International Fertilizer Industry Association

IFA Technical Conference

Venice, Italy
2-4 October 1990

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UREA GRANULATION PLANT AT FERRARA

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SUMMARY

The urea granulation unit at Ferrara is now under completion and the foreseen starting-up is July 1990. The plant will substitute the existing prilling tower and will have a capacity of 1,700 t/d.

The plant is based on the AGRIMONT process that has been experimented for 7 years at the Porto Marghera urea plant with a capacity ranging from 150 to 600 t/d.

Granulation occurs in a rotating drum by spraying the 99-99.7% urea solution on falling curtains; the crystallization heat is removed mainly in a fluidized bed cooler and the operation conditions are controlled by the recycle.

An efficient scrubbing system removes the dust entrained by the air from the fluidized bed cooler and from the granulator.

The new plant solves the problems connected with the prilling tower dust and produces granules with better mechanical characteristics than the prilled product.

Product quality and production costs are expected to be at the same level of the best granulation process, however the investment cost is very low (the investment cost for the Ferrara granulation unit is 11 billion Lire).

INTRODUCTION

AGRIMONT has been one of the leading urea producers for many years, with a yearly capacity of about 1,000,000 tons.

Until 1982, AGRIMONT urea was manufactured only by the prilling technique.

In 1982 it was decided to modify the Porto Marghera plant (500 t/d) in order to realize a trial production of 150 t/d granular urea, parallel to a make-up production of 350 t/d prilled urea.

The Porto Marghera plant was characterized by the fact that prilled urea was conditioned in a subsidiary plant (NSM process) in order to obtain free-flowing prilled urea; this coating plant is essentially based on a rotary drum, in which urea-formaldehyde solution is sprayed on the prilled product and on a final fluidized bed cooler, which employs air sub-cooled by a refrigerating cycle.

This coating plant has been adapted to produce granular urea with some modification of the existing equipment and adding some new apparatus.

A paper reporting details on the process, the plant modifications and the product characteristics was presented at the IFA Technical Conference in 1984.

During 1983-1988, the initial capacity was increased up to 500 t/d, thus utilizing all the urea solution produced in the urea synthesis and concentration sections; these results are linked to improvements and debottleneckings applied mainly in the fluidized bed cooling, screening and milling sections.

The plant has been followed by the research people as a pilot plant, studying the effect of many operating parameters (granulation temperature, dimensions of the sprayer droplets, water content in the concentrated solution, particle size and recycle ratio, etc.) on the product characteristics.

The plant has been in operation for a long time using prilled urea imported from Ferrara as seed to obtain well-shaped granules with very good physical characteristics and so the plant capacity has been increased up to 600 t/d.

PROCESS DESCRIPTION

A simplified flow-sheet is reported in figure 1. Feedstock is urea solution at a concentration of 99.4-99.7% by wt, and at a temperature of 136-140°C.

Formaldehyde is added to this urea solution in order to improve the physical characteristics of the produced granules.

The urea solution is then sent to the drum granulator, where it is sprayed at a pressure of 5-6 bar on a curtain of falling recycled granules, thus obtaining the coating of granules with the sprayed droplets.

Air and recycle granulated urea are fed to the granulator to remove crystallization heat and to cool the granules to the temperature required by the process.

Recycle granulated urea enters the drum at a temperature of 50-60°C and leaves it at a temperature of 115°C max.

The granulated product falls into a fluidized bed cooler.

The cooled product is sent to vibrating screens, where it is classified in three fractions: oversize, undersize and on-size.

Oversize granules are first crushed down to an average dimension of 0.5-0.8 mm and then fed back to the granulator to be used as a seed material together with undersize granules.

The part of the on-size fraction corresponding to the plant production is sent to storage, whereas the part in excess is recycled to the granulator.

Air sucked from the fluidized bed cooler and from the drum granulator is cleaned in a wet scrubber; the recovered 45% urea solution is recycled to the urea plant final concentrators.

The same plant can operate using prilled urea as seed. The maximum amount of prilled urea used as seed is 20% of the total production.

