COMPACTION-GRANULATION of FERTILIZERS

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ABSTRACT

Fertilizing is a critical point for the farmers : this process should be very precise. Therefore the fertilizers have to be produced in the optimal way to reach the maximum quality and the adequate form requested by the users. Mainly the fertilizers are produced in solid form by several methods of granulation : one of them is the granulation by compaction . This technology is a dry process where the powders are enlarged by means of high pressure developed inside a roller compactor. Being a dry process, compaction-granulation has many advantages compared to the other methods. No energy is required for drying of the granules. The level of pollution caused by this process is very low because there are no liquid or gas effluents to be processed. Using compaction-granulation, it is possible to manufacture products which are difficult or even impossible to obtain by wet processes. The formulation of the compound fertilizers is accurately reproduced in each granule. Thus, there is no problem of segregation during handling. Thanks to its great flexibility, the granulation-compaction process enables to produce very small quantities of granules, and thus adapt the fertilizers to the user's requirements. This process is fast-expanding and with very good prospects.

Keywords : Compaction, granulation, roller compactor, powder, granules

1. INTRODUCTION

From every point of view, precision is of paramount importance in fertilization. It is therefore important to produce fertilizers in such a form that can be applied to the soil in as exact amounts as possible.

Although liquid solutions or suspensions are the easiest forms of fertilizer for accurate application, the majority of fertilizers is used in solid form.

Since powdered or crystalline fertilizer materials give rise to a lot of dust, with all the attendant loss and nuisance (dust emission during handling at ports and in warehouses and workplaces, poor product flowability, caking tendency during storage and transportation, segregation of components, scattering by wind during the spreading on the fields), most fertilizers are consolidated into larger particles with more suitable properties by means of different processes, commonly named “granulation”.

The particle size of granular fertilizers in the Americas is usually in the range of about 1-4 mm, whereas a size range of about 2-5 mm is more common in Europe and many other areas.

Usually the multinutrient fertilizers are a mixture of several components, and the quantities of nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) are used to characterize the fertilizer product. Besides these three primary nutrients, a number of secondary nutrients and micronutrients can be added, if needed. Such a mixture of different products in powder form has the following well-known defects : homogenisation, segregation, uniformity, … It also makes spreading in the fields difficult.

Moreover, the availability of a combination of various essential nutrients in homogenous granules permits application in one operation.

Thus, three different methods are used to enlarge the fertilizer powders and to produce granules :

- the *wet granulation method*, named also pan granulation method or tumble agglomeration method. The fertilizer powders are enlarged by the chemical reaction through the presence of a liquid medium or by a binder (water, steam, …). It produces the granular compound fertilizer where all the ingredients are incorporated into the formulation before it is formed into granules, so each individual granule contains all of the

nutrients in the correct ratio. The granulation is done either inside a drum granulator, or a pan granulator, or a mixer-granulator. The main drawbacks of this granulation method are that it is expensive both to install (this process requires mainly a granulator, a dryer and a cooler) and, on account of the energy required for drying, to run as well ; it is also rather lacking in flexibility, because changing the formulation entails stopping the plant to reset many of the process parameters, and that can take some time. Most manufacturers of compound fertilizers, therefore, have to restrict their product range to a few standard grades. The grades available on the market are in fact a compromise : they do not necessarily have the correct nutrient balance for all combinations of crop, soil and climate. The economics of farming is nowadays so finely balanced that there is a growing demand for small batches of custom-formulated fertilizers, but not at the inevitable high cost of producing them in a wet granulation plant.

- an alternative which takes a certain popularity in the past compared to the wet granulation is the *bulk-blending process* . Here, a fertilizer is formulated by merely mixing together granules of the individual fertilizer materials. Individually, of course, the granules have very different nutrient contents. The mixtures may also segregate during loading and transport, further compounding the problem of uneven distribution. The main advantages of bulk blending are that it uses a cheap installation, it can quickly and easily be switched to make different grades over a wide range, and it can operate on a limited number of basic granular fertilizer materials, such as urea, DAP and granular potash, which are plentiful and therefore relatively cheap.

