Experience at ALEXFERT's World-Scale Stamicarbon Fluidized-Bed Urea Granulation Plant

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This paper describes the commissioning, start-up and further experience at the new urea granulation plant (2,000 t/d) of Alexandria Fertilizers Co. (ALEXFERT), which is based on Stamicarbon's granulation technology.

Stamicarbon introduced its fluidized bed granulation technology at the **Nitrogen 2003** conference inWarsaw. This market introduction was based on pilot-plant testing in combination with positive results in a commercial plant in Grodno, Belarus.

On the basis of the positive results in this commercial plant, Agrium decided to modify its existing Fort Saskatchewan plant to the Stamicarbon's film spraying based granulation technology. In spring 2003 the Egyptian companies ALEXFERT and EFC asked for a licence contract for 2000-t/d granulation units based on Stamicarbon's technology. The contracts were signed in December 2003. At that moment the Agrium plant had operated very satisfactory for a period of two months.

During the design phase of the project, meetings with the contractor were organized to emphasize the consequences for the design.

ALEXFERT – Alexandria Fertilizer Co. - was established as a joint stock company in October 2003 on the coast of Abu Qir bay, on the Mediterranean coast of Egypt. This location is close to the seaports of Alexandria and Abu Qir and is thus excellently positioned for exporting its products,liquid ammonia and urea granules, to Europe, America and West Africa. The main contractor for the total complex, including the granulation plant, was Uhde (Dortmund, Germany).
With the favourable location of the plant in a private free zone, total urea production and surplus ammonia (30,000 t/a) are directed to export.
The ALEXFERT plant consists of:

- Ammonia plant (1,200 t/d)
- Urea synthesis plant (1,925 t/d
- Urea granulation plant (2,000 t/d)
- Utilities, storage, bagging and loading units.

The commissioning and the start up of the plant had been achieved three months earlier than contracted.

- First ammonia production 15/06/2006
- First ammonia shipment 11/07/2006
- First urea production 12/07/2006.

GENERAL PROCESS DESCRIPTION

Melt plant layout

This project was started as a copy of the Abu Qir 3 / EFC 1 plant projects. These plants were commissioned in 1996 and 1999 respectively. All recent Egyptian projects have been based on this concept. In the interests of minimizing engineering work, the pre-evaporator was left in the process flow diagram, even though it is unnecessary with the Stamicarbon granulation process. The plant thus has a pre-evaporator, a first evaporator and a second evaporator.

For good performance the Stamicarbon granulation process requires a urea melt concentration of 98.5%, although – as will be shown in this presentation – it is possible to operate the plant with lower concentrations.

Evaporation section

The urea melt is concentrated in the evaporators to a concentration of about 98.5%. At this concentration the melt is transferred from the urea melt plant to the granulator by means of a urea melt pump. Urea formaldehyde is added to the urea melt in the pump suction line to serve as a granulation additive and anti-caking agent. It also improves the crushing strength of the granules.

Granulator

The urea melt is sprayed as a very thin film into a fluidized bed of urea particles in the granulator.

The granulator is divided into a granulation section and a small cooling section. In both sections fluidization air is evenly distributed by a perforated plate to fluidize and cool the granules.

A fan delivers the fluidization air to the air chambers in the granulator. The pressure drop of the fluidization plate is selected in such a way as to create an air distribution proportional to the area of the plate surface in the related compartment.

Seed (recycle) material is introduced into the first compartment of the granulation section, where the urea melt is introduced. As the granules move along through the granulation section, their size steadily grows up by layering to reach the required granule diameter, at which the product finally flows out the granulator.

Urea melt is fed to the injection headers, which are connected to the urea melt line and the secondary air system. The urea melt line is located in the air header. By this arrangement the air header serves as a tracer for the urea melt. All headers are provided with three way valves to enable flushing with steam during operation.

Provision has been made for preventing blocking of the urea melt nozzle by the particles in the fluidized bed if a header is not in operation.

