# STEPPING UP PRILLING AND GRANULATION

**RINAT ANDERZHANOV AND NIKOLAY SHESTAKOV, NIIK, RUSSIA,** OUTLINE RECENT DEVELOPMENTS THE COMPANY HAS UNDERTAKEN IN FERTILIZER PRILLING AND GRANULATION.

The demand for new fortified and tailored fertilizers, continues to grow. Production of such fertilizers helps producers add value and broaden the range of high-quality fertilizers, in turn making them more competitive and opening up new sales markets.

NIIK, a leading engineering and technological company with over 60 years of experience in construction and rebuilding of urea plants, produces prilling and granulation technology that enable production of different types of mineral compound fertilizers.

## Prilling

Most urea plants across the world operate a prilling tower. Prilling is the most effective way to produce uniform spherical particles from solutions or slurries. It essentially consists of two operations: first, producing liquid drops and second solidifying them via cooling as they fall through a rising air stream.

Old generation prilling towers were constructed as concrete structures typically over 40 m high and equipped with a solution dispersion unit, a scraping unit for product unloading and fans for supplying and removing cooling air. These conventional-type towers do not always meet all of the requirements of up-to-date regulations and market demand. The main disadvantages of these prilling towers are low yield of finished product, uneven prillometric

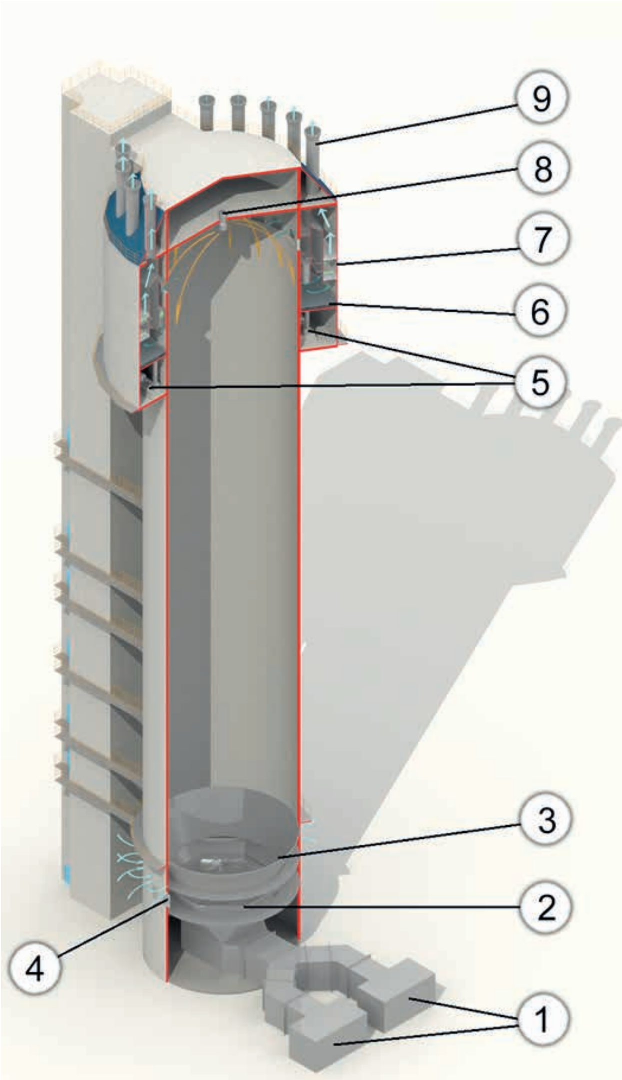


**Figure 1.** NIIK prilling tower: 1 – fans; 2 – in-built fluid bed cooler; 3 – guide cone; 4 – atmospheric air intake holes; 5 – melt filter and circulation pump; 6 – dust collector; 7 – treatment unit; 8 – vibropriller; 9 – vent pipe.

