APPLICATION OF LOAD ADAPTED HYBRID TEXTILES FOR A THERMOPLASTIC SEAT PASS-THROUGH

Michael Schreiter, Daniel Nebel, Enrico Körner, Arham Saleem, Manuel Schlegel

Fraunhofer
IWU

CONTENT

- Motivation
- Approach
- Load adapted design approach for a seat pass-through
- Thermoplastic process chain
- Conclusion

Motivation

- Low economic attractiveness of carbon fiber reinforced components in the automotive industry due to high material and process costs
- Limited design freedom of conventional fiber composite semi-finished products
- Challenging subsequent thermoplastic impregnation and processing of variable textile semi-finished products

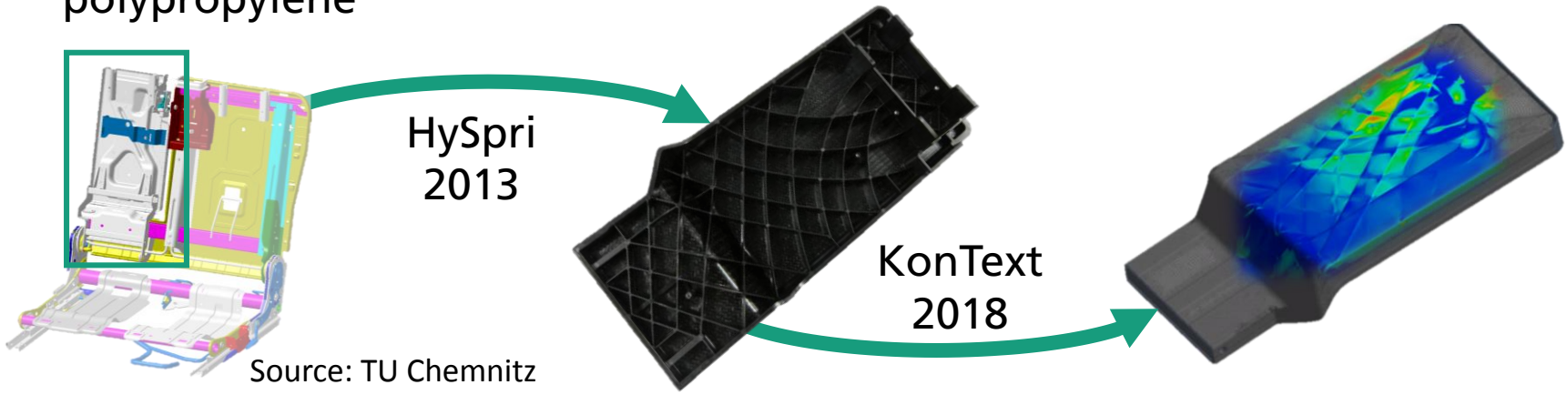
Source: BMW

Source: KraussMaffei

➢ Generating novel Use-Case through cost-effective materials and high material efficiency, especially for expensive high-performance fibers

Approach

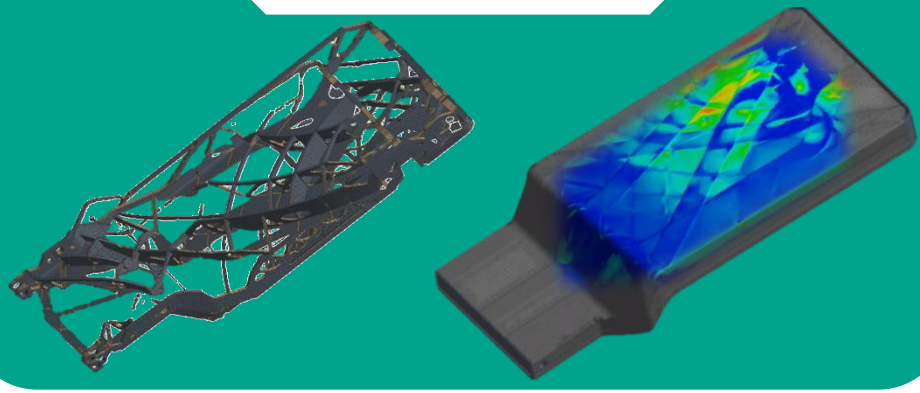
- Topology optimization of an organo-sheet based seat pass-through for a load-adapted and resource-efficient design approach
- Production of suitable hybrid non-crimp fabrics from e.g. carbon fibers on non-crimp fabrics made of inexpensive materials such as natural or glass fibers
- Thermoplastic processing (impregnation, forming and injection molding) of hybrid semi-finished products with cost-effective matrices such as polypropylene



