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FERTILIZER GRANULATION AND GROWTH THROUGH THE FLUIDIZED BED DRUM TECHNIQUE - EXPERIENCE AND INDUSTRIAL RESULTS IN THE LATEST UNITS BUILT

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ABSTRACT

The fluidized drum granulation process (FDG) is a combination of a drum granulation and a fluidized bed fitted inside the drum.

The granulation drum is fed with seeds which may be either recycled products, or prills or possibly compacted products to be rounded.

The granulation drum combines growth and cooling or drying operations, as the case may be.

The process was implemented at an industrial scale in 9 plants with a capacity ranging from 300 to 1100 tpd.

The paper deals with actual application cases:

- Urea granulation and growth,
- Nitrate growth,
- Ammonium sulphate growth,
- Rounding of PK or NPK compacted products.

In each of the above mentioned cases, references will be given as well as basic data such as granule size curves, properties of finished products, operational conditions, etc.

GRANULATION AND FATTENING OF FERTILIZERS USING THE KALTENBACH-THÜRING FLUID DRUM GRANULATION (FDG) TECHNOLOGY

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LAST EXPERIENCES AND RESULTS FROM SOME PLANTS

1 - PRINCIPLE OF THE FDG PROCESS

The heart of the process is a horizontally-aligned cylindrical granulating drum, which rotates about its axis in the conventional fashion. The interior of the drum is fitted with special anticlogging lifters. But the main feature distinguishing it from conventional drum granulators is an internal fluidized bed. This comprises a flat perforated plate through which fluidizing air is blown (direct from the atmosphere or after conditioning, according to the product being granulated).

The granulator is supplied with seed material, which can be recycled off-size but might also be prills that it is desirable to enlarge or a compacted product that it is desirable to make smoother and rounder. In the granulator it is subjected to the dual operations of size enlargement and cooling or drying, as the case may be. This occurs progressively in the following cyclic sequence: the lifters raise the seed material to the upper part of the drum, where upon it falls onto the surface of the fluidized bed. This is where the product is cooled or (when the feed material is a slurry) dried. Product flows on the bed and falls into the lower part of the drum. As it falls, it is sprayed with the feed melt or slurry. The coated granule is then lifted back to the fluidized bed, where the new surface layer solidifies by cooling or evaporation of its moisture content. The same cycle is then repeated as many times as are necessary to reach the desired grain size.

Various additives, such as fillers, micronutrients or other specific additives, can be added with the sprayed product.

An external fan draws the air out of the granulator.

2 - PRACTICAL APPLICATIONS

2.1. Granulation of molten salts

The pre-eminent application of the FDG process is in melt granulation where the feed material is either completely anhydrous or contains so little moisture that the heat of crystallization is sufficient to vaporize it. Cooling is all that is needed to solidify the successive liquid layers deposited on the surface of the granules, so the fluidized bed is actuated by ambient air. The product collected at the granulator outlet passes straight to the screens and the on-size fraction undergoes final cooling before passing to store. The undersize and the crushed oversize are recycled to the granulation.

2.2. "Fattening" of urea or ammonium nitrate prills

Most prilling towers cannot produce prills with a mean diameter of more than about 2.5 mm, whatever the nature of the product. Ideally, from the point of view of handling or storage - and especially when it comes to bulk-blending with other granular materials, which are usually larger in size - many users would like larger prills. Without changing the usual recycle rate of a prilling tower (5 - 10%), the weight of the prills can be doubled and the mean diameter can be increased by 25%. The prills coming from the tower are simply introduced into the fluidized drum granulator as seed material to be fattened.

2.3. Granulation of solutions or slurries

The process is applied to granulation of ammonium sulfate solutions or slurries resulting from scrubbing of the gas exhausting from power plants burning coal.

After granulation, the product is further dried in a rotary drum, screened and then cooled in a fluidized bed cooler.

Oversize product is crushed and returned to the FDG and the fines are recycled to the ammonium sulfate solution which is sprayed in the FDG.

Undersize product is recycled to the granulator for further size increasing.

2.4. "Rounding off" compacted products

One of the drawbacks of compacted products is that the particles have sharp brittle edges which break easily during handling, generating dust. The FDG process makes it possible to palliate this drawback by depositing a film of the same composition on the compacted product surface. The product obtained presents an aspect very similar to that of a granule. The edges are fairly rounded and the resistance to abrasion is significantly increased.

3 - CASE STORIES

Nine plants have been built since 1985 using the KALTENBACH-THÜRING FDG technology.

This paper concentrates on five reference cases:

- a urea fattening plant with a capacity of 1200 T/D

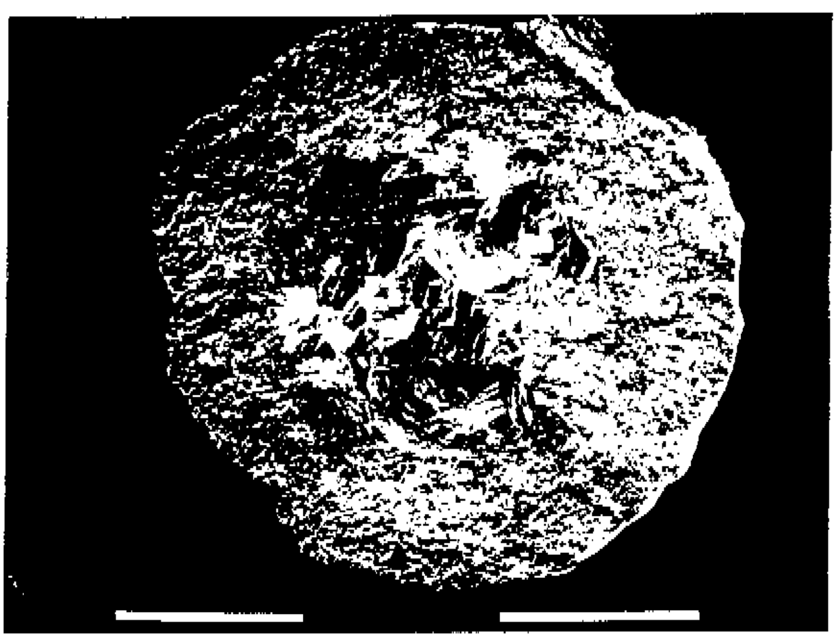
- an ammonium nitrate plant with a capacity of 400 T/D

