High-tech plastics for lightweight solutions

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Motivation
Weight reduction in automotive

- Resources are limited
- CO$_2$-emission is harmful for environment
- CO$_2$-emissions have to be reduced
- Influencing factors:
  - rolling friction/resistance
  - aerodynamic resistance
  - weight
  - …

Plastics are light - Plastics save the environment!

http://www.klimaherbst.de/und-ewig-druckt-der-raumwiderstand/
Global product and application development (GPAD) to drive innovation

- Tailored development activities and services
- Globally positioned and networked
- Head count (2012): 125
- Departments
  - Product development
  - R&D testing center
  - Application development
  - Customer engineering services

SCP product and application development center
Innovation programs with focus on megatrends

- **Urbanization**
- **Mobility**
- **Lightweight structures**
- **E/E applications**
- **Extrusion applications**
- **Truck applications**
- **E-mobility applications**
- **Green products**

“Green” as underlying trend
Agenda

- Plastic / metal hybrid technology
- Composite technology
- CAE – integrative simulation for thermoplastic composites
- Application fields
Plastic / metal hybrid technology (PMH) – the principle

Denting or buckling of lightweight structures due to the thin wall

Strengthening the structure with small forces carried by plastic ribs

Sheet metal

\[ \mathbf{F}_1 \]

\[ \mathbf{F}_2 \]

\[ \mathbf{F}_{\text{plastic}} \]

High-tech plastics keep metal "in shape"
Past and present
Plastic Metal Hybrid

Advantages against pure metal solutions
- 10-50% weight reduction
- 10-40% cost reduction
- High function integration with reduced process steps
- Higher accuracy and quality
- Higher load capacity

Additional benefits
- Suitable for e-coating
- easy recycling
- no change in assembly

Selection

More than 70 applications and 50 million manufactured parts
Current developments – cooperation across industries

Current technology – positive locking bond

New technology – adhesive bond

Expectations: weight neutral performance increase resp. ~ 30% weight reduction compared to standard PMH
LANXESS – product development for lightweight solutions

- Highly reinforced PA or PBT compounds
- Examples
  - Durethan® DP BKV 60EF (60% GF)
  - Pocan® T3150 XF (55% GF)
- High modulus (HM)
- High strength
- Low viscosity resins allow incorporation of high fiber amounts
Example – Audi A8 spare wheel well: HM grades with gas-injection-technology (GIT)

- Durethan® DP BKV 60 H2.0 EF (PA 6 + GF60)
- Heat stabilized and easy flow
- PMH with aluminum and GIT
- Shot weight: 12 kg
- Part weight: 9 kg

Advantages
- Cost and weight reduction compared to SMC* or metal design
- Enabling high function integration
- Glued into the BIW** contributing to the stiffness of the car
- Not feasible in pure metal design

Superior to pure metal designs

*Sheet Mold Compound  **Body in White
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Further development
Hybrid technology with composite sheets

Composite sheet
- Thermoplastic (PA) matrix materials reinforced with woven fabrics
- Glass, carbon or aramid fibers (also hybrid)
- Continuous fibers (fiber length = part length)

Advantages of hybrid composite parts
- Lightweight design
- High stiffness, strength and energy absorption
- No corrosion, simple recycling
- No investment for additional tools due to potential in-mold forming
- No chemical reaction in contrast to thermosets
- Easy processing

Example
Frontend Audi A8

Full-plastic composite parts as alternative to plastic-metal structures
Integration of composite sheet into the hybrid composite part through in-mold forming

- Heating up above melting point
- Shaping during the closing of injection molding tool
- Subsequent injection molding of rib pattern
- Demolding
Example – in-mold formed hybrid composites

Door impact beam (demonstrator)

Steering column bracket

Tepex® + Durethan®
BMBF-Project “SpriForm” in cooperation with

Tepex® + Durethan®
Project in cooperation with

Image of Door impact beam (demonstrator)
Image of Steering column bracket
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- Plastic / metal hybrid technology
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Simulation is mandatory for the development of new applications

Hybrid composite parts
- New material (composite sheets)
- New process (one shot molding)
- Simulation required for
  - Mechanical component behavior
  - Processing (forming and molding)

LANXESS’ contribution
- New technology in virtual reality
- Shortened development times
- Reduced development costs
- Parts designed to the limits

“No application without simulation”
Challenges encountered in composite sheet simulation

Main mechanical characteristics
- Anisotropy
- Non-linearity
- Strain rate dependency
- Different tension / bending stiffness
- Failure / breakage
- Rotation of fiber directions / non-orthogonal fiber directions
- Temperature dependency
- Moisture dependency

* Tepex® dynalite 102-RG600(x)/45%
Forming / draping simulation of composite sheet – example: mouse bath tube

Forming simulation

Forming behavior

Orientation of composite sheet

0°

22.5°

45°

+ 55°

- 55°

Change of fabric angle

+ 55°

- 55°

Change of fabric angle
Mechanical behavior depending on fiber orientation

Durethan® BKV30 H2.0

Alternative universal valid isotrop values do not exist
Bonding strength of injection-molded part to composite sheet

Injection-molded plates on composite sheet

Tensile test → bonding strength

Bonding strength depends on

- Preheating of composite sheet
- Injection-molded parameters
- Flow length
- Material
- …

* LANXESS tool
Integrative simulation of hybrid composite parts

**Material development**
- Forming properties
- Mechanical properties

**Virtual prototyping**
- Forming simulation
- Fiber orientation
- Mapping

**Interface properties**
- Material model: composite sheet

**Mechanical properties**
- Material model: Durethan® Pocan®

**Molding properties**
- Molding simulation
- Fiber orientation
- Mapping

Material models:
- Durethan®
- Pocan®
Validation example – three point bending test of the upper beam of a frontend (1/2)

Part testing setup

Tepex® + Durethan®
Projekt in Cooperation with Faurecia

Two different LANXESS rib materials
- Durethan® BKV 30 H2.0
- Durethan® DP BKV 60 H2.0 EF

Three point bending test

<table>
<thead>
<tr>
<th>Force [N]</th>
<th>Displacement [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation Durethan® BKV30</td>
<td>Measurement Durethan® BKV30</td>
</tr>
<tr>
<td>Simulation Durethan® BKV60 EF</td>
<td>Measurement Durethan® BKV60 EF</td>
</tr>
</tbody>
</table>
Validation example – three point bending test of the upper beam of a frontend (2/2)

Failure behavior

Three point bending test

Displacement [mm]

Force [N]

- Simulation Durethan® BKV30
- Measurement Durethan® BKV30
- Simulation Durethan® BKV60 EF
- Measurement Durethan® BKV60 EF
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High-tech plastics for lightweight applications

- Gas tank carrier
- Battery housing carrier
- Battery cell holder
- Steering rod
- Pedals / pedal brackets
- Brackets
- Roof frames
- Airbag housings
- Module carrier
- Cross car beams
- Frontends
- Roof frames
- Selection
LANXESS – for innovative lightweight solutions

- LANXESS offers extensive know-how in lightweight solutions
- Self-developed top-notch simulation tools
- Contributing to innovations with new technologies and high-performance materials
- Ready to jointly work on new applications
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