High Volume Manufacturing of Carbon Fiber Reinforced Plastics for Body in White
16.05.2017 - Materialien des Karosseriebaus, Bad Nauheim

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Global and Automotive Trends
Projects and Aims for the Introduction of CFRP
Technology Development Carbon Rear Wall
Realization at Voith Composites
Conclusion
Global Trends - Challenge for the Automotive Industry

- Emissions and Electrification
- Individualisation
- Regulations
- Digitalisation
- Smart Connect
- Sustainability
Automotive Trends - Challenge: Weight Increasing Factors

- Innovations and comfort - e.g. for self-driving concepts
- Safety requirements
- CO\textsubscript{2} emissions – e.g. electrification of power train (PHEV, BEV, ...)
- Legislation (NO\textsubscript{X}, Ad Blue...)
- Country specific regulations
Typical Materials for Body in White

Density of steel, aluminum, carbon fiber reinforced plastics (CFRP)

- Steel: 7.8 kg/dm³
- Aluminium: 2.7 kg/dm³
- CFRP: 1.5 kg/dm³

**Density:** approx. 5:2:1

Weight reduction potential in body applications

- Steel: 100%
- Aluminium: 70%
- CFRP: 60%

**Weight Reduction Potential:** approx. 100:70:60

Costs

- Steel: approx. 0 €/kg
- Aluminium: approx. 2:10:50
- CFRP: approx. 50 €/kg

**Costs:** approx. 2:10:50

Efficient weight reduction (€/kg) as the aim for the Audi Multimaterial Space Frame.

→ The right material at the right place in the right amount
Projects and Aims for the Introduction of CFRP

1st step: development of basic technology
- Class-A in RTM
- Visible CFRP in RTM
- Complex geometry

2nd step: built up competence for high volume
- Class-A in RTM with large component
- LB Gallardo Spyder Class-A evidence with large, horizontal component
- R8 Coupé predecessor Sideblade with visible-CFRP
- R8 Spyder predecessor Number of units 40/day Class-A CFRP

3rd step: cost reduction and integral design
- CFRP in structure Cost reduction with high number of units
- New Audi R8 / Lamborghini Huracán Number of units 45/day CFRP in structure
- R8 e-tron CFRP in structure CFRP in crash area
- RS3 Number of units 40/day Class-A CFRP
- New A8 Number of units 150-300/day Industrialization

Projects:
- Bugatti Veyron First-time evidence Class-A
- Lamborghini Gallardo Spyder Class-A evidence with large, horizontal component
- Audi R8 predecessor Number of units 20/day Class-A CFRP

Aims:
- Maximization of lightweight potential
- Standardization
- Cost reduction with high number of units
- Industrialization
Breakthrough technologies are developed at the Audi Lightweight Center and transferred with potential suppliers to serial production.
CFRP in the Audi R8 and the New Audi A8 - Multimaterial Audi Space Frame

Audi R8 Coupé and Spyder
Modular Sportcar System (MSS)

Small Series to High Volume

New Audi A8
Necessary Steps in Technology Development from R8 to A8

1. **Appropriate composite-based design**
   - Single part reduction and integration of function due to an integral design
   - Preassembled module within assembly line
   - Highly anisotropic layup with localized load paths

2. **Materials & Technology**
   - Cost efficient Composite Solution Package (Carbon Fiber, Resin & Adhesive)
   - New Ultra-RTM Technology (low mould pressure/ robust process / short cycle-time )
   - Innovative direct fiber placement technology (reduced scrap & optimized layup)
   - Highly automated and linked manufacturing process
Single part reduction and integration of functions are realized due to an integral design. 
Preassembly of several components parallel to assembly line.
Minimum use of carbon fiber due to highly anisotropic layup with localized load paths.

**Highlights**

- 6-19 optimized layers
- High variety in part thickness: 1.5 / 1.7 / 2.5 / 2.7 / 3.7 mm
- 30% of static torsional stiffness are related to the carbon rear wall
Materials - Efficient Composite Solution Package

Carbon Fiber

Zoltek Panex PX35

- Zoltek PX35 50k large tow fiber
- Optimized balance of performance and costs for high volume applications
- Long term price commitment up to 7 years
- Textile Type PAN based precursor
- Stability of Supply

Resin & Internal Mould Release

VORAFORCE™ 5300 - Epoxy RTM

- Curing time 90-120s @120°C
- Open - Cure time ratio 1:2
- Processing viscosity <20mPas
- Latent reaction behavior
- Effective mold release
- Excellent fiber adhesion
- No post cure required
- High machine compatibility

Adhesive

BETAFORCE™ 9050M

- Used for metal inserts and assembly
- Compatible with VORAFORCE™ & IMR
- Pretreatment-free adhesion
- Heat accelerated cure and ambient temperature latency
- Multi material mix – δα management (high elongation and stiffness)

Source: Dow Automotive Systems

Composite stiffness GPa/€

Performance automotive fibre

low-cost automotive fibre

Composite strength MPa/€

Source: Dow Automotive Systems
Main challenge: Infiltration of complex parts with ultra-fast-cure resins and very low cavity pressure could be solved by innovative process controlled injection and press step.
ultra-RTM technology can produce the same quality with smaller, efficient hydraulic presses and a very robust process also for high fiber volume content (50-55%).
Breakthrough technologies are developed at the Audi Lightweight Center and transferred with Voith Composite to serial production.
Voith Composites
From Fiber Straight to Component

Elimination of expensive semi-finished products, reduction of cycle time due to elimination of process steps, completely digitalized production based on “Carbon Production 4.0“
Industrialized Process Chain CFRP Rear Wall Audi A8

Manufacture:
- Mostly industrialized
  - Materials
  - Semi finished
  - Preforming
  - Consolidation
  - Milling
  - Assembly

Industrialized Production

Lean:
- Materials
- Preforming
- Consolidation
- Milling
- Assembly

Details:
- Fiber Placement (VRA)
- 3D Forming
- 3D Cutting
- Ultra RTM Process
- CNC Milling
- Surface Cleaning
- Riveting & Bonding

Fiber & Binder
- Resin
- Metallic Attachment Parts
Process Chain Step: Voith Roving Applicator (VRA)

- Industrialized production line
- Near net shape fiber placement
- Automated quality control
- Fully digitalized
- Flexible 2D fiber layup
- Variable fiber angle
Process Chain Step: 3D Forming

- Segmented stamp forming
- Complete automated handling
- Forming process 2D → 3D
- Activation of binder
- Tailored Preforms
- Stabil in RTM process
Process Chain Step: Injection & Consolidation Ultra RTM

- Fully industrialized process
- High production rate
- Curing time < 120 s.
- Low injection pressure
- Optimal surface quality
- No fiber washing
Process Chain Step: Riveting and Bonding of Metallic Parts

- Surface cleaning with water
- No mechanical treatment for bonding necessary
- Fully automated bonding
- Fast curing 2k PU System
- Automated riveting
- Riveting force documentation
The new A8 CFRP Rear Wall has a weight **reduction of 50%** compared to the current A8.

**Breakthrough technologies** have been developed at the **Audi Lightweight Center** and together with Voith Composites transferred to serial production.

Due to the new developed technologies it is possible for the first time to use the **full potential of CFRP** within high volume.

**Lean production:** **Voith Roving Applicator** for elimination of semi finished products

**Industrialization:** mechanization and **automation of processes**
Thank you