Ⅳ.Fertilizer Manufacturing Industry

1. Air Pollution in Fertilizer Plant

The principal ingredients of fertilizers are three of nitrogen, phosphorus and potassium. For nitrogen fertilizers, sulfuric acid (H_2SO_4), Nitric acid (NO_3), lime stone ($CaCO_3$), ammonia (NH_3), carbon dioxide (CO_2), and Chilean saltpeter are most widely used as raw materials.

Phosphate fertilizers are made from phosphate rock, consisting of calcium phosphate with hard solubility. Therefore the phosphate rock is converted to the water-soluble compounds by either way of:

(1) dissolution by acid (sulfuric acid, nitric acid)
(2) decomposing of stable apatite by high temperature
(3) reducing to element phosphorus (P) by thermo and converting to phosphate

The potassium fertilizers are utilized in a form of potassium chloride (KCl), potassium sulfate (K_2SO_4), potassium magnesium sulfate ($K_2SO_4MgSO_4$), etc as raw materials. The potassium chloride, most widely used potassium fertilizer is made from the ore by floatation method or calssification-crystallization method after grinding it.

Fertilizer	*Raw materials*
Nitrogenous F.	*: ammonia, Chilean saltpeter, limestone + N_2, ····*
Phosphate F.	*: phosphate rock*
Potassium F.	*: ore (ingredient ; KCl + NaCl), KCl, ····*
Coated F.	*: N, P, K + thermo plasticity resin*

Other than these fertilizers, there is a fertilizer in a form of which is wrapped in the thermo plasticity resin in order to control the releasing velocity of nutrients. These are called coated fertilizer and have a fair chance of air pollution.

In fertilizer manufacturing plant, the soot, SOx, NOx, dust, hydrogen fluoride, ammonia, and some solvent are typically given as considerable pollutants which are controlled by the Air Pollution Control Law.

Pollutants	*Origins of Pollutants*
Soot, SOx, NOx	*Boiler, Dryer, Calcining furnace, etc.*
Dust	*Raw material stock yard, Raw material feed equipment, Belt conveyer, Bucket conveyer, Crusher, Mill, Sieve*
HF	*Phosphate fertilizer plant------ Reactor, Calcining furnace, Melting furnace, Phosphoric acid concentration plant*
NH_3	*Pelletizer, Dryer*
Solvent	*Coated fertilizer manufacturing process*

Ammonia is designated as a "Specified Substance" in Air Pollution Control Law, which prescribes the necessary measures in case of malfunctions and damages in synthesis process and decomposition process. When ammonium sulfate, ammonium phosphate and urea are manufactured, the exhaust gas from the drying-pelletizing process of raw materials

contains ammonia but it is thin concentration. However, there is no need to provide with an ammonium-oriented abatement device, and for the most case the ammonia is captured together with fertilizer dust generated from drying-pelletizing process. The emission gas after the treatment by this way conforms to the permissible emission level for ammonia.

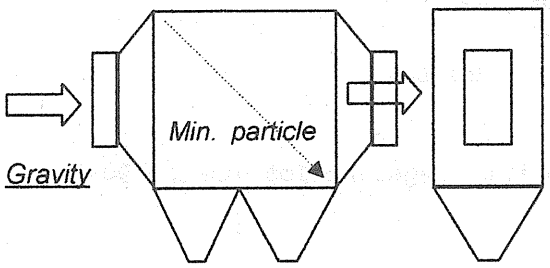
The origins of air pollutants in the processes or unit operations in fertilizer manufacturing plant are summarized in a slide.

For the detail information, refer to the pages at P.1~89.

2. Soot & Dust Collection

2-1 Gravitational, Inertial & Centrifugal Dust Collector

Because of the density difference between solids and gases, in laminar flow their stream lines are different if the direction of flow is changed. This fact is frequently exploited to separate solid particles from a gas stream, usually by suddenly changing the direction of flow of the gas stream.



Dust section view

In gravity dust collector, a settling chamber reduces the velocity (normally 1~2 m/second) of the gas stream so that the particles drop out by gravity. It is a large device not often used as a final control mechanism. If it is assumed that Stokes' s law applies, then the particle size which will be removed with 100% efficiency is given by the equation.

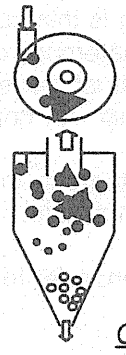
Stokes' Law

$V=(g/18\mu)(\rho 1-\rho)D^2$ (cm/s)

V: settling velocity (cm/sec)
μ: gas viscosity (kg/ms)
g: gravitational acceleration (cm/s^2)
$\rho 1$: particle density (g/cm^3)
ρ: gas density (g/cm^3)
D: particle diameter (cm)

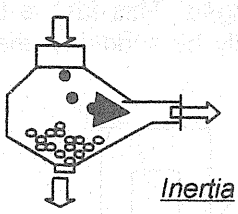
In the centrifugal force collector generally called cyclone dust separator, the centrifugal force exerted on a particle in a cyclone is given by the equation. For a large volume of gas treatment, small cyclones are connected in parallel and used as multi-cyclone. The inlet-gas velocity is set at 10 ~25 m/s.

Centrifugal force (F) = mv^2/R (N)
m: particle mass (kg)
V: particle velocity (m/ s)
R: cyclone radius (m)



Centrifugal

In an inertial dust collector, the gas stream is forced to collide with an obstacle or the gas flow direction is sharply changed to separate and collect dust particles in gas by using inertial force.