PROCESS MAIN FEATURES

Granule formation

Parallel rows of special lifters fitted inside the drum shell bring the granules to the upper part of the drum from where they fall on an inclined surface and then into the lower part of the drum; during this fall, a curtain is formed on which the concentrated solution is sprayed (see figure 2).

Crystallization occurs as soon as the solution droplets coat the surface of the granules.

The growth of the granules takes place gradually by the slow superimposition of urea droplets on the seed, due to the big internal recirculation of the granules.

The slow increase in the size of the granules allows some water of the solution to migrate from the inner part of the granules to the outer surface and then to be stripped continuously by air.

The quantity of feed seeds depends on the size required for the end products; a smaller end product requires higher quantity of seeds.

Occasionally, it may be necessary to send part of the on-size fraction to the mill to provide the granulator with more seed material.

Heat balance

It is well-known that removing the crystallization heat is an important factor influencing the urea granulation process.

The total heat to be removed is the sum of the following:

- the concentrate solution cooling heat down to 133°C	2.6%
- the crystallization heat	61.2%
- the solid urea cooling heat	36.2%

This heat is removed as follows (figure 3):

- by water evaporation	1.5%
- by air circulation in the drum	8.5%
- by cooling air in the fluidized bed	89.7%
- by thermal dispersion	0.3%

It appears evident that the heat is mainly removed in the fluidized bed cooler, where the heat is transferred by the recycle, which enters the drum at 50-60°C and exits with the product at 110-115°C.

In normal operating conditions the recycling ratio is 2.5-3.

This high recycle is only apparently a disadvantage because heat is always exchanged at a high coefficient; the granulating drum has a small diameter easily operated and maintained, the other apparatuses involved in the process (conveyors, fluid beds, screens) are not expensive and easy to scale up.

The process is especially advantageous when frigories are available to reduce the temperature of the air for the fluidized bed cooler, as in the case of the factories, where ammonia has to be evaporated at low pressure for use in nitric acid or ammonium nitrate plants (at Porto Marghera, a big quantity of ammonia is evaporated at 5 bar). A lower temperature of the cooling air requires a smaller fluidized bed cooler and thus reduced requirements of the fans and scrubbing devices, consequently a reduction in investment and operating costs.

When the amount of available frigories is limited, it is more convenient to use them to cool the product sent to storage, keeping the recycle temperature higher; the recycle ratio is increased as required by the heat balance, but the investment and operating costs are reduced.

This second case has been adopted at Ferrara, where there are not enough frigories available and therefore two fluidized bed cooler have been installed.

Biuret formation

The granulation unit slightly contributes to biuret content increase. Most of the biuret is due to the high temperature of the molten urea flowing in the piping from the vacuum separator to the granulator drum, where biuret formation is nearly zero.

According to our plant where the final concentrator of urea solution is located at the top of the prilling tower, the biuret content increases by 0.2% during the flowing down to the granulator.

Dust formation and abatement

The most significant reasons for dust formation are:

- **in the granulator drum**
  - the impact of the granules on the metal surface of the drum;
  - very high air flow rate through the drum, which results in the solidification of molten urea droplets prior to granule coating and in the entrainment of smaller particles;
  - very high vapour pressure of sprayed molten urea (due to temperature and water content);
  - very high granulation temperature producing soft granules, or low granulation temperature producing brittle granules;
  - granules friction bringing about abrasion of the surface roughness;
  - dust entrainment by milled product

- **in the fluidized bed**
  . entrainment of smaller granules by fluidization air
- **in the mill, screens and transporters**
  . entrainment of dust or smaller granules by air sucked in order to avoid working area contamination by urea.

The stream of air flowing through the granulator drum at a rate of about 1 m/sec entrains the very small particles.

Since the air leaving the drum contains very fine and plastic dust, easily adhering to surfaces, it must be promptly treated by the wet scrubber.

The dust coming from the fluidized bed cooler and from the screening and milling sections can be recovered in a dry cyclone battery and recycled to the drum as seed, or treated in a wet scrubber and recovered as urea solution at 50% by wt. max.

Operation control

System stability is one of the high-lights of the process.

Recycle ratios of the oversize and undersize product are self-adjusting at rather low levels.

