Generating waste is not an art, recovering its energy and resources is.

Dr. Edmund Fleck

Recent Developments in WTE Grate Combustion: Technology and Implementation
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1. Introduction

PAST
Waste Incineration Plant

Thermal Waste Treatment Plant

Waste Heating Power Plant

TODAY
Waste-to-Energy Plant
Energy from Waste Plant
2. Historic Overview

- First waste incineration plants were built in Europe in the middle of the 19th century.
- Simple, batch type technology - no heat recovery, no flue gas treatment.
- Large-scale application of waste incineration only after end of WW II.
  - Landfill space became more scarce.
  - Environmental consciousness increased.
  - Financial resources available.
2. Historic Overview, cont’d

- Technology substantially improved
- Continuous waste feeding and residue removal
- Heat recovery introduced
- Flue gas treatment in several steps
  - Particulate removal - ESP, FF
  - Removal of acid components (HCl, SOx etc) - wet, dry, semi-dry
  - Removal of organic substances and heavy metals - active carbon/coke (fixed bed, ‘filsorption’)
  - Removal of NOx - SNCR, SCR
2. Historic Overview, cont`d

Hamburg 1896

Source: A. Nabasik and A. Nottrotlt
2. Historic Overview, cont’d
2. Historic Overview, cont’d
2. Historic Overview, cont`d
2. Historic Overview, cont`d
2. Historic Overview, cont`d
2. Historic Overview, cont`d
3. Martin Technologies

- Reverse-acting grate 26°
- Reverse-acting grate 24° / SITY2000
- Horizontal grate
- Boiler design for vertical and horizontal boilers
- SYNCOM / SYNCOM-Plus
- Combustion control
- SNCR - DeNOx - system
- Sewage sludge co-combustion systems
- Ash handling systems
MARTIN reverse-acting grate System

1. Feed hopper
2. Feeder
3. MARTIN reverse-acting grate
4. MARTIN discharger
5. Furnace
6. Steam heated air preheater
7. Primary combustion air (underfire)
8. Secondary combustion air (overfire)
MARTIN reverse-acting grate

- Movement against the direction of waste flow
- Uniform covering of grate
- Protection against intensive heat from radiation
- Protection against thermal wear
- Long service life
- Excellent stoking and mixing of waste
Furnace with 5 runs
MARTIN horizontal grate system

1. Feed hopper
2. Feeder
3. Furnace
4. Horizontal grate
5. Discharger
6. Grate siftings conveyor
7. Primary combustion air (underfire)
8. Secondary combustion air (overfire)
4. Market Requirements

Background

- Waste ‘hierarchy’ (avoid, re-use, recycle, recover, disposal)
- Landfilling is considered the worst alternative (pollution, greenhouse gases, long-term liability) for residual waste; banned in many countries
- WtE is more and more accepted by legislators as one component in sustainable waste management (recover the energy)
- Still substantial public opposition against WtE plants though

- Waste is a Resource!
- Waste-to-Energy can be considered ‘recovery’
4. Market Requirements, cont’d

Challenges

• Use the energy contained in the waste ‘efficiently’
  ➢ Combine with steam users/heating networks
  ➢ Increase electrical conversion efficiency

• Recyclable residues
  ➢ Dry slag discharge
  ➢ Glass-like (‘inert’) residues

• Other types of waste
5. Martin Development Activities

- Electrical conversion efficiency => higher steam parameters, new concepts
- Residue quality => SYNCOM, SYNCOM-Plus
- Dry slag discharge
- Pre-treated waste (RDF, SF, CDR etc)
Increasing energy efficiency

Premium for electricity from renewable waste fractions

- 14.5 €/MWh for 10 years if efficiency > 26 % in the Netherlands (2003)
- 170 €/MWh with the CIP6 program in Italy (replaced by ‘Green Certificate’)
- 23.4 €/MWh in Spain (Directive 1998)
  Bilbao example: 30 % premium on the electricity price
Optimized conventional type - Brescia concept -

- Low excess air rate
- Cooling of flue gases to 130 °C
- High efficiency of equipment, e.g. variable-frequency motor drives
- High steam pressure and temperature: 60 bar and 450 °C

BREF 18 % Net efficiency of 26 %
Intermediate superheating
- Amsterdam concept -

135 bar
335°C

130 bar
480°C

14 bar
13 bar
190°C
320°C

13 bar
320°C

14 bar
13 bar
190°C
320°C

BREF 18%

Net efficiency of 30%

Superheater

Reheater
Combination with gas turbine
- Mainz concept -

- Condensate from turbine CC-plant
- Superheated steam to turbine CC-plant
- Low pressure steam for internal use

- Steam generator 1
- Steam generator 2

- Turbine for internal use

- Feedwater
- Electricity for internal use

BREF 18 %
Net efficiency > 40 %
Combined waste-to-energy / natural gas
- Bilbao plant realized by CNIM -