Inertia

For the detail information, refer to the pages at P.165~166 or E.90~92.

2-2 Scrubbing Dust Collector

The mechanisms of dust collection working in scrubbing dust collectors are:

(1) Adhesion of dust to water drops and water film
(2) adhesion by diffusion force between dusts
(3) increase of coagulation force of particles by increasing moisture
(4) moisture condensation triggered by dust as a nucleus
(5) particles adhesion by bubbles

The scrubbing dust collectors have been widely used for the abatement of waste gas recently as it can remove not only dust but also the toxic gas containing of fluorine and sulfur oxide at once. The scrubbing dust collectors are generally classified into spray type scrubber, packed type scrubber, jet scrubber, and venturi scrubber.

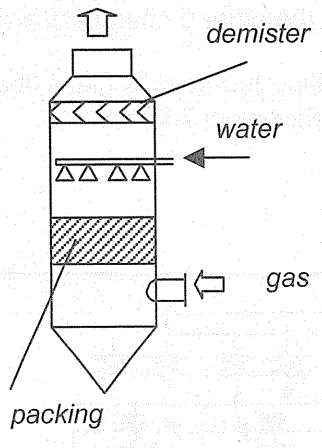
Typical Types of Scrubbers

Type	*Velocity m / s*	*L/G l / m³*	*ΔP kPa*	*Th. Φ μm*
Spray	*1~2*	*2~3*	*0.1~0.5*	*≧3*
Packed	*0.5~1*	*2~3*	*1~2.5*	*≧1*
Jet	*10~20*	*10~50*	*0~ -1.5*	*≧0.2*
Venturi	*60~90*	*0.3~1.5*	*3~8*	*≧0.1*

Th. Φ: Particle size of threshold to allowing 50 % removal

The outline of structure of packed tower scrubber is shown in a figure:

Packed tower



To achieve efficient performance of scrubbing dust collectors, it is important to select a gas flow velocity and liquid to gas ratio suitable for the each system.

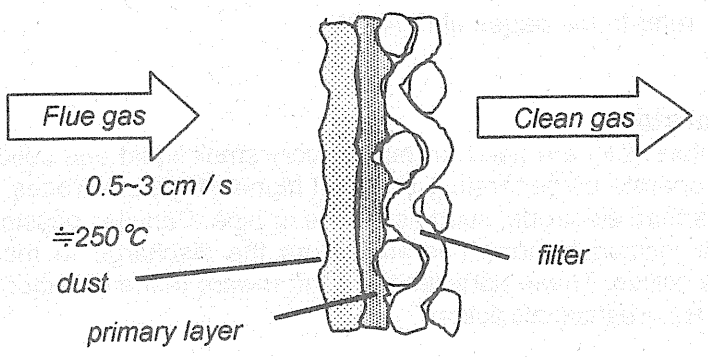
For the detail information, refer to the pages at P.92~94.

2-3 Filter Type Dust Collector

Bag filter dust collectors have the widest usage range of all the filter dust collectors. Bag filters can collect fine particles even 0.1 μm in size. When a bag filter is used for the treatment of flue gas from a glass melting furnace, a high dust-collection efficiency rate of 97~99% can be obtained.

The dust collector mechanism is that the primary layer, to which particles have adhered on the surface of the filter cloth, is used as the filtration layer to collect fine particles. The flow rate through the filter is usually around 0.5~3 cm/s. Therefore, when treating a large volume of gas, the dust collector equipment has multiple dust collecting chambers with many bag filters arrangement in parallel.

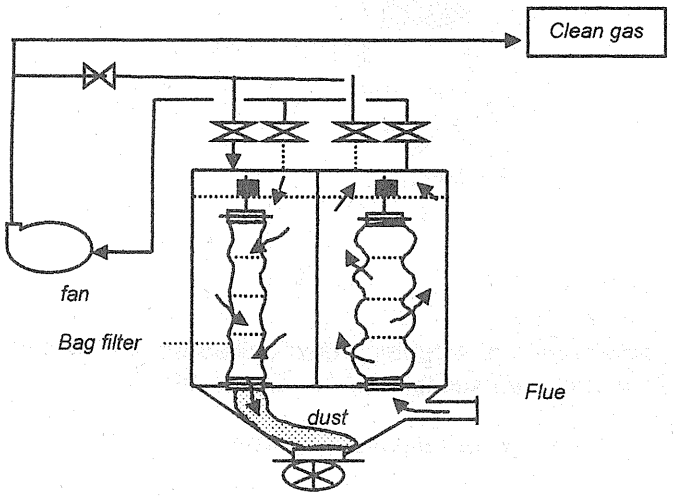
Filtration Action in Filter Cloth



$\Delta P \fallingdotseq 150$ mg Hg → dusting

For example, a bag filter with treatment capacity of 35,000 m3/h (250℃) for melting furnace has 6 dust collecting chambers, each with 50~60 cylindrical bag filters about 600 cm long and 30 cmϕ, arranged in each chamber. In this case, one of the 6 chambers is being scrubbed at any given time, while the other 5 chambers are in use.

The filter cloth used for glass melting furnaces is glass fiber because of erosion by sulfuric acid due to dew condensation under below 200 ℃.



When the pressure loss has reached about 150 mm Hg after accumulation of dust on the filter, dusting is needed. The dusting method can be either intermittent, most commonly used for glass melting furnaces, or continuous. Dust removal can be done by a method using vibration or a method using reversed air.

