TECHNICAL GRADE UREA GRANULATION

STAMICARBON

NEXTCHEM
MAIRE Sustainable Technology Solutions

Conference name	Stamicarbon Symposium
Conference date	May 18-21, 2026
Author(s)	Mohamed Mostafa and Bruno Teixeira
Classification	PUBLIC

SUMMARY

ABSTRACT

This paper presents the latest innovation in urea granulation technology, jointly developed by Stamicarbon and Helwan Fertilizers Company (HFC). The focus is on producing technical grade urea (TGU) granules using Stamicarbon's fluidized bed granulation process without the use of formaldehyde, resulting in a safer, more sustainable product. The new technology requires minimal capital investment for existing Stamicarbon granulation plants, reduces operational expenses, and delivers premium quality TGU granules with enhanced market value. HFC, operating in Egypt's Helwan Industrial Zone, successfully transitioned from batch to continuous TGU production, achieving industrial-scale output of 70,000 tons in 2025 and earning recognition for applied research excellence. The partnership demonstrates how technological advancements and process optimization can meet evolving market demands for high-purity fertilizers while supporting environmental and economic goals.

1 INTRODUCTION

1.1 Technical Grade Urea granulation

Stamicarbon, the nitrogen technology licensor of NEXTCHEM (MAIRE Group), and Helwan Fertilizers Company (HFC) are honored to present the latest innovation in urea granulation technology which allows to produce technical grade urea (TGU) granules with Stamicarbon granulation technology without the use of formaldehyde. This technology does not require major CAPEX investments in existing Stamicarbon granulation plants, reduces OPEX spent on formaldehyde consumption, avoids the application of a harmful chemical, and delivers premium granules with higher revenue (around EUR 100 per ton).

This technology was co-developed during a fruitful partnership between HFC and Stamicarbon and is now available to any Stamicarbon granulation client upon consultation. This technology is available for both grassroot and revamp projects.

1.2 Helwan Fertilizers Company

HFC is an Egyptian shareholding company established in 2004, operating within the Helwan Industrial Zone. It specializes in the production of granulated urea fertilizers and ammonia, serving both agricultural and industrial sectors with high-purity products. HFC operates a Stamicarbon fluidized bed granulation plant, constructed by the EPC contractor Thyssenkrupp, with a nameplate capacity of 1925 MTPD. The company is committed to sustainable development, environmental safety, and technological innovation, recently achieving continuous production of technical grade urea through a proprietary process. Despite economic market challenges, HFC posted a net profit of USD 80.5M in 2024 and continues to support Egyptian agriculture by supplying subsidized fertilizers while expanding into international markets.

HFC initiated the move to meet a market demand for TGU granules by utilizing Stamicarbon granulation technology. HFC began batch production of TGU granules in 2023. Subsequently, a cooperation agreement was signed in 2024 for proprietary process optimization. This enabled the transition to continuous production and the enhancement of product characteristics. In 2025, TGU production by HFC reached 70.000 tons.

HFC was awarded the Applied Research Award 2025 by the Arab Fertilizer Association due to the development and application of the technology described in this paper.

Figure 1: TGU grade granules exported by truck at HFC.

1.3 Stamicarbon urea granulation

Stamicarbon has over 20 years of experience in licensing urea granulation plants and has built its reputation in the business with its unparalleled fluidized bed granulation technology. This technology is well-known for its longer granulator running times, lower dust formation and lower formaldehyde consumption, bringing economic and environmental value to its customers. Stamicarbon's granulation market share since 2000 is over 30% and even over 60% if we consider awards in the last five years, based on awarded capacity that has reached FID phase, elevating Stamicarbon to the market leader position in this technology. Lower formaldehyde content in the final product of the standard Stamicarbon granulation technology – less than 0.3wt% – has placed Stamicarbon in a good position to produce urea granules with no formaldehyde at all. That was an enabler to succeed in developing the granulation of TGU. Currently, Stamicarbon has a patent pending on the technology described in this paper.

This technology is only one of the few examples which shows Stamicarbon's commitment to innovation in fertilizer granulation. Some other examples which will be left out of this paper include the following:

- **Urea ammonium sulfate (UAS) granulation**, where sulfur is added to the urea granule up to 32wt% of AS;
- **UAS recycle evaporator technology**, where a waste stream is upgraded into a valuable final product;
- **Automatic cleaning of Stamicarbon granulator**, where no operator intervention is required to wash the granulator during a washing cycle;
- **Revamping UFT granulation into Stamicarbon granulation**, where through the installation of newly developed nozzles, granulation plants can be smoothly revamped into Stamicarbon granulation. This innovation is described in detail in another paper of this Symposium (Reference 1);
- **MicroMist Venturi Scrubber**, where urea dust emissions at the granulation plant stack can be as low as 5 mg/Nm^3.

