

How to Start Manufacturing Industries

Compound Fertilizer NP Plant – Odda-Process (Nitrogen and Phosphate)

Introduction

Main nutrients for crops are Nitrogen, Phosphorous, Potassium and Calcium. These among others must be made available continuously and in correct proportions by the soil.

The individual effect of each of these nutrients is the following:

Nitrogen promotes:

- plant growth-speeds development both above and below ground, influencing the size, weight and colour of the plant yield, e.g. grain, tuber or fruit
- the synthesis of amino acids, protein and lipids, thus contributing in large part to the nutritional value of vegetable foodstuffs
- technical characteristics dependent on the protein content, e.g. the baking properties of wheat

Phosphorus promotes:

- the synthesis of organic phosphorus compounds in the plant organism e.g. phosphoric lipids, nucleic acids, and enzymes necessary for the formation of proteins, carbohydrates and other lipids and enzymes
- the plant's reproductive phase, e.g. the ripeness and quality of seeds and fruit
- the mineral content of plants used in foodstuffs and animal feed

Potassium promotes:

- nearly all metabolic processes leading to the synthesis of valuable components such as proteins and carbohydrates
- the vitamin and mineral content (especially of fruit and vegetables)
- technical properties dependent on the carbohydrate content (e.g. the processing properties of potatoes or the malting properties of barley)
- the development of strong plant tissue
- resistance to cold, drought, pests and disease

Calcium promotes:

- the intake of nutrients and transpiration and metabolism in the plant

Soils which are subjected to intensive agricultural usage especially after application of pure nitrogenous fertilizers over long periods such as ammonium nitrate or urea show a deficiency and unbalance in nutrients. This can be leveled by applying compound fertilizers. They offer the following main advantages:

- Compound fertilizers can be produced with different nutrient contents. It is thus possible to provide a fertilizer with optimum nutrient properties taking into account the needs of the crop, the soil conditions and the climate.
- The nutrient components can be dispensed in one operation only.
- Uniform distribution of the nutrients in the soil, since the main nutrient components are present in the desired ratio in every fertilizer granule.
- Separate calcium fertilizing is unnecessary, since many of the available fertilizer types contain calcium.
- Improvement of plant growth by using fertilizer types containing trace nutrients like Mg, Cu, Mn, Fe, Zn, B, Mo, Co as an additional component.

The nutrient content of compound fertilizers is quoted in

% by wt. N

for the nitrogen content

% by wt. P_2O_5

for the phosphate content

% by wt. K_2O

for the potassium content.

Fertilizers with only 2 main nutrients (NP types) – namely nitrogen and phosphate – are monoammonium phosphate, diammonium phosphate. Fertilizer with elevated nitrogen content are urea phosphates and the nitrophosphate

fertilizers. NPK fertilizers are produced by adding potassium compounds in the form of potassium chloride (KCl) or potassium sulphate (K_2SO_4).

Several processes are available to produce NP(K) fertilizers. The optimum process can be selected taking into account the availability of raw materials, the prevailing soil and climatic conditions and the type of crop whether the immediate effect or an expanded effect or a combination of both is desired.

Nitrogen in form of nitrate is of immediate effect as well as phosphorus in a water soluble form (mono- or diammonium phosphate and monocalcium phosphate).

Nitrogen in form of ammonium is of expanded effect as well as phosphate in form of dicalcium phosphate, the latter being citrate soluble.

The use of fertilizers with maximum water solubility of the P_2O_5 is recommendable for neutral soils and for plants with a short growth period.

The raw material phosphate rock is available and mined in many places of the world. The rock contains phosphorus in form of tricalcium phosphate which is water insoluble. The phosphorous has therefore to be transformed to a water and/or citrate soluble form, by "attack" with mineral acids such as sulfuric acid and/or nitric acid and/or phosphoric acid.