Dusting frequency	*Dusting drive*
- intermittent	*- vibration*
- continuous	*- reverse air*

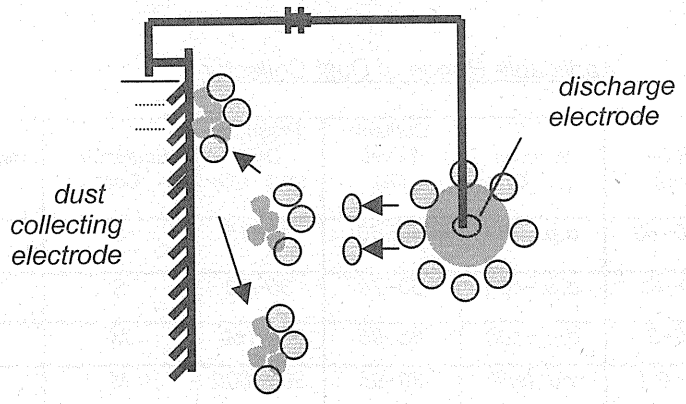
The gas temperature must be kept between 200 and 250 ℃ to avoid over heating for resistance temperature for filter cloth and dew point sulfuric acid.

For the detail information, refer to the pages at P.94~95.

2-4 Electrostatic Precipitator

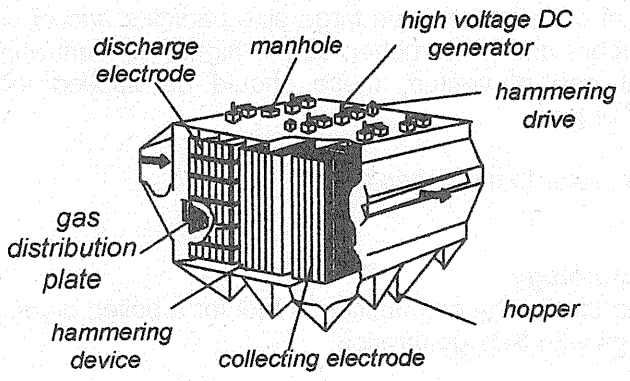
The electrostatic precipitators (EP) are used to remove very small liquid and solid particles from a gas stream. They operate by generating between high-voltage electrodes, usually a fine wire, and a passive earthed electrode, such as a plate or pipe. Particles passing through such an electric field are ionized by ions migrating from the discharge to the collector electrode, with whom they collide. These particles then drift toward to the collector electrode to which they are held by electrostatic attraction.

Principle of dust collection ;



The particles are removed from the collector by either a water spray or 'rapping' it periodically. The collector can either be flat or tubular units. Usually, a number of discharge electrodes will hang as shown in a slide.

Structure of EP



The EP is not much affected by the properties of gas and dust, can do highly efficient dust collection, and can collect fine particles without pressure loss.

For the detail information, refer to the pages at 95~96

2-5 Selection of Dust Collector

When we select the dust collectors, physical properties of particle and gases as shown in the slide should be taken into consideration;

Factors affecting Dust Collection:
dust concentration, particle size distribution, temperature of dust,
apparent electric resistance rate, due point, gas temperature,
composition of flue gas, gas volume, etc.

the particle sizes and particle distribution of dust in the flue gas have an effect significantly on the particle removal efficiency in each dust collector. The sizes of particle abated by dust collectors are shown in the table. Invisible particle concentration is said to be 20 mg/Nm^3.

Filter dust collectors become to be required frequent dust shakings if these are applied to high concentration dust gas. The EP will not be affected so much by the concentration of dust in flue gas.

Applicable Range of Dust Collector

Type	*Particle (μm)*	*Working (°C)*	*Cutback Level (%)*	*Pressure Drop (mm H_2O)*	*Equipment Cost*	*Running Cost*
Gravity	*1000~50*	*d.p.~400*	*40~60*	*10~15*	*S*	*S*
Inertia	*100~10*	*d.p.~400*	*50~70*	*30~70*	*S*	*S*
Centrifuge	*100~3*	*d.p.~400*	*85~95*	*50~150*	*M*	*M*
Scrubbing	*100~0.1*	*no- limit*	*80~95*	*300~800*	*M*	*L*
Filtration	*20~0.1*	*no- limit*	*90~99*	*100~200*	*≧M*	*≧M*
EP	*20~0.05*	*d.p.~400*	*90~99.9*	*10~20*	*L*	*S~M*

S: cheap, M: average, L: expensive

Regarding the dust concentration, the higher concentration of dust in a gas brings the higher removal efficiency of particle removal for the gravity collector and inertial force dust collector due to the acceleration of collision between large size particles and of coagulation of fine particles. In venturi scrubber and jet scrubber, as the higher concentration of dust causes the wear at the throat part of venturi, these should be applied the gases of dust concentration 10 g/ Nm^3 or less.

For the detail information, refer to the pages at P.97.

3. SOx Reduction Technology

In fertilizer manufacturing plants, the combustion of fuel for a boiler, dryer, calcining furnace and melting furnace brings with SOx generation.

