Makroskopische Umformsimulation von unidirektionalen Kohlenstofffasergelegen: Hyperelastische Materialmodellierung und 3D-Solid-Shell-Ansatz

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Gutachter/-innen: Prof. Luise Kärger (KIT), Prof. Emmanuelle Vidal-Sallé (INSA Lyon), Prof. Frank Henning (KIT)

Institut für Fahrzeugsystemtechnik – Institutsteil Leichtbau

Technologietag Leichtbau 2024

06. November 2024

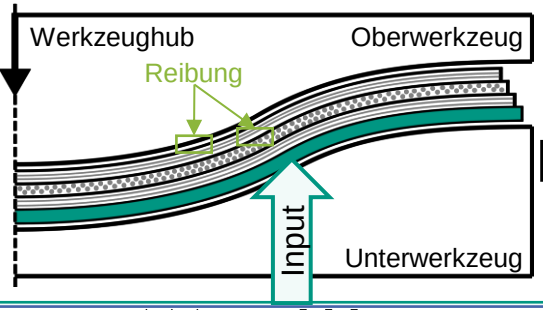
Stuttgart, Deutschland

Umformsimulation endlosfaserverstärkter Halbzeuge

Motivation | Hyperelastisches Modell | 3D-Solid-Shell Ansatz

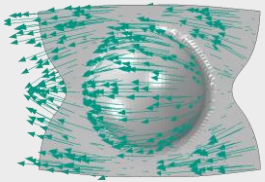
Karlsruher Institut für Technologie

Schichtweiser Ansatz

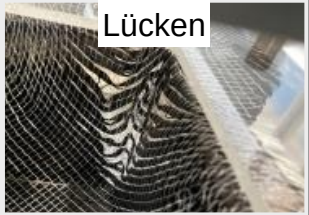


Output

Veränderung der Faserarchitektur

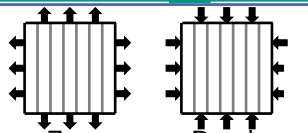


Umformdefekt

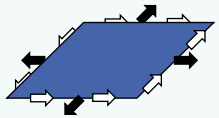


Intra-ply Mechanismen

In der Ebene x_2 x_1

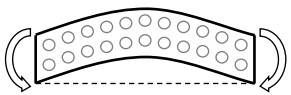


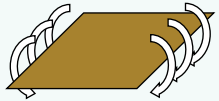
[1]



Membranverhalten

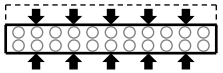
Aus der Ebene x_3 x_1



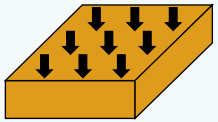


Biegeverhalten

Aus der Ebene x_3 x_1

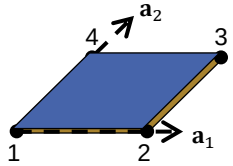


Kompaktierung in Dickenrichtung



Kompaktierungsver.

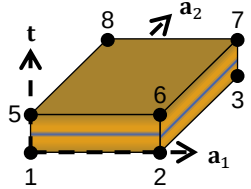
2D-Ansatz [2]



Überlagerte Membran- Und Plattenelemente

➢ **Komplexes Materialverhalten**

3D-Ansatz [1]



Spezielles Solid-Shell Element

➢ **Numerisch herausfordernd**

[1] Schäfer, *Macroscopic forming simulation of unidirectional non-crimp fabrics: Hyperelastic material modeling and 3D-solid-shell approach*, 2024, Dissertation, KIT doi:10.5445/IR/1000170739

[2] Schäfer et al. *A hyperelastic approach for modeling the membrane behavior in finite element forming simulation of unidirectional non-crimp fabrics (UD-NCF)*, 2024. Comp. Part A,185:108359. doi:10.1016/j.compositesa.2024.108359

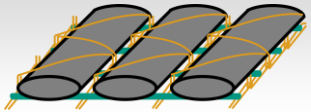
Effiziente 2D-Modellierung unidirektionaler Kohlenstofffasergelege

Motivation | Hyperelastisches Modell | 3D-Solid-Shell Ansatz

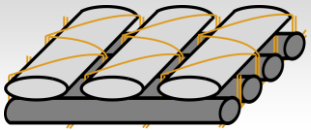
Karlsruher Institut für Technologie

Kohlenstofffasergelege

unidirektional

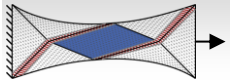


bidirektional

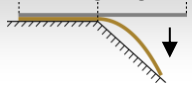


Experimentelle Charakterisierung aller Deformationsmoden

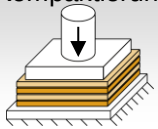
Membran [3]



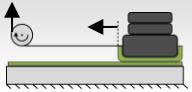
Biegung



Kompaktierung



Reibung

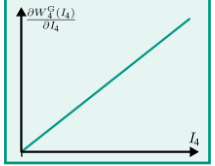


Umformung

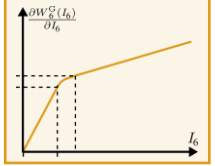
[4]

Hyperelastisches Materialmodell [2]

