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THE FLUIDIZED DRUM GRANULATION PROCESS (FDG) AND ITS VARIOUS APPLICATIONS

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I - INTRODUCTION

The KT fluidized drum granulator consists in the combination of a drum granulator and a fluidized bed installed inside of the granulator.
According to the applications, the fluidized bed is fed with cold air or hot air.
The process offers the interest to be suited to the granulation of numerous fertilizers types and various products.
Its advantages lie :

- in its simplicity,
- in the very wide range of its applications,
- in the rather low investment costs involved in the achievement of a plant,
- in the possibility of adapting the process to existing granulation plants easily,
- in the results obtained by the production of very high quality products.

Up to day, various applications of the process have been carried out in the KT pilot plant in BEAUVAIS (FRANCE) The capacity of this plant varies from 300 to 800 kg/h of final product.

A first 15 t/h industrial plant is being implemented and KT is presently studying and negociating several plants for the granulation of different fertilizers types.

II - DESCRIPTION OF THE PROCESS

Equipment

It includes :

- a drum granulator. This is a cylindrical horizontal drum turning around its axis.

  This drum is inner-coated with soft rubber panels and fitted with special flexible anti-clogging lifters.

- a fluidized bed installed inside of the granulator. This bed is fed with atmospheric or conditioned air according to the desired applications.

- an external fan that blows the air out of the granulator.

- other equipment corresponding to equipment generally used in a granulation plant : elevator, conveyor, sieve, cyclone, washing tower, etc ...

The process

The granulator is fed with recycled solid raw material constituted by :

- priming product, called seeds, coming from the oversize crushing

- recycled granules, called recycle fines, having to go on growing, during one or several passages through the granulator, to become a marketable product.

It is fed by a spout installed at the drum inlet.

- liquid raw material that can be a molten salt or a slurry, these liquids being sprayed into the drum by a series of sprayers fixed on a header.

The recycled product undergoes a double operation in the granulator :

- size increase,
- cooling and/or drying as the case may be by air of the fluidized bed.

This is obtained in a series of cycles performed as follows :

The lifters bring the seed material to the upper part of the drum from where it falls on the surface of the fluidized bed.
On the table the product is cooled and/or dried.
The table surface is inclined, the product flows down along the table and falls into the lower part of the drum.
During this fall, it is sprayed as the case may be with molten salt or slurry.
The lifters lift the granule coated with a new material layer to be crystallized or dried.
The same cycle is then renewed as many times as necessary to reach the desired grain size.
The cycles number is determined by the residence time in the drum obtained by an overflow threshold of convenient height.
Various additives such as filler, micronutrients or other specific additives can be added in the sprayed product.

It can be concluded that the process enables to perform :

- the granulation
- the cooling and/or the partial or total drying of the granulated products

in a unique equipment.

III - PARTICULAR REMARK

Whatever the process, the granulation consists in enlarging in the granulator particles the diameter of which is lower than the marketable product granulometry. These particles form the so-called seeds. According to the process, the little particles to be enlarged have a different origin.

In some processes, a fraction of granules the diameter of which is lower than the required grain size develop naturally in the granulator itself. After screening, these granules, in one or several runs in the granulator, grow bigger and become marketable granules. In this granulation type, the formation of too big granules is a drawback. It is tried to limit their formation as far as possible.

In other processes, no granules develop in the granulator itself naturally. Then the granulation consists only in increasing, by successive layers, the size of the particles originating from the oversize crushing.

In this granulation type, the oversize production and the crushed product nature are particularly important and have ever been described in other communications.

The FDG granulation applies to several uses of this second type.

I think that this preliminary explanation was necessary for the understanding of some cases of application of the process reported here-after.

IV - APPLICATIONS

The process can be used for :

- molten salts granulation,
- prills size increase,
- rounding-up of compacted products,
- coating of various particles with slurries or hot solutions,
- slurries granulations.

Cases of practical applications relating to the granulation or to the enlargement of particles from molten salts, as well as the rounding-up or the coating of various or compacted products have ever been described in several publications; therefore these applications will merely be summarized and we will only deal in details with the slurries granulations.

