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Fertilizer Focus

NPK production technologies

Single and dual pipe reactor technologies are safe, flexible and efficient

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One of the most important progressions in agriculture is the knowledge regarding soil quality and each crop requirement. This has put the farmers in a position of using the proper quantity and quality of fertilizer at the proper time to get the best efficiency.

As a result, knowing the crop requirement and the soil analysis (which also indicates the remaining nutrients from previous period), the farmer can calculate the quantity and quality of fertilizer to be sprayed on the field as well as the frequency and timing of application.

A fertilizer can be characterized by the total nutrient content and the ratio between these nutrients. For example:

- Urea contains 46% of nutrients with a ratio of 1-0-0 (N, P and K elements)
- Pure ammonium nitrate contains 35% of nutrients with a ratio of 1-0-0
- 20-20-20 contains 60% of nutrients with a ratio of 1-1-1
- 10-5-5 contains 20% of nutrients with a ratio of 2-1-1

The plant needs varying nutrients according to their type and the period of growth.

Compound NPKs are generally preferred over NPK blends

To promote the root growth, a fertilizer with higher P content (e.g. ratio 1-2-1) is to be applied.

To promote flowers and fruits, more K is required such as in the fertilizers with a ratio of 1-1-2, 1-2-2 or 2-1-2.

To promote leaf and vegetation, a nitrogen rich fertilizer is preferred such as in fertilizers with a ratio of 2-1-1, 3-1-1.

It can be that a fertilizer with only one nutrient, such as ammonium nitrate, CAN or urea, will deliver N to the plant. Similarly, it might be TSP or SSP to bring only P.

But it can be also MAP or DAP or USP to bring N and P or fertilizers which are called NPKs.

NPK variations

There are two main categories of NPKs depending on how their constituents are combined.

They can be produced, for example, by physically mixing together separate granules of AN, MAP and MOP in a process known as bulk blending.

Compound fertilizers can also be produced using a granulation process to combine all three nutrients homogeneously within a single granule.

Compound NPKs are generally preferred over NPK blends because they do not segregate during storage and transportation, helping to ensure that nutrients are spread evenly during field application.

Compound NPKs are manufactured using a range of different raw materials. The N source is usually a mix of ammonia with ether ammonium nitrate or urea. Ammonium sulphate can also be used, being sourced as an external product or produced in-situ from sulphuric acid and ammonia.

The P source can be sourced via phosphate rock or via the phosphoric acid route (even if phosphoric acid is originated from phosphate rock).

When using phosphate rock as P source, there is a big disadvantage which is that the calcium content of the rock remains as a diluent in the fertilizer and thus some fertilizer grades can not be produced, such as MAP and DAP, or must be treated separately generating a side production of CAN.

On another hand, when using the phosphoric acid, while costing slightly more as P2O5 source, if the site is far from a phosphate mine, the shipment and storage requirements are less demanding.

The K source can be potassium chloride or, for some very special cases, potassium sulphate.

