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How to Start Manufacturing Industries

Ammonium Nitrate/ Calcium Ammonium Nitrate Fertilizer

Introduction

Soils subjected to modern agricultural intensive usage require the frequent addition of a number of mineral nutrients.

Nitrogen is the most important among them.

Ammonium Nitrate (AN) is a pure nitrogenous fertilizer having a nitrogen (N) content of about 35%. 50% of the N is immediately available to the plants in form of nitrate. The other 50% being ammonium is made available by the soil bacteria. This means that the immediate effect of fertilizing after spreading as well as an expanded effect are achieved.

Nitric acid is an intermediate product in the production of AN.

As early as 1905 Friedrich Uhde, in cooperation with Prof. Oswald, both pioneers in the development of fertilizers, designed and constructed a pilot plant for the production of nitric acid by burning ammonia with air in the presence of a catalyst.

This invention is the basis of the worldwide use of AN in all agriculturally developed areas. The world's consumption in 1985 is estimated to be 70 million metric tons.

Soils, especially grass land, will become acidic after intensive utilization under application of nitrogenous fertilizers. A countermeasure is the addition of limestone meal ($CaCO_3$) to the AN thereby producing Calcium Ammonium Nitrate (CAN). Furthermore, the lime itself is also a nutrient for the plant.

Nitric acid other than ammonia is usually not shipped and stored in big quantities.

Therefore, nitric acid plants are installed together with AN-plants. Both plants are advantageously connected process-wise.

For the production of nitric acid various processes are available. These are mainly:

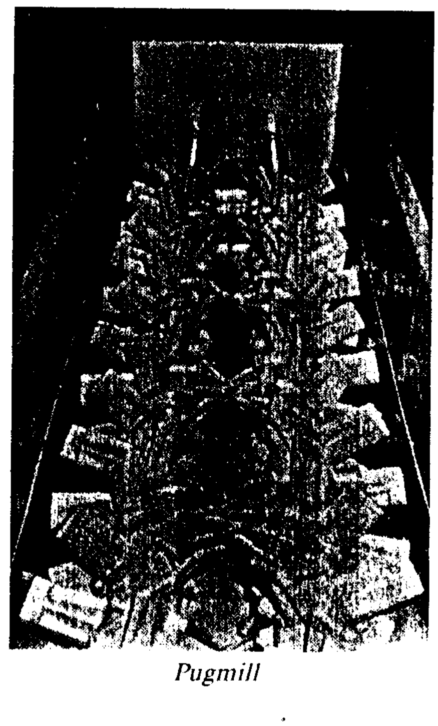
- the mono medium pressure process (4–6 bar),
- the mono high pressure process (7–10 bar) and
- the dual pressure process which employs 4–6 bar for the ammonia combustion section and 9–14 bar for the nitric acid absorption section.

The optimum process is selected taking into account the cost of raw materials and catalyst, energy cost, capital investment cost and requirements of the local authorities for emissions. The dual pressure process is presented herein.

The production of AN and CAN is performed in two process steps:

1. Neutralization of nitric acid by ammonia to achieve AN and the concentration of the AN solution,
2. Conversion of the AN melt to solids.

Neutralization, the first process step takes place:



Pugmill

- under atmospheric pressure,
- under vacuum or
- under elevated pressure.

The optimum pressure for neutralization is selected considering local energy and investment cost.

For the second process step:

- the pugmill,
- the fluidized bed granulator,
- the pan granulation,
- the prilling tower

are alternatively employed. However, the prilling tower requires high investment cost for purification of gaseous effluents. It is therefore applied only in special cases.

For the production of CAN lime meal is added to the granulator.

The pressure neutralization in combination with pugmill granulation is presented herein.

Process Description

Nitric Acid

Nitric acid is produced from ammonia which is oxidized by combustion with air in the presence of noblemetal catalyst.

A platinum-rhodium alloy (9 : 1 composition) has proved to be the most economical catalyst for this purpose.

The production of nitric acid takes place in 3 process steps according to the following equations:

1. Ammonia combustion
   $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O + 905\ kJ$
2. Oxidation of the nitric oxide
   $2\ NO + O_2 \rightarrow 2\ NO_2 + 113\ kJ$
3. Absorption of the nitrogen dioxide in water
   $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3 + 343\ kJ$

These three process steps can be carried out under different conditions, resulting in several nitric acid processes as mentioned above.

