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Ashland Technologies GmbH
Michael Jäger
&
Plasticon Composites International Contracting BV
Gunar Krause

High temperature resins and their use in hot flue gas applications
Outline

- Companies
- Materials and High Temperature Resistant (HT) Resin
- Case Studies
- Engineering and Fabrication
Introducing
Plasticon Composites

• Headquarter in NL, founded in 1952.
• Worldwide presence, production facilities and sales all over the world.
• More than 700 employees in 16 Production Locations with approx. 80,000 m² size in 13 countries.

• Approx. 1,500,000 hours production capacity per year.
• Capability of 200,000 h/a to do Installation projects.
• 15 stationary and 5 onsite winding machines.
Corporate Profile
Ashland

- Headquartered in Covington, Kentucky, founded 1924
- Specialty Chemicals, sales in over 100 countries
- 6000 Employees, 1100 in Composites

41 Production Plants, 16 for Composite Resins
Revenue: $3.2bn, $770M in Composites

Composite Resin Plants

Diverse set of geographies and target industries

% of Sales (FY '17)

- LATAM: 45%
- APAC: 32%
- EMEA: 5%
- NA: 8%

Ashland Specialty Ingredients

- North America
  - Bartow, Florida
  - Fort Smith, Arkansas
  - Jacksonville, Arkansas
  - Los Angeles, California
  - Philadelphia, Pennsylvania
  - Pittsburgh, Pennsylvania

- South America
  - Aracariguama (SP), Brazil

- Europe
  - Banino, Poland
  - Benicarló, Spain
  - Porvoo, Finland
  - Etain, France
  - Istanbul, Turkey

- Asia Pacific
  - Changzhou, China (2)

- Middle East
  - Jeddah, Saudi Arabia
  - Jubail, Saudi Arabia

- India
  - Mumbai, India

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  - Jeddah, Saudi Arabia
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- India
  - Mumbai, India

- South America
  - Aracariguama (SP), Brazil

- North America
  - Bartow, Florida
  - Fort Smith, Arkansas
  - Jacksonville, Arkansas
  - Los Angeles, California
  - Philadelphia, Pennsylvania
Why “HT” Resin?

- Fluegases and their condensates etc. can be very corrosive (Chlorides…)
- FRP can even outperform exotic materials such as high nickel alloys
- FRP is cost competitive with stainless steel

HT Novolak Epoxy Vinyl Ester Resin successfully used since 25 years in Quenches, Scrubbers, Ducts and Chimneys
Data Generation

- Physical Properties
- Thermal shock and cycling
  - Thermal ageing
  - Upset performance testing

Field Experience:
E.g. Quench with brick lining failure exposing the FRP structure to 260°C for > 1 year.

Excellent Emergency Running Properties!
• Not insulated: Max. continuous Fluegas Temperature: ~230°C
• Insulated: Max. continuous Fluegas Temperature: ~200°C
3mm VE-HT resin Laminate after 12 months at 200°C: Approx. 0.25mm of the surface is oxidised, the core looks like new!
Weight retention of laminate during aging in air at 230 - 280°C
(Both sides exposed of 3 mm (thin) CSM laminate, 35 wt% glass)
TGA HT Resin, 25-900°C, 40K/min

- Flash Point, estimated (~350°C)
- Auto Ignition (~500°C)

Long Term Operation max. 200°C (insulated)

Upsets to 330°C
Laminate heat-up to 320°C, 30 min

Heating Curves over a 10mm CSM laminate cross section, one side exposed to 320°C air, Carbon veil, insulated

"Inner" Thermocouple

"Outer" Thermocouple
Weight Retention vs. Temperature, 280-330°C

Weight retention of 10mm laminate in air at 280 - 330°C
(One side exposed, insulated, CSM laminate, Carbon veil)
Weight retention of 10mm laminate in air at 330°C
(One side exposed, insulated, C- vs Carbon-veil, Carbon CSM, and Graphite)
Alkmaar Case Study

- 1 million tons of waste per year
- 4 trains with FRP quench and scrubber
Fluegas Treatment System, HVC Alkmaar:
- 4 Quenches, HT resin, designed for max. 230°C
- 4 Scrubbers, two-stage (acid/alkaline), VE resin, designed for 90°C
Quench History:

- Flue gas with HCl, HF, SO$_2$, SO$_3$, NO$_x$, dust.
- Service time 1$^{st}$ unit: 1995 – 2008 (average service life = 13 years)
- CR Liner renovation every ~3 years
Alkmaar Case Study

Quench CR Liner before and after renovation

Before renovation
Local erosion by solids

After renovation
• FRP based on “HT” resin outperforms conventional materials in hot flue gas applications since 25 years

• The Alkmaar HVC WTE plant is in operation since over 20 years and confirms the superior performance of quenches based on HT resin in flue gas cleaning.

• Data for short and medium term upset conditions have been generated. While several weeks of operation appear feasible at 230°C (insulated), it seems reasonable to limit excursions to 330°C to max. 30 min, followed by an inspection. Higher temperatures are not considered.

• Fillers like e.g. graphite may have a detrimental effect above 300°C. This needs to be further studied.
Chimney Liner

Ducts inside Cooling Tower

Chimneys
Ducts outside Cooling Tower

Absorber

Storage Tanks
Recirculation pipes

Spray header
Plasticon Composites always makes a detailed FEM analysis and assessment for the choice of the laminate (Combination and type of Resin and Glass) for major power plant components, to ensure reliability and long term performance of the product considering required loads and combination of loads:

- Medium
- Own weight
- Temperatures
  - (Operating under FGD, Malfunction/Bypass)
- Pressure
- Seismic
- Ash load
- Snow load
- Wind
- Connected platforms
• Installation on concrete foundation, provided by the client.
• Air conditioned double wall tent.
• Winding wagon, movable on rails.
• Mould made of steel or carbon fibre.
• Length of the can 6 or 10 m, and diameter up to 21 m.
• Can ø 8 m and length of 6 m incl. stiffeners = 2 days production
• Assembly of single cans to modules incl. internals, pipes and attachments such as platforms and ladders to modules.
• Installation of the bottom made of board material.
• Installation of the modules with mobile cranes.
• Access to the seams with console scaffolds.
Assembly and installation

- Assembly of the transition piece and the lowest chimney can.
- Installation of the modules with a mobile crane.
- Access to the seams with console scaffolding.
• Assembly of 2 Cylinders in vertical Position.
• Assembly of in each step 2x2 Cylinders in horizontal Position, incl. internals, pipes and attachments such as platforms and ladders to modules.
• Installation of the modules with a mobile crane.
• Access to the outer seams with console scaffolds.
• Access to the internal seams with a mobile platform.
**Project:** Cabot Project

**Customer:** Babcock Wilcox

**Product:** GRP Absorber including all internals, with self-supporting stack, and FRP holding tank.

**Medium:** Clean Flue Gas

**Year:** 2017

**Country:** United States of America

**Description:** Turnkey incl. Engineering, Prefabrication, Transport, Lifting, Installation, Supervision and Quality control.

<table>
<thead>
<tr>
<th>Absorber</th>
<th>Stack</th>
<th>Aux. Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions:</td>
<td>Dia. 8,23 m Height 25,1 m</td>
<td>Dia. 3,8 m Level + 66,8 m</td>
</tr>
<tr>
<td>Temperature:</td>
<td>82°C (255°C at Flue Gas Inlet)</td>
<td></td>
</tr>
<tr>
<td>Pressure:</td>
<td>-0.012 / 0.087 bar</td>
<td></td>
</tr>
<tr>
<td>Project:</td>
<td>Turow, Integration of WFGD</td>
<td></td>
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<td>-------------</td>
<td>---------------------------------------------</td>
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</tr>
<tr>
<td>Customer:</td>
<td>Babcock Noell GmbH</td>
<td></td>
</tr>
<tr>
<td>Product:</td>
<td>3 x Chimney liner &amp; Bypass</td>
<td></td>
</tr>
<tr>
<td>Dimensions:</td>
<td>Dia. 5.3 m / Length 690 m</td>
<td></td>
</tr>
<tr>
<td>Temperature:</td>
<td>20°C to 163°C</td>
<td></td>
</tr>
<tr>
<td>Pressure:</td>
<td>-10 mbar / +20 mbar</td>
<td></td>
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<tr>
<td>Medium:</td>
<td>Clean Flue Gas</td>
<td></td>
</tr>
<tr>
<td>Year:</td>
<td>2014 / 2015</td>
<td></td>
</tr>
<tr>
<td>Country:</td>
<td>Poland</td>
<td></td>
</tr>
<tr>
<td>Description:</td>
<td>Engineering, Prefabrication, Installation,</td>
<td></td>
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<td></td>
<td>Supervision and Quality control.</td>
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### References

