Comparison Between the Three Most Profitable Process Schemes For Urea Mased NPK's

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Urea is a major source of nitrogen in the world. The use of urea in the production of NPKs offers substantial cost savings over other raw materials as ammonium nitrate as source of nitrogen.

KT offers three major routes which are equivalent on a cost basis. The choice will be fixed according to the client raw material capabilities (production of urea, several P_2O_5 sources, ...).

The present paper compares the three best economic routes. It demonstrates that the best way consists in using a straight concentrated urea melt which is partly diluted with the washing water from the scrubber.

A table shows the cost benefits resulting from the use of urea instead of ammonium nitrate in the production of 15-15-15 NPK in a 1000 MTPD plant.

All three processes are described technically and the main economical factors such as material costs, investment and energy consumption are compared to an AN based NPK production plant.

1- Economical Comparison of the Three Routes Versus Ammonium Nitrate Based NPK Production

The following table shows the cost benefits resulting from the use of urea instead of ammonium nitrate in the production of 15-15-15 NPK in a 1000 MTPD plant.

The formulations used for the comparison are listed in Appendix 2.

The ammonium nitrate reference takes into consideration the real situation of an existing NPK plant using ammonium nitrate solution, single super phosphate and ammonium sulphate. This plant is synthesising ammonium salts (phosphate and sulphate) in a pipe reactor.

The prices for raw material are based on the French market (see price list in Appendix 1).

Urea is supposed to be used as solution (95% urea) if the NPK plant is to be built besides a urea plant or as prills if no urea is manufactured on site (the product is supplied from the market). Urea in the solution is supposed to be at the same cost as the urea prills (dry basis).

When urea prills are used they are melted as a pure melt and immediately mixed with scrubbing solution to prevent excess formation of biuret.

TABLE 1. LIST OF THE THREE MAJOR ROUTES

	UREA SOURCE	P_2O_5 SOURCE	SULPHURIC ACID
Route n°1	95% urea solution	Solids (MAP, DAP, SSP, TSP)	as additive
Route n°2	Prills	H_3PO_4 and solids	as raw material
Route n°3	Prills	Solids (MAP, DAP, SSP, TSP)	as additive

Amortization costs are established on a difference basis. It refers to complementary equipment necessary to manufacture the product in comparison with an AN based NPK plant.

ROUTE	**Reference**	**1**	**2**	**3**
Main economical costs (FF/t NPK)	NPK (AN)	NPK (urea solution)	NPK (prills + pipe reactor)	NPK (Urea melter)
Raw materials cost (France basis - October 99)	827	726	714	726
Amortization difference (FF/t) versus the reference	0,0	3,1	15,3	5,0
Electrical power consumption (kwh/t)	35	45	45	45
Electrical power cost (0,35 FF/kWh)	12	16	16	16
Steam (FF/t) for urea melter	0	0	0	5,4
Fuel oil (kg/t)	13	11	7	11
Fuel oil cost (1 FF/kg FOL)	13	11	7	11
Total (FF/t)	852	755	752	763
Gain over AN based NPK (comparison with the reference) (FF/t)	0	96	100	89

2 - Production of Urea Based NPK using urea solution

ROUTE N°1

2.1 Process Description

Typically, the solids used as raw materials are : MAP, DAP, KCl, K_2SO_4, filler... and the liquid is molten urea solution. The urea solution to be sprayed in the granulator is a 95% urea solution mixed with recycled washing solution. Anhydrous ammonia and fertilizer grade sulphuric acid are used as additive to promote the granulation.

The premixed solid raw materials are introduced into the granulator through the recycled product. Urea solution is sprayed onto the rolling bed. Steam and a small amount of sulfuric acid and ammonia are added to promote the granulation. The granules fall into a dryer, cocurrently with air heated in a burner, then into a second dryer. This second drum increases the crushing strength of the granules. In order to minimize the amount of air required in the process, the air from the second dryer is dry dedusted before being recycled into the first dryer.

The granules pass through the screening section. The oversize granules are crushed and recycled with the fines and the undersize granules to the granulator. A controlled amount of on-size product is also added with the recycled product to keep the recycling flowrate constant. The on-size product is conditioned (cooling, coating) before being sent to storage.

2.2. Utilities (assuming a 1000 MTPD plant)

Electricity	:	45 kWh/t
Make up water	:	140 kg/t
Fuel oil	:	11 kg/t
Steam (mean pressure)	:	75 kg/t

2.3. Effluents Treatment

The air from the first dryer is sent to cyclones before being mixed with the granulator air in the scrubber to be efficiently washed before being sent to the atmosphere.

