Heavily loaded extreme lightweight components made by Tailored Fiber Placement – Computational Design

ICCM23 – International Conference on Composite Materials

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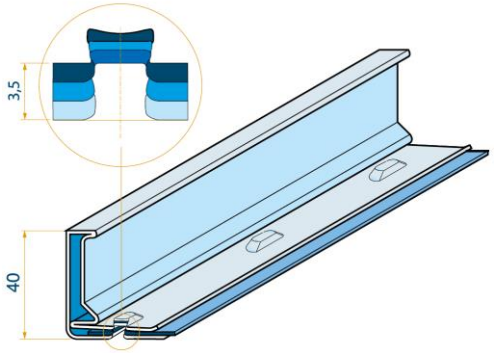
Summary

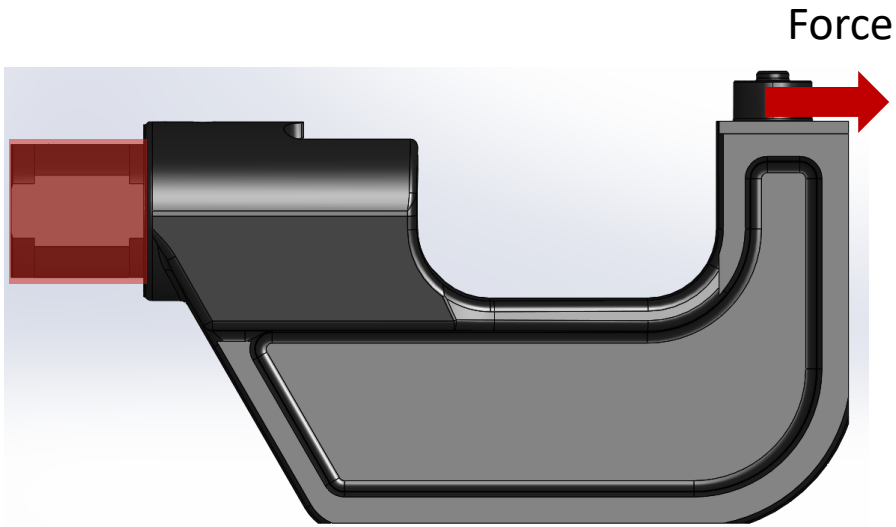
- Substitution of a metallic heavy loaded part for a CFRP one

- Equipment and part to be substituted
- Flowchart of activities
- Results
- Application for presenting the concept of extreme lightweight structures (for kids and adults)

