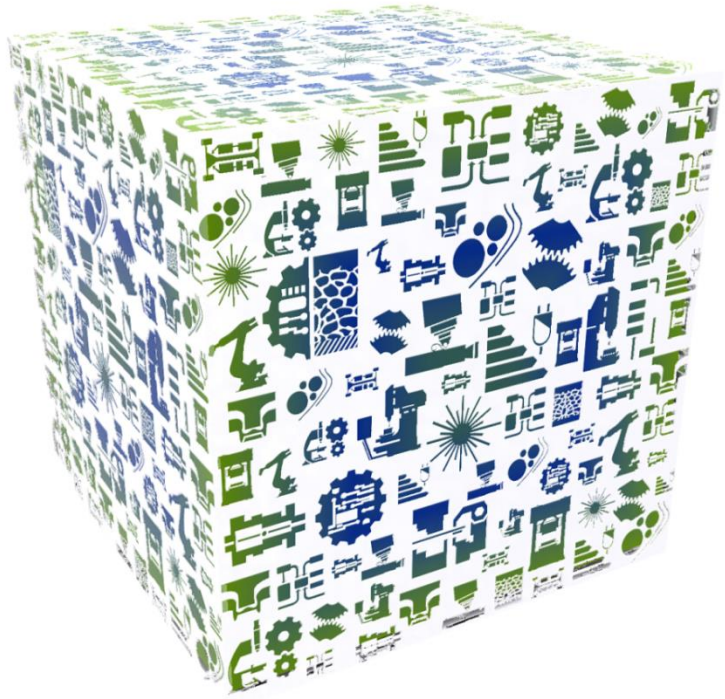
LATEST TRENDS IN MANUFACTURING TECHNOLOGY FOR INCREASING USE OF COMPOSITES IN AEROSPACE AND AUTOMOTIVE SECTOR

INTERNATIONAL SEMINAR ON FORMING TECHNOLOGY, 24h JANUARY 2018, BANGALORE, COINCIDING WITH IMTEX FORMING 2018 EXHIBITION



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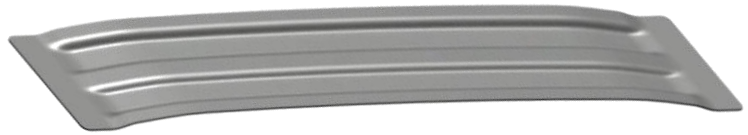
AGENDA

- Introduction
- Component Manufacturing by Hybrid Processes
  - Lightweight Battery Carrier
  - Back Seat Component
- Manufacturing of Fibre-reinforced Plastic -Metal Components
  - Cockpit Cross Beam
  - Roof Crossmember
  - Wheel Rim
- Continuous Orbital Wrapping (COW)
- Selective-Laser-Melting (SLM)
- Conclusion and Future Prospects

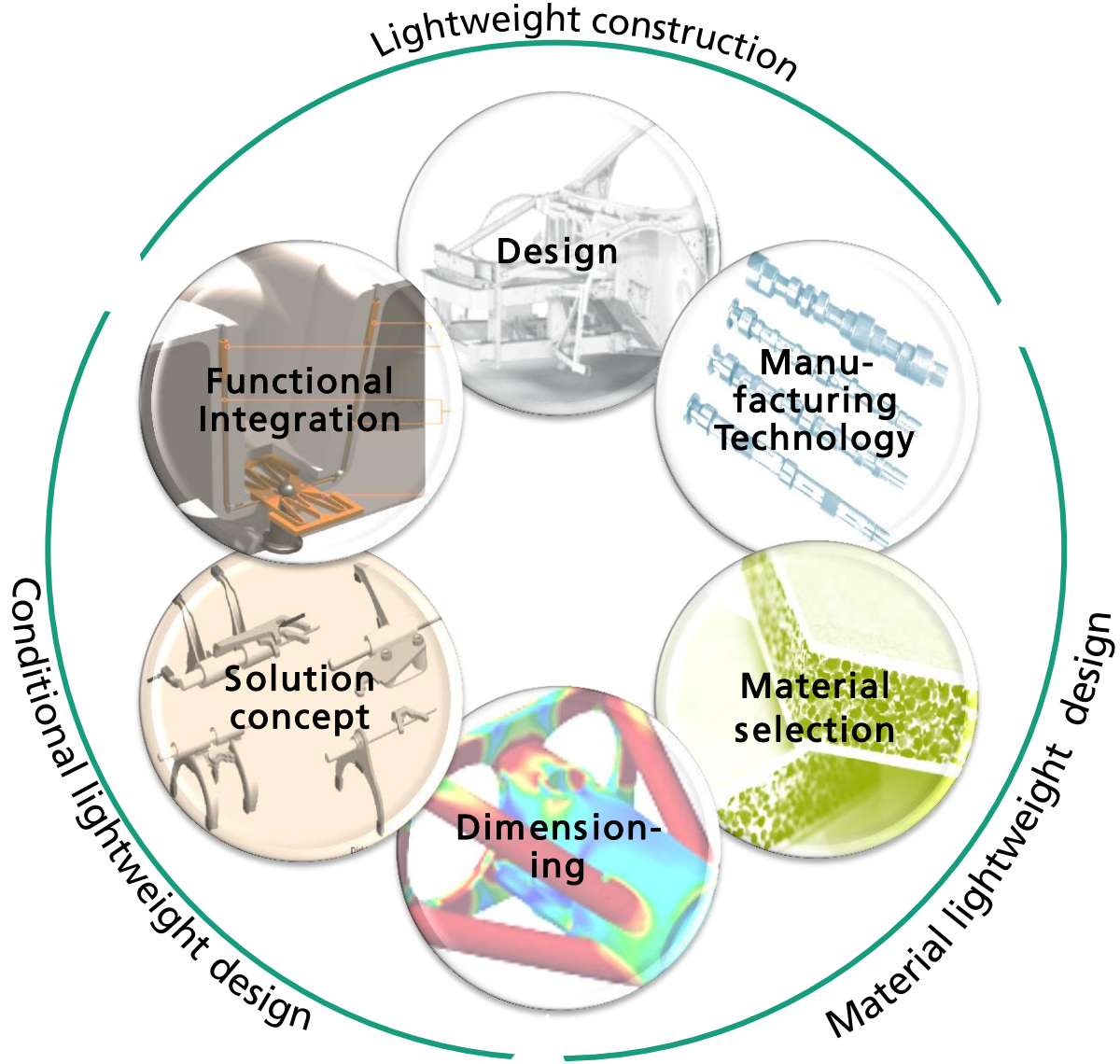


Introduction

- Lightweight design – different strategies

➢ Composites with best lightweight design potential

➢ Demand of efficient and cost effective technologies



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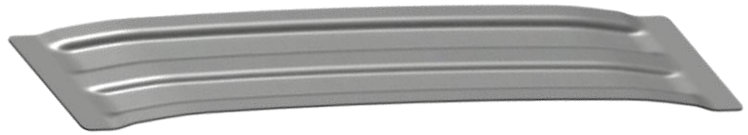

