Latest Results of Bottom Ash Handling in Japan

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Japan Environmental Facilities Manufacturers Association (JEFMA)

NIPPON STEEL & SUMIKIN ENGINEERING CO., LTD.
Nobuhiro Tanigaki
Contents

1. Classification of Bottom Ash in Japan

2. Regulation of Bottom Ash
   ✓ Driving force for ash melting
   ✓ Some figures
   ✓ Related regulation

3. Recycling of Bottom Ash and Slag
   ✓ Material Balance
   ✓ How to reused bottom ash
   ✓ Metal recovery from bottom ash
   ✓ Slag recycling
   ✓ Slag regulation

4. Summary
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4. Summary
Classification of Bottom Ash in Japan

WASTE

Industrial Waste

General Waste*

Commercial Waste

MSW, Bottom Ash

- Bottom ash from incinerator is classified as waste and it is not allowed to reuse as secondary materials for road construction directly.

Specially-controlled municipal waste

- Fly ash,
- Bottom ash with higher DXNs concentration (>3 ng-TEQ/g)

* Waste should be landfilled following the leaching regulation.
Classification of Bottom Ash in Japan

**Specially-controlled municipal waste** should be stabilized by the following methods before transferring to landfill site.

1) Melting
2) Sintering
3) Cement
4) Chemical (Chelate)
5) Stabilization with acid or other solvent

- Bottom ash with lower DXNs is classified as "**general waste**" can be landfilled if the leaching values are satisfied (see right table).

- If the leaching values is not satisfied, the stabilization of bottom ash should be required.

- Bottom ash with higher DXNs and fly ash are classified as "**Specially-controlled municipal waste**" and landfilled after stabilization (leaching limit is the same as bottom ash)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>0.3</td>
</tr>
<tr>
<td>Lead</td>
<td>0.3</td>
</tr>
<tr>
<td>Cr(VI)</td>
<td>1.5</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.3</td>
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4. Summary
Driving Forces for Ash Melting

✓ Bottom ash was specified as “WASTE” and as a specially-controlled municipal waste if the DXNs concentration is higher than 3 ng-TEQ/g.
✓ Due to DXNs problems, an optimum treatment was required.

✓ WTE facilities are subsidized (1/2 or 1/3 of CAPEX) by Central Government if the facility fulfills “certain conditions” in order to facilitate “environmental measure” and “installation of the EFW”

✓ In 1996, a statement was issued, which mentioned that a new WTE facility should have a melting equipment for ash in order to reduce and recycle bottom ash.

✓ In 1997, a statement WTE with a melting equipment for reducing DXNs emissions.

✓ In 1998, a guidance for recycling molten slag from MSW

“Melting” became a basic condition for granted money from Central Government.
### Number of Melting & Gasification Facilities

As of FY2011

<table>
<thead>
<tr>
<th>Type</th>
<th>Numbers of facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ash melting</strong></td>
<td></td>
</tr>
<tr>
<td>Electrode 108</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Alternating current arc 11</td>
</tr>
<tr>
<td>55</td>
<td>Electric resistance 10</td>
</tr>
<tr>
<td>55</td>
<td>Plasma arc 34</td>
</tr>
<tr>
<td>Fuel 53</td>
<td>Rotating surface 38</td>
</tr>
<tr>
<td>53</td>
<td>Rotary kiln 5</td>
</tr>
<tr>
<td>53</td>
<td>Shaft furnace 4</td>
</tr>
<tr>
<td>53</td>
<td>Others 6</td>
</tr>
<tr>
<td><strong>Gasification – melting</strong></td>
<td></td>
</tr>
<tr>
<td>Integral 102</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Shaft furnace 50</td>
</tr>
<tr>
<td><strong>Gasification – gas reforming</strong></td>
<td></td>
</tr>
<tr>
<td>Separation 52</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Rotary kiln 13</td>
</tr>
<tr>
<td>52</td>
<td>Fluidized bed 39</td>
</tr>
<tr>
<td><strong>Gasification – gas reforming</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>
Number of Melting & Gasification facilities

Total number of facility is approx. 1,200
In 2003, a statement for exceptions of WTE with melting equipment.

In 2005, institution has been changed (granted money to “subsidy scheme”) following requests from some municipalities. At this moment, “a melting equipment” is not mandatory for the subsidy receiving.