2 TGU PRODUCTION

The starting point for the following operating description assumes that the plant is running stable during fertilizer grade urea (FGU) mode. This paper describes the switch to the TGU mode without special precautions, such as performing a granulator wash.

2.1 DEF-32 specifications

This paper focuses on the production of TGU for Diesel Exhaust Fluid (DEF) applications. Possible other applications like melamine production or medical applications are excluded.

As per the ISO22241-2 standard, the DEF-32 urea solution must meet, amongst others, the specifications listed in Table 1 below. However, Table 1 does not present an exhaustive list of all requirements of the said ISO standard and must only be used for indication purposes. For full compliance, the said ISO standard must be consulted.

Component	Specification	Unit
Urea	31.8 – 33.2	wt%
Biuret	0.3 max.	wt%
Formaldehyde	5 max.	ppm

Table 1: Non-exhaustive list of DEF-32 specifications as per ISO22241-2.

For TGU granules production, Table 1 above implies that the maximum allowable biuret and formaldehyde concentrations in the final granulated product must be approximately 0.9wt% and 15ppm, respectively. Such requirements are not met by any of the currently available urea fluidized bed granulation technologies.

2.2 Formaldehyde in urea granules: Background

During the development of urea granulation technologies, it was found that due to the properties of urea, formaldehyde should be added as an additive to:

- Increase the crushing strength of the granules,
- Reduce the caking properties of the granules, and
- Reduce dust formation in the granulation process.

The reaction between urea and formaldehyde is relatively straightforward and proceeds through a polymerization mechanism. In this process, a formaldehyde molecule reacts with a urea molecule and can subsequently link to additional urea molecules, forming polymeric chains that may grow to considerable size. This reaction pathway has been extensively studied, particularly in relation to urea–formaldehyde resins used in plywood applications. Formaldehyde primarily reacts with the amine groups of urea, while ammonia, typically present in the urea melt, also reacts readily with formaldehyde. Although the reaction between ammonia and formaldehyde is faster, the resulting complexes are less stable than those formed with urea. Under normal ammonia concentrations in the melt, formaldehyde therefore performs effectively.

The urea–formaldehyde reaction product is amorphous and becomes embedded within the crystalline urea structure. This amorphous phase located between urea crystals enhances granule crushing strength and shock resistance. During spraying in the fluidized bed granulator, melt layers of varying size are introduced into the bed. Most layers adhere to existing particles and contribute to granule growth, while some agglomerate to form new seed material. A fraction of the layers crystallizes in the fluidizing air and exits the granulator as dust, part of which consists of sub-micron particles. These fine particles cannot be completely removed by the scrubbing system and may partially escape via the stack. Formaldehyde plays a key role in binding loose particles to the granule surface, thereby reducing dust formation.

In addition, formaldehyde acts as a crystallization retarder, prolonging the liquid state of the urea melt. This extended wetting period promotes the capture of fine particles on the granule surface, further limiting dust carryover to the scrubbing system. More details on the formaldehyde binding mechanism in urea granules can be found in a Stamicarbon Symposium paper of 2004 (Reference 2).

As a result of its investigations, Stamicarbon designed a urea melt spray nozzle that through its layering mechanism can achieve good properties of the urea granules, only requiring a percentage of 0.3wt%

formaldehyde in the urea granule while achieving average running times of three months, which are unmatched in the market.

During a TGU run, since formaldehyde injection in urea melt must be avoided as the formaldehyde specs are 5 ppm in DEF-32 solution, corresponding to 15ppm in TGU, it is natural to expect a deterioration of the abovementioned characteristics of the final product. This paper describes the measures to handle such decline in product proprieties to still achieve premium quality of TGU.

Through the method described in this paper, the impact on the granulator's operational life is minimal. As demonstrated in Figure 2 below, a 54-day continuous run was successfully achieved, during which three TGU batches, totaling approximately 11,000 tons, were produced.