IV.1 - Molten salts granulation

In this case, the granulation is made by spraying molten salt solution into the granulator on the bed formed by the recycle fines and the seeds coming from the oversize crushing.

The drying and the cooling are carried out by removing the crystallization heat, both by the cold air of the fluidized bed and by the evaporation of the water contained in the molten salt.

During the granulation of urea, 33.5% nitrate and 28% nitrate in our pilot plant, we reached the following results, without further drying :

Specification of inlet products

Hot solution	Urea	33.5% nitrate	28% nitrate
Concentration	96.0 %	97.5 %	97.5 %
Temperature	130° C	185° C	180° C
Flowrate	400 kg/h	500 kg/h	500 kg/h

Specification of outlet products

	Urea	33.5% nitrate	28% nitrate
Nature	Granule	Granule	Granule
Granulometry	0% > 5mm 17% > 4 mm 87% > 3 mm 100% > 2 mm	0% > 5 mm 35% > 4 mm 98% > 3 mm 100% > 2 mm	0% > 5 mm 30% > 4 mm 97% > 3 mm 100% > 2 mm
Hardness	5/8 kg	10 kg	10 kg
Water content max.	0.2 %	0.2 %	0.2 %
Recycle rate	1.5 to 2	1	1

Cooling air required by the F.D.G.

	Urea	NA 33.5%	NA 28%
kg of air / 100 kg of product	1500	1000	1000

Electric power consumption

For a line including the F.D.G, the sieving/crushing system, the fluidized bed final cooler and the recycle circuit, the consumption reaches approximately 15 kWh per ton of marketable product for a plant with a daily nominal capacity of 1000 t.

IV.2. Prills size increase

Most of the prilling towers do not allow to exceed a mean diameter of 2.5 mm, whatever the nature of the prilled products.
In many cases the mean diameter does not exceed 1.6 mm.

To facilitate handling or storage, or to blend them with products of larger granulometry (bulk blending) , many users wish to get prills with a larger granulometry.

The installation of a FGD between the tower bottom and the sieving station enables to increase the mean diameter of the granules.

For example, to enlarge a prill having a mean diameter of 1.6 mm to a mean diameter of 2.0 mm, the following ratios have to be observed :

- 50% of prills from the tower
- 50% of size increasing solution

It is to be noted that a solution adjunction lower than 50% has not much sense.
To obtain a larger size increase in their pilot plant, KT performed many tests in which the proportion of product coming from the tower varied between 10 and 50 % of the final product.

Provided that the solution production allows it, it is possible to significantly increase the capacity of a prilling tower, without high investments, by installing a FDG.

The following results have been obtained when increasing urea size with equal proportions of prills from the tower and solution.

Specification of inlet products

a) Urea prills

Granulometry	0.6% > 3 mm 15.4% > 2 mm 66.2% > 1.4 mm 93.6% > 1.0 mm
Hardness	0.700 kg
Water content	0.25%

b) Urea hot solution

Concentration	96 %
Temperature	130°C

Specification of outlet products

Nature	Granules
Granulometry	8.6% > 3.0 mm 54.6% > 2.0 mm 99.2% > 1.4 mm 100% > 1.0 mm
Hardness	1.7 kg
Water content	0.28%

IV.3 - Rounding-up of compacted products

One of the drawbacks of the compacted products is to present sharp and brittle edges, generating dust. The FDG makes it possible to palliate this drawback by rounding-up the marketable compacted product which is introduced into a first section of the FDG that is entirely smooth.

On the compacted product rotating in the cylinder bottom, it is possible to inject :

- either steam,
- or water sprayed as a mist,
- or a slurry obtained by preparing a concentrated solution of water and dedusting fines having the same composition as the compacted product.

In the 3 cases, the surface humidification enables to round up the compacted product by softening its edges and by the mechanical action of the granulator.

In the second section of the granulator, the wetted product is lifted by lifters that bring it on the table of the fluidized bed. On the bed the rounded product is dried by the hot air blown under the table. The drying is the easier and the faster as the humidification has been limited to the surface of the compacted product. This operation is performed in a unique passage through the FDG without any recycling.

In addition to the rounding up of the compacted product edges, a noticeable improvement of the grains hardness can be stated.

