Fertilizer Finishing Process for AN and NPK's with Rotoform HS 2000

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Introduction

Innovation has always been the key to success in the fertilizer industry. Better performance figures plus a proven track record support these innovations. The key question is how to introduce a new technology in situations where it is not yet considered?
Recent successes in the use of the Rotoform system for sulphur and urea solidification have opened up new opportunities in other fertilizer plants. Furthermore, growing demand for higher capacity solutions has resulted in the development of the unique Rotoform HS 2000, a system that makes use of a 2000 mm wide steel belt to deliver a 33% increase in capacity compared with standard Rotoform systems.
Alongside growth in the use of Rotoform systems for sulphur and urea, Sandvik has also been working on the development of Rotoform solutions for new fertilizer products. One such project has seen the installation of a mobile Rotoform unit at the site of Romanian fertilizer producer Azomures, and pilot tests have resulted in the successful development of a number new products and applications, including Ammonium Nitrate (AN) and AN-based NPK fertilizers, both pure and in mixtures.
As a result, Azomures decided to invest in two Rotoform HS 2000 lines for its AN and NPK modernization project; these two units were delivered in July 2011 and commissioning is scheduled for completion by the end of 2011.
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Alongside growth in the use of Rotoform systems for sulphur and urea, Sandvik has also been working on the development of Rotoform solutions for new fertilizer products. One such project has seen the installation of a mobile Rotoform unit at the site of Romanian fertilizer producer Azomures, and pilot tests have resulted in the successful development of a number new products and applications, including Ammonium Nitrate (AN) and AN-based NPK fertilizers, both pure and in mixtures.

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INTRODUCTION

1. Existing AN & NPK facilities in Azomures

The existing Stamicarbon-design plant at Azomures SA's facility in Tirgu Mures, Romania was installed in 1972. It is an ammonium nitrate (AN) 33.5% / calcium ammonium nitrate (CAN) 27% plant with a design capacity of 1400 mtpd AN and 1600 mtpd CAN.

Some 750 mtpd of the AN solution is produced as a byproduct of the N-H Odda process Nitrophosphate NPK plant and the rest is a product of three plants applying direct neutralization of nitric acid and ammonia. The AN solution from the Nitrophosphate plant (at 82 wt%) – together with synthetically produced AN – is pre-concentrated to 95 wt% and then pumped to a granulation plant. The third neutralization plant still operates with a prilling tower.

The following plants were considered for the revamping project:

Ammonium Nitrate 1+2

- Up to 625 mtpd AN produced by neutralization
- Up to 750 mtpd AN produced as by-product from NPK plant
- Total 1,400 mtpd granulation unit at downstream

Ammonium Nitrate 3

- Up to 800 mtpd AN produced by neutralization
- Solidification by prilling

NPK Plant

- Two lines, each neutralizing up to 165 mtpd 100% P2O5
- Physical capacity limits around 1,300 mtpd per line
- Both lines have solidification by prilling

2. Need for modernization and alternatives evaluated

The aim of the management team at Azomures was to replace the AN/CAN prills with a product of a higher quality, one that would better meet the needs of international markets and therefore attract a higher prices.

The following finishing technologies were compared and evaluated:

1. Prilling tower
2. Granulation technology
3. Sandvik Rotoform

Prilling and granulation are the most common processes used to produce solid ammonium nitrate.

PRILLING

To produce prills, concentrated melt is sprayed into the top of a prill tower. In the tower, ammonium nitrate droplets fall countercurrent to a rising air stream that cools and solidifies the falling droplets into spherical prills. Prill density can be varied by using different concentrations of ammonium nitrate melt.

GRANULATION

Various granulation technologies are available to produce solid ammonium nitrate: high solid recycle processes like rotary drum & pug mill and low solid recycle processes like pan & fluid bed granulation technology.

High recycle processes have a typical recycle of 1.5-2 while the low recycle processes stay below a recycle rate of 1. These differences result in different AN concentrations or amount of liquid phase required by the granulation process. A high solid recycle granulation usually requires a lower AN concentration (94-96.5%) than a low solid recycle process (98-99.5%). This correspondingly means that the amount of water to be removed from the product by drying is higher for a high recycle process. Some low recycle processes operate with such a low water content so that a dryer is not required.