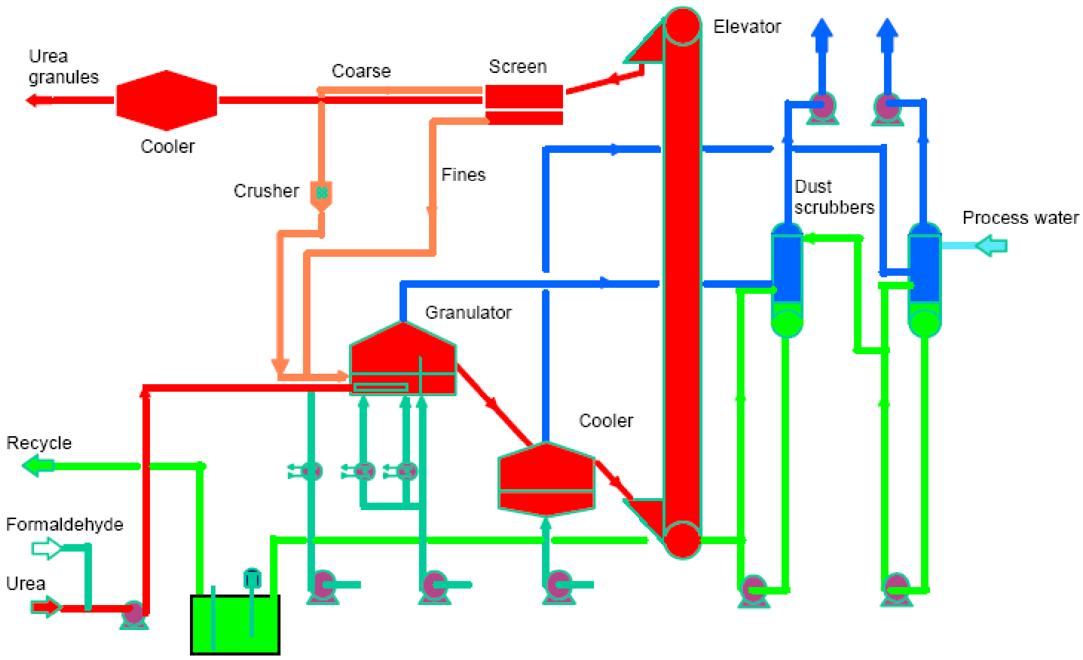

FIG. 1: FLOW SHEET OF STAMICARBON GRANULATION PROCESS

Each injection header features vertically placed risers fitted with spray nozzles, which spray the urea melt onto the seed particles. The conditions for the spraying process are as such that a thin film is formed on the surface of the seed material. The secondary air, necessary to transport the granules through the urea melt film, is delivered by a sprayer air blower.

The granules flow from the granulation section to the cooling section, where there are no spray nozzles. Here they cool down and harden before further processing. The product from the granulator is extracted by an extractor and flows through a lump screen to prevent any lumps from reaching the granulate cooler.

Fluidized-bed first cooler

The granulate cooler is of the fluidized-bed type. The fluidization/cooling air is delivered by a dedicated granulate cooler air fan.

The fluidization/cooling air exhausted from the top of granulate cooler contains some dust. It is combined with the air from the product cooler and the dedusting air, and the combined stream is cleaned in the cooler scrubber system.

Scrubbing section

Exhaust fluidization and secondary air leaving the top of granulator are drawn through the granulator scrubbers by a fan in the scrubber off-gas line. In the scrubbers the dust content of the air is arrested by the scrubbing solution and clean air is exhausted to the atmosphere.

The scrubbing solution (a dilute urea solution) is partly recirculated through the scrubber and partly pumped to the urea dissolving vessel and thence recycled to the urea melt plant. Dust-laden air from the granulate and product coolers and from various dedusting points are exhausted to another scrubber. The film-type sprayer used in the granulator does not produce any fines; the dust present in the granulator off-gas results merely from some attrition in the fluidized bed and in the crusher. There is thus relatively little dust in the off-gas and it is relatively easy to clean. In the urea dissolving vessel the urea lumps from the lump screen are dissolved in the urea solution from the granulator scrubber.

Screens and crushers

Cooled urea granules are lifted by a bucket elevator to the main screens for granule size selection.The granules are classified into coarse particles (oversize), final product (on-size) and fines(undersize).

The fines are recycled to the granulator and used as seed material. Coarse product is directed to the crushers. After crushing the small-sized product is discharged to the granulator or, alternatively, to the granulate cooler.

Final cooler

The final product is transported to the fluidized-bed product cooler, where it is air-cooled to 40°C. Lastly, the final product is conveyed to storage

MAIN FEATURES OF THE STAMICARBON GRANULATION PROCESS

- Limited dust production in the granulator
- Low energy consumption for the sprayer air fan
- Low formaldehyde consumption
- Low urea dust emission
- More uniform and spherical shape of the urea granules

These features are attributable to the use of film spraying technology, as the 98.5 wt-% urea melt is sprayed in the form of a thin film. Secondary air, supplied through an annulus around the melt sprayer, draws the urea granule through the film. Each time a granule passes through the liquid film it grows in size by layering, as shown in Fig 2.