A classical abrasion test gives the following results :

- not treated compacted product : abrasion = 9.8 %
- compacted product rounded up in the FDG : abrasion = 1.9 %

In case of coating with a slurry, the following further advantages are gained :

1) deposit of a film having the same composition on the surface of the compacted product, which favours a still better rounding-up.

2) increase of the production correponding to the quantity of dry matter contained in the slurry.

   According to the specifications of this slurry, this production increase can vary between 5 and 10 %.

IV.4 - Coating of various particles with slurries or hot solutions

The principle of this production is identical to the one used for increasing the prills size, except that :

1) the grain to enlarge can be a prill or a granule
2) the enlarging product has not the same nature as the grain to be treated.

Examples :

- coating of urea or ammonium phosphate with liquid sulphate,
- coating of ammonium sulphate with urea or ammonium nitrate,
- coating of binary PK with ammonium nitrate or urea,
- even applications out of the fertilizers field, such as coating of food particles with sugared, concentrated, etc ... solutions.

Only qualitative and orientating tests have been performed up to now in our pilot plant.

This application will still give rise to many developments that will be described in further publications.

IV.5 - Slurries granulation

In conventional processes the granulation of slurry fertilizers involves high recycle ratios to absorb the quantity of water contained in the slurry. It is not unusual in some cases to have recycle ratios of 5 or 6 for 1, which requires of course large production units for rather small capacities. It is the case particularly for the granulation of ammonium phosphate slurries and slurries produced by sulfo- and phosphonitric attacks.

Granulation tests with ammonium phosphate slurry have been performed in the FDG of our pilot plant and gave very satisfactory results with a recycle ratio comprised between 2 and 2.5 for 1. However it is not with this type of production that we wish to conclude our report but with the granulation of fertilizers coming from the recovery of nitrogen by-products resulting from the scrubbing of industrial units gases.

More and more the treatment and the scrubbing of the flue gases will become a requirement that the industries, particularly the power stations, will no longer be able to escape.

These recovered products have always the form of very diluted sulphate and/or ammonium nitrate solutions.

The concentration of these solutions in view to get ammonium sulphate or sulfonitrate in powder and their granulation in a final stage raise technological hard to solve problems and lead to a cost price inconsistent with the selling price of these raw materials.

In order to find a solution to these problems, an exemplary collaboration was born between the KRUPP KOPPERS WALTHER Group in F.G.R. and the KALTENBACH-THÜRING Company.

The first ones achieved the concentration of the diluted solutions to obtain a solution containing 75/80 % of dry matters in an original concentration unit.

Starting from this slurry, KT studied and performed in the FDG the granulation of ammonium sulphate and sulfonitrate.

In a conventional granulation, the granulation of such a slurry requires high recycle rate envolving the risk of "de-granulating" a significant part of the grains in the dryer because of the fragility inherent to a salt coming out of the granulator with 8 or 10 % of water.

The interest of the granulation of such slurries in the FDG lies in the simultaneousness of the granulation and the drying. As soon as a slurry layer has been sprayed on a recycle grain, it is dried on the fluidized bed fed with hot air. In the same equipment, it is possible to successively spray and dry several slurry layers, so that the humidity of the granule coming out of the FDG is approx. 1 to 1.5%. At this drying stage, the granule has a sufficient hardness to undergo the final drying in a conventional drying drum without being destroyed.

On the other hand, in order to increase the nitrogen content of these slurries, tests have been carried out involving enrichment with urea or dicyandiamide (66.66% N)

Specification - Consumptions - Results

- Ammonium sulphate slurry

Concentration	75-80 %
Temperature	50-75 %

- Marketable product

Nature	granule
Granulometry	0% > 5 mm 33% > 4 mm 98.6% > 3 mm 100% > 2 mm
Hardness	3 kg after production 4 kg after 8 days
Water content	0.2 %
Recycle ratio	2.5

Utilities consumption

- Electric power	30 to 32 kWh/t of final product
- Calories	280 to 300 000 Kc/t

Similar granulation tests have been carried out successfully with slurries concentrated at 75/80 % :

- ammonium sulphate, by-product of Caprolactam production,
- ammonium sulphate obtained by neutralization of H_2SO_4 from zinc pickling reconcentrated to 60 % approx.
- ammonium sulfonitrate from power station gases scrubbing.