- the third method is *compaction-granulation process* which has gained popularity in the recent years compared to both previous ones. It combines some of the advantages of both wet granulation and bulk blending. Many amorphous solid fertilizer materials, including some that are difficult to granulate by conventional means, can be consolidated in any desired proportions by the simple application of a mechanical pressure. No added moisture is required, so there is no need for a dryer (a large and expensive item of equipment in its own right) or its substantial energy requirement. Changing the formulation is a very quick and simple procedure. The technique may also be used to enlarge single materials, as potash (potassium chloride) in particular, which cannot be granulated by the conventional drum or pan granulation methods.

Compaction has a further relation to bulk blending : as a low-cost method of regranulating bulk-blend feed material which has deteriorated during transport or storage.

2. HOW DOES COMPACTION-GRANULATION WORK ?

The compaction process is basically a dry granulation process, so there is no liquid medium and no binder. Instead, the fine particles of fertilizer material are subjected to a sufficiently high pressure to squeeze them together and bring their surfaces close enough for short-range intermolecular and electrostatic forces to cause cohesion. The equipment used for the compaction of fertilizers is called a roller compactor.

The roller compactor comprises a feed unit and two parallel rolls rotating on horizontal axes and separated by a small but precisely determined gap (up to 25 mm). One roll is fixed, while the axis of the second roll can move perpendicular to its axis, towards or away from that of the fixed-axis roll. Usually the rolls speed is limited to 1 m/s.

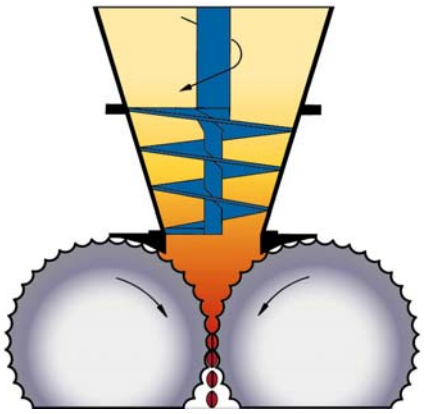

Figure 1. Principle of the compactor with the screw force-feeder.

A force by means of hydraulic jacks is applied on the mobile roll to bind and compact the particles. The compacting pressure in these jacks is regulated by means of an hydraulic circuit, and is defined for each type of compound fertilizer.

The rolls are mounted side by side with the feed section above. The powder is forced into the “nip” of the rolls by the combined forces of the feed system and the frictional force between the material and the rolls, which rotate so as to draw

the material into the gap.

To ensure uniformity in the product it is most important that the feed system should maintain an absolutely steady flow of material to the rolls. Its design is therefore very critical. The feed system is fitted with a screw force-feeder which includes one or two conical screws. The rotational screw speed is variable and the feed screw is tapered to squash out air voids and predensify the powder before going through the rolls.

The powder passes out of the nip of the rolls in the form of a laminar sheet (thickness up to 25 mm), which breaks into flakes under its own weight.

The size of a roller compactor is characterized among other features by the roll diameter (from 250 mm to 1400 mm) and the roll width (from 40 mm to 1200 mm). The flakes capacity can be up to 100 T/h.

The compaction of fertilizers involves a very large range of specific pressure, as for example :

- fertilizers based on urea : 40 kN/cml
- potash : 50 – 60 kN/cml
- fertilizers based on phosphate rock : 80 kN/cml
- ammonium sulphate : 80 kN/cml
- potassium sulphate : 90 kN/cml
- PK fertilizers based on phosphorus slag : 80 kN/cml

3. MAIN STEPS OF THE COMPACTION-GRANULATION PROCESS

There are five main process stages in a compaction-granulation unit : raw feed preparation, compaction, granulation, finishing, and storage-packing.

