisting of :
  - a scrubber for the preneutralizer gases Granivore type
  - a scrubber for the granulator gases Granivore type
  - two scrubbers for the dryer gases Airmix type
  - a scrubber for cleansing Airmix type
- an ammonia reservoir of capacity 320 t
- a DAP reservoir of capacity 45,000 t

1.1 Description of the plant at start-up

The operating parameters initially chosen were as follows:

N/P ratio of the slurry	= 1.40 - 1.45
slurry density	= 1500 - 1520
slurry temperature	= 115 - 118°C
recycling rate	= 6

The specific consumptions resulting from this choice of parameters are as follows :

natural gas	: 9.2 Nm^3
electrical energy	: 35 kWh

Problems encountered

a) Operating parameters

Right from start, a rapid and frequent clogging of the granulator due to a bad choice of operating parameters (mainly the density and the molar ratio of the slurry) was noticed and this has slowed down the production and the level of activity considerably.

b) Clogging of the slurry sprayers

Right from the beginning, the frequent clogging of the slurry sprayers has led to reductions in the operating level and to untimely stoppages of the unit.

c) Scrubbing

The rapid and frequent clogging of the acid sprayers of the granulator and preneutralizer gas scrubbing towers were responsible for frequent and long-term stoppages.

1.2 Increasing the operating level of the plant

SAEPA has introduced the modifications required for alleviating the problems mentioned above.

a) Choice of operating parameters

Taking into account the high humidity of the slurry, it was considered useful to increase the density of the slurry to 1550 in order to shift the liquid phase : solid phase ratio in the right direction.
This enabled a lower recycling rate to be achieved, thus facilitating an increase in production.
Simultaneously with the lowering of the water content of the slurry, it proved necessary to increase the molar ratio N/P of the slurry to 1.50 in order to minimize the quantity of water evaporated in the granulator. Thus, increasing the density and the molar ratio led to operating at a slurry temperature of 120°C.

b) Modification of the slurry sprayers

Following the frequent clogging of the slurry sprayers, it was decided to reduce their number to 3 (originally 6), and consequently, to change from a 15 mm to a 30 mm diameter.
As a result, the injection of ammonia into the granulator

was modified in order to provide the ammonia required for the slurry (modification of the number of injectors, positioning, diameter of the injection orifices, direction of the jet and the height of the granulation bed).

c) Scrubbing

The installation of sprayers of a model different from the original, with solid cone for the gas scrubber of the granulator and hollow cone for the gas scrubber of the preneutralizer, resolved effectively the problem of blockage of the spraying ramps. Nevertheless, the scrubbing yield remained well below the targets fixed.

1.3 Increase of production capacity

The new operating parameters and the various modifications introduced enabled the production of the plant to be increased from 1,000 to 1,200 t/day.

1.4 Specific consumptions after the modifications

The specific consumptions of the unit were improved as follows :

gas consumption	:	7.5 Nm^3 instead of 9.2 Nm^3
electrical energy consumption	:	31.5 kWh instead of 35 kWh

2. FIRST TRANSFORMATION OF THE PLANT BY THE INSTALLATION OF AN AZF TUBULAR REACTOR IN THE DRYER TUBE (Figure 2)

The improvement in the performance of the original plant as described above was significant after two years of operation and it seemed difficult to improve the performance further with the existing process.

Being aware of the existence of a new process which employs two tubular reactors developed by the company AZF (formerly GESA - Générale des Engrais), SAEPA has examined, with this company, the possibility of achieving a new break-through in the performance of the plant by using this process.

AZF, who already had a long industrial experience with their process in their own plants for the manufacture of NPK (AZF only rarely producing DAP) and who knew from pilot-scale productions that their process was perfectly suited for the DAP production, were interested by this industrial experiment.

An agreement was concluded between SAEPA and AZF for implementing only a part of the process, that which would bring about the most significant improvement in the performance of the plant with the minimum of investment and without interruption of operations.

This consisted simply in the installation of an AZF tubular reactor at the inlet of the dryer tube.