THE FDG FUTURE

We think that this process will develop according to the following orientations :

- molten salts granulation for new units to be designed,

- prills size increase,

- rounding-up of compacted products,

- slurries granulation

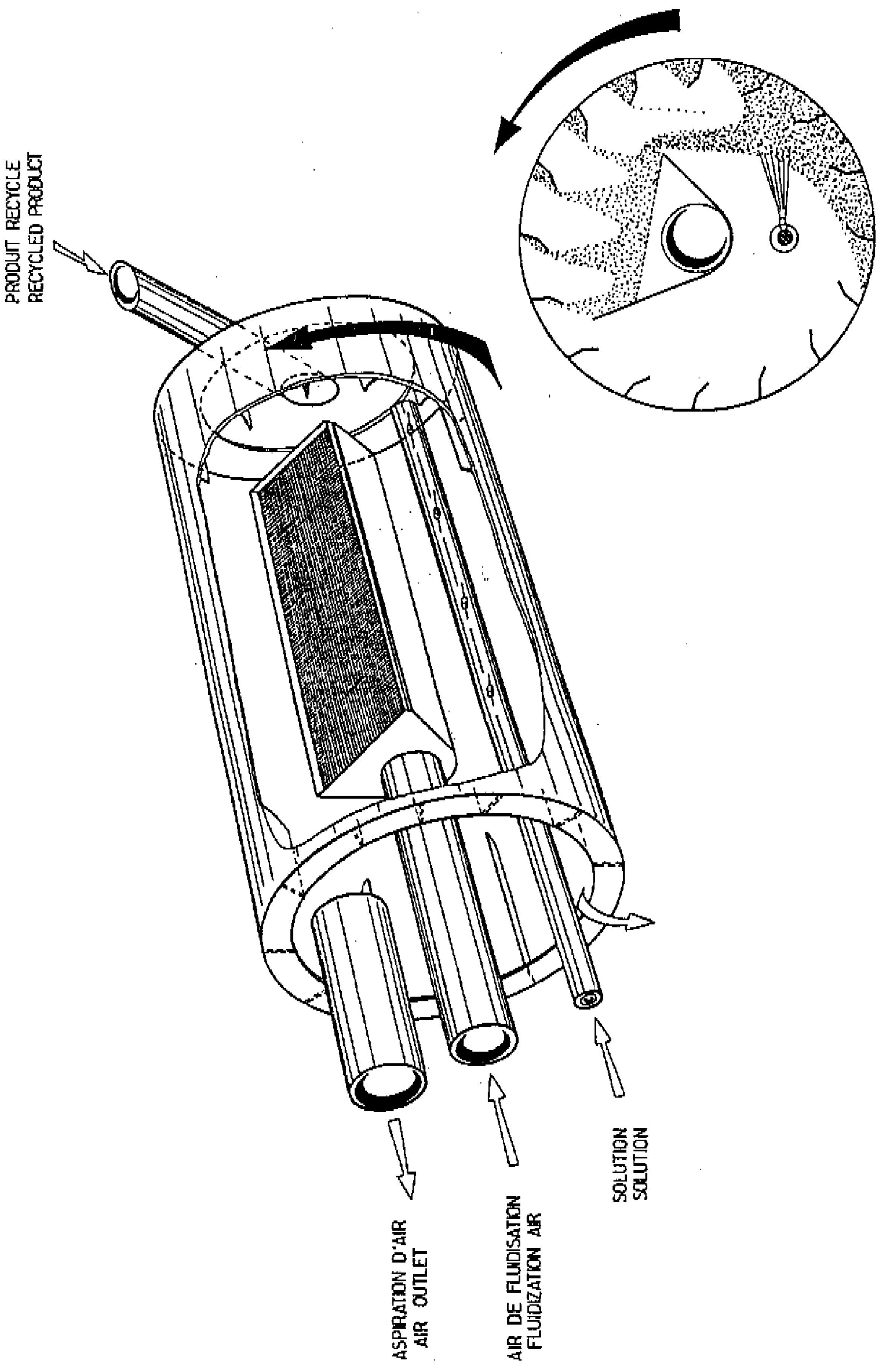
  . by revamping of existing units and replacement of the granulator by a FDG enabling this way to double the plant production at least.

