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GRANULATION TECHNOLOGY WITH FLEXIBILITY TO PRODUCE A RANGE OF SPECIALIST PRODUCTS

by

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SUMMARY.

The report considers the main principles of granulation technology in High Speed Drum Granulation (HSDG) unit, its technical and economic performances and advantages, the range of product produced in HSDG and recent references and associated engineering services provided by NIIK.

HSDG technology enables manufacturers of granular fertilisers to produce material comprised of hard, consistent spherical and dust free granules. It also provides a flexible production facility, able to switch between different types of product. It is suitable for installing into existing granulation plants.

HSDG technology can be used to produce fertilisers with a variety of amendments, in contrast to conventional NPK fertilisers. The value of this technology will grow as sales of these fortified fertilisers are forecast to increase their share of the market over the next few years. As demand for these types of fertiliser is characterised by small volumes of tailored formulations, the flexibility of plants equipped with HSDG technology will be increasingly advantageous.

NIIK has installed two commercial scale HSDG units, and two pilot scale units, so far. Each one of these was commissioned to address a different issue, and has been used in a different way.

The development and installation of NIIK's HSDG units is aided by extensive usage of 3D design software. This generates a number of benefits for NIIK, the customer, and the working relationship between the two. It can even be used to help with operator staff training before the plant has been commissioned and while they are unable to actually go on site.

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Keywords: granulation, fortified fertilisers, customised fertilisers, compound fertilisers, fertilisers with additives, high speed drum granulation, internal recycle, granules.

1. INTRODUCTION.

NIIK is a leading engineering and technological company with over sixty years of experience in the construction and re-building of urea plants. Its experience covers not only the Former Soviet Union countries but also, increasingly, projects in the Middle East and Asia.

NIIK is a licensor of several urea technologies. One of the technologies developed by NIIK is a High-Speed Drum Granulation (HSDG) technology for the production of urea-based fortified fertilisers. This has both Russian and international patents.

As demand for fortified and tailored fertilisers continues to grow, so the need for fertiliser producers to equip themselves to meet this demand grows with it. The key need will be for flexible plants that can cost effectively switch between different formulations of high quality fertiliser, whilst still operating efficiently and minimising wastage.

HSDG technology enables fertiliser producers to meet these challenges, as is being demonstrated by the facilities that have been installed so far. The design, installation and training processes are facilitated by extensive use of 3D design software.

2. FEATURES AND ADVANTAGES OF HIGH SPEED DRUM GRANULATION.

The main specific feature of the HSDG design is that the material is re-cycled internally, an action performed by a built-in classifier and a screw conveyor.

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 internal product recycling. At both ends of the drum there are loading and unloading chambers. The drum is equipped with a loading pipe to supply seeds and a nozzle to spray the product over them.

During the drum's operation the prills or crystals used as seeds are introduced into the main drum. While the drum is rotating, the product creates a 'curtain' within the drum's interior and fertiliser or compound solution is sprayed over the 'curtain' through the spraying nozzle.

The blades on the inner surface of the drum have several functions: they lift the prills or crystals, make the 'curtain' uniform and move the product through the granulator.

As a result, the product in the drum undergoes multilayer fattening – a seed is sprayed upon many times until it achieves the desired properties.

From 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 surplus water from the solution is evaporated during crystallisation and removed with the air exiting from the drum. Product at the desired size passes over the screen and is fed to the cooling phase.

Fine particles that have been returned into the main drum undergo the same process – they are transported by the blades inside the drum as a part of the 'curtain' and are repeatedly sprayed with the solution until they have attained the required size and thus can pass over the screen inside the drum. Material undergoes this cycle many times.

The production process in the HSDG has the following advantages:

- Only a small volume of air is required.

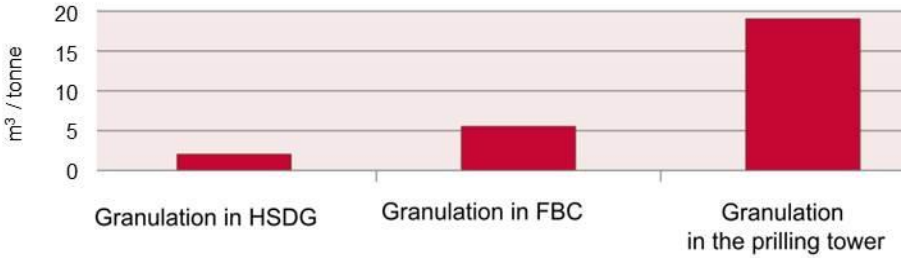

Figure 1: *Volumes of air required for different technologies.*

- It is easy to install on to an existing site: the unit has a relatively small size and weight. This is due to the process intensification and a low level of external product recycling. It can be used as a 'side stream' to an existing plant, improving the flexibility of the overall plant.
- The internal product classification and recycling of the material results in excellent product uniformity.
- The external recycle material does not exceed 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.
- There is a dense product curtain inside the main drum. This reduces the tendency of the material to stick to the drum walls and blades. The product sprayed through the nozzle does not make contact with the inner surface of the unit, and all of the solution is sprayed onto the curtain of particles. A dense and uniform curtain is obtained as the product leaves the blades in a parabolic curve, see Figure 2. This movement is achieved due to the nozzle design and the rotation speed of the HSDG.
- HSDG technology is a particularly flexible technology, because of its ability to produce a wide range of products.