Common parts of granulation processes are obviously the granulator, where the granules are formed from smaller parts (seeds). Granules are removed from the granulator and screened. Offsize granules are crushed and recycled to the granulator to supply additional seed particles or are dissolved and returned to the solution process.

The temperature of the ammonium nitrate product exiting the solids formation process is approximately 66 to 124°C. Rotary drum or fluidized bed cooling prevents deterioration and agglomeration of solids before storage and shipping.

Since the solids are produced in a wide variety of sizes, they must be screened for consistently sized prills or granules. Cooled prills are screened and offsize prills are dissolved and recycled to the solution concentration process. Granules are screened before cooling. Undersize particles are returned directly to the granulator and oversize granules may be either crushed and returned to the granulator or sent to the solution concentration process.

Emissions from the prilling tower and granulation sections are ammonium nitrate dust and ammonia. Emissions from prill towers result from carryover of fine particles and fumes by the cooling air flowing through the tower. These fine particles are from microprill formation, created by prills colliding with the tower or with one another, and from rapid transition of the ammonia nitrate between crystal states. The uncontrolled dust emissions from prill towers are therefore affected by tower airflow, spray melt temperature, condition and type of melt spray device, air temperature, and crystal state changes of the solid prills.

The amount of microprill mass that can be entrained in the prill tower exhaust is determined by the tower air velocity. Increasing spray melt temperature causes an increase in the amount of gas-phase ammonium nitrate generated. Thus, gaseous emissions from high density prilling (1.59 g dust per kg AN without scrubber, 0.6 g/kg AN with a wet dust scrubber) are greater than from low density ammonium prilling towers (0.46 g/kg AN without scrubber, 0.26 g/kg with a wet dust scrubber).

The granulation process in general provides a larger degree of control in product formation than does prilling. Granulation produces a solid ammonium nitrate product that, relative to prills, is larger and has greater abrasion resistance and crushing strength. The air flow in granulation processes is lower than that in prilling operations. The design and operating parameters of granulators may affect emission rates. Cooling and drying are usually conducted in rotary drums, fluid bed or bulk flow coolers. As with granulators, the design and operating parameters of the rotary drums, fluid bed and bulk flow coolers may affect the quantity of emissions. In addition to design parameters, prill and granule temperature control is necessary to control emissions from disintegration of solids caused by changes in crystal state.

Emissions from screening operations are generated by the attrition of the ammonium nitrate solids against the screens and against one another. Almost all screening operations used in the ammonium nitrate manufacturing industry are enclosed or have a cover over the uppermost screen. Rotary drum granulators have a typical dust emission of 0.22 g dust per kg produced ammonium nitrate when applying a wet dust scrubber.

SANDVIK ROTOFORM®

The Sandvik Rotoform system cools and crystallizes the ammonium nitrate melt indirectly with cooling water. The lack of any need for air flow in order to remove the heat delivers two key benefits. Firstly, as the ammonium nitrate can be solidified without the need for large air blowers, energy consumption is significantly lower, and secondly, there is no need to manage large air flows loaded with ammonium nitrate dust.

Another advantage of the Sandvik Rotoform is the production of a solid product with a very narrow size distribution. No screening, crushing or large recycle streams are involved, eliminating the investment costs associated with this equipment.

Following is an overview of various features of the different finishing technologies used to produce solid ammonium nitrate.

Table 1
Comparison of prilling, granulation and Rotoform

Product	Prilling	Granulation	Rotoform
Product size (mm)	1.5-2.0 mm	3.0-4.0 mm	1.5-4.0 mm
Control of size/size distribution	Relatively wide size distribution; partial control possible by adjusting prilling bucket design and rpm	Partial control via choice of screens, however typically large recycle flows, key elements are nozzle and residence time	Narrow distribution, can be controlled by exchanging Rotoform rotating shell.
Production of specialty products	Difficult	Limited	Easy and many possibilities
Control of discharge temp.	Difficult	Feasible	Easy and variable
Capacity (mtpd)	500 (minimum)	500 (minimum)	150 (based on product size); several lines can be installed in parallel enabling flexibility to cope with varying throughput. No upscale risks.
Cooling media	Large airflow	Significant amount of air depending on granulation technology	No air, indirect water cooling
L.P. Steam consumption	Low	Higher	Low
Electrical consumption	Moderate for forced draft prilling towers	High	Low
Dust generation	Yes, amount depends on plant load and ambient condition	Yes, amount depends on plant load and ambient condition (but <prilling due to extra dust scrubber)	No dust generation
Equipment washing	Scraper cleaning (monthly)	Monthly or flushing after stoppage (cleaning takes 8 hours)	Monthly or flushing after stoppage (cleaning takes 3 hours); One spare line for several units means no stoppage necessary.
Ease of operation	Easy	Less easy, cleaning required	Easy operation with minimum equipment