Granule size of the product is defined by the net openings of the screens; for a better definition of the product granulometric curve, it is sufficient to change the seed size, adjusting the mill opening and/or the seed flow by-passing part of the oversize product to the mill or adding to the mill a part of the on-size product to be recycled.

The final characteristics of the product (namely, moisture and crushing strength) are assured through controlling the molten urea concentration and the quantity of formaldehyde added.

FERRARA PLANT

Plant description

The simplified flow-sheet of the Ferrara urea granulation plant is attached, see figure 4.

The plant design capacity is 1700 t/d on a single train. The new unit has been installed in the existing building, erected for the coating plant for prilled urea; as in the Porto Marghera case, as much as possible of the existing apparatus has been adapted to the new process.

In the flow-sheet, this equipment can be identified by means of the item No.: numbers beginning with 11 are new, items beginning with 9 refer to the previous ones.

The drum granulator BF1101, the heart of the process, has been designed taking in particular consideration the high scale-up ratio referring to the P. Marghera granulator and the very high production capacity.

Drum rotation speed and inclination can both be adjusted in order to fix the retention time of the product at the best value.

The granulation operation is designed to use prilled or milled urea as seed; when prilled urea is used, it arrives directly to the granulator from the prilling tower.

The granulated product is sent to the vibrating grid PV1102, that separates the lumps, if any, to be dissolved in tank D921; obviously lumps would disturb the smooth operating of the fluidized bed cooler EA1101.

After going through the screens PV1101, the final product is cooled again to 40°C in the second fluidized bed cooler EA1102.

Effluent treatment

The air sucked from the drum granulator BF1101 and front the fluidized bed cooler EA1101 is sent to the wet scrubber D1102 in order to recover dust as urea solution at 45% by wt.

Steam condensate is used as make-up water.

Some ammonia may be present in the stream coming from the granulator, therefore a small quantity of sulphuric acid is added to the abatement solution.

Fan P903 keep the belt conveyors, bucket elevator T1101, screens PV1101 and mills P1101 under suction; this gaseous stream is conveyed to a second wet scrubber D923, fed with process water. The weak recovered urea solution is added as make-up to the first scrubber D1102.

The foreseen effluents sent to the stack:

- air from scrubber D1102:	flow	370000	Nmc/h
	dust content	6	kg/h
	ammonia content	10	kg/h
- air from scrubber D923:	flow	75000	Nmc/h
	dust content	3	kg/h
	ammonia content	1	kg/h

NO liquid effluent leaves the Ferrara granulation plant.

Economic data

The total investment cost of the urea granulation plant at Ferrara was 11 billion lire

Our estimated cost of a new plant having a capacity of 1700 t/d is 15 billion lire.

It appears that the value of the re-utilized existing apparatus and building is 4 billion lire; indeed, the value of the recovered material is higher, however some extra costs were incurred due to some modification to the existing apparatus and the building.

The following consumptions of utilities and chemicals, referring to the production of 1000 kg granular urea (starting from the urea concentrated solution at 99.4÷99.7%) are expected:

- electric power	22	kWh
- low pressure steam (to reconcentrate the recovered solution at 45%)	40	kg
- formurea 80 (as formaldehyde)	2.5÷3.5	kg

Product quality

Table 1 reports a list of typical granular urea produced at the Porto Marghera plant.

The table includes:

- the normal granulated product, average diameter	3.3	mm
- the granulated product using prilled urea as seed (8 and 16%)		
- lower size product, average diameter	2.43	mm

The importance is evident of the use of prilled urea on the granule sphericity.

The crushing strength is greatly influenced by the formaldehyde content; in our product we usually limit the formaldehyde content to a max value of 0.35%, considering that the end product maintains a good free-flowing characteristic.

Table 2 shows the foreseen characteristics of the Ferrara plant product, however taking into account that the design basis comes from the Porto Marghera experience, we believe that all the various products obtained at Porto Marghera can also be produced in the Ferrara plant.