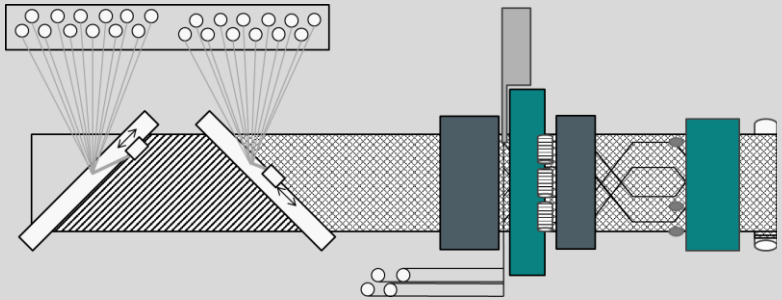
Source: TU Chemnitz

Approach
Overview

I - Optimization

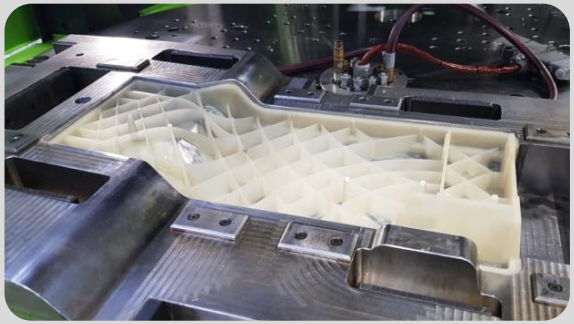


II - Textile Manufacturing



III - Impregnation

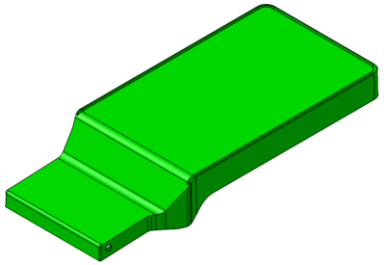
IV - Injection Moulding



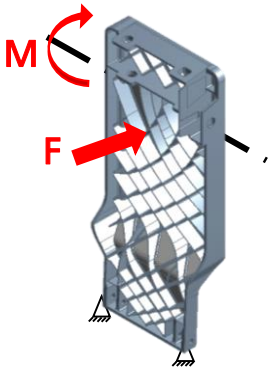
V - Component

Load adapted design approach for a seat pass-through
Process Overview & Boundary Condition

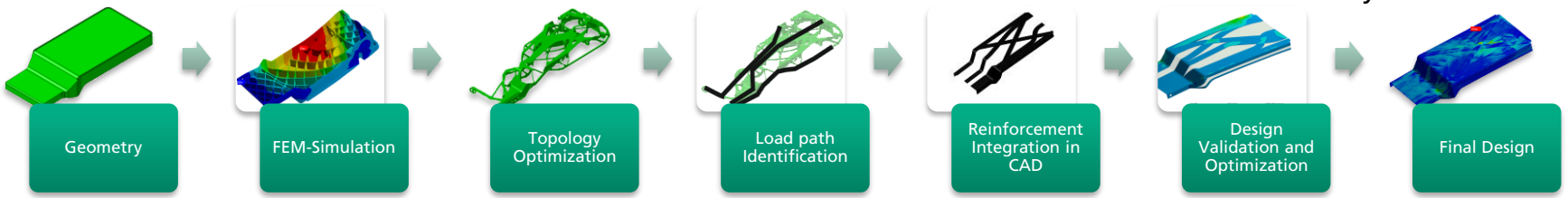
- Seat Pass-Through is Structural component in seat backrest:
  - Stiffness in tension of the belt
  - Protection of the vehicle occupant from baggage impact
  - Load absorption in rear crash