- an ammonium nitrate granulation plant of 250 T/D

- an ammonium sulfate granulation plant of 12 T/D

- a PK rounding off plant with a capacity of 1000 T/D

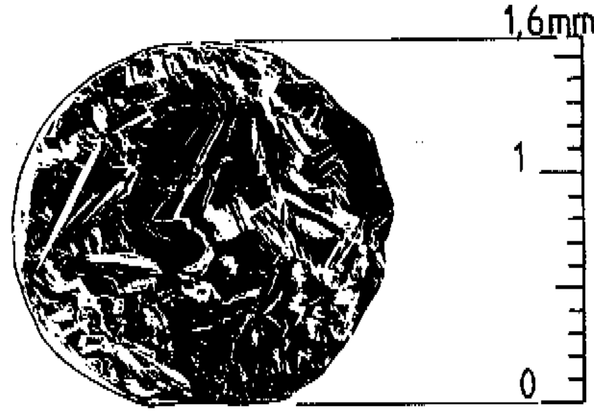
ORIGINAL PRILL - CROSS SECTION



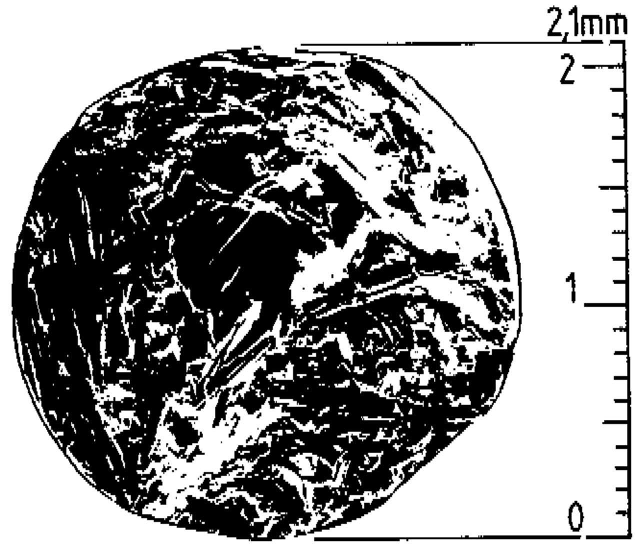
FATTENED PRILL - CROSS SECTION

THE TWO STEPS OF THE PRILL FATTENING

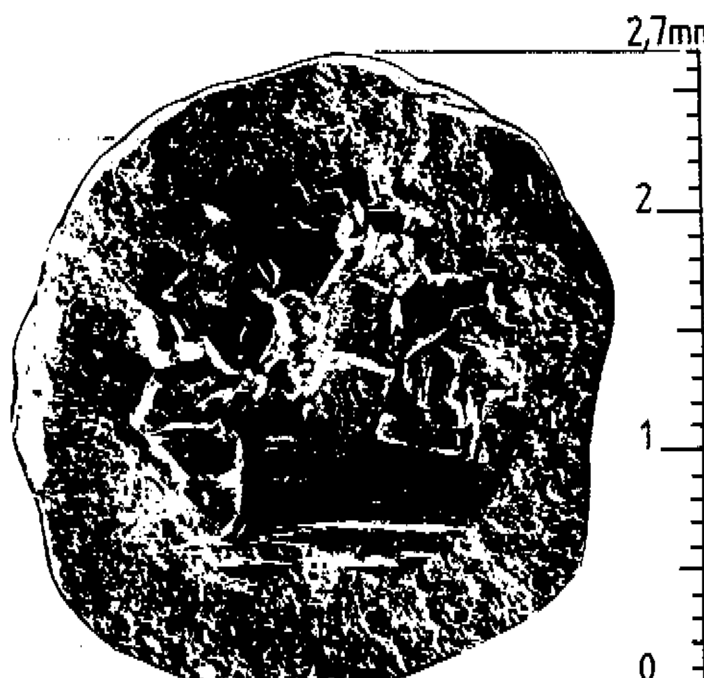
1 – ORIGINAL PRILL

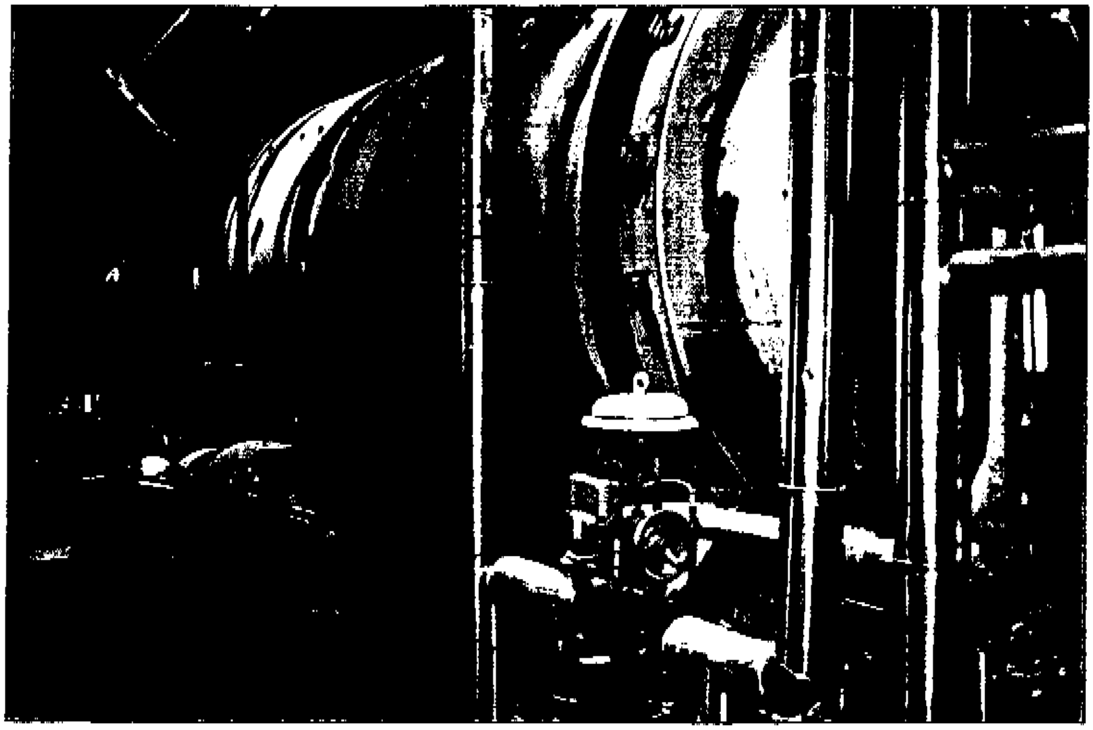


2 – FIRST STEP
Increase in the prilling tower

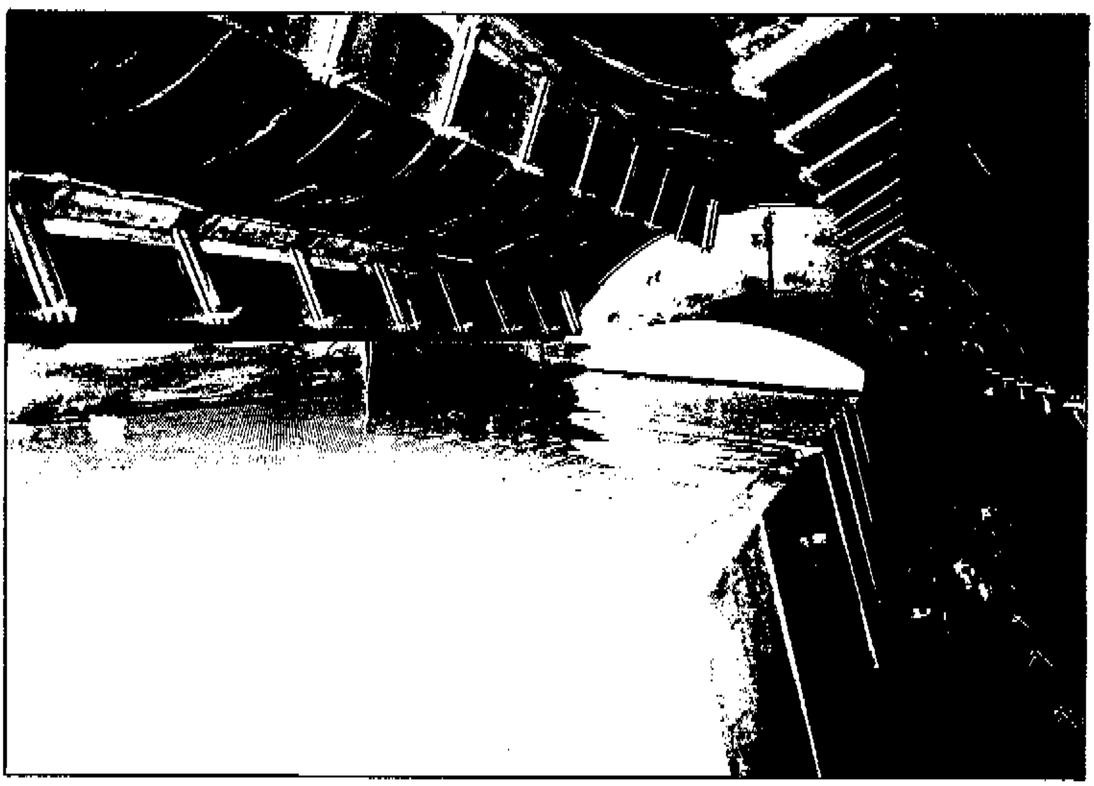


3 – SECOND STEP
Fattening in F.D.G.



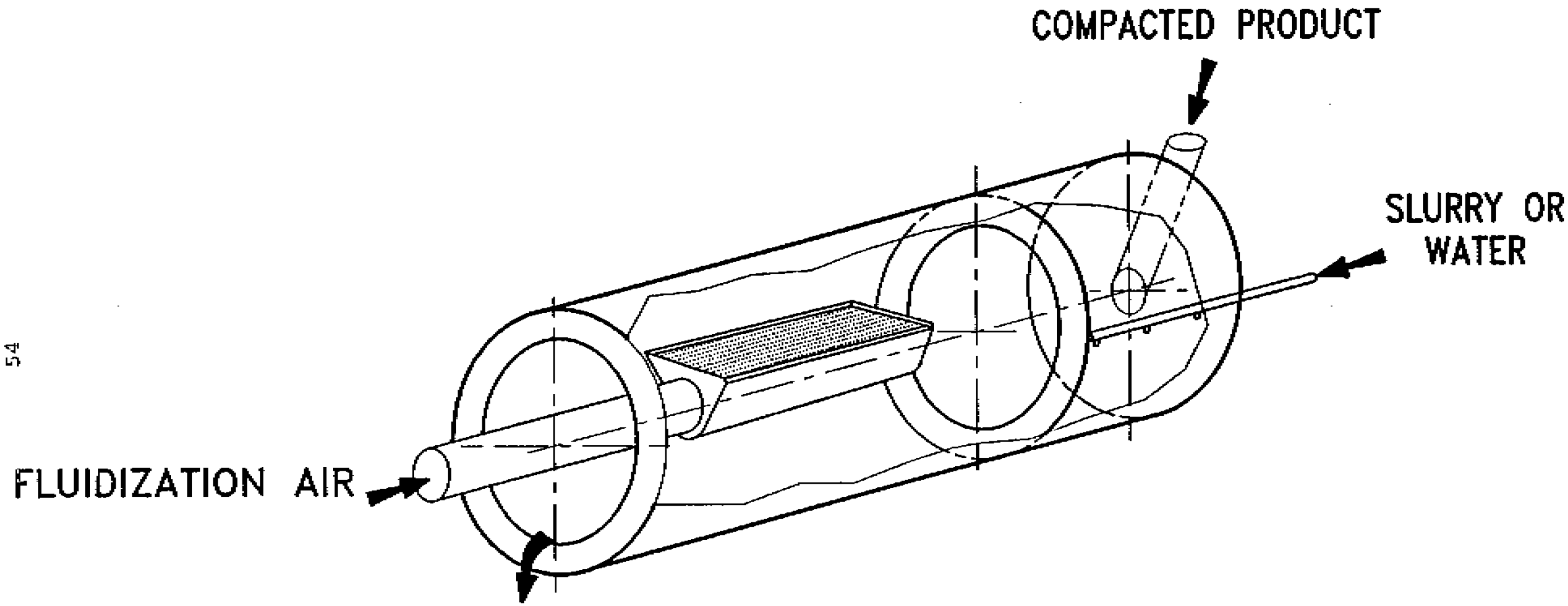


THE GRANULATING DRUM (EXTERNAL VIEW)