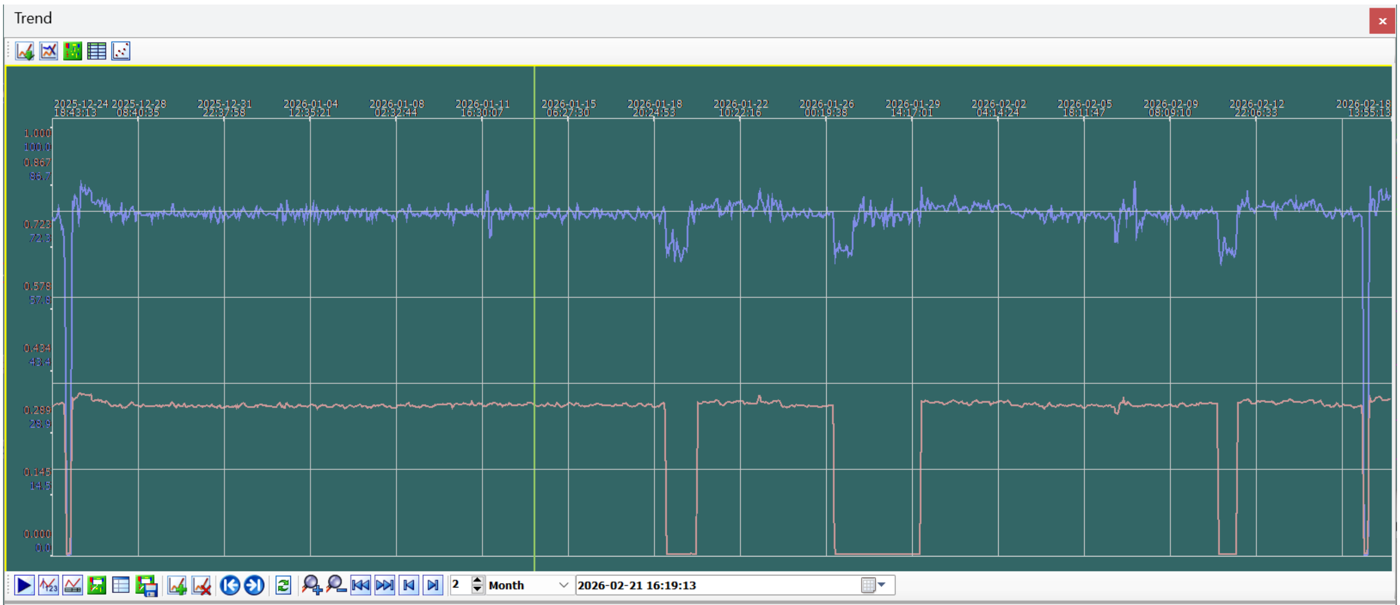

Figure 2: DCS screenshot from HFC - granulator cycle started on December 25, 2025, and ended on February 17, 2026. The blue line represents the flowrate of granules through the final belt and the light brown line represents the flowrate of urea formaldehyde added to the urea melt line. Three on-stream periods without urea formaldehyde injection are visible.

Moreover, the Stamicarbon granulation technology coupled with the operational control of HFC were critical in reducing and handling dust formation during the spraying process. The emitted dust remained well within the scrubbing system's capacity, and the scrubbing section was able to handle the additional dust amount without impacting the level of the environmental emissions.

2.3 Biuret formation

Common practices for biuret reduction often rely on lowering urea melt concentration and temperature at the second evaporation stage. However, this methodology leads to excessive dust formation inside the granulator and necessitates more frequent washing cycles. Instead, in a TGU run, higher melt concentration in the second evaporator is desired and as a side effect it results in higher biuret content in the final product. This higher melt concentration is advised to prevent dust formation and maintain the best possible crushing strength, because due to the lack of formaldehyde the crushing strength will be lower compared to FGU. As there is a limit in allowable biuret concentration of 0.3wt% in DEF-32 solution, corresponding to 0.9wt% in TGU granules, measures must be taken to reduce biuret production in the evaporators. In case biuret concentration in the final product in an FGU run is higher than 0.85wt%, Stamicarbon requests to install ammonia dosing provision in the evaporation section, also known as biuret reduction tool.

The biuret reduction tool works by injecting a precise amount of ammonia at the lowest point of the line between the first and second evaporator. Since the biuret formation reaction yields ammonia and is a reaction in equilibrium (see Figure 3), an increasing ammonia concentration will shift the equilibrium toward the side of reactants, such as urea:

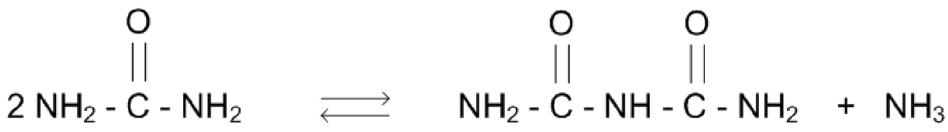

Figure 3: Biuret formation reaction through urea.