Input Geometry



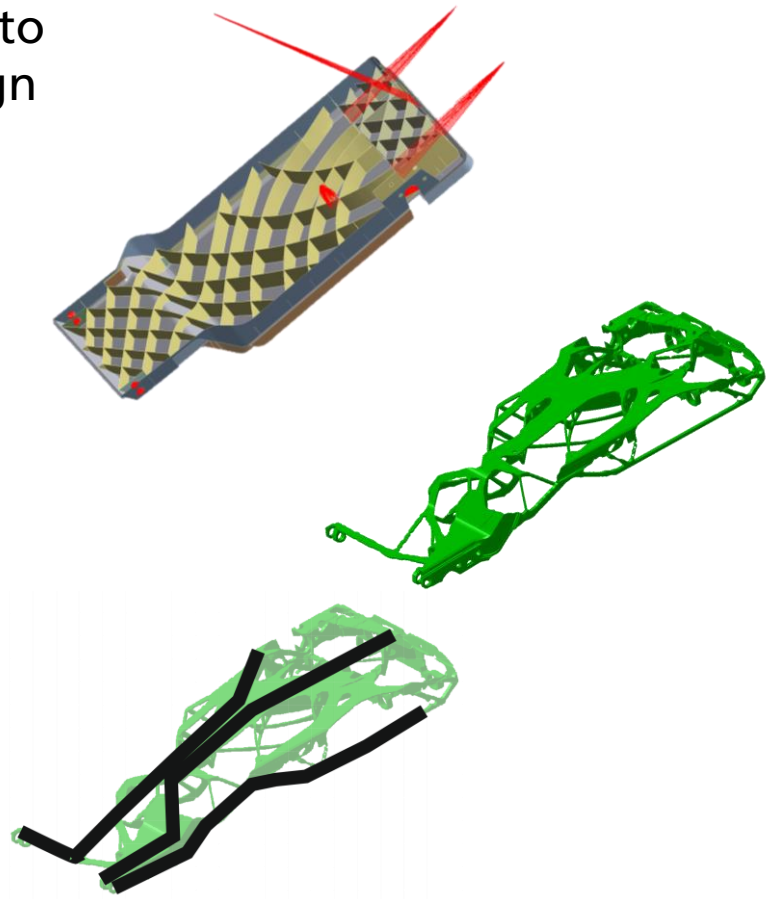
Boundary Conditions



Fraunhofer IWU

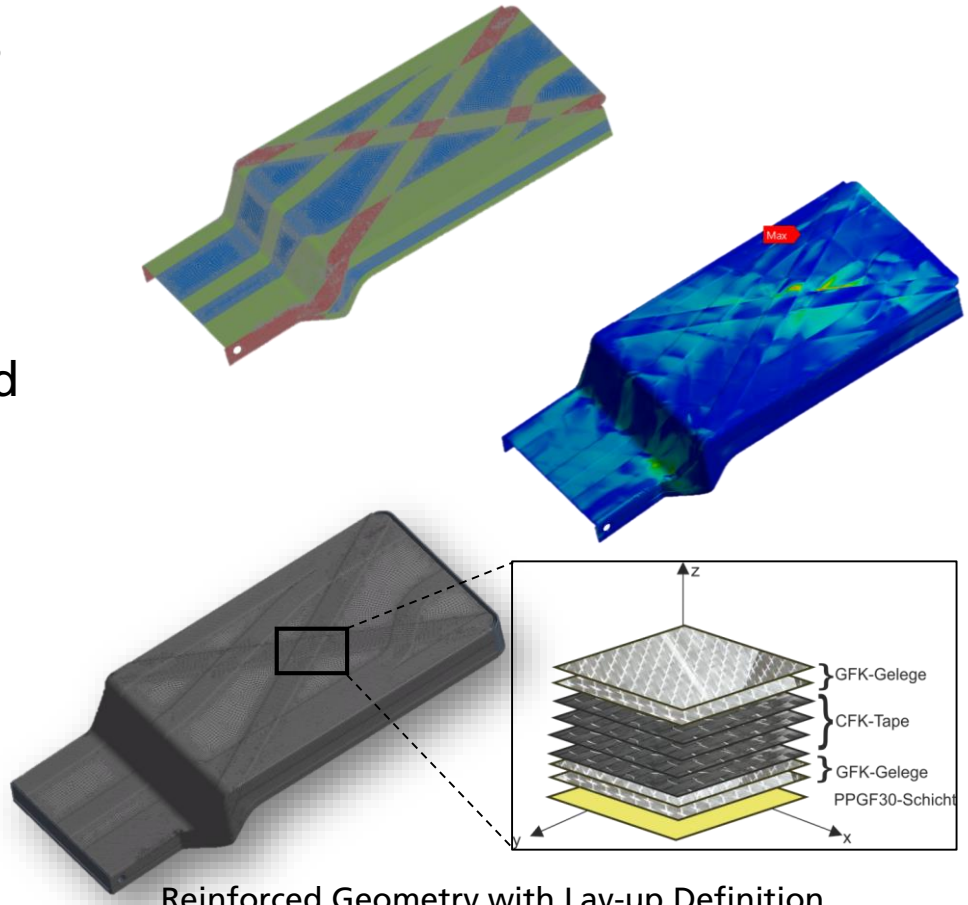
Load adapted design approach for a seat pass-through
Optimization