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Lightweight Battery Carrier

Audi R8 e-tron

Fusion of technologies

Thermoforming

Injection Moulding

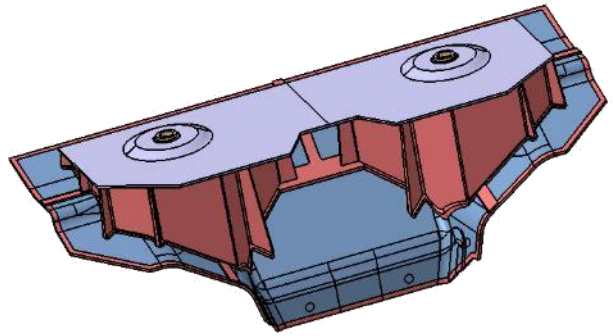
Thermal joining

Complex hybrid lightweight structure

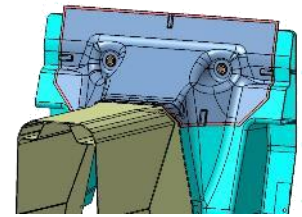
Lightweight battery carrier

1. Innovation price of Volkswagen Group

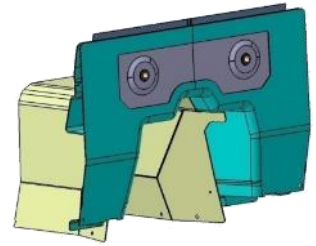
Patent: K 19979 DE



Front side



Back side



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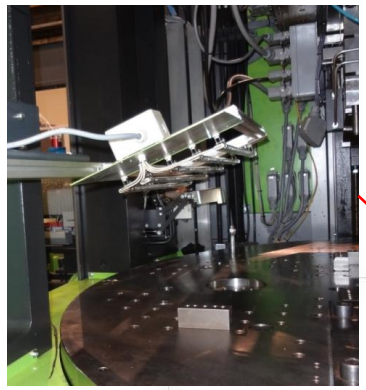
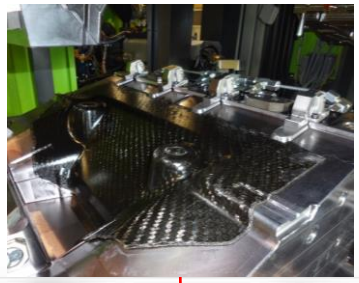
Lightweight Battery Carrier

Audi R8 e-tron

Pre-Heating



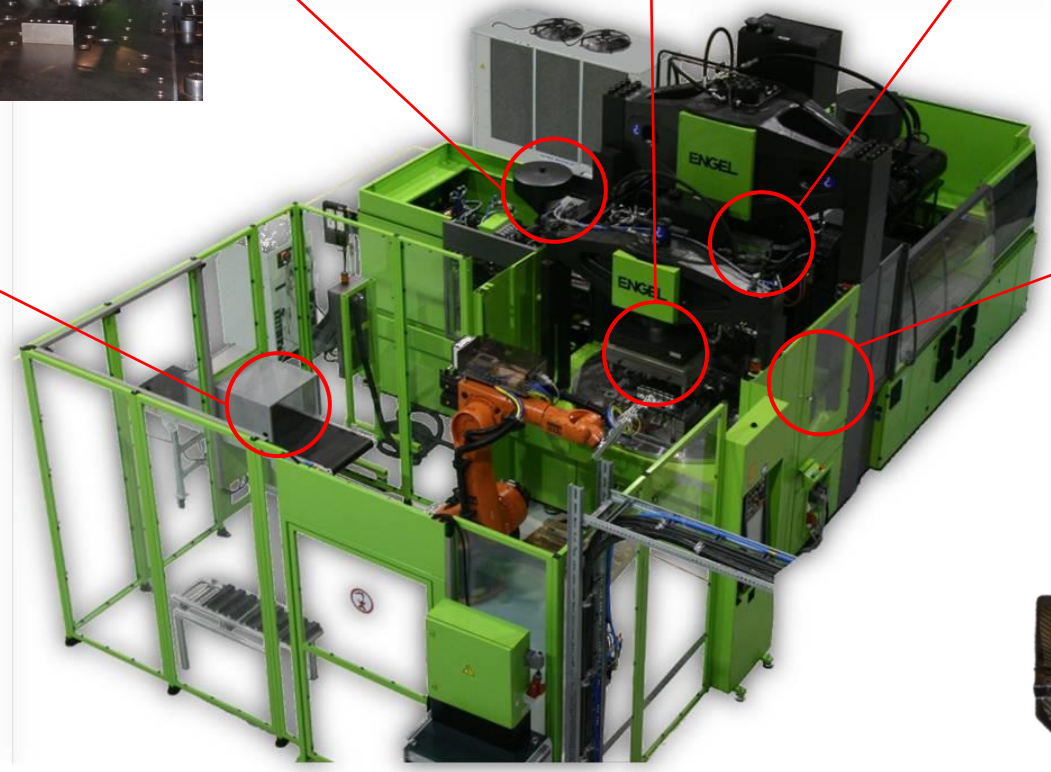
Forming

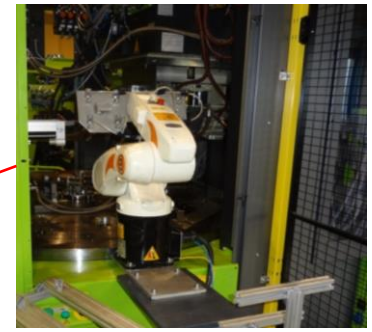


Injection Molding

Transfer

Cutting of organo sheet





Joining & Put-out

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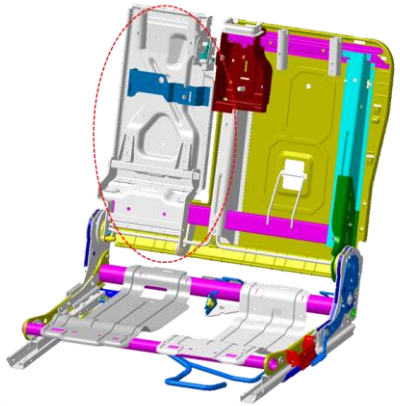
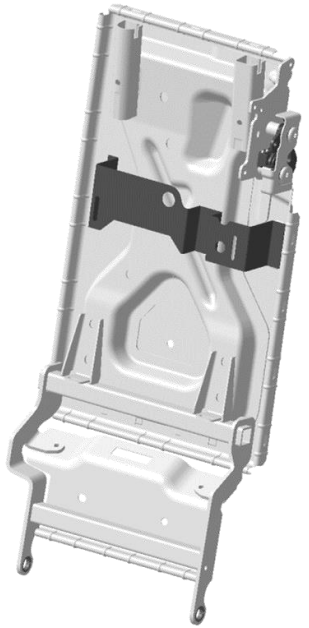
Back Seat Component

Process combination thermoforming and injection molding

- Weight reduction: -55%
- Representation of a large-scale production process chain from material cutting to the removal of the finished component
- → Serial production for Jaguar SUV F-Pace