Based on in-depth knowledge, the quantity of the injected ammonia is carefully designed to strike the exact balance between the desired effect and avoid additional ammonia emissions. This quantity depends on the capacity of the plant and the biuret concentration in the urea melt.

The biuret reduction tool is a patented feature developed by Stamicarbon which is available to both grassroot and revamp projects. It is expected that through this simple tool, granulation plants can reduce their biuret concentration in the final product by up to 0.05wt%, whereas for prilling plants by up to 0.1wt%.

2.4 Other points of attention

- **Formaldehyde dissipation time** – After stopping urea formaldehyde injection to the urea melt, the formaldehyde still present in the hold-up volume of the plant will still require time to dissipate to acceptable levels. Optimizing equipment mixing patterns and decreasing the levels in the vessels upfront the change to TGU production will accelerate formaldehyde dissipation.
- **New urea solution tank** (in case of revamp projects) – In an existing plant, a new urea solution tank must be added to store the wet recycle if this recycle flow contains formaldehyde. Traces of formaldehyde in the recycled solution are allowed below a certain threshold during TGU production (more details are described later in the paper). Since the big compartment of the urea solution tank is designed to at least accommodate the drained solution of a synthesis drain for a period of eight hours, having an additional tank will allow for a complete and safe draining procedure of the synthesis section in case of need. This feature also allows for faster dissipation time of formaldehyde from the system, which will shorten the waiting time of the switch to TGU production. For a grassroot project, additional volume can be considered during the design of the urea solution tank;
- **Storage** - during a TGU run, due to the absence of urea formaldehyde, the produced granules will be more prone to caking. As such, it is advised to bag granules produced during a TGU run immediately, instead of storing them in the warehouse for curing.
- **Dust formation** – also due to the absence of urea formaldehyde, a higher dust formation is expected in the granulation plant and warehouse. This nuisance is minimized to acceptable levels in HFC by applying a proprietary method.

2.5 Operational procedure

To start the formaldehyde-free run, five actions must be performed as described in the Figure 4 below:

Figure 4: Main operational steps to switch to a TGU run.

1. **Decrease hold-up volumes**

Upfront preparation is key to ensure a fast transition from FGU to TGU granulation. Decreasing the operational hold-up volumes in the circuit as practically possible – such as levels in granulator, first and second product cooler, dissolving vessel, etc. – will decrease the total amount of formaldehyde being held by the system, which in turn will result in a faster dissipation of this component from the plant during the following steps.

2. **Stop formaldehyde dosing**

Afterwards, the urea formaldehyde solution dosed to the urea melt shall be slowly reduced until fully stopped. From this moment, the formaldehyde content in the final product will slowly decrease. The exact moment at which the product is sufficiently formaldehyde-free must be assessed via analytical checks starting at least two hours after dosing ceased. The inertia of the system to get rid of this substance will depend on the total hold-up volume of the equipment involved. The transition product can be mixed with the fertilizer grade product in the storage or can be used as cattle feed.

3. **Apply measures to optimize mixing patterns, if applicable**

As mentioned in Section 2.4, in case mixing patterns in granulation plant equipment are found to be underperforming, it is advised at this moment in the sequence to start corrective measures.

4. **Redirect wet recycle flow**

At the same time of stopping formaldehyde dosing, the wet recycle flow shall be directed to the big compartment of the urea solution tank (grassroot project) or to the new tank (revamp project) in order to isolate the wet recycle, thus achieving shorter dissipation times of formaldehyde in the final product, as shown in Figure 6. As a result, the evaporation section will process a lower load which provides more operational margin in this section to increase the urea melt concentration.

As the formaldehyde-free run progresses, the formaldehyde content in the wet recycle flow will slowly decrease to a zero value. That might take up to 16 hours, depending on the plant design, because the total hold-up volume of the scrubber system and dissolving units must be free of formaldehyde. Once the analytical measurements prove that the wet recycle contains 50 ppm of formaldehyde (or lower), the wet recycle can be sent to the inlet of the pre-evaporator (or to the small compartment of urea solution tank, depending on the plant configuration). Analytical checks can start after 10 hours from the formaldehyde dosing shutdown.

This would need to be assessed on a case-by-case basis. Moreover, biuret concentration in the final product will decrease due to the absence of biuret in the wet recycle flow.

