The Urea Rotoformer: Upgrading your urea product

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Summary

The Rotoform process offers high flexibility in urea production and offers opportunities to add additional value to your existing urea products against low investment and operational costs, low energy consumption, negligible emission figures and a premium product quality. One or more Rotoform units can be added in parallel to any existing finishing section at any time. The Rotoform process is a good technical and economical method of debottlenecking or revamping existing urea finishing sections, for example tom reduce dust and ammonia emissions. Furthermore, it is possible to add additional value to the product by producing urea technical urea or specialty fertilizers in a parallel line. All kind of different macro, secondary and micronutrients can be added to urea and easily and in a flexible way being produced in a Rotoformer. Urea with Sulphur, Ammonium Sulphate, Sulphur with bentonite and many other macro and micro nutrients can be produced at any required capacity, allowing you to offer your customers a flexible and customized product portfolio. For new grass root urea plants Rotoformer technology offers besides the significant advantages such as negligible emission figures and low investment and operational costs, also other advantages such as the Rotoformer is proven for urea applications, there is no risk for large scale applications as it is simply several units in parallel. The large scale application has been proven for Sulphur (46 units in parallel). One adds one or two units extra in parallel to enable regular maintenance of each unit and to assure an availability (on stream time) of 100% (365 days a year).

Table of contents

1. Introduction

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2. Market segments

1. Urea fertilizer
Rotoform-produced urea has already been used as fertilizer and distribution tests and practical experience has proven that the quality is significantly better than prills. Rotoform has also proven to be the best choice in sulphur fertilizer production. Key advantages are low dust and ammonia emission, high flexibility and low investment and operation costs.

2. Technical urea
Technical urea quality typically means urea with no formaldehyde applied for urea resin production, Ad Blue (NO_X reduction), cattle feed, pharmaceuticals, etc. This market is growing faster than the fertilizer market as more and more clients are interested in diversifying their product range.

3. AS/urea fertilizer or other derivatives
AS/urea or UAS is a growing market in the fertilizer field. More and more urea manufacturers are shifting from bulk towards specialty fertilizer production by adding micronutrients, ammonium sulphate, sulphur or others.
Furthermore, the Rotoform UAS process can provide the perfect solution for handling the byproduct of ammonia emission reduction technologies with sulphuric acid for prilling and granulation plants.

3. Plant modifications required for Rotoform urea process

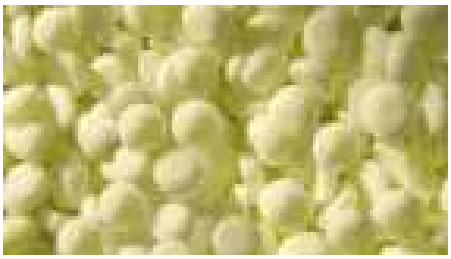
Rotoform-based urea pastille production has been proven with 99.6 wt% urea melt feed, the same as that used for feeding prilling towers. Debottlenecking of existing prilling towers by means of a Rotoform unit does not require any modifications to the evaporation section.
Some clients operate Uhde Fertilizer granulations and have only 96 wt % urea melt available.
Others operate a Stamicarbon granulation and have only 98.5 wt % urea melt. These clients would need to modify the evaporation section to produce 99.6 wt % urea melt. Solid handling and storage facilities for the pastilles might also be needed.

4. Correction of sulphur deficiency via the Rotoform process

Sulphur is vital for life and essential for plant growth, yet sulphur is now deficient in most of the agricultural areas of the world. This deficiency can be corrected by:
- pastillation of urea mixed with elementary sulphur
- pastillation of urea mixed with ammonium sulphate
- pastillation of sulphur mixed with bentonite

4.1 Pastillation of urea with elementary sulphur

The Rotoform process is the same as described in paper 2010 03 Baeder SPS UreaKnowHow.com Rotoformer Pastilles the Sustainable Premium product and the 99.6 wt% urea melt will be supplied from the existing urea melt pumps.



The liquid sulphur will be dosed into the urea melt directly before entering the Rotoformer. It will be atomized and mixed with an ultrasonic device. A constant liquid mixture of 92 % urea + 8 % sulphur will be achieved by exact dosing and mixing of the feeds into the Rotoformer system.
The formed US droplets of the mixture will crystallize on the steel belt, creating very hard pastilles with a content of 42 % N and 8 % S and displaying ideal storage behavior (no caking).
After the pastilles have been distributed on the soil, bacteria will transform the very fine elementary sulphur particles into sulphate. Because of the insolubility of elementary sulphur in water, this fertilizer is considered a slow release product with high anti-caking behavior.

