Lehrstuhl für Carbon Composites
TUM School of Engineering and Design
Technische Universität München

Semesterarbeit, Master's Thesis

Development of an Impregnation Model for Sustainable and Dynamic Matrix Systems in Basalt Fiber Composites

The construction sector is increasingly demanding sustainable reinforcement materials that combine high mechanical performance with recyclability and reduced environmental impact. At the chair of carbon composites, basalt fibers impregnated with dynamic polymer matrices are being developed as a novel alternative to conventional steel and thermoset-based composite reinforcements. A key challenge is understanding and predicting the impregnation behavior of these systems within fiber bundles to ensure homogeneous fiber impregnation and robust composite performance.

Following an in-depth familiarization and literature review, the objective of this thesis is the development of a numerical impregnation model on mesoscale describing the interaction between matrix material and fiber reinforcement during processing. Existing theoretical approaches for flow through porous media, capillary-driven impregnation, and composite manufacturing processes will be reviewed and adapted to the specific requirements of vitrimer and related matrix systems. Generated experimental data will serve as input for model calibration and validation.

The developed simulation framework will provide predictive insights into impregnation quality and process efficiency and support the design of future manufacturing processes for sustainable basalt fiber composite reinforcements. The work offers a unique opportunity to combine computational fluid dynamics, composite manufacturing, and advanced polymer systems within an industrially relevant research project.

Figure 1: Use of Steel Reinforcement on the Construction Site for Concrete Pouring

Figure 2: Basalt Fiber Reinforcement

Main focus on this thesis:

- Development of a mesoscale impregnation model
- simulation of matrix flow within basalt fiber bundles
- Investigation of the influence of viscosity, fiber architecture and process conditions
- Validation and optimization of the simulation framework using experimental data

Requirements:

- Programming experience and familiarity with Linux environments
- Experience with CFD tools (e.g., OpenFOAM, ANSYS Fluent, STAR-CCM+) is beneficial
- Good knowledge of German and English

Start: As soon as possible

Contact for application and questions:
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