International Fertilizer Industry Association

IFA Technical Conference

Chennai, India

24-27 September 2002

International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
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PROCESS TECHNOLOGY OF UREA - BASED NPK AND PRACTICAL EXPERIENCE OF INDUSTRIAL PLANTS (a)

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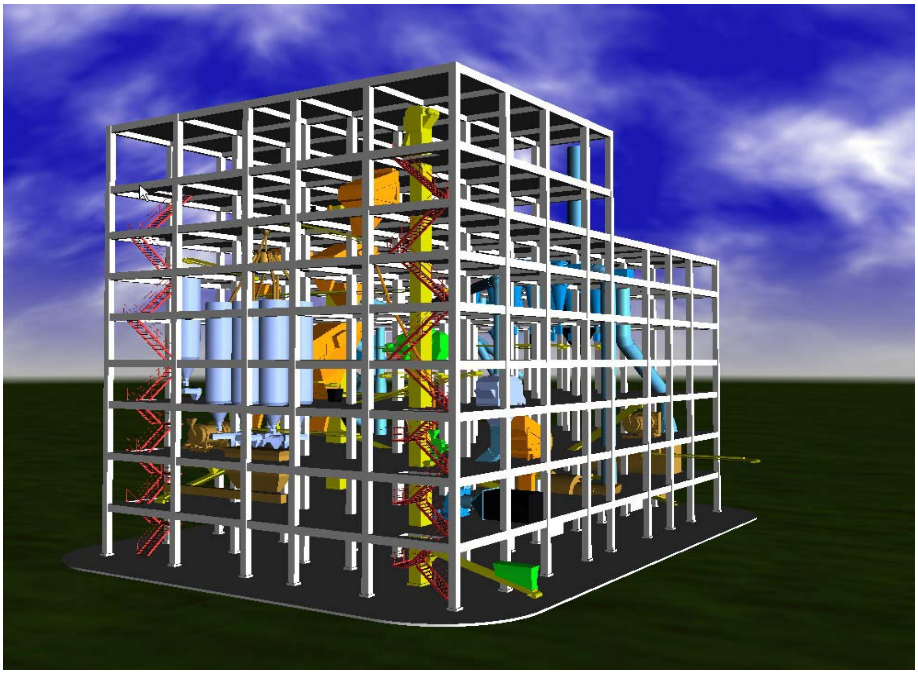
1. Abstract

Urea is a major source of nitrogen, especially in Asia, and the tendency today is to increase its use in compound fertilizers. However its introduction in a NPK process usually results in a significant decrease in production quantity and quality (poor crushing strength,) as well as numerous operating problems (plugging, screen blinding,).

Kaltenbach Thüring (KT) has developed its own granulation process, which is adapted for high urea ratio in NPK granulation.

KT has already designed five such plants in Asia, and the largest one, Zhongyuan Dahua, is already in operation. The design capacity is 300 000 MTPY and a second identical line in parallel is already scheduled.
This process is especially convenient for any urea producer who would like to diversify its activities into the production of complex fertilizers.



3-D Layout of a 1000 mtpd NPK Plant

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2. Urea in NPK Fertilizers

The use of urea in compound fertilizers represents obvious advantages:

- urea is a cheap and widely available nitrogen source
- urea has a high nitrogen content, compared with ammonium nitrate or ammonium sulphate. Thanks to the use of urea, high grade NPK's like 19-19-19 can be reached, whereas ammonium nitrate does not allow more then 17-17-17 and ammonium sulphate 14-14-14.
- urea is safe, it has absolutely no explosive hazard.

However the introduction of urea in compound fertilizers induces specific problems, mainly:

2.1 During storage and use

The granules of urea based NPK are quite hygroscopic and require special care for storage (air conditioning, bagging…)

2.2 During the manufacture of the product itself

Due to the high hygroscopicity and sensitivity to temperature among urea based NPK's, the drying step is critical and more difficult, compared with other NPK.

Moreover, the introduction of urea makes the handling, screening, crushing difficult because that kind of product tends to be soft and plastic during manufacturing.