TABLE 1 - TYPICAL GRANULAR UREA PRODUCED AT PORTO MARGHERA PLANT

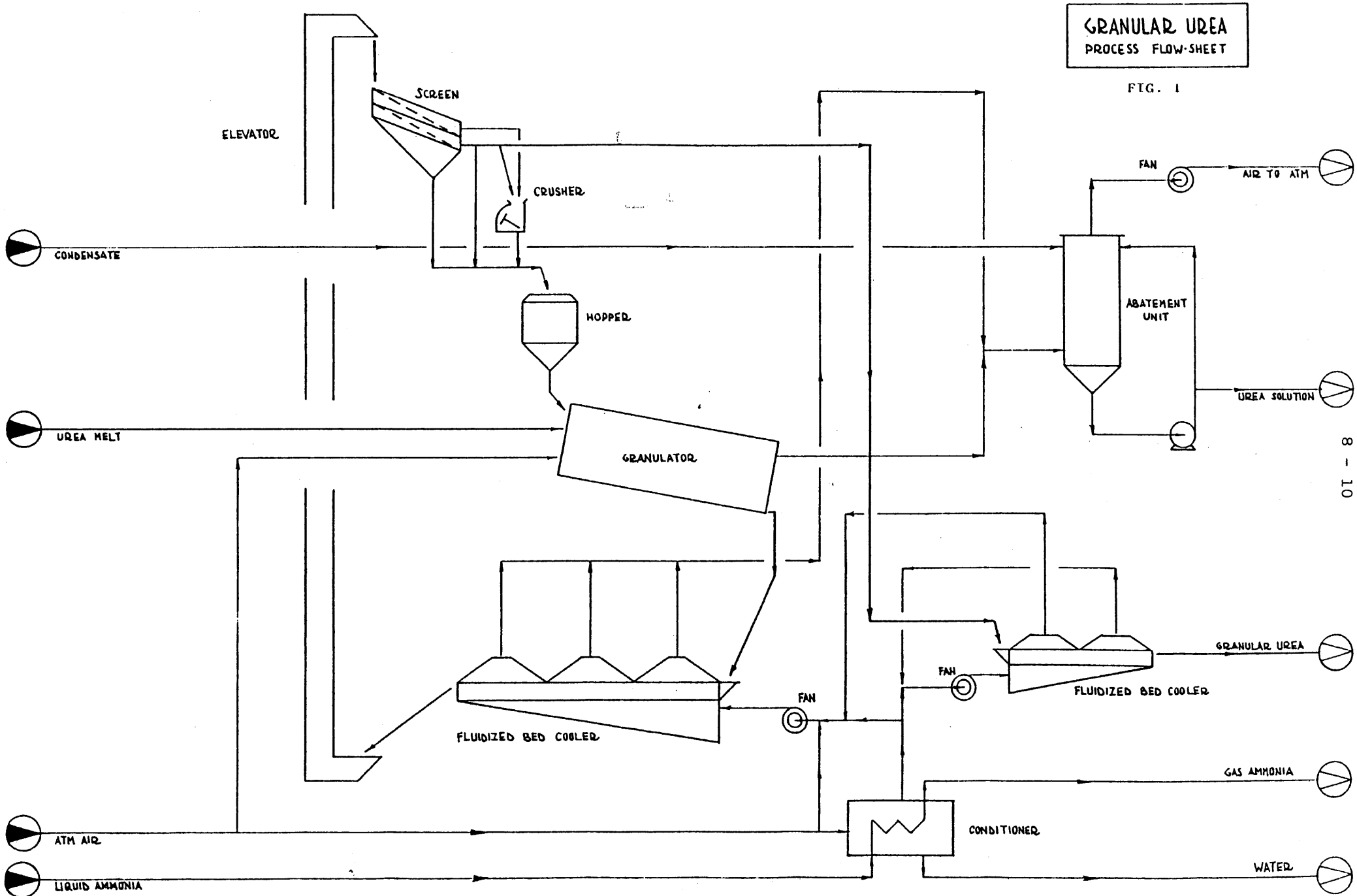
CHARACTERISTICS	UNIT	WITHOUT PRILLED SEED	WITH PRILLED SEED (8%)	WITH PRILLED SEED (16%)	LOWER SIZE PRODUCT
Chemical analysis					
- moisture	%	0.2	0.2	0.2	0.2
- biuret	%	1.0	1.1	1.1	1.1
- formaldehyde	%	0.22	0.23	0.21	0.25
- free ammonia	ppm	120	100	130	100
- pH (10% solution)	-	8.5	8.5	9.0	8.6
Particle size					
- > 5 mm	% W	0.3	0	0.7	0
- 4-5 mm	"	20.4	4.6	16.4	1.6
- 2-4 mm	"	76.2	94.1	82.3	93.0
- 1-2 mm	"	7.1	1.3	0.6	15.3
- < 1 mm	"	0	0	0	0.1
- mean diameter (Sauter)	mm	3.3	3.05	3.24	2.43
Physical characteristics					
- crushing strength (2.5 mm)	kg	1.8	1.6	1.6	1.8
- sphericity		0.75	0.86	0,90	0,91
- bulk density	kg/dmc	0.73	0.77	0.78	0.80