Figure 1. NPK granulator

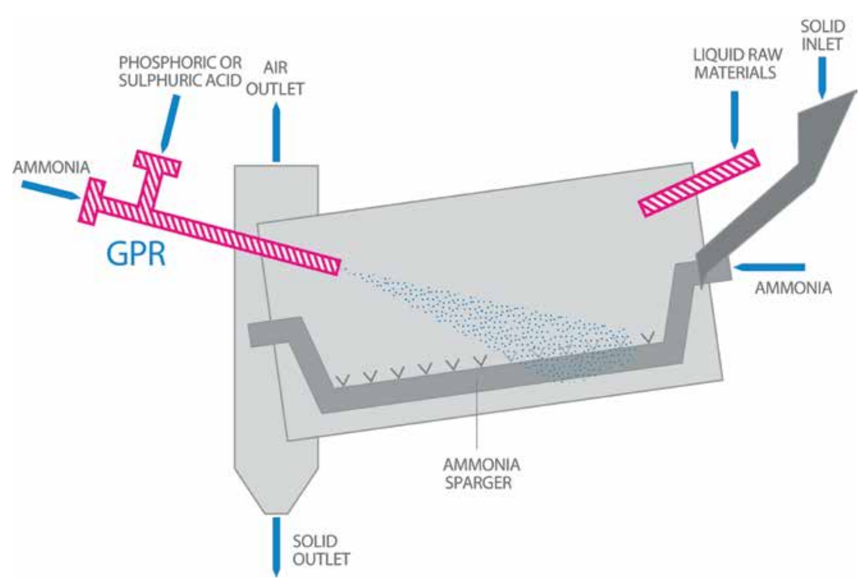


Figure 2. Scrubbing system

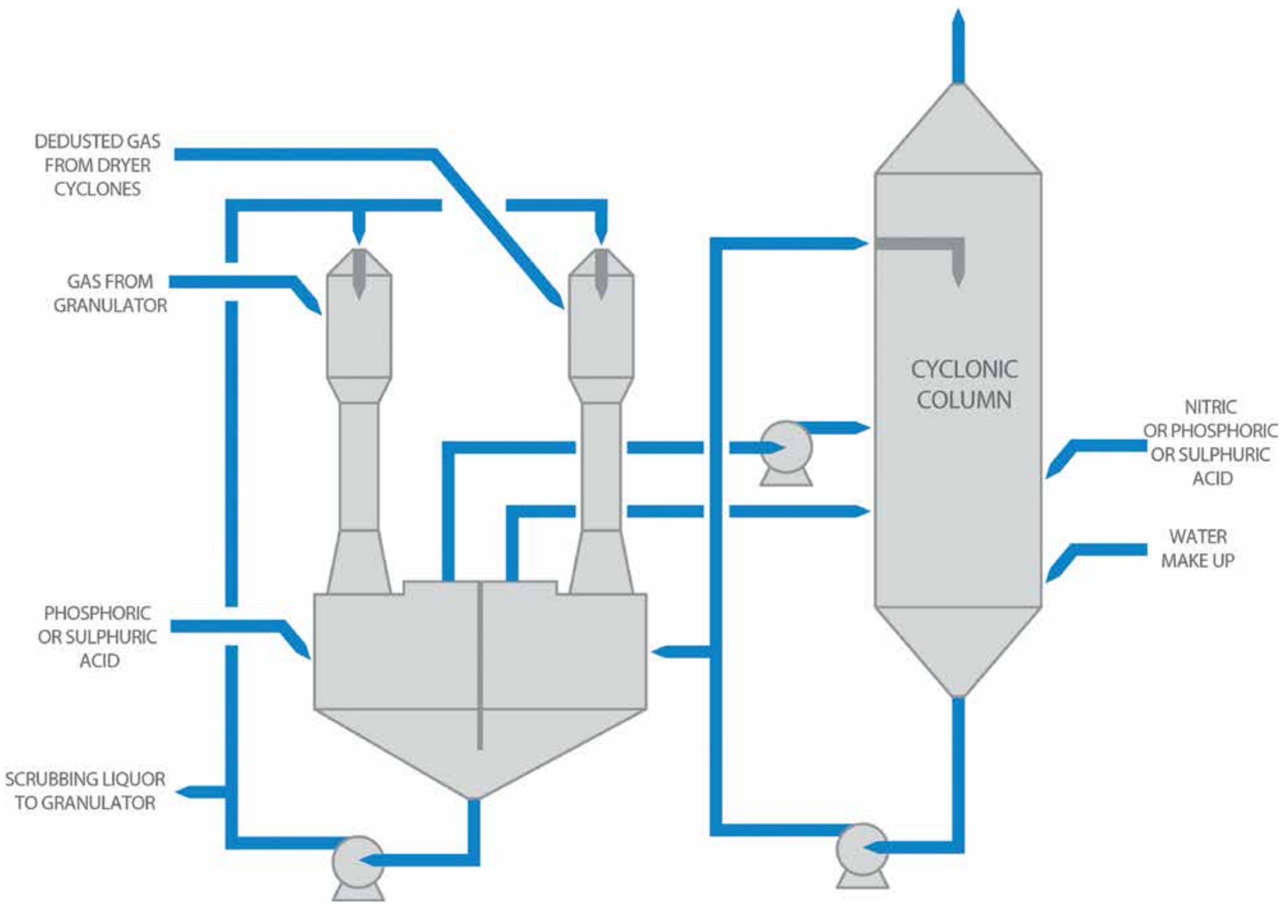
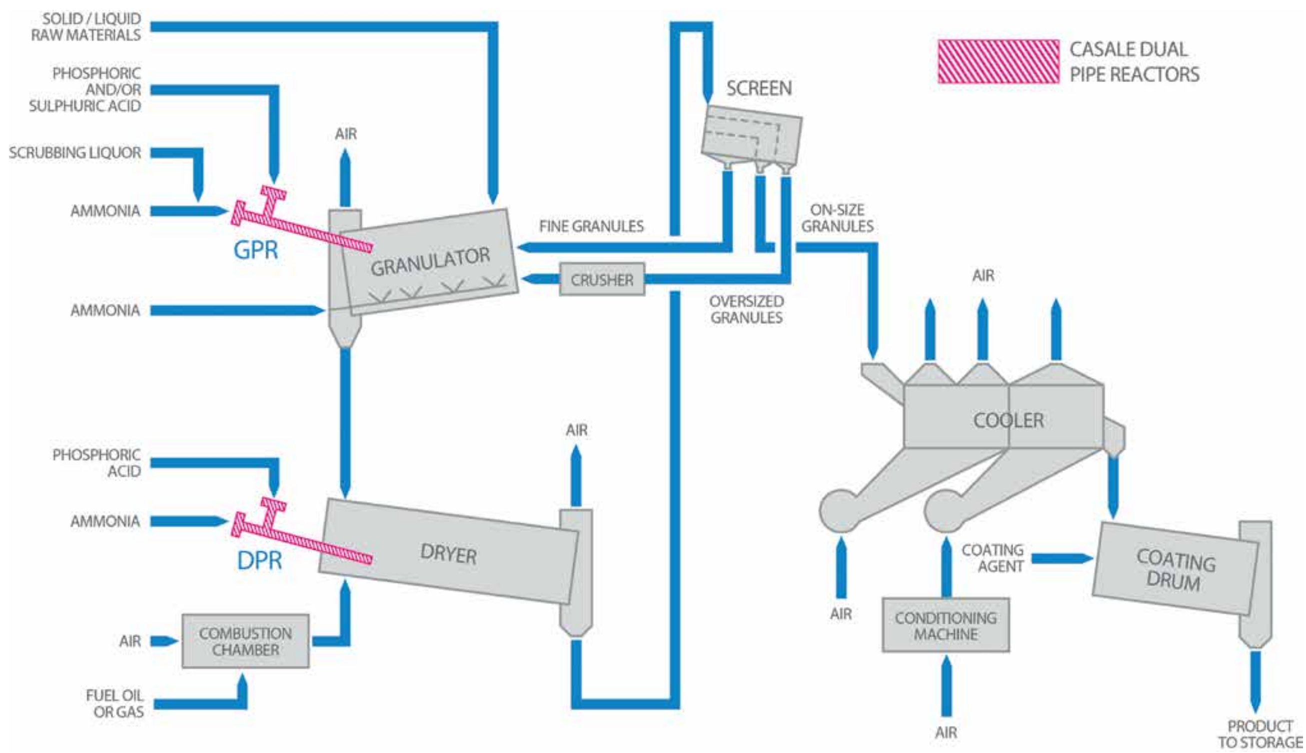