- FEM Simulation with the given load cases to establish a benchmark for optimized design
- Topology optimization
  - With individual load cases
  - Isotropic material definition to give liberty of orientation
- Identification of Load-Paths
  - Analysis of optimization results
  - Extraction of load paths
  - Integration in CAD-Model



Load adapted design approach for a seat pass-through
Optimization

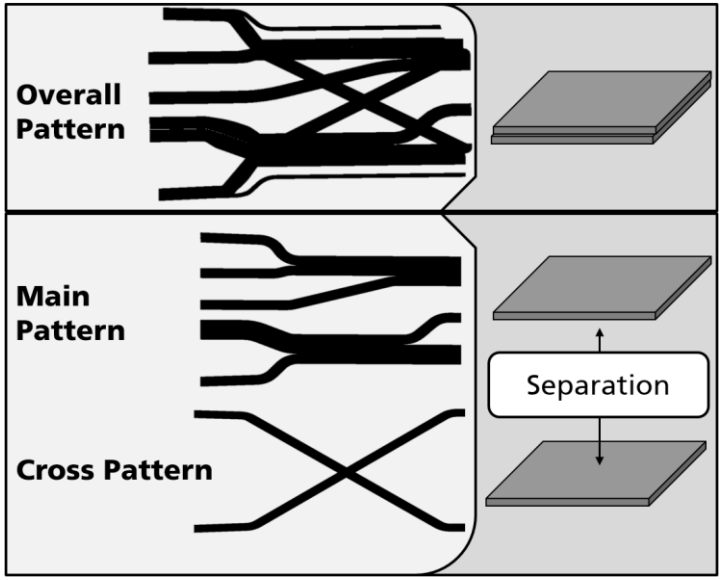
- Design validation & adjustments
  - Definition of composite layups with proper material orientations along the load paths
  - Simulation with relevant load cases for the validation of the proposed reinforcement design
- Thickness optimization for higher stiffness and lower weight and design finalization