This tubular reactor, supplied with concentrated phosphoric acid and with liquid ammonia (the ammoniation ratio N/P being fixed at a value of between 1 and 1.1), produces an ammonium phosphate slurry at approximately 160°C, which, as soon as it leaves the reactor nozzle, separates into superheated steam and into monoammonium phosphate particles which crystallize rapidly in the air stream passing through the dryer.

This system has two advantages :

a. The heat of neutralization of phosphoric acid with ammonia is entirely available in the dryer.

b. The monoammonium phosphate particles formed in the dryer are well suited for fixing an additional amount of ammonia in the granulator without significant interference with the gas-scrubbing operation.

2.1 Start-up of the modified plant

The installation of the tubular reactor at the dryer inlet could be carried out without difficulty although the position of the chute in the middle of the sheath of hot air coming from the combustion chamber was not ideal.

The top of the tubular reactor stands in the open on a platform, the reactor body passes through the hot air sheath and runs along the chute ending substantially in the axis of the dryer tube.

The rest of the plant was not modified and the management of the plant remained unchanged.

When the tubular reactor was put into operation for the first time, a problem related to the unit design of the shovelling of the dryer was noticed. In fact, a few metres from the dryer inlet, the size of the shovels was enlarged, choking the free section inside the dryer just at the point where the jet leaving the tubular reactor spreads out. The original hammering of the dryer not being operational in this zone, this caused the monoammonium phosphate particles to stick to the shovels.

The problem was solved easily by installing a new, simple and efficient hammering system and by cutting out a blank along the first six metres of the spirals in order to reduce the height thereof, a precise centering of the tubular reactor being a prerequisite for its proper functioning.

2.2 Tests of guarantee

Tests of guarantee were carried out over 3 days in April 83 and the results obtained were as follows :

Capacity

Dates	Hours of operation	Production in 24 h t/d	Increase in capacity due to T.R. t/d
23/4	24	1,637	
24/4	22	1,640	492 on average
25/4	24	1,680	
		4,957	1,476 (+43%)

On 28/4, outside the test period, the increase in capacity was 576 t/d (+49%).

Consumption of heating gas

During the 3 days of the test of guarantee, the gas consumption was 3.12 Nm^3/t DAP. The consumption without the tubular reactor was 6 Nm^3/t. Therefore, there is a 48% saving.

The operators of the plant learned very quickly how to use the tubular reactor and they themselves introduced some modifications thereto.

In addition to this first modification phase of the plant, it was necessary to increase the size of the fluidized-bed cooler two-fold as it could not absorb the additional 70% capacity created since the commissioning of the plant in 1979.

3. END OF THE REMODELLING OF THE PLANT. INSTALLATION OF AN AZF TUBULAR REACTOR IN THE GRANULATOR - REPLACEMENT OF A PART OF THE GAS-SCRUBBING SYSTEM (Figure 3)

The capacity of the SAEPA 1 DAP plant as used at present, appears to be close to the maximum possible capacity.

In fact, it would appear that it exceeds the capacities of most of the DAP plants of comparable size around the world.

However, one of the characteristics of this plant is unsatisfactory : the ammonia yield. Despite the improvements introduced to the initial gas-scrubbing equipment by the SAEPA operators, its efficiency still remains average. Additionally, the release of unfixed ammonia coming from the granulator, and perhaps mainly from the preneutralizer, is considerable.

All these factors contribute to the fact that the ammonia yield of the DAP plant hardly exceeds 94%, which is quite unsatisfactory, considering the fact that the gas-scrubbing equipment was not modified when the plant capacity was increased from 1,000 to 1,200 t/d.

Following this observation, a second stage of collaboration between SAEPA and AZF was initiated.

The AZF engineers often talk about the 3rd reactor of their two-tubular-reactor process. This refers to the gas-scrubbing system that they developed and perfected a few years ago, in order to solve problems similar to those occurring at SAEPA 1 today.

Following a detailed study of the possibilities for improvement, jointly carried out by the two companies, a programme was recently finalized for a new project which would enable maximum efficiency to be achieved at minimum cost.

