Air Pollution Control Technology
In
Glass Manufacturing Industry

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Overseas Environmental Cooperation Center, Japan
Air Pollution Control Technology in Glass Manufacturing Industry

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Product: Flat glass, Automotive glass, others
1. Glass Manufacturing Process and Air Pollutants

- **Quartz sand**
- **Soda ash**
- **Limestone**
- **Cullet**
- **Others**

**Pot furnace**
- **Tempering furnace**
- **Bending furnace**
- **Laminating process**

**Tank furnace**
- **Decorating**
- **Firing oven**

**Pot furnace**
- **Manual forming**
- **Annealing**

- **SOx, NOx**
- **Dust**
- **Heavy oil**

- **Sheet glass**
- **Glasses for car**
- **Others**
- **Fluorescent tube**
- **Optical glass**
- **Flit**
- **Bottle, Container**
2. Soot & Dust Reduction

2-1 Reduction by means of Fuel and Furnace Operation

Causes of Dust

- Fuel — Dust (soot, ash, heavy metal)
- Raw Material — Scattered substances (ash, heavy metal)
- Non-uniform mixing fuel and air

Dust Reduction Method in Soda-Lime Glass Melting

- Switching fuel; Solid — Liquid — Gas
  Heavy oil — Kerosene
- Effective atomization of fuel
- Careful manipulation of air supplying
- Adequate proportion of furnace configuration to flame shape
- Reviewing particle size of batch (glass raw material)
- Adjustment of batch moisture content in batch wise charge
- No direct striking surface of batch with flame
2. Soot & Dust Reduction

2-2 Properties of Dust and Applicable Scope of Dust Collection

<table>
<thead>
<tr>
<th>Flue gas (400~600 °C)</th>
<th>Dust</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O₂</strong> 8~9%</td>
<td>Dust conc. 0.2~0.4 g/Nm³</td>
</tr>
<tr>
<td><strong>CO₂</strong> 10%</td>
<td>Particle size ~ 0.5 µm 25%</td>
</tr>
<tr>
<td><strong>H₂O</strong> 10%</td>
<td>0.5~ 0.3 µm 50%</td>
</tr>
<tr>
<td><strong>SOₓ</strong> 500~1,500ppm</td>
<td>0.3~0.1 µm 20%</td>
</tr>
<tr>
<td><strong>NOₓ</strong> 400~600ppm</td>
<td>0.1 µm ~ 5%</td>
</tr>
</tbody>
</table>

- **Soda-Lime Glass Melting Furnace Flue Gas**

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**Dust Collection**

- Tabacco smoke
- Oil smoke
- Flue dust
- Cement
- Pulverized coal
- Fly ash
- Cyclone
- Spray tower
- Packed tower
- Cyclone scrubber
- Venturi / jet scrubber
- Bag filter
- EP
2. Soot & Dust Reduction

2-3 Filter Dust Collector

Filtration Action in Filter Cloth

Flue gas
0.5~3 cm/s
P 250 dust
primary layer

Filter cloth

Clean gas

Dusting frequency
- intermittent
- continuous

Dusting drive
- vibration
- reverse air

Clean gas

Fan

Bag filter

Dusting frequency

Dusting drive

Flue gas

Clean gas

Dust

Flue gas
2. Soot & Dust Reduction

2-4 Electrostatic Precipitator

**Feature**
- Less influence of flue gas & dust
- Low pressure loss

**Peeling dust from electrode**
- Dry EP: hammering impact
- Wet EP: flow down with water film

**Factors affecting dust collection**
- particle size
- temperature, moisture, \( \text{SO}_3 \)

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**Diagram:**
- Discharging electrode
- Dust collecting electrode
- Dust removal (%)
- Discharge current (mA)

**Legend:**
- A: re-scattering
- B: normal
- C: frequent occurring of sparks
- D: counter electric dissociation
3. SOx Reduction Method

3-1 Desulphurization using Caustic Soda

\[
\begin{align*}
\text{SO}_2 + 2 \text{NaOH} & \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O} \\
\text{Na}_2\text{SO}_3 + \text{H}_2\text{O} + \text{SO}_2 & \rightarrow 2\text{NaHSO}_3
\end{align*}
\]

NaOH

\[
\begin{align*}
\text{Na}_2\text{SO}_3 + \frac{1}{2}\text{O}_2 & \rightarrow \text{Na}_2\text{SO}_4 \\
\text{NaHSO}_3 + \text{NaOH} & \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}
\end{align*}
\]
3. SOx Reduction Method

3-2 Desulphurization using Magnesium Hydroxide

Glass Melting Furnace

Waste Heat Boiler

Mg(OH)₂ + SO₃ \rightleftharpoons MgSO₃ + H₂O

Mg(OH)₂ + 2SO₂ \rightleftharpoons Mg(HSO₃)₂

MgSO₃ + 1/2O₂ \rightleftharpoons MgSO₄

Mg(HSO₃)₂ + Mg(OH)₂ \rightleftharpoons 2MgSO₃ + 2H₂O

Diatomaceous Earth Filter

Dehydrated cake

Wastewater

Stack
3. SOx Reduction Method

3-3 Dry-type Flue Gas Desulphurization

- Flue gas: \( \text{SO}_2, \text{SO}_3, \text{CO}_2 \)
- \( \text{Na}_2\text{SO}_4 \), \( \text{Na}_2\text{SO}_3 \), \( \text{Na}_2\text{CO}_3 \)
- Washing water
- Compressed air
- Reaction tower
- Cooling tower
- Stack

