

Compaction-Granulation of Fertilizer An Economical Process for à la carte Formulations

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, and because they tend to become clogged during storage and handling, most fertilizers are consolidated into larger particles with more suitable properties.

The granular compound fertilizer is one kind of solid multi-nutrient fertilizer. 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 main drawbacks of the conventional granulation (wet granulation by tumbling in the presence of a liquid medium) are that it is expensive both to install and, on account of the energy requirement for drying, to run as well; it is also rather inflexible, because changing the formulation entails stopping the plant to reset many of the process parameters, and that can take some time. Most compound manufacturers, therefore, have to restrict their product range to just a few standard grades. These grades are a compromise: they do not necessarily have the correct nutrient balance for all combinations of crop, soil and climate in the market which their producers supply. The economics of farming are 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 compound granulation plant.

An alternative which has grown in popularity in recent years is bulk blending. 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 installa-

tion, 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.

There is a third method of making particulate solid fertilizers which combines some of the advantages of both compounding and bulk blending. That is compaction-granulation. 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 pressure. No added moisture is required, so there is no need for a dryer (a large and expensive equipment item 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 consolidate 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 re-granulating bulk-blend feed material which has deteriorated during transport or storage.

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 compactor.

The compactor comprises a feed unit and two parallel rolls rotating on horizontal axes and separated by a small but precisely determined gap. The axis of one of the rolls is fixed, while the axis of the second roll can move towards or away from that of the fixed-axis roll.

It is pushed towards the fixed roll to provide a constant compacting pressure by means of hydraulic jacks. The pressure in these jacks is regulated by means of a 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 compaction 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 pre-densify the powder before the rolls.

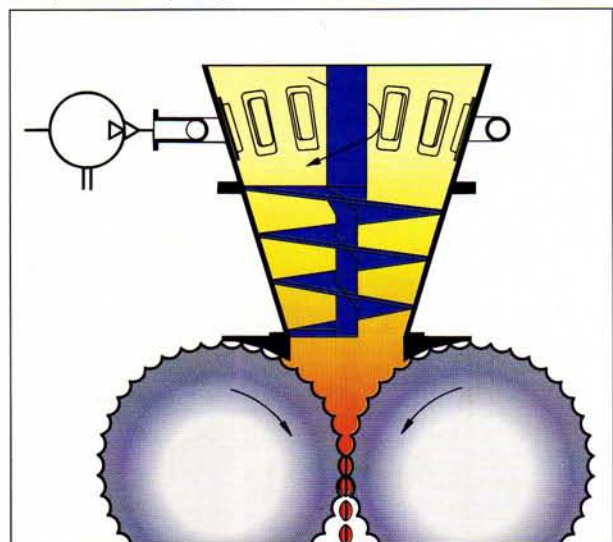
The powder passes out of the nip of the rolls in the form of a laminar sheet, which breaks into flakes under its own weight.

The size of a compactor is characterized, besides other features, by the roll diameter (from 250 mm to 1400 mm) and the roll width (from 40 mm to 1200 mm).

Main Steps of a Compaction-Granulation Process

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

Principle of the compacting unit with force feeder



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The raw feed preparation 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.
- Material storage hoppers before dosing or weighing.
- Weighing system (for batch operation) or dosing system (for continuous operation).
- 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.
- Homogenizing system (mixing).
- Controlled feeding system to compactor.

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

The compaction section comprises a number of sub-units: a feed hopper, the compactor with its force-feeder, and a flake breaker.

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

The granulation 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 compactor. Particles in the desired size range are screened and removed as product, while oversize is returned to a secondary crusher-granulator and undersize to the compactor. This stage of the compaction-granulation process has a significant effect on plant capacity. Simply by selecting a different type of crusher-granulators, or choice of their working parameters (rotor speed, grid, ...) it is possible to change the yield by a factor of two.