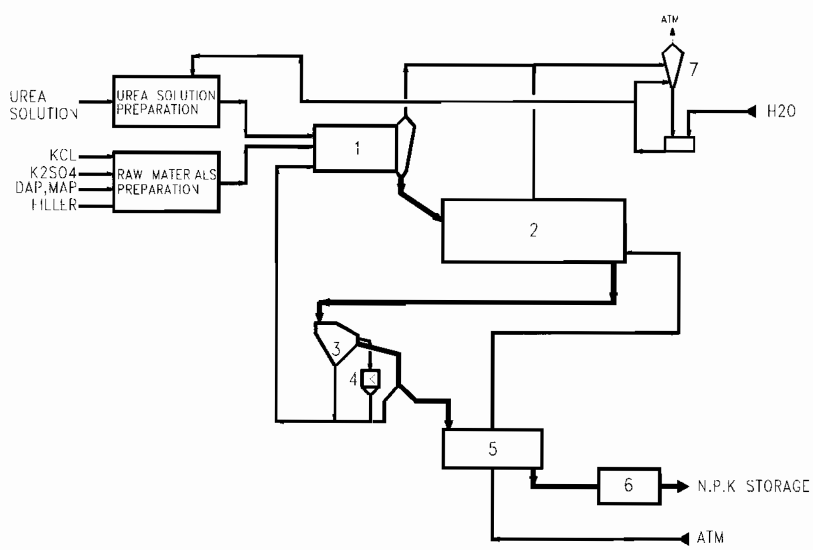
The air sent to the atmosphere typically contains:
- less than 50 mg dust/Nm^3
- less than 50 mg NH_3/Nm^3

The washing solution is totally reused in the process through the urea solution.

2.4. Final Product Characteristics

Typically a 15.15.15 (for example) :

Moisture	:	1% max.
Screen analysis	:	94% between 2.5 and 4.5 mm
Crushing strength	:	4 kg (on 2.5 - 4.5 mm granules)



1 : Granulator
2 : Drying section
3 : Screening section
4 : Crusher
5 : Cooling section
6 : Coating section
7 : Scrubbing section

3 -Production of Urea Based NPK with a Pipe Cross Reactor

ROUTE N°2

3.1. Process DescriptionS

NPK is typically made from :

- Solid raw materials such as KCl, MAP, UREA, ammonium sulfate, SSP, and a filler such as GYPSUM or SAND
- Anhydrous liquid ammonia
- Fertilizer grade phosphoric acid (at a pre ferred concentration of 54% P_2O_5)
- Sulphuric acid (concentration of 98%)

The process described is based on a three step neutralisation of ammonia :

First step	:	in a pipe reactor installed in the granulator
Second step	:	in the rolling bed of granules in the granulator
Third step	:	in the scrubbing system

Liquid ammonia for the reactor is evaporated and superheated with warm air coming from the stack. This completes the energy integration of the KT process.
All the liquids are fed through the pipe reactor where the acids react with gaseous ammonia to produce a melt of MAP/DAP/AS. The N/P ratio is adjusted to obtain a granulating slurry and to allow a very low recycling ratio (between 2 and 3).

The scrubbing solutions are fed to the pipe reactor to control the temperature of the reaction and to control the moisture of the granules exiting the granulator.

The granules exiting the granulation fall into a chute entering the first rotary dryer where heated air mixed with the warm air recycled from the second dryer ensures the main drying.

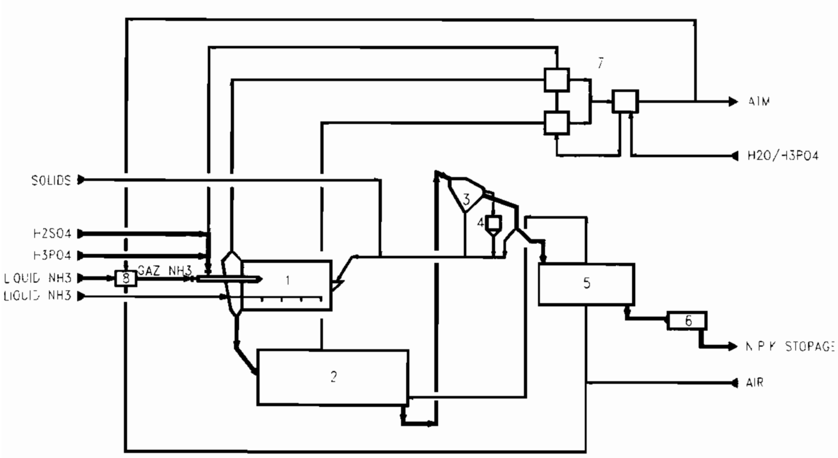
The product goes through a second dryer to continue the drying and mainly to harden the granules before being screened and crushed.