Figure 3. NPK granulation process



Casale's granulation process for NPK production is described below. It is based on phosphoric acid and potassium chloride as raw materials for P and K respectively, while the N source used can be ammonia with either ammonium nitrate or urea.

General concepts

The NPK process uses the phosphoric acid route. The main advantages are that it can be operated on any site and that it produces the best quality products, particularly when compared with NPK bulk blends. In addition, it offers flexibility in terms of the different fertilizer grades which can be marketed and it also generates a high level of nutrients in the fertilizer because the calcium associated with phosphate rock is avoided

Some processes according to this route are based on a pre-neutralizer. In the case of Casale, the process is based on pipe reactors, a production technology that offers distinct advantages in terms of flexibility, safety and cost (both capex and opex). As a result, less equipment is required, neutralization energy is not lost and the granulation loop capacity is lower than in the case of a pre-neutralizer. Furthermore, there is less changeover time required when a plant shifts production between different grades, enabling some operators to produce three different NPK grades in a single day.

History

The Casale granulator pipe reactors process has a history stretching back almost 50 years, having originally been designed and owned by Grande Paroisse (GP). GP designed its first granulator pipe reactor (GPR) in 1970 and its first Dryer Pipe Reactor (DPR) in 1974.

Both types of pipe reactors were subsequently incorporated – without any pre-neutraliser – into two new NPK plants at GP's own manufacturing sites later in the 1970s.

Since then, GPN has designed a range of NPK units with capacities ranging from 110 t/d to more than 2,800 t/d.

In 2014, Casale acquired from Borealis (formerly GPN) the complete set of process technologies for the production of compound fertilizers (NPKs), superphosphates (SSP, TSP, USP), nitric acid (NA), ammonium nitrate (AN) and urea-ammonium nitrate solution (UAN).

The transfer of these technologies to Casale was supported by a dedicated internal project to master all of the necessary technical know-how.

Single pipe reactor process

The granulation plant comprises a drum granulator, a drum dryer, screens and crushers, a cooling equipment and if required a coating drum. In addition to the main equipment, transportation equipment is also implemented as well as gas treatment devices in order to reduce the emissions of contaminants to air.

The different solid raw materials are fed directly to the granulator along with the solids recycled from the process. The liquid raw materials are fed mainly to the pipe reactor where the phosphoric acid is neutralized by ammonia.

Molar ratio (MR) between phosphoric acid and ammonia fed to the pipe reactor is the important parameter for tuning the pipe reactor.

For the GPR, the MR is usually kept at 0.7-0.8 or 1.2-1.4 so that the fluidity of the slurry is at a maximum. For NPK's containing a high quantity of SO_3 sourced from sulphuric acid, the latter is fed also in the GPR.

Various designs of GPR can cope with almost any proportion of sulphuric acid to be neutralized. The difficulty is the corrosion issue due to the heat and a special set of materials is used to prevent this.