Equipment

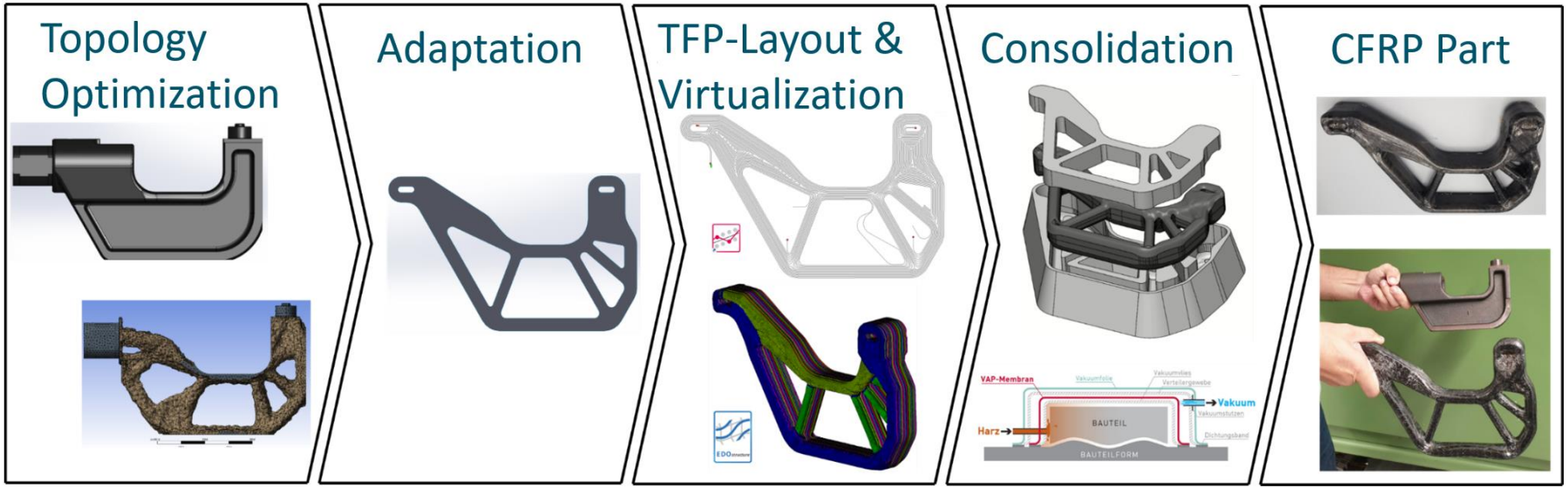


Part to be substituted: C-Frame

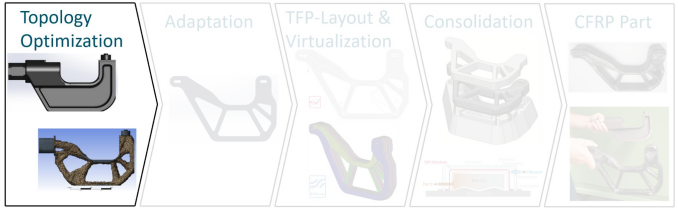


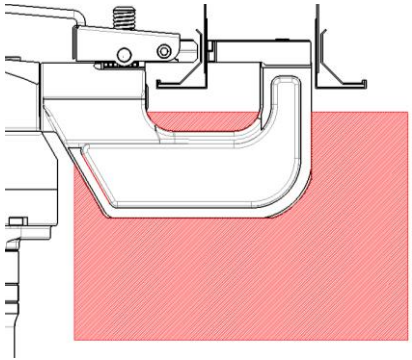
- Mass of the part (Steel): approx. 2.4 kg (around 30% of the equipment)
- Displacement: 1.21 mm @ Force = 20 kN
- Stiffness: 16.5 kN/mm
- Specific stiffness: 6.9 kN/mm/kg

