Entwicklungen für das Automobil der Zukunft aus Sicht von Johnson Controls

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Johnson Controls GmbH, Burscheid

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- Need for new seat concepts
- New CFRP thermoplastic materials
- Simultaneous development of a multi-material concept
- Processing of the multi material demonstrator
- Joining of metal and composites
- Validation of the demonstrator in seat system environment
- Summary
Change

“It is neither the strongest of the species that will survive, nor the most intelligent ... It is the one that adopts fastest to change.”

Charles Darwin

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Introduction – Company Structure Johnson Controls

Automotive Experience
Interior systems for cars, light trucks and vans.

Building Efficiency
Controls systems, services and integrated facility management for non-residential buildings.

Power Solutions
Automotive batteries and hybrid solutions for the replacement and original equipment markets.
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Introduction – Financial Highlights Johnson Controls

- Founded 1885 in Milwaukee, WI.
- Listed on the New York Stock Exchange since 1965

Net sales (in billion USD)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>25.4</td>
</tr>
<tr>
<td>05</td>
<td>27.0</td>
</tr>
<tr>
<td>06</td>
<td>32.2</td>
</tr>
<tr>
<td>07</td>
<td>34.0</td>
</tr>
<tr>
<td>08</td>
<td>36.1</td>
</tr>
<tr>
<td>09</td>
<td>34.3</td>
</tr>
<tr>
<td>10</td>
<td>40.8</td>
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</table>

Employees (in thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>122</td>
</tr>
<tr>
<td>05</td>
<td>136</td>
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<tr>
<td>06</td>
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<td>09</td>
<td>137</td>
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<tr>
<td>10</td>
<td>132</td>
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</table>

CAMISMA
Introduction – Technology & Advanced Development

- AE Product Groups drive product and process excellence
- Our mission: Provide our Product Groups with unique technologies that help them to be best-in-class with innovative, differentiating products
- Key to these technologies: Teams of leading experts in "Technology Domains" who develop world-class capabilities
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Introduction

- Lessen carbon footprint for CFR thermoplastics by using recycled fiber material
- Development of tailor made CFRP hybrid construction for an automotive interior structure demonstrator
- Cost competitive manufacturing processes with short cycle times
- Weight reduction >40% compared to metal structure.

Source: Evonik

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Introduction

CFRP’s show negative CO₂eq balance compared to steel and aluminum for automotive use

Emission balance for steel, aluminum, and CFRP at 150,000 km (kg CO₂eq)

<table>
<thead>
<tr>
<th>Material</th>
<th>Production (100 kg)</th>
<th>Use (75 kg)</th>
<th>Recycling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>228</td>
<td>885</td>
<td>115</td>
<td>804</td>
</tr>
<tr>
<td>Aluminum</td>
<td>228</td>
<td>360</td>
<td>376</td>
<td>736</td>
</tr>
<tr>
<td>CFRP</td>
<td>525</td>
<td>1,094</td>
<td>804</td>
<td>1,823</td>
</tr>
</tbody>
</table>

1) In-use equals relative to steel (Steel defined as 100)

Source: Evonik
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**Introduction**

Leading research institutes and experts collaborate along the value chain

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Topics</th>
<th>Simulation and</th>
<th>Semi-finished</th>
<th>Integrated</th>
<th>Automotive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>recipes</td>
<td>part</td>
<td>Component</td>
<td>Sanctor</td>
</tr>
</tbody>
</table>

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**Need for new seat concepts**

Seat structure development over the last years show the need for new seat concepts

**Weight History of 6 Way manual**

<table>
<thead>
<tr>
<th>Structure weight [kg]</th>
<th>D-segment</th>
<th>C-segment</th>
<th>C-segment</th>
<th>Modular Lightweight</th>
<th>Extreme Lightweight</th>
<th>Optimized steel structure</th>
<th>Multi Material Design</th>
</tr>
</thead>
</table>

- Functional integration
- 25 kg headrest + back panel
- Functional decontenting
- 15 kg additional decontenting
- Actual weight benchmark for mass production structures

**Competitors**

- Johnson Controls
- Optimized steel structure
- Multi Material Design

**Competition**

- Multi Material Design
- Optimized steel structure
- Multi Material Design

**Technology & Advanced Development – Confidential – Ulrich Riedel**
**Weight distribution of current seat structure (average)**

- **Total 1st Row Complete Seat:** $m = 16.254$ kg
- **Total 1st Row Structure:** $m = 10.357$ kg