Some ammonia is also fed into the granulator throughout an ammonia sparger. This helps to adjust the composition of the fertilizer and to assist the granulation process.

The ammonia sparger is injecting the ammonia inside the rolling bed of granules. It is equipped with a brace-shaped moving arm, enabling it to be lifted outside of the bed if necessary, such as in case of plant stoppage. Moreover, this particular design, together with the movement provision, make it possible to create free space inside the granulator. This allows the GPR to spray into the rolling bed without creating a build-up inside the granulator.

The granulated product exits the granulator through a chute to enter the dryer. The chute is a critical operational part of the plant because it can easily get choked. The chute is particularly designed to limit this risk by using a special material of construction for the part in contact with the product. This material limits the adherence of the granules and remains flexible so that the automatic hammering system which is in place gets its full efficiency.

The NPK process can be operated on any site

The granules are then fed to the dryer which is a rotary drum with a co-currant flow of hot air. The drum is fitted with optimized lifters to ensure a maximum contact between the granules and the hot air while the residence time is endured by a ring at the outlet whenever required.

A lump screen at the outlet of the dryer separates large agglomerates and directs these to the lump breaker. This device protects the elevator located at the outlet of the dryer from the risk of blockage and damage.

After being lifted up to the top of the plant, the granules are fed to the screening devices.

Two deck screens move in a circular motion being fitted with an unbalanced shaft. These separate the granule in three parts:

- Undersized granules flow down directly to the recycling belt conveyor
- Oversized granules flow down to the crushers, where their size is reduced before they join the undersized granules on the recycling belt conveyor
- The desired on-size granules are then fed to the cooling system

Granules on the recycling belt conveyor is recycled to the granulator where their size is increased again by the feeding material. The cooling system can be different (e.g. fluid bed cooler, rotary drum cooler or bulk flow cooler) depending on client preference as well as site and ambient conditions.

Selection is made on a case-by-case basis. Weighing up the pros and cons of each system.

Once the product is cooled down, it is usually coated before going to storage or packaging unit. A lot of air is used in the NPK production and this air can be contaminated with chemicals (particularly ammonia, acids and fluorine) and dust and therefore needs to be treated before it is released back to the atmosphere.

The treatment of this air consists, when the air is dry enough, of cyclones to remove the dust that, remaining as solid, can be directly recycled to the granulator as solid material.

All the contaminants that can not be collected as a solid, are collected in the subsequent wet part of the scrubbing system consisting of a series of venturi and cyclonic columns.

Thanks to the particularly optimized management of the gas treatment, all the scrubbing liquors generated are recycled within the process. As a result, this process is a zero liquid effluent under normal conditions.

Dual pipe reactor process

Casale acquired the DPR process as part of its technology acquisition from Borealis.

This technology optimises the granulation process by installing a second pipe reactor, the DPR, into the dryer, in addition to the GPR.

The DPR works in almost the opposite way to the GPR, as it is designed to produce a solid rather than a slurry. The DPR is located in the dryer and in order to avoid clogging the MR needs to be chosen so that the DPR is producing only solid MAP. No sulphuric acid is used in the DPR, other than that, all of the other components of the NPK plant remain the same.

Granulation plant

The DPR process allows real optimization. To increase the capacity of the plant, increased volumes of raw materials have to be used and a large part of these will be liquid or contribute to bringing more liquid into the granulator. Therefore, to keep control of the granulation, more solids have to be recycled into the granulator which means the full loop capacity has to be increased (granulator, dryer, elevators, screens and crushers).

Within the DPR process a large part of the phosphoric acid and ammonia is fed directly to the DPR where they react to form MAP which is then recycled into the granulator. Essentially, the DPR raises output without the need for extra loop capacity by suppling the granulation loop with extra MAP and allowing some N and P feed to be introduced directly as a solid.

In addition, because the neutralisation of phosphoric by ammonia is exothermic and takes place into the dryer, the heat produced by the DPR contributes effectively to the drying of material. This contribution is so great that, in some plants, the dryer is operated entirely by this heat.

The shutdown time needed to implement the revamp is very short

Operating experience

The DPR process was not only licensed but also operated by Grande Paroisse for more than 30 years.

Thanks to the high flexibility of the process, the use of the Casale process at one particular 2000 MTPD plant has successfully produced more than 200 different grades in A single year.

In total more than 80 Casale licensed pipe reactors have been designed and operated worldwide. These have been installed in revamped as well as grassroot plant.

Revamps typically involve:

- Replacement of pre-neutralizer by GPR or DPR process
- Addition of a DPR to a plant already equipped with a GPR
- A DPR addition to a plant running with a pre-neutralizer

The shutdown time needed to implement the above revamp solutions is very short compared with the alternative option – the modification of the granulation loop. ■