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REDUCTION IN INVESTMENT AND OPERATING COSTS ACHIEVED THROUGH THE USE OF NEW AMMONIATION SYSTEMS 1/

by

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1/ The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been translated from an unedited original.

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The granulation of fertilizers is a well-established technique, which is used because granulated products are easier to handle and apply than powders.

There are various types of granulation, but a basic distinction can be made between processes using mainly solid raw materials and those in which the main input of nutrients (N, P) comes from the direct use of ammonia and phosphoric acid. The latter process is usually known as the slurry granulation process and is widely used because, among other things, it provides a wide range of formulations and employs raw materials which have undergone little processing, and are therefore cheap (1).

We shall here describe an alternative to the slurry process, developed and used by S.A. CROS, the main purpose of which is to reduce investment and operating costs. This alternative involves the use of a specially designed pipe reactor.

On other occasions, organizations concerned with research and development relating to fertilizer production processes have reported on the savings achieved by the use of a pipe reactor in a pilot plant (2). Our own experience in industrial plants is based on different operating conditions and the savings achieved are substantial enough to make it worth while to enter into the details here.

SLURRY PROCESS

General description

A simplified flow chart for a typical slurry process is given in figure 1.

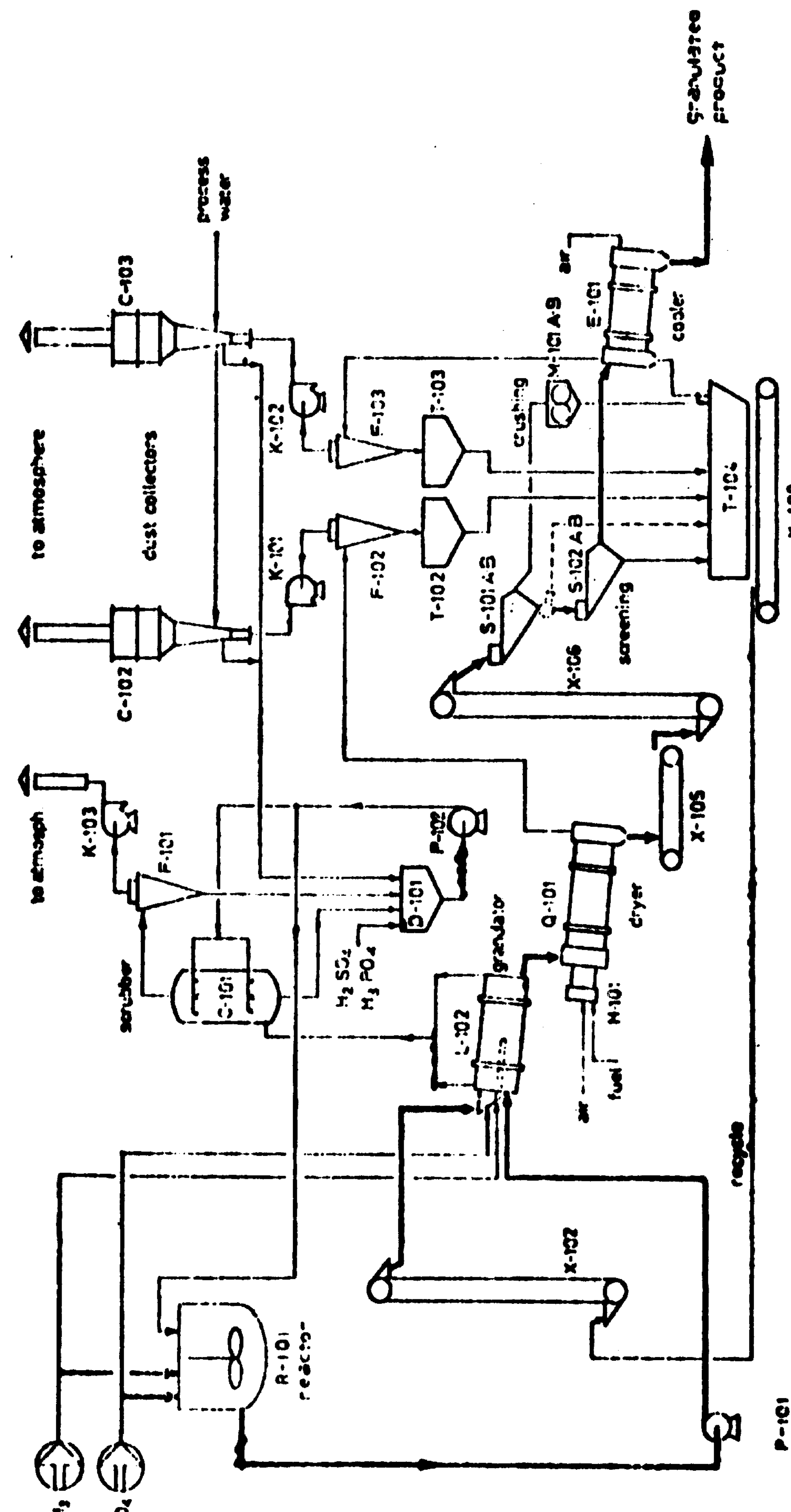
The preliminary neutralization of the ammonia and phosphoric acid takes place in a tank equipped with an agitator. Liquid ammonia and a blend of concentrated phosphoric acid (52-54 per cent P_2O_5) and dilute phosphoric acid (30 per cent P_2O_5) coming from the scrubber and dust collectors are normally used.

