Material and Energy Recovery from Waste via Waste Gasification

8th ISWA Beacon Conference in Malmö, Sweden
28th NOV. 2013
BLOCK 3: Technical State of the Art and New Technologies

NIPPON STEEL & SUMIKIN ENGINEERING CO., LTD
Nobuhiro Tanigaki
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1. Company Overview
# 1.1. NSENGI Company Profile

<table>
<thead>
<tr>
<th><strong>Company name:</strong></th>
<th>NIPPON STEEL &amp; SUMIKIN ENGINEERING Co., Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launched</strong></td>
<td>2006 (Spun off from NIPPON STEEL CORPORATION) 100% owned by NSSMC</td>
</tr>
<tr>
<td><strong>Group</strong></td>
<td>NIPPON STEEL &amp; SUMITOMO METAL Group (2nd Largest Steel Company in the world)</td>
</tr>
<tr>
<td><strong>Total Revenue:</strong></td>
<td>2.3 b € (13/3A)</td>
</tr>
<tr>
<td><strong>Capital Stock:</strong></td>
<td>115 m € (as of 1 Apr. 2013)</td>
</tr>
<tr>
<td><strong>Number of Employees:</strong></td>
<td>4,149 (As of 1 Oct. 2012)</td>
</tr>
<tr>
<td><strong>Business Fields</strong></td>
<td>Environmental Solution, Steel Plant, Energy Facility, Marine Construction, Buildings &amp; Steel Structures</td>
</tr>
</tbody>
</table>

*Note: Exchange rate : JPY/EUR = 130.0*
1.2. NSENGI Oversea Bases

1) Nippon Steel & Sumikin Engineering USA Inc.
2) NIPPON STEEL & SUMITOMO METAL Empreendimentos Siderurgicos Ltda.
3) European office (Düsseldorf, Germany)
4) Beijing JC Energy & Environment Engineering Co., Ltd.
5) Nippon Steel & Sumikin Engineering (Shanghai) Co., Ltd.
6) Maanshan Sino-Japan Resource Recycling Engineering Technology Co., Ltd.
7) CN Steel Plant Engineering Co., Ltd.
8) Nippon Steel Engineering India Plant & Machinery Private Ltd.
9) Thai Nippon & Sumikin Engineering & Construction Corp., Ltd.
10) Ho Chi Minh Representative office
11) PNS Advanced Steel Technology, Inc.
12) Manila office
14) Singapore office
15) PT. Nippon Steel & Sumikin Batam Offshore Service
16) PT. Nippon Steel & Sumikin Construction Indonesia
17) Jakarta Office
18) Nippon Steel Engineering (Australia) Pty Ltd.
1.3. Environmental Solutions Division Business Line-up

- Waste Gasification and Melting Technology (Direct Melting System (DMS))
  - The world’s highest number of facilities (42 orders)
  - The world’s largest facility capacity (230,000 t/annual)
  - The world’s longest-term operation (34 years)

- Waste Tire Pyrolysis Facility

- Biomass Gasification

- Biomass to Ethanol Technology

- Processing hazardous waste

- Soil remediation

- Groundwater cleaning

(Night Melting System)

(Gasification Recycling Facility for Waste Tire)
2. Technical Introduction of Direct Melting System
2.1. Basic Concept

**STABILITY**
- High Temperature Gasification
- Processing Various Kinds of Waste
- High and Homogeneous Quality of Slag and Metal Production

**PURITY**
- Homogeneous Syngas Combustion
- Low Dioxins Emissions
- Less HCl and SO$_2$ Emissions

**SUSTAINABILITY**
- Energy Recovery
- Material Recovery (Slag and Metal)
- Contribution to “Recycle -based Society”

**RELIABILITY**
- More than 34 Years Operation & Maintenance
- 42 Commercial References
- Technical Improvement (R&D)
2.2. Process Flow - Direct Melting System -

- Gasification/Material Recovery
- Flue Gas Cleaning/Energy Recovery

Waste Pit → Gasifier → Combustion Chamber → Boiler → Gas Cooler → Baghouse

- Recyclables
- Metal
- Slag

Coke and Limestone → O2-PSA → Combustion Air Draft Fan (CDF) → Magnetic Separator → Recyclables

Water Granulator → Gas Cooler → Gasification/Material Recovery

Forced Draft Fan (FDF) → Gasification/Material Recovery

Stack → SCR → Wet Scrubber

ID Fan → Re-Heater → Landfilling
2.3. Gasifier - Co-gasification -

- **Flexibility of Processed Waste**
  No Pretreatment (Max. 800 mm)
  Co-gasification

- **High Syngas NCV**
  Continuous syngas measuring
  Approx. 5.9 MJ/m³, based on 9.1 MJ/kg-waste
  *refer to N.Tanigaki et. al. Waste Management*

- **High Temperature & Reducing Atmosphere**
  Produced by coke burning heat
  Toxic heavy metals are volatilized and distributed to fly ash.
  Few toxic heavy metals remain in slag and metal.
2.4. Environmental Impact (HCl & SO₂)

- **Desulfurization** by limestone injection to the gasifier

- Both the dry and wet flue gas cleaning achieved the same removal efficiency.