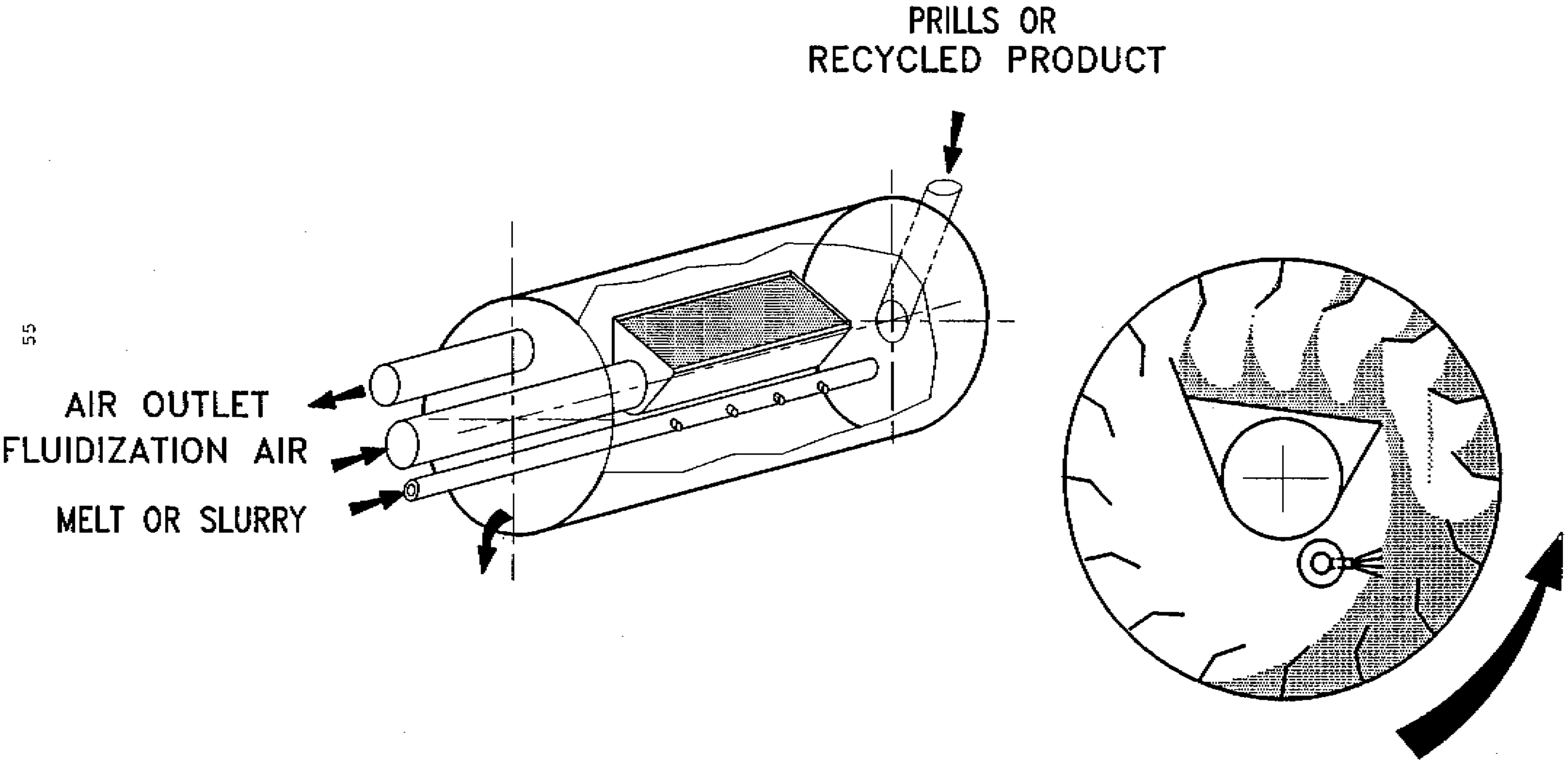
THE GRANULATING DRUM (INTERNAL VIEW)

KALTENBACH-THURING



FLUID DRUM GRANULATOR
ROUNDING OFF - COMPACTED FERTILIZERS

KALTENBACH-THURING



FLUID DRUM GRANULATOR

REFERENCES

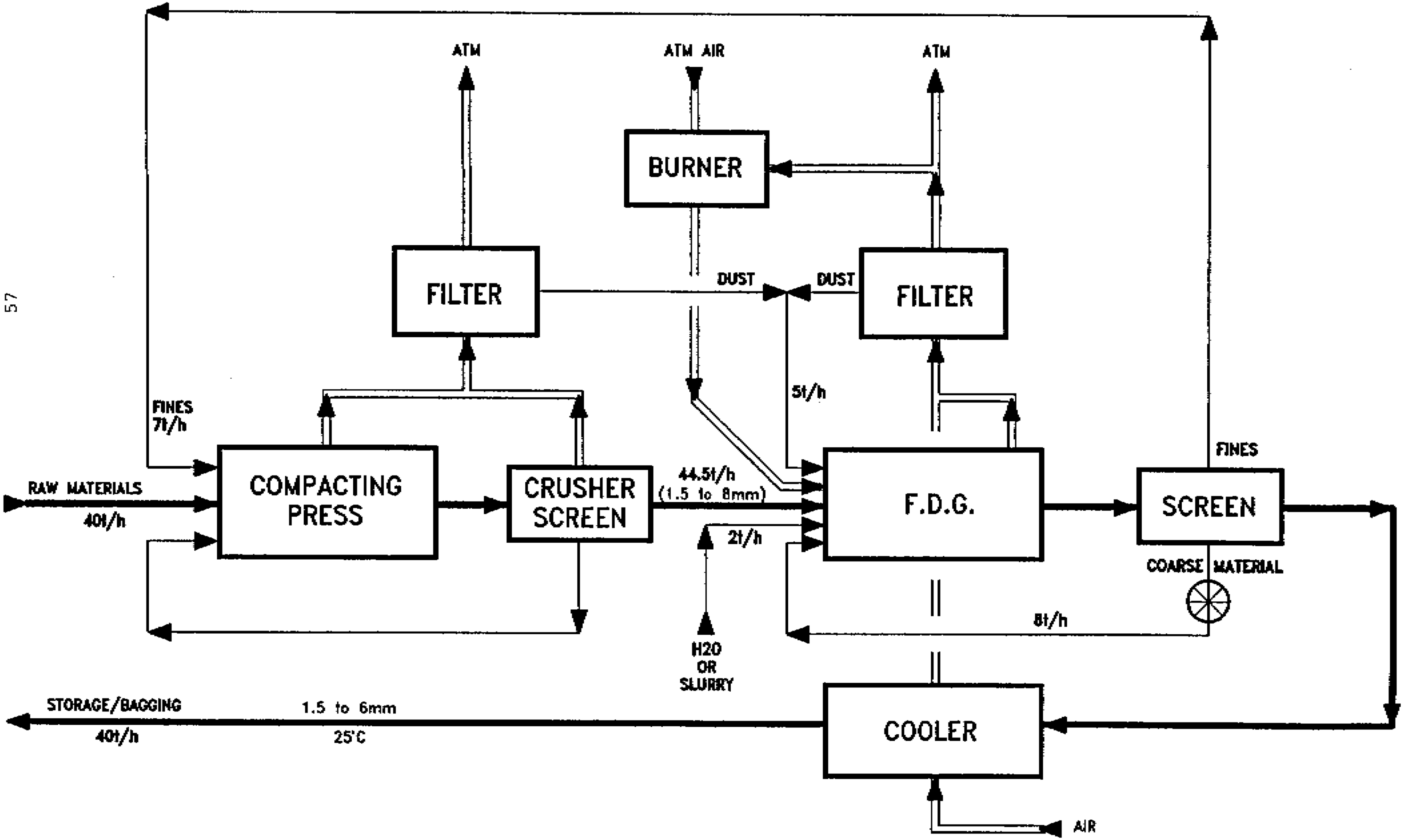
FLUIDIZED DRUM GRANULATION

FDG

NAME OF OWNER	LOCATION	TYPE OF PLANT	CAPAC. (t/d)	COMMISSION ING YEAR
SAPEC	SETUBAL (Portugal)	Compacted PK/NPK "rounding-off"	500	1986
TIMAC	SAINT-MALO (France)	Compacted PK/NPK "rounding-off"	1450	1987
CEDEST	THIONVILLE (France)	Compacted PK/NPK "rounding-off"	1000	1988
S.K.W	KARLSRUHE (Germany)	Ammonium sulphate granulation	30	1988
I.F.I.	CORK (Ireland)	Urea prills fattening	1100	1990
INCITEC (Eastern Nitrogen Ltd)	NEWCASTLE (Australia)	Ammonium nitrate granulation	250	1990
ENICHEM	TERNI (Italie)	Urea and/or calcium nitrate granulation	400	1991
ENEL	SULCIS (Italy)	Ammonium sulphate granulation	12	1991
SIMPLOT	BRANDON (Canada	Ammonium nitrate fattening	400	1991

ROUNDING OFF AND COATING OF COMPACTED FERTILIZERS

CEDEST/DISTROF (FRANCE)



Plant owner : **CEDEST**
Location : **Thionville (France)**
Product : **Compacted PK and NPK**
Type of process : **"Rounding off"**

Specifications of the FDG inlet products

Solid

. nature	:	compacted PK (12-12-0) / NPK (13-11-15)
. particle size	:	2 % below 1 mm - 15% above 5 mm
. water content	:	0.5 to 1 %
. temperature	:	30 to 35°C
. flowrate	:	45 t/h
. dust index	:	2% to 6%

Liquid

. nature	:	water or slurry
. concentration (dry mater.)	:	0 to 50%
. temperature	:	ambient
. flowrate	:	2 t/h

Specifications of the final product

. nature	:	"rounded off" PK or NPK
. particle size	:	2% below 2 mm - 3% above 6 mm
. water content	:	0.5 %
. dust index	:	# nil
. temperature (to storage)	:	80°C
. flow	:	40 t/h