The slurry formed is pumped through an insulated tube to the granulator, where it is poured on to the moving bed constituted by the recycle. In the granulator, ammoniation can also be brought up to the N/P_2O_5 ratio desired by adding more of the raw materials (ammonia and phosphoric acid) through a system of injectors.

The product leaving the granulator goes to the drying drum, where the excess water is eliminated. The following stages of cooling, screening and crushing are typical for any granulation process. The recycle of solids consists of granules larger than the maximum desired size (normally more than 4 mm) after crushing, and

Figure 1

SLURRY PROCESS DIAGRAM



those finer than the smallest size accepted (less than 1 mm). The granules grow through the formation of a coating of slurry on a solid particle in the granulator and evaporation of the water from the coating as a result of the heat of reaction and the heat in the drier, producing an approximately spherical distribution of the solid phase.

Thus, the amount of solid matter recycled depends on the amount of water present in the slurry, and the greater the liquid phase, the larger will be the recycle.

The main items of equipment whose size is influenced by the recycle are:

- The granulator
- The drier
- The cooler
- The conveyor belts and elevators
- The screens
- The crusher
- The scrubbing columns
- The dust collecting system

SIMPLIFICATION OF THE AMMONIATION SYSTEM

Pipe reactor

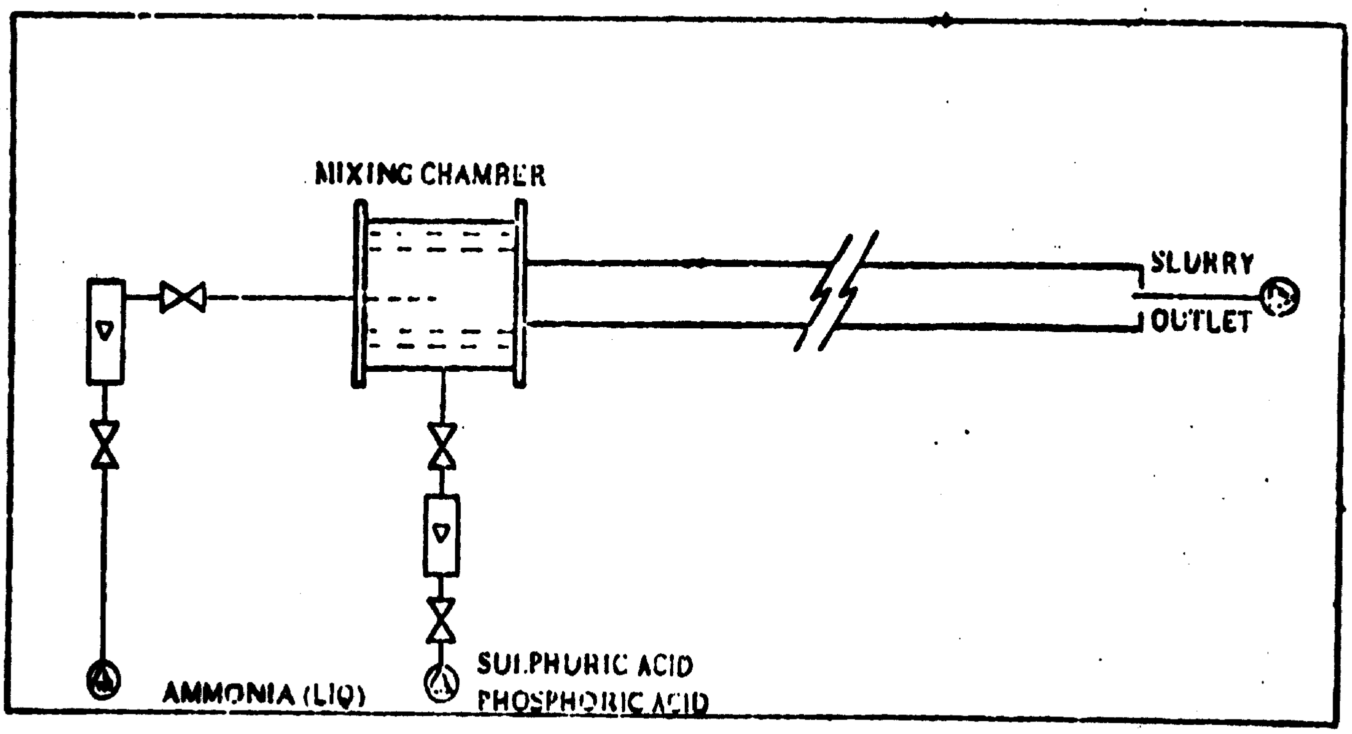
In order to simplify the equipment for a slurry plant, a pipe reactor has been developed (3) (4) (5) (6) (7) to take the place of the agitated tank type reactor in which the ammonia and phosphoric acid react.

