Local continuous-fiber reinforcement

3D Skeleton Winding process (3DSW)

Lightweight potential for injection-molded parts

Minimizing components' mass is becoming increasingly important for achieving reductions in CO_2 emissions in automotive applications. In many cases, metal load-bearing parts can be replaced by short- or long-fiber-reinforced thermoplastics. These composites have become such an integral part of industrial large-scale production that it is impossible to imagine production without them, especially due to their economical processability and increased functionality.

Limited mechanical properties, such as stiffness and impact strength, prevent the use of injection-molded thermoplastic fiber composites in applications with higher loads. In addition, the viscoelastic behavior of the polymer matrix at high temperatures or under permanent load is a disadvantage (→ tendency to creep). Local continuous-fiber reinforcements can overcome these disadvantages, improving the mechanical properties of injection-molded components.

Functionality

Topology optimizations can be used to analyze parts with pre-defined dimensions to determine load-bearing and non-load-bearing component areas. Lines of flux can be identified which show the load gradient inside the injection-molded part. The targeted placement of continuous-fiber structures along the application-specific load paths reinforces the component in the areas relevant to its stability.

Smart lightweight construction

When short- or long-fiber pellets are used, the fibers reinforce all areas of the component equally. As the fibers have a higher density than the matrix, the total weight of the component is therefore unnecessarily high, due to the reinforcement of component areas which do not bear significant loads. The targeted placement of continuous-fiber reinforcements in highly loaded areas means that the overall weight of the component is increased only minimally, which leads to significant weight savings compared to components processed from fiber-reinforced granules. Ideally, the continuous-fiber structures connect the load application points of the component, for example through metal inserts.

1 3DSW production line at Fraunhofer ICT.

2 Wound fiber skeleton structures made of PP/GF hybrid yarns.

To exploit the full potential of local continuous fibers, the reinforcements are integrated in component areas subjected to tensile stress. 3D Skeleton Winding (3DSW) is a novel robot-based composites manufacturing process, which enables the production of continuous-fiber-reinforced thermoplastic skeleton structures made of hybrid yarns or UD tapes. By embedding such hybrid skeleton structures using conventional injection molding, it is possible to locally reinforce structural thermoplastic components with continuous fibers. The high degree of automation of the 3D winding process ensures the manufacturing of fiber skeleton structures within cycle times typical for injection molding. This means that the developed technology can also be used economically for highly optimized structural injection-molded components in high-volume applications.

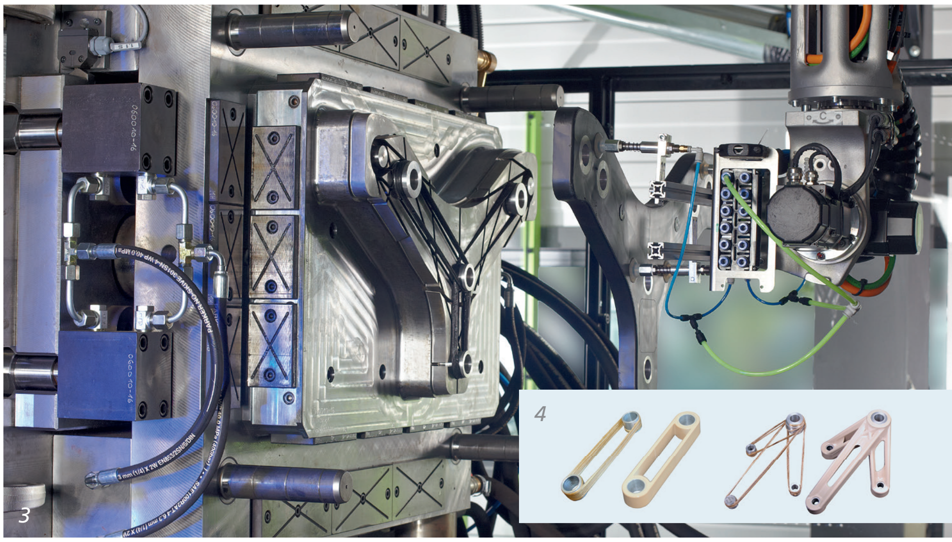
Benefits

- increased lightweight potential due to excellent weight-specific mechanical properties
- increased form stability at high temperature
- lower tendency to creep
- tailored component reinforcement
- optimized load-dependent orientation of reinforcing fibers
- integral design, integration of functional elements

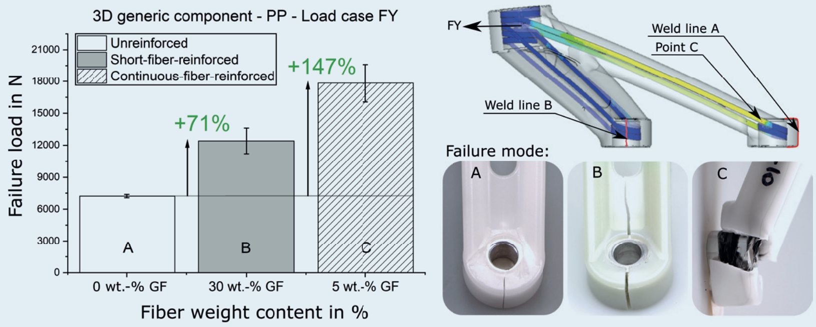
Our service offer

We offer our customers a variety of services, from baseline investigations, feasibility studies and part optimization through to procedural implementation:

- feasibility studies incl. mech. testing
- benchmark trials
- process development
- consulting service in process and part configuration
- performance of overmolding trials
- robot-assisted winding studies



Results of tensile testing of generic 3D structural component – Figure 4 (right)



3 Overmolding of fiber skeleton structures.

4 Tensile loop component (left); generic 3D structural component (right).

Contact

Dr.-Ing. Björn Beck
Phone +49 721 4640-593
bjoern.beck@
ict.fraunhofer.de

Jonathan Haas
Phone +49 721 4640-153
jonathan.haas@
ict.fraunhofer.de

Fraunhofer ICT
Joseph-von-Fraunhofer Str. 7
76327 Pfinztal (Germany)
www.ict.fraunhofer.de