Further, the introduction of urea in a NPK granulation may rapidly result in many operating problems such as plugging, blockages, etc, a significant decrease of the production rate and finally, poor quality of the end product. Typically the hardness may fall as low as 0.5 kg or less, resulting in a non marketable product.

If the introduction of urea is not fully understood, it leads to disappointing results thus creating a producers impression that among the urea is an unsuitable raw material.

3. KT Process

According to the availability of raw materials, KT has developed different processes adapted to the introduction of large amount of urea in the formulation.

- For phosphoric acid producers: at the liquid phase and with the heat for the granulation is a slurry of ammonium phosphates, typically synthesized in a KT pipe reactor, discharged directly into the granulator. In such a case, urea is introduced as prills.
- For urea producers: direct use of urea solution in liquid phase in the granulator and P2O5 is introduced in a solid form, typically powdered MAP or TSP.

KT has already designed five urea based NPK plants in Asia, all of them are based on urea solution use. However two of them wanted the possibility to use phosphoric acid as raw material. A pipe reactor was installed in the granulator and subsequently two stages of fluorine/ammonia scrubbing were added.

Zhongyuan internal study has established that the use of phosphoric acid was not economical in their case. The plant has therefore been designed on the basis of urea solution use, according to KT process. This process is described hereafter:

3.1 Raw materials preparation

Due to the recycling rate in the granulation process as well as the long residence time, the analysis of the nutrients contained in the final product is used mainly to state the quality of the granules and does not allow an efficient correction of the flow rate of the raw materials. Therefore getting the desired formulation requires careful dosage at the inlet of the plant.
Thus KT prefers, to dose the solids raw materials, the principle of batch weighing, chosen for its accuracy and reliability, in comparison to belt weighers, where accuracy is much lower and requires frequent adjustment.
The different raw materials are discontinuously extracted from their own storage bins into a common weighter. The quality of the formulation is ensured by the accuracy of the batch weighing; the quantity is ensured by the weight and the frequency of batch operations.

3.2 Process loop

The granulation is an agglomeration type, the different solids raw materials being cemented by the crystallizing urea solution sprayed onto the rolling bed.
The granules fall directly into a large dryer where most of the drying takes place. However the granules at the outlet of the dryer cannot be submitted to strong handling yet, as they are still soft and too plastic. Such a product would rapidly blind the screens and give a poor crushing efficiency, resulting in poor quality of the seeds, which is one of the key to a good granulation.
Therefore the granules after drying are conveyed into a second rotary drum, which is the process cooler. That second drum improves greatly the physical properties of the granules (hardness, handling properties…) and it allows the product to achieve its drying under smooth conditions.
The product is then sent to the screening/crushing section; Undersize and crushed oversized are recycled to the granulator whereas the on size product is sent to the final cooling step. Part of the on-size product is recycled into the granulator in order control the recycling rate to the granulation, ensuring stable working conditions.

3.3 Final cooling and conditioning

The precooled granules are fed to a fluidised bed cooler for final cooling. The granules are then conveyed to a coating drum to be coated with anticaking agent (e.g. amine oil), in order to improve its storage characteristics.

3.4 Air loop

The total air loop is optimised by the recycle of air from one equipment to upstream one, completed with the necessary atmospheric air addition.
Thus the air blown into the Fluidized Bed Cooler is conditioned in a chilling unit, then it is recycled into the process cooler, then finally recycled into the dryer.
This air is finally sent to the scrubbing section and discharged to the atmosphere.

3.5 Scrubbing section

There are two different scrubbing sections: the process components (granulator and dryer) and the dedusting network. The two systems are independent for easier adjustment as well as to allow to dedust the plant even when the process loop is stopped.
The air from the granulator is directly sent to the wet scrubbing, while the air from dryer and from the dedusting network pass first through cyclones in order to trap most of the dust particles, then washed in a one step wet scrubber of KT Venturi type.

4. Zhongyuan Dahua

Zhongyuan Dahua is located in Puyang, Henan Province, in the center of People's Republic of China, at around 500 km south west of Beijing.
The climate is continental, cold in winter (average -3°C in January), wet and hot in summer (average 80%HR and 30°C in July), which of course has to be taken into consideration for the design of hygroscopic NPK plant like urea based.

