Topic 3 : NPK fertilizer

* → straight fertilizers such as urea, single superphosphate (SSP), triple superphosphate (TSP), monoammonium phosphate (MAP), di-ammonium phosphate (DAP) are well defined products made using well defined processes.

→ compound or complex fertilisers such as NPK are more difficult to define as there is an infinite number of N/P/K ratios and processes applied in their production are numerous.

* product Name NPK is followed by 3 numbers to indicate the percent of N, P_2O_5, and K_2O which the product contains

ex: 24-6-12 indicates 24% N 6% P_2O_5 12% K_2O
phosphorus compounds potassium compounds

(fertilizer contain magnesium, boron, sulpher, ... etc
so typical content of nutrients ($N + P_2O_5 + K_2O$) normally be in the range of 40-60%)

*** Grades with no P_2O_5 or no K_2O are also included in the NPK product range but normally named NP & NK fertilizers

* NPK fertilizers can be produced in four, basically different ways :

✓ ① Ammonium phosphate/ ammonium nitrate based NPK. fertilizers

✓ ② Nitrophosphate based NPK fertilizers (mixed acid route).

③ Nitrophosphate based NPK fertilizers (ODDA-route).

④ mechanical blending of single or multi effect components.

production processes

① Granulation with a pipe reactor system

② Drum granulation with ammoniation

③ mixed acid process with phosphate rock digestion

Granulation with a pipe reactor system

* incroporates one or two pipe reactors ;
  one pipe reactor is fitted in the granulator and another may be used in the dryer.
* phosphoric acid or a mixture of phosphoric and sulphuric acids is neutralised in the pipe reactors with gaseous or liquid ammonia ;
  wider range of grades, including ammonium phosphate can be produced

* ① Granulation and drying section
  → – required solid raw materials such as KCl, ... are metered and fed into granulator together with the recycle
  – the pipe reactor fitted in the granulator is designed to recieve phosphoric acid, ... and all the other liquid feeds.
  – concentrated ammonium sulfate may be added directly into the granulator
  → granules obtained are dried in drying section using heated air stream

② screening, crushing, cooling and coating
- dry granules are screened into 3 fractions
  oversize is removed and returned via crusher together with the fines
- than it cooled in classical cooling equipment such as a fluidized bed cooler or cooling drum
- cooled product is fed into coating drum where surface coating is applied to prevent caking.

③ Gas scrubbing and dust removed

venturi scrubbers → scrubbed Gases

efficiency cyclones → re-dusted Gases

Drum Granulation with ammoniation

* process consists granulation loop using mainly solid raw materials Ammonium nitrate solution is fed to the granulator

* ① Granulation and drying

→ - solid raw materials are metered and fed into granular together with the recycle.

- Ammonium nitrate solution sprayed into granulator and sulphuric acid may be fed.

→ the granules obtained are dried in a drying section using heated air stream.

② screening, crushing, cooling and coating

- dry granules are screened into 3 fractions over size is removed and returned to the granulator via the crusher with fines.
- on spec fraction is cooled in classical cooling equipment such as fluidized bed cooler or cooling drum

③ gas scrubbing and dust removal

~~gases from~~ same as method ①

Mixed acid process with phosphate rock digestion

① phosphate rock digestion and ammoniation

→ first step is digestion of phosphate rock with nitric acid resulting in a solution of phosphoric acid and calcium nitrate.

→ other raw materials such as phosphoric, sulfuric acid and nitric acid are added after digestion which is exothermic process

acid slurry is ammoniated with gaseous ammonia and after neutralization other components are added

② Granulation, drying, screening, crushing cooling and coating

* in principle, the dry section divided into granulation part, drying part, screening / crushing part, a cooling part and a coating part.
* granulation can be performed by different equipment

drum
blunger

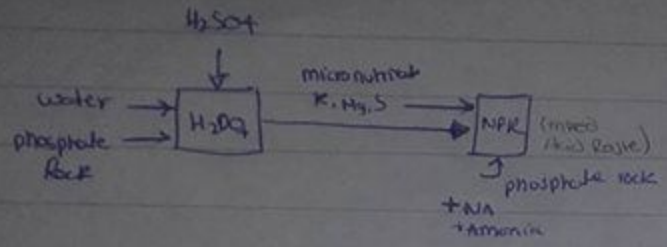
spherodiser :-

all granulation processes require drying operation after granulation except the spherodiser process

local Industries

Best Available techniques for pollution prevention and Control in European Fertilizer industry

Production of phosphoric acid



- the process is "thermal" (known as) when the raw material is elemental phosphorous.
- this process abonded due to amount of energy needed

- wet process: that use phosphated minerals which are decomposed with an acid. This is the only economic way to produce phosphoric Acid.