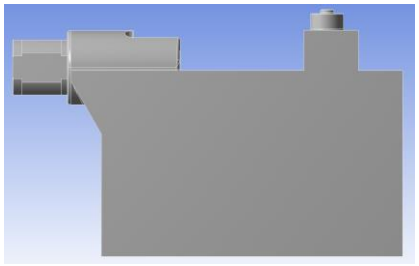
Flowchart of the development process



Topology Optimization



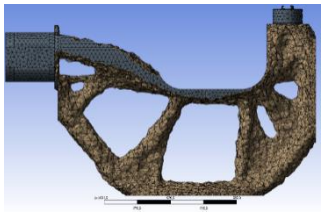


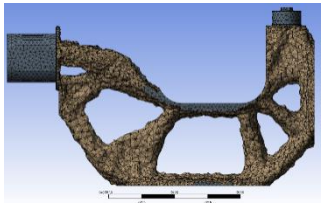


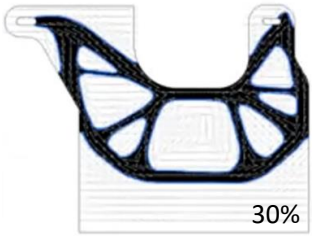
Optimization

Isotropic

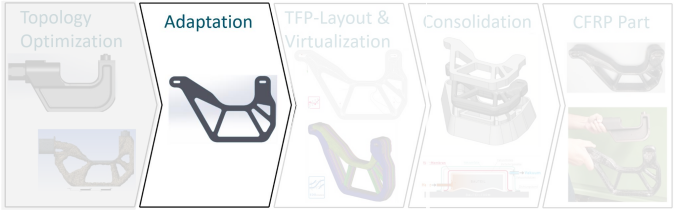
Anisotropic

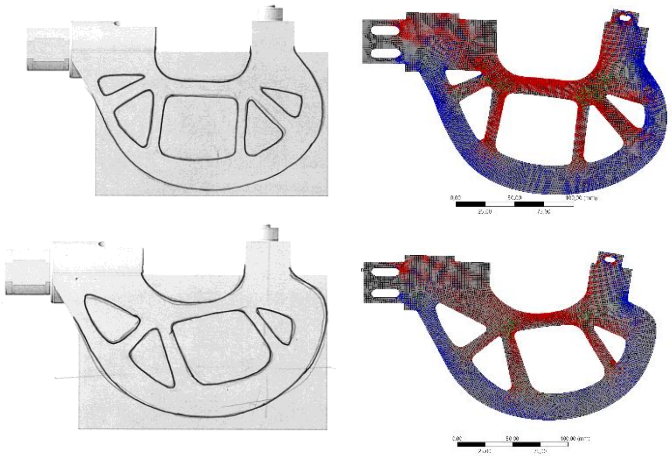






Design Adaptation

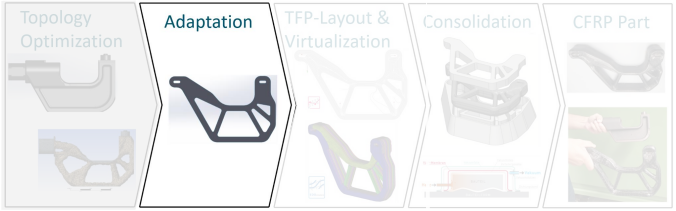


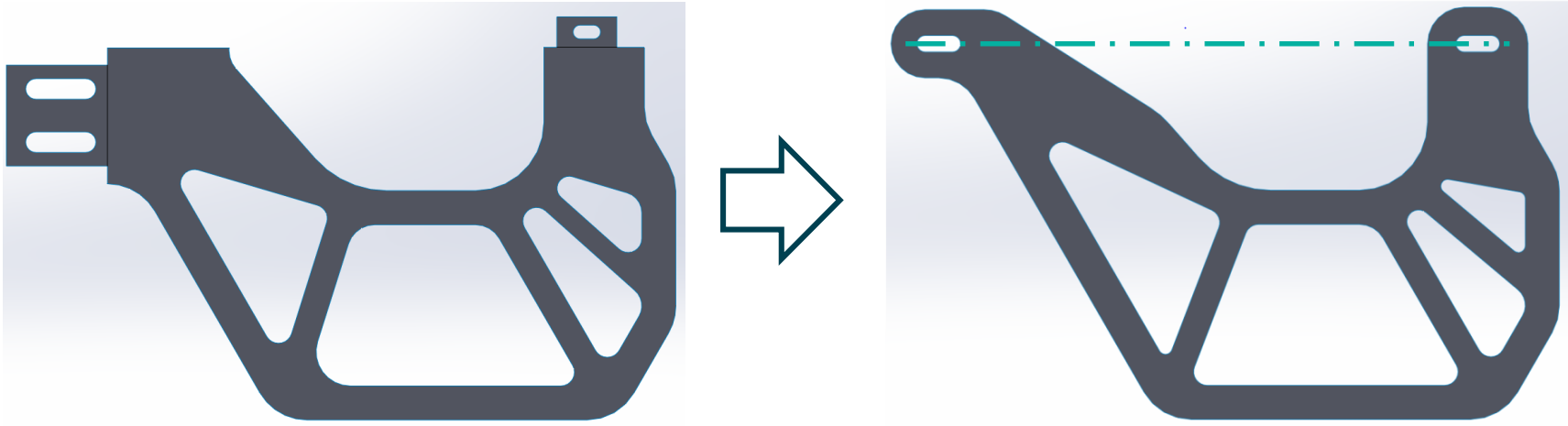


Adjusting/adapting the fiber orientations

Consideration of manufacturing bondary conditions & design aspects

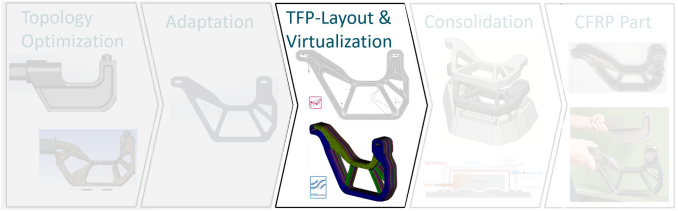
Design Adaptation



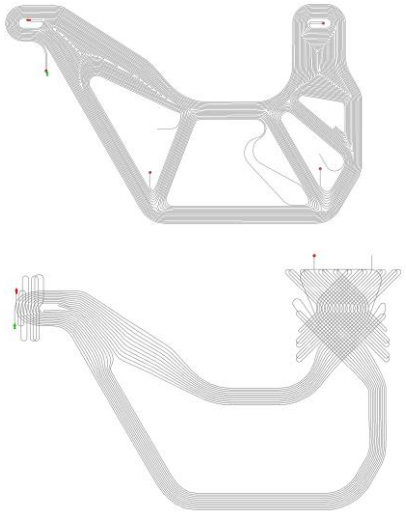


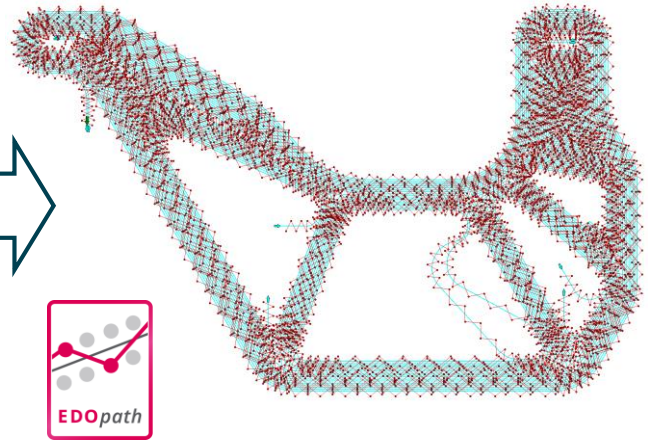
Adjustment of the griping position for testing

