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10.01.2019

Project title:	**NCF-CAE** - Simulation of Non-Crimp Fabrics based on Computational isogeometric shell elements, analytical averaging and experimental analysis
Partners:	AICES – Aachen Institute for Advanced Study in Computational Engineering Science, RWTH Aachen; Department of Continuum Mechanics, RWTH Aachen University
Duration:	01/2019 – 12/2021
Funding agencies:	DFG (Deutsche Forschungsgemeinschaft)

Mission Statement

Non-crimp fabrics (NCFs) are textile reinforcement structures for composites with straight (non-crimped) fibres. Due to their economical fabrication, NCFs have become prominent in the automotive and aeronautic industry. The complex interactions between the fibres and plies lead to significant challenges in the computational modelling of NCFs. To the best of our knowledge, there is no computational framework able to reproduce the complex material behaviour of NCFs in a precise and numerically efficient way. The main objective of the project is to advance the computational technology for the simulation of draping processes of NCFs in terms of both accuracy and efficiency.

Solution:

To this end, a computational framework for NCFs based on an isogeometric rotation-free shell formulation and different constitutive models is developed and the accuracy of this framework is investigated. The proposed material models take into account all important deformation mechanisms of NCFs, such as stretching, bending and anisotropic in-plane shear response, intra-ply and inter-ply sliding, as well as the change in fibre volume ratio. So far, all these features have not been captured in a single framework. The proposed computational shell formulation will allow the efficient and robust simulation of textile behaviour including the presence of structural instabilities such as wrinkling and in-plane shear instability. For the development of the computational framework, the deformation mechanisms of NCFs are studied by detailed experimental analysis. The acquired data provide a basis for development of material models and their validation. By this experimental study, the influences of the NCFs properties on the deformation behaviour are identified and complemented. The result of the project is a validated new computational framework that has a better efficiency, accuracy and robustness in comparison to classical finite element method approaches for the draping simulation of NCFs. Additionally, all deformation mechanisms of NCFs are comprehensively understood. In order to disseminate the research results, the new finite element routines will be posted online at the end of the project for free downloading.

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