3.1 STAGE 1: THE RAW FEED PREPARATION SECTION

This section usually consists of the following components :

- Feed hopper with a rough screening system, for removing big lumps, and possibly a lump-breaking system and a magnet.
- Raw material grinding system if required. It is advisable to have particles smaller than 1 mm to improve the homogeneity of the final product as well as the production yield.
- Raw material storage hoppers .
- Weighing system (for batch operation) or dosing system (for continuous operation).

- Homogenizing system (mixing).
- Controlled feeding system to the roller compactor.

This is, in fact, much the same as the feed preparation system for a conventional wet granulation plant or a bulk-blending plant.

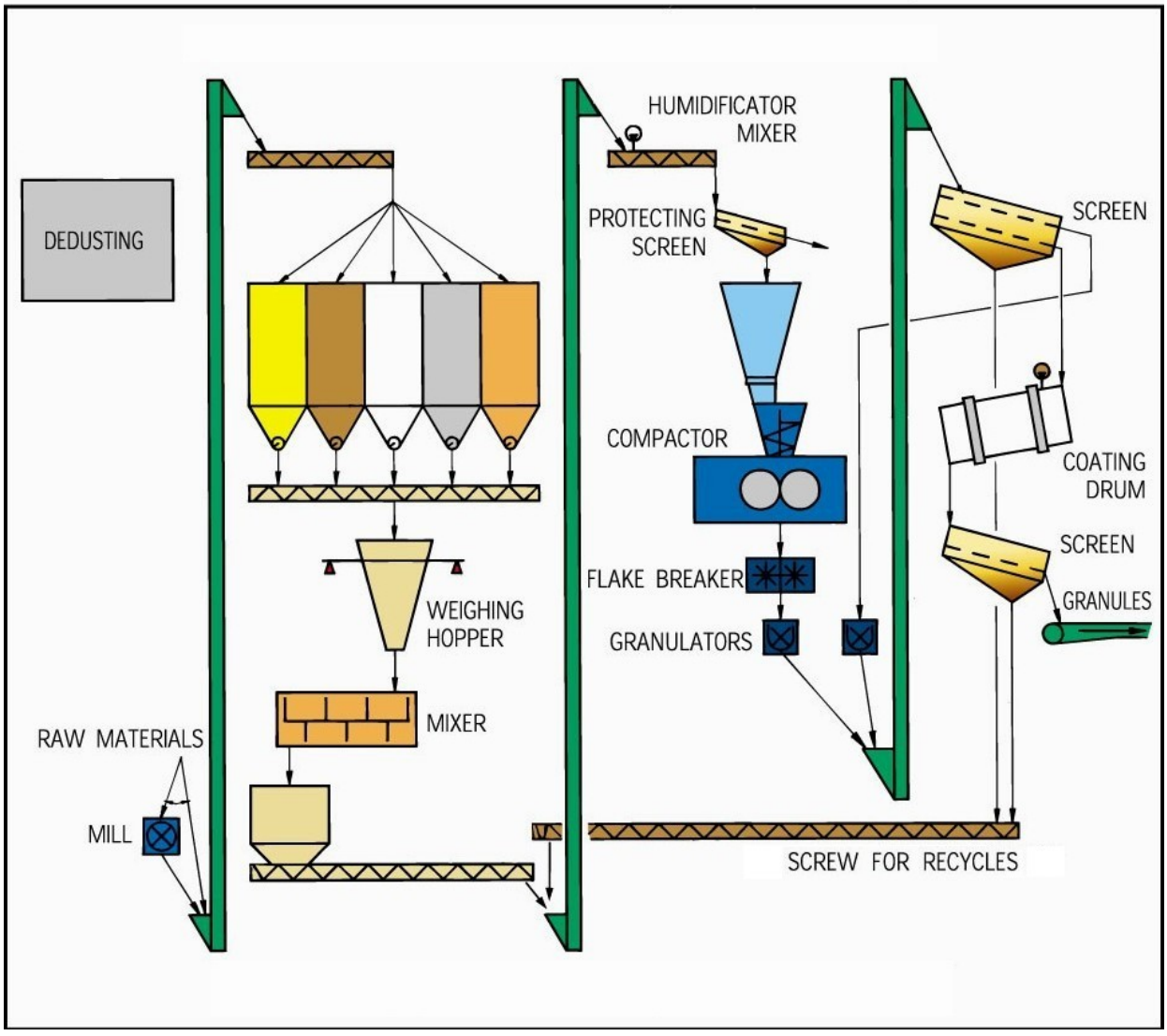

Figure 2. Flowsheet of a fertilizer compaction-granulation plant.

3.2 STAGE 2 : THE COMPACTION SECTION

This section comprises a number of sub-units :
- the compactor feed hopper

- the roller compactor with its force-feeder

Figure 3. Compactor type HP1/800/400 - (Rolls diameter : 800 mm – Rolls width : 400 mm - Flakes capacity : 40 T/h).

- the flake-breaker, if required depending on the size of the flakes produced by the roller compactor

Figure 4. Flake-breaker.

At the outlet of the compaction section, rough flakes (approximately > 40 mm) are obtained.

3.3 STAGE 3 : THE GRANULATION SECTION

This section comprises the equipment to make the granules from the flakes : it is broken up into smaller fragments in a primary crusher-granulator installed downstream of the roller compactor. Particles in the desired size range (for example, between 2 and 4 mm) are screened and removed as product, while the oversize (above 4 mm) is returned to a secondary crusher-granulator and the undersize (under 2 mm) to the roller compactor. This stage of the compaction-granulation process has a significant effect on plant capacity. Simply by selecting a different type of crusher-granulator, or choice of their working parameters (rotor speed, grid, ...) it is possible to change the yield by a factor of two.

Figure 5. Hammer-mill granulator.

Figure 6. Double-deck grid granulator.

3.4 STAGE 4 : THE FINISHING SECTION

This section comprises a dry polishing unit and a coating unit.