  . by designing small plants for the granulation of recovered sulphate and ammonium sulfonitrate slurries.

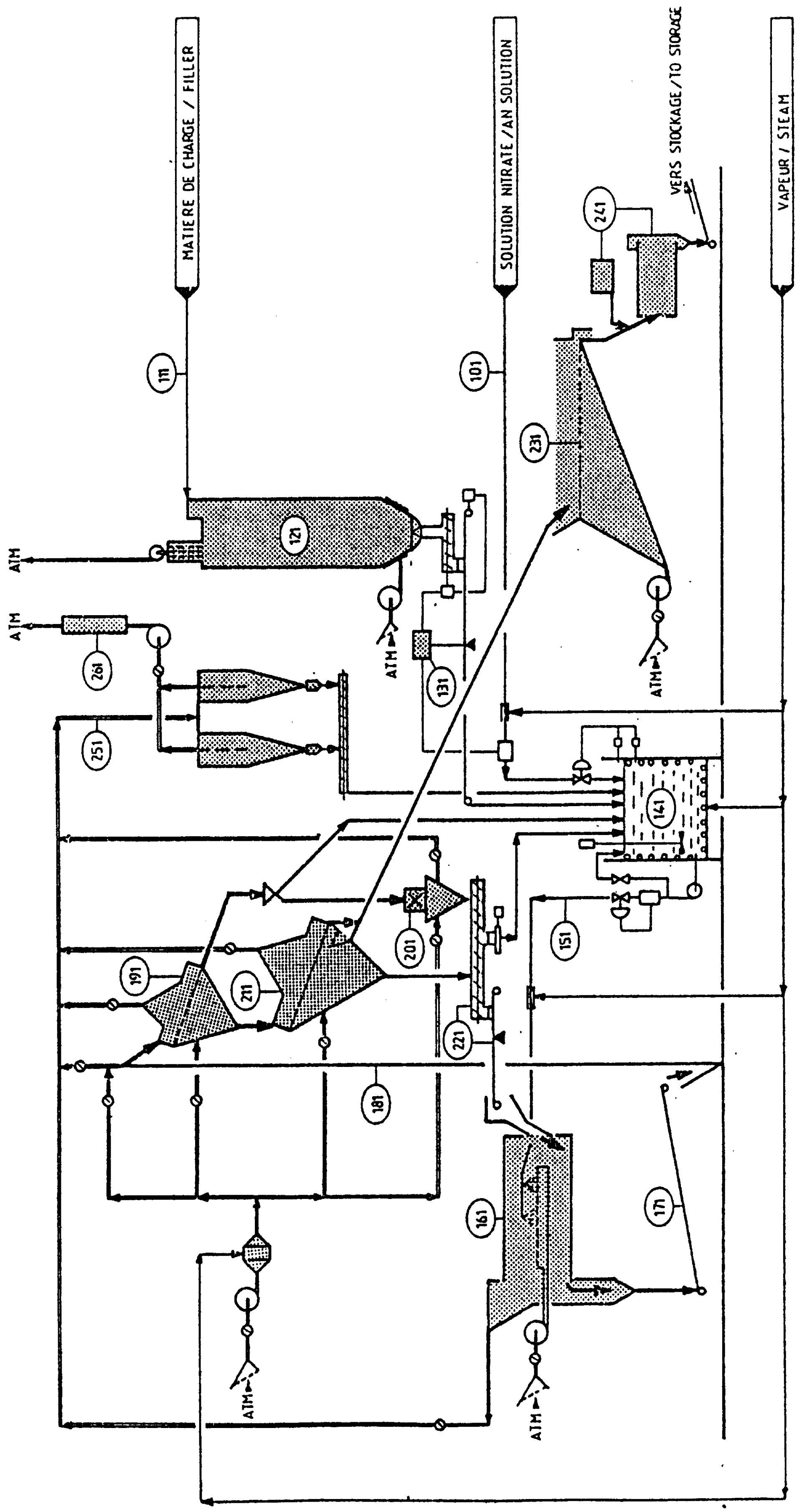
Encl. - FDG drawing
- Process flow-sheet of a urea granulation plant.