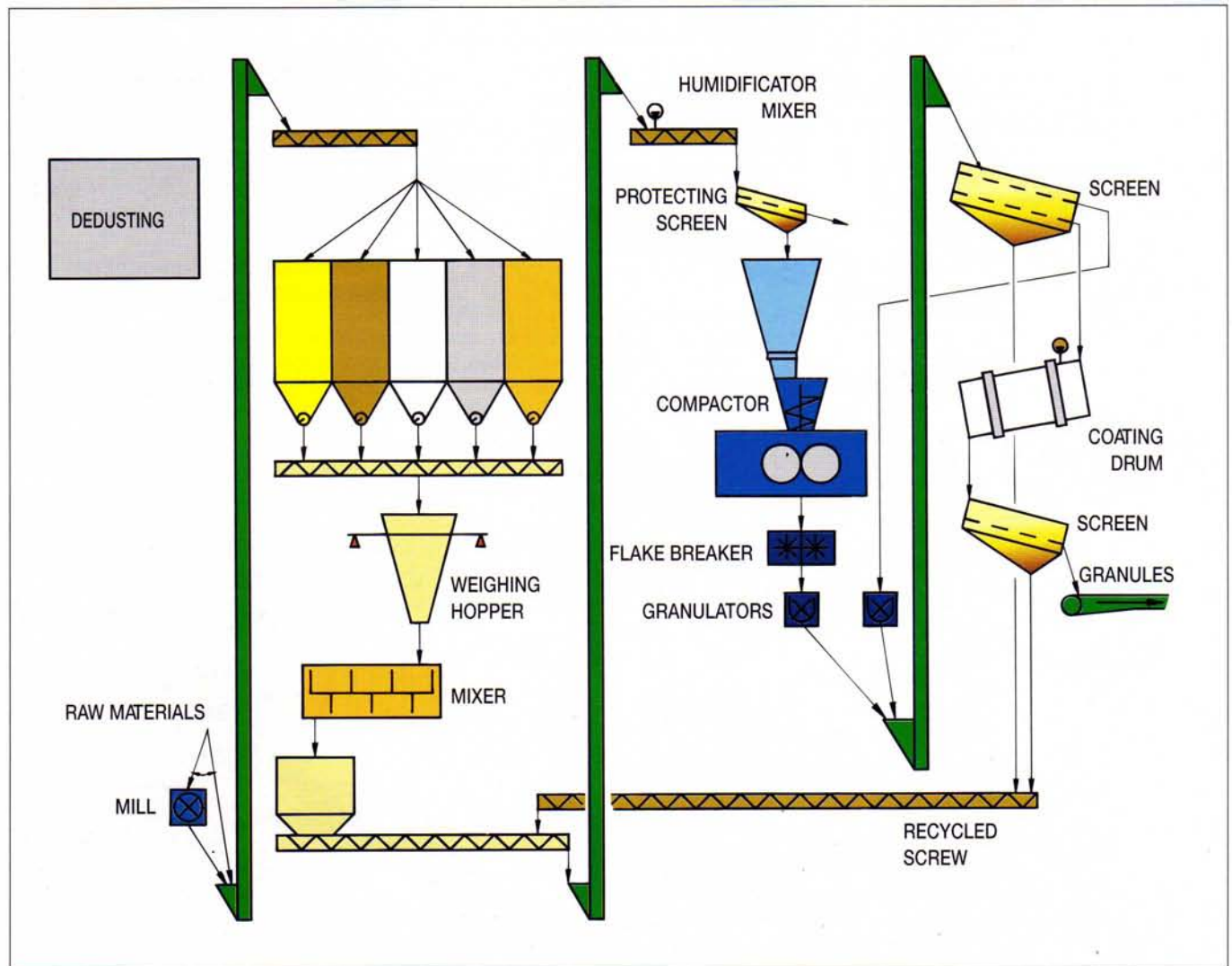
In the finishing section, there is a dry polishing unit and a coating unit. The dry pol-

ishing 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 clods 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.

Granulation of NPK fertilizer in a compacting unit



The storage-packing section of the plant 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 optimization of compaction-granulation is achieved by a combination of three interdependent stages: compaction, granulation and finishing.

Process Limitations

There are very strict limits for the free moisture content of mixtures before compaction. Superphosphates are difficult to compact, and pre-drying, or at least prolonged ageing, is required. The thermal balance for the compaction process, however, remains favorable.

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.

Process Advantages

Being a dry process, compaction-granulation has many advantages. No energy is required for drying; energy for the process is supplied in the form of electricity. 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



Examples of compacted material before and after granulation

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 (fertilizer with a high urea content for instance). The fertilizer products manufactured using this process are less prone to caking and are more durable.

Further advantages of the process include its low investment cost, which can be attributed to the use of simple equipment and materials, a shorter delivery time, and wide adaptability to local conditions (products, raw materials, production capacity). 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; staff do not require special training. And finally, only a very small staff is required to operate the plant.

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.

