Implementation of HTW™ Gasification at Pilot Scale

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engineering. tomorrow. together.
Agenda

- Introduction to thyssenkrupp
- Introduction to High Temperature Winkler (HTW™) Gasification
- New state of the art pilot plant
  - Motivation
  - Technical data
  - Implementation
- Commercial application
- Summary and outlook
thyssenkrupp in figures
Fiscal 2014/15 in a year-on-year comparison

<table>
<thead>
<tr>
<th></th>
<th>2013/2014</th>
<th>2014/2015</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order intake [€ mn]</td>
<td>41,376</td>
<td>41,318</td>
<td>0%</td>
</tr>
<tr>
<td>Sales [€ mn]</td>
<td>41,212</td>
<td>42,778</td>
<td>4%</td>
</tr>
<tr>
<td>Adjusted EBIT [€ mn]</td>
<td>1,329</td>
<td>1,676</td>
<td>26%</td>
</tr>
<tr>
<td>Number of employees</td>
<td>162,372</td>
<td>154,906</td>
<td>-5%</td>
</tr>
</tbody>
</table>

1. Change on a comparable basis (without divestment & currency effects): Order intake -5%; Sales -2%
## Diversified Industrial Company: Our Business Areas

### Key indicators – fiscal 2014/2015

<table>
<thead>
<tr>
<th>Components Technology</th>
<th>Elevator Technology</th>
<th>Industrial Solutions</th>
<th>Materials Services</th>
<th>Steel Americas</th>
<th>Steel Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales [€ mn]¹</td>
<td></td>
<td>6,256</td>
<td>14,254</td>
<td>1,773</td>
<td>8,697</td>
</tr>
<tr>
<td>EBIT [€ mn]²</td>
<td></td>
<td>313</td>
<td>424</td>
<td>206</td>
<td>-138</td>
</tr>
<tr>
<td>Employees³</td>
<td></td>
<td>29,627</td>
<td>51,335</td>
<td>19,388</td>
<td>27,601</td>
</tr>
</tbody>
</table>

1. Before consolidation  
2. Before consolidation/Corporate  
3. Before Corporate
Industrial Solutions

Business Area

Business Unit

Marine Systems
Submarines
Surface Vessels
Services

Process Technologies
Fertilizer/
Coke Plant Technologies
Chemicals/Oil & Gas
Services

Resource Technologies
Mining
Cement
Services

System Engineering
Assembly Systems
Car Body Technology
Lightweight Solutions
Forming Dies
Testing Solutions
Services

Regional Organization

Americas
Europe/CIS
Middle East
India
Asia Pacific
Sub-Saharan Africa
Introduction to HTW™ Gasification

History and technology

- **History**
  - Pressurized version of the Winkler process from 1920s
  - Developed by Rheinbraun (now RWE)
  - Since 2010 owned by thyssenkrupp

- **Technology**
  - Fluidized bed gasification process
  - Use of post gasification zone (pgz)
  - Air or oxygen blown
  - Temperatures below ash softening point

![Diagram of HTW™ Gasification process](image-url)
Introduction to HTW™ Gasification

Commercial reference: Berrenrath

- 12 Years operation
- > 67,000 hours of gasification
- Feedstock: 720 t/d lignite
- Pressure: 10 bar
- Product: 300 t/d methanol
Pilot plant
Motivation

• Broaden feedstock portfolio
  – Experience for
    – Lignite, various coals
    – Biomass (peat)
    – Waste (MSW, RDF/lignite mixture)
  – Expand to
    – Biomass (wood chips and pellets)
    – Other customer feedstocks

• Minimize
  – Technical uncertainties
  – Commercial risks

Wood chips
Wood pellets
Customer coal
Waste
Pilot plant
Technical data

- 0.5 MW$_{th}$ power
- Up to 100 kg/h coal feed
- Up to 1200 °C
- Atmospheric pressure
- Inner diameter 0.4 m
- Height ~11 m
- Fluidization with steam, oxygen and CO2
Pilot Plant
Test campaigns in 2015

- Long term test runs
  - Rhenish lignite
  - Subbituminous coal
- Syngas produced and analyzed
- Empirical data evaluated
Pilot plant
First campaign after commissioning, Rhenish lignite

- Aim was to get a reference point
- Data given is specific to pilot plant
- Events
  - Preheating with propane gas
  - Ignition at 17.6. with coke
  - Switch to lignite at 19.6.
  - Test of different operating parameters
  - Test of hot start on late 24.6.
Commercial application

- Use of empirical data from pilot plant for scale-up
- Commercial scale
  - Pressure 1 - 30 bar
    - Up to 160 t/h feed
    - Air or O2/Steam/CO2
    - C-Gasification degree > 95 %
- HTW™ is ideal for
  - Coals with high ash melting point
  - High ash coals
  - Lignite
  - Biomass
Summary and outlook

- 0.5 MW HTW™ pilot plant in Darmstadt
- Successful commissioning and test campaigns in 2015
  - Rhenish lignite
  - Subbituminous coal
- Pilot plant is currently updated
  - New cyclone
- Next test campaigns in Q3/Q4 2016
- Use for further research and development projects
  - Polygeneration

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