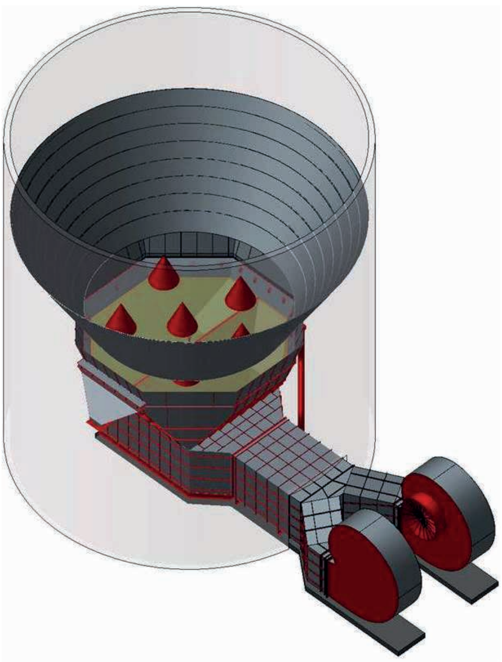

**Figure 2.** Fluid bed cooler.

composition, rather small sized prills, as well as environmental problems due to high ammonia and urea dust emissions. All of these factors point towards improving conventional prilling towers.

NIIK has developed its prilling towers to focus on finished product quality enhancement and emission abatement. These prilling towers are made of reinforced concrete and metal structures with an internal diameter from 12 to 18 m (depending on their capacity), a ~80 m prills fall height, and total height of the tower at ~100 m. The tower is equipped with an in-built fluid bed cooler installed at the bottom along with air supply ducts and fans taking in air from the atmosphere.

The vibropriller located at the top of the tower is equipped with a vibrating device enabling it to produce uniform prills with a size of 2.5 – 3 mm.

Holes in the tower allow exhaust air to be directed through an advanced injection-type dust collection system. The treated air is discharged into the atmosphere via the vent pipes.

Increasing a prilling tower's height, thus the urea prills' fall height, can also have a positive effect on cooling air circulation within the tower, and in turn affecting the quality of the final product.

Advantages of this prilling tower design include:

- Wide capacity range.
- Simple design and operating reliability: the prilling tower can be shut down for turnaround once a year.
- Enhanced product quality: resistance to mechanical stress during delivery and storage, anti-caking properties, product monodispersity, optimal size and roundness of prills.
- Environmentally friendly: low emissions and no acids.
- Production of uniform prills, with a 2.5 – 3 mm prill size distribution, a main fraction content of 95 %, prills strength of ~1 kgf/prill min. and no off-spec recycle.

The following details the different units that make up the prilling tower.

## The priller

A priller is one of the main sections in the prilling tower: both an equal distribution of urea droplets inside the tower and the size distribution of prills depends on the priller's design and operation. The enhanced prills are produced by a vibropriller, which has a magnetic vibrator with an automatically-controlled vibration frequency.

The operation of a vibropriller involves jets sprayed from the priller's holes that fall into equal droplets due to regular vibrations. The use of a magnetostrictive vibrator with automated control ensures stable operation of this section in a frequency range from 200 to 1200 Hz. The frequency can be adjusted by a microprocessor controller, depending on the load.

The design of a vibropriller bucket depends on the diameter and height of a prilling tower. The bucket's size, as well as the direction of holes in it, are chosen to assure uniform distribution of urea melt droplets across the tower in order to improve the cooling of the product during its free fall.

The formed droplets are cooled and solidified as they fall downwards. They are then collected at the bottom of the tower and discharged. The size and monodispersity of particles can be modified by adjusting the vibration frequency and using buckets with a different hole size.

## Integrated fluid bed cooler

To avoid prills caking and degradation of the product quality during storage and delivery, the product must be cooled to the required temperature. The fluid bed cooler in the prilling tower is therefore used to reduce the temperature. Its operation is based on intensive mixing of prills in the fluid bed. The air flow becomes turbulent and the effective mass transfer between the prills and the cooling air is developed. The heat is removed from the prills and consequently the finished product achieves the required temperature.

The hydrodynamics of upward flowing air ensures careful descending of granules to the fluidised bed preventing them from cracking and any deformation.

## Injection-type scrubbers

NIIK's revamping method takes into consideration the environmental safety of equipment. Therefore special attention is given to air scrubbing. Such systems should be compact, provide a high degree of treatment and consume little energy and utilities. The company's scrubbers meet all of these requirements.