Sources of SOx: Fuel SOx

- Boiler - Dryer - Calcining furnace - Melting furnace

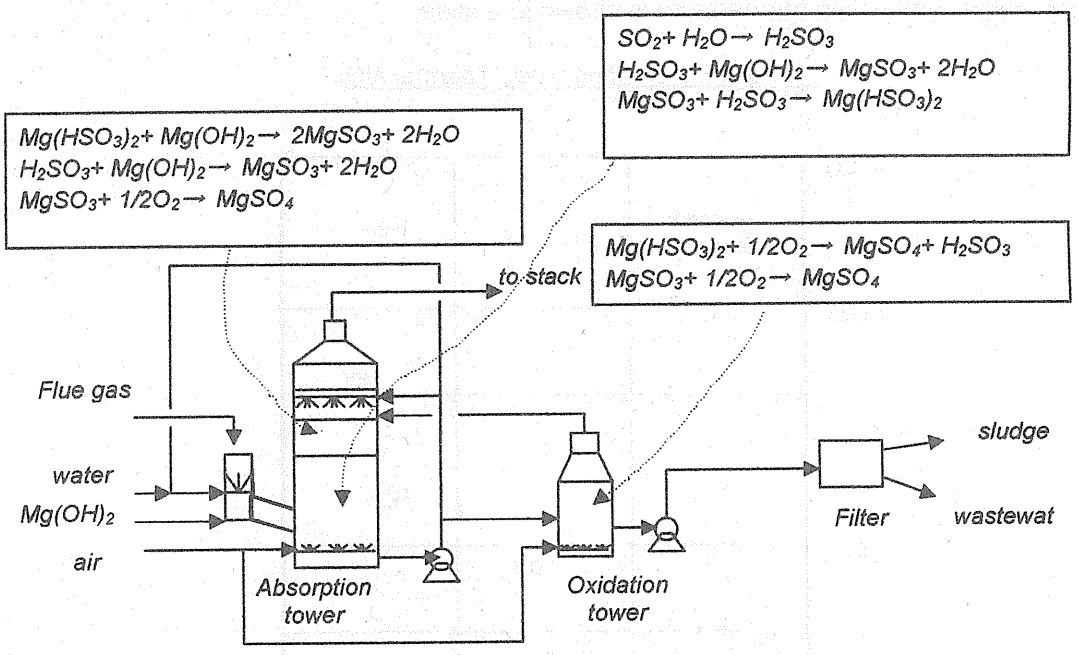
However, few fertilizer manufacturing plants have equipped with flue gas desulphurization system in order to fulfill the emission standard in Japan and the prefectural stringent emission standards, but they cope with these to certain extent by using a fuel with low sulfur content.

It is anticipated that the necessity of desulphurization plant will come out when the permissible emission level is strengthened in future,. Flue gas desulphurization systems are classified into wet type, dry type and semi-dry type. About 70% or more of total number of installed desulphurization plants have been wet type method and about 80% or more in gas volume abated.

In wet type method, there are processes such as lime slurry absorption method, magnesium hydroxide slurry absorption method, alkaline solution absorption method, double alkaline method, oxidation absorption method and etc. Among them, magnesium hydroxide absorption process is suitable for the treatment of small-to-medium sized boilers. This

process is simple, as shown in a slide, with low construction cost, low raw material cost, less toxicity, less corrosion and safety. The byproduct has a high solubility, so it could avoid clogging problem. The byproduct of magnesium sulfate can be reused as raw material of fertilizer production.

Wet Type Absorption



For the detail information, refer to the pages at P.98~99.

4. NOx Reduction Technology

4-1 NOx Generation in Fertilizer Plant

The term of NOx implied two major oxides, nitrogen oxide (NO) and nitrogen dioxide (NO_2). In Combustion, NO is the dominant of the two, NO_2 mainly a downstream derivative of NO. There are two main mechanisms of NOx production from combustion process:

(1) from the reaction of N2 in the air with oxygen at the high temperature of the burner chamber, known as thermal NOx

(2) from the reaction of nitrogen existing in the fuel with oxygen at the high temperature, known as fuel NOx.

The figure shows relation between air ratio and NOx concentration generated at theoretical combustion temperature, known as fuel NOx. In fertilizer manufacturing plants, the generation of fuel NOx is not so much though C-heavy oil, in which contains nitrogen relatively high, is used. The major NOx generated in the fertilizer plant is considered as thermal NOx.

Thermal NOx ≫ Fuel NOx

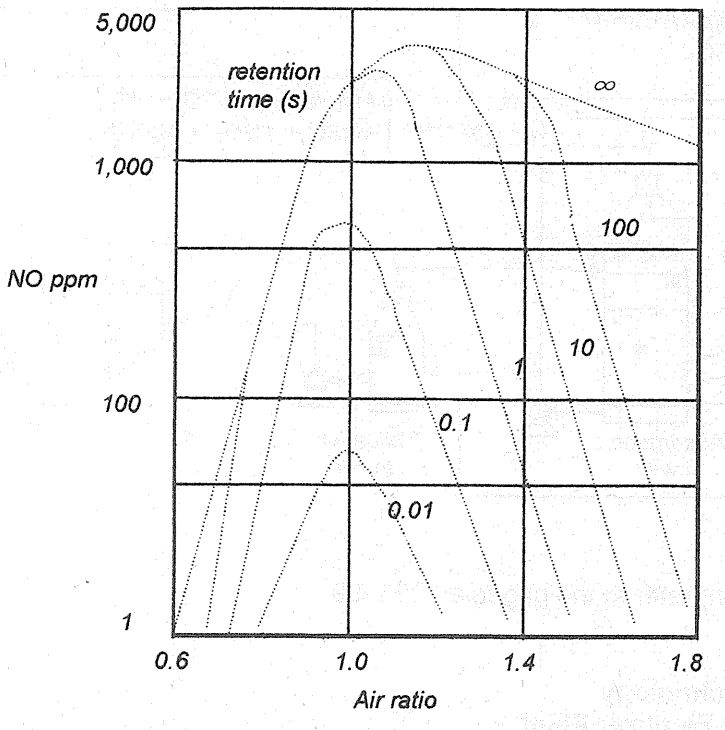
When the following operating conditions are formed, NOx concentration in the flue gas

increases:

(1) combustion at high temperature
(2) high concentration of oxygen in combustion area
(3) longer retention time of combustion gas in high temperature combustion area

The relationship between NOx generation and air ratio at different retention time at theoretical combustion temperature is shown in a slide.

