Friedrich-Alexander-Universität
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LEHRSTUHL
FÜR KUNSTSTOFFTECHNIK
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Numerical Simulation

Motivation

Fiber reinforced polymers (FRPs) represent a key enabler for obtaining a broad range of mechanical properties, not accessible by means of unmodified polymers. For optimizing the large-scale production of continuous fiber reinforced and long-fiber reinforced thermoplastics and thermosets, numerical approaches offer the opportunity for virtual process optimizations and scientific evaluations of underlying part-property relations (Fig. 1). Hence, numerical approaches allow for tailoring mechanical properties, enable efficiency improvements of manufacturing processes and prepare a foundation for enhancing the economic and ecological viability of FRPs.

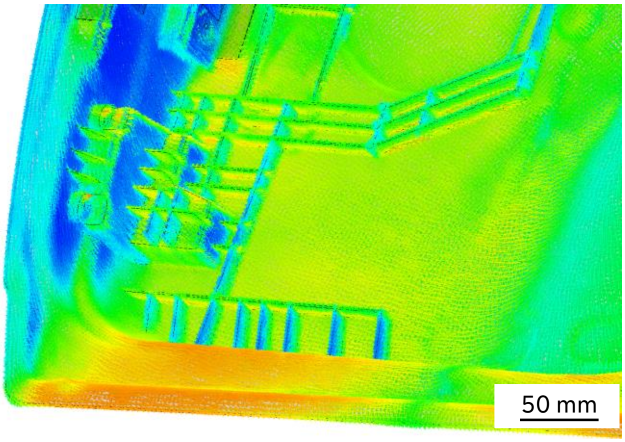

Fig. 1: Application-specific numerical simulation of long fiber orientations in complex geometries

Application

Numerical applications are frequently applied for assessing the general process capability, for the prediction and avoidance of material- and geometry-induced shortcomings and for the holistic process optimization. Furthermore, assessing causal connections of processing parameters, geometric boundary conditions and emerging part properties becomes feasible by applying advanced, tailored simulation tools, complementary analytical material models and experimental validation (Fig. 2).

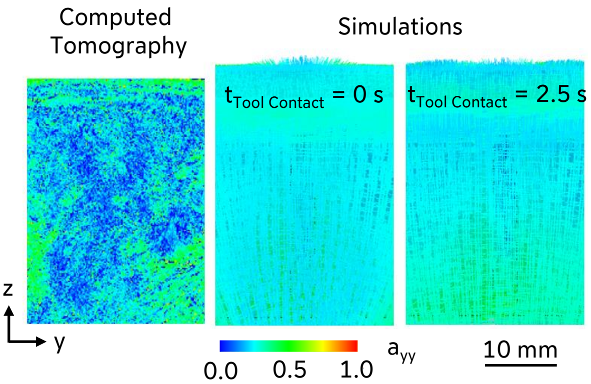

Fig. 2: Experimental validation of simulative fiber orientation predictions

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Research focus

The Institute of Polymer Technology (LKT) engages in a variety of numerical approaches for the holistic simulation. Given the pre-dominant application of flow processes (Fig. 3), both short-fiber and long-fiber flow processes and the near-process characterization as well as the interlinked development of complex material models represent a major research focus.

Main research results

In recent years, research at LKT provided insights into a variety of numerical and analytical modeling approaches in the field of long and continuous fiber reinforced composites.

With regard to the modeling of draping processes, novel insights have been obtained that allow the analytical description of complex fiber-fiber-interactions and the modeling of the temperature-dependent and geometry-dependent draping of thermoplastic organic sheets, hence improving the large-scale manufacturing of load-bearing and complex, light-weight components.

Furthermore, the holistic modeling of compression molding of long-fiber reinforced composites has been enhanced applying combined in situ measurements and analytical ex situ material characterizations (Fig. 4). At LKT, the integration of in situ and ex situ measurements by means of viscosity models has been demonstrated, allowing for the implicit integration of time-dependent, complex material-process interactions not accessible by means of traditional ex situ models.

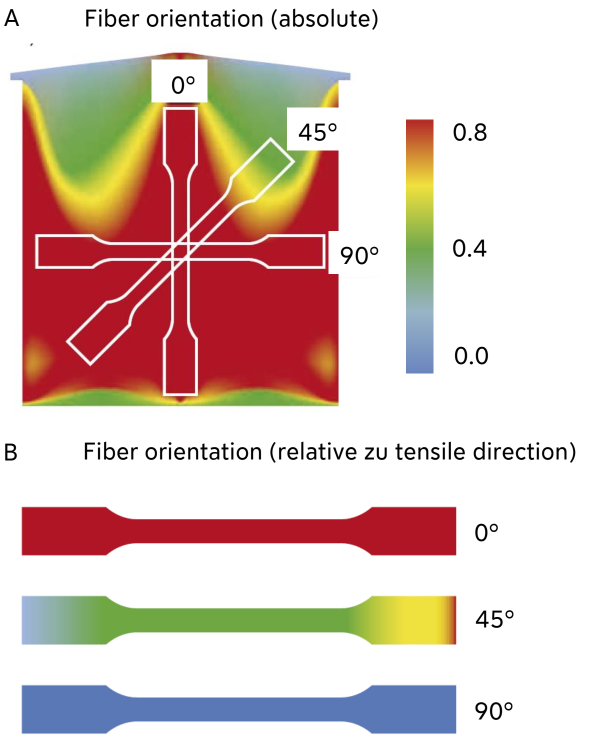

Fig. 3: *Simulative correlation of emerging:*
A) flow-dependent fiber orientations
B) corresponding tensile specimens

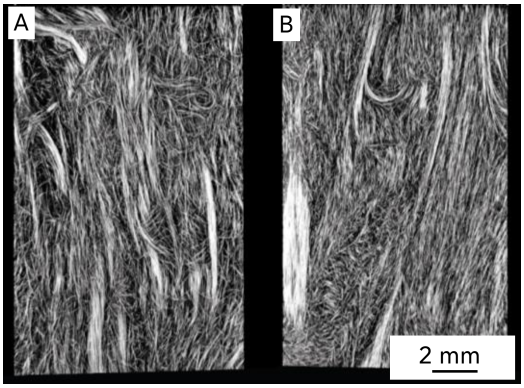

Fig. 4: *Ex situ detection of fiber agglomerations by means of computed tomography of glass fiber reinforced:*
A) regular
B) highly crystalline polypropylene

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