Its scrubbers are designed to achieve effective heat and mass transfer from gas to liquid, which allows them to partially recycle ammonia along with urea dust, avoiding the use of ID fans and reducing power consumption.

Injection-type wet scrubbers have two scrubbing zones. The first zone comprises injection devices with spraying nozzles. The second zone is sprayed with wastewater and has mist eliminators. After the second scrubbing zone, the clean air is emitted through the vent pipe to the atmosphere.

The following are advantages of the company's scrubbing systems:

- Efficient scrubbing of urea dust: 98 – 99 %.
- Partial scrubbing of ammonia – no acid reagents required.
- Safe and easy operation and maintenance.
- Simple design: access to all elements of the scrubbing system.
- Resource saving: recovery of urea and ammonia for reprocessing.

## Prilling towers in use

NIIK is a market leader in the construction of modern prilling towers for urea production units. In 2012, one of the company's new prilling towers with a capacity of 1500 tpd was commissioned at Phosagro Cherepovets (Russia). The company is currently working on the construction of three prilling towers with different capacities. It's experience of prilling tower construction can also be effectively used when undertaking construction and modernisation projects for ammonium nitrate production units.

**Table 1.** Prilling tower performance, consumption index

| Parameter | Value |
|---|---|
| Steam consumption | 0 t/t |
| Cooling agent consumption | 0 t/t |
| Formaldehyde-containing agent consumption | kg/t |
| Energy consumption | Maximum 25 kW/t |
| Recycle/off-spec | 0% |
| Ammonium emissions | 60 mg/nm$^3$ |
| Urea emissions | 30 mg/nm$^3$ |

**Table 2.** Quality of commercial urea

| Parameter | Value |
|---|---|
| Main fraction | 2.5 – 3 mm |
| Main fraction content | 95% |
| Static strength of prills | Minimum 1.0 kgf/prill |
| Water content | 0.3 – 0.4% |
| Biuret content | 0.8 – 1% |
| Product temperature | 50˚C |
| Prills' shape | Spherical |

**Figure 3.** Prilling tower designed by NIIK (Cherepovets, Russia).

## Granulation

R&D Institute of Urea (NIIK) provides flexible granulation technology for high-speed drum granulators, enabling production of urea and compound fertilizers.

The technology is patented and can be used to granulate straight fertilizers (urea, ammonia nitrate), produce fortified and compound fertilizers with various nutrients and improve the quality of the main product, while simultaneously increasing overall capacity of the unit.

One method of upgrading a urea unit is to undertake a low-investment, small-scale revamp, which can enhance capacity by 15 – 20%. Very often capacity increases over 20% to the urea finishing section are limited by the existing equipment and economical inefficiency, since it requires high capital costs and long shut-downs of the entire unit. In this regard, space-saving drum granulators could prove to be very useful if a customer wants to

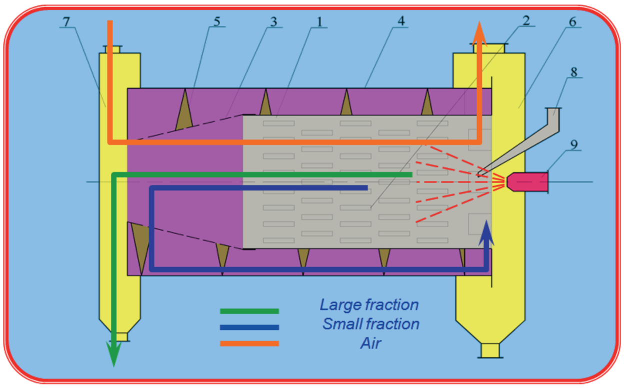


**Figure 4.** High-speed drum granulation unit. 1 – main drum; 2 – transporting blades; 3 – classifier; 4 – outer drum; 5 – reverse screw; 6 – loading chamber; 7 – unloading chamber; 8 – discharging tube; 9 – spraying nozzle.