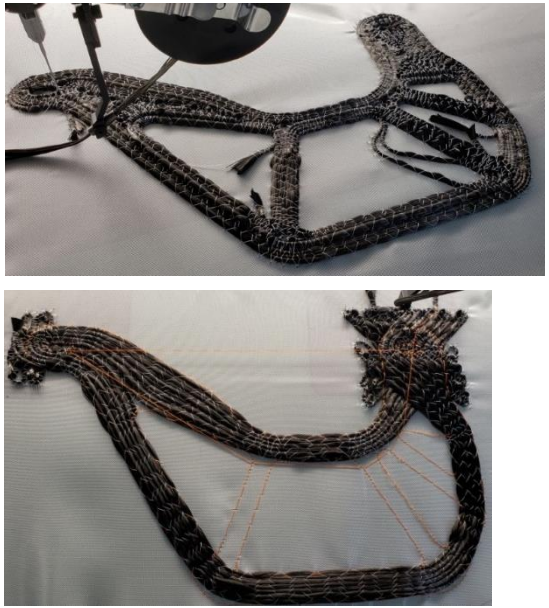
TFP-layout and Virtualization



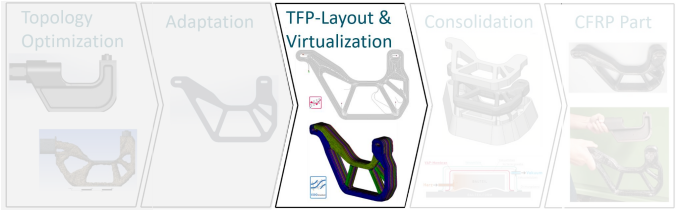
Design and manufacturing of preforms

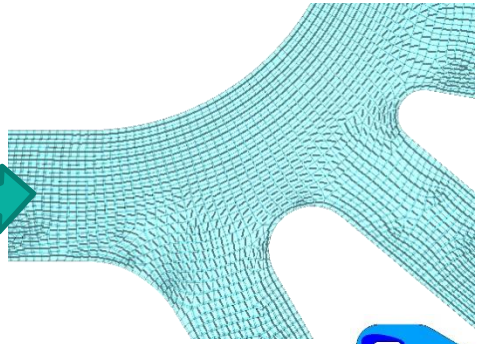




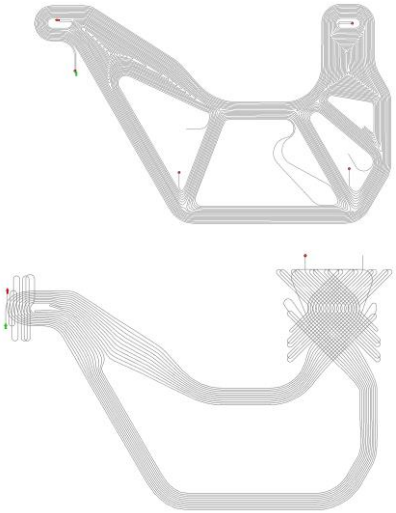


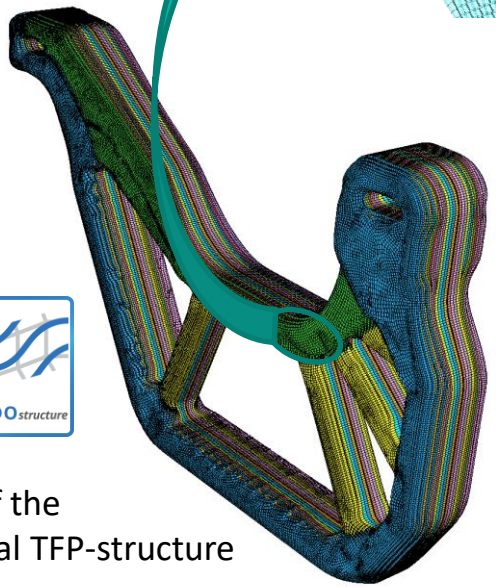
TFP-Layout and Virtualization

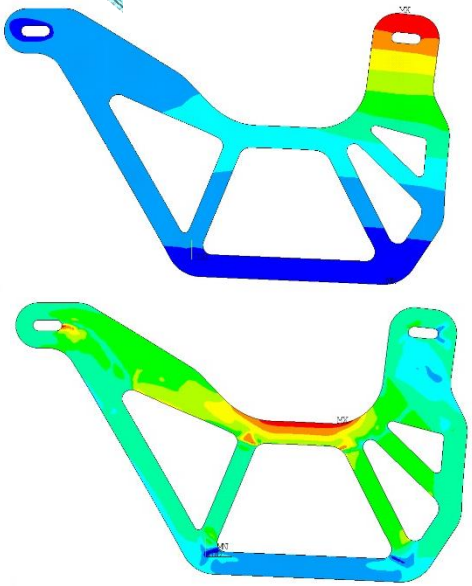




Finite Elemente Analyses

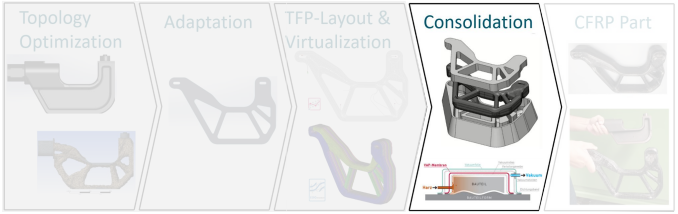


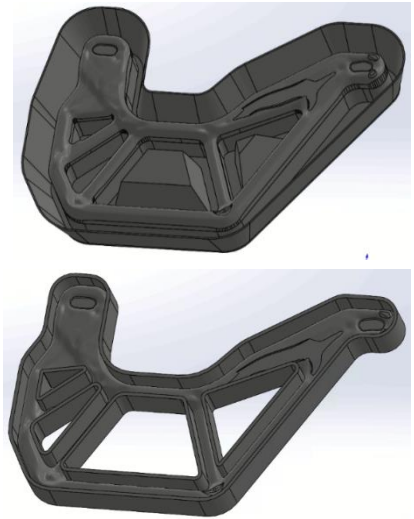