Air ratio ~ Retention time ~Thermal NOx



When the air ratio is increased to certain level and when the retention time is longer, the NOx concentration is increased proportionally. However, the air ratio exceeds at certain level, NOx concentrations begin to decrease due to the lowering the temperature of combustion, as can be understood from a figure.

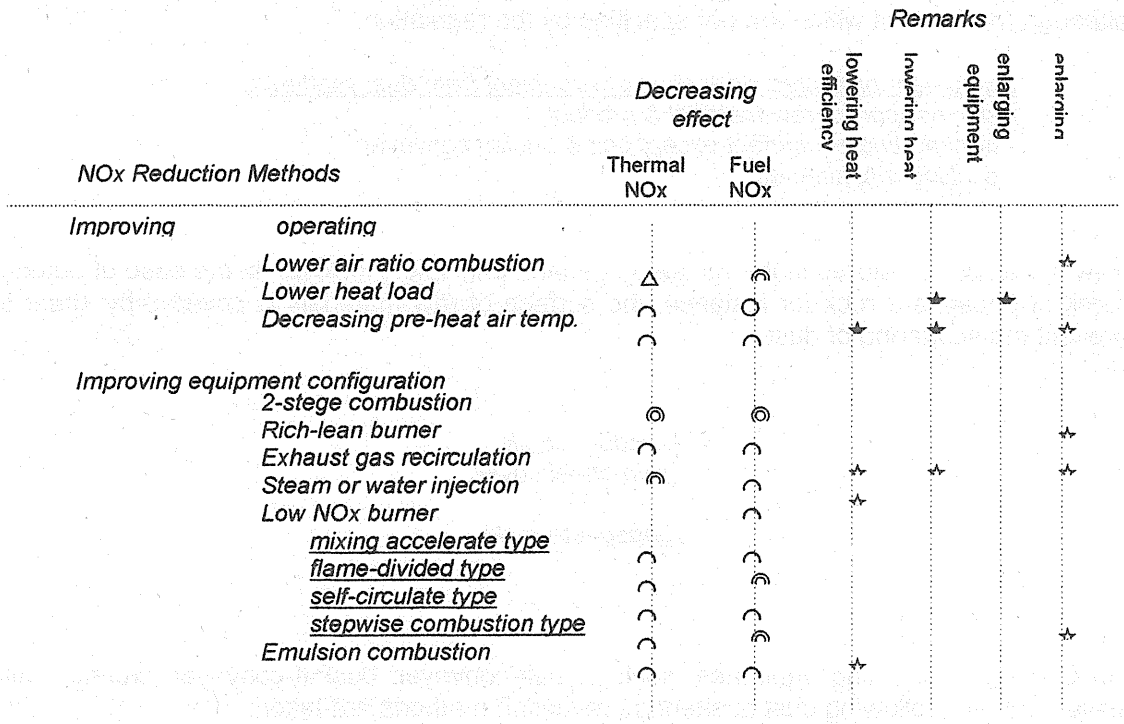
NOx concentration increases at:
- higher temp. in combustion
- higher O_2 conc.
- longer retention in high temp. zone

For the detail information, refer to the pages at P.99~100.

4-2 NOx Control Methods

Various NOx reduction methods on the basis of previously mentioned theory have been developed and adopted under limited conditions as shown in the table. The marks in the table means;

◎; large effect is expected
○; not so large effect is expected
△; effects vary depending on the equipments
★; affecting on existing equipment is predicted
☆; careful application is required



To summarize: In fertilizer plant, following measures are implemented to reduce the NOx emission;

- low air ratio operation in order to lower the oxygen concentration as much as possible in combustion area
- low heat load operation in order to lower the temperature and heat load in combustion chamber
- adoption of low NOx burner

For the detail information, refer to the pages at P.101.

5. Dust Scattering Prevention

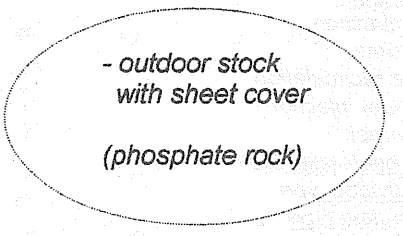
In fertilizer plant, the equipment and facility which are regulated by the air pollution control law are stock yard of raw materials, belt-conveyer and bucket-conveyer, crusher and mill, and screen.

Dust generating equipment & location designated by air pollution control law
- *belt conveyer*
- *bucket conveyer*
- *crusher, mill*
- *sieve*
- *ore stock yard*

Other than these, silo and hopper for raw materials and products, transporting equipment except belt-conveyer and bucket-conveyer, packing machine, etc., are provided with dust collectors to secure the working environment against the risk for the health of workers, although for those of which are not specified by the regulation.