4.2 Pastillation of urea with ammonium sulphate

The preparation of the mixture of 99.6 wt% urea melt with, for example, 50 % ammonium sulphate (solid particles) will take place in an inline mixer installed upstream of the Rotoformer.

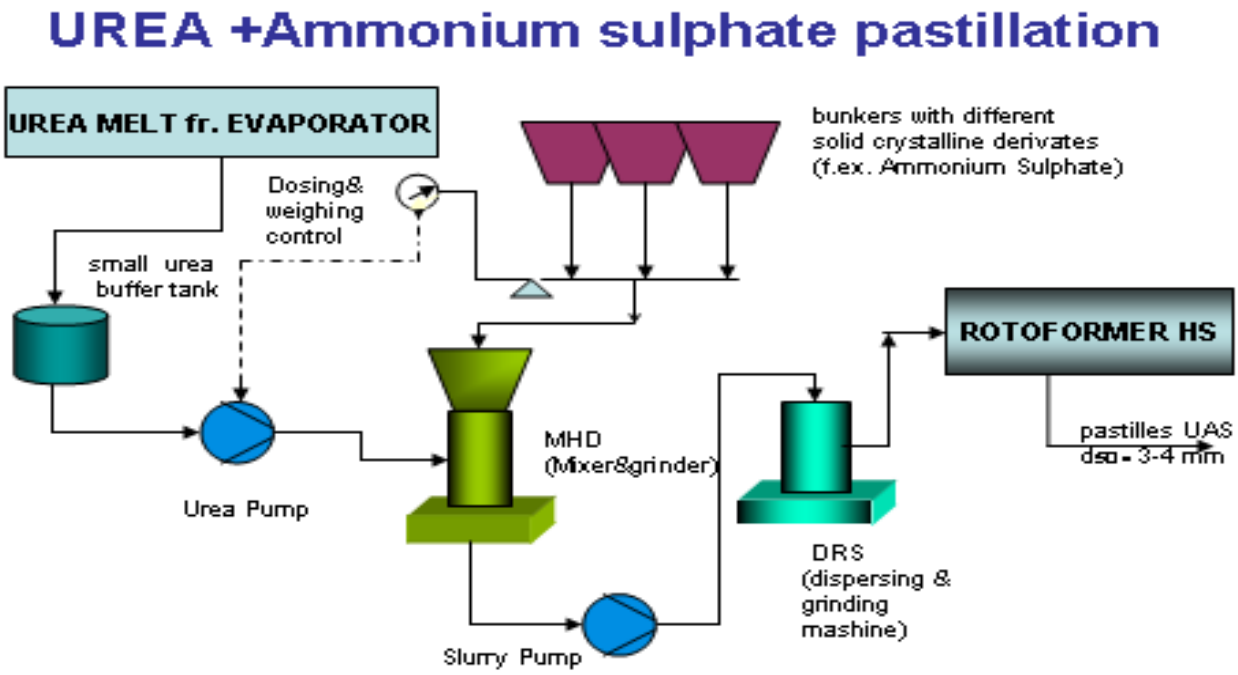


Figure 1: Process flow diagram for UAS production

The ammonium sulphate will be added in the form of powder or fine particles (< 2 mm) in the mixer via a dosing system. The dosing system can be adjusted as desired for various mix ratios of urea and ammonium sulphate (70:30, 60:40, 50:50 etc).

Picture 1: Two mixing & grinder units

The inline mixer & grinder unit will mix the urea melt and particles of ammonium sulphate and, at the same time, will grind the larger sizes. In order to avoid plugging of the Rotoform, the particles of ammonium sulphate should be max. 200µm.
The final UAS pastilles are very hard, dust free and have a very low caking tendency. The product can be bagged immediately.

4.3 Pastillation of sulphur with bentonite

There are currently more than twelve Rotoformer plants around the world making use of this technology to produce sulphur bentonite pastilles (granules are not used in this market); these are then distributed directly onto the field by the farmers.

The process description is similar to that for urea and ammonium sulphate, but uses a mix of 90% of liquid sulphur and 10% bentonite powder. The final product is very hard, dust free and has a no caking tendency.
Bentonite will swell up to 11 times its original volume when wet so,

when applied to a field, each pastille will explode into very fine particles of elementary sulphur which bacteria in the soil then transforms into sulphate.
The design of the Rotoformer unit itself remains essentially unchanged for all applications with mixed products, so the customer gains the ability to produce different kind of fertilizer products with the same machine.