The dust collected directly at the outlet of the cyclones (air from both dryers and cooler) is recycled to the drum granulator.

The dry product is calibrated on a vibrated screen. The oversize fraction is crushed.

The undersize product is recycled to the granulator together with a controlled amount of on-size product to keep the recycling flowrate constant.
The on-size product is conditioned (cooling, coating) before being sent to storage.

The warm air from the cooling section is recycled to the second dryer, and after passing through goes to the first dryer, ensuring the total recovery of the heat.



1 : Pipe reactor and granulator
2 : Drying section
3 : Screening section
4 : Crusher
5 : Cooling section
6 : Coating section
7 : Scrubbing section
8 : NH_3 evaporator

3.2. Utilities

Electricity	:	45 kWh/t NPK (for a 1000 MTPD plant)
Process water	:	120 kg/t
Fuel oil	:	7 kg/t
Steam	:	nil

3.3. Effluents Treatment

The air from the first dryer passes through dry cyclones and is washed in a first stage scrubber. The air leaving the granulator is also washed in a separated scrubber before being mixed with the air from the dryer scrubber in a second stage scrubber.

The excess ammonia liberated in the granulator by the pipe reactor and the sparger as well as the fluorine are trapped in the scrubbing system.

The air sent to the atmosphere fulfils the EFMA BAT recommendations and typically contains :

- less than 50 mg dust/Nm^3
- less than 50 mg NH_3/Nm^3
- less than 5 mg F/Nm^3

The total amount of the scrubbing solution is pumped to the pipe reactor.

3.4. Final Product Characteristics

(based on a typical fertilizer grade phosphoric acid)

Typically a 15.15.15 (for example) :

Moisture	:	1% max
Screen analysis	:	94% between 2.5 and 4.5 mm
Crushing strength	:	6 kg (on 2.5 - 4.5 mm granules)

4 - Production of Urea Based NPK Using Urea Prills or Granules and a Melter

ROUTE N°3

4.1. Process Description

Typically, the solids used as raw materials are: urea prills, MAP, DAP, KCl, K_2SO_4, filler...

Liquid ammonia and fertilizer grade sulphuric acid are used as additive to promote the granulation.

Urea prills are melted and mixed with recycled washing solution to prepare the urea solution.

The premixed raw materials are introduced with the recycled product into the granulator. Urea solution is sprayed onto the rolling bed. Steam and a little amount of sulfuric acid and ammonia are added at optimum level to promote the granulation. The granules fall into a dryer, cocurrently with air heated in a burner, then into a second dryer. This second drum improves the crushing strength of the granules. In order to minimize the amount of air required in the process, the air from the second dryer is dry dedusted before being recycled into the first dryer.

The granules pass through the screening section. The oversize granules are crushed and recycled with the undersize granules to the granulator, with a controlled amount of on size product to keep the recycling flowrate constant. The on-size product is conditioned (cooling and coating) before being sent to storage.

4.2. Utilities (assuming a 1000 MTPD plant)

Electricity	:	45 kWh/t
Make up water	:	140 kg/t
Fuel oil	:	11 kg/t
Steam (mean pressure)	:	111 kg/t

4.3. Effluents Treatment

The air from the first dryer is sent to cyclones before being mixed with the granulation air in a scrubber to be efficiently washed before being sent to the atmosphere.

The air sent to the atmosphere fulfils the EPMA BAT recommendations and typically contains :