There are 3 subgroups of wet Process:-

1. Nitric 2. hydrochloric 3. sulphuric ←

There are 3 types of sulphuric Acid process, according to Calcium Sulfate Produced :-

1. anhydrite 2. hemihydrate 3. dihydrate.

processes are the following:-

1- Dihydrate process
2- hemihydrate process
3- Di-hemihydrate process (double stage)
4- hemidy (single)
5- " (double)

- different processes are needed due to different 1. Rocks + 2. gypsom disposal.

The storage and transfere of phosphoric Acid is the same for all acids and doesn't depend on the method of production.

Description of Production Processes:-

* Raw Material for phosphoric Acid

- Bones used to be the principle natureal source. (phosphorous)
- today it is produced from phosphatic oreas mines.

phosphate oreas are 2 ~~major~~ geological ons:

1. ~~In~~ Igneous → Kola, south Africa, Brazil
2. sedimentry → Morocco, Jordan, Algeria, USA.

Phoprate minerals in both types of ores are apatite group ; the most encountard are

- Fluorapatite → Igneous
- Francolite → Sedimentry contain $(CO_3)_x$

* the most easily mined oreas are in Sedimentation.

these sedimentary are connected to matter derived from organic compound (living Creature) + waste + gangue minerals.

→ Sedimentary ~~have~~ phosprate ores have differing compositions within the same source.

* phosphate oreas have to be concentrated or beneficated before using/selling.

different techniques are used in benifiation.

this gives rise to further variation in the finished ore concentrate product.

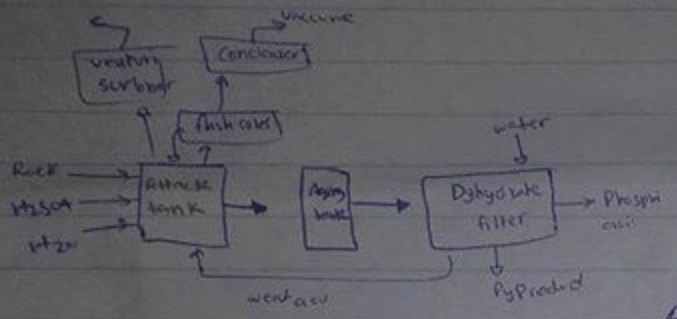
→ rely on great material variety

The dihydrate stage are maid of 4 stages.

1-grinding 2- reaction 4- concentration

3- filtration

(Figure 3 page 15)



[1] grinding

- ball/rod mill < wet / dry
- 60-70% ~ < 150 µm.

[2] Reaction

$Ca_3DO_4 + H_2SO_4 \rightarrow H_3PO_4 + CaSO_4$

- in circulation.
- Series of separated agitated reactors:

Can be replaced by Circle tank (economical)

Can be separated by compartments.

- T= 70-80 26-32 P_2O_5
- cooler → degas the slurry → easier pumping.

[3] Filtration

1 ton P_2O_5 → 5 ton gypsum

separate phosphoric acid from $CaSO_4$

1- inetial Separation must be followed by

at least 2-stage washing? (Effect)

Recover P_2O_5

- Pressure/ vaccine Filtration
  ↓
  Always used

Filtration equipments

[1] tilting pan

[2] rotary table

[3] travelling belt

[4] Concentration / direct contact concentrators

forced circulation (Figure 4)

consists of
- HE
- vapour/flash chamber
- condenser
- Vaccume pump
- acid circulating pump
- circulation pipes

[2] Hemihydrate process (HH)

- $CaSO_4$ precipitated in hemihydrate
- produce 40-52% P_2O_5
- energ saving
- Same previous stages but without grinding

Advantages:-

[1] Reduction of evaporation heat requirments.

[2] capital Saving [3] purer acid

→ Acid from HH proces tend to contain less free Sulphate Sulphur

↓ suspended Solids ↓ Al, F

[5] lower rock grinding requirment.

Disadvantages:

[1] Filtration rate

HH crystals are small + less well formed than DH crystal.

than slurry are harder to filtrate this insures to the crystal habit modifier.

[2] phosphate loss [4] filter cake impurities: more audric F + Cd + P_2O_5

[3] Scaling [5] corrosion < light / high acid concent.

↑ Recrystallization

[1] HRC Acidulate → recrystallize → separate

[2] HDH 40-52% " → separate → recrystallize → filter

[3] DH/HH 32-35% Acid Dyh → Separate → " → " → Return to digest

- Rebulping process:

further optimization of HRC process can be done by re-slurrying and washing gypsum → 2nd filtration

So called Rebulping

table 2; Advantages and disAd