- The concentration in the inlet of BF is low enough

- Removal efficiency is not high due to low concentration in the inlet.


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3. Material and Energy Recovery from Waste
3.1. Material Recovery - Recycling of slag and metal -

Discharging Molten Materials (mixture of slag and metal)

- Metal
- Slag

Materials of Iron industries

Counterweight for construction machine

<table>
<thead>
<tr>
<th></th>
<th>Slag (DMS)</th>
<th>Natural Sand (example)</th>
<th>Japanese Standard limited value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb (lead) mg/kg</td>
<td>5~20</td>
<td>1~15</td>
<td>&lt;150</td>
</tr>
<tr>
<td>Arsenic mg/kg</td>
<td>&lt;0.5</td>
<td>~2</td>
<td>&lt;150</td>
</tr>
<tr>
<td>Cd mg/kg</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;150</td>
</tr>
<tr>
<td>T-Hg mg/kg</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Chromium mg/kg</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;250</td>
</tr>
<tr>
<td>Selenium mg/kg</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>&lt;150</td>
</tr>
<tr>
<td>Fluorine mg/kg</td>
<td>50~200</td>
<td>&lt;400</td>
<td>&lt;4,000</td>
</tr>
<tr>
<td>Boron mg/kg</td>
<td>100~250</td>
<td>&lt;400</td>
<td>&lt;4,000</td>
</tr>
</tbody>
</table>

Acid leaching test (JIS K0058-2)

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3.2. Slag Recycling

Concrete block

Interlocking block

Asphalt paving

Marine Block

Slag

Natural sand

Soil
3.3. Heavy Metal Distribution

![Graph showing heavy metal distribution across different sources: FLY ASH, METAL, SLAG, and FLUE GAS. The metals Ca, Si, Al, Mg, Pb, Zn, Na, K, T-Cl, T-S, Cu, and T-Fe are shown with their respective percentage distributions in each category.]

3.4. Narumi Plant - Co-Gasification of Bottom Ash -

- Bottom ash recycling is not allowed.
- The municipality has no landfill site.

⇒ *Need solutions: Co-Gasification and recycling*

1) Completion: July 2009
2) Capacity: 11 t/h x 2 lines (540 t/day)
3) Processing Waste: Municipal Solid Waste, Bottom Ash, Combustible Residues, Incombustible Residues
4) Waste LHV: 6.5 MJ/kgₐ.r.
5) FGT System: BF + Wet scrubber + SCR
6) Power Generation: 9 MWₑₑₑₑₑₑ (Gross)
7) Boiler Conditions: 400 °C, 40 Bar
### 3.5. New Waste Management Scheme

#### Conventional Scheme

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSW</td>
<td>62,883 t</td>
</tr>
<tr>
<td>Bulky Incombustibles</td>
<td>4,627 t</td>
</tr>
<tr>
<td>Bottom ash</td>
<td>12,577 t</td>
</tr>
</tbody>
</table>

#### Final Landfill

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Ash*1</td>
<td>7,407 t</td>
</tr>
<tr>
<td>Bulky Incombustibles</td>
<td>4,627 t</td>
</tr>
<tr>
<td>Bottom ash</td>
<td>12,577 t</td>
</tr>
</tbody>
</table>

**Total**: 25,862 t² (32.3%)

**87% Reduction**

#### New Scheme

<table>
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<tr>
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#### Final Landfill

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated Fly Ash*1</td>
<td>3,228 t</td>
</tr>
</tbody>
</table>

**Total**: 3,228 t² (4.0%)

#### Recycling

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slag</td>
<td>18,475 t</td>
</tr>
<tr>
<td>Metal</td>
<td>2,915 t</td>
</tr>
</tbody>
</table>

**Total**: 21,390 t² (26.7%)

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Refer to N. Tanigaki et al.: *ISWA World Congress 2012*, Florence, Italy


*1 wet-base,  *2 recycling / total processing waste

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3.6. Shin-Moji Plant - The Largest Gasification Plant -

1) Completion: April 2007
2) Capacity: 10 t/h x 3 lines (720 t/day)
3) Processing Waste: Municipal Solid Waste, Incombustibles, Sewage Sludge
4) Waste LHV: 9.1 MJ/kg\(_{a.r.}\)
5) FGT System: BF + SCR
6) Power Generation: 23.5 MW\(_{\text{Gross}}\) (23%\(_{\text{Gross}}\)) \textit{The highest efficiency in Japan}
7) Boiler Conditions: 400 °C, 40 Bar
4. References in Japan and South Korea

- 42 references
- 34 years operation
- 10,000 - 230,000 t/a
5. Summary and Conclusion

✓ NIPPON STEEL & SUMIKIN ENGINEERING (NSENGI) has the largest and longest references of “Waste Gasification and Melting Technology”.

✓ High temperature gasification process leads flexibility of waste to be processed and production of high quality slag and metal

✓ Slag and metal can be recycled without any further post-treatment and be widely utilized not only for secondary materials but also for agriculture (fertilizer).

✓ Due to the flexibility of waste to be processed, this technology has a possibility to approach to environmental conservation and resource recycling from waste.

✓ Direct Melting System can be an alternative thermal treatment for material and energy recovery from waste.
Thank you very much for your attention

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