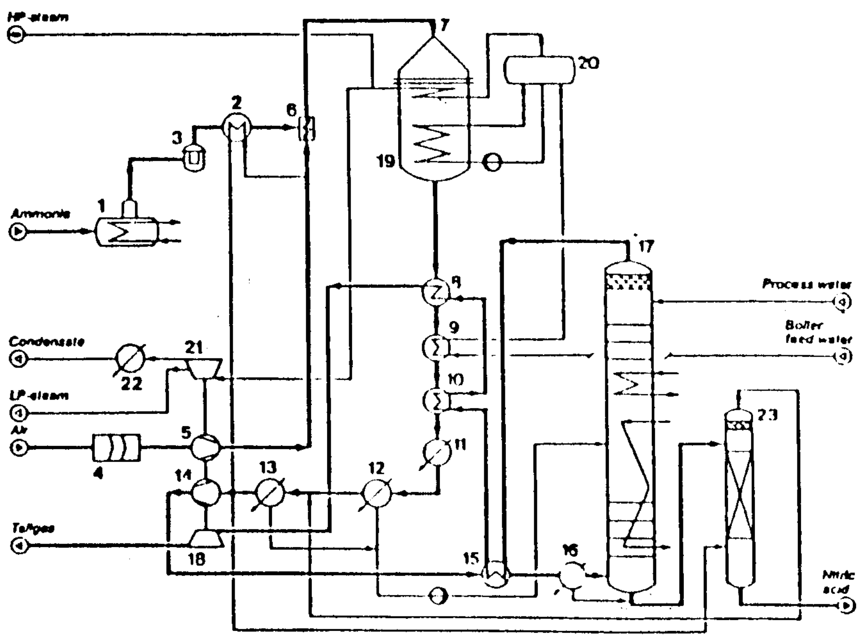
The dual-pressure process employs the medium pressure of 4–6 bar for ammonia combustion and a high pressure of 9–14 bar for nitric acid absorption.

The dual-pressure process was developed with a particular view to the ever more stringent environmental pollution control requirements.

Depending on the plant capacity, the process air is compressed by either a radial or an axial compressor to a final pressure of p abs. = 4–6 bar.

The combustion gases are cooled in a waste heat boiler, then passed through heat exchangers

Process Flow Diagram
Dual-Pressure Plant including Heat Recovery



1. NH_3 evaporation
2. NH_3 gas preheater
3. NH_3 gas filter
4. Air filter
5. Air compressor
6. NH_3/air mixer
7. NH_3 burner
8. Tailgas heater III
9. Economizer
10. Tailgas heater II
11. Feed water preheater
12. Cooler condenser I
13. Cooler condenser II
14. NO compressor
15. Tailgas heater I
16. Cooler condenser III
17. Absorption tower
18. Tailgas expans. turbine
19. La Mont waste heat boiler
20. Steam drum
21. Condensing turbine with extract. steam
22. Steam turbine condenser
23. Bleaching tower

for further cooling and finally compressed to p abs. = 9–14 bar.

The final pressure is selected such that the absorption section is optimized for the specified NO_x content of the tailgas (100 to 200 ppm) and that the compressor, driven by a condensing steam turbine, can be operated using only the steam generated in the waste heat boiler, while ensuring that some excess steam will always be available in order to guarantee steady operating conditions at all times.

Plant capacities of 1,500 tpd HNO_3 100% can be achieved in one single train (1 burner and 1 absorption tower).

The nitrogen yield in a plant of this type is 96.8% at a NO_x content in the waste gas of less than 200 ppm.

Acid concentrations of up to 70% can be achieved. Two or more product streams with different concentrations are also possible.

Production and Consumption per metric ton of HNO_3 100%

Acid concentration	60% HNO_3
Operating pressure	4.5/11 bar
Ammonia	279 kg
Electric power	9.0 kWh
Platinum	0.11 g
Cooling water (Δ t = 10 °C)	130 t
Process water	0.3 t
LP heating steam	0.1 t
HP excess steam	
25 bar, 400 °C	0.75 t
NO_x in tail gas	< 200 ppm

Ammonium Nitrate/Calcium Ammonium Nitrate (Neutralization under Pressure)

