Multiscale modelling of the forming process of thermoplastic fibre reinforced composites (TPFRCs)

TPFRCs are fundamentally well suited for the application in lightweight (vehicle) construction.

**Project goal:** Efficient, scale-bridging simulation tool for the thermoforming process of TPFRCs.

<table>
<thead>
<tr>
<th>BMW 7 series</th>
<th>Part scale</th>
<th>Textile scale</th>
<th>Fibre &amp; Matrix scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>[BMW AG]</td>
<td>e.g. side impact protection</td>
<td>[Spriform]</td>
<td>[Compositeworld]</td>
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<td></td>
<td></td>
<td></td>
<td>[N. Haque et al.]</td>
</tr>
</tbody>
</table>

Possible topics (Bachelor’s or Master’s thesis)

- Multiscale material modelling (Fortran or/and Matlab)
- Experimental testing of TP and TPFRC specimens
- Finite Element simulations with Abaqus

In collaboration with:

Contact: sebastian.felder@rwth-aachen.de
The goal is to predict the macro-mechanical properties of paperboard using micro-scale modelling.

Possible topics include:

- image based microstructure analysis (microscopy and CT data)
- fiber length, diameter, and orientation distribution identification
- representative volume element generation
- modelling of fibers and interfiber bonds
- validation against experiments

Contact: jaan.simon@rwth-aachen.de
Modelling of Shear Cutting of Carbon Fiber Reinforced Plastics (CFRP)

CFRP: Ideal material for light weight products but high costs in production and processing.

Aim: Reduce the processing costs by substituting milling and drilling with shear cutting.

Tasks:
- Simulation of the cutting process by using a new material approach
- Validate the simulations with experimental results
- Provide a simulation toolset of shear cutting within Abaqus framework

Contact: Lukas.Poggenpohl@ifam.rwth-aachen.de
Modelling Adhesives in Glass-Façade Constructions

**Motivation:**
- Adhesive connection between metal and glass
- No consistent design method for glass-façade-constructions

**Possible topics include:**
- Investigate hyperelastic material (silicone adhesive: GD920)
- Extend a material model
- Consider damage (Mullins Effect)
- Validate the established material model

Contact: elisabeth.toups@ifam.rwth-aachen.de
Matching nodes within the structures specially on material interfaces can become very challenging in the numerical setting. In this master's thesis, hanging nodes are to be implemented in an already existing DG/CZ model.

You are:
- a master student of Mechanical/Civil Engineering or related
- experienced and interested in programming (Fortran, MATLAB, FEAP …)
- are holding good marks in FEM & Continuum Mechanics
- independent and interested in research.

Contact us and send your CV and your transcript!

Hamid Reza Bayat, Shahed Rezaei

Contact: hamid.reza.bayat@rwth-aachen.de
Possible topics include:
- How to handle nonlinearities like damage in combination with MOR?
- Extension of MOR to improve the accuracy and efficiency
- Combining the existing models with new mathematical approaches

Nowadays, FEM is used in many different fields. Most calculations are very expensive. The goal of the project is to speed up the simulations and make them cheaper without losing too much accuracy.

Contact: steffen.kastian@rwth-aachen.de
Nozzle structures made of ceramic matrix composites exhibit:
• lower weight and higher stiffness
• much higher service temperatures than conventional copper alloy nozzle structures.

The goal of the project is to develop an efficient finite element model for nozzle structures made of ceramic matrix composites (CMCs).

Theses concerning the following topics are possible and can be arranged individually:
• FE technology for thin-walled structures
• FE simulations with FEAP and/or Abaqus
• Material modeling in Fortran and/or Matlab

Contact: oliver.barfusz@rwth-aachen.de
Modeling of Anisotropic Damage

Motivation:

- Damage $\equiv$ microcracks
- The phenomenon of damage is complex and is in its nature anisotropic $\rightarrow$ damage should be modeled anisotropic, e.g. with a 2nd-order damage tensor $\mathbf{D}$

$$\mathbf{D} = \begin{pmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{xy} & D_{yy} & D_{yz} \\ D_{xz} & D_{yz} & D_{zz} \end{pmatrix}$$

Possible topics include:

- Investigate the differences between isotropic and anisotropic damage models
- Improve/extend the existing anisotropic damage model
- Finite element simulations with FEAP/Abaqus

Contact: marek.fassin@rwth-aachen.de
Thermal buckling can occur in aerothermodynamically loaded thin-walled structures. The goal of this project is to provide a computational model which takes thermo-viscoplasticity effects and thermomechanical coupling into account.

Possible topics include

- Including radiation in the model
- Finite Element Technologies for thin structures
- Simulations for fluid-structure interaction

Contact: katharina.martin@rwth-aachen.de
aim
phase-field modeling of martensitic phase transformations in 42CrMo4 steel based on experimental data

steps
• review on material models for 42CrMo4
• parameter identification/fitting
• phase-field simulation
• comparison between experimental and numerical results

EBSD data, material parameters, stress-strain curves, …
Failure of nano-layered coatings

• Do you find fracture behavior and damage inside the materials interesting?

• Does studying the coating layers in high-tech engineering equipment fascinate you?

• Do you want to expand your knowledge in numerical modeling?

Then, I have a unique offer for you …

Contact: shahed.rezaei@rwth-aachen.de
Modelling of Roll Bonding of Alloys

The goal of the project is to identify the key factors influencing the bond strength in roll bonding processes.

Steps:

1. Literature review on roll bonding technology
2. FE simulation of the roll bonding process
3. Sensitivity analysis of results with respect to different parameters (material + geometry)

Contact: khaledi@ifam.rwth-aachen.de
Clinching is a promising technique to join metallic layers together. The main goal of the project is to investigate the effect of different material and geometrical parameters on the joining quality in clinching processes.

Steps:

1. Literature review on clinching methods
2. FE simulation of the clinching process
3. Sensitivity analysis of results with respect to different parameters (material + geometry)
The goal of the project is the development of computational methods for crystal microscale plasticity theories and their verification by analytical solutions.

Steps:

• Review on small scale crystal theories

• Finite element simulation with geometrical and material nonlinearity (Fortran)

• Application of the FE simulation to the small scale gradient plasticity problems (FEAP/Fortran)
Modeling the Wet Paper Compression and Expansion Behavior during Dewatering

Combination of internship and Master’s thesis within the company is possible.

The process of papermaking may be regarded as a continuous dewatering and drying process. One essential part of this process is the press section, where the mechanical dewatering of the paper web takes place. This section has a crucial influence on energy efficiency and defines significantly the properties and quality of the final product. To support process- and product development and analyze the physical behavior, the mechanical dewatering process is described with a simulation model.

In this thesis, a suitable mathematical model of wet paper compression and expansion should be developed, with – if possible – reduced complexity, i.e. a small number of parameters.

Contact: jaan.simon@rwth-aachen.de
Ceramic Matrix Composites (CMCs) are a relatively new group of materials, with

- low weight and
- high thermal shock resistance designed to improve e.g. machine efficiency in aircrafts.

**Project goal:** Development of a microscale approach for modelling woven CMC components.

**Possible topics:**

- automatic mesh generation in 2D and 3D
- further development of a cohesive zone formulation including friction
- combination of continuum damage and cohesive zone
- thermal coupling

[MTU Aero Engines AG]