PROCEDE DU CYLINDRE GRANULATEUR A LIT FLUIDISE / FLUIDIZED DRUM GRANULATION PROCESS

DETAILS DU GRANULATEUR / DETAILS OF THE GRANULATOR



NA/NAC. CYLINDRE GRANULATEUR A LIT FLUIDISE / AN/CAN. FLUIDIZED DRUM GRANULATION FLOW SHEET



ITEMIZED EQUIPMENT

101 - Ammonium nitrate solution inlet circuit

111 - Filler inlet circuit

151 - Circuit for granulator feeding with nitrate solution

161 - Granulator

171 - Collecting conveyor at granulator discharge

181 - Pick-up elevator

191 - Oversize separation

201 - Oversize crushing

211 - Fines separation

221 - Fines and oversize recycle circuit

231 - Marketable granules cooler

241 - Coating

251 - Dedusting station

TA/86/6 The fluidized drum granulation process (FDG) and its various applications by P. Thuring & E. Vogel, Kaltenbach-Thuring, France

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

Q - Mr T. NURMI, Kemira Oy, Finland

a) Do the supports of the fluidizing table have any adverse effects on the operation of the drum and how is the table supported?

b) How often must the grid of the table be cleaned?

A - a) At the inlet of the fluidizing table there is a pipe for the air supply of the fluidizer and, at the outlet, a simple closed pipe. The ends of the these two pipes lie on bearings located before and after the granulator. These bearings are used to support and to adjust the slope of the table. Inside the granulator these tubes can collect the materials produced by granules which normally flow when the angle of repose is exceeded. They do not disturb.

b) The frequency of cleaning the table depends on the product made and on the type of application. In the case of urea or nitrate, one can operate several days without cleaning. TSP or DAP granulation could necessitate daily cleaning with a 10-15 min stop.

Q - Mr J.D.R. MARCAL, Quimigal, Portugal

a) What is the lowest possible AN concentrations used in your granulator?

b) In that case: problems in the granulation and additional hot or cold air?

c) Hardness of the granules (less hardness?)

A - a) Ammonium nitrate and urea granulation was achieved down to a concentration of 95%. No test was made with a lower concentration. It might be possible to granulate a more dilute solution, but we feel granulating less than 95% is of little interest, since it is easier to concentrate a dilute solution of these materials in a conventional concentrator with a higher efficiency.

b) Down to a 95% concentration, we used cold air. We cannot answer your questions without some calculation to know if, for lower concentrations, we need to use hot air or cold air or at which level hot air should be used.

c) For ammonium nitrate granulated with GFT, we obtained 10-12 kg crushing strength for 2-5 mm granules and for urea 4 to 6 kg for the same size.

Q - Mr R. BAROUNI, SAEPA, Tunisia

You mentioned some applications of GTF to the coating of fertilizer particles, in particular the coating of PK fertilizers with ammonium nitrates; is the reverse possible, for example the coating of ammonium nitrate prills with a slurry containing P and K nutrients to make NPKs? Have you carried out tests in that direction?

A - So far only the coating of PK granules on compacted fertilizers was done with a hot solution of ammonium nitrate or urea. The coating of prills or granules of ammonium nitrate or urea by a slurry containing PK has not been done. Tests will soon be achieved on these products. There should not be any difficulty in this regard.

Q - Mr R. BAROUNI, SAEPA, Tunisia

In the case of the application of GTF to prill growth, did you meet difficulties associated with, on the one hand, the formation of large particles and, on the other, the fixation of the major part of the slurry on the fines? These two factors generally affect the quality of the granulation and require the use of more powerful separation systems. What do you think?

A - In the growth of nitrate or urea prills, the problem of fines or oversize is solved in two ways:

Case No 1
Prills from the prilling tower are first screened. Fines and oversize are thus removed before the GTF. The latter then only plays the role of a thickener and the scaling which might fall out of the drum is then removed in the safety screening of bagging plants.