The reactor designed and used by S.A. CROS (figure 2) consists basically of a hollow cylinder with an internal mixing system. The desired amounts of ammonia and acid, previously measured, are fed into the cylinder, where they react, and the slurry formed leaves the cylinder through the openings in the outlet tube connected to it.

The cylinder is very small in size and can therefore be placed at the inlet to the granulating drum, with the outlet tube located in the drum, over the rotating bed of solids.

Figure 2

PIPE REACTOR



All the heat of reaction produced in neutralization of the ammonia by the acid is absorbed in the evaporation of the water present. Since the slurry formed need not be pumped, its water content, and thus its fluidity, may be much lower than in the case of the conventional processes described above. The water is eliminated in the form of vapour at the exit from the outlet tube, and since the liquid phase in the granulator is smaller it is possible:

- To reduce the proportion of recycle substantially,
- To reduce fuel consumption in the drier and even, for some formulations, to eliminate the need for this very costly piece of equipment

The feed pressure of the raw materials and the pressure of the steam generated in the reactor facilitate the exit of the slurry from the reactor and its distribution over the solids in movement inside the granulator.

For formulations with a low N/P ratio (e.g. MAP), there is no loss of ammonia. When the N/P ratio increases, the unreacted ammonia is recovered by scrubbing with dilute acid in a column no larger than those used for conventional slurry processes, with recycling of the scrubbing liquid.

APPLICATION TO A SPECIFIC PLANT

In order to make the above more specific, we shall refer to a plant for the manufacture of DAP (18-46-0) in the two alternative versions - the traditional slurry process and the use of the pipe reactor.