The fertilisers produced by the HSDG are comprised of strong granules with a spherical shape, see Table 1. The finished product does not contain dust.

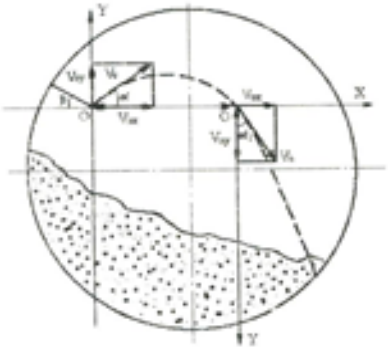

Figure 2: *The parabolic curve followed by material that has been separated from the blades (left), and a detail of the nozzle design (right).*

Table 1: *A comparison of measures of granule quality achieved by alternative technologies.*

Parameter	Granulated in FBC	Prilled	Granulated in HSDG
N content, %	46.1 – 46.2	46.2 – 46.3	46.2 – 46.3
Biuret content, %	1.0 max	1.0 max	1.0 max
Water content, %	0.2 – 0.5	0.3 – 0.5	0.2 – 0.5
Fraction <2 mm, %	None	None	None
Main fraction, mm	2 – 4	2 – 3	2 – 4
Main fraction content, %	95.0 min	90.0 min	95.0 min
Granule strength, kgf/granule	3.0 – 3.5	0.8 – 1.1	3.0 ± 0.5
Finished product temperature, °C	45 ± 5	45 ± 5	45 ± 5

The flexibility of the HSDG technology is one of its main advantages. It can be used to produce a wide range of products on the same HSDG unit, enabling producers to respond to changes in market demand. For instance, the same plant can switch between urea with sulphur, urea with ammonium sulphate, and urea-based fertilisers fortified with other nutrients specified by customers' requests.

Thus HSDG technology has various applications. It can be used to produce:

- Straight fertilisers (urea, ammonia nitrate).
- Urea-based fortified fertilisers (urea + zinc, + copper, + iron, + boron).
- Customised fertilisers (compound fertilisers with various nutrients):
  - NS-fertilisers (urea with sulfur, urea with ammonium sulphate, ammonium nitrate with ammonium sulphate).

  - NP-fertilisers (ammonium superphosphate).
  - NPK-fertilisers (urea+potassium chloride +ammonium phosphate).
- Two-layered fertilisers, such as ammonium phosphate coated with sulphur, and phosphogypsum coated with urea.
- HSDG granulation technology can also be used for the production of potash based products.
- The ability of HSDG to be used for the production of a wide range of fertilisers is due to the simultaneous spraying and fattening at the same time as supplying different elements for granulation.

3. DEMAND FORECASTS FOR FORTIFIED FERTILISERS.

An important consideration in relation to the flexibility of HSDG is the forecast growth in demand for various types of fortified fertilisers, as alternatives to conventional ones. This growth will dramatically affect patterns of global fertiliser trade.

An example is the forecast development of one of the most popular fortified fertilisers on the global market, sulphur coated urea (SCU), over the period from 2016 till 2026.

According to Future Market Insights forecasters the current consumption of SCU is about two million tonnes per annum (tpa). It is expected to approach three million tpa by 2026, growing at 3.5% compound annual growth rate (CAGR) over the period 2015 - 2026.

As a high efficiency fertiliser, SCU is used in a variety of applications. The largest usage is in agriculture – about 35% of the total consumption of the fertiliser. Due to its extended and controlled release properties SCU is also applied on turf grass and golf courses, which accounts for 25% of its total consumption. About 20% of SCU is used for landscape design, gardening and greenhouses.

The Asia-Pacific region (except Japan) and North America are the largest users of SCU. The market in the Asia-Pacific region is anticipated to grow at between 4-6% per annum during 2016–2026, and is expected to exhibit the highest CAGR of 5.1% over the forecast period.

Overall market growth in the North America region is projected to range from 2.6% to 3% in the initial years, but is expected to stabilise briefly and then decline towards the end of the forecast period. Declining growth implies the growing use of alternative products to sulphur coated urea. The growing use of substitute products, along with the development of lower cost controlled release fertilisers, is expected to reduce the use of sulphur coated urea in the already saturated North American market. This segment is anticipated to exhibit a CAGR of 2.3% over the forecast period.