5. Pastillation of urea with other macro and micro nutrients

By using the scheme as illustrated above numerous different kinds of fertilizer can be produced with the Rotoformer. Following are just some of the mixtures that have been successfully tested: Urea+ S; U+ AS; U+ KCL; U+ boron; U+ Cu; U + P_2O_5, U +K_2O etc.
The solid additives have been mixed in the urea melt in a range of 2% to 50%.
The production of mixed fertilizers via a Rotoformer is reliable and delivers a stable production without any plugging or interruptions.
The mixed fertilizer is very homogenous, has a high crushing strength and is less caking.

In 2009 Petrobras in Brasil has performed successful tests for mixing urea with other macro and mico nutrients such as P_2O5, K_2O and micronutrients (ZnO etc). Petrobras bought one Urea Rotoformer line including mixing/grinding unit and expects to start operation in March 2011. Petrobras intends to produce urea based mixed fertilizers and also to develop new kind of fertilizers with this plant.

6. Pastillation of pure urea

With the Rotoformer it is also very well possible to produce pure urea, so urea without formaldehyde, which finds its application in technical urea, cattle feed or AdBlue (SCR). The uniform large size products enable the handling of this product without too much caking risks.
Several Rotoformers are already in operating for these applications.

7. References of the Rotoform urea process

More than 1500 Rotoformer units are installed since 1983.

More than 450 units are for Sulphur and more than 30 units for urea, magnesium nitrate, calcium nitrate, sulphur bentonite etc.

The development of the Rotoform for the urea process started nearly ten years ago.

First small scale experiments at the test facilities of Sandvik Process Systems in Fellbach, Germany provided encouraging results.

Small pilot commercial runs were later carried out at SKW Piesteritz in Germany.

PCS in the USA have been successfully operating five Rotoform units for urea for more than four years.

In December 2007, trials involving the addition of elementary sulphur (8%) to the urea melt were successfully carried out on a commercial Rotoform line at Yara Brunsbüttel in Germany and the quality of the S-Urea pastilles is very good. The Rotoform plant at Yara has been also used for production of fertilizer urea and technical urea, which quality has been very much appreciated by the German farmers en even worth a premium price as the hardness and size was better than prills and the pastilles did not show any caking problems.

Picture 2: German farmer with Urea pastilles are willing to pay premium prices

Acron in Russia is installing two Urea Rotoformer lines as part of their debottlenecking project, which will start operation in Q2 2010

In 2009 Petrobras in Brasil has performed successful tests for mixing urea with other macro and mico nutrients such as P_2O5, K_2O and micronutrients (ZnO etc). Petrobras bought one Urea Rotoformer line including mixing/grinding unit and expects to start operation in March 2011. Petrobras intends to produce urea based mixed fertilizers and also to develop new kind of fertilizers with this plant.

More than 450 Sulphur Rotformer lines are in operation, also in large scale applications. For example Shell Canada has 46 lines in operation in parallel since1993 producing 6000 mt/day during 365 days a year !

Picture 3: Shell Canada has 46 Rotoformer lines in operation producing 6000 mtpd during 365 days a year

Rotoform-based sulphur bentonite plants are in operation at a number of different fertilizer companies including: Esseco/Italy, NEAIS Saud Arabia, Coromandel Fertilizer/India, Martin Resources /USA, Montana/USA, Coogee/AUS. New plants at Kanghiran /Iran and Ilam /Iran (both 600 ton/day) are under construction.

Several urea producers are currently evaluating the Rotoform process and soon we can expect more Sandvik Rotoform pastilles to enter the market.

7. Conclusions

The Rotoform process offers high flexibility in urea production and offers opportunities to add additional value to your existing urea products against low investment and operational costs, low energy consumption, negligible emission figures and a premium product quality. One or more Rotoform units can be added in parallel to any existing finishing section at any time. The Rotoform process is a good technical and economical method of debottlenecking or revamping existing urea finishing sections, for example tom reduce dust and ammonia emissions. Furthermore, it is possible to add additional value to the product by producing urea technical urea or specialty fertilizers in a parallel line. All kind of different macro and micronutrients can be added to urea and easily and in a flexible way being produced in a Rotoformer. Urea with Sulphur, Ammonium Sulphate, Sulphur with bentonite and many other macro, secondary and micro nutrients can be produced at any required capacity, allowing you to offer your customers a flexible and customized product portfolio. For new grass root urea plants Rotoformer technology offers besides the significant advantages such as negligible emission figures and low investment and operational costs, also other advantages such as the Rotoformer is proven for urea applications, there is no risk for large scale applications as it is simply several units in parallel. The large scale application has been proven for Sulphur (46 units in parallel). One adds one or two units extra in parallel to enable regular maintenance of each unit and to assure an availability (on stream time) of 100% (365 days a year).

