Structural optimization of locally continuous fiber-reinforcements for short fiber-reinforced plastics

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OBJECTIVES

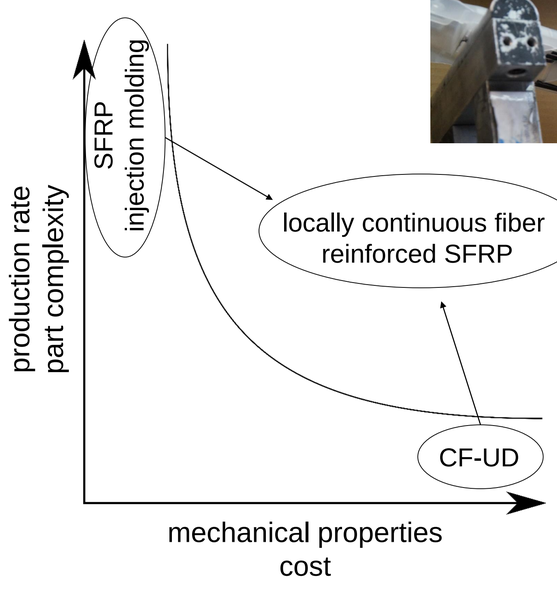
Combining strength and stiffness of continuous fiber-reinforced plastics (CoFRP) with the excellent moldability and cost-efficiency of short fiber-reinforced plastics (SFRP)

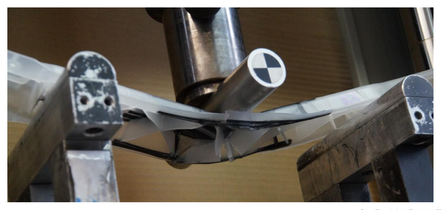
In order to obtain economical solutions, the volume fraction of continuous fiber-reinforced structure must be kept as low as possible. For this purpose, the continuous fiber reinforcement may only be used in the most highly stressed areas.

Quelle: https://www.kgk-rubberpoint.de/23179/fakuma-2018-kunststoffkomponenten-fuer-die-mobilitaet/

Injection molding of SFRP:

- Excellent moldability
- High production rate
- High part complexity
- Function integration





Quelle: IVW EntHyLT

Continuous FRP:

- Highest specific strength
- Highest specific stiffness

Quelle: IVW Flexiframe

CHALLENGES

Identifying highly stressed areas by topology optimization:

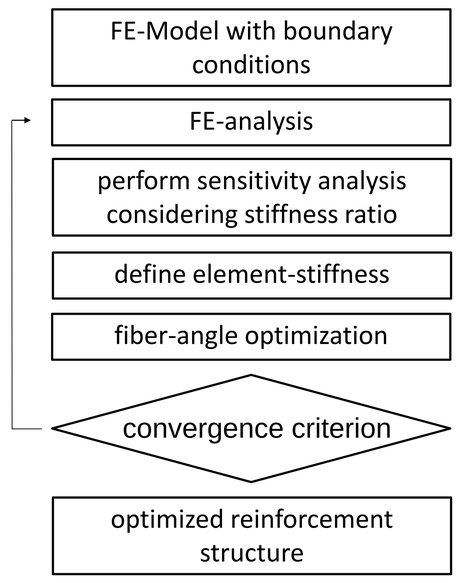
Topology Optimization removes material from low loaded regions by analysing the stress-strain-state. Stress-strain-state depends on:

- Design space
- Load case
- Material distribution
- Fiber orientation
- Stiffness ratio of materials

} standard topology optimization

} proposed topology optimization for local continuous fiber reinforcements

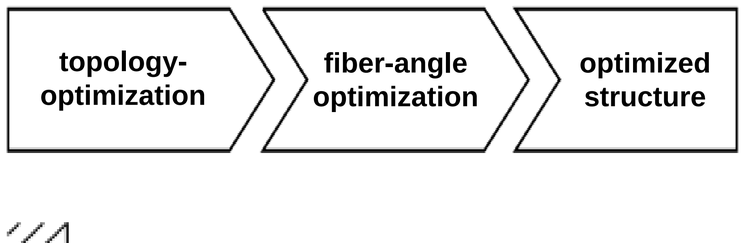
The proposed algorithm combines a multi-phase approach to topology optimization [Huang X., Xie YM 2008] with fiber angle optimization. Thus, the anisotropy of CoFRP as well as the stiffness ratio of CoFRP and SFRP are considered in every iteration.



RESULTS

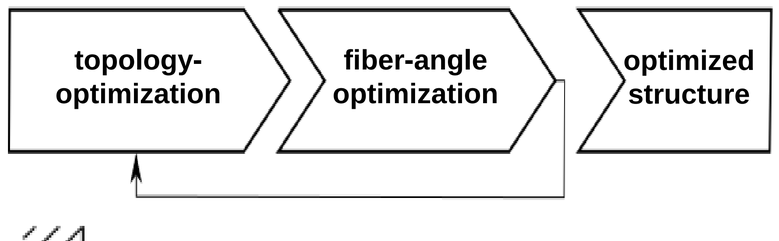
To demonstrate the potential of various optimization algorithms, optimizations were performed for a cantilever beam clamped on one side. The results show the optimized reinforcement structure with a given CoFRP fraction of 40%:

Standard isotropic BESO Topology-Optimization:



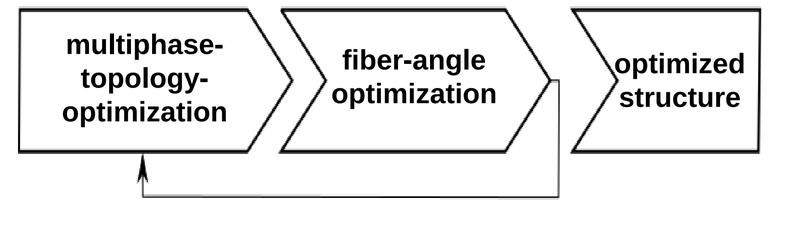
- Standard topology optimization for isotropic materials
- Bidirectional Evolutionary Structure Optimization (BESO) [Huang X., Xie YM 2007]
- Comparable to commercial topology optimization software

BESO Topology-Optimization with fiber-angle-optimization in every iteration:



- Topology optimization considering anisotropy of the reinforcement material
- BESO
- In addition to the BESO algorithm the fiber-angle is optimized in each iteration to account anisotropic properties
- The consideration of anisotropy reduces part complexity

BESO Topology-Optimization with fiber-angle-optimization and residual stiffness of removed Elements:



- Topology optimization considering anisotropy of CoFRP and stiffness of SFRP
- Multiphase BESO [Huang X., Xie YM 2008]
- In addition to the BESO algorithm the fiber-angle is optimized in each iteration to account anisotropic properties
- Stiffness of the “removed” material is not set to zero
- Depending on the stiffness ratio shear carrying elements of the lattice structure are reduced or completely removed
- The consideration of the stiffness of SFRP further reduces the complexity of the reinforcement structure

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