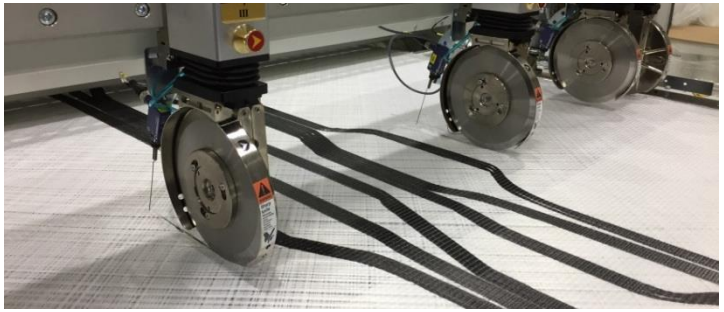


Reinforced Geometry with Lay-up Definition

Thermoplastic Process Chain
Textile Production

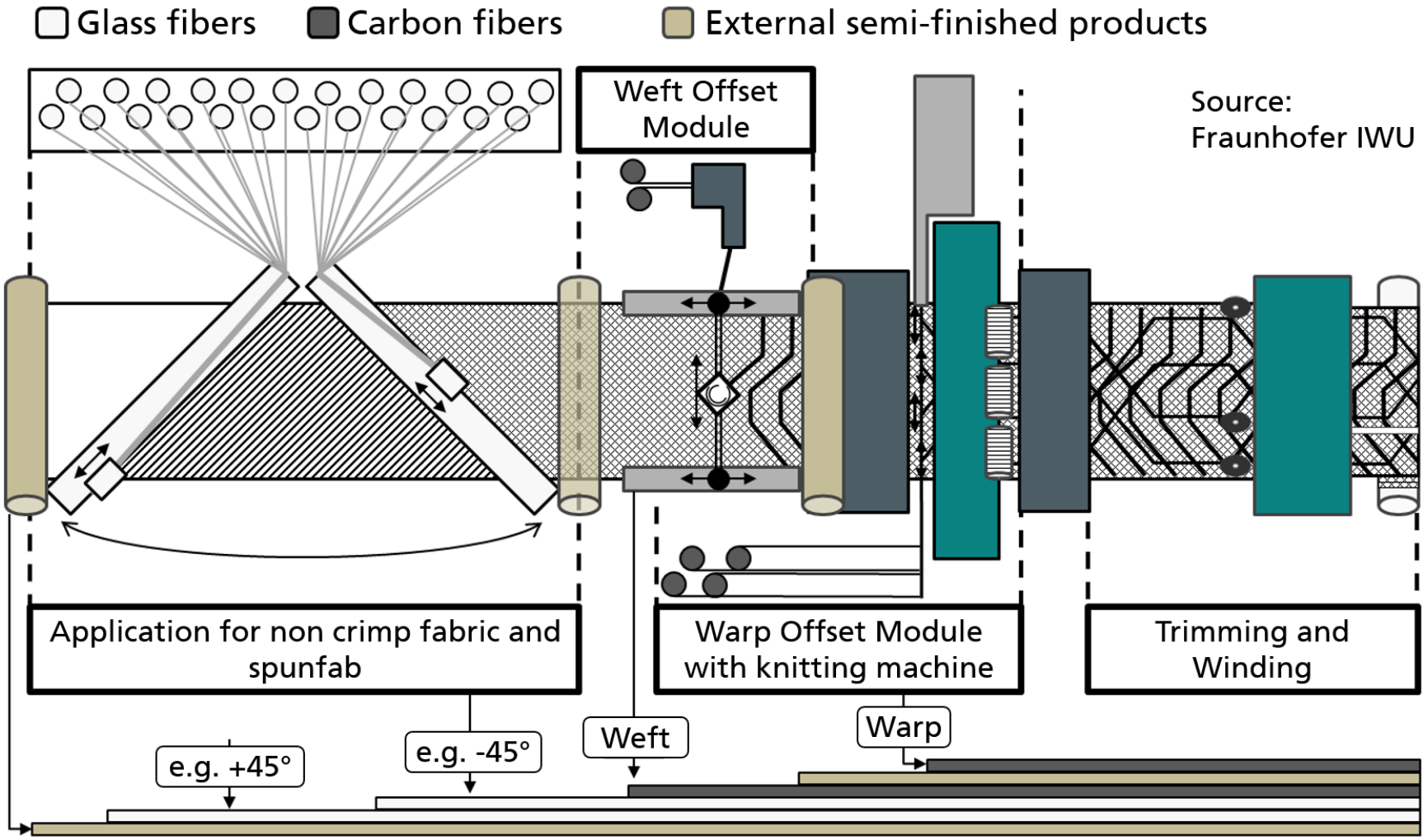
- Inverse drape of the three-dimensional load paths to the two-dimensional plane
- Separating the entire pattern into a main pattern with six three-roving load paths and a cross pattern with two three-roving load-paths to ensure sufficient impregnability
- Production of the main pattern on non-crimp fabric and in addition like the cross pattern on pure matrix foil for the later impregnation





Thermoplastic Process Chain

Textile Production

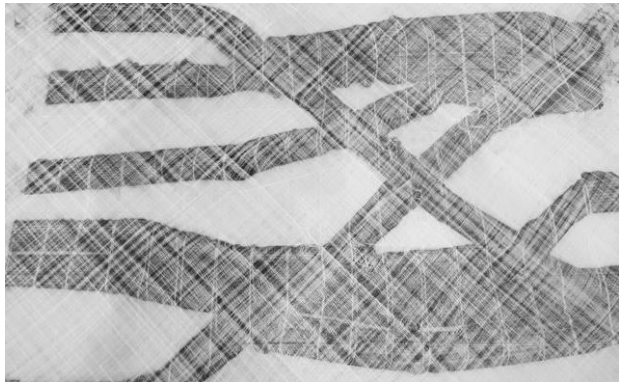


Fraunhofer IWU

Thermoplastic Process Chain

Production of pre-impregnated semi-finished products

- Cutting, stacking and prefixing of the layers and additional matrix foil for insertion into the press
- Consolidated laminate thickness 0.6, 1.25 and 1.9 mm
- Use of metallic stencil to compensate for load path thicknesses of 0.65 mm
- The dynamic change in thickness during the impregnation leads to significant fiber washing up to 40 mm