Azomures chose for the Sandvik Rotoform system for the following key reasons:

- ✓ to minimize the emission of dust and free-ammonia from the prilling plants
- ✓ to produce more higher value, specialty fertilizer products

The following options are currently under evaluation:

1. Install Sandvik Rotoform lines plus a mixing unit at AN 3 plant and shut down the current prilling tower

2. Install Sandvik Rotoform lines plus a mixing unit at NPK plant and shut down the existing two prilling towers
3. Analyze feasibility of installing Sandvik Rotoform lines plus a mixing unit for independent production of greenhouse grade calcium nitrate

3. Chosen finishing technology: Sandvik Rotoform HS 2000

The figure below shows the flow scheme of the Rotoform technology.

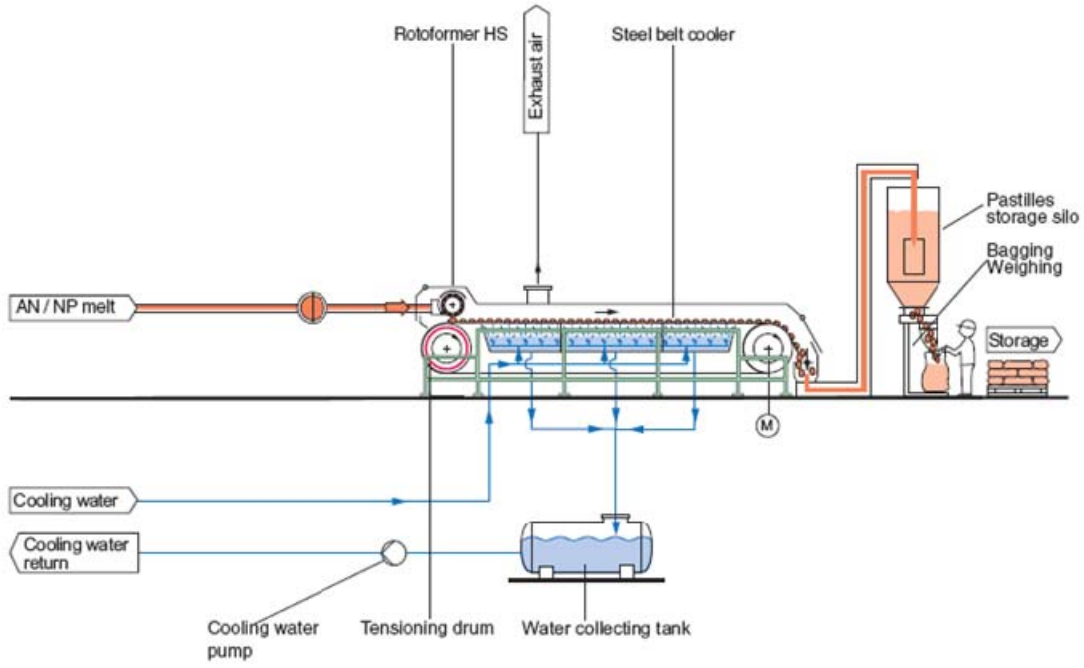


Fig 1: Sandvik Rotoform pastillation process

The feed to the Rotoform is ammonium nitrate melt at a concentration of 99.8 wt%; in existing AN plants this feed can be branched off from the ammonium nitrate evaporation section downstream of the ammonium nitrate melt pumps.

Ammonium nitrate melt is introduced under pressure (2-3 bar) to the dropformer. The Rotoform HS (High Speed) 2000 dropformer, patented by Sandvik, consists of a heated stator and a perforated rotating shell that turns concentrically around the stator to deposit drops of ammonium nitrate across the full width of the 2000 mm wide steel belt.

