High-performance functional textiles - Development of weaving technologies for simulation-driven, integral manufacturing'

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Abstract

The increasing requirements for energy-efficient, sustainable and functionally integrated composite materials result in a growing demand for textile preforms with a highly complex, integrally woven multi-la
Such structures not only offer high and controllable mechanical performance and a load-specific fiber orientation, but are also adaptable for complex geometries and multifunctional applications.
Considering this perspective, innovative development approaches for integrally woven multilayer fabrics are presented, which reflect the entire CAE-supported process chain. Based on specific mechanical requirements, a simulation-based design of the three-dimensional target topology and fiber paths coupled with AI-driven algorithms is conducted to ensure a fiber arrangement for optimized load tra within the composite. Following this, the binding pattern for the woven 3D-structure is developed iteratively using jacquard technology. This generates complex three-dimensional woven structures which form defined cavities up to branching structures after the weaving process and the 3D-shaping of the structure to integrate functional elements, to create complex 3D-structures or to reduce component mass.

To manufacture these structures existing weaving machines are extensively modified and new AI-driven algorithms are developed. These newly developed data-driven production technologies enable, for example, the insertion of nonwovens as weft material, contour-compliant and fabric-take-off-free we
The result is an efficient manufacturing process which enables the production of integrally woven, geometrically complex structures without post-processing draping or cutting processes. The technologies are engineered for the use of high-performance materials such as transverse force-sensitive carbon and glass fibers and also allow, for example, the inline integration of heating wires into the woven structure as well as branching tubular structures.
The potential of these technologies will be demonstrated using practical applications such as innovative multi-component insulation structures that eliminate cold bridges, complex branching pipe geometries that allow for chemical or highly aggressive media transportation and conical folded woven composite structures that exhibit crash absorbent properties.

Keywords: Integral 3D multilayer weaving, CAE, based preform design, Jacquard weaving technology, high, performance fiber composites, load, oriented fiber architecture

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