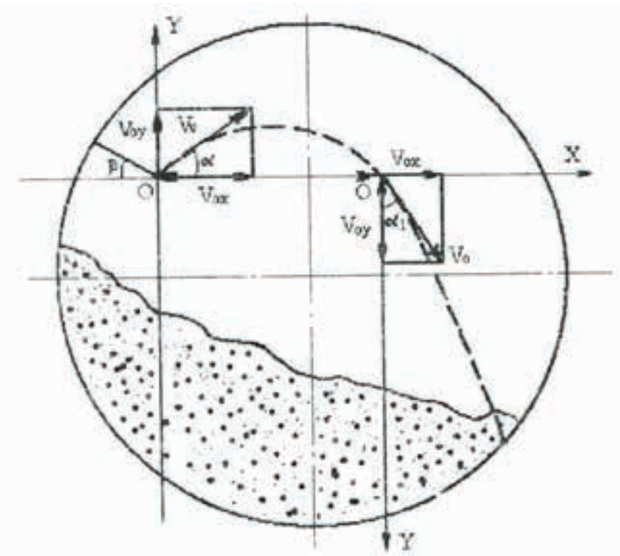


**Figure 5.** Creation of a curtain in the HSDG.

increase the capacity of the prilling/granulation section. They improve urea quality and do not require large amounts of air. They can be easily installed on the existing site, have a space-saving design and incorporate prills/granules enlargement. The main advantage of drum granulators is the production of large and uniform urea prills that have granulated product and anti-caking properties.

NIIK has designed a high-speed drum granulator (HSDG) with all the previously mentioned advantages. The distinctive feature of this HSDG as compared to the other drum granulators is a small external recycle (which recycles off-spec material that does not pass through the screening back to the process) and low air consumption, consequently making it smaller and reducing the production cost.

The externally recycled material does not exceed 5 – 10% of the total amount of granulated product. In comparison, this percentage is 50% when using fluidised bed granulation, and 30% when using drum drying technology.

The HSDG consists of an outer drum, inside of which there is an internal drum with blades and a classifying screen. Between the outer and internal drums there is a reverse screw for recycle of internal product. There are fixed loading and discharging chambers at both ends of the drum and, on the loading chamber's wall, there is a loading tube and an inlet nozzle.

During the drum's operation, the granules are introduced into the main drum. While the drum rotates, the product inside the drum creates a curtain in its cross section and a fertilizer, or compound solution, is sprayed over the curtain by the spraying nozzle. The blades on the inner surface of the drum serve several purposes: they lift the granules and maintain the uniformity of the curtain, and they move the product through the granulator.

As a result, the product in the drum undergoes multilayer fattening: the same granule is sprayed over many times until it reaches the designed characteristics.

After the spraying chamber, the product moves to a classifying screen inside the drum. Fine particles fall through the screen and are returned to the beginning of the drum by a reverse screw. The desired size product passes through the screening and is discharged to storage or for handling.

The fine fraction returned into the main drum undergoes the same process. It is transported by the blades inside the drum as part of the curtain and sprayed over the solution repeatedly until it has achieved the required size and can pass through the screen inside the drum. The product undergoes this cycle many times. To remove heat from the process and cool the product, atmospheric air is introduced into the drum and the outer surface is cooled with water. To remove surplus water from the solution, the air introduced into the drum can be heated and heated air can also be directed to the nozzle.

## Enhancing urea quality

The following outlines the HSDG technology used for the prilling section capacity enhancement and urea quality improvement for Kemerovo Azot (Russia).

The HSDG was part of a revamping operation at Kemerovo Azot, which aimed to increase capacity by up to 1700 tpd, as well as improve the urea quality.

The product output from the existing prilling tower was less than 1700 tpd and the load was reduced down to 1500 – 1600 tpd.

Installation of the HSDG unit enabled the prilling tower to hit its design capacity of 1500 tpd and stabilised the operation, reducing the number of defective prills and increasing the number of 2 – 4 mm prills. The quantity of undersize prills smaller than 1 mm is reduced, the number of 2 – 4 mm prills is increased due to fattening of the small prills under 2 mm, consequently the strength of prills improved.