<table>
<thead>
<tr>
<th>Project:</th>
<th>Orot Rabin &amp; Rutenberg</th>
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<tbody>
<tr>
<td>Customer:</td>
<td>CDI</td>
</tr>
<tr>
<td>Product:</td>
<td>4 x GRP liner in Concrete chimney</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>Dia. 7.0 m / Height +210 m</td>
</tr>
<tr>
<td>Temperature:</td>
<td>52°C (150°C Excursion)</td>
</tr>
<tr>
<td>Pressure:</td>
<td>-100 mbar / +100 mbar</td>
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<tr>
<td>Medium:</td>
<td>Clean Flue Gas</td>
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<tr>
<td>Year:</td>
<td>2015 – 2016</td>
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<tr>
<td>Country:</td>
<td>Israel</td>
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<tr>
<td>Description:</td>
<td>Engineering, Prefabrication, Lifting, Jacking System, Installation, Supervision and Quality control</td>
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<tr>
<td>Project: Fort Martin; Stack liner</td>
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<tr>
<td>----------------------------------</td>
<td></td>
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<tr>
<td>Customer: Karrena</td>
<td></td>
</tr>
<tr>
<td>Product: 1 x Stack liner</td>
<td></td>
</tr>
<tr>
<td>Dimensions: Dia. 8.2 m – Height 125 m</td>
<td></td>
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<tr>
<td>Temperature: 65°C (190°C @ 4 hrs)</td>
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<tr>
<td>Medium: Clean Flue Gas</td>
<td></td>
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<tr>
<td>Year: 2008</td>
<td></td>
</tr>
<tr>
<td>Country: USA; West Virginia</td>
<td></td>
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<tr>
<td>Description: Turnkey incl. Engineering, Prefabrication, Transport, Lifting, Installation, Supervision and Quality control.</td>
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</tbody>
</table>
**Project:** KW Neurath BoA 2&3  
**Customer:** RWE Energie AG / GEA  
**Product:** 2 x Flue gas duct Absorber to CT  
**Dimensions:** Dia. 10,0 m / Length 150m + 30m Elbow  
**Temperature:** -10°C to 73°C  
**Pressure:** -0,005 bar / +0,01 bar  
**Medium:** Clean Flue Gas  
**Year:** 2007 / 2008  
**Country:** Germany  
**Description:** Turnkey incl. Engineering, Prefabrication, Transport, Lifting, Installation, Supervision and Quality control. Project scope M€ 20

We faced the challenge to construct a FRP duct of 10 m Ø at a support distance of 75 m.
<table>
<thead>
<tr>
<th>Project</th>
<th>PP Opole (PL); Clean gas ducts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>Alstom Power Italia S.p.A</td>
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<tr>
<td>Product</td>
<td>2 x Clean gas ducts</td>
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<tr>
<td>Dimensions</td>
<td>Dia. 8,0 m / Length 65 m</td>
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<tr>
<td>Temperature</td>
<td>52°C</td>
</tr>
<tr>
<td>Pressure</td>
<td>-10 / + 10 mbar</td>
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<tr>
<td>Medium</td>
<td>Clean Flue Gas</td>
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<tr>
<td>Year</td>
<td>2012 / 2013</td>
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<tr>
<td>Country</td>
<td>Netherlands</td>
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<tr>
<td>Description</td>
<td>Turnkey incl. Engineering, Prefabrication, Transport, Lifting, Installation, Supervision and Quality control.</td>
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<td><strong>Country:</strong> Poland</td>
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<td><strong>Description:</strong> Engineering, Prefabrication, Installation, Supervision and Quality control.</td>
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</tbody>
</table>
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