Zhongyuan Dahua is a large fertilizer producer (prilled urea), based on local gas fields. It produces ammonia, melamine, and 520 000 MTPY of urea. They have now developed an urea-based NPK. The first line of 300 000 MTPY started up this year and a second identical line is scheduled later.

As a urea producer, Zhongyuan has been interested in introducing a maximum amount of urea in its formulation.

If urea is available at 95% concentration, the water inlets and outlets are balanced in the plant. However it was not available in Zhongyuan, and it has been decided to mainly supply the urea as an 80% solution, directly coming from the urea synthesis plant, prior to the concentration/evaporation section. In order to equilibrate the water balance of the plant, the remaining urea is fed under solid form.

As a consequence, the NPK plant allows Zhongyuan to considerably improve the efficiency of its urea prilling unit and the quality of the urea prills: Indeed,

- a part of the urea solution is taken upstream to the concentration unit, which is often a bottleneck in urea plants.
- a part of the solid urea is sent to the NPK unit to be melted and mixed together with the urea solution in order to achieve the right liquid phase to be sprayed onto the rolling bed in the granulator. For that purpose, off spec product and lumps can be used.

- a part of the solid urea is directly fed to the granulator to be agglomerated with the other raw materials and the recycled fines. For such purpose, microprills/broken prills/fines from storage are preferred (and actually used) for a better homogeneity of the NPK granules.

5. Schedule of the Project, Training

July 2000:	effective date of the contract, kick off meeting
September 2000:	delivery of the basic engineering package
Spring 2001:	start of the civil works
September 2001:	start of building erection
October 2001:	practical training by KT
April 2002:	start up of the plant

Zhongyuan Dahua was not skilled in granulation process, therefore the training of its staff was a very important step of the contract. The operators have visited different granulation plants in China to get familiar with the industrial life of a NPK plant, and finally a whole team has finalized its formation in France in KT pilot plant.
The programme took place as planned, and training has been performed on the actual raw materials to be as close as possible to the future operating conditions.

6. Plant Working Conditions

6.1 Raw materials flexibility

The plant has been designed to allow a large flexibility for the raw materials:
Urea:
80% urea solution and off spec prills/urea dust
When the plant is shutdown, the 80% urea solution becomes unavailable. Therefore the NPK plant melters capacity must be sufficient to supply the whole urea solution required for the granulation.
P2O5:
The plant has been designed to accept two main sources of P2O5, in order to face the raw materials availability and prices fluctuations: ammonium phosphate and superphosphates.
Both MAP and TSP have been used during the start up of the plant. MAP is directly fed to the common batch weigher with KCl, urea microprills, filler, etc, whereas the TSP is weighed separately since it must be pretreated to avoid unwanted reaction with urea, resulting in water release.
K2O
Standard KCl is used, but K2SO4 could also be used for chloride free production.
Filler:
The plant uses clay as well as coal ashes (large amount available from the central steam generator of the plant).

6.2 Type of formulas produced

Since the start up, different formulation have been produced. Of course this list is not exhaustive.

15/15/15 (using MAP and around 250 kg/t of urea)
15/15/15 (using TSP and around 320 kg/t of urea)
20/5/20 (using around 450 kg/t of urea)
20/10/10 (using around 450 kg/t of urea)
22/8/15 chloride free (using K_2SO_4 instead of KCl)

6.3 Product quality

(sample of 15-15-15)
Size: 90% between 2 and 4 mm
Hardness: 3.5 kg
Moisture: 0.9%

7. Conclusion

The right approach and understanding of the specific problems linked to the introduction of large amounts of urea in NPK granulation allow us to exploit the advantages of the urea and at the same time overcome its disadvantages (which have often been experienced by different plants throughout the world, leading to discouraging results).
It enables large single train granulation unit to be built, producing high quality NPK granules, both with high nutrient content and good physical properties.
Zhongyuan Dahua (China), a brand new plant with a capacity of 300 000 MTPY, designed and licensed by KT (France), is a good example.