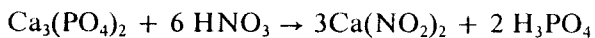
In cases of local availability of natural gas or other suitable fossil energy sources being raw

materials for the production of ammonia which in turn is the raw material for nitric acid and if sulphur or pyrites, the raw materials for sulphuric acid are not available locally then the attack by nitric acid can be the most economical choice.

The process applying this principle is world-wide known as "Odda-Process".

Process Description

Phosphate rock is attacked by nitric acid in the digester according to the main reaction equation:



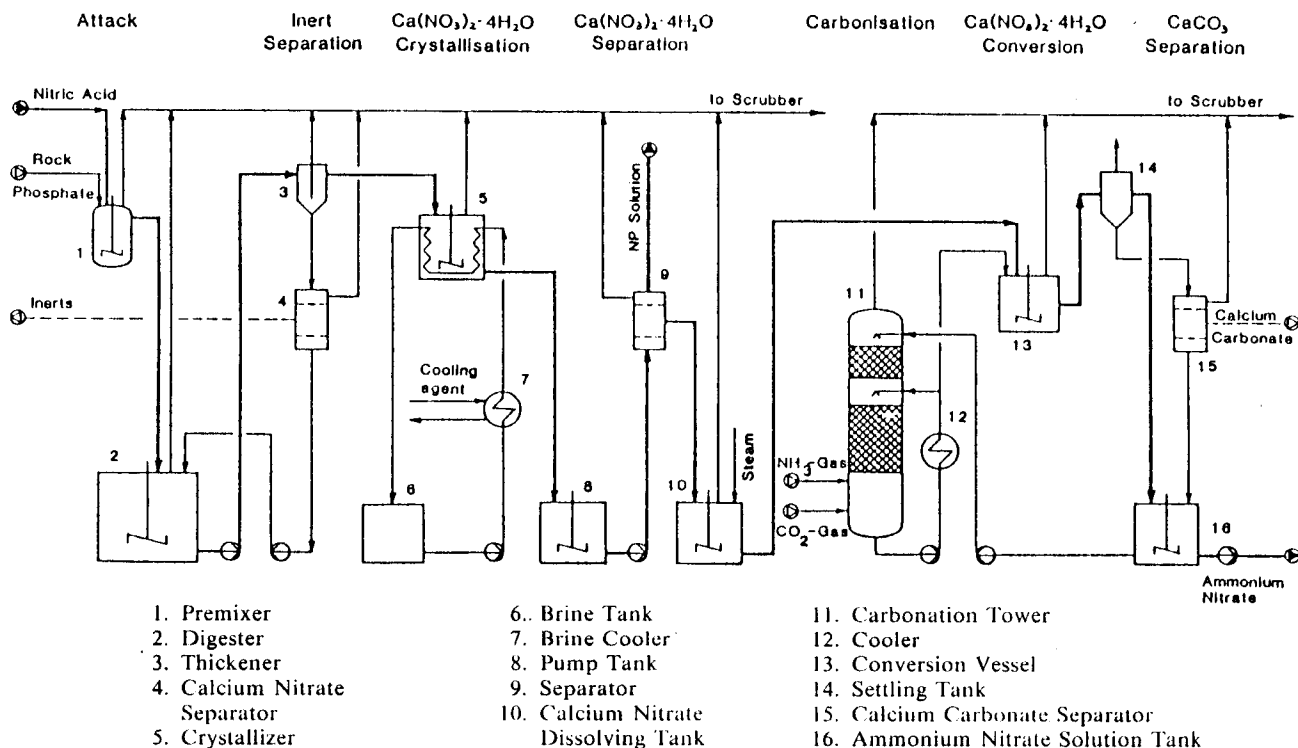
The waste gases containing F, NO_x and CO_2 are scrubbed with water.

By cooling the solution, part of the calcium nitrate crystallizes to calcium nitrate tetrahydrate. The cooling temperature and, consequently, the degree of crystallization is determined by the desired water solubility of the P_2O_5 in the final product.

By this process a water solubility of the phosphorous content of over 80% can be achieved. The remaining portion is present in form of dicalciumphosphate.