Quelle: Autozeitung

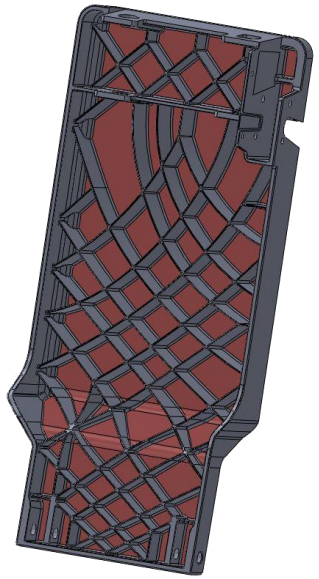




Weight of
steel part
3,8 kg

→ Welded assemblies
made of sheet steel

m = -55%



weight of
fiber reinforced plastics
1,6 kg

→ Organo sheet with ribbings
made of injection molding

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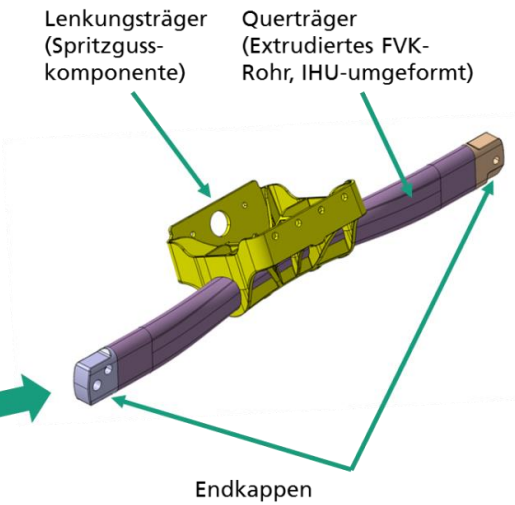
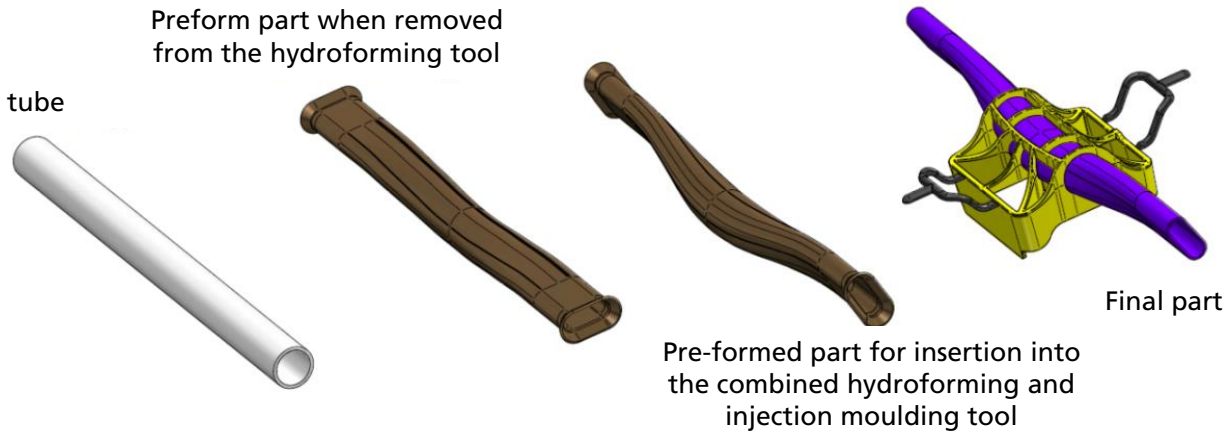
Cockpit Cross Beam

Process combination hydroforming and injection molding



- Process chain (start with tube)
  - Preform:
    1. Heating up the tube (Ø38mm, 500mm long)
    2. Part handling into the tool
    3. Hydroforming of the preform
  - Combination of hydroforming and injection moulding
    1. Heating up the preformed part
    2. Part handling into the tool
    3. Hydroforming and injection moulding process



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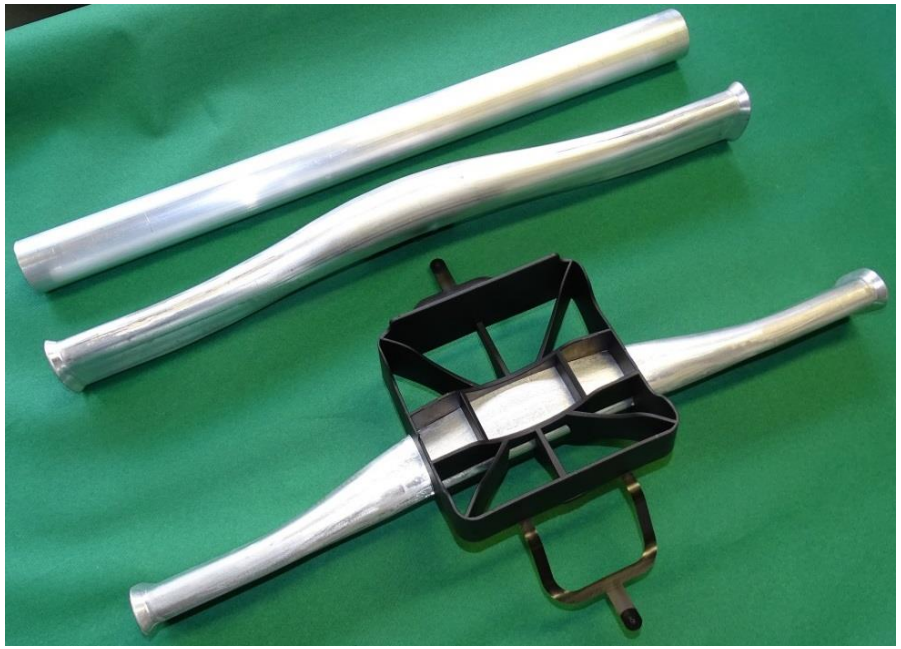
Cockpit Cross Beam

Process combination hydroforming and injection molding

- Tests with aluminum tubes were successful

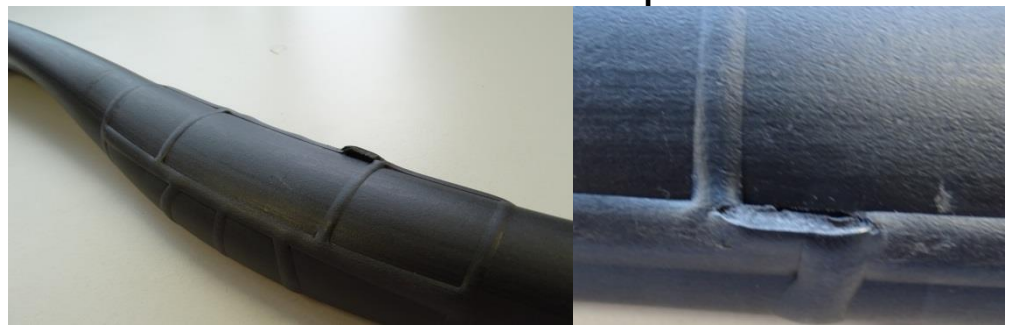


Production steps cockpit cross beam Kulan

  - Above: Semi - finished tube (Ø38mm, EN AW 6060)
  - Middle: hydroformed preform
  - Below: final part produced by the combination of hydroforming and injection moulding

- First experiments with FRP-tubes (hydroforming process without injection moulding):
  - Good process with 10 MPa inner pressure

  - Crack with 13 MPa inner pressure



- Min. 20 MPa inner pressure are necessary!

