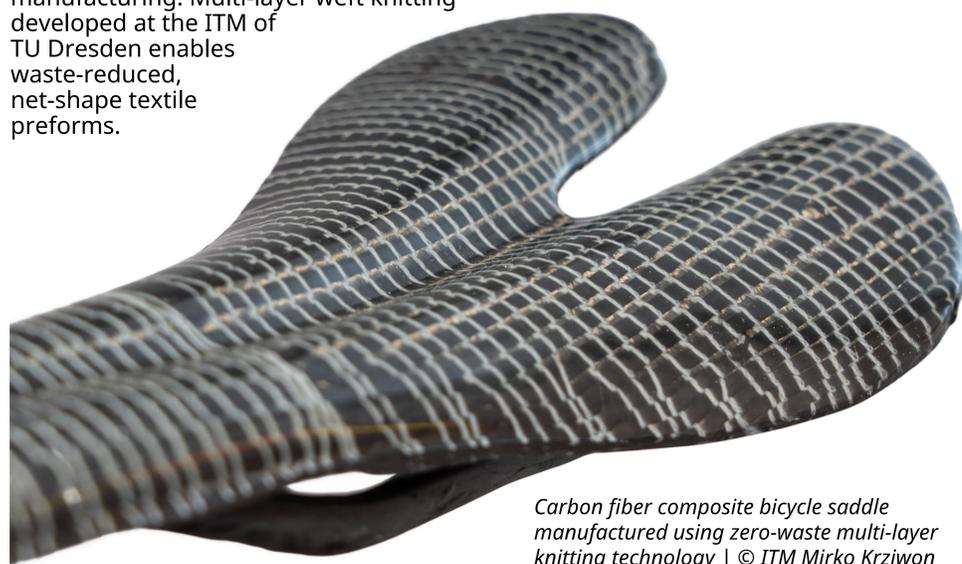© ITM Mirko Krziwon

Multilayer Knitting For Advanced Composites

From Net-Shape Manufacturing to In-situ Health Monitoring

Knitting Machinery

Constantly rising material and energy costs, together with the drive to reduce CO_2 emissions, highlight the need for lightweight structures and resource-efficient manufacturing. Multi-layer weft knitting developed at the ITM of TU Dresden enables waste-reduced, net-shape textile preforms.

Carbon fiber composite bicycle saddle manufactured using zero-waste multi-layer knitting technology | © ITM Mirko Krziwon

Lightweight Composites

The technology allows locally adapted yarn types and counts—e.g., carbon, glass, aramid, basalt, natural or hybrid yarns—so that fibre areal weight, thickness and through-thickness connections can be tailored to the load path. Using widening, narrowing and short-row knitting, 2D contours and complex 3D geometries are formed directly on the machine from a single, uncut fabric, with drape behaviour tuned via loop length. Sensoric Yarns can adopted for In-situ Health Monitoring of Composites.

- ✓ **Near-net-shape preforms:** less cutting, minimal scrap, faster lay-up.

- ✓ **Multi-layer in one run:** many reinforcing layers integrated without secondary stacking.

- ✓ **2D/2.5D shaping on-machine:** widening, narrowing, short-row knitting; curvilinear forms via segmented take-down.

- ✓ **Excellent drape control:** loop-length tuning reduces wrinkles over complex molds.

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Multi-layer weft-knitted (MLG) preforms enable lightweight, near-net-shape composites for sports gear with minimal scrap and fast cycles. Straight, biaxially placed reinforcements fixed by loop yarn provide stiffness along load paths while the knit architecture drapes cleanly over complex shapes. For bicycles, MLG supports lugs, seat posts, bars and fork areas with locally tuned thickness, optional through-thickness links for damage tolerance, and vibration-damping zones. For paddles, it forms wrinkle-free blade camber and smooth shaft transitions, balancing torsional stiffness and flex for feel.

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The A segmented pull-off (take-down) system enables 2.5D, curvilinear preforms to be knitted directly on the machine. Multiple narrow, independently driven segments apply locally programmed pull-off to create controlled differential draft and in-plane shear, steering fibre paths and forming radii, S-curves, and flanges without cutting. An active per-needle warp feed synchronized with the segments—and closed-loop tension control—preserves stitch quality and fibre straightness. CAD-defined geometry is translated into time-synchronized motion tables (segments, loop length, yarn feed), so shape emerges during knitting.

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Spacer knits pair two cover layers with pile threads to create a breathable, cushioned gap. With tunable thickness, porosity, and compression, they excel in **prosthetic liners, sockets, and orthoses**—reducing pressure points and moisture buildup. Using medical-grade or bioresorbable polymers, they can be zoned for local stiffness, damping, or friction and finished for antimicrobial/sterilizable performance. In implants, their open structure supports **tissue ingrowth** for meshes, cartilage substitutes, and composite implant interfaces, and can integrate **sensing yarns** for pressure/temperature monitoring.

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From Atom to Product

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