MODE A
“NOMINAL MODE”
net power : 93.2 MWe
availability : 7230 h/y
net output ratio : 42 % (with waste)

BREF 18 %
Net efficiency of 43 %
# New WTE plants with increased efficiency

<table>
<thead>
<tr>
<th>Plant</th>
<th>Brescia # 1+2 (Italy)</th>
<th>Brescia # 3 (Italy)</th>
<th>Amsterdam # 5+6 (Netherlands)</th>
<th>Mainz (Germany)</th>
<th>Bilbao (Spain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion system</td>
<td>MARTIN reverse-acting grate</td>
<td>MARTIN reverse-acting grate</td>
<td>MARTIN horizontal grate</td>
<td>MARTIN reverse-acting grate</td>
<td>MARTIN reverse-acting grate</td>
</tr>
<tr>
<td>NOx reduction</td>
<td>SNCR</td>
<td>SNCR</td>
<td>SNCR</td>
<td>SNCR</td>
<td>SNCR</td>
</tr>
<tr>
<td>Special feature</td>
<td>Optimized for high efficiency</td>
<td>Optimized for high efficiency</td>
<td>Intermediate steam superheating and water condenser</td>
<td>Coupled with combined cycle process (natural gas turbine)</td>
<td>Integration with combined cycle process (natural gas turbine)</td>
</tr>
<tr>
<td>Fuel</td>
<td>MSW, sewage sludge, biomass</td>
<td>Biomass, sewage sludge</td>
<td>MSW</td>
<td>MSW, natural gas</td>
<td>MSW, natural gas</td>
</tr>
<tr>
<td>Steam pressure [bar]</td>
<td>61</td>
<td>73</td>
<td>130</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Superheated steam temperature [°C]</td>
<td>450</td>
<td>480</td>
<td>440</td>
<td>400 / 555</td>
<td>540</td>
</tr>
<tr>
<td>Gas temperature at boiler outlet [°C]</td>
<td>135 (135 °C with additional heat recovery after ESP and fabric filter)</td>
<td>135</td>
<td>180</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Electricity produced [%; gross]</td>
<td>27</td>
<td>28</td>
<td>&gt; 30</td>
<td>&gt; 40</td>
<td>46</td>
</tr>
<tr>
<td>Electricity exported [%; net]</td>
<td>24 (referred to total gross heat of waste + natural gas)</td>
<td>25</td>
<td>30</td>
<td>25,8 (referred to gross heat of waste)</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; 40 (referred to total gross heat of waste + natural gas)</td>
<td>23,3 (referred to gross heat of waste)</td>
</tr>
</tbody>
</table>
Inert ash with grate based technology: SYNCOM-Plus

**DIOXIN DESTRUCTION**
- Residual waste
- IR camera

**ENERGY RECOVERY**
- Flue gas recirculation
- Boiler
- Fuel bed temperature > 1150 °C

**FLUE GAS CLEANING**
- Coke or activated carbon
- Flue gas flow reduced by 35%

**SINTERING OF BOTTOM ASH**
- Bottom ash recirculation
- Air preheater
- Oxygen enrichment
- Increase in fuel bed temperature

**RESIDUES**
- Fly ash
- Granulate
- Metals
- Loss on ignition < 0.1%
  Lead leaching < 0.01 mg/l

**REUSABLE PRODUCTS**
- Fly ash recirculation
- Wet-mechanical treatment of bottom ash

**Increased efficiency**
- Air preheater
- Oxygen enrichment
- Fuel bed temperature > 1150 °C
Temperature of main combustion zone

Conventional operation
boiler load = 75%

SYNCOM operation
boiler load = 100%
oxygen enrichment UFA = 25,0 %

temperature mean value = 994 °C

SYNCOM operation
boiler load = 100%
oxygen enrichment UFA = 27,9 %

temperature mean value = 1074 °C

Waste bed temperature increased by 150 °C
SYNCOM reference plant in Arnoldstein
CDR, RDF and similar fuels

- **CDR:** (from Italian: “Combustibile Derivato dai rifiuti”)  
  Synonym for all kinds of waste processed to achieve a high calorific value
- **RDF:** Refuse derived fuel - “secondary fuel“ etc. from municipal solid waste
- **Industrial waste** (such as DIB - “Dechets industriels banal”)
- **Car shredder residues and shredded tires**
- **Biomass**
## CDR, RDF and similar fuels