After the evaporation section, the urea melt divides into two streams. The first stream goes to the prilling bucket in a prilling tower (1500 tpd of the finished product), the second one is pumped to the HSDG unit (100 tpd per each drum granulator of the finished product). After the prilling tower, the prilled urea is conveyed to the classifier in which it is divided according to prills sizes:

under 2 mm are considered small prills, 2 – 4 mm are commodity prills, and over 4 mm are big prills. Big prills are delivered for dilution, commodity prills go to the fluid bed cooler and small prills are supplied to the HSDG unit's feed chamber. The small prills are supplied from the feed chamber to the drum granulator, while the finished product is discharged from it. Simultaneously, exhaust air from the HSDG containing ammonia and urea dust is fed for treatment to the existing wet-type scrubber. The urea solution from the dilution section and from the scrubber is then delivered to the vacuum evaporation section.

If the HSDG is stopped for any reason, the prilled urea from the prilling tower is delivered to the classifier, which separates the product according to its size: prills under 1 mm are small prills, 1 – 4 mm prills are commodity prills, and prills over 4 mm are big prills. The commodity prills are supplied to the fluid bed cooler and further conveyed for storage or handling. The undersized (less than 1 mm) and oversized (over 4 mm) prills are moved on to dilution.

The implementation of NIIK's technical solutions for a urea unit revamp, which included the installation of the HSDG unit, enabled the unit to enhance capacity and significantly increase finished product quality.

One of the advantages of the HSDG technology is its flexibility – a wide range of fortified fertilizers can be produced on the same unit depending on the market demand.

## Conclusion

Fortified value-added fertilizers are forecast to be applied more widely in the future because of their advantages compared to conventional fertilizers. The other motivation for its increased application is the possibility of using byproducts of the chemical industry, in particular ammonium sulfate, which results from caprolactam production and sulfur when producing hydrocarbons.

More companies are now seeking granulation methods for carbosulphate and sulphonitrate (urea with ammonium sulfate and ammonium nitrate with ammonium sulfate). HSDG technology can be used for this production.

NIIK is currently involved in supplying a HSDG for a pilot plant project that intends to produce granulated urea with additives at Qatar Fertilizer Co. (QAFCO). The pilot HSDG with a capacity of 2.4 tpd is designed to produce urea with ammonium sulfate with different percentages of ammonium sulfate in the finished product and urea with sulfur.

A similar unit with a 2.4 tpd capacity has been installed at Petrovietnam Fertilizer & Chemicals Corp. to produce a wide range of urea-based complex fertilizers with ammonium sulfate, potassium chloride, boric acid and other additives.

Other projects for the development of commercial-scale HSDG plants are also being considered.

Selecting a suitable technique at the finishing stage – prilling in a prilling tower, granulation in drum granulators, fluidised bed process, etc. – depends on the requirements of the finished product, as well as on the manufacturing technology used at a site. Each option has advantages and disadvantages that, depending on the situation, will carry more weight than others. **WF**

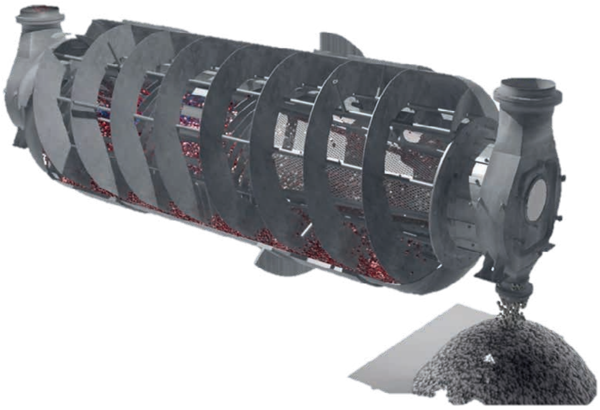

**Figure 6.** High-speed drum granulation unit.

**Table 3. Commercial product quality**

| Parameter | Value |
|---|---|
| Main fraction | 2.5 – 4 mm |
| Main fraction content | 95% |
| Static strength of granule | 1.5 – 2,5 kgf/prill |
| Water content | 0.3 – 0.4% |
| Biuret content | 0.8 – 1% |
| Finised product temperature | 50°C |
| Granule shape | Spherical |

**Figure 6.** 3D model of the pilot HSDG unit in Vietnam.

**Figure 7.** HSDG unit at PetroVietnam Fertilizers & Chemicals Corp. in Vietnam.