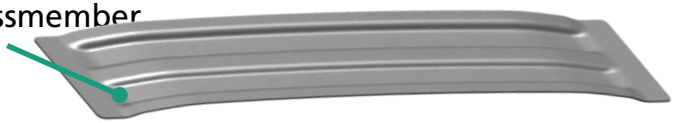
Roof crossmember

Forming of hybrid fibre-reinforced plastic - metal laminates for high-volume production

Objectives

- more than **20 % weight reduction** for the demonstrator component at the same component performance in terms bending stiffness
- providing high-volume production compatible forming technologies for the production of complex 3D parts made of hybrid laminates

technology demonstrator roof crossmember



Approach

- laminate design
- design of the hybrid forming process
- development of the forming tool
- forming trials under serial conditions
- component testing and benchmarking

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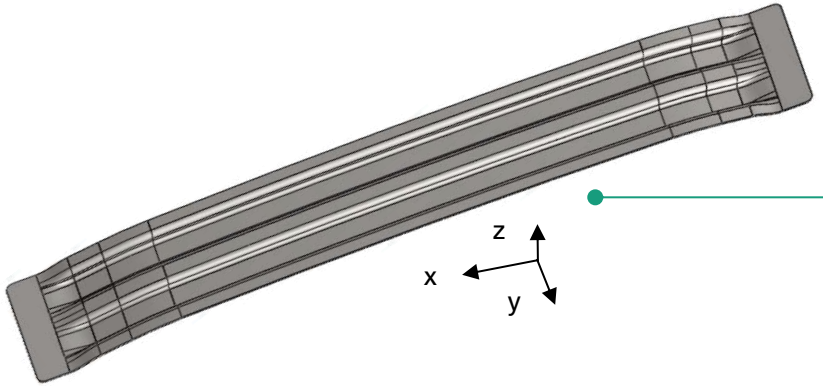
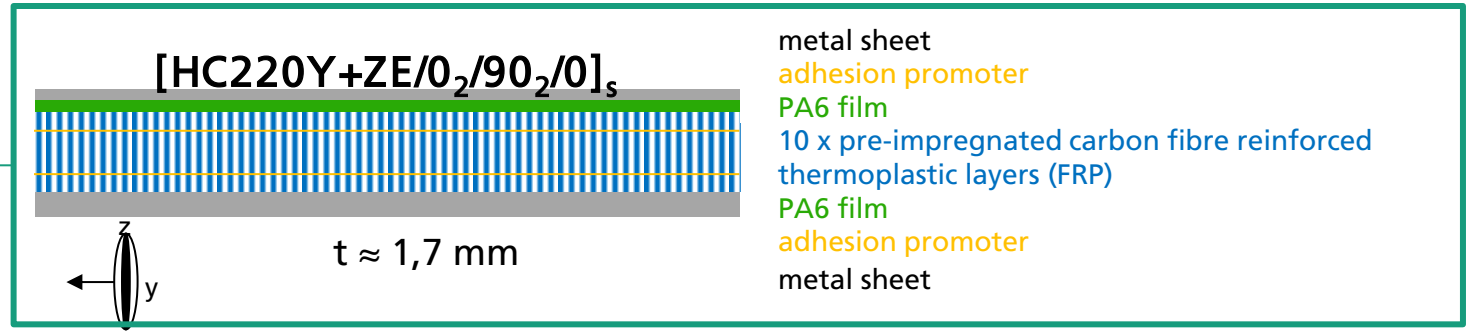
Roof crossmember

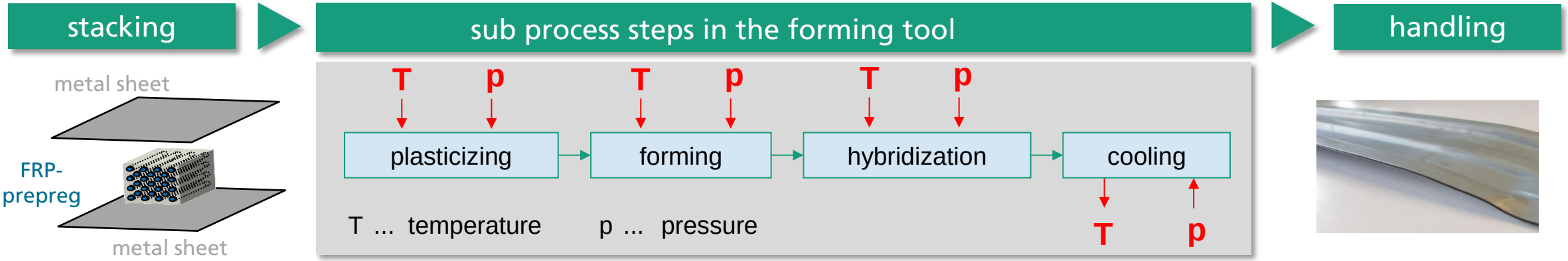
Laminate layout and process design

- Layer structure based on bending stiffness comparison with the steel reference part





- One step process → hybridization (joining of the different materials) and forming in a single process step



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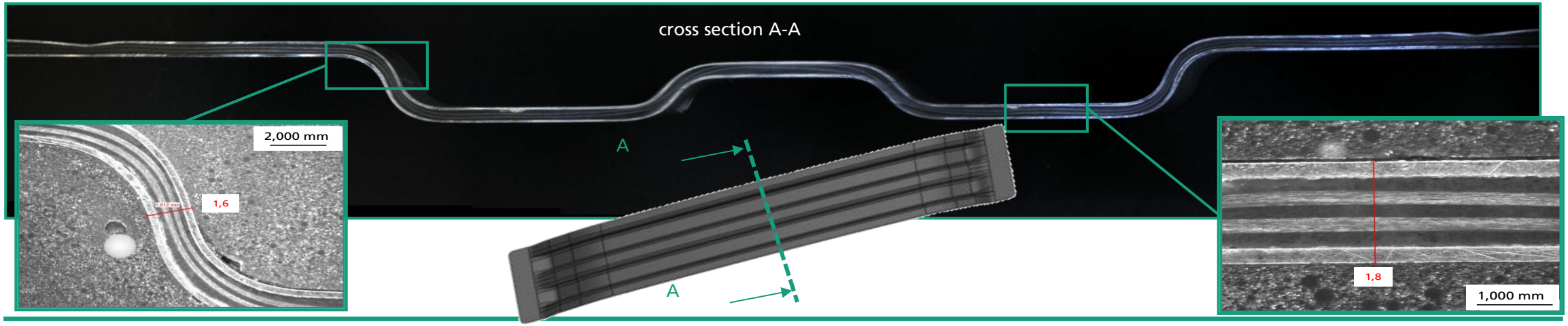
Roof crossmember

