Environment oriented light weight design in steel
Oliver Hoffmann, Hannover, 25.4.2012
ThyssenKrupp Group Structure
7 business areas including Steel Europe

Steel Europe
Steel Americas
Materials Services
Stainless Global *)

Elevator Technology
Plant Technology
Components Technology
Marine Systems

Division Materials
Division Technologies

*) Discontinued operation (as of September 30th, 2011). Carved-out new entity is called Inoxum.
Business Area Steel Europe

Company profile

Key figures 2010/2011

Sales € 12.8 bn
Employees (30.9.) 28,843

Operating Units

ThyssenKrupp Steel Europe AG
Volumeplayer

Processing
Nicheplayer

Key strategic elements

- Focus on premium flat carbon steel products
- Optimum realization of economies of scale and differentiation potential through “large-scale, multiple niche” approach
- Systematic strengthening of the well acknowledged technological competencies in processes and products
- Continuous development of innovative steel grades to achieve technology leadership in all relevant product groups
Internationalization of ThyssenKrupp
Expansion of relationships with international customers

Steel mill Alabama
ThyssenKrupp Steel
USA

Steel mill Duisburg
ThyssenKrupp Steel Europe

Hot-dip galvanizing line
Tagal
Dalian, China

Hot-dip galvanizing line
ThyssenKrupp Galmed
Sagunto, Spain

Slab plant
ThyssenKrupp CSA
Sepetiba, Brazil

ThyssenKrupp Steel Japan
## Lightweight Design & innovative Steels

### R&D activities at ThyssenKrupp Steel Europe

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<th>High-strength grades</th>
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Innovative steels for the automobile industry

Time horizon today … 15 years

- Deep drawing steels
- High and ultra high strength steel
- Multiphase steels

Elongation A (%)

<table>
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<tr>
<th>Tensile strength R_m (MPa)</th>
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<tr>
<td>200</td>
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<td>300</td>
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<td>1400</td>
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<td>1500</td>
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*as delivered

- Steels with special properties (ρ, E)

- AHSS-3. generation: M³, Q&P, UHBA+RA,
- RA-development
- DP-development
- CP-development

- MBW-K*
- MBW-W*

- High Mn(Al-) steels
Density reduced (particle strengthened) steels

Pre-development

- **Chemical composition**: high alloyed steel with light elements and low carbon content
- **Microstructure**: ferritic matrix with a fine distribution of particles
- **Properties**:
  - high yield strength (350-500 MPa) and tensile strength (Rm = 450-650 MPa) by solid solution hardening and particle strengthening
  - significant reduced density ($\Delta \rho = 8\text{-}13\%$) compared to conventional steels
- **Application**: BIW components with reduced weight and improved Eigen frequencies
- **Status**: laboratory developments carried out; due to the chemical composition specific process facilities and parameters necessary, industrial production trials in preparation

InCar®-BIW: Several Components, Weight reduction: -13 kg (-13 %)
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Oliver Hoffmann
Materials and manufacturing strategies for hot forming applications

Challenge
• Optimization of functional properties for modern steel based lightweight design structures

Material ➔ development of different steel grades and coatings

Hotform Blanks ➔ different steel grades or thickness

Tailored Tempering ➔ adjusted heat treatment for varying strength level

Realization
• Implementation of lightweight strategy by new materials and manufacturing technologies
Material trends in hot stamping
Development of new manganese-boron steels MBW®

- Increase in elongation at moderately lower strength level, e.g. $R_m=1400$ MPa
- Higher energy absorption capacity
- New joining partners for Hotform Blanks with strengths around 800 MPa

$\rightarrow$ Tailor-made material properties possible by using Tailored Tempering
GammaProtect® from ThyssenKrupp Steel Europe
Cathodic corrosion protection for hot stamping

- Cathodic corrosion protection
- Outstanding forming properties in direct and indirect hot stamping process
- No alloying necessary
  - Rapid heating possible
  - Shorter process times
- Easy to process using methods typical for auto parts
- Suitable for Hotform Blanks
- Components have already been stamped under production conditions

Now available: cathodic corrosion protection for the direct process
MBW® 1500 in 0.5 mm thickness
Further weight reduction due to reduced blank thickness

Customer benefits
• Further weight reduction by application of thinner blanks
• Enhancement of the MBW® 1500 +AS dimensions
• New possible applications for thin walled parts

Investigation results
• First field test successful (0.5 x 1250 mm)

Current status
• Suitability for series strip production will be tested by further field tests, width enlargement is planned
• Further coils under production trials
• First test material available

→ Weight reduction by use of thinner blanks is possible

<table>
<thead>
<tr>
<th>MBW® 1500 +AS, 0.50 mm</th>
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<tr>
<td>Possible Applications: Floor Panel, Tunnel, Firwall</td>
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<tr>
<th>Cost</th>
<th>Weight</th>
<th>CO₂/km</th>
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To be analyzed by further tests