The circumferential speed of the Rotoformer is synchronized with the speed of the steel belt ensuring that the drops are deposited on the belt without deformation and, after solidification, results in regular pastilles with an optimum shape.

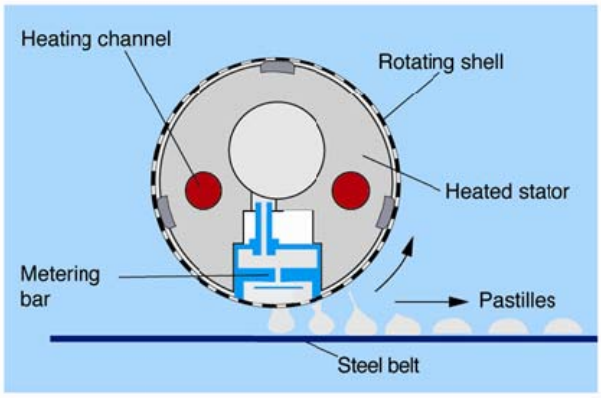


Fig 2: Rotating shell delivers droplets of the required size

Picture 1: Ammonium nitrate pastilles on the steel cooling belt

The rotating shell contains rows of small holes which are sized to deliver the melt onto the belt in the required product size. As the belt travels along the system, cooling water sprayed against the underside of the belt absorbs the heat released from the melt – and transferred via the steel belt – during crystallization and cooling. The water is collected in pans, cooled in a cooling system (cooling tower) and reused over and over again.

As well as enabling continual recycling of cooling water, this indirect cooling method also means there is absolutely no risk or cross-contamination between product and cooling medium; the cooling water cannot come into contact with the ammonium nitrate, and vice versa.

ACCURATE TEMPERATURE CONTROL

It is well known that ammonium nitrate (33.5 %) has a critical temperature at 32.2 oC. At this temperature, the crystalline structure of ammonium nitrate is rhombic system 4, which changes to rhombic system 3 if the temperature exceeds this temperature. In addition, it will change to tetragonal system 5 if the temperature falls below -16.8 oC. These changes in crystalline structure lead to disintegration of the product after a few cycles around these temperatures and increase the tendency to caking.

Table 2
Crystal structures of Ammonium Nitrate

System	Temperature (°C)	State	Volume change (%)
-	>169.6	liquid	-
I	169.6 to 125.2	cubic	+2.1
II	125.2 to 84.2	tetragonal	-1.3
III	84.2 to 32.3	α-rhombic	+3.6
IV	32.3 to −16.8	β-rhombic	−2.9
V	−16.8	tetragonal	-

The Sandvik Rotoform enables efficient and extremely accurate control of product temperature by the simple means of setting the right cooling water temperatures at the cooling belt areas.

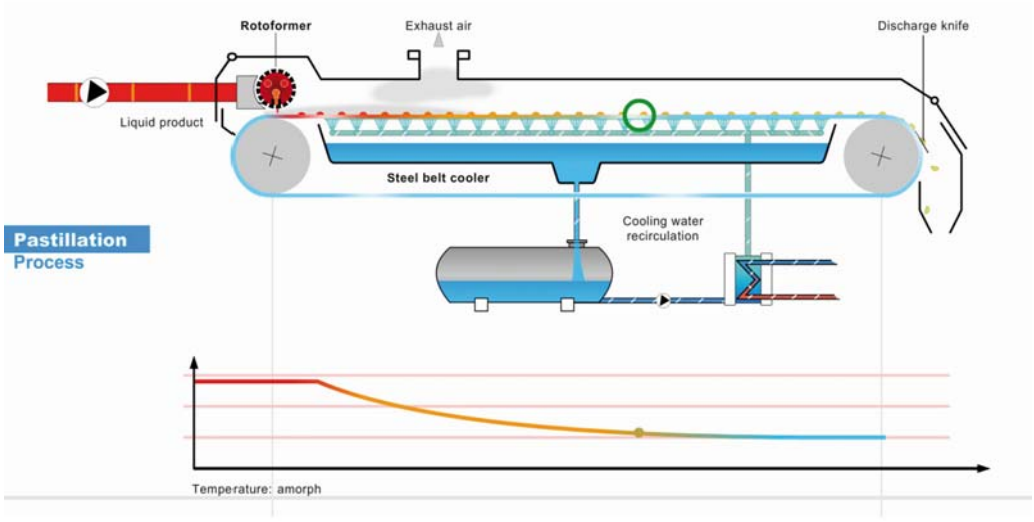


Fig 3: Precise temperature control with Rotoform

After solidification, the pastilles are released smoothly from the steel belt via an oscillating scraper. The product then falls directly onto a conveyor belt for transfer to storage. The section above the moving steel belt is enclosed with a hood and vented to an existing vent system.

