DIRECT MELTING SYSTEM
Waste Gasification Technology for Energy and Material Recovery
Creating a Better Society for the Next Generation

As the world progresses towards modernization, environmental issues such as the recycling of waste and the conservation of energy have become a global theme.

We, the engineers and professionals at NIPPON STEEL & SUMIKIN ENGINEERING (NSENG), are able to respond to such issues by using our latest technologies, supported by our unmatched knowledge acquired through years of experience.

Gasification as an Alternative Waste to Energy

Waste gasification is recognized as an alternative thermal treatment technology. NSENG's gasification and melting technology is a proven waste gasification technology based on more than 34 years of operating experience.

Our Principle

NSENG's gasification technology consists of four main concepts.

- **Stability**: A variety of waste is processed and converted to recyclables.
- **Purity**: Cleaned gas is discharged from the facility.
- **Sustainability**: Energy and recyclables from waste contribute to a recycle-based society.
- **Reliability**: Long-term operation and maintenance lead the way for technical innovation.

Waste hierarchy is a classification of waste management in order to minimize environmental impact; this hierarchy has been widely introduced across the globe. Waste-to-Energy technology is classified as "Other Recovery". NSENG's technology can contribute to minimizing "Disposal" and maximizing "Recycling" in addition to "Other Recovery".

Conventional Energy Recovery

NSENG's Technology

Prevention & Reduction

Reuse

Recycling

Other Recovery

Disposal

Resource Recycling Energy Recovery
DIRECT MELTING SYSTEM - Deriving Energy and Materials from Waste -

**Waste Charging Equipment** (No Pretreatment)
A double damper system is used for waste charging. Air, which is introduced during waste charging, is purged by nitrogen. This system avoids syngas leakage from the gasifier.

**Syngas Analysis**
Syngas compositions are continuously assessed in terms of safety and operating optimization. Combustible dusts are captured by the cyclone. This conserves the consumption of coke and reduces the final landfill amount.

**Water Granulating Equipment**
Molten materials are discharged automatically and intermittently. This produces homogeneous molten materials and extends the lifetime of refractory.

**Independent Combustion Chamber**
Syngas is combusted by air. Homogeneous combustion gas-gas combusted can significantly reduce the Dioxins and NOx generation.

**Boiler / Steam Turbine**
Flue gas energy is effectively recovered by a boiler. Power is generated by a steam turbine and is transferred to a grid.

**Flue Gas Treatment**
An optimum cleaning system can be ensured in this section, e.g., filtration and SCR (Selective Catalytic Reduction). Flue gas components from the stack are reduced to be significantly low.

**Gasification / Material Recovery Process**

**Flue Gas Treatment / Energy Recovery Process**

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Additional annotations:
- **Recycling**
- **Final Landfill or Heavy Metal Recovery**
- **Cyclone**
- **Combustion Air Draft Fan**
- **Combustion Chamber**
- **Boiler**
- **Steam Turbine**
- **District Heating**
- **Reactor Agents**
- **Bag Filter**
- **ID Fan**
- **APC Dust**
- **Ammonia**
- **SCR**
- **Stack**
Minimize "Disposal" and Maximize "Recycling" via Co-Gasification

Stable Waste Processing
Processed waste is gradually gasified in a packed-bed which can homogenize raw gas quantities regardless of the processed waste compositions. No pretreatments such as drying, sorting or crushing are required.

High-Temperature Gasification
Able to process a variety of waste and produce high-quality slag and metal.

Integrated gasification and melting furnace

- Drying & Preheating Zone 300°C ~ 600°C
- Thermal Decomposition Zone 300°C ~ 1000°C
- Combustion Zone 1000°C ~ 1700°C
- Melting Zone 1700°C ~ 1800°C

Minimizing Final Landfill
A high-temperature reducing atmosphere volatilizes toxic heavy metals such as lead and zinc, and produces high-quality slag and metal, which can be completely recycled. In addition to slag and metal recycling, recycling fly ash leads to "Zero Waste".

Final Landfill Amount
Conventional vs NSENGII's Technology

Stability
A variety of waste is processed and converted to recyclables.
Complete Syngas Combustion and Significant Reduction of Dioxins

**Independent Combustion Chamber**
Syngas independent combustion can contribute to a reduction of Dioxins and NOₓ.

- **3 Ts** (Temperature, Time and Turbulence) for the reduction of Dioxins
  - It is designed to achieve 3 Ts. The temperature at the outlet is kept higher than 1000°C and the retention time after the second air injection is longer than 2 seconds. The main burner system leads to turbulent and complete syngas combustion.

- **High-Temperature Retention Zone**
  - 950°C - 1050°C

- **Main Combustion Zone**
  - 1050°C - 1100°C

**Homogeneous Syngas Combustion**
Syngas is combusted completely by air. Homogeneous combustion reduces Dioxins and thermal NOₓ generation optimizes the combustion control.

**Flue Gas Treatment**
Optimization of flue gas treatment can minimize the environmental impact.

- **Reactant Optimization**
  - Feedback and feedforward control optimize the reactant quantity.

- **Lower Environmental Impact**
  - Lower flue gas components are discharged from the thermal unit. Limestone injection in the gasifier can lead to lower HCl and SO₂ emissions in the flue gas. Limestone reacts with HCl and SO₂ to reduce emissions.