Recycle

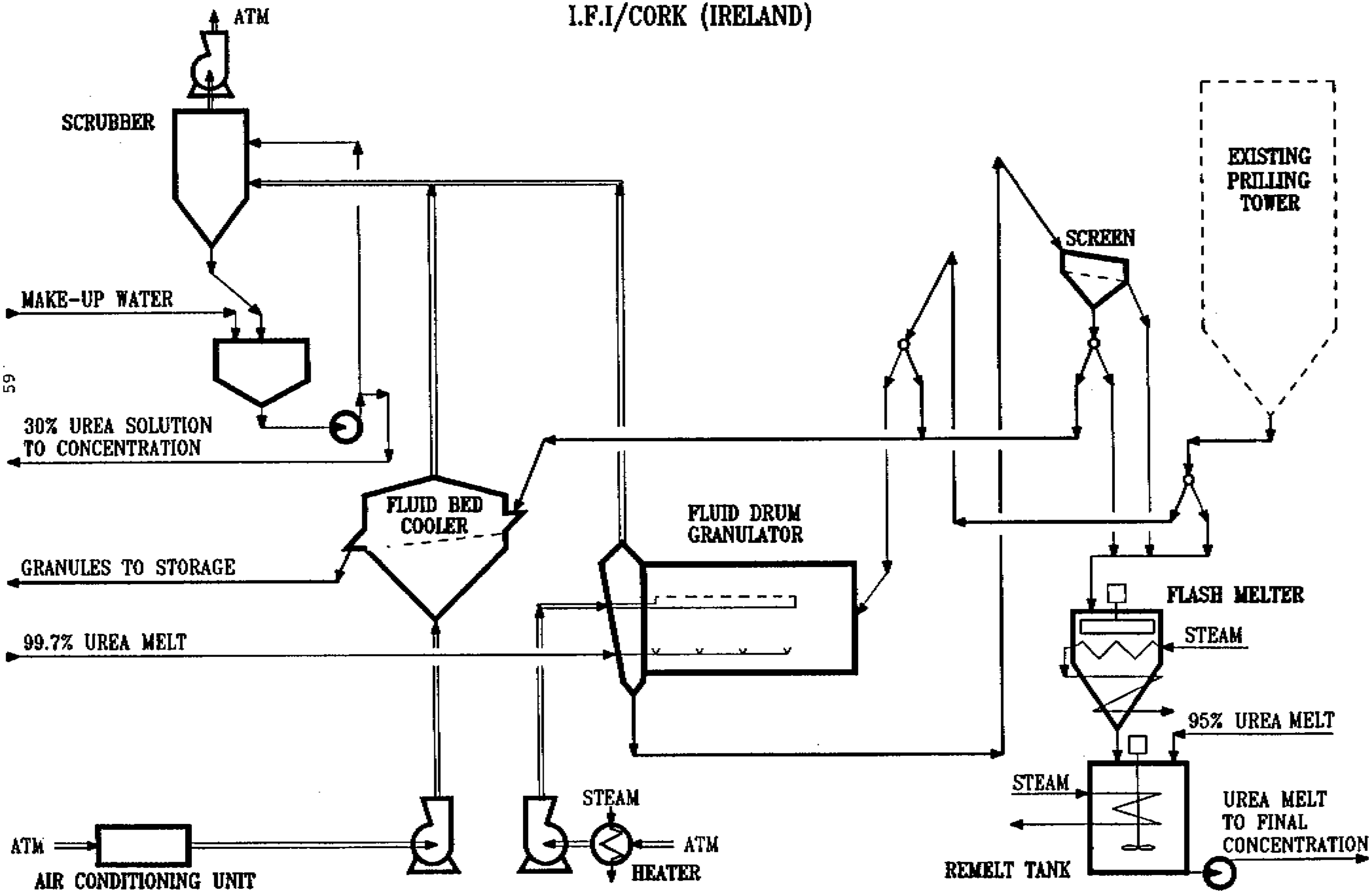
Solid

. nature	:	undersized product and crushed oversize
. ratio	:	0.125 / 1

Liquid

. nature	:	water or PK or NPK slurry
. ratio	:	0.05 / 1

UREA FATTENING
I.F.I/CORK (IRELAND)



Plant owner	:	**I.F.I.**
Location	:	**Cork (Ireland)**
Product	:	**Urea**
Type of process	:	**Fattening**

Specifications of the FDG inlet products

<u>Solid</u>

. nature	:	urea prills
. mean particle size	:	2.1 mm
. water content	:	0.3 %
. temperature	:	75°C to 85°C
. biuret content	:	1%
. crushing strength	:	0.75 kg
. resistance to abrasion (% breakdown)	:	5 %
. flowrate	:	22 t/h

<u>Liquid</u>

. nature	:	urea melt
. concentration	:	99.7 %
. temperature	:	140°C
. flowrate	:	23 t/h

Specifications of the final product

. nature	:	"fattened" prills
. particle size / mean diameter	:	2.7 mm
. water content	:	0.2 %
. biuret content	:	1 %
. crushing strength	:	2 kg
. resistance to abrasion (% breakdown)	:	0.3 %
. temperature (to storage)	:	45°C to 50°C
. flow	:	45 t/h

Recycle

<u>Solid</u>

. nature	:	nil
. ratio	:	nil

<u>Liquid</u>

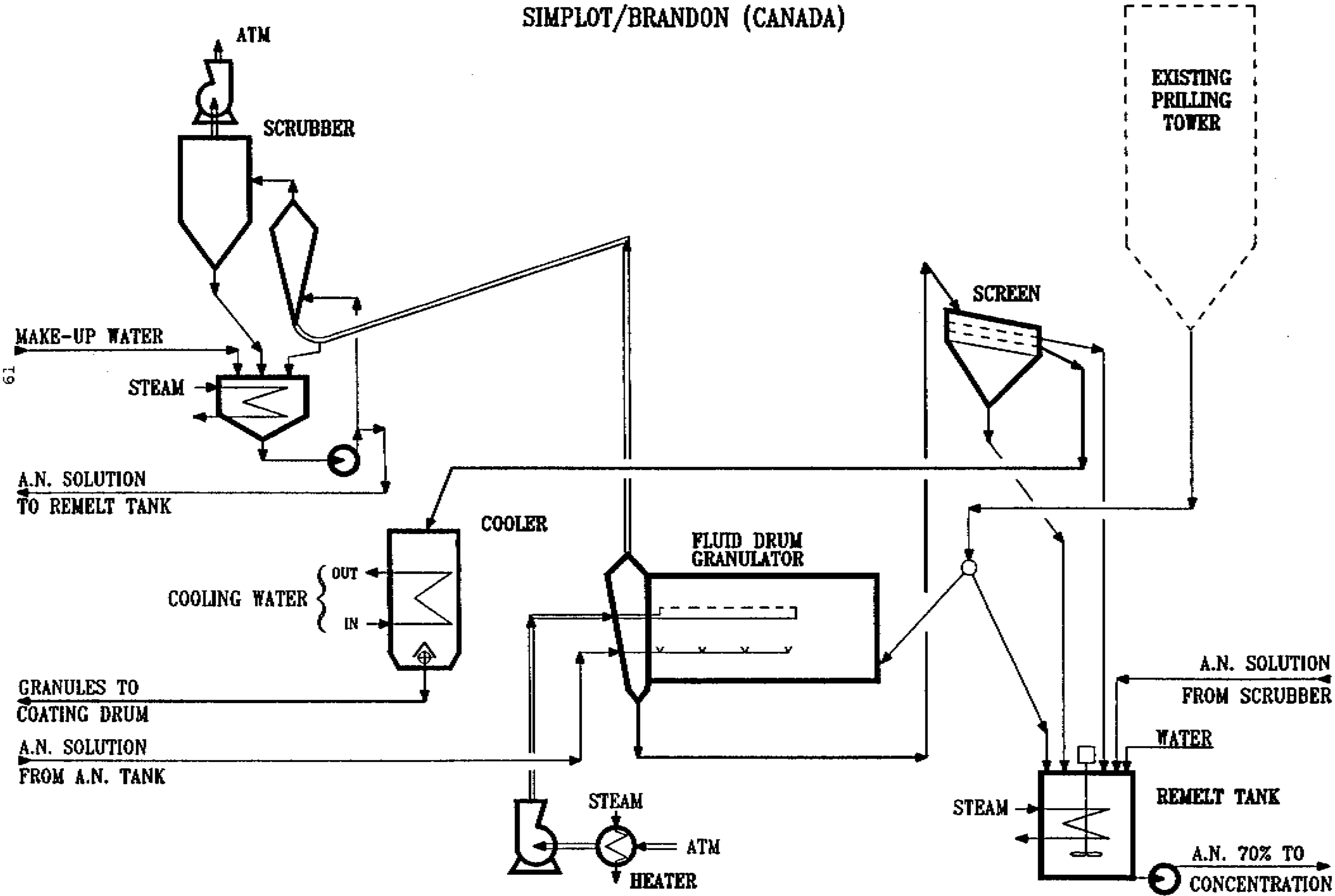
. nature	:	Urea solution
. ratio	:	0.025 / 1 to 0.050 / 1

Emissions

. Prill tower to atmosphere		
– before installation of FDG	:	38 kg/h
– after installation of FDG	:	18 kg/h
. Scrubber of FDG to atmosphere	:	1 kg/h

A.N. PRILL FATTENING

SIMPLOT/BRANDON (CANADA)



Plant owner	:	**SIMPLOT**
Location	:	**Brandon (Canada)**
Product	:	**Ammonium Nitrate**
Type of process	:	**Prill fattening**

Specifications of the FDG inlet products

<u>Solid</u>

. nature	:	AN prills
. mean particle size	:	2 mm
. water content	:	0.05 %
. crushing strength	:	1,6 kg
(resistance to abrasion)	:	48%
. temperature	:	111°C
. flowrate	:	10 t/h

<u>Liquid</u>

. nature	:	AN melt
. concentration	:	99.9 %
. temperature	:	190°C
. flowrate	:	8 t/h

Specifications of the final product

. nature	:	"fattened" AN prills
. particle size / mean diameter	:	2.5 mm
. water content	:	0.05 %
. crushing strength	:	2.9 kg
(resistance to abrasion)	:	82 %
. temperature (to storage)	:	24°C
. flow	:	16 t/h