In our experience, for the manufacture of this product:

- The proportion of recycle used with the pipe reactor is no more than 4:1, by comparison with conventional levels of 8:1, owing to the smaller amount of liquid phase present in the pipe reactor alternative.
- The items of equipment whose size is substantially affected by this reduction in the amount of recycle are, as pointed out above, those relating to transport of solids (bucket elevators and intermediate conveyor belts) and those which make up the screening and crushing system. Other items of equipment, such as the granulator and the dust collector system, are also affected, although to a lesser degree, owing to the smaller volume of solids circulating through the plant for the same hourly output

- With the use of the pipe reactor, the moisture level at the outlet from the granulator does not exceed a maximum of 2 per cent, and it is therefore possible to eliminate the drier and thus also the consumption of fuel oil involved in the use of the drier.

Figure 3 shows a typical flow chart for the production of DAP using a pipe reactor

Figure 4 indicates the items of equipment which are made superfluous by the use of this process (agitated tank type reactor, pump, slurry pipes and drier).

DIRECT OPERATING COSTS

Figure 5 contains a comparative table of fuel oil and electricity consumption for the two alternatives considered here.

Consumption of raw materials, other auxiliary services and labour are not indicated because they are virtually equal in both cases.

Fuel oil consumption is null when the pipe reactor is used because it is unnecessary to dry the DAP, whose final moisture content at the exit from the plant is from 1.5 to 2 per cent.

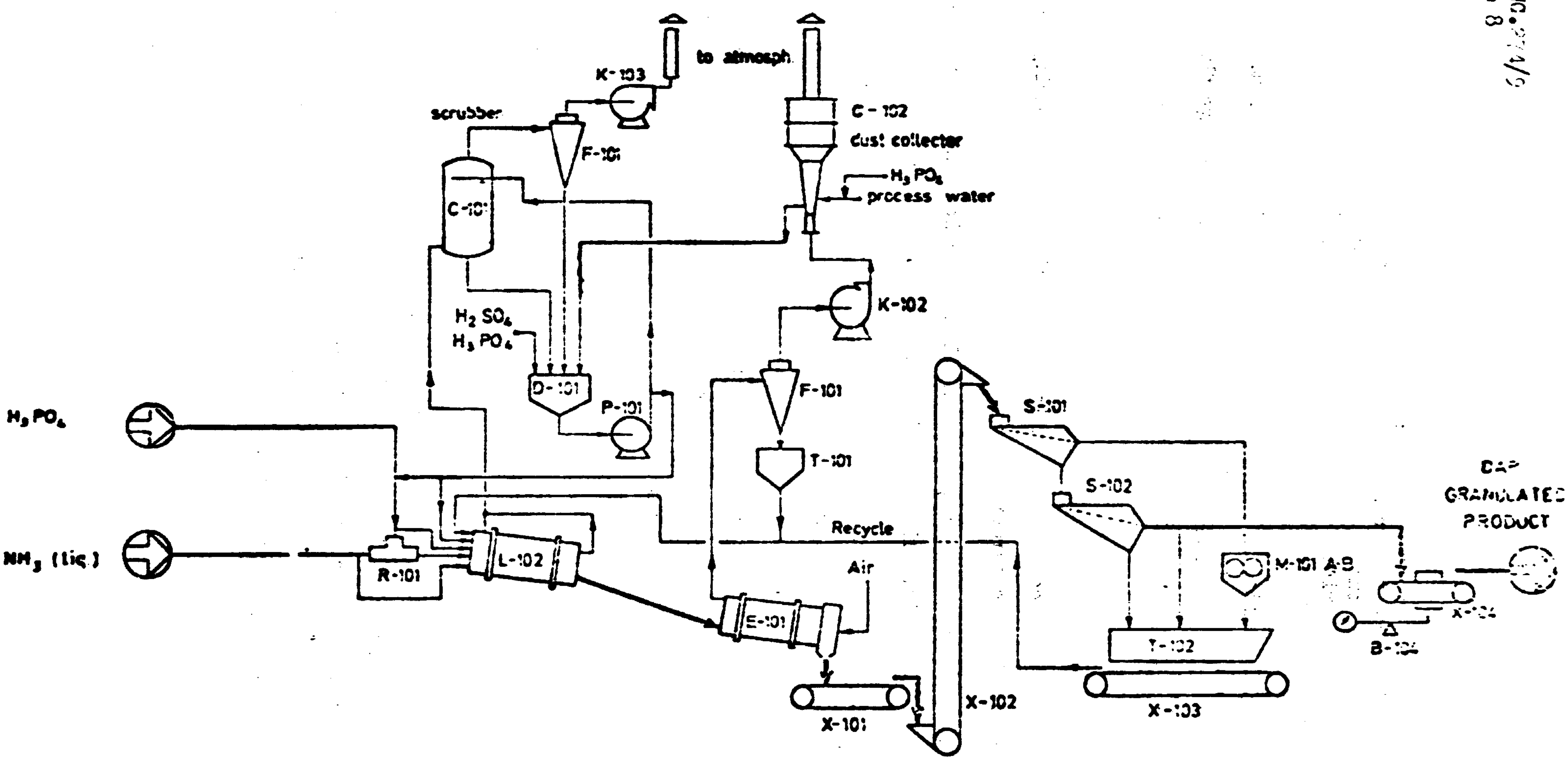
The difference in electricity consumption results from the absence of the drier and the smaller amount of power required for the motors as a result of the smaller total flow of recirculated solids.