Processing of layer materials by an integrated forming and consolidation process

- shaping and pressing is realized in a vario-thermal forming tool

- analysis of the forming results in microscopic cross sections shows neither delamination nor ondulations ➔ layer adhesion is secured



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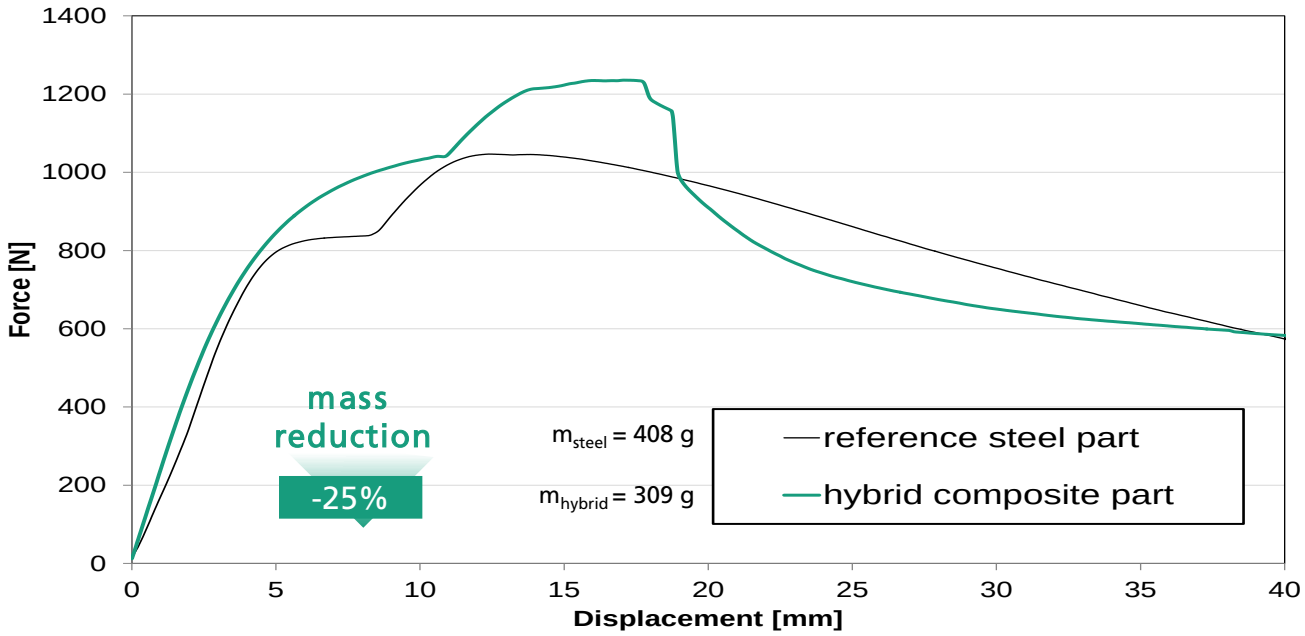
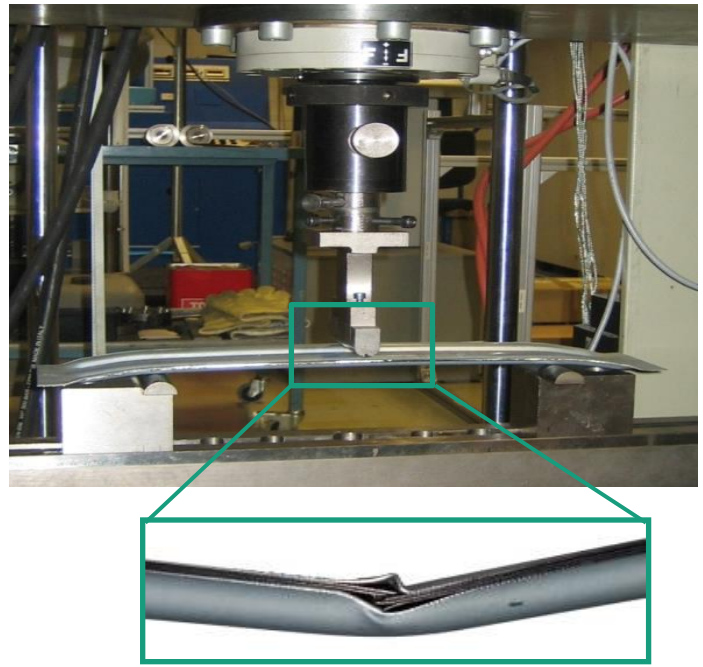
Roof crossmember

Component tests under application-oriented load case: hybrid versus reference

- 3-point-bending tests are performed on Zwick universal testing machine





25% weight reduction compared to the monolithic steel reference at same stiffness

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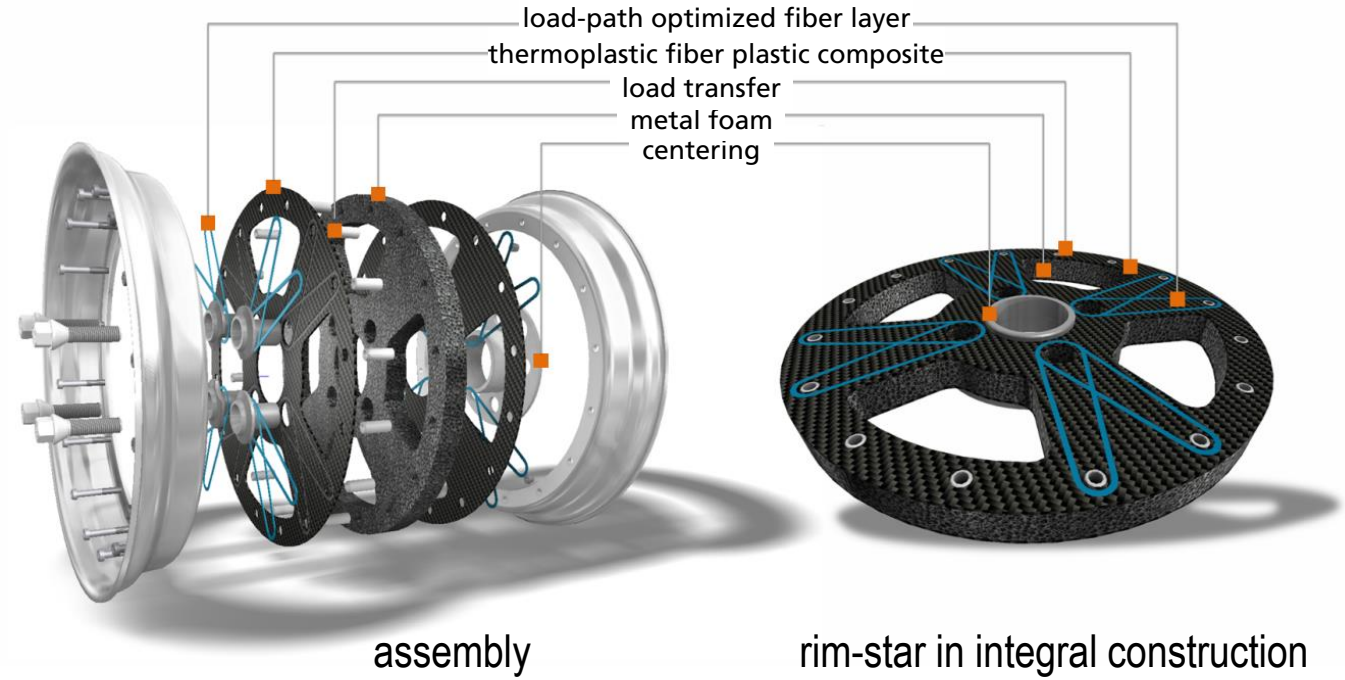
Hybrid wheel rim made from metal/fiber reinforced plastic