- **Lower Emissions**
  - Emissions are significantly lower than the EU regulation limit.

- **Examples**
  - Dust: g/m³ N
  - NOₓ: mg/m³ N
  - HCl: mg/m³ N
  - SO₂: mg/m³ N
  - Dioxins: ng-TEQ/m³ N

<table>
<thead>
<tr>
<th>Unit of Eff.</th>
<th>N/E/G/1's Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td>1-3</td>
</tr>
<tr>
<td>NOₓ</td>
<td>300</td>
</tr>
<tr>
<td>HCl</td>
<td>300-400</td>
</tr>
<tr>
<td>SO₂</td>
<td>30-100</td>
</tr>
<tr>
<td>Dioxins</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

(People on the waste compositions)
Contribution to a "Recycle-Based Society"

Energy from Waste
Power generation is the most important issue in Energy from Waste plants. NS Eni has developed state-of-the-art and highly efficient plants in Japan where the main priority of waste processing is volume reduction. NS Eni has been improving its boiler and power generation system in line with market demand.

Materials from Waste
High-temperature gasification produces high-quality slag and metal. The produced slag is almost the same quality as natural sand. Slag can not only be recycled for secondary construction materials, but also for agricultural use.

Sustainability
Energy and recyclables from waste contribute to a recycle-based society.

<table>
<thead>
<tr>
<th>Slag Recycling</th>
<th>Natural Sand (Recycled)</th>
<th>Natural Sand (Unrecycled)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate mg/kg</td>
<td>5-20</td>
<td>1-15</td>
</tr>
<tr>
<td>Arsenic mg/kg</td>
<td>&lt; 0.5</td>
<td>1-15</td>
</tr>
<tr>
<td>Cu mg/kg</td>
<td>&lt; 0.1</td>
<td>1-15</td>
</tr>
<tr>
<td>Hg mg/kg</td>
<td>&lt; 0.05</td>
<td>1-15</td>
</tr>
<tr>
<td>Chromium mg/kg</td>
<td>&lt; 1</td>
<td>1-15</td>
</tr>
<tr>
<td>Selenium mg/kg</td>
<td>&lt; 0.2</td>
<td>1-15</td>
</tr>
</tbody>
</table>

Metal Recycling
Materials for iron industry  Materials for non-ferrous industry  Counterweight for construction machine

Soil
Marine block
Concrete blocks
Asphalt paving

NS-HE05EA-23
Confidence Confirmed by Long-Term Operation and Development

Operation & Maintenance (O&M)
In order to optimize the waste to energy plant capacity, O&M is also an important factor. NSENGI's gasification plants are operated by our subsidiary company NIPPON STEEL & SUMIKIN ENVIRONMENTAL PLANT SOLUTIONS (NSES).

Research & Development (R&D)
Gasification pilot plants are located in NSENGI's technical center in Japan. Fundamental areas of research, new technical applications, and operating optimization methods have been explored. Biomass-coke, for example, has been developed to reduce greenhouse gas emissions.

Reliability
Long-term operation and maintenance lead the way for technical innovation.
Reference Plants

The Direct Melting System has been operating for more than a generation. Over 40 plants have been employed and operated continuously.

- **Shin-Moji Plant**
  - Capacity: 10.0 t/h, 3 lines(3270 t/d)
  - Gross Power Generation: 23,500 kW
  - Start of operation: Apr, 2007
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Incombustibles
    3) Sewage Sludge

- **Kamaishi Plant**
  - Capacity: 2.3 t/h, 2 lines(119 t/d)
  - Gross Power Generation: District Heating
  - Start of operation: Sep, 1979
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Incombustibles
    3) CFC Gas

- **Ibaraki Plant**
  - Capacity: 6.3 t/h, 2 lines(3150 t/d)
  - Gross Power Generation: 10,000 kW
  - Start of operation: Aug, 1980 Apr, 1999
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Incombustibles

- **Iwate Plant**
  - Capacity: 3.1 t/h, 2 lines(147 t/d)
  - Gross Power Generation: 2,400 kW
  - Start of operation: Apr, 2011
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Bulky Waste

- **Kazusa Plant**
  - Capacity: 4.2 t/h, 2 lines(209 t/d)
  - Gross Power Generation: 5,000 kW
  - Start of operation: Mar, 2006
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Incombustibles
    3) Sewage Sludge
    4) Incineration Residues

- **Narumi Plant**
  - Capacity: 11.0 t/h, 2 lines(5700 t/d)
  - Gross Power Generation: 9,000 kW
  - Start of operation: Jul, 2009
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Incombustibles
    3) Incineration Residues

- **Akita Plant**
  - Capacity: 9.6 t/h, 2 lines(440 t/d)
  - Gross Power Generation: 8,500 kW
  - Waste to be treated:
    1) Municipal Solid Waste
    2) Incombustibles
    3) Incineration Residues
    4) Sewage Sludge

- **Himeji Plant**
  - Capacity: 5.6 t/h, 3 lines(402 t/d)
  - Gross Power Generation: 10,500 kW
  - Start of operation: Apr, 2010
  - Waste to be treated:
    1) Municipal Solid Waste

Largest gasification plant with high power generation efficiency.