There are no large air flows involved in this technology and there is no visible ammonium nitrate dust emission. Should ammonia vapours be produced, these can be easily captured in a simple atmospheric absorber; this results in negligible emissions of ammonia and dust, a unique feature of this technology.

Picture 2: Rotoform skid mounted equipment showing the hood that captures any ammonia and dust emissions

Picture 3: Front view of installation of four Rotoform units.

The size of the Rotoform product is same as for granules, and can be easily varied between 1.5 and 4.0 mm. The pastilles are extremely uniform, even more so than granules. It goes without saying that the Rotoform product quality is significant better than prills; experience has shown that farmers who have applied the pastilles were very satisfied and prepared to pay a premium price compared with prills.

Picture 4: Farmers prefer pastilles to prills

Using Rotoform solidification, with a typical capacity of some 125-150 mtpd, it is possible to produce all kinds of specialty ammonium nitrate and NPK products. The following products have been all been produced on Rotoform systems:

- Fertilizer grade urea
- Technical urea for urea-formaldehyde, melamine, ad blue production
- Urea blended with macro nutrients
- Urea blended with micro nutrients
- Urea with ammonium sulphate
- Ammonium nitrate
- Ammonium nitrate derivatives (KCl, Zeolite, AS < 10% and NPK)
- NPK complex fertilizer from nitrate & ammonium nitrate route
- Calcium nitrate based on special melts prepared by customers
- Magnesium nitrate
- Sulphur bentonite
- Sulphur bentonite and zinc

Following is a reference list of Rotoform technology used for fertilizer products

Table 4: Rotoform reference list

Year	Plant capacity	Company/ location	Status	Product/application
2000	1 Flaker	KEMIRA / Dubai	Operational	Urea + phosphates / Fertilizer
2000	1 Rotoform 120 mtpd	ESSECO / Italy	Operational	Sulphur bentonite / Fertilizer
2002	1 Rotoform 120 mtpd	Coogee / Australia	Operational	Sulphur bentonite / Fertilizer
2004	1 Pilot unit, Rotoform	PCS / Tennessee, USA	Operational	Fertilizer urea / technical urea
2005	1 Rotoform 120 mtpd	Coromandel / India	Operational	Sulphur bentonite / Fertilizer
YEAR	PLANT CAPACITY	COMPANY/ LOCATION	STATUS	PRODUCT/APPLICATION
2006	5 Rotoforms 300 mtpd	PCS / Georgia, USA	Operational	Technical grade urea
2006 till 2009	4 Rotoforms 240 mtpd	Zlotniki / Poland	Operational	Mg-N + CaN / Fertilizer
2008	Pilot production unit 125 mtpd	YARA. / Brunsb. Germany	Pilot	Urea +10%S / Fertilizer urea
2008	1 Rotoform 120 mtpd	ACRON / Velikiy Novgorod / Russia	Operational	Technical and fertilizer urea
2010	1 Pilot Rotoform + dosing, mixing & grinding	Petrobras Sergipe / Brazil	Pre commissioning	Urea + additives / Urea based fertilizers
2010	Rotoform + mixing and grinding 200 mtpd	Azomures Romania	Commissioning	AN with ingredients / Fertilizer
2010	Rotoform + dosing, mixing & grinding 200 mtpd	Azomures Romania	Commissioning	NPK with ingredients / Fertilizer
2011	2 Rotoforms 240 mtpd + down stream	SABIC Al Bayroni / KSA	Installation	Technical grade urea

The production process of these specialty fertilizer products is fairly simple and straightforward. In some cases one simply injects a liquid additive in the melt, in others a blending unit is applied to grind and mix the solid additives in the melt.