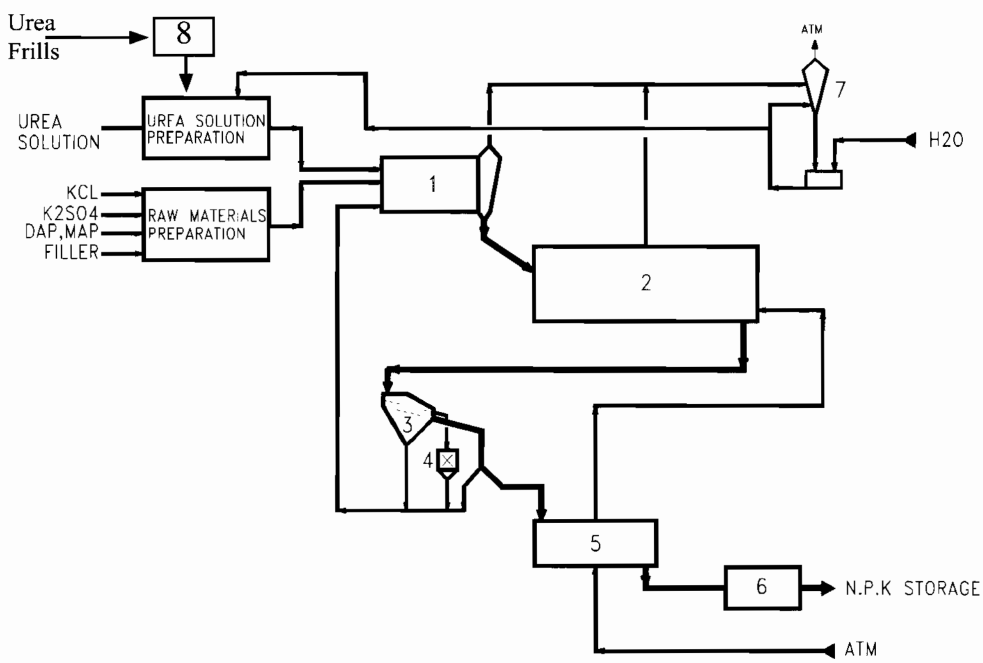
- less than 50 mg dust/Nm^3
- less than 50 mg NH_3/Nm^3

The washing solution is totally recycled to the process by mixing with the urea solution.

4.4. Final Product Characteristics

Typically a 15.15.15 (for example) :

Moisture	:	1% max.
Screen analysis	:	94% between 2.5 and 4.5 mm
Crushing strength	:	4 kg (on 2.5 - 4.5 mm granules)



1 : Granulator
2 : Drying section
3 : Screening section
4 : Crusher
5 : Cooling section
6 : Coating section
7 : Scrubbing section
8: Melting section

Appendix 1

Raw Material Costs

Raw Material Costs for Calculation		
Basis: October-99		
	Cost FRANCO: (FF/t DRY BASIS 100%) France basis	
NH_3	1000	FF/t DRY BASIS 100%
H_3PO4(62.4% P_2O_5)	1310,4	FF/t DRY BASIS 100%
UREA prills	600	FF/t DRY BASIS 100%
H_2SO_4 100%	255,1	FF/t DRY BASIS 100%
KCl	750	FF/t DRY BASIS 100%
$CaSO_4$	100	FF/t DRY BASIS 100%
AS	480	FF/t DRY BASIS 100%
Single Super Phosphate (SSP) (18% P_2O_5)	265	FF/t DRY BASIS 100%
Ammonium nitrate solution	900	FF/t DRY BASIS 100%
MAP	1200	FF/t DRY BASIS 100%
DAP	1200	FF/t DRY BASIS 100%

Appendix 2

Formulations (3 x 15)

1. Routes n° 1 and 3
Urea basis formulation with DAP

	Route 1 Urea solution	Route 3 Urea prills
Formula dry basis (kg/t NPK)	15,15,15	15,15,15
NH_3	0	0
H_3PO_4 (62.4% P_2O_5)	0	0
UREA (solution)	144	0
UREA (prills)	0	144
DAP	267	267
SSP 18	151	151
KCl	250	250
AS	178	178
H_2O + add	10	10
Raw material cost (FF/t NPK)	726	726

2. Route n°2
Urea basis formulation
Pipe reactor and urea prills

Formula dry basis (kg/t NPK)	15,15,15
NH_3	64
H_3PO_4 (62,4% P_2O_5)	204
H_2SO_4	70
UREA (prills)	38
DAP	0
SSP 18	126
KCl	250
AS	225
H_2O+add	10
Raw material cost (FF/t NPK)	714

3. AN basis formulation
Pipe reactor and AN melt

Formula dry basis (kg/t NPK)	15,15,15
NH_3	27
H_3PO_4 (62,4% P_2O_5)	82
H_2SO_4 100%	40
AN solution (100% AN)	282
MAP	120
SSP (18% P_2O_5)	115
KCl	214
AS	0
NPK fines	110
H_2O + add	10
Raw material cost (FF/t NPK)	827