This process enables to produce, all in the same plant, a wide range of feasible for-

mulations: for example, a fertilizer containing soft ground phosphate, a traditional concentrated NPK (17-17-17), very specific formulations such as 14-6-24+MgO+B₂O₃, an NK product (14-0-20), multiple formulations combining highly specific materials adapted to local farming conditions and to economical supply facilities, raw material products for bulk blends (ammonium sulphate, potassium sulphate), intermediate fertilizing agents between fertilizers and soil amendments, fertilizers which are difficult to produce in the traditional way for technical reasons.

The formulation is reproduced in each granule. Thus, there is no problem of segregation during handling, as is experienced with bulk blends comprising granules of different size and density.

The process can use powdery raw materials (KCl, (NH₄)₂SO₄, crushed phosphate, etc.), which cannot be easily used in bulk blending.

On the basis of the points mentioned above regarding the advantages of the process, its flexibility (applicability to a wide range of formulations) and ability to optimize raw material costs according to market conditions, it can be said that an interesting and original style of production management should or even must be adopted. And, as the overcapacity of production does not bring a significant increase in the operating fixed charges, the plant can adapt its production to the market demand and work with minimal stocks of finished products.

The process is mainly of interest to medium-sized companies which 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.

For compound fertilizers, small units (5 t/h) have been installed in Europe more than 20 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 and China.

In 1998, a compaction plant was put in operation in Vietnam with Sahut-Conreur technology. In 1999, two new compaction plants with Sahut-Conreur compactors were started in Poland: one with a capacity of 4 t/h, the other with a capacity of 18 t/h. Numerous projects all over the world are currently at the feasibility stage.

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.

Compactor in Sahut Conreur's manufacturing plant prior to shipment





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With an experience of nearly a century, Sahut-Conreur is a leading designer and manufacturer of briquetting and compaction-granulation plants.

These processes of particle size enlargement use a dry process in which powders are formed into a densified product, in the shape of individual briquettes (briquetting - from a few cm³ up to 600 cm³ and more) or granules (compaction-granulation - 2-5 mm granules; 0,4-1,2 mm granules; for example). Densification is obtained by mechanical compression through a double roll press (also named compactor). The fine particles of 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. With the feed system above the rolls, 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 between the rolls.

Very different aims can be reached with these technologies:

- obtaining uniform products (size, volume, weight)
- reducing the volume of a powder (to cut packaging, storage and transport costs)
- stabilizing unstable mixtures (problems of segregation are eliminated)
- improving the powder flowability (to prevent problems of feeding, dosing or packaging)

- keeping a dust-free product



- recycling the value-added products
- upgrading the by-products.
- replace the wet process of agglomeration involving costly drying and binder addition techniques
- ...

These processes have been extended to a wide range of industries using powders: chemicals, detergents, fertilizers, food, minerals, nuclear products, ores, oxides, pharmaceuticals, sewage sludge, steel-works by-products, ...

The range of double roll presses proposed by Sahut-Conreur is very large: from the laboratory equipment (only 2,5 dm³ per batch test) up to industrial presses of high capacity (up to 100 T/h), each one is specifically adapted to one application: roll diameter (from 150 mm to 1400 mm) and roll width (from 40 mm to 1600 mm).

Furthermore in the 1980's, Sahut-Conreur has expanded the use of the double roll presses for grinding. Compared with the traditional techniques, the use of this process (bed comminution) means energy savings (up to 30%) and throughput increases (30 to 100 %) when the roller press is fitted into an existing grinding circuit as pre-grinder.

In addition to the double roll press, Sahut-Conreur has developed a range of additional equipment specifically adapted to the requirements of these processes: mixers, pug mills, flake-breakers, hammer-mills, knife crushers, grid granulators, ...

This equipment is installed worldwide in multiple applications.

Sahut-Conreur's plant is located in Raismes, Northern France and consists mainly of:

- a pilot plant at customers' disposal to carry out feasibility tests with lab presses on small quantities (about 20 kg) and/or semi-industrial tests with industrial presses on larger quantities (from 200 kg to 500 kg).
- a toll production plant for production of batches of briquettes or granules (up to a few hundred tonnes) for checking of technical data and/or for potential market testing and/or testing of industrial processes downstream after the briquetting or granulation unit
- a number of presses and ancillary equipment available for rental for site testing and/or industrial production.
- an engineering and design department for design of the plants and equipment.
- a construction workshop for manufacture of the equipment (double roll presses, mixers, pug-mills, flake-breakers, hammer-mills, knife crushers, grid granulators, ...)

Experience, know-how, service, Sahut-Conreur has all the necessary means to propose a global solution and implement it.