Recycle

<u>Solid</u>

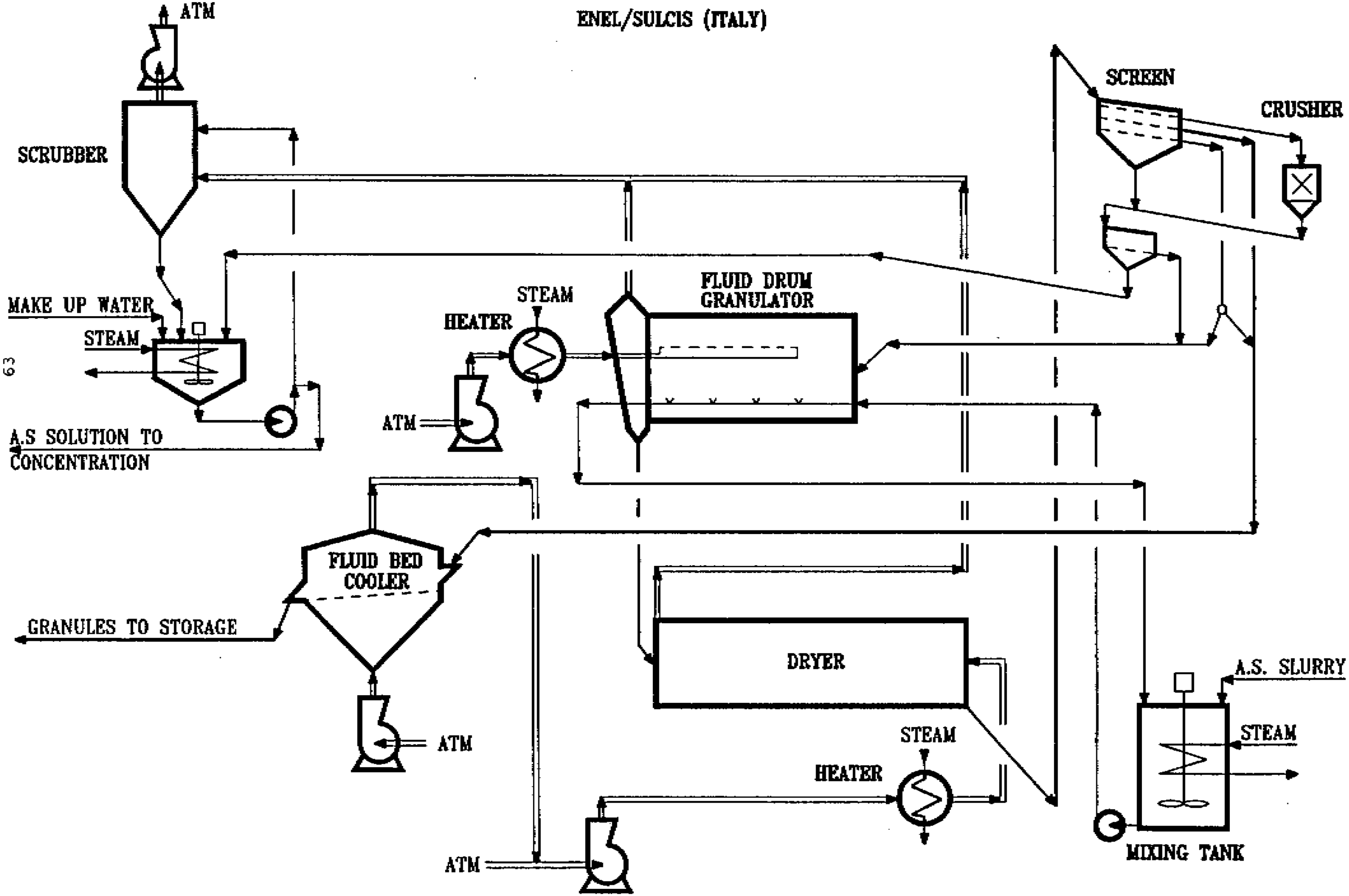
. nature	:	nil
. ratio	:	nil

<u>Liquid</u>

. nature	:	AN solution
. ratio	:	0.125 / 1

GRANULATION OF AMMONIUM SULPHATE

ENEL/SULCIS (ITALY)



Plant owner	:	**ENEL**
Location	:	**Sulcis (Italy)**
Product	:	**Ammonium Sulphate**
Type of process	:	**Granulation**

Specifications of the FDG inlet products

Solid

. nature	:	AS granules (recycle)
. mean particle size	:	2.1 mm
. water content	:	0.2 %
. temperature	:	55°C
. flowrate	:	700 kg/h

Liquid

. nature	:	AS slurry
. concentration	:	52 %
. temperature	:	80°C
. flowrate	:	450 kg/h

Specifications of the final product

. nature	:	AS granules
. particle size / mean diameter	:	3.1 mm
. water content	:	0.2 %
. hardness	:	3.5 kg
. temperature (to storage)	:	30°C
. flow	:	230 kg/h

Recycle

Solid

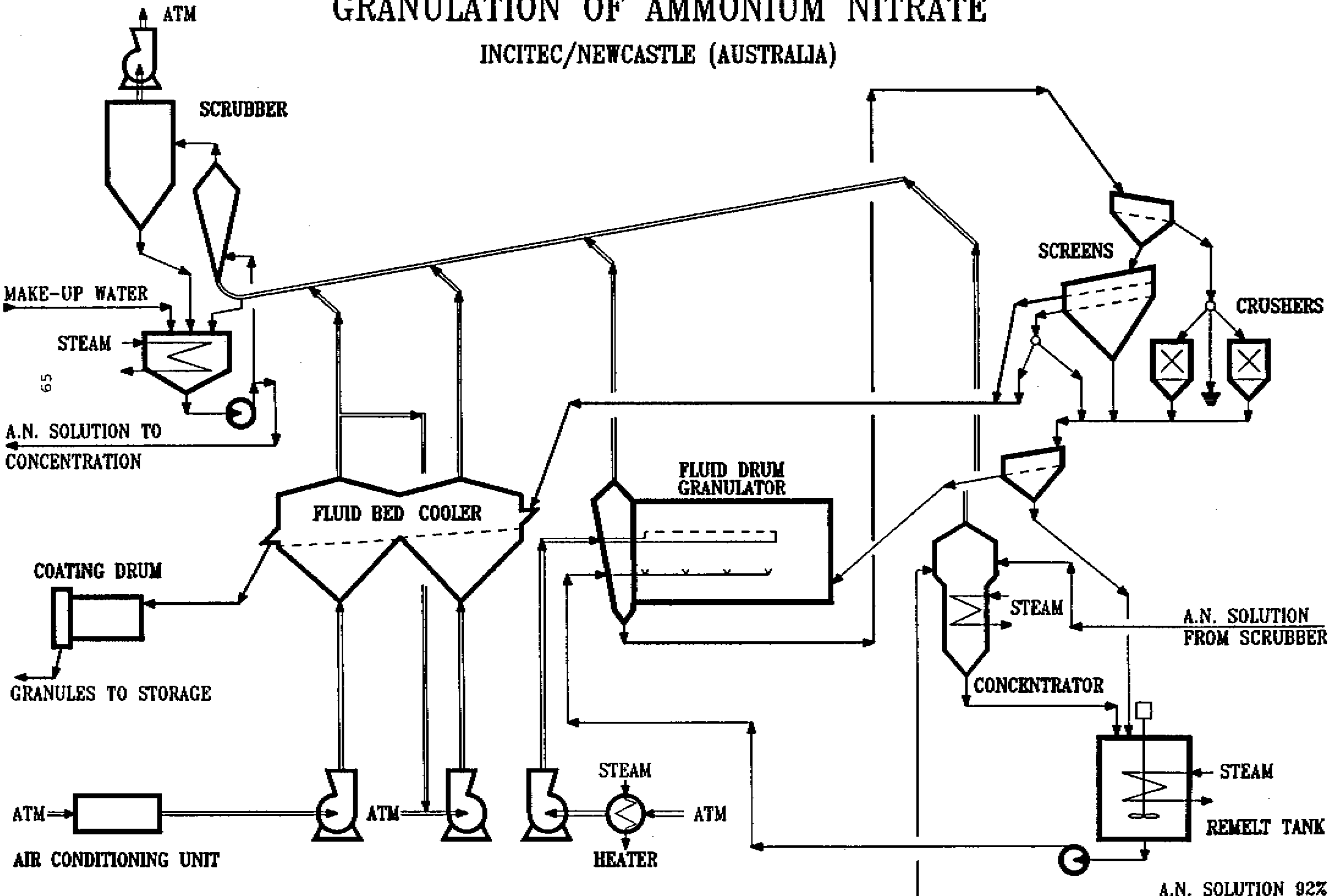
. nature	:	undersized and crushed AS
. ratio	:	3/1

Liquid

. nature	:	AS solution
. ratio	:	0.05 / 1

GRANULATION OF AMMONIUM NITRATE

INCITEC/NEWCASTLE (AUSTRALIJA)



Plant owner	:	**INCITEC**
Location	:	**Newcastle (Australia)**
Product	:	**Ammonium nitrate**
Type of process	:	**Granulation**

Specifications of the FDG inlet products

<u>Solid</u>

. nature	:	AN granules (recycle)
. mean particle size	:	2 mm
. water content	:	0.2 %
. temperature	:	102°C
. flowrate	:	13 100 kg

<u>Liquid</u>

. nature	:	AN solution
. concentration	:	99.3 %
. temperature	:	173°C
. flowrate	:	12 500 kg

Specifications of the final product

. nature	:	AN granules
. particle size / mean diameter	:	98% between 2.5 mm and 3.8 mm
. water content	:	0.15 % to 0.18 %
. hardness	:	2 to 4 kg
. temperature (to storage)	:	27°C
. flow	:	10 000 kg/h

Recycle

<u>Solid</u>

. nature	:	undersize and crushed oversize AN
. ratio	:	1.3 / 1

<u>Liquid</u>

. nature	:	AN solution
. ratio	:	0.25 / 1

SPECIALIZED LIQUID COMPLEX FERTILIZERS IN LITHUANIA

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ABSTRACT

The main standard fertilizers: urea, ammonia, liquid ammonia, ammonium nitrate, superphosphate, ammonium phosphate, are produced in large scale at two Lithuanian chemical plants - Kedainiai and Jonava.

The new research objective of the last years was seeking technology for the production of specialized liquid fertilizers and these were developed at Jonava "Azotas" state enterprise-nitrogen factory.

According with results obtained, many grades of specialized liquid fertilizers were developed at Jonava "Azotas" state enterprise-nitrogen factory.