Goal

- Weight reduction of relevant chassis components
- Interchangeability in series production
- Modular scaling in different frame size

Patent DE: 10 2014 009 180.5
Utility Model DE: 20 2014 005 111.9

Structure and implementation



assembly

rim-star in integral construction

Wheel rim: 5,5 x 14 (4x100)

Steel (VW up!):	7,42 kg
Aluminum (BBS RXII):	6,03 kg
Sandwich (CCC):	3,02 kg

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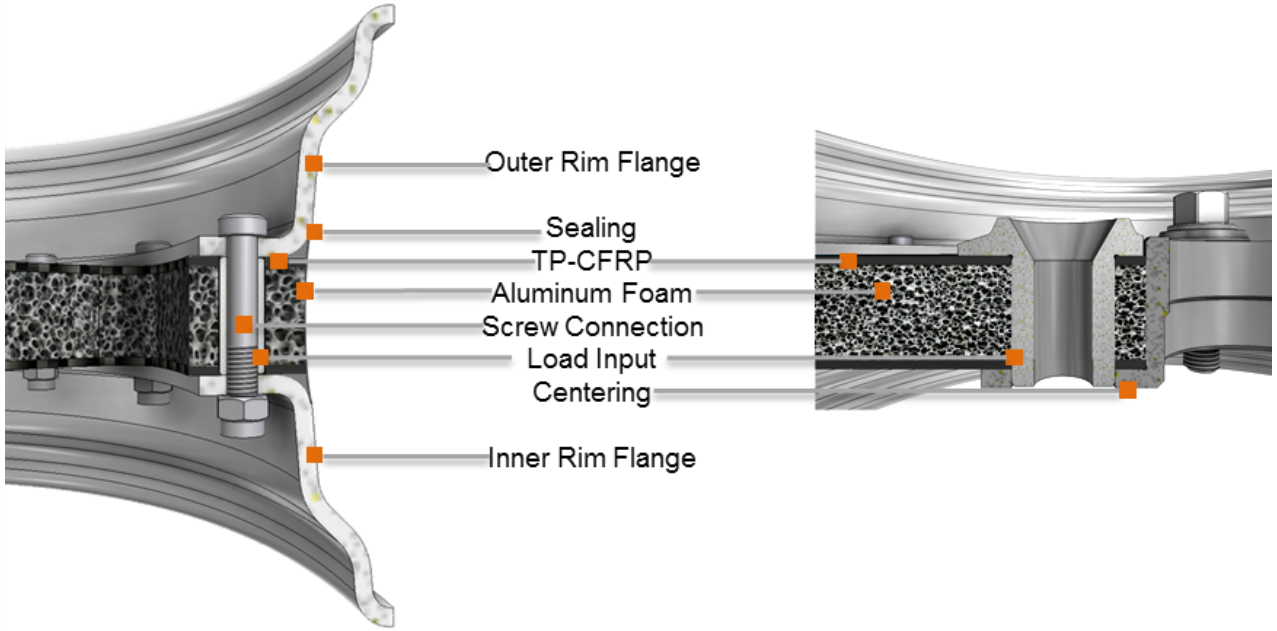
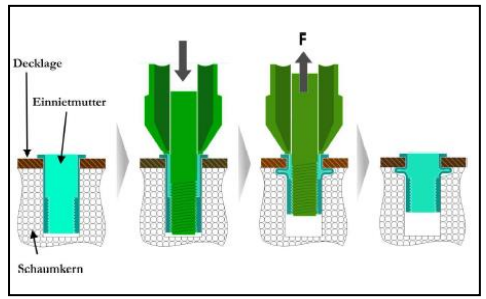
Hybrid wheel rim made from metal/fiber reinforced plastic

Results

- Graded structure and variable star-geometry by standardized interface to vehicle
- High stiffness in sandwich composite
- Load-path oriented structure of the top layer made from thermoplastic carbon fiber-reinforced plastics
- Integration of load transfer in the forming process

Patent	DE: 10 2014 009 180.5
Utility Model	DE: 20 2014 005 111.9





rivet nut

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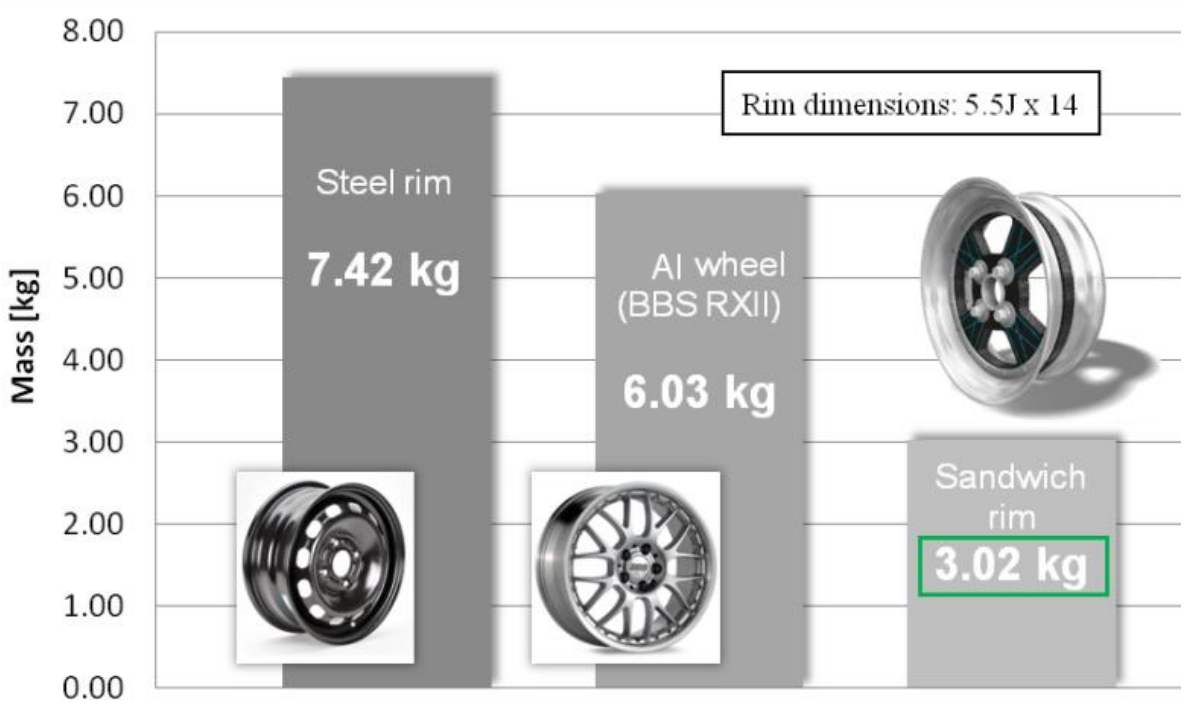
Hybrid wheel rim made from metal/fiber reinforced plastic