For example, for urea plus ammonium sulphate, urea melt and solid AS are mixed and ground in two steps in a blending unit (a standard packaged unit). Up to 40% wt. AS has been mixed with urea with excellent results.

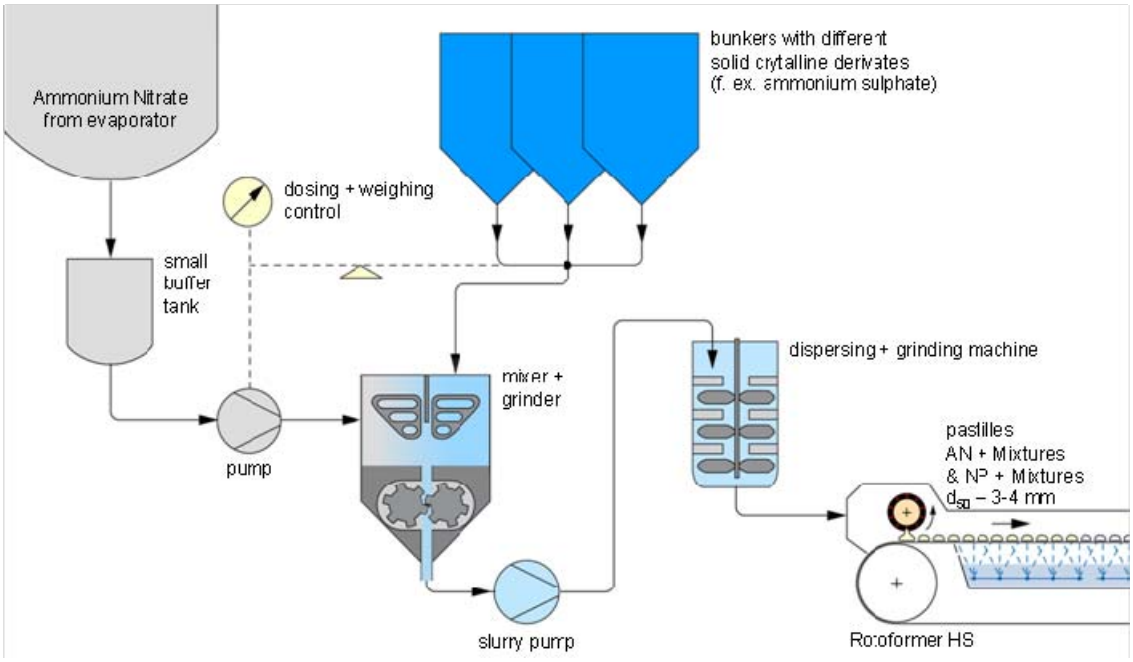
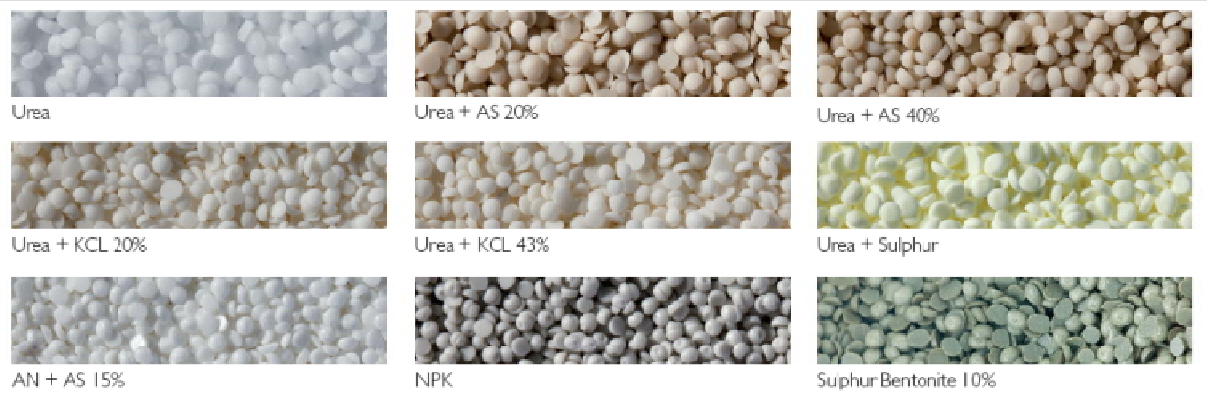


Fig 3: Flow scheme to produce urea+AS

Picture 5: Blending unit to produce urea/AS

The introduction of specialty ammonium nitrate products can be achieved smoothly and easily, requiring just a single Rotoform line which can be brought into and out of production whenever required. When market demand increases, additional lines can be installed in parallel. The pictures below show various specialty products.