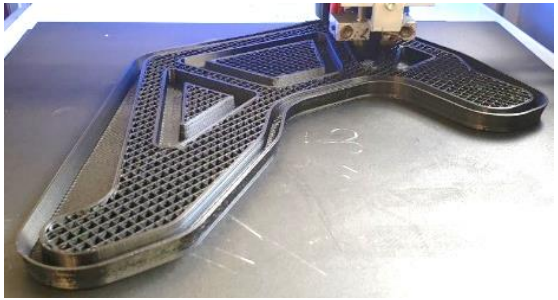


FE Model of the variable-axial TFP-structure

Consolidation of the part: fast low-cost protityping



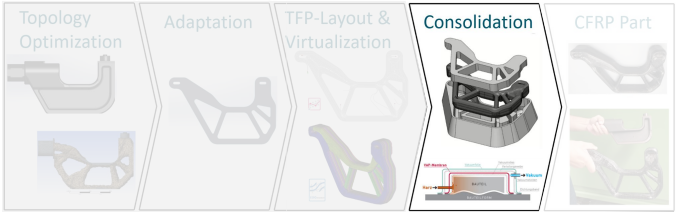


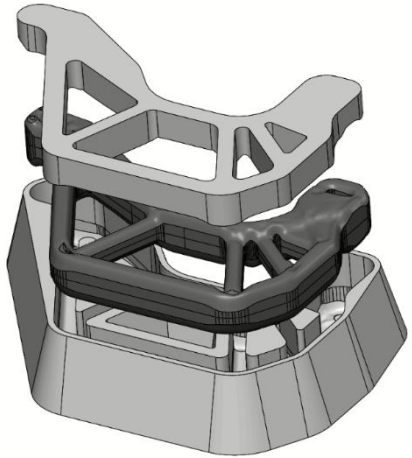


Positive 3D-printed cast molds

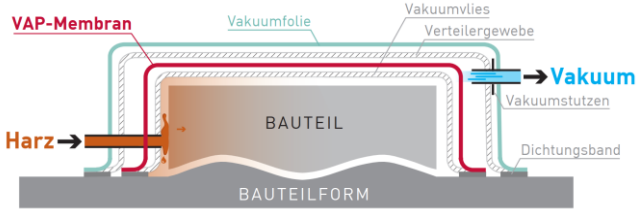
Silicone mold for the consolidation

Consolidation of the part: fast low-cost prototyping

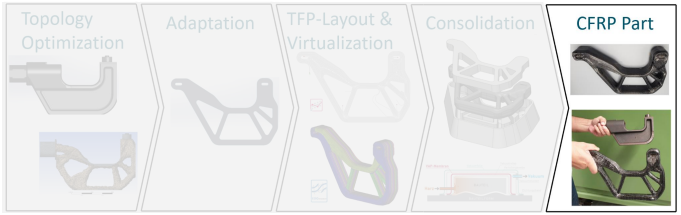


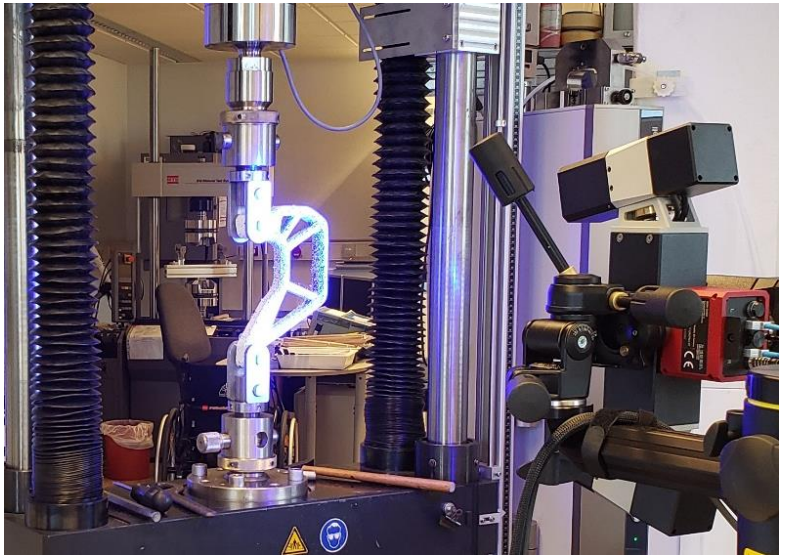