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Extended applications for hot stamping
Tailored Tempering

• Tool with different temperature zones for defined cooling rates
• Increased part complexity in comparison to cold stamping, yet at the same time extremely high material strengths
• Elimination of components (lower B-pillar reinforcement) and the upper/lower welded assembly B-pillar
• Targeted increase in deformation reserve in lower area of B-pillar reinforcement
• Soft transition between strength zones has positive impact on crash behavior

➤ For different local properties in monolithic parts
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ThyssenKrupp Steel Europe
Stiffness Optimized Sandwich Material

Product overview

- Alternative Lightweight design solution to Aluminum
- Very thin outer panels
- Polymer core made of PE/PA-Compound
- Core layer / cover sheet composite with high shear stiffness
- Very high bending stiffness
- Structure borne noise damping properties existing (Potential to reduce secondary acoustic damping and insulation material)

Goal: at least 30% cost benefit compared to an Aluminum application, maximal 10% weight penalty compared to an Aluminum solution

<table>
<thead>
<tr>
<th>Outer panel parts</th>
<th>Inner panel parts</th>
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<table>
<thead>
<tr>
<th>Steel sheet (0,20 - 0,30 mm)</th>
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<table>
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<tr>
<th>Total costs [€/part]</th>
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<tbody>
<tr>
<td>Aluminum</td>
</tr>
<tr>
<td>30</td>
</tr>
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Part weight [kg]

- Aluminum: 12 kg
- Sandwich: 16 kg
- Steel: 16 kg

Further benefits by reducing acoustic damping and insulation.
## Part production from Stiffness Optimized Sandwich Material

### Test results - summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Forming</td>
<td>✔</td>
</tr>
<tr>
<td>Stiffness</td>
<td>✔</td>
</tr>
<tr>
<td>Dent resistance (Hailstorm), Snowload</td>
<td>✔</td>
</tr>
<tr>
<td>Cold joining technologies</td>
<td>✔</td>
</tr>
<tr>
<td>Thermical joining technologies</td>
<td>✔ under construction</td>
</tr>
<tr>
<td>Deformation before/after KTL-painting</td>
<td>✔</td>
</tr>
<tr>
<td>Deformation at operating temperature (Dilatometric)</td>
<td>✔</td>
</tr>
<tr>
<td>Dynamic</td>
<td>✔</td>
</tr>
<tr>
<td>Corrosion</td>
<td>✔</td>
</tr>
<tr>
<td>Acoustic</td>
<td>✔ / under construction</td>
</tr>
<tr>
<td>Crash</td>
<td>✔</td>
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Stiffness Optimized Sandwich Material
Taking Off with Pilot Plant 09/2011

Schematic illustration: Pilot plant for stiffness optimized sandwich material

- Plant Capacity: ca. 2,500t Lightweight Sandwich per year
- Dimensions: (0.7 – 1.5mm) x max. 1600mm width*
- Low volume series from 12/2011
- High volume series (capacity of 40,000t/a) planned from 2nd half of 2014

* Depending on availability of steel layer
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**High-strength grades**

**Hot stamping**

**Sandwich materials**

**Life cycle assessment**
Life Cycle Assessment
What is Life Cycle Assessment?

I Production

II Use Phase

III Recycling

Evaluation of the environmental impacts of a product throughout its life cycle

Sources: Internet
Benefits of LCA

- GHG emissions over the life cycle phases of a product
- Shift of environment burden from one phase to another can be recognized
- It promotes objective evaluation of a product’s environmental performance

Our LCA analysis is based on the certified phase 1 model of Dr. Roland Geyer University of California, Santa Barbara
Comparative LCA for BiW Materials
Scenario SE-AG

- Fuel Reduction Value:
  - L/100km/100kg: 0.30

- Allocation of recycling credits: 50/50

- Weight reduction:
  - AHSS vs. conv. steel: -15%
  - Aluminium vs. conv. Steel: -40%

- With plausible assumptions, same level of GHG emissions over the lifecycle
Technologies to reduce Fuel Consumption

- Automatic Transmission with reduced friction and 8 gears: 6%
- Use of lost heat: 30%
- Downsizing: 30%
- Lean combustion: 10%
- Reduced friction turbo charger: 6%
- Optimization of the direct fuel injection: 15%
- Cylinder deactivation: 20%
- Tyres: Reduction of the Rolling resistance: 5%
- Lightweight Design: 10%

Source: Wirtschaftswoche
Conclusion

• Based on the currently available steels and in light of future developments there is a high potential for an innovative lightweight design

• For the design of BIW, hot-stamping technologies become more important

• Steel-plastics-composites such as LITECOR® provide additional solutions for lightweight design

• The Life Cycle Assessment assures sustainable lightweight solutions