The calcium nitrate tetrahydrate crystals are separated. The remaining solution is then neutralized with gaseous ammonia according to the following main reaction equations:

Process Flow Diagram



1. $\text{HNO}_3 + \text{NH}_3 \rightarrow \text{NH}_4\text{NO}_3$
2. $\text{Ca}(\text{NO}_3)_2 + \text{H}_3\text{PO}_4 + 2 \text{NH}_3 \rightarrow \text{CaHPO}_4 + 2\text{NH}_4\text{NO}_3$
3. $\text{H}_3\text{PO}_4 + \text{NH}_3 \rightarrow \text{NH}_4\text{H}_2\text{PO}_4$
4. $\text{H}_3\text{PO}_4 + 2\text{NH}_3 \rightarrow (\text{NH}_4)_2\text{HPO}_4$

The nitrogen content can be increased by adding ammonium nitrate or nitric acid. The phosphate portion can be increased by adding phosphoric acid, DAP or MAP.

Part of the water introduced with the nitric acid is evaporated during neutralization by the heat of reaction.

The NP melt is granulated jointly with return material in a granulator.

The granules are then dried in a drum and subsequently classified. The fines, crushed over-size and the dust removed from waste air are returned to the granulator.

The on-size material is cooled. The storage properties are improved by conditioning, e.g. with an oil amine mixture.

The exhaust gases from the drying drum and cooling facilities are cleaned in the dust removal facilities.

The product can be bagged ex-bulk storage or directly.

Bags at 50 kg weight are normally used.

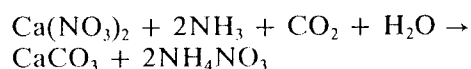
To obtain NPK fertilizers, potassium salt is admixed to the NP slurry prior to granulation.

Calcium nitrate conversion:

The by-product calcium nitrate crystals obtained in the ODDA process is converted to ammonium nitrate and calcium carbonate.

The crystals are dissolved in hot ammonium nitrate solution.

Further ammonium nitrate solution in which CO_2 and ammonia is dissolved is added in an agitator tank. Then the conversion reaction according to the following formula takes place:



The precipitate calcium carbonate is filtered off the ammonium nitrate solution. The latter is concentrated to about 95% and under addition of calcium carbonate further processed to calcium ammonium nitrate fertilizer.

The production of NP(K) fertilizers using phosphoric acid as intermediate raw material causes in most cases environmental problems, since high amounts of gypsum, the by-product of phosphoric acid, have to be disposed of. This problem does not arise in case of the Odda-process.

Crystallisation, Calcium Nitrate Separation and Conversion

Odda Process Plant

BASF, Antwerp/Belgium

Plant Features

(Example of the Plant for 3 Different Capacities)

● Raw materials	Rock phosphate Nitric Acid Ammonia		
● Consumption figures per metric ton of product (N:P ₂ O ₅ :K ₂ O = 22,0:22,0:0, rel. wat. sol. 80%)			
Rock phosphate (Jordan 73 BPL)	681 kg		
Nitric acid (60% HNO ₃)	785 kg (as 100% HNO ₃)		
Ammonia	253 kg (as 100% NH ₃)		
CO ₂	300 kg (as 100% CO ₂)		
Steam (LP)	0.3 kg		
Electr. Energy	140 KWh		
Cooling Water	60 m ³		
Oil/Gas	—		
Process Water	1.1 m ³		
By product Ammonium nitrate	440 kg		
Plant capacity	300	800	1,000
	MTPD	MTPD	MTPD
● Budgetary investment cost for the process plant under West European conditions in 1986 FOB:			
Licence, know-how, engineering and equipment	US \$ 40.4 Mill.	62.0 Mill.	80.0 Mill.
● Required area for plant site	1,500 m ²	2,000 m ²	2,400 m ²
● Manpower			
Operating staff	2 foreman + 8 skilled workers/shift		
Other technical staff	Engineers: 2 Chemist: 1 Maintenance: 3		
The necessary production machinery and equipment is itemized in the Process Flow Diagram.			

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