Case No 2
Prills out of the prilling tower are not screened and GTF receives everything from the prilling. A screen is then installed just after GTF and fines and oversize are recycled to melting before the prilling tower. The amount of fines and oversize to be recycled after GTF if about the same as in the case of screening prior to GTF. This applies to prill growth in the case of quantitative growth based on 50% prills and 50% solution. In the case of less than 50% prills and more than 50% solution, screening is always done after GTF. The screen always includes an additional cloth, which makes it possible to feed the melting vessel with particles less than 1 mm. Only particles between 1 and 2.5 mm are recycled to GTF for growth. According to the desired granulation it can be raised to 3.5.
The first question has already partly been answered.
The formation of large particles is not very important. It only amounts to a few % of the production. When fines are recycled, we remind you that all those under 1 mm are removed to the melting vessel, as these fines, if they were sent to GTF, tend to form binding bridges between on size granules. As long as the proportion of fines is low, they do not disturb. When the percentage exceeds 2-3%, it can affect the quality of granules.

Q - Mr R. MONALDI, Agrimont, Italy

I found that the hardness of fertilizer granules reported in your paper is much higher than what is given by other producers. Can you give details on the method used by you to determine granule hardness?

A - The hardness is determined on granules with the average required granule size. The method used is a conventional one. The granule is put on scales. With an appropriate tool, one presses on the granule until is breaks. At breaking the weight corresponding to the pressure put to break the granule is read on the scale.

Q - Mr M. BARLOY, SCPA, France

You define the size of the granulator for its granulation function and that of the fluidizer for its drying and cooling function. Although the definition of these equipments have something in common, namely the production capacity, there are many other independent factors to achieve their respective functions. Are the sizes determined that way for each equipment always compatible so that the fluidizer can be introduced in the granulator?

A - For each specific application, we calculate separately the size of the granulator and of the fluidizer. If the calculated sizes are not compatible, we adjust the size of the granulator or of the fluidizer to the size of the equipment requiring the greatest volume.

Q - Mr KOLMEIJER, Windmill Holland, Netherlands

For the solidification of slurries such as ammonium sulphate or a mixture of ammonium sulphate and ammonium nitrate, a spherodizer could be used. Is your system preferable and, if so, why?

A - I agree that the spherodizer is suitable to solidify and granulate slurries such as ammonium sulphate or sulphate nitrate. There is, however, an important difference between GTF and a spherodizer. This difference applies mostly to the quality of the air distributed in these two types of granulation. In the spherodizer the hot air flows through the granulator. It becomes steadily more humid and, near the exit of the equipment, the granules are in contact with cool and humid air. In the case of GTF and all along the table, the granules are in contact with hot and dry air. It is a very important difference which means that, in the case of GTF, several layers of slurries can be added to the granule which, in all cases, would be dried by dry and hot air.

Q - Mr V. BIZZOTTO, NSM, Netherlands

1- Referring to page 1: When passing from the pilot plant (with a capacity ranging from 300 to 800 kg/h) to an industrial plant, you should face a large scale-up factor. What do you expect the drum size would be for a 1000 T/D plant or for a 1500 T/D plant?

2- Referring to page 6: For urea and ammonium nitrate products, what type of additive do you utilize, if any?

A - 1- Our pilot plant is 900 mm in diameter and 1200 mm long. The fluidizing table has an area of 0.4 m2. In both the cases we studied and for a first achievement, it is obvious that, in agreement with our buyers, we used a rather great safety coefficient.

2- I agree with you. The specificity of our equipment is that the product which, in a normal fluidized bed, is introduced in one end and leaves from the other, here circulates across the equipment. As a result the product comes back 100-200 times on to the table after being lifted in the granulator. Another interesting point is that the product never exceeds 95-98°C, which enables to operate the granulator at temperatures reaching 180°C without affecting the rubber. Last advantage: the possible existence of oversize in the circuit does not affect the cooling operation, a problem raised in conventional coolers.

But I agree with you. May be that instead of calling that equipment GTF, fluidized bed granulator, we should have used a longer name to indicate that the cooler is inside the granulator.