Municipality can choose an optimum option, depending on their facing situation
1) Recycling, minimizing landfill amount => Slag, vitrification (major choice, ½ of CAPEX is subsidized from Central Government)
2) Minimizing operation cost => incineration without melting facilities
3) Cooperation with industries => RDF, cement etc.

In 2014, a condition was changed to “a WTE facility with high power generation”. The requirement varies depends on the capacity etc.

80% of bottom ash is still landfill without recycling.
Many municipalities still want to minimize final landfill amount due to the lack of landfill site and higher landfill cost. In the case, the measures to minimize landfill amount will be required and subsidized (gasification, melting, cement etc).
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4. Summary
Material Flow of MSW thermal processes in Japan

As of 2011, Unit: x1000 t/y

- **MSW Thermal Treatment**: 35419
- **Incineration**: 31769
  - **I-Fly Ash**: 1070
    - To Ferrous, Aluminum
  - **Bottom Ash**: 2589
    - Ash Melting: 679
      - Metal: 40
      - MF-Fly Ash: 121
        - Slag: 632
          - Landfill: 3162
          - Smelting feeds: 29
          - Ferros (incl. Metal): 73
  - **Gasification-Melting**: 3650
    - Reuse: 1045 ton (25%)
    - Landfill: 3162 ton (75%)
Example of Material Balance in Incineration Facility

- **Incinerator**
  - 1000 kg
  - Flue gas
  - Dust
  - Bottom ash

- **Melting Furnace**
  - 50 kg
  - Molten slag
  - Molten metal

- **No.1 Bag filter**
  - Fly ash
  - 7 kg

- **No.2 Bag filter**
  - Residue
  - 14 kg

- **Chimney**
  - Lime, etc
  - 14 kg

- **Fly ash treatment**
  - Treated residue
  - 29 kg

- **Preclusives**
  - 12 kg

- **Agents, water**
  - 8 kg

- **Molten slag**
  - 50 kg

- **Molten metal**

- **Much lower than in Europe**

須坂市提供（長野市A焼却施設の処理フローにより作成）
Recycling of Bottom Ash and Slag

Main recycling pathways of incineration bottom ash in Japan are;

as of 2011

(1) Sintering (24,000 t/a)

(2) Cement kiln (173,000 t/a)
   Bottom ash is prepared for cement production
   i.e. crushing, metal separation etc.
   Cement with bottom ash is called “Eco-Cement” which is regulated by Japan
   Industrial Standard (JIS) strictly.

(3) Slag (526,000 t/a)
   There are several regulation for slag recycling

   JIS A 5031: Melt-solidified slag aggregate for concrete derived from
               municipal solid waste and sewage sludge

   JIS A 5032: Melt-solidified slag material for road construction derived from
               municipal solid waste and sewage sludge
Example of Bottom Ash Recycling (Cement)

Example of Bottom Ash Recycling (Cement)

Recycling of Bottom Ash and Slag

MSW

Bottom Ash

Air-cooled

water-quenched

slag

Concrete block

Interlocking block

Asphalt paving
Slag Recycling Regulations

Guidance for inspection of chemicals in slag

JIS K 0058
Testing method for chemicals of slag
  JIS K 0058-1
  Leaching test method
  JIS K 0058-2
  Acid extractable content

JIS A 5031
Melt-solidified slag aggregate for concrete derived from municipal solid waste and sewage sludge

JIS A 5032
Melt-solidified slag material for road construction derived from municipal solid waste and sewage sludge

JIS A 5011 – 1~4
Slag aggregate for concrete
  Part 1: Blast furnace slag aggregate
  Part 2: Ferronickel slag aggregate
  Part 3: Copper slag aggregate
  Part 4: Electric arc furnace oxidizing slag aggregate

JIS A 5015
Iron and steel slag for road construction

2 testing methods of slag recycling

National Institute of Environmental Studies, Japan
Ideas for Slag Testing Regulation

2 testing methods of slag recycling

Soil Pollution Countermeasure Act

“Leaching Pathway”
“Direct Intake Pathway”

Testing methods and limit values

Fujikura M (1999)
J Mtrl Cycle Waste Manage 10(2)138-146 (Amended)