5. **Increase melt concentration and use biuret reduction tool**

After the wet recycle is fed to the pre-evaporator again, the nameplate capacity of the granulation plant will be restored. At this moment it is advised to closely monitor the biuret concentration in the urea melt and increase the dosing of ammonia via the biuret reduction tool if necessary.

To summarize the steps listed above, Figures 5, 6 and 7 illustrate the initial, intermediate and final states of the granulation plant when switching from a FGU to a TGU operation.

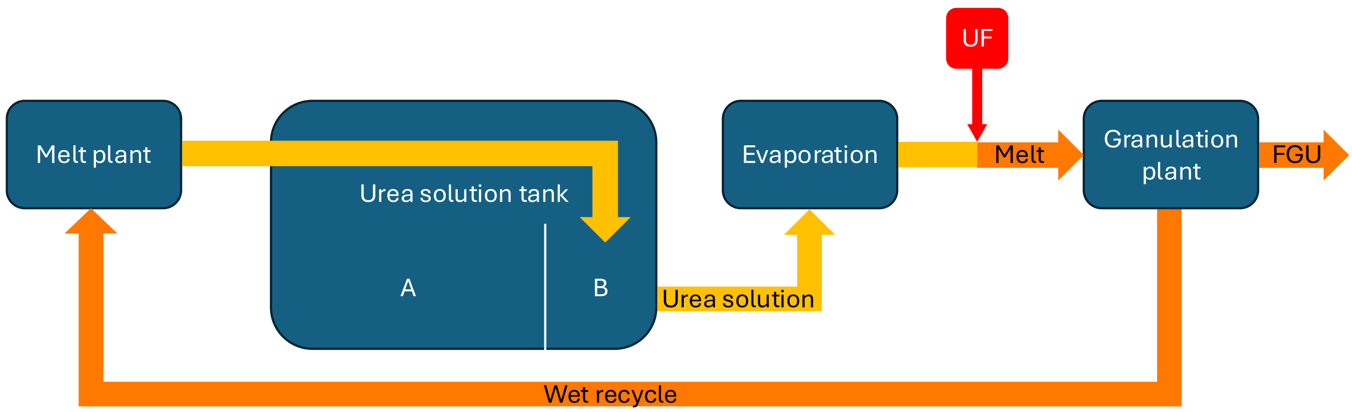

Figure 5: Fertilizer grade urea operation (initial state).