It was decided to make the following changes :

1. Installation of a tubular reactor in the granulator

2. Installation of the AZF special ammonia-injection ramp in the granulator.
Provisional maintenance of the preneutralizer so as not to take any risks (AZF would have preferred to omit it)

3. Replacement of the existing preneutralizer and granulator gas-scrubbing equipment with a unit consisting of a Venturi scrubber, a separator and a cyclone column. This new equipment, designed for treating the gases leaving the granulator equipped with the tubular reactor, may also treat the gases originating from the preneutralizer if it is decided to keep it in operation.

The main targets of this new project are as follows :

	Guaranteed performance	Expected performance
Capacity	1,650 t/d	2,000 t/d
NH_3 yield of the granulation section	97%	98%

Other secondary improvements of the plant relating to the internal cleansing of the plant and the cooling of the final product which was originally designed to handle 1,000 t/d, will also be jointly studied.

As the results appear promising, the two companies are keen to see this new project implemented quickly.

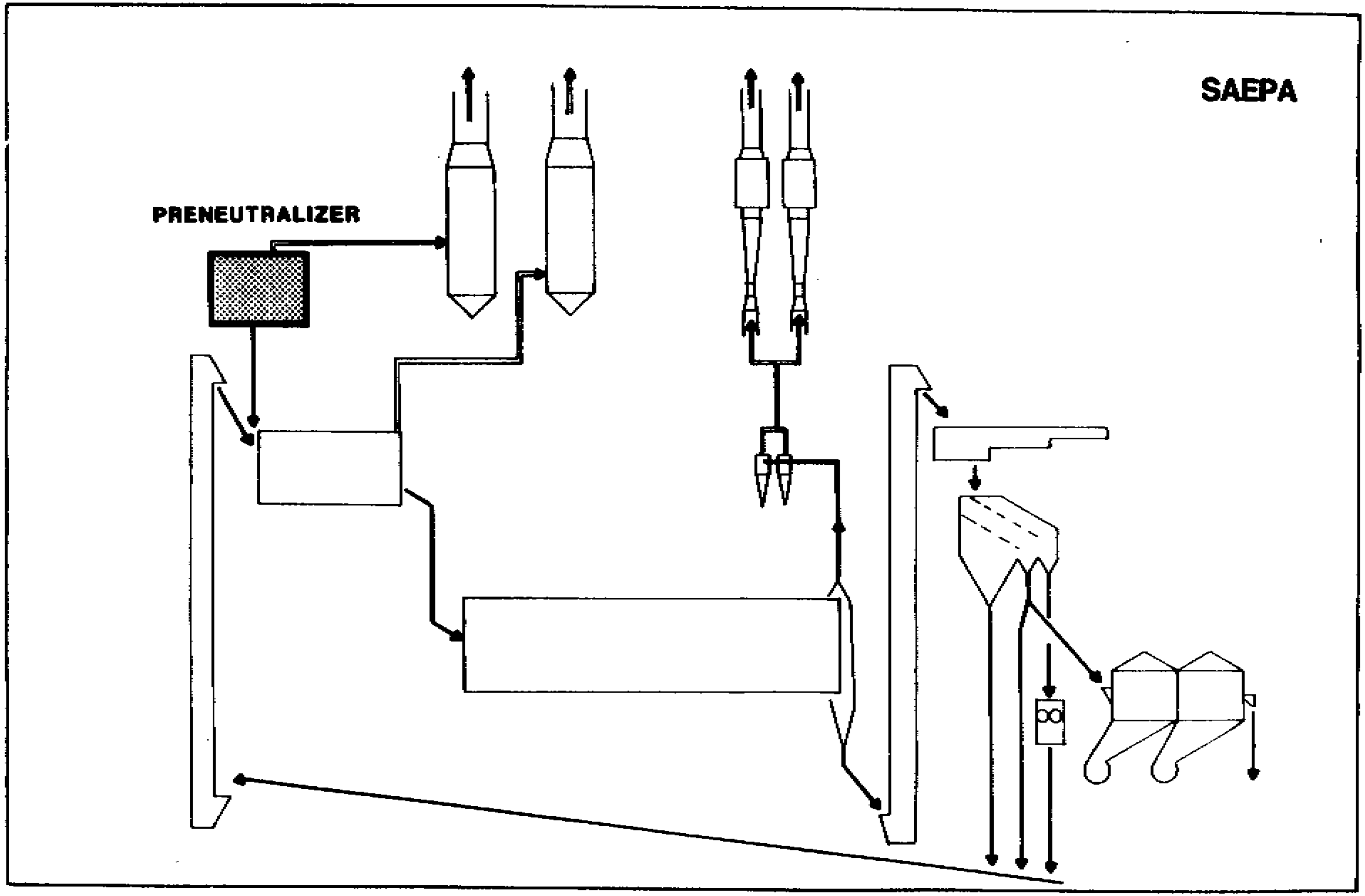