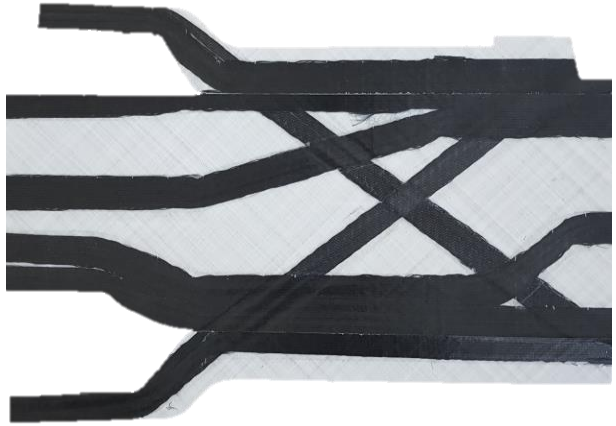


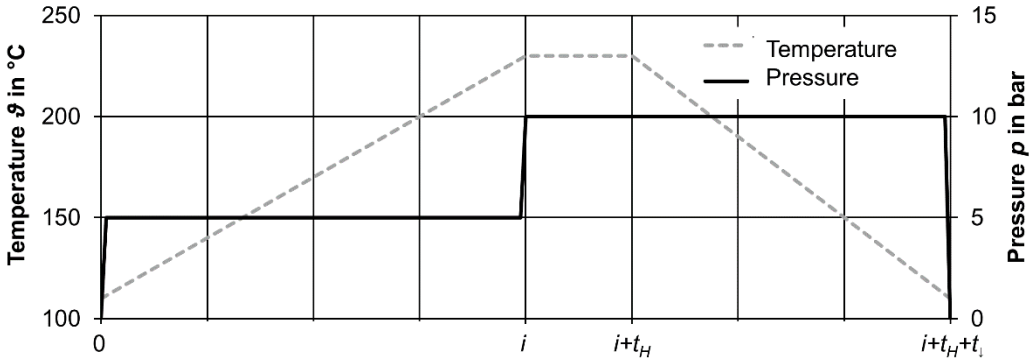
Fraunhofer IWU

Thermoplastic Process Chain

Production of pre-impregnated semi-finished products

- Solution was made by combining the stencils with a fluid-based variothermal tool insert which is fundamentally transferable to a process such as an interval heating press
- The fluid transfers the pressure evenly to the surface and the stencils prevent undercuts and maintain contour accuracy
- Injection molding inserts were then cut out in the water jet
- Pressing parameter are shown at the bottom right

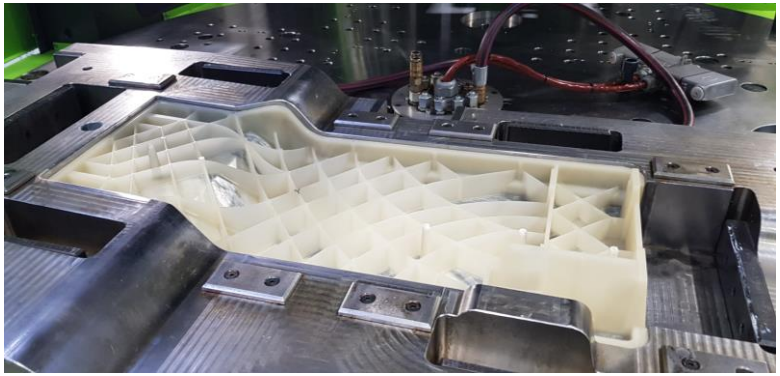




Fraunhofer IWU

Thermoplastic Process Chain
Component manufacturing in injection molding

- Production of the demonstrator in the original injection molding tool of the reference component on the Engel Insert 1800H / 400 of the MERGE Center
- Lateral semi-finished product areas separated and preformed for insertion into molding tools and laminat of original semi-finished product was directly formed when molding tool was closed
- Injection Molding Material Scolefin 52 G 13-0 by Screw temperature 240°C and mold temperature 75°C



Thermoplastic Process Chain

Component manufacturing in injection molding

- Principle application of novel semi-finished products with component production of a load-adapted seat pass-through demonstrated
- Challenge of too rapid cooling of the semi-finished products in the closed mold and the resulting poorer adhesion between semi-finished Product and Injection Molding Material
- Adaptation of the injection mold, as well as a variothermal pre-tempering with e.g. external induction temperature control, is recommended

Weight: **1.95 kg**

Reduction of **18%** compared to the reference component

Fraunhofer IWU

Conclusion

- Carbon fiber reinforced plastics are currently less competitive compared to other materials, especially in the automotive sector
- It could be shown how a load adapted design of fiber composite semi-finished products lead to a savings potential of a seat pass-through, which was already optimized with a glass fiber organo sheet
- The large-scale production on the textile level could be shown
- For a successful impregnation of such textiles, a fluid-based variothermal press process was successfully tested
- Production of the components in injection molding process could be carried out and shows the need of customized injection molding tools and thermally efficient processes for such applications