Liquid fertilizers process is based on flow type technological scheme. It involves the production of potassium nitrate, ammonium nitrate and ammonium phosphate solutions as well as the preparation of chelated microelements and mixing all components. The compounds mentioned above are produced simultaneously.

1. INTRODUCTION

Specialized complex fertilizers destined for greenhouse plants, flowers, horticulture are usually produced by dissolving and mixing salts in water.

This paper describes the NPK process using only liquid ammonium phosphate, ammonia and potassium nitrate solutions. Corresponding laboratory investigation was carried out to ensure an extraction of the compounds mentioned from by-products and intermediates of large scale nitrogen and phosphoric fertilizers production.

Crystallization temperature and solid phase of:

KNO_3 - $(NH_4)_2HPO_4$ - NH_4NO_3- H_2O and KNO_3 - $(NH_4)_2HPO_4$ - $CO(NH_2)_2$ - H_2O

systems were determined by visual -polythermic method. Chemical composition of the solutions with salting out temperature at 0°C was defined.

Production involves processes to obtain potassium nitrate, ammonium nitrate and ammonium phosphate solutions by the neutralization of potassium carbonate with nitric acid as well as ammonia water solution by nitric acid and phosphoric acid simultaneously. By mixing all the components, 10-7-5, 7-7-5, 5-7-7 and 5-3-7 NPK liquid grades are produced.

Magnesium-nitrogen liquid composition was investigated:

$Mg(NO_3)_2$ - $Ca(NO_3)_2$ - NH_4NO_3-H_20 salting out temperature was determined.

Liquid magnesium-nitrogen fertilizers technology consists of:

1) magnesite decomposition by nitric acid,
2) ammoniazation of acid magnesium nitrate solution,
3) liquid fertilizers standardization and packing.

2. LABORATORY SCALE EXPERIMENTS ON COMPOSITION OF LIQUID NPK

These experiments were carried on using visual-polythermic method to determine crystallization temperature of:

$$KNO_3 - CO(NH_2)_2 - (NH_4)_2HPO_4 - H_2O \quad (1)$$

$$KNO_3 - NH_4NO_3 - (NH_4)_2HPO_4 - H_2O \quad (2)$$

systems. The results are summarized below:

2.1. Polythermic crystallization data of 9 different initial compositions of (1) and 8 compositions of (2) systems were obtained. The graphic view is presented in Figure 1.

2.2. Compositions of liquid and solid phase in critical points of each curve were determined. These results are given in Table 1.

Table I - Chemical composition of critical points of systems (I and II)

N° of System	Section	Composition of liquid phase (w)				Crystallization temperature, °C	Composition of solid phase
		KNO_3	$CO(NH_2)_2$ or NH_4NO_3	$(NH_4)_2HPO_4$	H_2O		
I	I	8,76	30,00	8,76	32,48	- 6,0	KNO_3↓$CO(NH_2)_2$
	II	7,36	26,50	11,04	55,10	- 12,0	KNO_3↓$CO(NH_2)_2$
	III	9,86	34,30	6,57	45,07	- 0,2	"
	IV	12,03	38,50	9,23	40,24	16,6	"
	V	7,80	4,61	18,44	69,15	- 9,8	ice ↓ KNO_3
	V	18,00	4,10	16,40	61,50	21,0	KNO_3↓$CO(NH_2)_2$
	VI	8,00	9,20	13,00	69,00	- 12,6	ice↓ KNO_3
	VI	13,00	8,70	13,05	65,25	3,5	KNO_3↓$CO(NH_2)_2$
	VII	7,70	4,61	23,07	64,62	- 10,8	ice↓ KNO_3
	VII	13,90	4,30	21,32	60,27	11,2	KNO_3↓$CO(NH_2)_2$
	VIII	8,70	4,56	13,69	73,05	- 8,5	ice↓ KNO_3
	VIII	17,40	4,13	12,39	66,08	14,6	KNO_3↓$CO(NH_2)_2$
	IX	6,50	4,67	28,05	60,77	- 12,9	ice ↓ KNO_3
	X	15,00	4,25	25,50	55,25	23,4	KNO_3↓$CO(NH_2)_2$
2	I	8,9	28,8	8,9	53,4	- 4,8	KNO_3↓NH_4NO_3
	II	7,7	62,30	11,6	57,7	- 8,3	"
	III	11,9	20,8	7,9	59,4	2,2	"
	IV	16,0	20,0	12,0	52,0	24,4	"
	V	6,8	4,7	13,6	69,9	- 10,5	ice ↓ KNO_3
	V	15,0	4,3	17,0	63,7	14,0	KNO_3↓ NH_4NO_3
	VI	6,4	9,4	14,0	70,2	- 12,7	ice ↓ KNO_3
	VI	13,5	8,7	13,0	64,8	8,4	KNO_3↓ NH_4NO_3
	VII	5,0	4,7	23,8	66,5	- 10,5	ice ↓ KNO_3
	VIII	15,0	4,3	21,3	59,4	20,6	KNO_3↓NH_4NO_3
	IX	7,7	4,6	13,9	73,8	- 10,0	ice ↓ KNO_3
	X	17,5	4,1	12,4	66,0	18,5	KNO_3↓NH_4NO_3

2.3. Composition of solutions in crystallization point at 0°C, obtained from polythermic investigations by extrapolation, is presented in Table 2. It was suggested to be used as liquid complex fertilizers. The manufacturing of 10-7-5, 7-7-5, 5-7-7 and 5-3-7 grade were chosen according to agrochemical requirements.

Table 2 - Composition of solution with crystallization temperature 0°C

N° solution	Composition of solution (w)				Composition of nutrients (w)				Ratio of $N:P_2O_5:K_2O$
	$KNO_3(NH_4)_2$	HPO_4	$CO(NH_4)_2$	NH_4NO_3	H_2O	N	P_2O_5	K_2O	
1	8,4	8,4	33,0	-	50,2	18,3	4,5	3,9	4:1:0,9
2	8,7	10,1	32,6	-	50,6	18,3	5,4	3,1	3,4:1:0,6
3	10,1	6,7	32,8	-	50,4	18,2	3,6	4,7	5:1:1,3
4	9,9	6,6	34,2	-	49,3	18,7	3,5	4,5	5,3:1:1,3
5	11,2	17,8	4,4	-	66,6	7,4	9,6	5,0	0,8:1:0,5
6	12,0	13,2	8,8	-	66,6	8,5	7,2	5,4	1,2:1:0,7
7	10,6	22,3	4,5	-	62,6	8,3	12,0	4,8	0,7:1:0,4
8	11,8	13,2	4,4	-	70,6	6,5	7,0	5,6	0,9:1:0,8
9	8,7	8,7	-	30,3	52,3	13,7	4,7	4,1	2,9:1:0,9
10	7,4	11,2	-	25,7	55,7	12,4	3,5	6,0	3,5:1,1,7
11	10,3	17,9	-	4,5	67,3	6,8	9,7	4,8	0,7:1:0,5
12	10,6	13,4	-	8,9	67,1	7,4	7,2	4,9	1:1:0,7
13	8,3	22,9	-	4,6	64,2	7,2	12,3	3,9	0,6:1:0,3
14	11,2	13,3	-	4,4	71,1	6,0	7,2	5,2	0,8:1:0,3

3. CHEMISTRY AND FLOW SHEET OF LIQUID NPK PROCESS

Liquid complex fertilizers process is represented by equations as follows:

$$2NH_4OH + H_3PO_4 \text{ -----> } (NH_4)_2HPO_4 + 2H_2O$$

$$NH_4OH + HNO3 \text{ -----> } NH_4NO_3 + H_2O$$

$$K_2CO_3 + 2HNO_3 \text{ -----> } 2KNO_3 + CO_2 + H_2O$$

Referring to the liquid NPK process (Figure 2), ammonia water solution as by-product from tank (4) is reacted simultaneously with nitric acid from tank (1) in reactor (3) as well as with phosphoric acid from tank (5) in reactor (6). Potassium carbonate is reacted with nitric acid in reactor (2). The products obtained are diluted by water in appropriate reactors at 60-80°C. Ammonia nitrate, ammonia phosphate and potassium nitrate solutions are mixed in reactor (8), which is supplied with chelated microelements. These are prepared in reactor (7). The final product is pumped by (9) to standardization (10) and packing (11).

Physical and chemical properties of liquid NPK are presented in Table 3.

Table 3 - Physical and chemical properties of liquid complex fertilizers

Grade of liquid complex fertilizers	Temperature (°C)	Viscosity (sst)	Electro-conductivity (sm)
	20	2,50	4,8
5-7-5	40	1,91	4,2
	60	1,72	3,8
	20	1,63	5,0
5-7-7	40	1,35	4,5
	60	1,26	4,1
	20	1,84	5,5
10-7-5	40	1,73	4,9
	60	1,54	4,1
	20	2,10	5,1
5-3-7	40	1,96	4,6
	60	1,85	4,1

Liquid NPK contains six microelements: Cu, Zn, B, Mn, Co, Mo usually in chelated form free of chlorine, heavy metals and other toxic substances. Agrochemical research illustrates that liquid NPK obtained decreases nitrate amount in vegetables and fruits as well as increases amount of sugar and lemon acid. The equipment desired was used from the other plant necessary for restructuring. The capacity of plant complex is 10 000 tons per year.

4. LABORATORY SCALE INVESTIGATION OF LIQUID MAGNESIUM-NITROGEN FERTILIZER

These experiments were carried out on by visual-polythermic method too in order to determine crystallization temperature of $Mg(NO_3)_2$ - $Ca(NO_3)_2$ - NH_4NO_3 - H_2O system. The results are as follows:

4.1. Polythermic crystallization data of 5 different initial compositions are presented in Figure 3. Each curve consists of two parts corresponding to crystallization of $Mg(NO_3)_2.6H_2O$ and NH_4NO_3.

4.2. Composition of solutions corresponding to crystallization temperature at 0°C obtained by extrapolation is presented in Table 4.