The Latin America, Middle East and African and Eastern Europe regions are projected to expand at CAGR's of 3.9%, 4.7% and 4.0% respectively over the forecast period. The lowest growth rate is forecast for Japan. This country is anticipated to exhibit a CAGR of 1% over the forecast period. Western Europe is characterised by a minimal consumption of SCU, compared to other regions. It is anticipated to exhibit a CAGR of 1.8% over the forecast period.

In general, an increase in the production and consumption of grains (requiring the use of high efficiency fertilisers at a stable price) together with such factors as rising urbanisation, emerging markets and rising concerns about eutrophication across the globe, and increasing GDP (Gross Domestic Product) in developing economies such as Asia Pacific are projected to drive growth of sulphur coated urea over the forecast period.

One of the main drawbacks of SCU is the weakness of the coating. In contrast, sulphur coated granules produced by HSDG are characterised by the high durability of their coating, which does not wear or break up during storage or transportation.

4. THE ADVANTAGES PROVIDED BY FORTIFIED FERTILISERS.

Fortified fertilisers are forecast to be applied more widely in the future because of their advantages relative to conventional fertilisers. These advantages are as follows:

- Higher concentration of nutrients and lower content of inefficient (thus not available for plant growth) substances in the fertiliser, which results in a balanced application and consequent increase in yield and reduced environmental impact.
- The ability to produce a wide range of fertiliser types meeting various demands, depending on soil content and crops.
- Fortified fertilisers have better properties than do conventional ones: their mechanical resistance and anticaking abilities are determined by the method of their production (as compared to products made in a prilling tower).
- Slow-release fertilisers are resistant to leaching, and consequently do not pollute water.

In addition to the above advantages for end-users of fortified fertilisers, there are also advantages for fertiliser producers:

- Increasing market demand.
- Added value of the fortified fertilisers as compared to the conventional ones.
- The ability to broaden their range of fertilisers, increasing their ability to compete and providing new sales opportunities.

5. EXPERIENCE OF THE IMPACT OF INSTALLED HSDG PLANTS.

So far NIIK has implemented four HSDG units:

- Two commercial-scale HSDG units. The total capacity of each unit is 500 tpd for fattening of urea in Kemerovo (Russia) and ammonium nitrate in Actau (Kazakhstan).
- Two pilot HSDG units. The capacity of each unit is 100 kg/h (2.4 tpd) for the production of fortified fertilisers in Vietnam (Petrovietnam) and Qatar (QAFCO).

The commercial-scale HSDG unit in Kemerovo (Russia) is designed for the fattening of prills, in order to improve the quality of the finished product. Small prills (under 2 mm) coming out of the prilling tower are fed into the HSDGs for fattening.

Table 2: *Improved quality of urea granules at KemerovoAzot, Russia.*

Product	< 1 mm, %	1-4 mm, %	2-4 mm,%	Static strength, kgf/granule
Prilling tower	3.0	97.0	77.4	0.56
Fattened in HSDG	None	99.7	99.3	1.5 – 2.0

The commercial-scale HSDG unit at Actau, Kazakhstan was installed for the production of granulated ammonium nitrate. The ammonium nitrate produced in NIIK's HSDG unit has a high quality, as measured by granule uniformity, high density, and anti-caking properties.

Table 3: *Improved quality of ammonium nitrate granules at KazAzot, Kazakhstan.*

Parameters used for comparison	Ammonium nitrate granulated by other technology	Ammonium nitrate granulated in HSDG
2-4 mm fraction content	80% min	95% min
Static strength, kgf/granule	0.8 kgf/granule min	2.5 kgf/granule min

The other quality values for ammonium nitrate granulated in the HSDG plant meet the requirement of GOST 2-2013.

NIIK has also implemented a pilot HSDG plant at Petrovietnam Fertiliser & Chemicals Corporation,Vietnam. Before the contract for the pilot HSDG, NIIK undertook research work for the production of the samples required by Petrovietnam at NIIK's laboratory scale HSDG unit. (NIIK has its own laboratory scale HSDG unit where NIIK's specialists produce new fertiliser samples and carry out various tests. Its capacity is 100 kg/h and it is located on one of NIIK's sites.)

The pilot HSDG unit in Vietnam is designed to produce four formulations of fortified urea-based fertilisers:

1. N-Si-Mg-B

2. N-K-Si-B
3. N-S-Si-Mg-B
4. N-S-B

A rack-supported unit, with an area of approximately 110 m^2, is located at the 0.0 m/3.5 m/7.0 m levels.