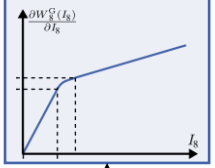
Faserzug



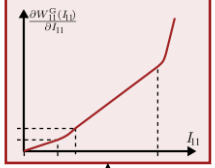
Schub

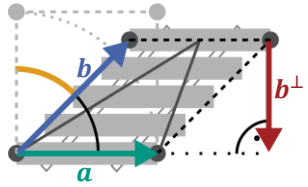


Nahtzug

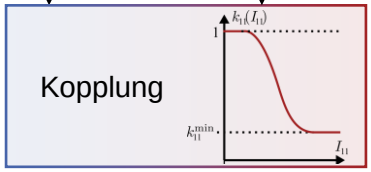


Querdruck

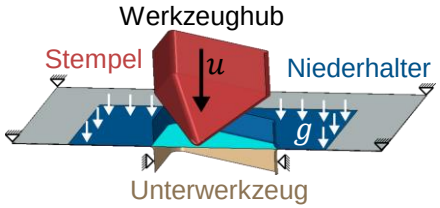


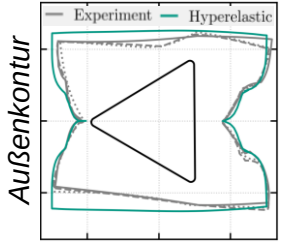


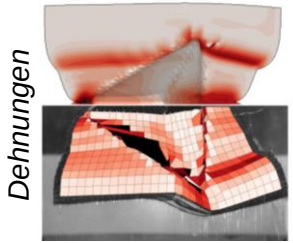
Kopplung



Validierung durch Umformsimulation verschiedener Geometrien [2]





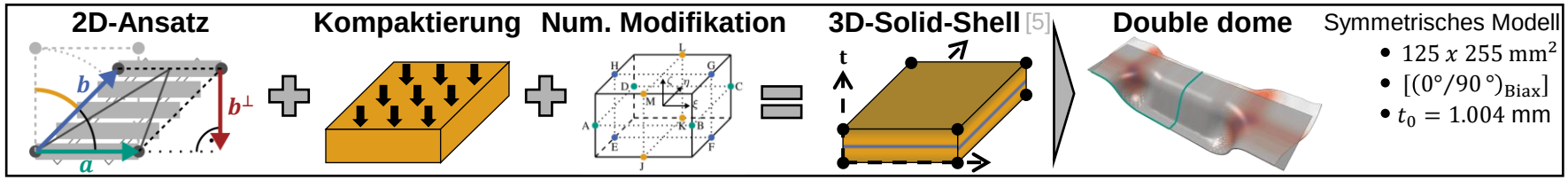


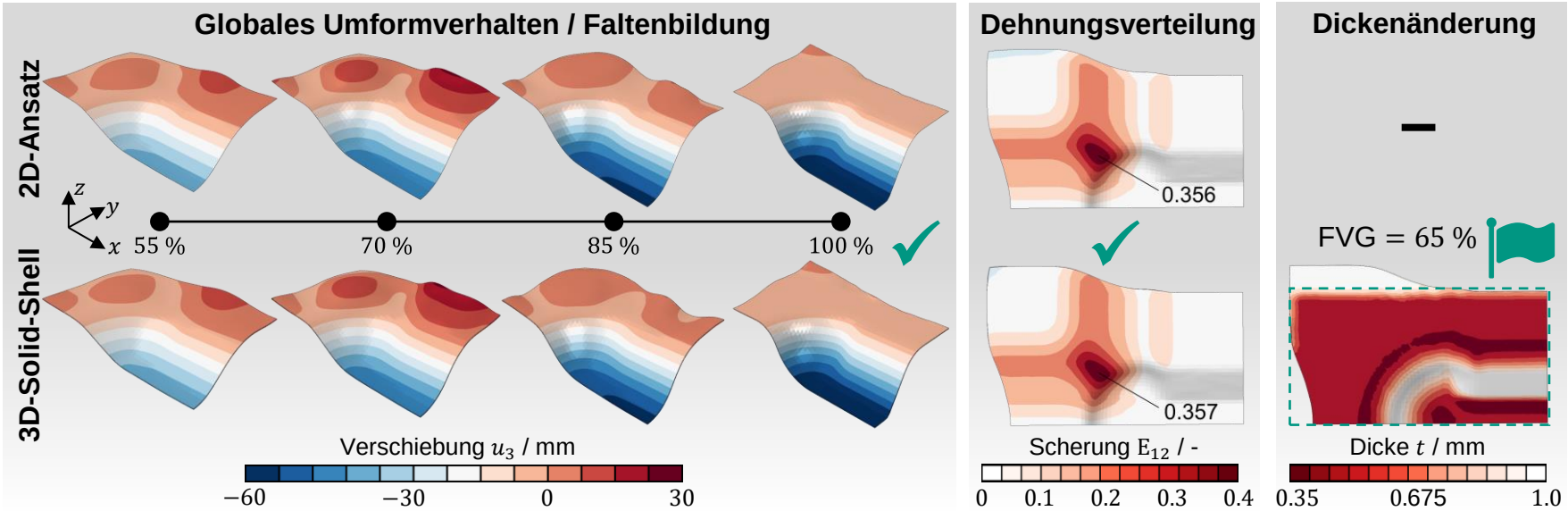
- **Umfangreiche Charakterisierungsdaten**
- **Hohe Vorhersagegüte**
- **Vereinfachte Parametrisierung**
- **Direkte Anwendbarkeit für andere Werkstoffe**

[3] Schäfer et al. *Membrane behavior of uni- and bidirectional non-crimp fabrics in off-axis-tension tests*, 2023. Int. J. of Mat. Form., 16(6):68. doi:10.1007/s12289-023-01792-x

[4] Schäfer et al. *Experimental analysis of the forming behavior of uni- and bidirectional non-crimp fabrics for different geometries*, 2024. Comp. Part B, 287:111765. doi:10.1016/j.compositesb.2024.111765

3D-Solid-Shell-Ansatz für die Umformsimulation





[5] Schäfer et al. *Potential and challenges of a solid-shell element for the macroscopic forming simulation of engineering textiles*, 2021. ESAFORM 2021, ULiège Library. doi:10.25518/esaform21.883

Vielen Dank für Ihre Aufmerksamkeit

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