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How to Start Manufacturing Industries

Compound Fertilizer DAP Plant – Pipe Reactor Process

(Diammonium 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 case sulfuric acid is used, a suspension of gypsum crystals in phosphoric acid is achieved. This process can be described by the following formula:

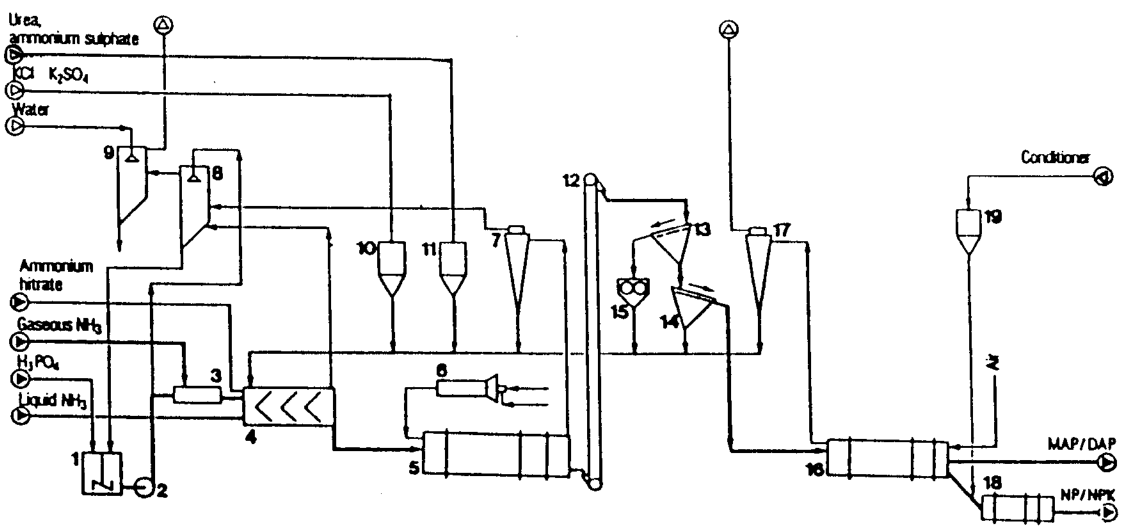
$$Ca_3(PO_4)_2 + 3\ H_2SO_4 + 6\ H_2O$$
$$\rightarrow 2\ H_3PO_4 + 3\ CaSO_4 + 2\ H_2O$$

The gypsum is separated by means of filtration to produce phosphoric acid which is an intermediate product for mono-/diammonium-phosphate (MAP/DAP)

MAP again is normally used as an intermediate in the production of fertilizer, whereas DAP can be applied as a fertilizer as such.

MAP/DAP can be produced by different processes. Most common are the "Preneutralizer Process" and the "Pipe Reactor Process". The latter is presented here due to its merits in low capital investment and low energy cost.

Process Flow Diagram
Pipe Reactor Process



1. Mixing vessel
2. Reactor feed pump
3. Pipe reactor
4. Ammoniator/granulator
5. Drying drum
6. Air heater
7. Dust removal facilities
8. Ammonia scrubber
9. Water scrubber
10. KCl/K_2SO_4 bin
11. Urea/AS bin
12. Bucket elevator
13. Coarse screen
14. Fine screen
15. Crusher
16. Cooling drum
17. Dust removal facilities
18. Coating drum
19. Conditioner bin

Process Description

To obtain MAP phosporic acid is ammoniated in the pipe reactor with ammonia to a molar NH_3/H_3PO_4 ratio of approx. 0.6.

The heat of reaction causes most of the water introduced with the phosphoric acid to evaporate at the outlet of the pipe reactor, resulting in a highly concentrated ammonium phosphate melt. This melt is sprayed onto the return material in the drum granulator and granulated.

By introducing ammonia into the granulation bed, further ammoniation to a molar NH_3/H_3PO_4 ratio of about 1.0 takes place. The reaction heat evaporates a further portion of the water introduced with the phosphoric acid.

The granules formed are then dried and cooled in a drum.

Depending on the concentration of the phosphoric acid, the drying will either proceed autothermally or with the aid of hot air.

The product is then classified. The fines, the crushed oversize and the dust removed from the waste air are returned to the drum granulator.

The on-size material is further cooled in a fluidized bed cooler or in a cooling drum and conveyed to product storage.

The exhaust gases from the drying drum and cooling facilities are passed through dust removal systems. The exhaust gases from the drying drum and drum granulator are then jointly scrubbed with phosphoric acid to recover ammonia. By subsequent water scrubbing fluorine is eliminated.

To obtain DAP, a molar NH_3/H_3PO_4 ratio of approx. 1.35 is adjusted in the pipe reactor and this will be raised to about 1.8 in the granulator. Due to the larger reaction energy, the drying normally proceeds autothermally.

To produce a NP fertilizer with a higher nitrogen content, an additional nitrogen component, such as urea, ammonium sulphate or ammonium nitrate is admixed to the return material and granulated jointly with the ammonium phosphate melt in the drum granulator.

For the production of fertilizer containing potash, potassium chloride or potassium sulphate is admixed in the granulator.

The product can be bagged ex bulk storage or directly. Bags at 50 kg weight are normally used.

Plant Features

(Example of the Plant for 2 Different Capacities)

• Raw materials	Phosphoric acid Ammonia Potassium Chloride	
• Consumption figures per metric ton of product DAP ($N:P_2O_5$ = 18:46):		
Phosphoric acid (45% P_2O_5)	1,035.2 kg P_2O_5	
Ammonia (100% NH_3)	221.9 kg (100% NH_3)	
Steam (LP)	–	
Electr. Energy	35 KWh	
Cooling Water	–	
Oil/Gas	–	
Process Water	0.005 m^3	
Plant capacity	300 MTPD	1,000 MTPD
• Budgetary investment cost for the process plant under West European conditions in 1986 fob: Licence, know-how, engineering and equipment	US $ 4.4 Mill.	US $ 6.9 Mill.
• Required area for plant site	900 m^2	1,800 m^2
• Manpower Operating staff	1 foreman + 2 skilled workers/shift	
Other technical staff	Engineers: 1 Chemist: 1 Maintenance: 2	

The necessary production machinery and equipment is itemized in the Process Flow Diagram.

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