Equipment protected work shop environment from dust scattering
- *silo, hopper for raw material & product*
- *transporting equipment except belt & bucket conveyer*
- *packing machine, etc.*

Raw materials are stored in the house on general principle. However, in the case of outdoor stock of phosphate rock for instance, the surface of raw materials is covered by sheet to prevent the scattering of dust.



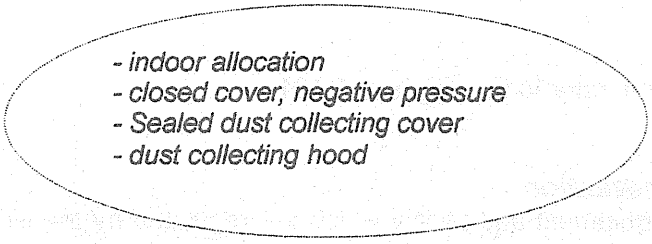
For the dust generating equipment such as belt-conveyer, bucket-conveyer, crusher, mill, sieve, and etc., following dust scattering prevention methods are taken:

(1) to install the equipment and to store materials in the house with the structure to prevent the dust scattering

(2) to install these inside the closed cover structure induced by suction blower to reduce the pressure below atmosphere pressure

(3) to seal off the whole equipment by a cover and to collect dust by suction blower

(4) to hood the dust at generating portion partially by hood covers



The dusts captured by these methods are generally led to the cyclone dust collectors and

bag filters.

For the detail information, refer to the pages at P.102.

6. NH_3 Removal Technology

Ammonia is regulated by air pollution control law as a specified material, however no legal standard figure for permissible level has been settled. The permissible emission level of ammonia is settled on the basis of the Offensive Smell Control Law both for the boundary of premise and the exhausting points. The former figures is settled by the prefectural governors in the range of between 1 and 5 ppm. The allowable ammonia concentration emitted from a exhaust point are calculated by the equation shown in a slide.

1. *Permissible NH_3 emission:*

   1~ 5 ppm at boundary of premise (set forth by prefecture governors)

   $Q = 0.108 \times He^2 \times Cm$

   Q : gas volume (Nm^3 / h)
   He : effective height of exhausting outlet (m)
   Cm : concentration at boundary line of premise (ppm)

The ammonia treatment in the fertilizer plant, as an example, is shown in a slide.

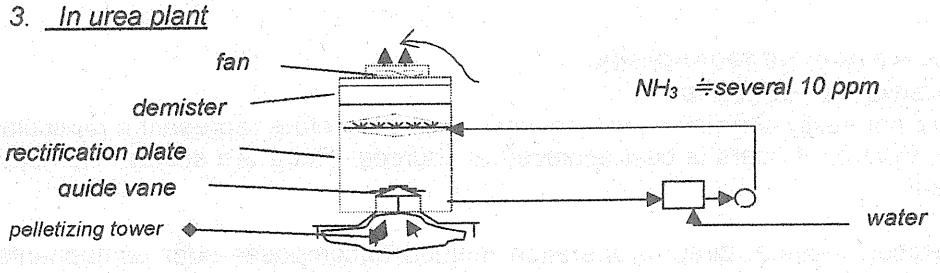
2. *In compound fertilizer plant :*

Process	*Origin*	*Abatement*
pelletizer & drying	$(NH_4)_2SO_4$ $(NH_4)_3PO_4$ $CO(NH_2)_2$	*reservoir type wet scrubber* *pressurized water scrubber* *packed bed water scrubber* *(NH_4 removal 70~90%, 20~50ppm)*

Ammonia is generated from the processes of a pelletizing and a drying, where the raw materials such as ammonium sulfate, ammonium phosphate, urea, etc. are partially decomposed by heat and contacts among raw materials. These exhaust gas is thin in its ammonia concentration and accompanies with powdered fertilizer dust, so that ammonia in the gas is absorbed and recovered by the wet scrubber (as shown in a slide) using water spray or dilute sulfuric acid solution or phosphoric acid solution along with dust. The removal rate of ammonia by these methods is in the range of between 70~90%, and emitted ammonia concentration is 20 to 50 ppm.

At pelletizing tower in an urea manufacturing plant, a particular type of dust collector is used because of that its gas volume is huge and it contains fine urea particles with 1~5 μm in diameter. The structure of dust collector mounted on a pelletizing tower is shown in a slide. The ammonia concentration at the outlet of dust collector is several ten ppm.

3. *In urea plant*



For the detail information, refer to the pages at P.104~106.