TABLE 2 - CHARACTERISTICS OF GRANULAR UREA
(Foreseen for the Ferrara plant)

- Moisture content	0.2 -0.25%
- Nitrogen content	46.0-46.3%
- biuret content	less than 1.2%
- formaldehyde content	0.25 -0.35
- free ammonia	less than 150 ppm
- pH	9-9.8
- color	less than 20 Apha
- bulk density	780÷800 kg/mc
- particle size:	
. more than 5 mm	less than 1 %
. 2-5 mm	more than 93.5%
. 1-2 mm	less than 5 %
. less than 1 mm	less than 0.5%
- crushing strength (2.5 mm)	more than 1.6 kg

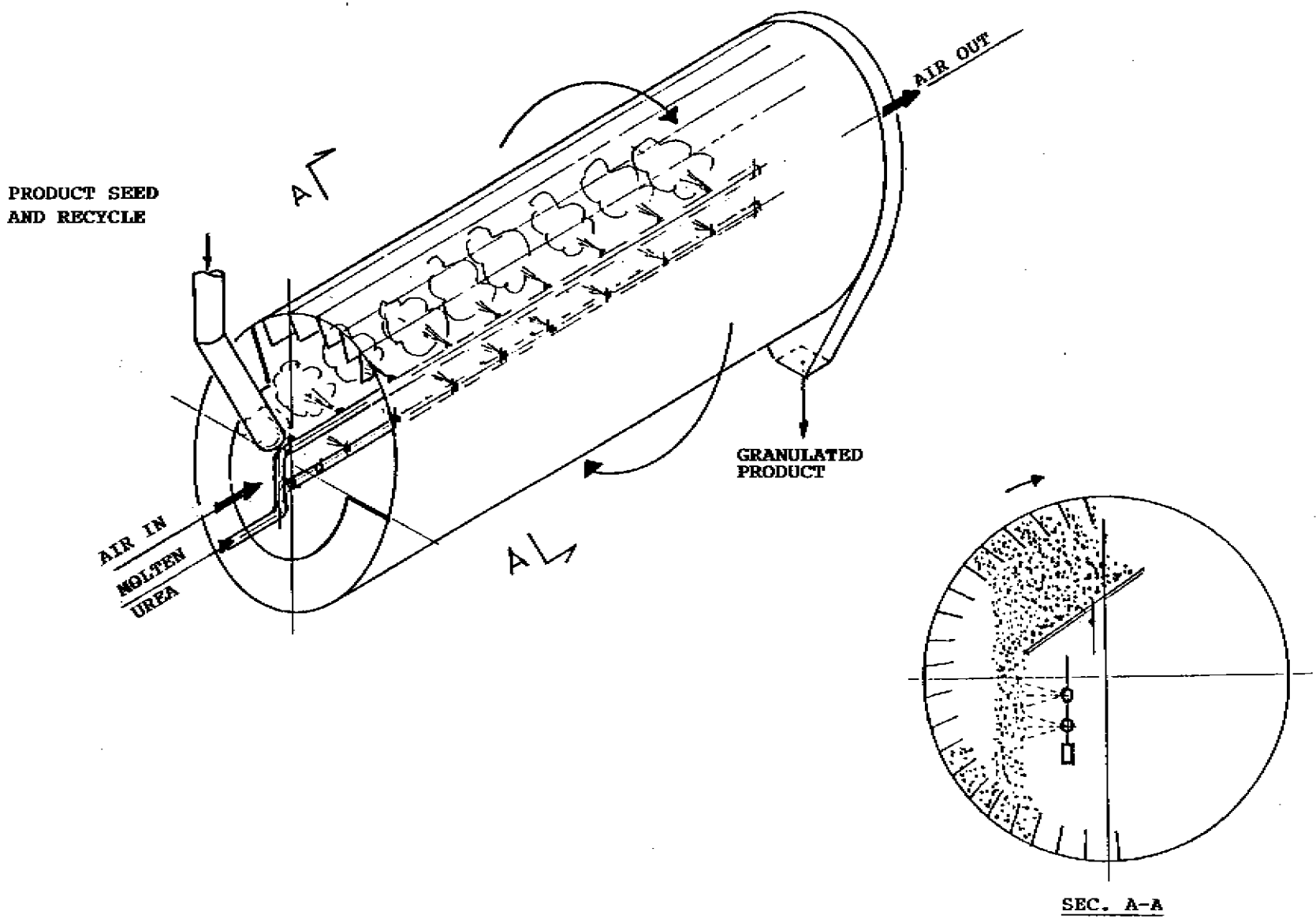
GRANULAR UREA
PROCESS FLOW-SHEET

FIG. 1



DRUM GRANULATOR

FIGURE 2



UREA GRANULATION
heat balance

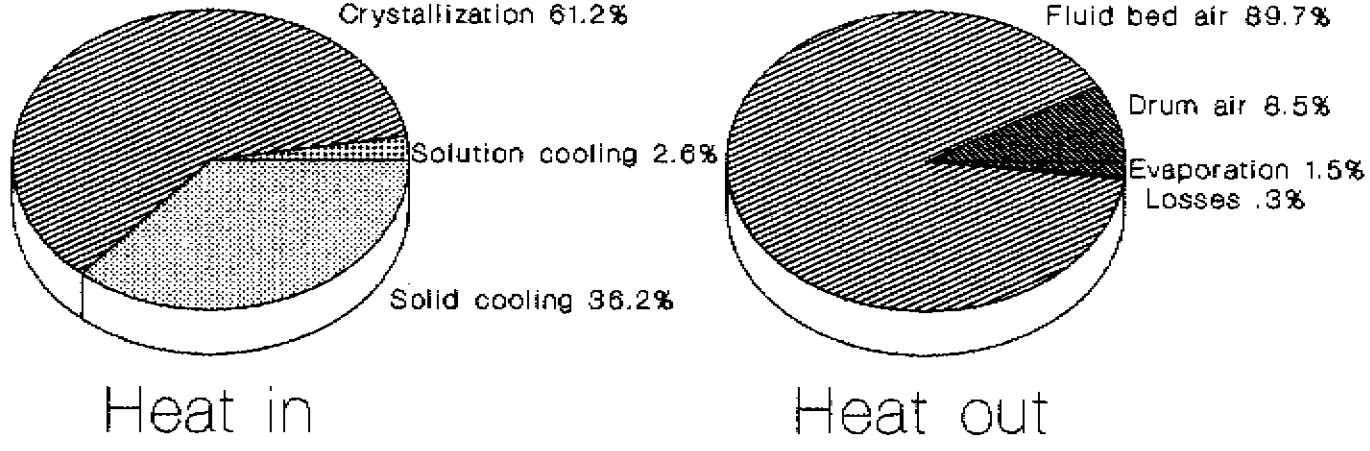


FIGURE 3

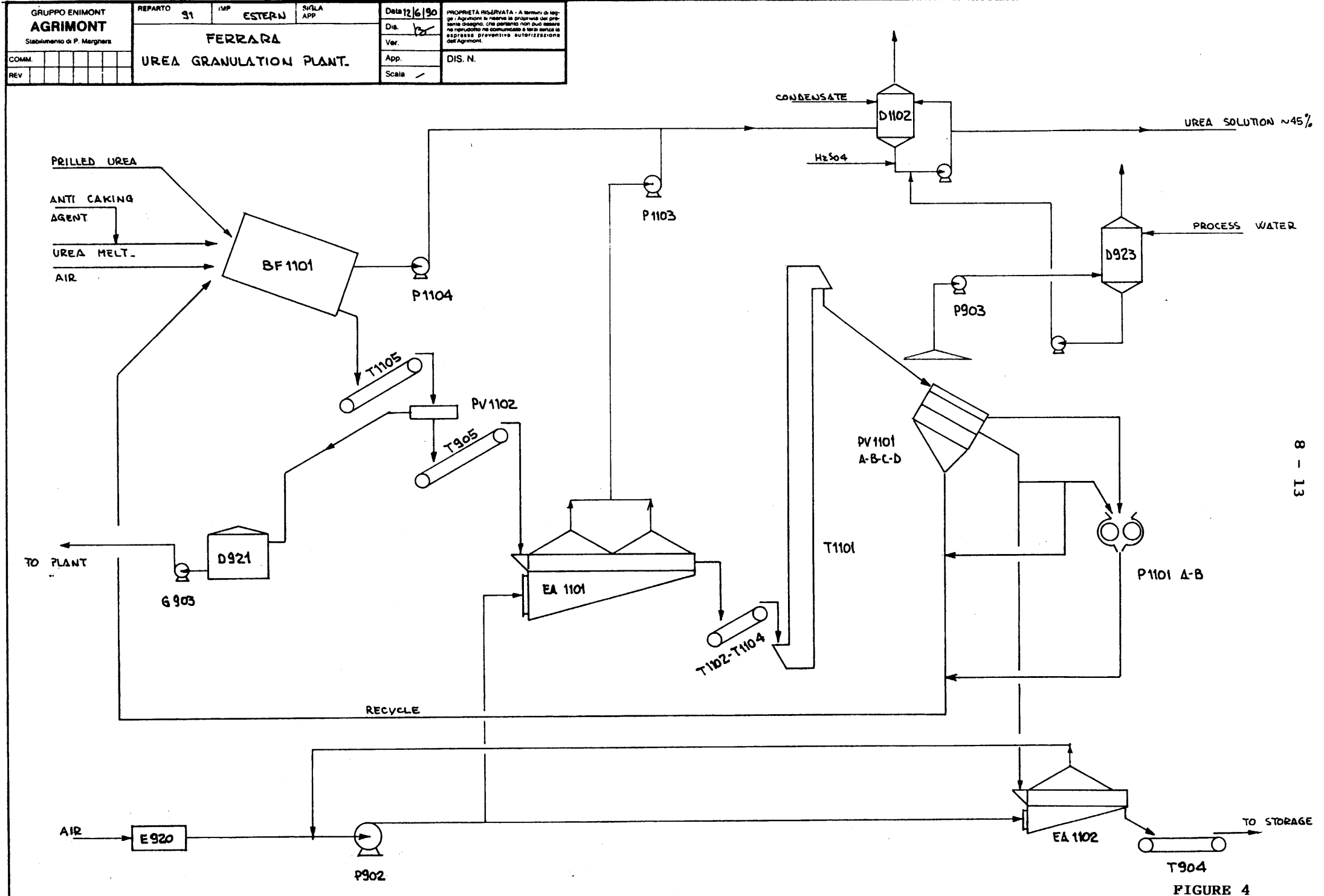

GRUPPO ENIMONT
AGRIMONT
Stabilimento di P. Marghera
REPARTO 91
IMP ESTERN
SIGLA APP
FERRARA
UREA GRANULATION PLANT.
Data 12/6/90
Dis.
Ver.
App.
Scala
DIS. N.
PROPRIETÀ RISERVATA - A termini di legge l'Agrimont si riserva la proprietà del presente disegno, che pertanto non può essere ne riprodotto ne comunicato a terzi senza la espressa preventiva autorizzazione dell'Agrimont.
CONDENSATE
D1102
UREA SOLUTION ~45%
H2SO4
PRILLED UREA
ANTI CAKING AGENT
UREA MELT.
AIR
BF 1101
P1104
P1103
PROCESS WATER
D923
P903
T1105
PV1102
T905
PV1101 A-B-C-D
TO PLANT
D921
G903
EA 1101
T1101
P1101 A-B
T1102-T1104
RECYCLE
AIR
E920
P902
EA 1102
TO STORAGE
T904

FIGURE 4