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Microscale numerical simulation of yarn tensile behavior using a high-fidelity geometrical fiber model extracted from micro-CT imaging

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Yarns are essential components in textile manufacturing. Therefore, in order to understand and improve textile manufacturing processes, adequate yarn models are required. Due to the complex and stochastic nature of the yarn geometry, the derivation of analytic expressions of the yarn's tensile behavior based on real-life geometries is unfeasible. As such, analytic structural yarn models often resort to simplified geometries, e.g. an ideal helix model [1]. Numerical simulations using finite element analysis offer an alternative to analytic models and are generally not restricted by simplifying assumptions regarding the yarn geometry. However, despite the recent advancement in high-fidelity geometric yarn models based on microcomputed tomography (µCT) imaging [2], these geometrical models have not yet been used in structural simulations. Current research aims at combining high-fidelity geometrical yarn models with structural simulations on microscale.

To this extent, a woolen yarn of fineness 28.8 tex was investigated. A high-fidelity geometrical model was reconstructed from µCT data by tracking the individual fibers. This geometry served as input for the structural model in Abaqus 2021 (Dassault Systèmes). The tensile properties of individual fibers were piecewise linear approximations of experimentally determined load-elongation curves using the Textechno Favimat. The fibers in the structural model are represented by Timoshenko beam elements. Boundary conditions are set as to imitate the experimental conditions of a yarn tensile test in the Textechno Statimat M. The experimentally and numerically obtained force-elongation curves are compared and show reasonable agreement.

In future research, these microscale yarn properties will be incorporated in a macroscale yarn model using beam elements. The resulting multiscale structural yarn model will be coupled to a multiscale flow model in order to capture the Fluid-Structure Interaction (FSI) phenomena occurring in the yarn insertion phase of air jet weaving processes.

REFERENCES

[1] T. Liu, K.F. Choi, and Y. Li, Mechanical Modeling of Singles Yarn. *Textile Research Journal*, Vol. **77**(3), pp. 123–130, 2007.

[2] P. Henyš, and L. Čapek, Individual Yarn Fibre Extraction from Micro-CT: Multilevel Machine Learning Approach. *The Journal of The Textile Institute*, Vol. **112**(12), pp. 1979–1985, 2021.