7. Fluoride Compounds Removal Technology

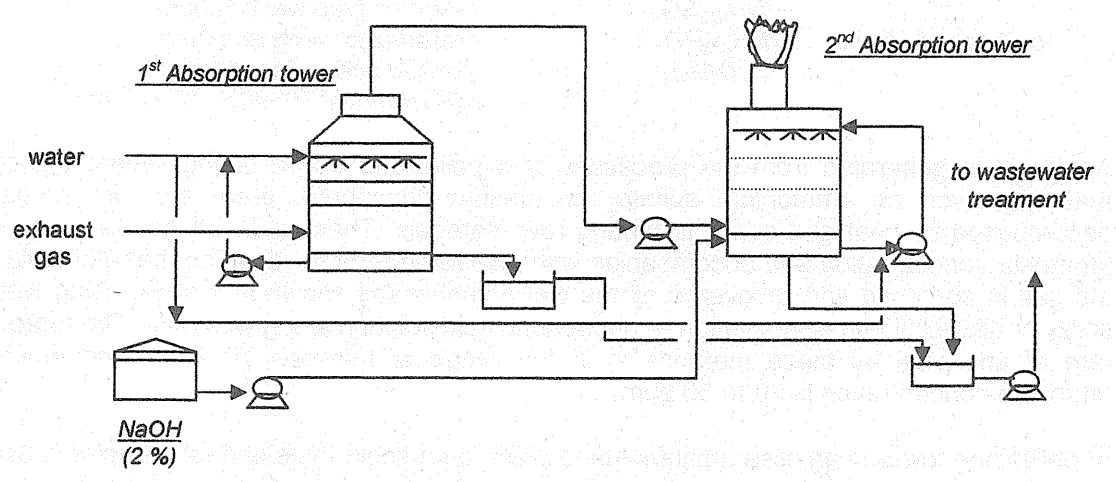
In fertilizer manufacturing plant, fluoride compounds as form of hydrogen fluoride (HF) and tetra fluoride silicon (SiF_4) are generated from the reaction process and concentration process for raw phosphoric acid, calcium superphosphate (P. 41, $Ca(H_2PO_4)_2$), and reaction furnace for fused phosphate, calcined phosphate, etc.

Generation of F
- reaction & condensation process for H_3PO_4 production
- reaction process for $Ca(H_2PO_4)_2$ production
- reaction furnace for fused P and calcined P production

For a treatment method of fluoride compounds, wet process has been adopted as both HF and SiF_4 has a strong affinity with water and relatively large solubility in water.

HF, SiF_4 → with greater hydrophile property

The wet scrubber, packed tower scrubber, jet scrubber, etc are commonly used for the abatement of fluoride compounds. When SiF_4 is absorbed to water, it forms a silicon dioxide (SiO_2) and causes problems of adhesion and clogging, to which should be attentive. Water is generally used for scrubbing liquid, but alkaline such as Na, Ca, etc. is also used for lowering fluorine concentration in exhaust gas furthermore. The abatement system is shown in the slide.



For the detail information, refer to the pages at P.102~104.

8. Odors Abatement technology

8-1 Abatement Processes

Odors are not easily characterized or quantified and therefore represent a particular design problem. Control of odors is best achieved at sources. There are several methods in odor abatement.

In incineration method, direct incineration method decomposes odor components to non

smell materials of CO_2 and H_2O for 0.3 to 1.0 second at around 800℃. This method is widely used and has high efficiency in reduction of odors. The regenerative thermal oxidizer is equipped with a regenerator inside the furnace, which is heated up by the combustion of odor components. If the odor components contain the caloric value of equivalent to the toluene of 500 ppm or more, these are burned by themselves without any additional fuel. This system is simple in structure and easy in maintenance, and has high heat exchange efficiency of 95%. The catalytic incineration burns the odor components under the existence of catalyst and converts to non smell substances. The combustion efficiency of odors is 99% or more under the economical combustion temperature of 200 to 350℃.

Incineration method	*decompose to CO_2, H_2O by heat*
direct incineration	*at ≒800℃*
regenerative thermal oxidizer	*regeneration, heat efficiency >80%*
catalytic incineration	*using catalysis at 200~ 350 ℃, rem.>99%*

In scrubbing method, gases with odors are scrubbed in the scrubbing tower by chemical solution or water. This system is cheap and can remove the mist and dust in the gas simultaneously.

Scrubbing method	*scrubbing by chemical solution*
	water, acid, alkaline, oxidant, etc.

In an adsorption method, the activated carbon is used as an adsorbent in a form either recovery type, concentration type or replacement- adsorption type. The regeneration of activated carbon is done by either way of steam regeneration, heated nitrogen gas, oxidation by oxidant, or replacement.

Adsorption method	
recovery type	
fixed bed	*activated carbon, steam regeneration*
fluidized bed	*activated c., heat regeneration by N_2 gas*
concentration type	
honeycomb	*separating odor from low concentration gas*
replacement type	*replacing saturated adsorbent or oxidant*

In biological method, odor components are decomposed by microorganisms in soil bed or in the bio-film media.

Biological method	*biodegradation by microorganisms*
soil bed	*using soil bacteria*
packed tower	*using bio-film on the media*

Deodorizer or masking agent converts chemically the offending compounds into harmless inoffensive compounds.

Deodorizer, masking agent	*deodorize or easing offending gas*

For the detail information, refer to the pages at P.106.

8-2 Troubles in Abatement Processes (examples)

Examples of troubles in deodorizing methods are shown in a slide.

In combustion method, as the direct incineration is operated at high temperature, it generates higher concentration of NOx, exceeding the permissible emission level. In regenerative thermal oxidizer and catalytic incineration, when the solvent with chlorine compounds are mixed in the gas, hydrochloric acid is generated. When paints are mixed in the gas, clogging problem and catalyst deterioration would occur.

Combustion method

Deodorizing Method	*Trigger*	*Trouble*
direct incineration	*NOx ↑*	*permission level ↑*
regenerative thermal ox.	*mixture of Cl_2, paint, etc.*	*HCl ↑, clogging*
catalytic incineration	*mixture of Cl_2, paint, S, etc.*	*catalyst deterioration*

In adsorption method, the mixture of solvents such as ketone, cycohexane, etc. causes firing of activated carbon, raising temperature of exhaust gas, and deterioration of activated carbon, etc.