### Typical compositions

<table>
<thead>
<tr>
<th>Waste type</th>
<th>CDR (I)</th>
<th>RDF (GB)**</th>
<th>DIB (F)***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorific range</td>
<td>&gt; 15 MJ/kg *</td>
<td>15 - 17 MJ/kg</td>
<td>13 - 18 MJ/kg</td>
</tr>
<tr>
<td>Moisture</td>
<td>&lt; 25 % *</td>
<td>10 - 18 %</td>
<td>9 - 18 %</td>
</tr>
<tr>
<td>Ash (dry)</td>
<td>11 - 25 % expected</td>
<td>15 - 22 %</td>
<td>8 - 16 %</td>
</tr>
<tr>
<td>Chlorine</td>
<td>&lt; 0.9 % *</td>
<td>0.6 - 1.2 %</td>
<td>0.8 - 2.2 %</td>
</tr>
<tr>
<td>Sulphur</td>
<td>&lt; 0.6 % *</td>
<td>0.1 - 0.4 %</td>
<td>0.02 - 0.1 %</td>
</tr>
</tbody>
</table>

* Values for “combustibile derivato da rifiuti“ pursuant to Italian ordinance
** Refuse derived fuel
*** Déchets industriels banals (shredded)
RDF combustion tests
WTE plant St. Gallen

Start up: 1988
Number of lines: 2
Waste throughput:
5.2 t/h - 9,600 kJ/kg
Design heating value:
5,200 kJ/kg - 14,650 kJ/kg
Gross heat release: 50.24 GJ/h
Grate run width: 2,250 mm
Grate steps: 13
Grate area: 18.1 m²
Steam parameters: 40 bar / 400 °C
Steam production: 15.1 t/h
## Fuel properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Range</th>
<th>Range</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating value</td>
<td>12,000 kJ/kg</td>
<td>15,000 kJ/kg</td>
<td>19,000 kJ/kg</td>
</tr>
<tr>
<td>Heating value range</td>
<td>12 - 14 MJ/kg</td>
<td>15 - 17 MJ/kg</td>
<td>18 - 20 MJ/kg</td>
</tr>
<tr>
<td>Moisture</td>
<td>12 - 16 %</td>
<td>10 - 18 %</td>
<td>7 - 13 %</td>
</tr>
<tr>
<td>Ash (dry)</td>
<td>28 - 34 %</td>
<td>15 - 22 %</td>
<td>14 - 20 %</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.4 - 1.0 %</td>
<td>0.6 - 1.2 %</td>
<td>0.8 - 1.3 %</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.1 - 0.3 %</td>
<td>0.1 - 0.4 %</td>
<td>0.2 - 0.4 %</td>
</tr>
<tr>
<td>Waste throughput</td>
<td>158 t</td>
<td>200 t</td>
<td>138 t</td>
</tr>
</tbody>
</table>
Fuel properties

19,000 kJ/kg

15,000 kJ/kg

12,000 kJ/kg

15,000 kJ/kg
Test results

Overview steam, O2 and furnace temperature

Test results:

- Normal operation: 15,000 kJ/kg
- 12,000 kJ/kg
- 15,000 kJ/kg
- 19,000 kJ/kg

Date and times:

- 13.01.2006 11:30
- 20.01.2006 14:30
Test results (grate bar temperature)

- Reduction of UFA temperature
- Normal operation 12,000 kJ/kg
- Grate step 4 15,000 kJ/kg
- Grate step 8 19,000 kJ/kg

Graph showing temperature changes with time and energy inputs.
Conclusions from St. Gallen tests
- for existing MARTIN WtE plants -

- Co-combustion of high-calorific fractions is already reality in several WtE plants

- Combustion of high calorific monofractions on existing MARTIN reverse-acting grates is possible, some characteristics have to be checked and possibly adjusted:
  - Secondary air system
  - Construction of feeding area

Additional components/assemblies for the handling of this fuel are NOT necessary !!!
6. Summary

- Waste-to-Energy has a long history
- Continuous development has taken place
- Modern Waste-to-Energy plants are safe and reliable to operate, have high availability and pose no harm to the environment
- Waste-to-Energy is ‘the’ choice in Europe to treat residual MSW
- Focus is on high efficiency of the energy recovered and on recyclable residues

- Martin is the leading supplier of the core technology
- Martin has strong development activities in order to meet future challenges
MARTIN®, MARTIN Rückschub® and SYNCOM® are registered trademarks in selected countries. The MARTIN technologies described in this presentation are protected by numerous patents in many countries.
Mainz, Germany
ASM Brescia, Italy
Amsterdam, Netherlands
Technical features of the new grate type „VARIO“

Grate

- Design with inclination of 24°-26°
- Clinker weir for all grate sizes
- Pre-assembled design
Technical features of the new grate type „VARIO“

Feeder:
- Smaller feeder access opening between front wall header and feeder
- Increased height of the feed ram
- Adaptation of the stroke frequency to the higher calorific value
- Slightly inclined feed table with low feed edge

Grate:
- Three individual drives for grate movement

Air supply:
- Possibility of "staging" the UFA temperature
  i.e. zone 1, 4 and 5 without preheating
  zone 2 and 3 individually preheated