Picture 6: Various Rotoform fertilizer products

4. Validation tests

The finishing sections traditionally used in the production of ammonium nitrate and ammonium nitrate based fertilizer products – i.e. prilling towers and granulation sections –typically have minimum capacity of 500 to 1000 mtpd. With the Sandvik Rotoform, the capacity of a single line is about 150 mtpd. However, as multiple lines can be installed in parallel, it is possible to achieve much higher capacities and – importantly – vary production in response to market demand.

Although the performance and reliability of Rotoform was proven and recognized in relation to sulphur and urea processing, no Rotoform line had previously been installed for pure ammonium nitrate or ammonium nitrate based NPKs.

Understandably, Azomures therefore wanted to undertake a validation process to ensure that the company's investment in Rotoform was the right one, and that the exact process and operational data for each product would be readily available at the full scale commercial start up.

Moreover the production of different mixtures of ammonium nitrate and ammonium nitrate-based NPKs during validation tests would provide a series of special fertilizer products, with which market testing could be carried out. By doing so, Azomures was able to streamline long term marketing strategy during the implementation of commercial scale project.

Over the course of few weeks, Azomures will be able to validate the following products:

- ✓ Ammonium sulphate/nitrate – by feeding solid ammonium sulphate to the ammonium nitrate melt
- ✓ Urea/ammonium nitrate – by using AN and urea melts
- ✓ Non-detonating grade AN – by feeding anti-detonation agent to AN melt
- ✓ CAN – by feeding dolomite to AN melt
- ✓ NK 21-0-21 – by feeding MOP to AN melt
- ✓ Higher K_2O containing NPK fertilizers – by adding higher quantities MOP to AN melt
- ✓ Flexibly to produce other more exotic NPK formulations – by adding higher quantities of P_2O5 as MAP and/or K_2O as MOP

5. Project details and status

After the successful validation tests on a pilot scale Rotoform line, Azomures decided to install two commercial scale Sandvik Rotoform HS 2000 lines.

Delivery time for the two Sandvik Rotoform HS 2000 lines was only eight months. Six weeks were needed to install the two Rotoform lines and over the next three months Azomures would produce several batches of different products on these units.

After six months, Azomures would decide to install an additional 17 Rotoformer HS 2000 lines to convert its total product capacity into Sandvik Rotoform. The delivery time for two trains of six Rotoformer HS 2000 lines – each with a mixing unit – was only nine months. The final train of Rotoform HS 2000 lines with mixing unit will be delivered in twelve months.

By October 2011 the two Rotoformer lines had been delivered and installed at Azomures. The commissioning phase has been started and commercial production is expected in March 2012.

6. Benefits to Azomures of Sandvik Rotoform solution

The installation of Sandvik Rotoform as finishing technology for Azomures' ammonium nitrate plant will bring the following benefits:

- ✓ Ability to produce specially customized, premium quality fertilizer products
- ✓ Flexibility in production in order to meet market demand for each of these products
- ✓ Ability to undertake market introduction and field trials in parallel with implementation of commercial scale capacity
- ✓ Significant reduction in emission figures
- ✓ Easy operation and maintenance due to small footprint
- ✓ 100% availability through the use of parallel extra line

References:

1.Revamping of an AN/CAN prilling plant to produce a granular product of high quality, Pan and Dimitri Orphanides, Orphanides Consultants, Greece, 2000 IFA Technical Symposium, New Orleans, USA

2.Inorganic Chemical Industry, Ammonium Nitrate (7/93), p. 8.3-1 to 8.3-9

3.Guidance for the storage, handling and transportation of solid mineral materials, EFMA, April 2007

4.The Uhde Pugmill Granulation, the process for safe and reliable production of CAN and other AN based Fertilizers, Peter Kamermann, 2006 IFA Technical Symposium, Vilnius, Lithuania