Installation and commissioning of the unit was performed, followed by the signing of a test certificate. The quality of the product is excellent and meets all stated requirements. At present PFCCO specialists are progressing with the development of new products with specified component ratios, as well as other fertiliser types. The results provided by the soil test reports for four formulations granulated in HSDG show their strong positive influence on crop production. A project for the development of a commercial-scale HSDG plant is being considered.

We are currently undertaking the commissioning and start up of a pilot plant to produce granulated urea with additives at QAFCO (Qatar Fertilizer Company). The pilot HSDG at the QAFCO site is designed to produce the following fertilisers:

1. Urea with ammonium sulphate with different percentages of ammonium sulphate in the finished product.
2. Urea with sulphur (inclusive of SCU – slow-release fertiliser).

NIIK, supported by our customers, is confident that the operating experience of pilot HSDGs with a capacity 100 kg/h is a step to commercial-scale HSDGs for the production of various types of fortified fertilisers.

NIIK's scope of works includes the following:

- A license for the technology.
- Design works (3D model of the HSDG unit).
- Equipment procurement.
- Contract and field supervision and commissioning.
- A guaranteed performance test.

6. ADVANTAGES OF USING 3D DESIGN SOFTWARE.

NIIK used 3D design software to help develop the design of the projects described above. The use of such software generates a number of advantages for our customers:

- The customer receives a detailed, high quality 3D design of the future HSDG unit, which ensures that there are no mismatches or inconsistencies between the technology, equipment items, utilities, etc. See Figure 3. The 3D model shows the developmental phase acceptances, so that these can be agreed between NIIK and the customer. It helps to see the total concept and the layout of the 3D model of the future HSDG unit. So the design solutions can be revised and modified at early phases of the project, at the customer's request. In addition, this helps both NIIK and a customer come to a common understanding of the future project.

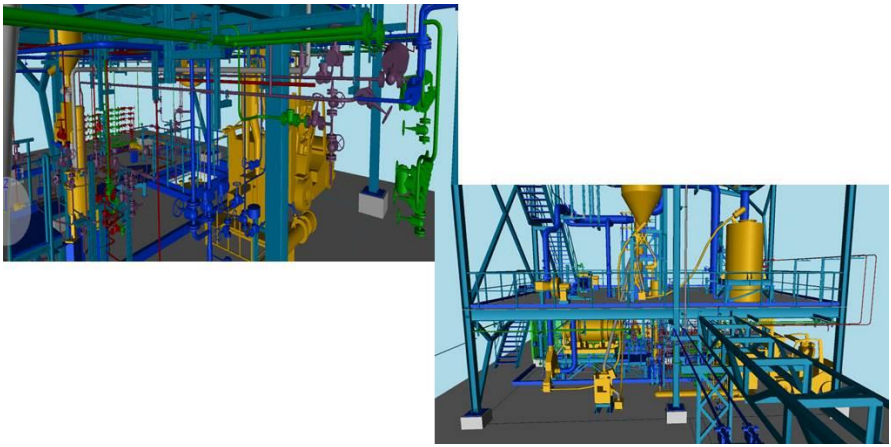

Figure 3: *Illustrations of the designs produced by the 3D design software.*

- Project managers can access any views, sections or layers of the design, even when off site.
- Managers can specify the location of any hidden utilities (for example – underground ones).
- Managers can find the size of any item of equipment from the 3D model, rather than by having to calculate this based on several drawings.
- The model can be used for staff training at both the design and installation phases. During the installation phase, when it is not safe for the plant operators to be present on the site, the 3D model can be used for operators' studying and training.

7. CONCLUSIONS.

HSDG technology enables producers of granular fertilisers to produce material comprised of hard, consistent spherical and dust free granules. It also results in a flexible production facility, able to switch between different types of product. It is suitable for installing into existing granulation plants.

HSDG technology can be used to produce fertilisers that have been fortified in various ways, as opposed to conventional NPK fertilisers. The value of this technology will grow as sales of these fortified fertilisers are forecast to increase their share of the

market over the next few years. As demand for these types of fertiliser is characterised by small volumes of tailored formulations, the flexibility of plants equipped with HSDG technology will be increasingly advantageous.

This growth in demand for fortified fertilisers will be driven by a combination of benefits for end users and the environment. In turn, increasing demand for fortified fertilisers will generate benefits for fertiliser producers.

NIIK has installed two commercial scale HSDG units, and two pilot scale units, so far. Each one of these was commissioned to address a different issue, and has been used in a different way.

The development and installation of NIIK's HSDG units is aided by extensive usage of 3D design software. This generates a number of benefits for NIIK, the customer, and the working relationship between the two. It can even be used to help with operator staff training before the plant has been commissioned and while they are unable to actually go on site.

Every HSDG designed by NIIK is a bespoke development, tailor-made for the customer and meeting all their requirements.