The dry polishing unit consists of a polishing drum and a finishing screen. The polishing drum improves the quality of the final product by rounding off the sharp edges of the granules and destroys any that are of substandard strength. The undersize finishing screen subsequently removes the dust generated by the abrasion of granules in the polishing drum. This limits the amount of dust that is formed when the product is handled and used.

As in traditional granulation plants, the main purpose of the coating unit is to limit caking and, in some cases, to treat the external surface of the granules for the production of slow release fertilizers. The coating unit comprises a drum fed with solid or liquid coating products and a rough safety screen to remove any lumps formed in the coating drum.

It should be noted, however, that compacted fertilizers are, as a rule, less prone to caking than other solid forms.

3.5 STAGE 5 : THE STORAGE-PACKING SECTION

This section is the same as for other fertilizer plants. Apart from a few rare exceptions, such as fertilizers with a very high urea content, compaction-granulated fertilizers do not require a curing period before delivery.

Process optimisation of compaction-granulation is achieved by a combination of three interdependent stages : compaction, granulation and finishing.

4. LIMITATIONS OF THE COMPACTION-GRANULATION PROCESS

There are very strict limits for the free moisture content of mixtures before compaction. Super phosphates are difficult to compact, and predrying, or at least prolonged ageing, is required. The thermal balance for the compaction process, however, remains favourable.

Compaction-granulation is not suitable for phosphate rock. Nevertheless, arrangements can be made for the production of

partially solubilized phosphates where water and free acidity can be easily controlled.

Granules produced by compaction-granulation are not as spherical as those obtained in a conventional granulation process. Furthermore, the granule size range is more irregular.

5. ADVANTAGES OF THE COMPACTION-GRANULATION PROCESS

Compared with the others granulation processes, there are many advantages to be found with the compaction-granulation process, and among them :

- being a dry process, no water or binder consumption (or in some cases, 1 or 2 % of water are added to the product before the roller compactor : due to the small rise in temperature (around 20°C) during run-through of product in the roller compactor, the water is eliminated naturally).