INVESTMENT

Taking into account only investment attributable to equipment and materials within the battery limits, the conclusion is that replacement of the agitated tank and the slurry transfer system by the pipe reactor, elimination of the drier and reduction of the size of the screening, crushing and solids transport systems reduces the investment in equipment by at least 50 per cent as compared with the investment necessary for a conventional plant. We have ascertained that, under standard Spanish conditions, the installed plant represents an investment 2.5 to 2.7 times the value of the equipment.

Figure [illegible]

DAP PROCESS DIAGRAM



R-101 CROS-Reactor · C-101 Ammonia Scrubber · L-102 Granulator · E-101 Cooler · C-102 Dust-Collecter · S-101/2 Screening · M-101 Crushing

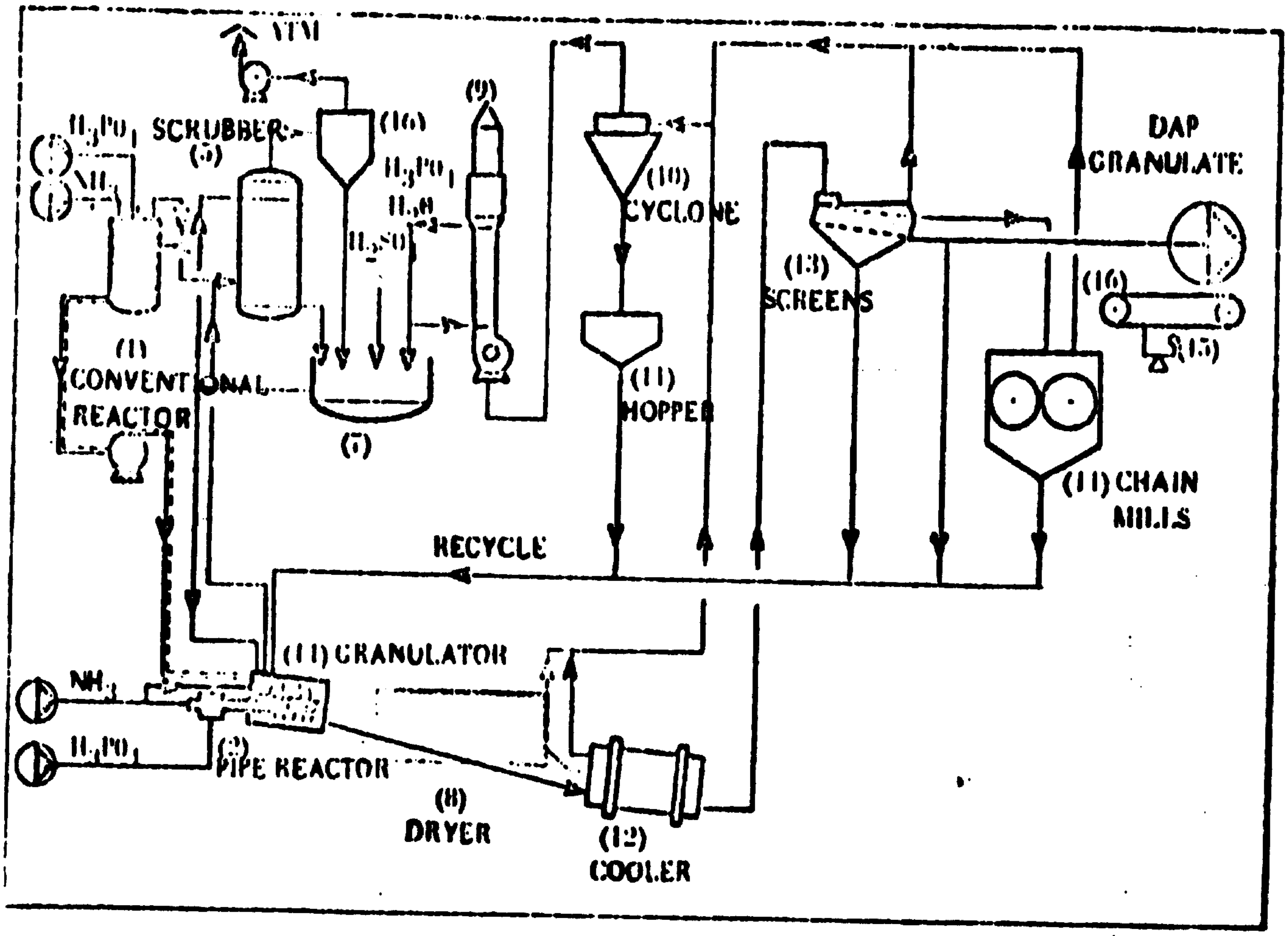

SCRUBBER
(5)
(16)
(9)
(10)
CYCLONE
DAP
GRANULATE
(13)
SCREENS
(16)
(15)
(1)
CONVENTIONAL
REACTOR
(7)
(11)
HOPPER
(11) CHAIN
MILLS
RECYCLE
(11) GRANULATOR
NH3
PIPE REACTOR
(8)
DRYER
(12)
COOLER

Figure 4

Figure 5

COMPARISON OF INPUTS

	Conventional process		Pipe reactor	
	per tonne	pesetas/tonne	per tonne	pesetas/tonne
Fuel oil (kg)	17	119	-	-
Electricity (kWh)	45	90	21	42
Total, pesetas/tonne		209		42

Price of fuel oil: 7 pesetas/kg

Price of electricity: 2 pesetas/kWh

Figure 6

INDIRECT OPERATING COSTS (per tonne of product)[1]

	Pipe reactor	Conventional process
Investment	125.7	1 851.0
Maintenance	50.3	74.0
Depreciation	125.7	185.1
Taxes and insurance	25.1	37.0
Profits	188.6	277.7
	389.7	573.8

1/ Note: An output of 25 tonnes/hour x 7,000 = 175,000 tonnes/year has been assumed.

INDIRECT OPERATING COSTS

Indirect operating costs are those related to the total value of investment in the plant:

- Maintenance 4%
- Depreciation 10%
- Profits on capital 15%
- Taxes and insurance 2%

Financial costs on investment and operating capital are not included, although in a more rigorous analysis they could of course have to be taken into account.

The comparative values of these indirect costs are indicated in figure 6.

The sum of total operating costs indicates a savings of approximately 350 pesetas/tonne.

OTHER APPLICATIONS

Use of the pipe reactor also makes possible:

- Utilization of raw materials which have undergone little processing (ammonia and phosphoric acid) rather than derivatives which already have a certain value added incorporated in them (8);
- Transformation of a solid granulation process into a slurry process with limited additional investment, making possible greater flexibility in production.

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