Results

- Reduction of weight
- Plate tool with near-net-shape fiber orientation



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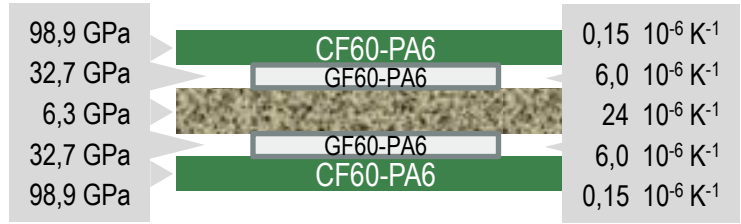

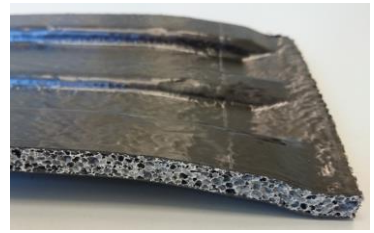

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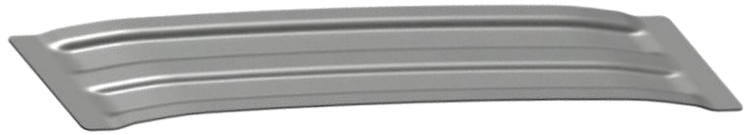
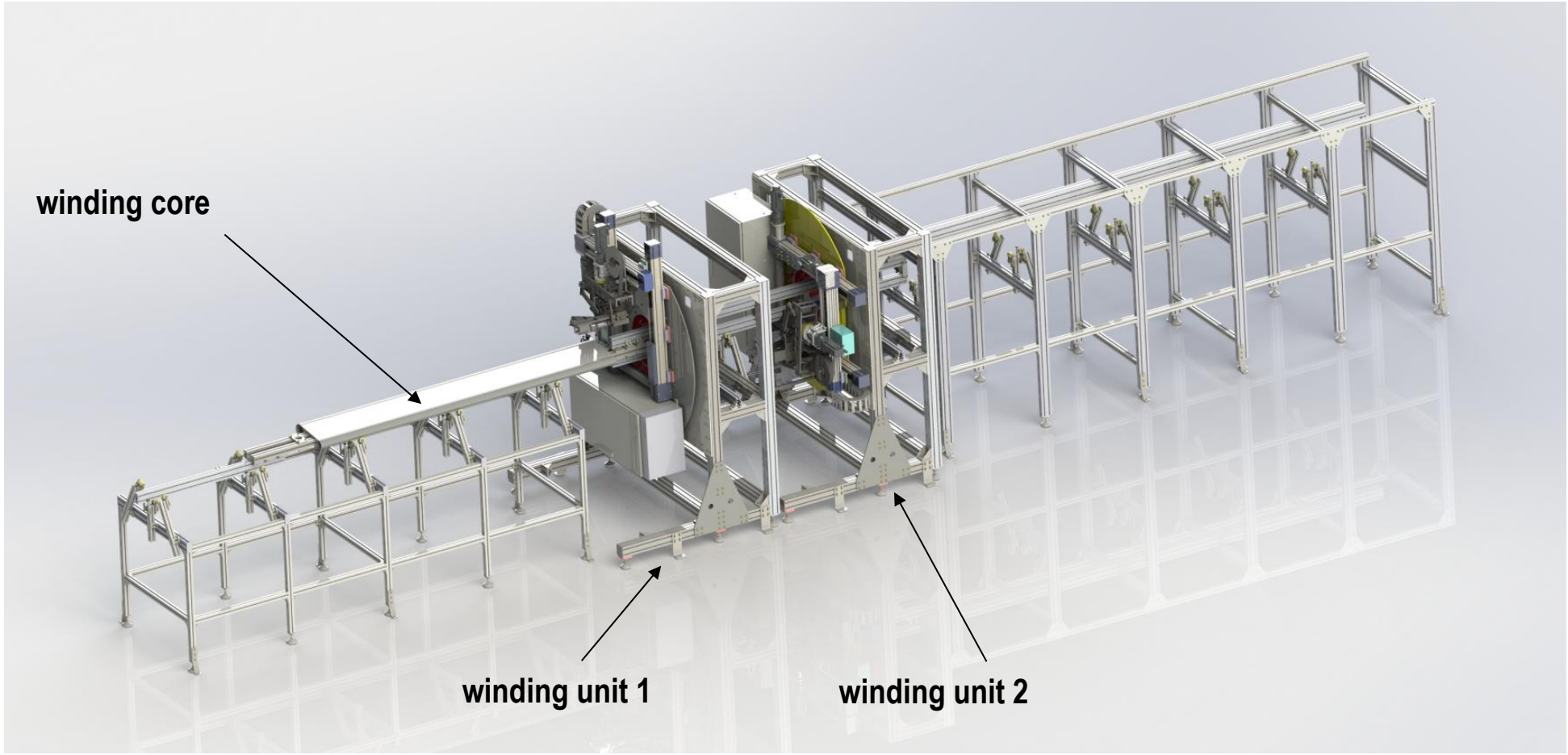
- Selective-Laser-Melting (SLM)
- Conclusion and outlook



Continuous Orbital Wrapping (COW)-System: Prototype system



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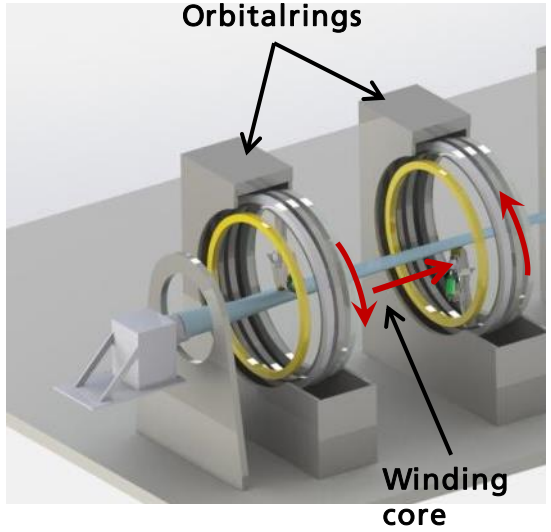
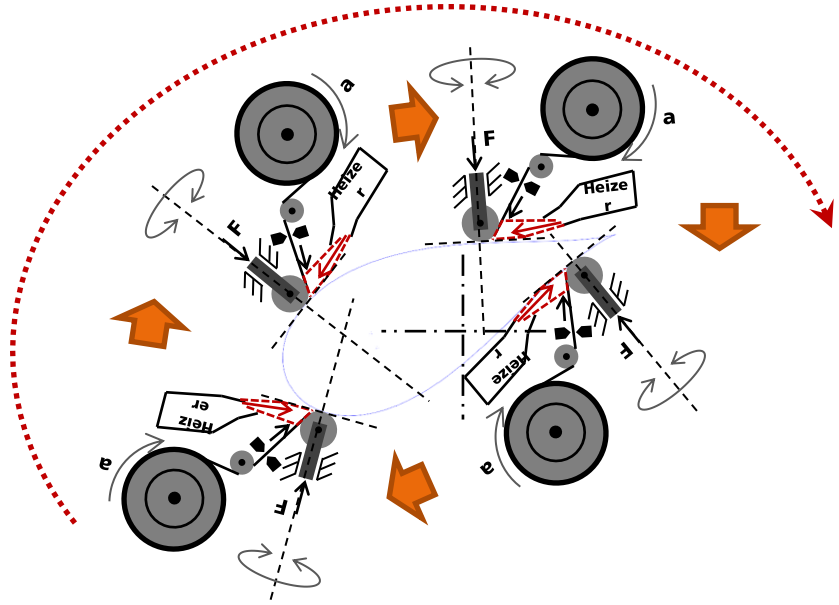
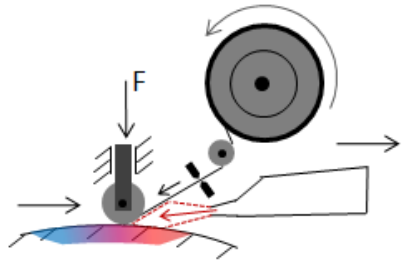