Table 4 - Composition of magnesium-nitrogen solutions

Composition of solutions %		Nutrient concentration %					Solid phase
$Mg(NO_3)_2$	$Ca(NO_3)_2$	NH_4NO_3	H_2O	MgO	CaO	N	
33,20	3,00	11,50	52,20	8,97	1,06	10,83	$MgO(NO_3)_2.6H_2O$
28,63	2,67	23,66	45,04	7,78	0,91	14,15	NH_4NO_3
28,67	1,91	23,66	45,80	7,78	0,65	14,01	NH_4NO_3
32,50	1,67	16,67	49,16	8,83	0,57	12,26	$MgO(NO_3)_2.6H_2O$
30,47	1,56	21,88	46,09	8,28	0,53	13,68	NH_4NO_3
31,82	2,07	17,36	48,75	8,65	0,70	12,26	$MgO(NO_3)_2.6H_2O$
29,39	1,91	23,66	45,04	7,98	0,66	14,16	NH_4NO_3

It shows the possibility of production of 14-7 and 10-9 N:MgO grade liquid magnesium-nitrogen fertilizers.

5. CHEMISTRY AND FLOW SHEET OF THE LIQUID MAGNESIUM-NITROGEN FERTILIZERS

The chemistry of the liquid magnesium-nitrogen fertilizers technology is presented by following chemical equations:

$$MgO + 2HNO_3 \text{ -----> } Mg(NO_3)_2 + H_2O$$

$$CaO + 2HNO_3 \text{ -----> } Ca(NO_3)_2 + H_2O$$

$$R_2O_3 + 6HNO_3 \text{ -----> } 2R(NO_3)_2 + 3H_2O$$

The magnesium-nitrogen liquid fertilizers process is described below by reference to Figure 4.

Magnesite (storage 2) is flowed by pneumotransport to reactor (4) fed by nitric acid (5) and condensate from set. The mixing continues about 30 min. at 85°C. Magnesium nitrate solution is pumped (11) to settler (6) and depositives are sent to (12). A clear solution is pumped for neutralisation (7) with ammonia water solution while pH value 4,5 is reached. Liquid magnesium-nitrogen fertilizer manufactured is sent to storage tank (9) and into cartank or bottles.

This process is mastered in pilot plant scale.

CONCLUSIONS

1. The chemical compositions of specialized liquid complex and magnesium-nitrogen fertilizers are chosen as result of visual-polythermic investigations of multicomponent systems.

2. Flow sheet of liquid complex fertilizers is proposed and pilot plant process is mastered.

3. Chemical and physical properties of liquid fertilizers are determined.

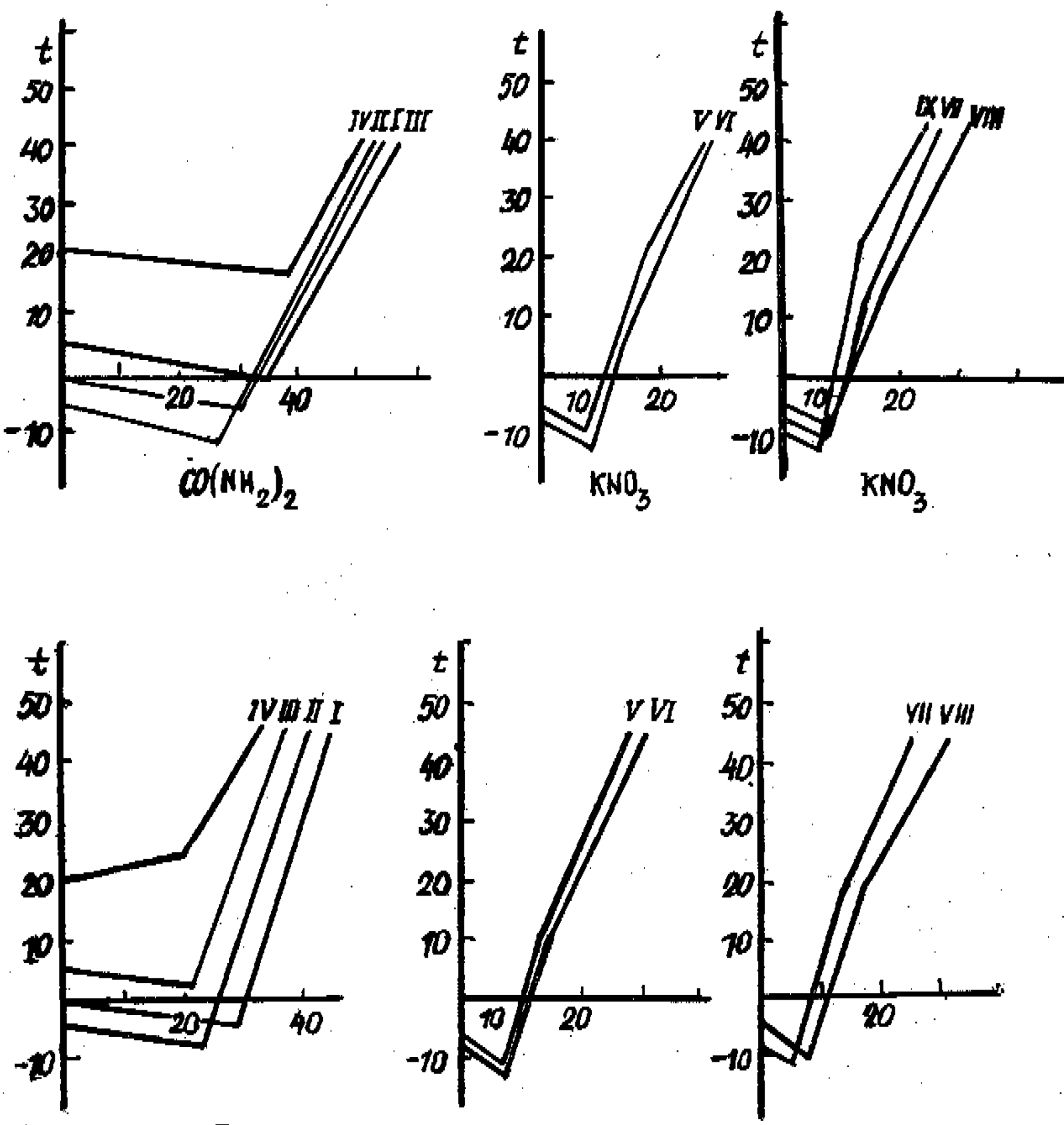

FIGURE 1 Polythermic curves of systems 1(a) and 2(b)

t - temperature (°C)

Section (%, w): a) I – [12.5 KNO_3 + 12.5 $(NH_4)_2HPO_4$ + 75 H_2O] → $CO(NH_2)_2$, II – [10 KNO_3 + 15 $(NH_4)_2HPO_4$ + 75 H_2O] → $CO(NH_2)_2$, III – [15 KNO_3 + 10 $(NH_4)_2HPO_4$ + 75 H_2O] → $CO(NH_2)_2$, IV – [20 KNO_3 + 15 $(NH_4)_2HPO_4$ + 65 H_2O] → $CO(NH_2)_2$, V – [20 $(NH_4)_2HPO_4$ + 5 $CO(NH_2)_2$ + 75 H_2O] → KNO_3, VI – [15 $(NH_4)_2HPO_4$ + 5 $CO(NH_2)_2$ + 80 H_2O] → KNO_3.

b) I – [12.5 KNO_3 + 12.5 $(NH_4)_2HPO_4$ + 75 H_2O] → NH_4NO_3, II – [10 KNO_3 + 15 $(NH_4)_2HPO_4$ + 75 H_2O] → NH_4NO_3, III – [15 KNO_3 + 10 $(NH_4)_2HPO_4$ + 75 H_2O] → NH_4NO_3, IV – [20 KNO_3 + 10 $(NH_4)_2HPO_4$ + 75 H_2O] → NH_4NO_3, V – [20 $(NH_4)_2HPO_4$ + 5 NH_4NO_3 + 75 H_2O] → KNO_3, VI – [15 $(NH_4)_2HPO_4$ + 10 NH_4NO_3 + 75 H_2O] → KNO_3, VII – [25 $(NH_4)_2HPO_4$ + 5 NH_4NO_3 + 70 H_2O] → KNO_3, VIII – [15 $(NH_4)_2HPO_4$ + NH_4NO_3 + 80 H_2O] → KNO_3.