Fig. 1 SIMPLIFIED ORIGINAL SCHEMATIC DRAWING

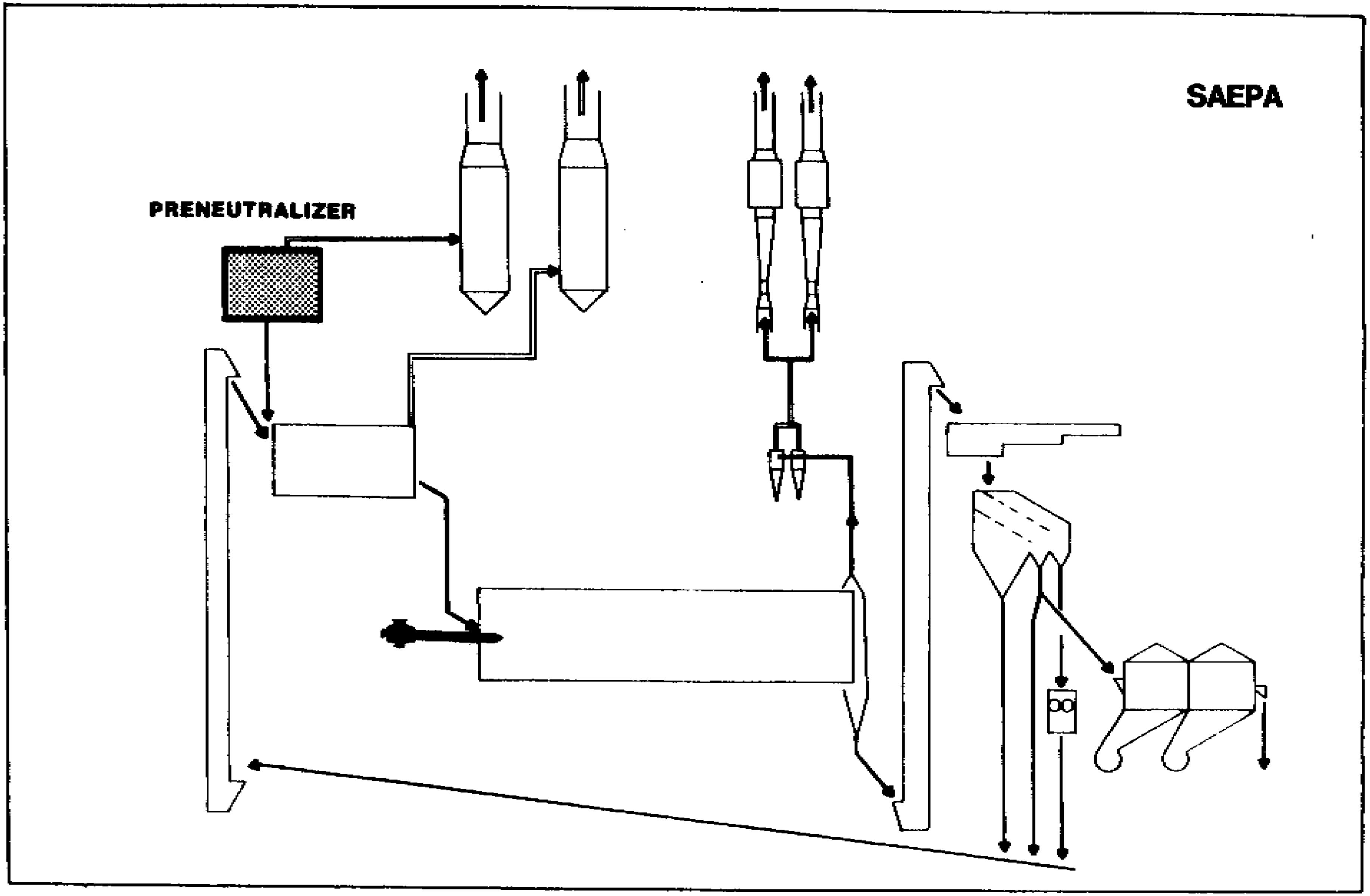

Fig. 2 FITTING OF AN AZF PIPE REACTOR ON THE DRYER

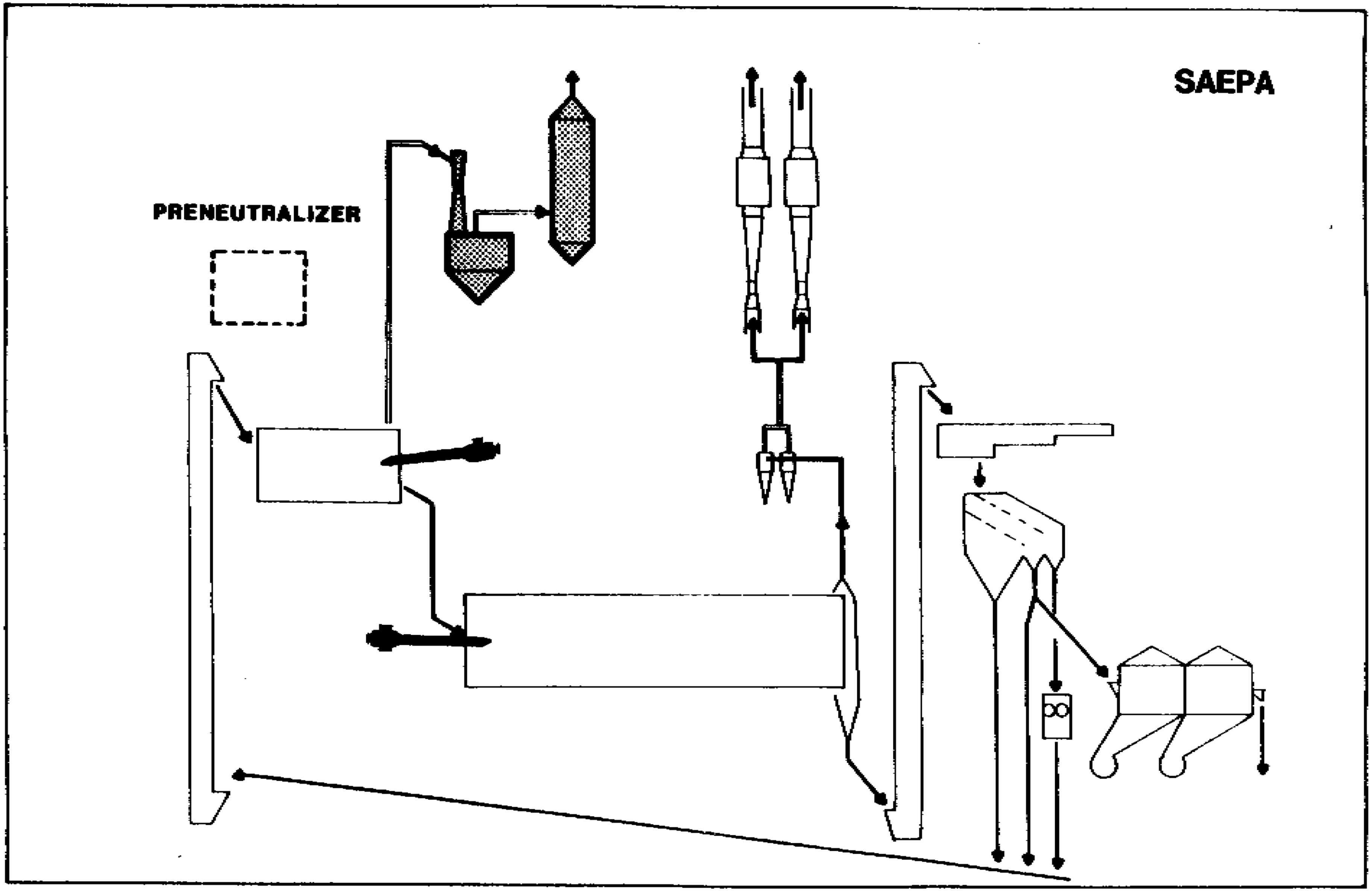

Fig. 3 AZF PIPE REACTOR ON THE GRANULATOR_AZF SCRUBBING UNIT FOR THE GRANULATOR EXHAUST GASES

TA/86/10 SAEPA 1 plant (Gabes). History of a continuous improvement increasing the capacity from 1000 t/d to 2000 t/d by M.L. Ranoui, SAEPA, Tunisia

DISCUSSION : (Rapporteurs Messrs A. Constantinidis, SICNG, Greece & V. Bizzotto, NSM, Netherlands)

Q - Mr D.W. LEYSHON, Jacobs Engineering, USA

We believe the requirement to ammoniate in the granulator additional MAP made in the dryer overloads the ammoniating capability of the granulator leading to excessive NH3 slip. In the DAP process the granulator is in fact the bottleneck equipment and compared to the conventional DAP process, you are expecting almost 50% more ammmoniation to take place there. Can you give us any further details on the special sparger you are using to accomplish this ammoniation?