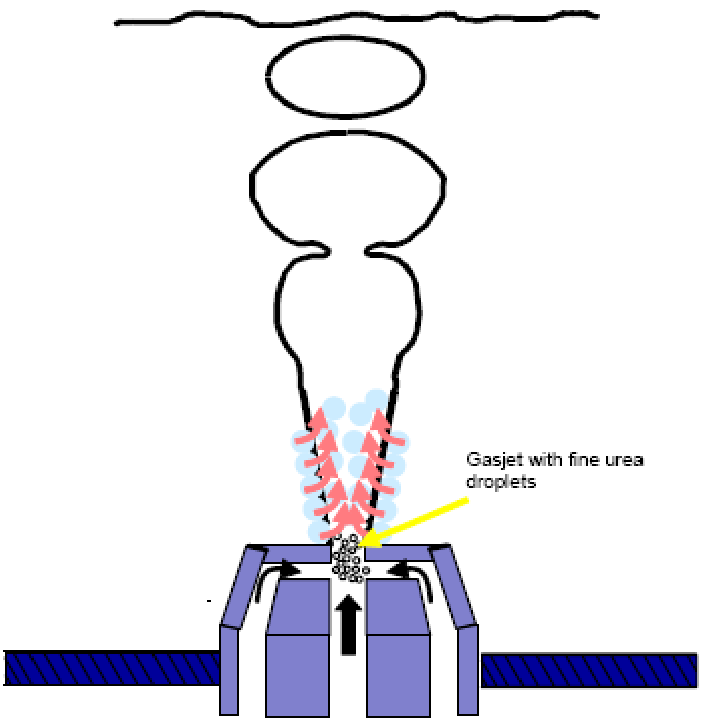

FIG. 2: CROSS-SECTION OF FILM SPRAYING NOZZLE

START-UP OF ALEXFERT'S GRANULATION PLANT

After the pre-commissioning of the granulation plant , the dry test run was carried out to check the performance of all equipment like fluidized-bed coolers, bucket elevators, crushers and belts, without and with solid material. Inevitably some problems appeared such as continuous tracking and stopping of the extraction belts at the outlet of the granulator. This problem was solved by the mechanical, electrical and instrument groups. The gaps between the drums of the crushers (upper and lower) were adjusted on the basis of laboratory measurements, the levels of the scrubbers were checked. Vibration measurements were made on all blowers and were found to be satisfactory. The dry test took about 8 hours, after which the granulator was washed through the spray nozzles of the headers and dried. The fluidized bed coolers were also washed and dried.

At dawn on 12 July 2006 the granulation plant of ALEXFERT was started up smoothly. The synthesis plant had been started at 11 o'clock the previous night. The start-up was very successful . There were no problems at all with the main equipment. Only minor adjustments were required. At about 5 a.m. on 12 July the evaporation section was started while the granulator was filled with product from the start-up bin. Melt was first injected into the granulator at 6 a.m. and the load was increased gradually from one header to eight headers. At 6:30 a.m. urea granule production began. Watching the first heap of our product – with good shape and roundness – building up in the bulk store really was an historic moment for all the employees of ALEXFERT.

The plant ran without interruption for about nine days, when there was a trip in the ammonia plant. This provided an opportunity to empty the granulator and examine it inside, when it was found to be essentially clean. There was a thin layer of urea dust on the sidewalls and the ceiling, particularly around the dust recycle inlet. The granulator was washed with condensate through the headers as specified by Stamicarbon. This procedure was modified several times by agreement between the ALEXFERT and Stamicarbon groups until a completely successful procedure had been arrived at. After a while the plant was started again without any problem except for a problem in one of the roll crushers. The V-belts were damaged. After changing the belts the plant ran smoothly; during the commissioning period the granulation plant did not cause any loss of production. Several trips occurred, but none was related to the granulation plant.

Performance test

The timing of the performance test deserves particular attention. The first performance test was announced on 15 July. The contract specified that the melt plant should run at 1,750 and 1,925 t/d and the granulation plant at 2,000 t/d.

These performance tests took place in the period 20 August to 10 September, during a period of high prevailing summer temperatures and high ambient humidity.