Adsorption method

Deodorizing Method	*Trigger*	*Trouble*
recovery type		
fixed bed	*mixture of ketone, high B.P. substance*	*firing, deterioration of activated carbon*
fluidized bed	*high temp. of exhaust gas*	*A.C. deterioration*
concentration type		
honeycomb	*mixture of cyclohexane*	*firing*
replacement type	*conc.> several ppm*	*short term A.C. replacement*

In biological methods, if the soil bed is become dry, the decomposing function is getting weak and finally gets out of order. In the case of packed tower, it takes a relatively long period to grow the microorganisms on the surface of media.

Biological method

Deodorizing Method	*Trigger*	*Trouble*
soil bed	*drying of soil*	*malfunction*
packed tower	*slow acclimatization*	*slow starter*

In scrubbing method, less sprinkling water volume leads to the deterioration of performance. When the gas contains a lot of dust, it would cause a clogging problem at the inner part of scrubbing tower.

Scrubbing		
	less sprinkling water	*malfunction*
	dust in gas	*clogging internals*

For the detail information, refer to the pages at P.110~111.

9. Solvent Recovery & Abatement technology

The occasion which needs a recovery of organic solvent is only for the production process of thermo plasticity resin based coated fertilizer. The coated materials concentration in the solution is generally estimated at around 10%.

1. Sources of Generation
coated fertilizer (thermoplasticity resin)

The recovery of solvent from the exhaust gas process exerts a great influence on the economics of product cost. Therefore, the recovery of solvent has become the inevitable conclusion for cost control before the measures for pollution control. Then, the residual solvent that is left over due to economical reason is abated by air pollution control device.

2. Abatement
recovery of solvent brings profit ⇒ production cost reduction
residual solvent value ≪ recovery cost ⇒ pollution control

Previously mentioned abatement methods are applied to control the air pollution. In cooling condensation method, the solvent vapor is cooled down to the lower temperature against the vapor pressure for liquid. This method is not so practical because of remaining of solvent equivalent to its partial pressure.

3. Abatement Process
- cooling condensation method
cool down flue gas below vapor pressure

In absorption-diffusion method, when the absorbent with high solubility against targeted solvent and extremely low vapor pressure can be obtained, this method could be applied.

- absorption & dispersion method
absorbing of solvent to absorbent with lower vapor pressure

In adsorption-diffusion method, these methods can be applied to the solvent containing exhaust gas with low vapor pressure and non-existence of antagonist ingredients. These systems are simple in mechanism and inexpensive in operating cost. There are three types of adsorber; fixed bed, moving bed and fluidized bed. The typically used adsorbents are an activated carbon (granular type, powder type), silica gel, molecular sieve, aluminum gel, etc. The regeneration (diffusion) of adsorbents are generally done by the method using heated gas, steam, heat transfer, extraction under decompression, etc.

- adsorption & dispersion method
- ☆ *applicable to compositions with low vapor pressure and non-existence of antagonist. Adsorbed at under pressure or lower temp..*
- ☆ *adsorber: fixed bed, moving bed, fluidized bed*
- ☆ *adsorbent: A.C., silica gel, molecular sieve, aluminum gel*
- ☆ *regeneration method: heated gas, steam, heat transfer, extraction under decompression*

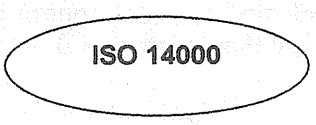
For the detail information, refer to the pages at P.112~114.

10. Environmental Management System

1. In EMS, trend of environmental management: Under worsening of global environmental circumstances, "sustainable development" was agreed on in the United Nations Conference

on Environment and Development held in 1992. Based on this, International Organization for Standardization (ISO) has set the international standard of "environmental management / audit (ISO 14000) in 1996. This is that a company sets a basic policy and a goal for its environmental problems based on the environmental influence caused by its business activities and the legal regulations. The company makes, executes, corrects and audits the system, rules and manuals in order to attain the goal. Such process is repeated so that the system is continuously improved. This cycle is called as PDCA cycle (Plan-Do-Check-Action). The ISO 14000 requires forming the appropriate organization, its duty and controlling system to establish and promote the pollution control.

1. *Environmental Management System*
   - *Organization for Environmental Control*
   - *ISO 14000 series----- PDCA cycle*
   - *Responsible for environmental protection*



2. The pollution control is managed based on manuals which settle the operating method of pollution control equipment, inspection of pollution control equipment, education and training, emergency measures at the malfunction of system, and etc.

2. *Environmental Control Manual*
   - *Operation Standard Manual*

3. In education and training of employees, the person in charge of pollution control, the pollution control chief manager, and etc are required to possess the qualifications necessary for the environment control. Therefore, well organized education and training program and the maintenance of environmental control manual are important.

3. *Education & Training*
   - *legally qualified expert of environment control*
   - *training program and preparation of manual*

4. As a lot of inorganic powders are handled in a fertilizer manufacturing plant, the dust control is important to protect the health of workers and to minimize the loss.

4. *Environmental Control at Work Shop*

5. Environment monitoring: The enterprises must observe the emission standard of atmospheric pollutants set by laws. For this purpose, it is necessary to measure, monitor and record regularly the emission concentration of pollutants. The emission of SOx, NOx, and dust are regulated by air pollution control law for fertilizer manufacturing plant.

5. *Environment Monitoring*
   - *maintaining monitoring system*
   - *monitoring of air pollution state*
   - *legal emission permissible level*

For the detail information, refer to the pages at P.147~160, 118~131.

Instructions for Power Point of Air pollution Control Technology

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