National Institute of Environmental Studies, Japan
### Slag Recycling Regulation

#### Soil Recycling Regulation

<table>
<thead>
<tr>
<th>Soil Environmental Standard</th>
<th>Soil Pollution Countermeasure Act</th>
<th>JIS A 5031</th>
<th>JIS A 5032</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test method</td>
<td>Leaching</td>
<td>Content</td>
<td>Leaching</td>
</tr>
<tr>
<td>Unit</td>
<td>mg/L</td>
<td>mg/L</td>
<td>mg/kg</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.01</td>
<td>0.01</td>
<td>150</td>
</tr>
<tr>
<td>Lead</td>
<td>0.01</td>
<td>0.01</td>
<td>150</td>
</tr>
<tr>
<td>Cr(VI)</td>
<td>0.05</td>
<td>0.05</td>
<td>250</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.01</td>
<td>0.01</td>
<td>150</td>
</tr>
<tr>
<td>Total-Hg</td>
<td>0.0005</td>
<td>0.0005</td>
<td>15</td>
</tr>
<tr>
<td>Alkyl-Hg</td>
<td>Not detected</td>
<td>Not detected</td>
<td>-</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.01</td>
<td>0.01</td>
<td>150</td>
</tr>
<tr>
<td>Fluorine</td>
<td>0.8</td>
<td>0.8</td>
<td>4000</td>
</tr>
<tr>
<td>Boron</td>
<td>1</td>
<td>1</td>
<td>4000</td>
</tr>
</tbody>
</table>

**JIS K 0058-1:** Leaching to the soil  
**JIS K 0058-2:** Based on the direct ingestion of contaminated soil (Child 200 mg/d, Adult 100 mg/d), leaching test by 1M HCl (the same as stomach acid)
Production of MSW Slag

The Japan Society of Industrial Machinery Manufacturers
## Recycling of MSW Slag

<table>
<thead>
<tr>
<th>Material</th>
<th>2008 (kt)</th>
<th>2008 (%)</th>
<th>2009 (kt)</th>
<th>2009 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate for road</td>
<td>239</td>
<td>33.3</td>
<td>222</td>
<td>30.6</td>
</tr>
<tr>
<td>Aggregate for concrete &amp; brick</td>
<td>139</td>
<td>19.4</td>
<td>127</td>
<td>17.5</td>
</tr>
<tr>
<td>Soil stabilization material</td>
<td>110</td>
<td>15.3</td>
<td>127</td>
<td>17.6</td>
</tr>
<tr>
<td>Top cover material in landfill</td>
<td>89</td>
<td>12.3</td>
<td>84</td>
<td>11.6</td>
</tr>
<tr>
<td>Base material of engineering works (e.g. pipes)</td>
<td>43</td>
<td>6.0</td>
<td>39</td>
<td>5.4</td>
</tr>
<tr>
<td>Backfill, banking</td>
<td>57</td>
<td>8.0</td>
<td>88</td>
<td>12.1</td>
</tr>
<tr>
<td>Frost heave control material</td>
<td>5</td>
<td>0.7</td>
<td>8</td>
<td>1.0</td>
</tr>
<tr>
<td>Others</td>
<td>36</td>
<td>5.1</td>
<td>31</td>
<td>4.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>719</strong></td>
<td><strong>100</strong></td>
<td><strong>725</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The Japan Society of Industrial Machinery Manufacturers
Summary

1) Bottom ash is generally classified as “general waste” in Japan.

2) When the DXNs concentration is high, the bottom ash is classified as “Specially-controlled municipal waste” and additional treatment is mandatory for stabilizing heavy metals.

3) Subsidy scheme has been changed in Japan. Ash melting equipment was necessary to receive subsidy but now it has been changed. **Melting equipment is not mandatory for subsidy, meaning that municipalities can select whether they have melting equipment (subsidized) or not.**

4) 80% of bottom ash from incinerators are landfilled. 20% is recycled. The main recycling method is “Slag” via melting.

5) Many municipalities still want to minimize final landfill amount due to the lack of landfill site and higher landfill cost. In the case, the measures to minimize landfill amount will be required and subsidized (gasification, melting, cement etc).

6) In these days, an incineration with bottom ash recycling using Cement Kiln becomes one of the main streams for minimizing final landfill amount.