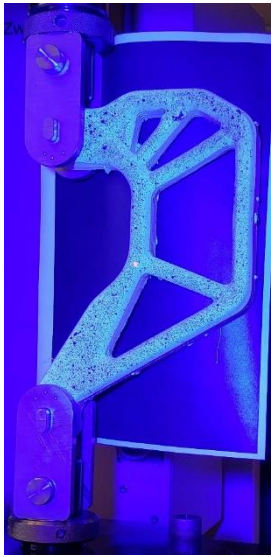
VAP Infusion



Part and testing

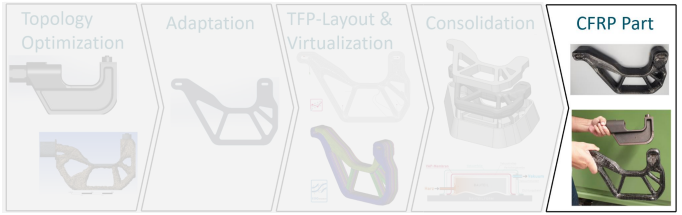


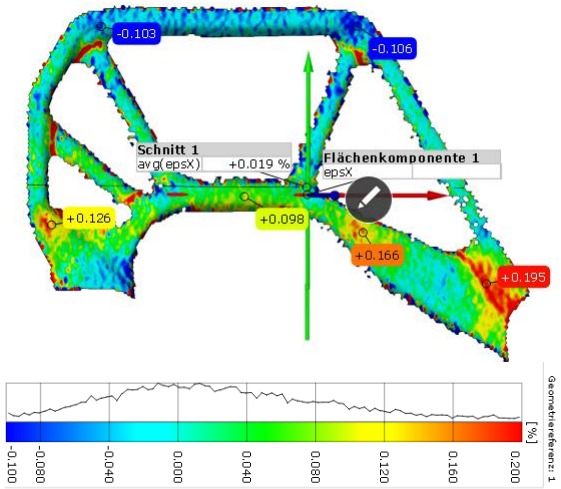


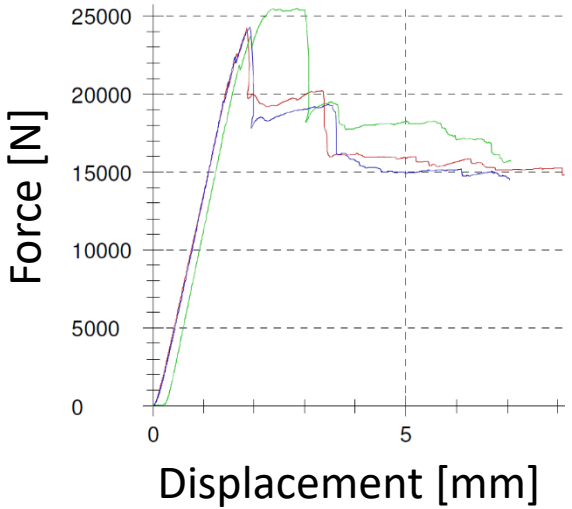


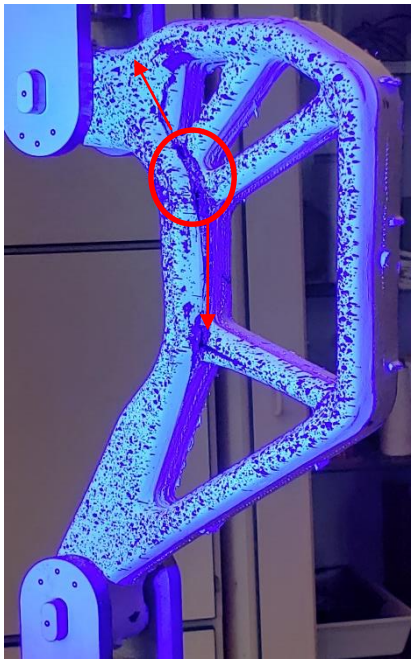
Testing with DIC

Part and testing

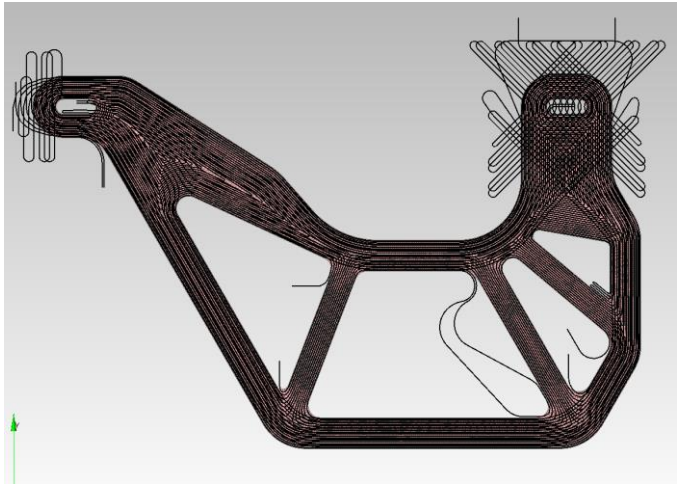


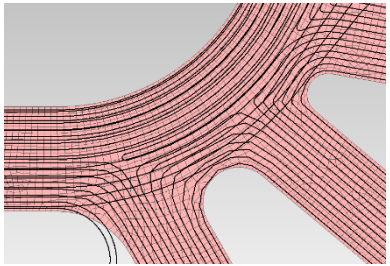


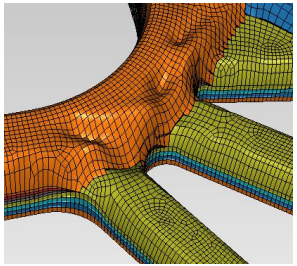


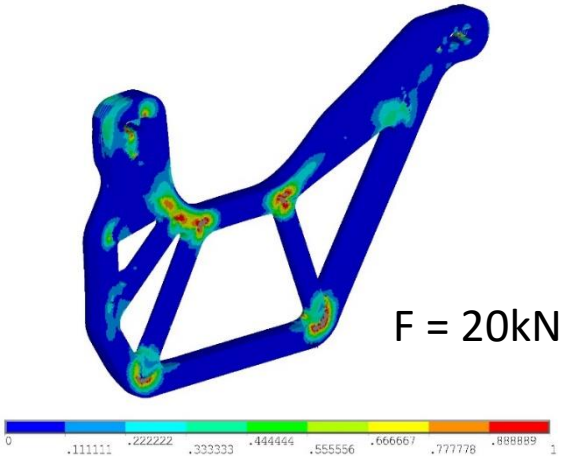


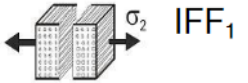