In the course of the performance test, samples were taken of the product from the automatic sampler, twice per shift, to monitor the quality of the product with the plant operating at different loads (1,750 t/d and 1,925 t/d). Important parameters affecting the quality of the product are crushing strength, caking tendency and guaranteed chemical composition. Special attention was paid to the moisture content of the product because our plant is located on the coast in a very humid atmosphere and previous experience in adjacent plants has shown that this high humidity leads to a high moisture content in the final product. But in fact the quality of the final product was very satisfactory; especially when the solution plant was operating at the high load (1,925 t/d), the sphericity of the granules and the other specifications were superior. This was achieved by fine adjustment of the gaps between the drums of the crushers on the basis of analysis of many samples taken from that point, since the crusher is the main source of the seed particles required for the formation of granules and is responsible for the sphericity of the granules.

The quality of the product was also excellent at the minimum turn-down load (60%) and at the maximum load of the granulation (2,000 t/d), as shown in Table 1.

Table 1: Product Specifications During Performance Test

Performance test	Average cap achieved per day	Total N %	Biuret %	Moisture %	Hardness Kp	On-size (2-4.5 mm), %
1,750 t/d	1,820 t/d	46.2	0.85	0.22	4.4	99
1,925 t/d	1,927.8 t/d	46.2	0.84	0.21	4.3	99
Maximum load in granulation unit (2000 t/d)	2,150.4	46.2	0.86	0.25	4.2	99
Minimum turn-down (60%)	1,050	46.2	0.90	0.21	4.5	99.16

Environmental aspects

During the performance tests dust and ammonia emissions were measured by taking samples from the vent stack of the granulation. These samples are not normally taken on a routine basis. One set of samples, taken and analysed by the Department of Occupational Health and Air Pollution of Alexandria University, indicated an ammonia emission of about 135 mg/Nm^3 and a dust emission of about 15 mg/Nm^3. These results were confirmed by measurements taken simultaneously by Uhde's specialist and analysed in ALEXFERT's own laboratory.

Operational experience during the first months

The plant was in continuous production for about 48 days without any serious problem, during which the granulation plant was not stopped for cleaning.
There was some dust formation in the granulator. The dust forms a loose layer on the wall of the granulator. When the granulator was inspected after a long period of production there was a thin layer of dust on the side walls and other possible lay down areas. This dust never caused any problems that might have forced us to stop the plant for flushing and cleaning.

Up to now, there has only been one upset condition in the urea synthesis section which led to a decrease of the melt concentration from 98.5% to 97.5%. Even during that period of low melt concentration, the plant kept operating at full load. The only drawback was the moisture content, which increased from 0.23% to 0.28% (requirement less than 0.3%). Consequently the crushing strength dropped from 4.1 Kp to 3.6 Kp, which is still within the specification. This problem in the melt plant was partially solved and the melt concentration increased again to 98.1%. By this means the moisture decreased to 0.24% and the crushing strength increased again to 4.1 Kp.

When the plant was shut down because of a problem in the ammonia plant, the granulator was checked from inside and found to be clean except for a dust layer on the walls. The granulator was washed and dried again in about three hours and was then restarted smoothly.

During that long time of operation the d_{50} (the average diameter of 50% of the granules) and the uniformity of the urea granules was measured once per week and was always 3.25 mm.

Table 2, shows the specifications of the product with running days.

Table 2: Product Specifications versus Running Days.

Running days	Total N %	Moisture %	Hardness Kp	On size (2–4.5 mm), %
1	46.26	0.22	4.6	99.35
8	46.26	0.25	4.3	99.5
15	46.26	0.24	4.3	99.4
22	46.26	0.26	4.3	99.1
29	46.26	0.26	4.1	99
36	46.26	0.28	3.6	98.5
43	46.26	0.24	4.1	98.5