Desulphurization rate: 50~90% \( 0.05 \text{g/ Nm}^3 \)
4. NOx Reduction Method

4-1 Reduction of Nitrate in Raw Material

**NOx generation : NaNO₃ (oxidation, refining agent)**

**Reduction Method :**

1. Reducing NaNO₃ additives
   - Quantity of pull : 100 t / day
   - Flue gas volume : 17,000 m³ / h
   - Trial calculation : NaNO₃ : silica sand = 0.5 : 100  NOx 169 ppm
     -  = 0.3 : 100  = 102  reduction 67 ppm

2. Changing refining agent  (Sb₂O₃ ⌂ Na₂O ⌂ Sb₂O₅ ⌂₆H₂O)

   Sb₂O₃ + O₂ ⇌ high temp. Sb₂O₅ ⇌ high temp. Sb₂O₃ + O₂ ⇌ + thermal NOx ⇌

   Na₂O ⌂ Sb₂O₅ ⌂₆H₂O ⇌ low temp. Na₂O ⌂ Sb₂O₅ + 6H₂O ⇌

   high temp. Na₂O ⌂ Sb₂O₃ + O₂ ⇌
4. NOx Reduction Method
4-2 NOx Reduction Related to Fuel

Furnace temp. 1,500 ~ 1,600 °C Thermal NOx ▶ Fuel NOx

**N in Fuels**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Nitrogen (wt %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>0.7 ~ 2.2</td>
</tr>
<tr>
<td>C-heavy oil</td>
<td>0.2 ~ 0.4</td>
</tr>
<tr>
<td>A-heavy oil</td>
<td>0.0005 ~ 0.08</td>
</tr>
<tr>
<td>Light oil</td>
<td>0.004 ~ 0.006</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.0005 ~ 0.01</td>
</tr>
<tr>
<td>LNG</td>
<td>Tr.</td>
</tr>
<tr>
<td>LPG</td>
<td>Tr.</td>
</tr>
</tbody>
</table>

- JIS K2205 kinematic viscosity (cSt, mm²/s)
  - C-heavy oil: 50 ▶ ~1,000, A-heavy oil: ▶ 20
4. NOx Reduction Method

4-3 NOx Reduction by Furnace Operation Method

1. Declining Glass Melting Temp.
   - chemical composition ---- melting at lower temp.
   - using the largest possible quantity of cullet

2. Lowering Primary Air Pressure
   - lowering air pressure for fuel injection
   - ex. 4 kg/cm² → 3 kg/cm² → NOx ↓ 24%

3. Lowering Secondary Air Volume
   - decreasing air ratio ex. 1.2 → 1.1 → NOx ↓ 25%

4. Lowering Furnace Temp. (Max. Temp.)
   - allotting fuel distribution to maintain uniform temp. in furnace
   - electric boosting

5. Combustion Control Work Standards
4. NOx Reduction Method

4-4 Using Low NOx Burner

1. Hydraulic burner

- Low O₂ combustion ex. Air 170 → 120 m³/h → NOx → 25~30%

2. Supersonic burner
- Primary air: 30~40% less than conventional burner → lower NOx

3. Laidlaw burner
- Town gas is used instead of primary air → NOx → 20~25%

Burner | Heavy oil use ratio | NOx conc. ratio
---|---|---
Air atomizing | 1.00 | 1.00
Hydraulic | 0.88 | 0.62
5. Removing Toxic Substances

5-1 Cd & its Compounds

- Bag filter
- EP

Generating Source

special glass
- neutron cut-off glass
- others

dust & soot in volatilized fume

- CdS
- CdCO₃
5. Removing Toxic Substances
5-2 Pb & its Compounds

Crystal glass, TV-CRT, flit

Melting furnace

NaOH tank

Humidity controlling tower

500 μ
Particle 0.01~1 μm
Electric R. $10^{12}$ Ω cm

special EP

Stack

needle shaped discharge electrode
5. Removing Toxic Substances  
5-3 F & its Compounds

**Dry type defluorination**

- Flue gas
- Air
- Water
- Cooling tower
- Ca(OH)$_2$ powder
- Bag filter
- Dust tank

Dust:
- CaF$_2$, Ca(OH)$_2$
- CaCO$_3$, CaSO$_4$

Removal:
- F > 95%
- Dust > 98%

**Wet type defluorination**

- Flue gas
- Air
- Heat exchanger
- Venturi scrubber
- Absorption tower
- Oxidation tower
- Oxidation
- NaOH
- Slaked lime

Removal:
- F > 95%
- Dust > 75%
6. Environmental Management System

**Items to be considered at factory construction & operation**

1. **Environmental impact assessment**
2. **Environmental standards & emission standards**
3. **Planning of plant & air pollution control equipment**
4. **Operation control & worker training**
5. **Environmental monitoring**
6. **Environmental management system**
7. Energy Saving Technology

1. How to promote energy saving
   - Basic policy
   - Understanding current state
   - Goal
   - Measures

2. Energy saving methods
   - Acceleration of glass melting
     - increasing cullet use ratio
     - refining of grain of raw material
     - moisture control of batch
     - improvement of fusibility by glass composition
   - Combustion
     - combustion control
     - work standards
     - preventing of air intrusion
     - improvement & change of burner
   - Heat insulation & reduction of cooling air
   - Waste heat recovery
   - Others
     - introduction of cogeneration system & inverter control
     - development thinner & lighter glass bottle
     - stabilization of production process