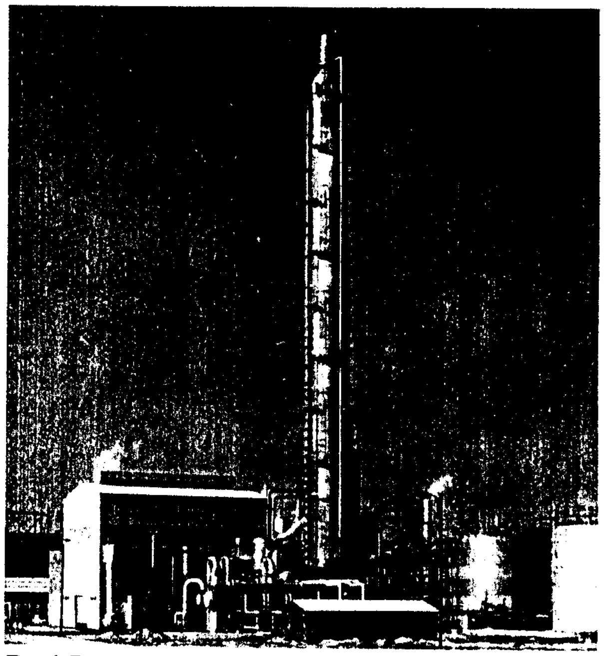
In the reactor ammonium nitrate is formed from gaseous ammonia and aqueous nitric acid; the reaction takes place as follows:

$$NH_3 + HNO_3 \quad NH_4NO_3;\ Q\ (kJ)$$

Besides using pure gaseous NH_3, it is also possible to admit ammonia-bearing gas, for example carbamate gas from an urea plant. Simple design and moderate dimensions of the reactor have resulted in a reduction of capital and fabrication cost.

Ammonium nitrate solution passes through the reactor by natural or forced circulation. Depending on the concentration of the feed acid, the ammonium nitrate solution reaches a concentration of approx. 93%–94%.

For more efficient utilization of the process steam, the neutralization takes place under elevated pressure. Ideally, the pressure in the flash evaportor should be between 1.0 and 3.5 bar (abs.).



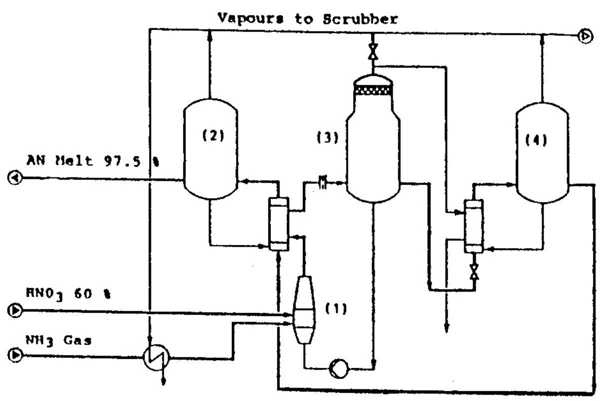
Dual-Pressure Process Nitric Acid Plant,
Capacity: 540 MTPD (100% HNO_3)
Acid Concentration: 60/68% HNO_3
Tailgas: 150 ppm NO_x
BASF/Antwerp, Belgium

Using 60% HNO_3 and a system pressure of 1.0–3.5 bar for neutralization, the concentration at the outlet of the neutralization section will be in the order of 70%.

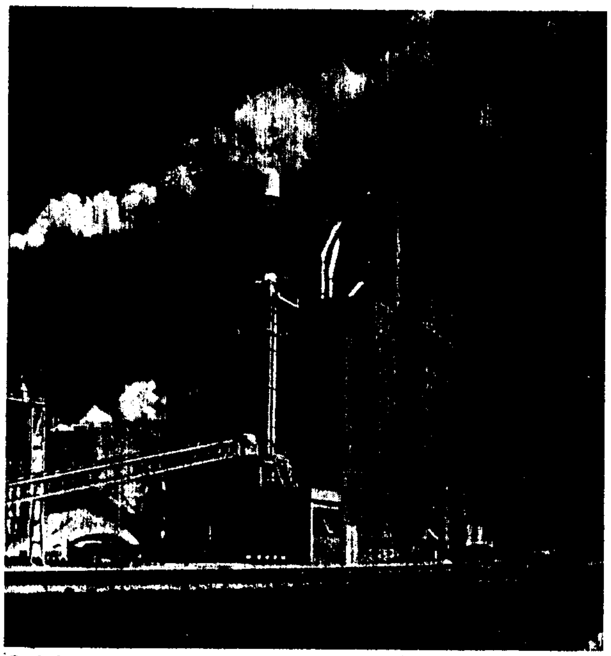
Vapours which are contaminated with AN are used for further concentration of the AN melt to 96.5%–97.5%. This is applicable for CAN and AN granulation.