Enclosure: Fertilizer elements

(source: www.uralchem.com)

Macro-elements

Application rate 30-300 kg/ha (of active material):

- N = nitrogen (consumed in form of $(NO_3)^-$ and $(NH_4)^+$ ions;
- P = phosphorus (consumed in form of (H_2PO_4));
- K = potassium (consumed in form of $(K)^+$ ion).

Nitrogen

- Nitrogen is the main protein (building) element necessary for development of plants and animals.
- It determines and speeds up the growth of plants' vegetative part
- It is necessary for root system, stalk, foliage development, as well as to form the reproduction organs, seeds and fruits.
- Nitrogen should be available to plants through the whole growing process
- Lack of nitrogen reduces the output and the quality of the final product.
  - Protein and fat content decreases
  - Plants grow unhealthy and small
  - The volume of harvest decreases

Crops that require higher doses of nitrogen:

- All grain-crops
- Corn
- Fodder crops
- Renewable meadows and pastures

In fertilizers nitrogen is usually present in 2 forms – nitrate and ammonium.

Ion formula	Universal name	Fertilizers that contain the ion	Availability for plants
$(NO_3)^-$	Nitrate	Ammonium nitrate, ammonium nitrate limestone, urea and ammonium blend, nitrogen sulphate, complex fertilizers (based on ammonium nitrate)	Immediate effect Easily travels through the soil Easily flammable
$(NH_4)^+$	Ammonium	Ammonia, ammonium sulphate, urea and ammonium blend, complex fertilizers (based on ammonium nitrate), nitrogen sulphate	Available but has a more prolonged effect due to adsorption on soil particles, consequently becomes available and absorbed by plants
$(NH_2)^-$	Amide	Urea, urea and ammonia blend, complex fertilizers (based	Unavailable to plants

		on urea)	However due to soil microorganisms activities NH_2 restores to NH_4. The reaction speed depends on the soil temperature (>+12) Doesn't leach
$(CN_2)^-$	Cyanamide*	Calcium cyanamide	Unavailable to plants CN_2=>NH_2=>NH_4 Restores due to the activities of microorganisms. The reaction speed depends on the soil temperature (>+12) Doesn't leach

* Not in fact used in agriculture.

Phosphorus

- Supplies any reactions (fission, fusion) inside cells with energy
  - improves nitrogen nutrition (a plant spends 2 phosphorus molecules to to assimilate nitrogen from NO_3);
  - supplies energy for seed germination;
  - secures rapid growth and development of root system;
  - accelerates ripening;
  - is necessary for reproduction.
- Forms the new harvest:
  - The volume of the future harvest (amount of seeds) is determined during the first weeks of a seedling's development. If a plant doesn't receive the necessary amount of phosphorus, it will form the number of seeds using the available nutrition only. This is the natural species maintenance: the plants tent to produce the least amount of seeds, which will however be strong and able to produce healthy seedlings. It is impossible to change the negative effect caused by the lack of phosphorus in any subsequent stages of a seedling's development.
- Improves the quality of the final product:
  - Increases the sugar and carotene content.

Crops that require higher doses of phosphorus fertilizers:
Vegetables, leguminous plants, roots.
Phosphorus travels very little through the soil and easily interacts with soil. particles generating new compounds and taking forms not available for plants. This is why the efficiency of phosphorus fertilizers does not usually exceed 15-22 %.

Plants assimilate phosphorus in form of (H_2PO_4) anion
According to the degree of availability for plants phosphorus fertilizers are differentiated as:

- Water soluble phosphorus fertilizers:
  - Simple superphosphate
  - Triple superphosphate
- Partly soluble in water and weak acids soluble:
  - superphosphate (23-26% P_2O_5).
- Soluble in weak acids:
  - dicalcium phosphate
  - precipitate

- soluble in strong acids:
- Very little available for plants, effective for use on humid and acid soils:
    - Phosphorite powder(30% P_2O_5).

Potassium
Potassium is responsible for the intensity of nutrients assimilation, increases the resistance to fungal diseases and dry weather, secures the effective assimilation of nitrogen and phosphorus, improves the quality of final agricultural production.