<table>
<thead>
<tr>
<th>Component</th>
<th>Mass (kg)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4W Manual Chassis</td>
<td>2.23</td>
<td>19.90%</td>
</tr>
<tr>
<td>4W Manual Track</td>
<td>3.065</td>
<td>38.42%</td>
</tr>
<tr>
<td>Foam Pads</td>
<td>5.06</td>
<td>55.11%</td>
</tr>
<tr>
<td>Manual Back</td>
<td>2.37</td>
<td>69.73%</td>
</tr>
<tr>
<td>Manual Recliner</td>
<td>1.75</td>
<td>80.42%</td>
</tr>
<tr>
<td>Head Restraint</td>
<td>0.7</td>
<td>90.89%</td>
</tr>
<tr>
<td>Trim Covers</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

**Additional weight saving through new innovative seat systems**

- **Example: Comfort thin seat concept**
  - Use of coil spring technology from mattress industry
  - Use of standardized parts
  - Elimination of spacious foam parts
  - Improved heat and moisture transfer
  - Additional weight reduction of up to 20%
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Need for new seat concepts

IAA 2011 lightweight rear seat concept
- Full plastic 60% structure with glass/PA6 organo sheet reinforcement
- 30 % weight reduction achieved
- Most critical test requirements fulfilled (ECE R17, ECE R14)
- Functional integration through injection mold being process
- Tact times comparable to injection molding
- Correlation of simulation results comparable to metal

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New CFRP thermoplastic materials

Typical total manufacturing cost of different lightweight material options

Source: MIT, 3C
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New CFRP thermoplastic materials

Matrix impregnation processes' under the project plan CAMISMA

Source: Evonik

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New CFRP thermoplastic materials

Carbon fiber pre-processing for non-woven and continuous fiber tapes

Source: ITA
CAMISMA – Simultaneous development of multi material concept

Through the further development of the process there is a high focus on functional integration:

- Integrated Headrest
- Airbag attachment
- Trim channel
- Back panel
- Recliner attachment

Financial optimization through integrated system approach

CAMISMA – Simultaneous development of multi material concept

Legal requirements for front seat application:

- Rear impact
- Front impact with luggage rotation
CAMISMA – Simultaneous development of multi material concept

- Transfer metal requirements to composite structure
- Simultaneous development with multi-material approach: material, design, process
- Transfer topological results into composite design
- Laminate design incl. fiber orientations
- Develop metal/composite joining
- Build and correlate CFRP material cards
- Process simulation of draping

CAMISMA – Simultaneous development of multi material concept

- Optimization of structure with multi layer approach
- Include different material properties for non woven-, UD- Tapes, Injection molding material and metal
- Optimized load management through optimization of fiber layers and orientation
- Various wall thickness (not possible in classic injection molding)
CAMISMA – Simultaneous development of multi material concept

Actual weight status

<table>
<thead>
<tr>
<th>Reference</th>
<th>Target</th>
<th>Actual*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2 kg</td>
<td>2.5 kg</td>
<td>1.8 kg</td>
</tr>
</tbody>
</table>

* After static/topological simulation study not including additional weight for surface coating

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Processing of the multi material demonstrator

One-shot process (Spri-Form)
Thermoform + mold behind of the multi-material demonstrator

First demonstrator (partial) available end of 2012
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Processing of the multi material demonstrator

New development aspects:
- Additional metal insert
- Handling of fiber reinforced tapes
- Varying wall thicknesses
- No contour cutting

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Metal Composites joining

Optimized joining of metal and composite materials

Challenges
- Variance in thermal expansion
- Contact corrosion between steel and carbon fiber
- Load transfer from carbon fiber tapes into metal interface area

Development approach
- Local inserts versus large metal inserts
- Surface treatment to improve material connection
- Bonding agent to improve chemical connection
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Validation of the demonstrator

Validation of the demonstrator in a seat environment
- Main static requirements for backrest and headrest loads
- Front and rear crash with dummy and luggage
- Climatic requirements need to be fulfilled (-30°C +80 °C)

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Summary

- Improve carbon footprint by using recycling material for medium load areas
- Improved material properties due to in-situ polymerization of PA12 on carbon fibers
- Develop multi material demonstrator that lower the structural weight by > 40 % at a high level of functional integration
- Focus on continuous and economical processes that allow high volume industrialization

After 1 year of work we are convinced that the defined goals are reachable
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Acknowledgement

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Thank you for your attention!