Focus

- combination of tape-laying and winding process
- continuous manufacturing of thermoplastic prepregs
- modular construction
- suitable for mass production



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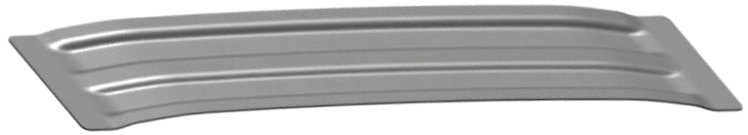

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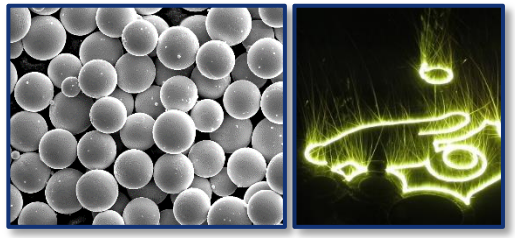
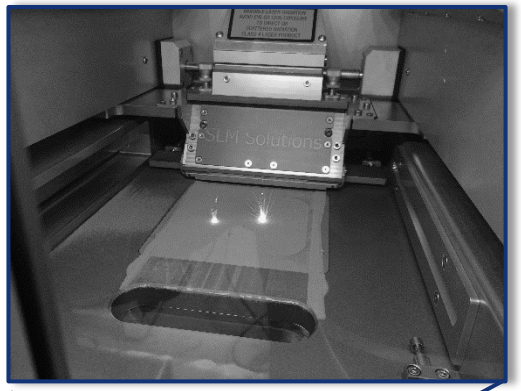
Selective-Laser-Melting (SLM)





Aluminum alloys
(AlSi10Mg, AlSi9Cu3,…)

Titanium alloys
(Ti6Al4V, Ti5553,…)

Steel alloys
(17-4PH, 316l, 1.2709 …)

Nickel base alloys
(Inconel 718,…)

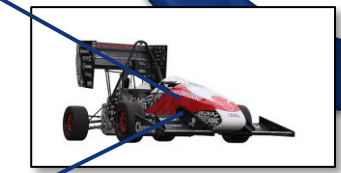
Palate implants

Hydraulic valve block

Medical

Aerospace

Automotive



Racing

Water cooling frame

Drive shaft

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Selective-Laser-Melting (SLM)

Requirements

- Class 1 equipment of primary flight control
- System pressure: 5,000 psi
- Impulse fatigue: 11·106 pulse cycles

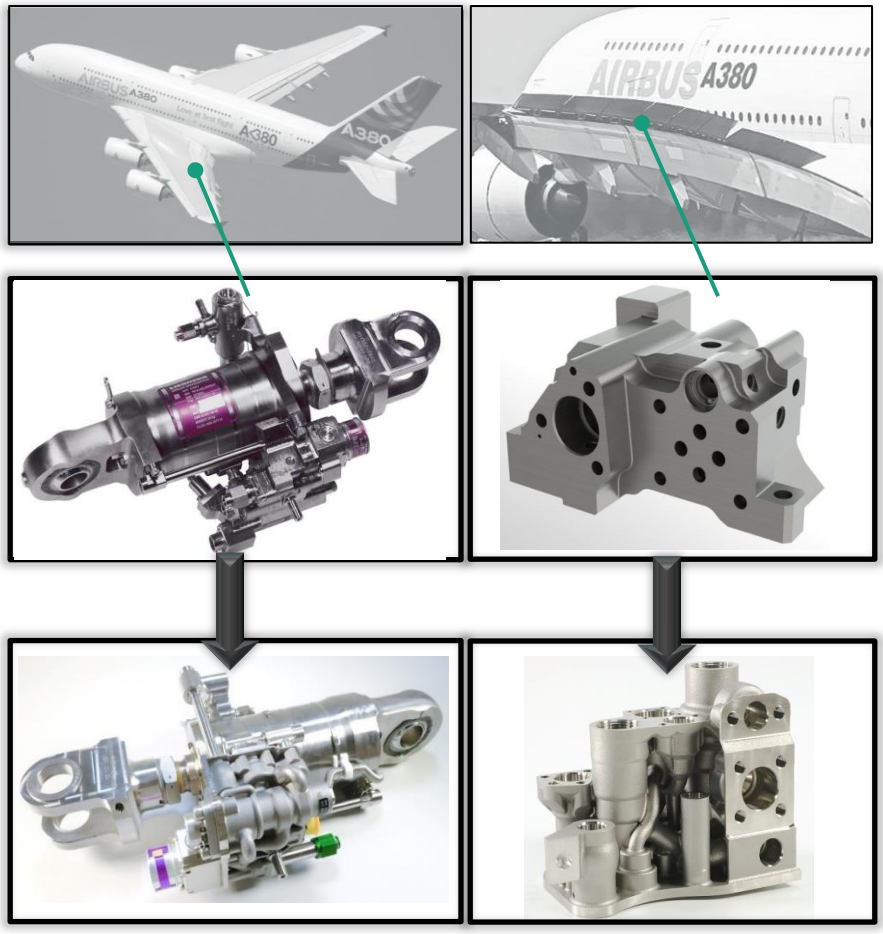
Project Part of TU Chemnitz

- SLM process development
- Design to manufacture rules
- Component design

Results

- Weight Reduction: -35%
- Performance: equal to reference component
- Flight Test: since march 2017 on MSN001

hydraulic valve block



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Conclusion and Future Prospects

- New Processes and process combinations lead to outstanding lightweight solutions
- Extensive automation leads to an effective serial production of hybrid components

- Next step industrialization
- Live cycle / recycling aspects will be a challenge especially for hybrid components