Air Pollution Control Technology In Glass Manufacturing Industry

March 2005

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

Committee Members

Chairman:
Dr. K. Nishida, Researcher, Department of Urban and Environmental Engineering, Kyoto University (Retired)

Member:
Mr. S. Iwasaki, Director, Metocean Environment Inc.
Dr. S. Fujii (P.E.), Takuma Co., Ltd.
Mr. Y. Ogino (P.E.), Environment Technology L.R.C.

Prepared by
Dr. A. Hogetsu (P.E.), Research Commissioner, OECC
Asahi Glass Co., Ltd. Kashima Plant

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

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

**Heavenly oil**

- **Tank furnace**
  - Tempering furnace
  - Bending furnace
  - Laminating process

- **Pot furnace**
  - Decorating
  - Firing oven
  - Manual forming
  - Annealing

- **Glasses for car**
- **Others**
- **Fluorescent tube**
- **Optical glass**
- **Flit**

**SOx, NOx Dust**

**SOx, NOx Dust**

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

Soda-Lime Glass Melting Furnace

Flue Gas

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 → Filter cloth → Clean gas

- 0.5~3 cm / s
- 250 ˚P
- 150 mg Hg
- dust
- primary layer

Dusting frequency
- intermittent
- continuous

Dusting drive
- vibration
- reverse air

Clean gas

Flue gas

Fan

Bag filter

Dust
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, SO$_3$ $rac{\mu}{\mu}$ - cm

---

**Diagram:**
- Discharging electrode
- Dust collecting electrode
- 60kVA

**Graph:**
- 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

SO_2 + 2NaOH \rightarrow \ Na_2SO_3 + H_2O

Na_2SO_3 + H_2O + SO_2 \rightarrow 2NaHSO_3

EP with demister

after burner

NaOH

Na_2SO_4

crystallization can

melting furnace

waste heat boiler

absorption tower

oxidation tower

evaporation can

SOx

500 \degree C

air

300 \degree C

60~80 \degree C

Na_2SO_3 + 1/2O_2 \rightarrow Na_2SO_4

NaHSO_3 + NaOH \rightarrow Na_2SO_3 + H_2O
3. SOx Reduction Method

3-2 Desulphurization using Magnesium Hydroxide

Glass Melting Furnace

Waste Heat Boiler

Mg(OH)₂ + SO₃ → MgSO₃ + H₂O
Mg(OH)₂ + 2SO₂ → Mg(HSO₃)₂

MgSO₃ + 1/2O₂ → MgSO₄
Mg(HSO₃)₂ + Mg(OH)₂ → 2MgSO₃ + 2H₂O

Diatomaceous Earth Filter

Dehydrated cake

Stack

Wastewater

Absorption tower

Oxidation tank

Demister
3. SOx Reduction Method

3-3 Dry-type Flue Gas Desulphurization

- Flue gas: \( \text{SO}_2, \text{SO}_3, \text{CO}_2 \)
- Washing water
- Compressed air
- Cooling tower
- Reaction tower
- Powder: \( \text{Na}_2\text{SO}_4 \), \( \text{Na}_2\text{CO}_3 \)
- Desulphurization rate: 50~90%
- \( \leq 0.05 \text{g/ Nm}^3 \)

Desulphurization reactions:

- \( \text{Na}_2\text{SO}_4 \)
- \( \text{Na}_2\text{SO}_3 \)
- \( \text{Na}_2\text{CO}_3 \)
4. NOx Reduction Method

4-1 Reduction of Nitrate in Raw Material

\textbf{NOx generation : \textit{NaNO}_3 (oxidation, refining agent)}

\textbf{Reduction Method :}

1. Reducing \textit{NaNO}_3 additives
   
   Quantity of pull : 100 t / day
   
   Flue gas volume : 17,000 m\(^3\) / h
   
   Trial calculation : \textit{NaNO}_3 : silica sand = 0.5 : 100  \quad \text{NOx} \quad 169 \text{ ppm}
   
   
   \[ y = 0.3 : 100 \]
   
   \[ y_{\text{reduction}} = 67 \text{ ppm} \]

2. Changing refining agent  \textit{(Sb}_2\text{O}_3 \cdot \textit{Na}_2\text{O} \cdot \textit{Sb}_2\text{O}_5 \cdot 6\text{H}_2\text{O})

   \text{Sb}_2\text{O}_3 + \text{O}_2 \xrightarrow{\text{low temp. vitrification}} \text{Sb}_2\text{O}_5 \\
   \text{Sb}_2\text{O}_3 + \text{O}_2 \xrightarrow{\text{high temp. refining}} \text{Sb}_2\text{O}_3 + \text{O}_2 \quad + \quad \text{thermal NOx}

   \text{Na}_2\text{O} \cdot \text{Sb}_2\text{O}_5 \cdot 6\text{H}_2\text{O} \xrightarrow{\text{low temp.}} \text{Na}_2\text{O} \cdot \text{Sb}_2\text{O}_5 + 6\text{H}_2\text{O} \xrightarrow{\text{high temp. refining}} \text{Na}_2\text{O} \cdot \text{Sb}_2\text{O}_3 + \text{O}_2
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>0.005 ~ 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
   - Air atomizing
   - Use ratio: 1.00
   - NOx concentration ratio: 1.00
   - High hydraulic
   - Heavy oil

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

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

4. Gas atomizing heavy oil burner
   - Town gas is used instead of primary air → NOx 20~25%
5. Removing Toxic Substances

5-1 Cd & its Compounds

- Bag filter
- EP

dust & soot in volatilized fume

special glass
- neutron cut-off glass
- others

Generating Source

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

- Crystal glass, TV-CRT, flit
- Melting furnace
- NaOH tank
- Humidity controlling tower
- 300 \text{\textmu}m
- 500 \text{\textmu}m
- Particle 0.01~1 \text{\textmu}m
- Electric R. $10^{12}$ \text{\textmu}cm
- Special EP
- Stack

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

**Dry type defluorination**
- Flue gas
- Air
- Water
- Ca(OH)$_2$ powder
- Cooling tower
- Bag filter
- Dust tank
- Removal $F > 95\%$
- Dust $> 98\%$
- CaF$_2$, Ca(OH)$_2$
- CaCO$_3$, CaSO$_4$

**Wet type defluorination**
- Flue gas
- Air
- NaOH
- Slaked lime
- Heat exchanger
- Venturi scrubber
- Absorption tower
- Oxidation tower
- CaF$_2$
- 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