In plants potassium regulates the following functions:

- Effectiveness of water consumption (turgor, resistance to dry weather);
- Circulation of water and nutrients inside the plant (ripening);
- Sugar transportation (accumulation of nutrients);
- Protein synthesis;
- Starch generation.

Crops sensitive to the lack of potassium:

- Potato, white beet, carrot, sunflower, soy.

Kinds of potassium fertilizers:
Potassium chloride – 40-60% K_2O:

- Used for most crops on almost all soils;
- Applied mostly in fall with major application.

Potassium sulphate – 50% K_2O:

- Applied in fall, in spring and before sowing;
- For chlorine-sensitive crops (potato, buckwheat, essential oil plants, fruits and berries, vine).

Potassium metaphosphate and potassium nitrate

- For fertilization in greenhouses and additional nutrition by irrigation.

Secondary elements

Application standard: 1-30 kg/ha (of active material)

- S = sulphur (consumed in form of ion $(SO_4)^{2-}$);
- Ca = calcium (consumed in form of ion $(Ca)^{2+}$);
- Mg = magnesium (consumed in form of ion $(Mg)^{2+}$).

Sulphur

Second protein element

- Sulphur deficit causes weak development which leads to a lower yield. Sulphur is necessary for the growth and development of every crop;
- Plants consume a volume of sulphur equal to the volume of consumed nitrogen;
- Sulphur is the basic element that increases protein and oil content in agricultural crops;
- Improves resistance to:
  - diseases;
  - low temperatures;
  - dry weather.

Sulphur-sensitive crops:

- Oil-bearing crops, grain crops, vegetables, rape, mustard, summer rape, corn, sunflower.

Calcium

Calcium is an important component of cell walls and an integral component of chromosomes; its application helps to strengthen the stems of grain crops and reduces losses during roots storage.

In leguminous crops calcium takes part in sugar transportation process and organic acids neutralization process.

Calcium is the basic regulator of enzyme activity which in its turn secures the assimilation of other nutrients (especially nitrogen).

Calcium is essential for:

- Root system growth;
- Protection against damage during harvesting.

Plants are able to assimilate calcium from gypsum, lime and calcium chloride.

Calcium is usually applied together with lime on acid soils in order to reduce the toxic effect of aluminum ions in soil solution.

Crops that give positive reaction to calcium application:

- Vegetables, fruits, berries, soy.

Magnesium

Magnesium is the central atom of chlorophyll molecule.

As it is the central atom of chlorophyll molecule, magnesium is responsible for turning carbon dioxide into organic compounds with emission of oxygen.

Light soils with a low content of exchangeable cat-ions may not satisfy the demand of a plant for magnesium. In this case compounds of magnesium in the form available for plants are entered in the soil.

Magnesium plays a part in:

- Nitrogen assimilation;
- Protein accumulation.

Plants can consume and assimilate magnesium from various kinds of fertilizers:

- Fast-response:
  - Magnesium sulphate;
  - Potassium-magnesium.
- Slow-response:
  - gypsum (magnesium carbonate).

Crops sensitive to lack of magnesium:

- grain crops, potato, soy.

Micro-elements

Application standard: 50-1000 g/ha (of active material)

Microelements, the same as other factors, are responsible for the volume of harvest and its quality.

Microelements are subdivided into:

- 5 metals (consumed by plants in the form of bivalent cat-ions or in form of chelates):
  - Fe = iron;
  - Mn = magnesium;
  - Zn = zinc;
  - Cu = copper;
  - Mo = molybdenum (assimilated in form of ion $(MoO_4)^{2-}$).
- 2 nonmetals:
  - Cl = chlorine, consumed by plants in form of ion $(Cl)^-$ (essential for some crops, takes part in osmotic pressure regulation and increases resistance of plants to some fungi;
  - B = boron, consumed by plants in form of $(H_2BO_3)^-$;
- Specific microelements essential for some crops:
  - Na = sodium $(Na)^+$ (in some crops (white beets) can partly replace potassium
  - Si = silicon (used in form of silicate, increases the grain crops stem strength, reduces lodging);
  - Co = cobalt (necessary first of all for leguminous plants for better nitrogen fixation).

Microelements can be applied both as a complex fertilizer component and an an independent fertilizer.

Various crops are sensitive to the lack of certain microelements:

- Grain crops : Cu and Mn;
- Corn: Zn;
- Grain legumes: B, Mo and Co;
- Oil-yielding crops: B;
- White beet: Mn, B, Na;
- Potato: B and Cu;
- Rice: Zn;
- Cotton: Mn, B and Zn.