A - The introduction of the pipe reactor in the dryer did not raise any problem for the ammoniation of the additional MAP in the circulation loop and there was no noticeable disturbance. The absorption of ammonia in the granulator is probably made easier by the nature of the powder product as well as by rubber lining of the granulator and an increased diameter of the ammonia nozzles.

Q - Mr M. BARLOY, SCPA, France

Page 9 you indicate guaranteed and expected performances for ammonia of 98 and 97%. Is it not the reverse?

A - These figures should be changed, the guaranteed performance is 97% and the expected one 98%.

Q - Mr P.T. LAMMI, Kemira Oy, Finland

On page 6 you are saying that the original hammering was replaced by a new, simple and efficient one; could you please describe the new hammering system?

A - The new hammering system is a mechanical one whereas the old one was pneumatical. The operational principle is as follows: the hammering piston is lifted by a rod driven by an electric motor and then released at the top position. The weight of the piston and the dropping height determine the hammering power to be chosen.

Q - Mr E. CODINA, S.A. Cros, Spain

Concerning the tests described under 2.2 of the paper, I would like to know:

1. what was the total solid circulation at the granulator outlet (t/hr)

2. Of the total amount of P205 entering the plant, what percentage goes to gas scrubbing of the dryer and what N/P molar ratio was obtained in those liquids?

A - 1. The total circulation of solids leaving the granulator is about 3 to 1, that is 200 t/ha for a production of about 66 t/hr.

2. 28% of the total amount of P2O5 entering the plant go to the dryer scrubber. The molar ratios of the different scrubbings are:

	Scrubbing acid gas from the dryer	Scrubbing acid gas from the granulator	Scrubbing acid gas from the preneutralizer
N/P	0.4 to 0.6	0.4 to 0.6	0.6 to 0.85
Output	1350	1530-1600	1400-1450

Q - Mr M. SEDIEY, SCPA/PEC Engineering, France

When the reactor was first started, some difficulties led AZF to cut the lifting blades in the first part of the dryer. Did you cut these blades and change the position of the pipe reactor?

A - We had some difficulties when starting the pipe reactor, in particular owing to the scaling of the blades. In the first stage we made a slight cut in the blades of the dryer along the first 6 metres. We also relocated the pipe reactor at the dryer inlet with a resulting centering, which completely solved the problem of scaling.