- no energy is required for drying ; energy for the process is supplied in the form of electricity (around 30% less than the wet granulation process).

- as there are few corrosion problems, maintenance costs are kept low.

- the level of pollution caused by the process is very low because there are no liquid or gas effluents to be processed. The compaction process is environmentally friendly. In the compaction-granulation process, a dust collector with bag filter is usually installed. With the wet granulation processes, a wet scrubber is requested and this involves the problems associated with the utilization/disposal of unwanted scrubber liquor.

- low investment cost is possible, no need to invest in a dryer and a cooler (expensive equipments). The techniques used in this process present a high adaptability to local conditions (low level of complexity of the technology involved).

- the process can use powdery raw materials (KCl, $(NH_4)_2SO_4$, ground phosphate, etc...) which cannot be easily used in bulk blending.

- the process has much better adaptability to the local supply of raw materials and higher flexibility in their use which enable to free oneself from the supply constraints. The cost of the raw

materials can be optimised continuously depending on the local supply (sometimes the savings achieved on this item pay for the production cost). By-product raw materials and unusual materials such as dried sludge from municipal water treatment plants, can also be compacted.

- the process eliminates any segregation phenomenon in the chemical formulation as well as in the physical formulation. The formulation is reproduced in each granule. Thus, no problems of segregation appear during handling, as experienced with the bulk blends comprising granules of different size and density.

- the process enables to produce a wide spectrum of fertilizer formulas and to obtain very diversified fertilizers in the same plant, as, for instance, a fertilizer containing soft ground phosphate, a traditional concentrated NPK (17-17-17), very specific formulas such as 14-6-24+MgO+$B_2 0_3$, NK fertilizers (14-0-20), multiple formulas combining highly specific materials adapted to local farming conditions (soil, crop and climate) and to economical supply facilities, raw material products for bulk blends (potassium chloride, ammonium sulphate, potassium sulphate), intermediate fertilizing agents between fertilizers and soil amendments.

- the process allows the manufacturing of fertilizers difficult, or even impossible, to produce by means of the wet granulation process for technical reasons (for instance, high urea content fertilizer, potassium sulphate).

- the fertilizers manufactured using this process are less prone to caking (the compaction-granulation uses dry components) and are more durable.

- the process can be switched over to different formulations quickly and efficiently. A changeover requires 30 minutes at the most to drain the circuit and start a new product : the plant inertia is very low and the plant can be shortly at full capacity.

- due to its high level of flexibility, the plant can adapt its production to the market demand (with the production of small quantities of very specific fertilizers requested for a specific crop, soil and climate) and work with minimal stocks of finished products.

- an important flexibility for the plant capacity is possible : from small-scale (2 T/h) to fully automatized plants able to

produce 60 T/h and more.

- as the plant uses simple circuits, plant layout is compact.

- the service factor is very high : usually over 90%.

- operation and maintenance of the plant is easy ; therefore, staff do not require special training. And finally, only a very small staff is required to operate the plant.

6. CONCLUSIONS

The compaction-granulation process is really a highly versatile and inexpensive method of producing granular fertilizer which makes it particularly profitable for the fertilizer producers.

The process is mainly of interest to medium-sized companies who are not concerned by the production of a limited number of standardized formulations on a large scale.

The compaction-granulation process has been used for a very long time for the production of potash granules : it was introduced in the early 1960s.

For compound fertilizers, small units (5 T/h) were installed in Europe 30 years ago. Since then, new plants (up to 60 T/h capacity) have been built in France, Belgium, Switzerland, Germany, Portugal, Guatemala, the Philippines, Greece, Turkey, Finland, Poland, Italy, China and Vietnam. New compaction plants have been recently erected or will be started shortly in Italy or in Australia. Numerous projects all over the world are currently at the feasibility stage.

The compaction-granulation process is really a very interesting method to enlarge fertilizers powders : this process has true assets compared with the other granulation processes.