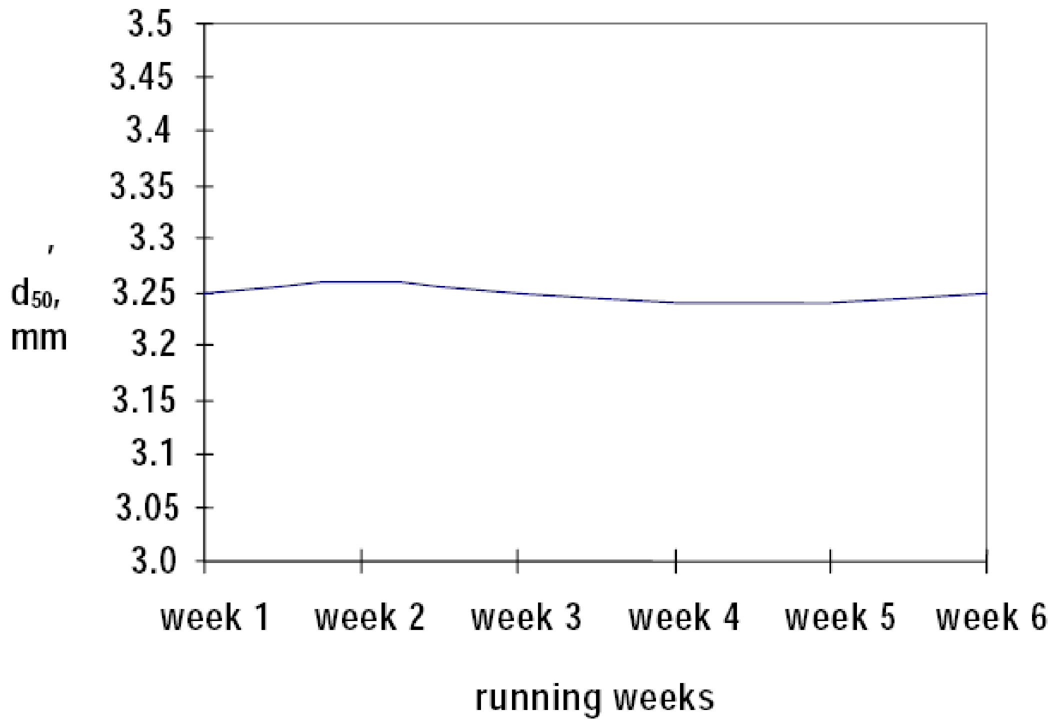

FIG. 3: RELATION BETWEEN RUNNING WEEKS AND D_{50}

Figure 3.illustrates the relation between d_{50} and running time.

At start-up the granulation plant was operated with 0.55 wt-% of urea-formaldehyde in the final product as a matter of company policy. But one of the main advantages of Stamicarbon's granulation technology is that it is possible to reduce formaldehyde consumption. So, after the initial period, we decided to reduce the formaldehyde content in the final product to 0.45%. There was no affect on the crushing strength, as it still averaged 4.1 Kp.

ALEXFERT intends to decrease the urea formaldehyde concentration to 0.3%, subject to satisfactory crushing strength and the moisture content.

STORAGE

The storage behaviour of the product is excellent. The air in the storage building does not suffer from the well-known ammonia smell and the visible dust content is low, so it is possible to see clearly a long way into the store. This experience is confirmed by the loading personnel at the seaport, who have reported that the product has excellent behaviour with respect to both dust formation and ammonia smell.

MARKETING

ALEXFERT has exported the product to a number of European clients. ALEXFERT urea granules are well accepted in most European countries and clients appreciate the superior quality of the product.

EVALUATION OF STAMICARBON GRANULATION'S TECHNOLOGY

Advantages

• Less dust formation (so it is advisable to decrease the urea formaldehyde
• concentration of the final product).
• Superior product quality (as mentioned in performance test) ,particularly in
• terms of sphericity and particle size distribution.
• Longer on-stream time without washing of the granulator.

Disadvantages

• Minor increase in power consumption owing to energy consumption of air blowers.

Improvement for equipment performance

• Better specification and selection of vendors for crushers.
• Reduce power consumption by further improvements of granulator design (as is established already in later design.

FURTHER DEVELOPMENTS

As a result of the good performance of the Egyptian granulation plants, Stamicarbon is ready to offer plant designs with larger capacities up to 3,600 t/d in one line. All equipment needed for that high capacity is available on the market. Looking at the process performance, the key item for upscaling is the granulator. The granulation process appears to be very flexible and forgiving under deviating conditions.

CONCLUSIONS

• The Stamicarbon granulation technology is very reliable, and flexible and smooth in operation.
• The quality of the product in all its common parameters is excellent.
• Dust formation during the granulation process is minimal.
• Dust formation during loading and unloading is minimal.
• The run time of the granulation is not limited by the need to flush the granulator.
• Urea formaldehyde usage can be reduced without sacrificing product quality.
• There is no smell of ammonia in the storage building.