FEM Analysis V1





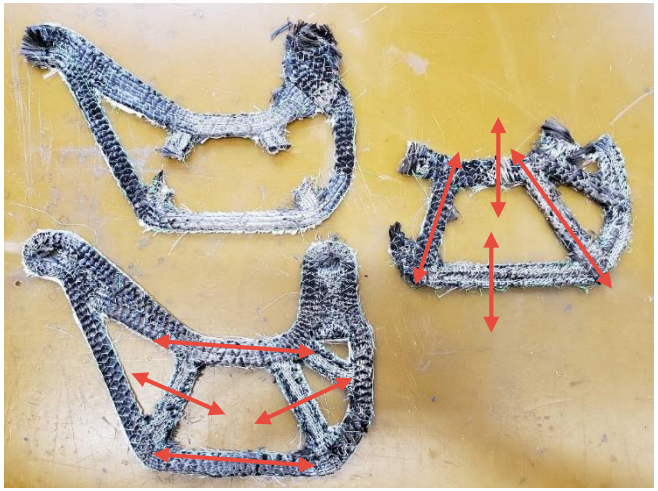




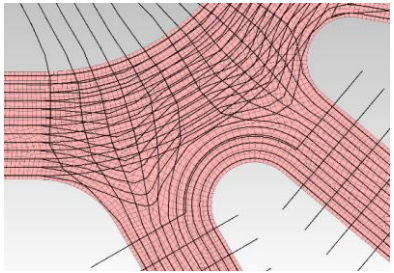


$$IFF_1 = \frac{\sigma_2 + \sigma_3 + \sqrt{(\sigma_2 - \sigma_3)^2 + 4\tau_{23}^2}}{2R_\perp^t} \leq 1$$

FEM Analysis V2

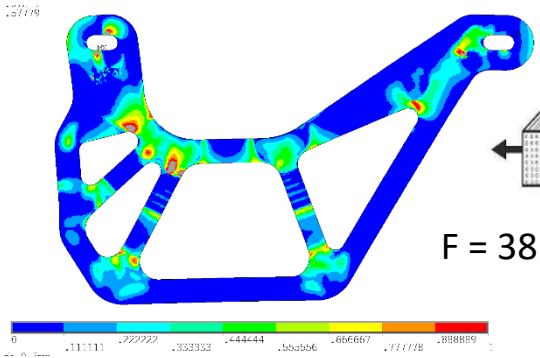


One has added “**fillers**” to avoid out-of-plane undulation, reducing σ_3



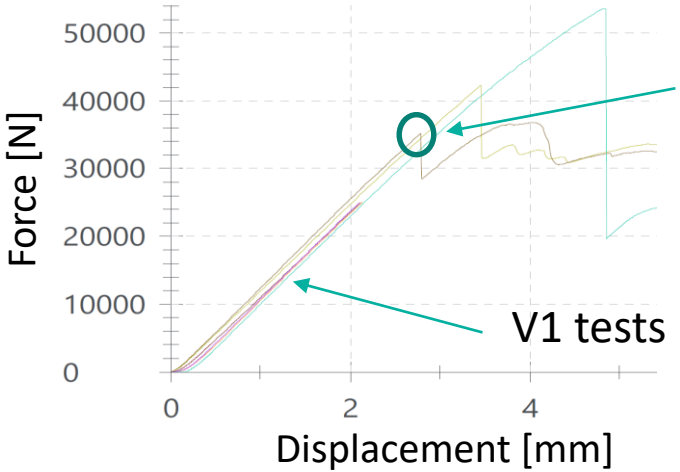
Cross-fibers

FEM Analysis V2



IFF$_1$

F = 38.5 kN



This specimen had a geometric problem

Material	Mass	Stiffness	Specific Stiffness	Strength
Steel	2,4 kg	16,5 kN/mm	6,9 kN/mm/kg	**~ 22 kN**
TFP V1 (HT-CF / EP)	**0,5 kg (-80 %)**	**~ 17 kN/mm**	**34 kN/mm/kg (+390 %)**	**~ 22 kN**
TFP V2 (HT-CF / EP)	**0,62 kg (-75 %)**	**~ 17 kN/mm**	**27 kN/mm/kg (+290 %)**	**~ 35 kN**

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Zentrales Innovationsprogramm Mittelstand

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Thank you for your attention!

Questions?