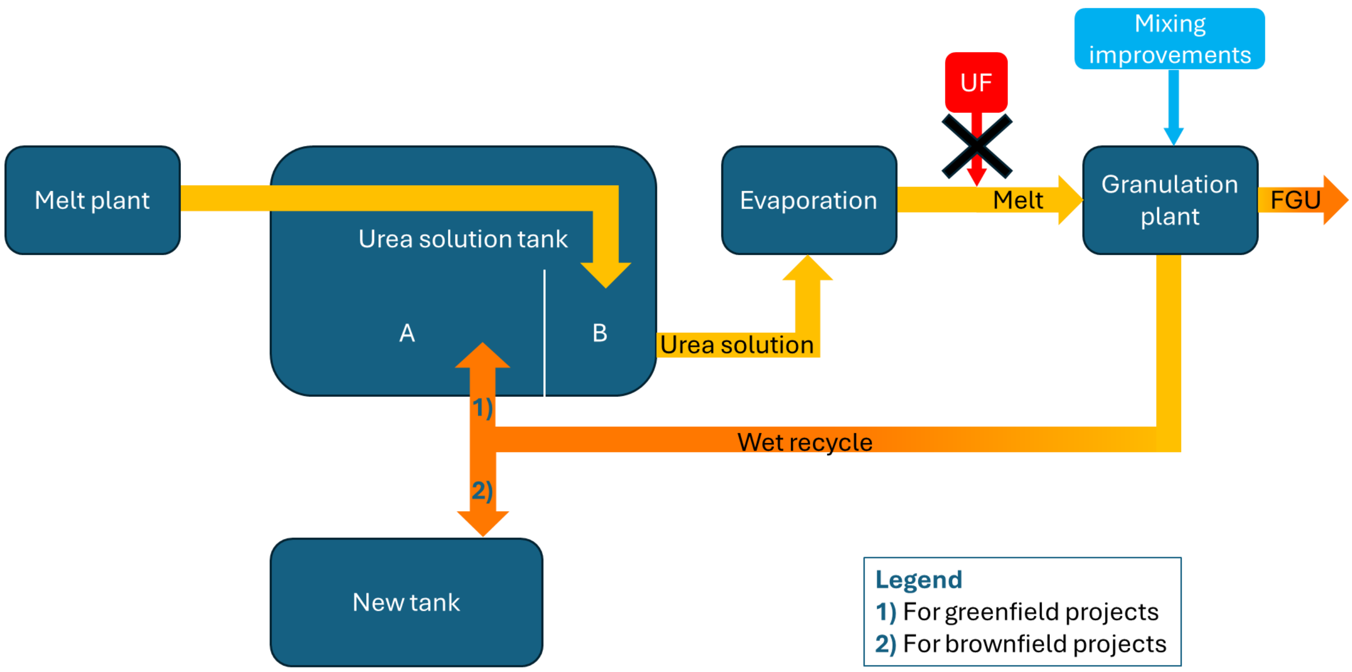

Figure 6: Switching to technical grade urea (intermediate state, as described in above sections).

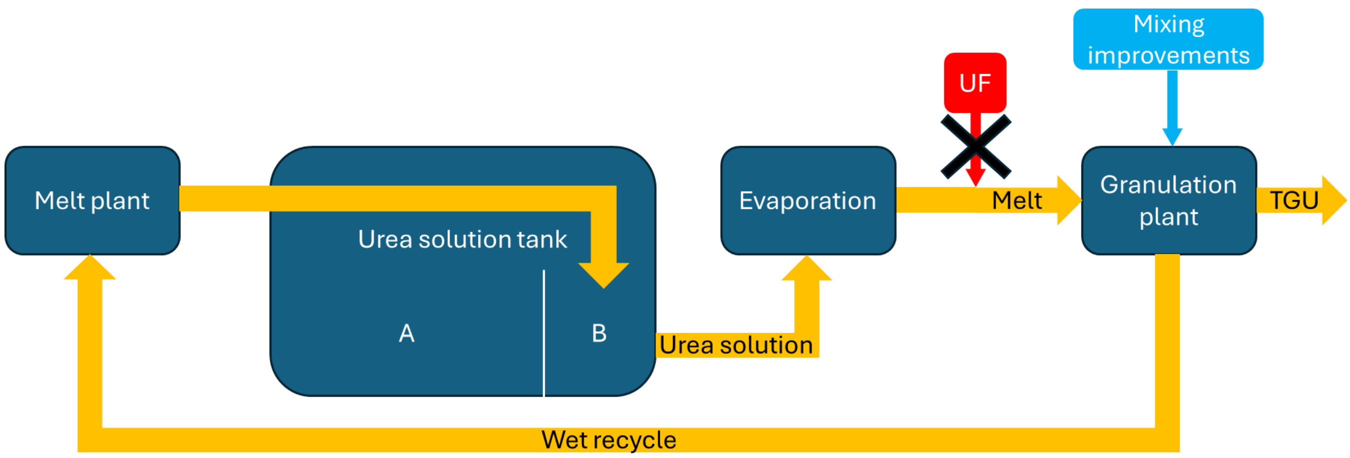

Figure 7: Technical grade urea operation (final state).

3 CONCLUSIONS

The key takeaways from this paper are:

- Urea granulation without formaldehyde for TGU production is achievable with Stamicarbon granulation process;
- Tests at the operating plant of HFC showed that it is possible to switch between fertilizer grade to technical grade production;
- Further optimization tests showed that increasing the d50 of TGU granules further enhances final product quality;
- This technology is now available to any Stamicarbon granulation client upon consultation, and it is available for both grassroot and revamp projects.

4 REFERENCES

1. “Upgrading a non-Stamicarbon granulation plant”, B. Cucchiella & J. Coloma; The Hague, The Netherlands; 2026.
2. “History, development and features of the Stamicarbon granulation process”, J. Meessen & W. Roos; Scheveningen, The Netherlands; 2004.

Stamicarbon B.V.

REGISTERED OFFICE
Mercator 3, 6135 KW Sittard,
The Netherlands
P.O. Box 53 - 6160 AB Geleen
P +31 46 4237000
F +31 46 4237001

b.teixeira@nextchem.com
Process Engineer

e.mostert@nextchem.com
Licensing Manager

stamicarbon.com

Helwan Fertilizers Co.

Autostrad Road, Arab Abo Saed, At Tebin
Helwan, Egypt
+2 (02) 254 303 08/13

m.mostafa@hfcegypt.com
Granulation Area Manager

www.hfcegypt.com

STAMICARBON
NEXTCHEM Sustainable Technology Solutions

NEXTCHEM