Process Flow Diagram

Neutralization under pressure using contaminated vapours for concentration of the AN solution.



1. Reactor
2. 2nd Concentrator
3. Flash Evaporator
4. Ist Concentrator



Calcium Ammonium Nitrate Plant,
Capacity: 1,500 MTPD of CAN (26% N)
Process: Pugmill Granulation

Production and Consumption per metric ton of AN (97.5%)

Pressure	3.5 bar abs.
NH_3	213 kg
NHO_3 100% as acid with 60% HNO_3	789 kg
Cooling water $\Delta t = 10\,°C$	18.9 m^3
Electric power	3.5 kWh
Concentration of AN-solution	97.5%

Granulation

The concentrated ammonium nitrate solution is fed through a metering station into the pugmill. Recycle material is added from the screening and crushing equipment and from the dust collecting facilities.

For the alternative granulating of calcium nitrate (CAN) the components fed into the granulator are supplemented by powdered lime.

From the pugmill, the hot granules are fed to the drying drum for drying by hot combustion gases or hot air.

The dried granules are screened and classified; the temperature of the normal grain size fraction is reduced by cooled air in a fluidized bed cooler to a level which permits storage of the product in bulk. The exhaust air from the cooler is vented through cyclones or filters for dust removal. The fines, the crusher oversize, and the dust from the dust removal facilities are sent back as recycle material to the granulator. The cooled final product is fed to a coating drum for conditioning to prevent caking of the granules and, consequently, to improve the storage properties of the product.

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

Plant Features

(Example of the Plant for 3 different Capacities)

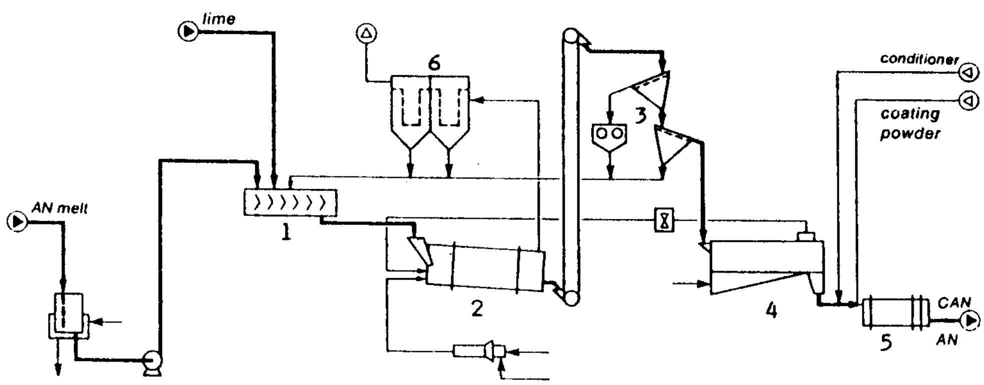
Raw materials:	Ammonia, Limestone
Intermediate product:	Nitric Acid
Economical plant capacities:	300 to 2,000 MTPD

Consumption figures per metric ton of product

	AN – 33.5% N	CAN 28% N	
Ammonia	417.7	348.9	kg
Cooling water	117	98	m^3
Additive	12	–	kg
Electric power	34.6	32.6	kWh
Lime meal	26	196	kg

Process Flow Diagram

Granulation of AN/CAN



1. Pugmill
2. Drying Drum
3. Screening and Crushing
4. Fluidized Bed Cooler
5. Coating Drum
6. Cyclones/Filter

Budgetory investment cost under Western European conditions in 1986 fob for the process plants (AN/CAN incl. HNO_3)

Plant capacity, CAN/AN	300/180 MTPD	1,000/600 MTPD	2,000/1,200 MTPD
Licence, know-how, engineering and equipment:	US-$ 18 Mill.	US-$ 58 Mill.	US-$ 85 Mill.
Required area for plant site:	1,100 m^2	1,800 m^2	3,500 m^2

Man power:
Operating staff:
HNO_3-Plant: 1 foreman + 1 skilled worker/shift
AN/CAN-Plant: 1 foreman + 4 skilled workers/shift.

Other technical staff: Engineers: 2
Chemist: 1
Maintenance: 4

The necessary production equipment and machinery are itemized in the process flow diagrams.

This information has been prepared by UNIDO as a result of the financial contribution to UNIDO from the Government of the Federal Republic of Germany and the close co-operation extended to UNIDO by the relevant industries in the Federal Republic of Germany.
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