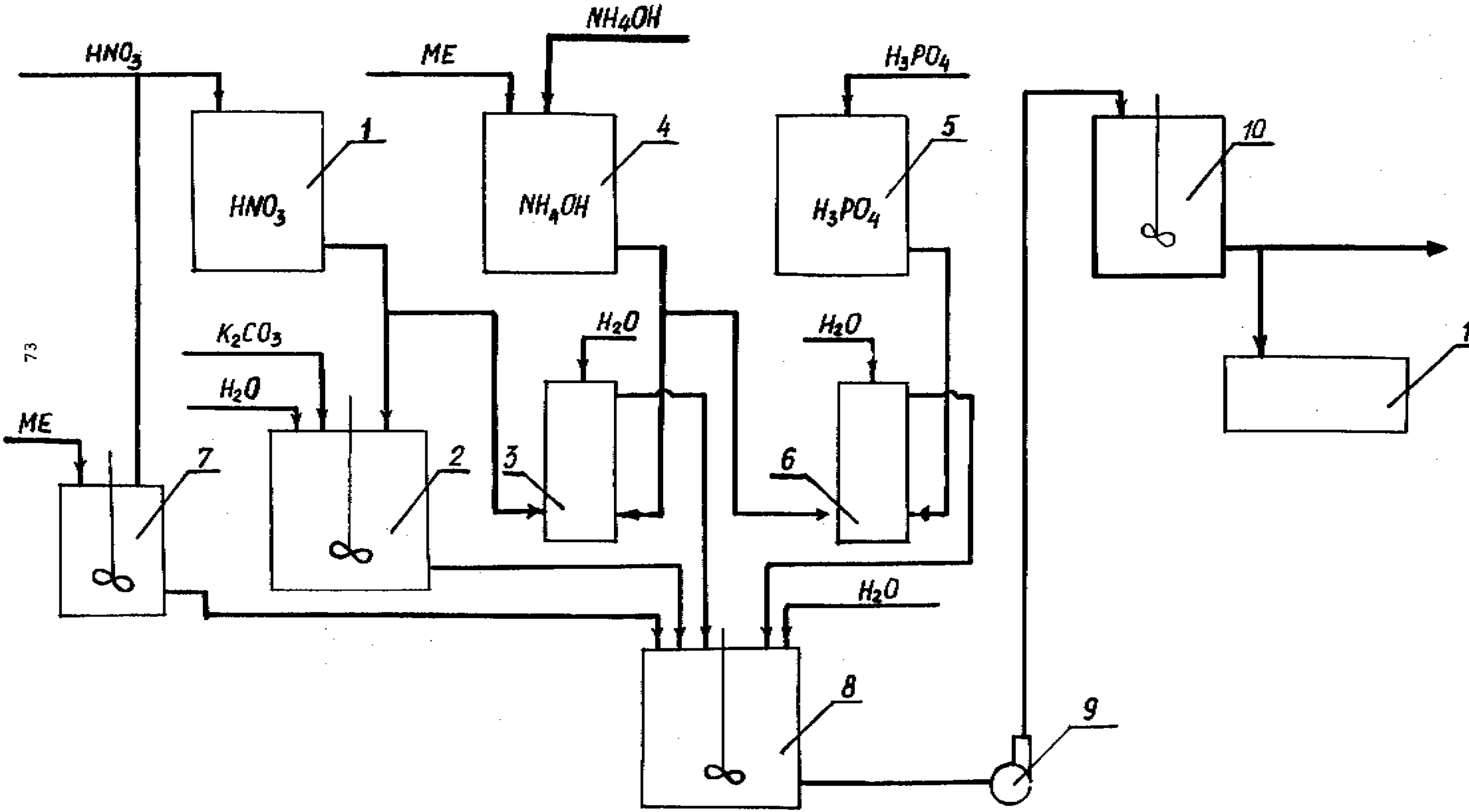

FIGURE 2 - FLOW SHEET OF LIQUID COMPLEX FERTILIZERS PRODUCTION

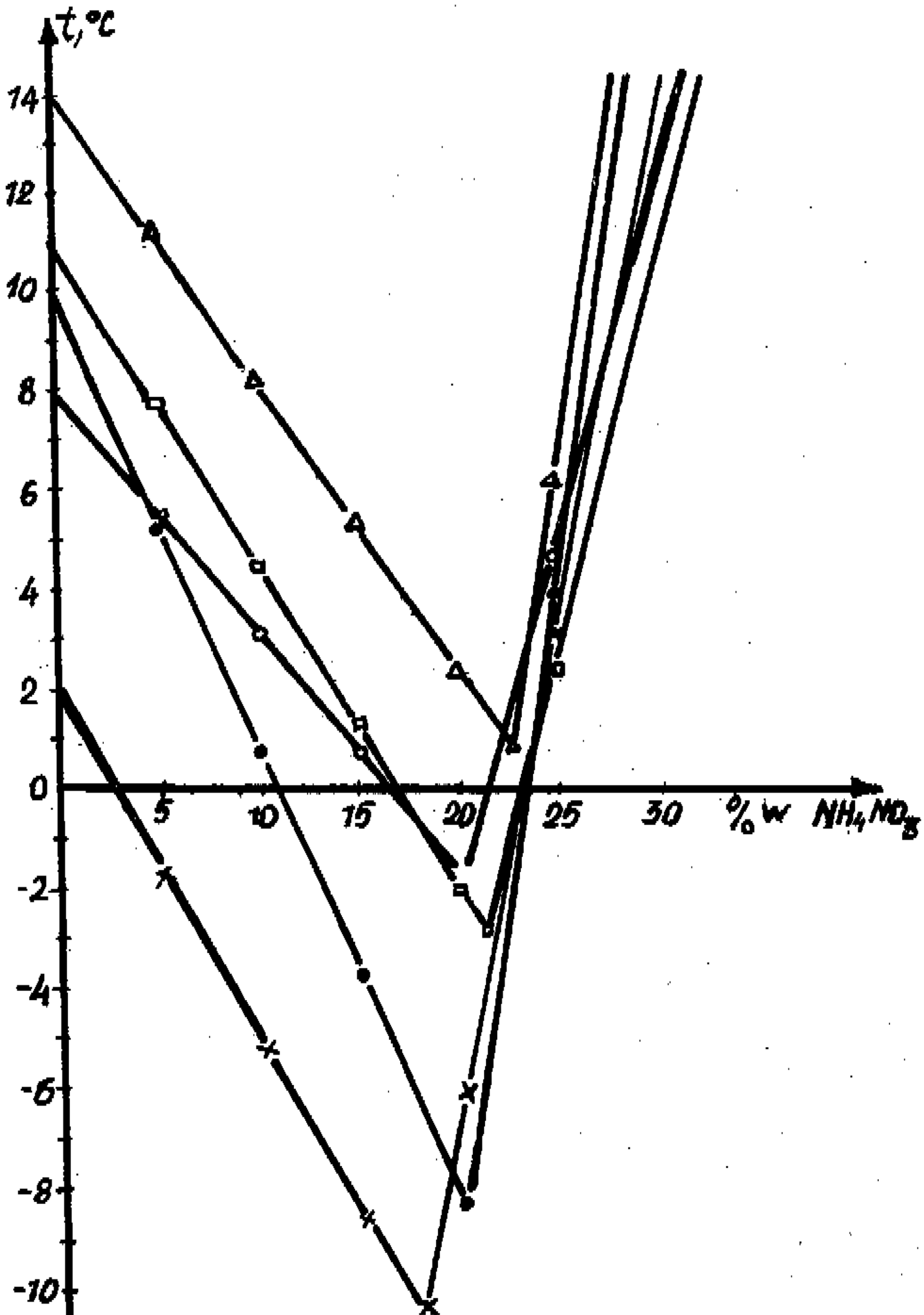

FIGURE 3 Polythermic curves of system $Mg(NO_3)_2 - Ca(NO_3)_2 - NH_4NO_3 - H_2O$

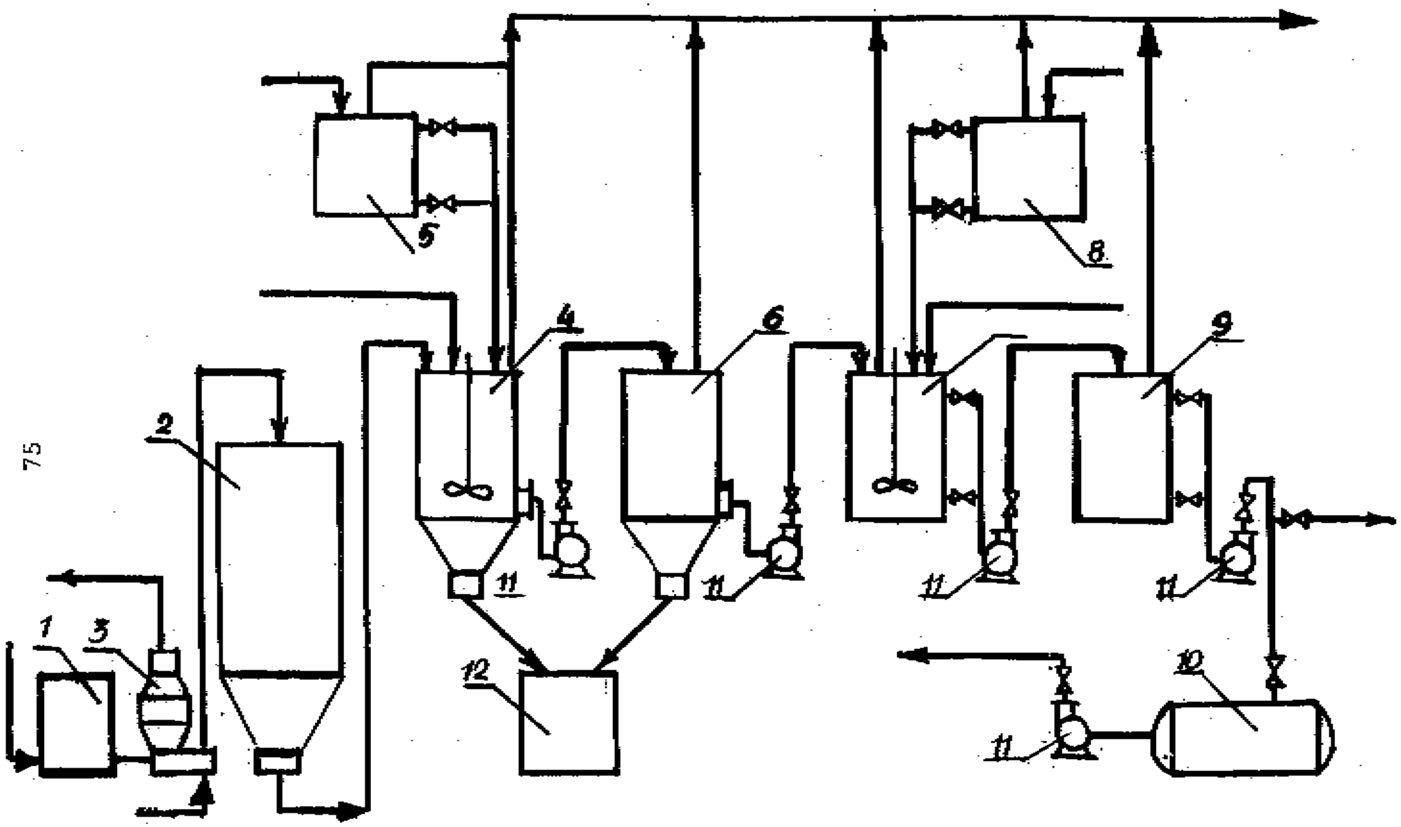

FIGURE 4 - FLOW SHEET OF LIQUID MAGNESIUM - NITROGEN FERTILIZERS