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# Light, but wow!

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Lightweight solutions  
made of carbon fibre-  
reinforced plastic

**LIEBHERR**

Components  
Fibre composites



A close-up photograph of carbon fiber strands, showing their intricate, woven texture and dark, glossy finish. The strands are arranged in a way that creates a sense of depth and movement, with some strands in sharp focus and others blurred in the background.

# New dimensions with CFRP solutions

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Robustness and longevity in components do not have to be in contradiction with weight optimisation and cost-effectiveness. This is precisely the challenge that Liebherr has set itself with its solutions using carbon fibre reinforced plastic. The fibre composite material has characteristic properties, which when used optimally in the product can lead to significant benefits in the application.

As a traditional mechanical engineering company, Liebherr shapes technological progress by implementing new materials and creating innovative processes.

As a strong development partner, Liebherr combines all steps of product development and production under one roof and provides customers with a complete package.

***“We enjoy developing new ideas and promoting innovation in the field of fibre composites. However, this requires more than simply substituting existing materials with other ones.”***

**Dominic Gottwald**  
Team leader fibre composite technology

# Convincing arguments

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Carbon fibre reinforced plastic (CFRP) offers freedom of design. The wide variety of starting materials and the orientation of the reinforcing fibres make for versatility in the modelling of the composites; By tailoring properties such as rigidity and strength, the material can be individually adjusted to a wide variety of requirement profiles.

Liebherr understands customer requirements. With the expertise in fibre composites, the solutions designed bring the performance of each component and that of the entire system to a new level.

Towards the end of making machines of all kinds even more efficient in the future, optimisation of the weight of all machine components is key. If the possibilities of lightweight construction using conventional materials have been exhausted, the use of fibre-composite materials, especially CFRP, increases the potential to further reduce weight and increase efficiency.



**Increased efficiency**

**Reduced emissions**

**Increased life expectancy**

**Adjustable properties**

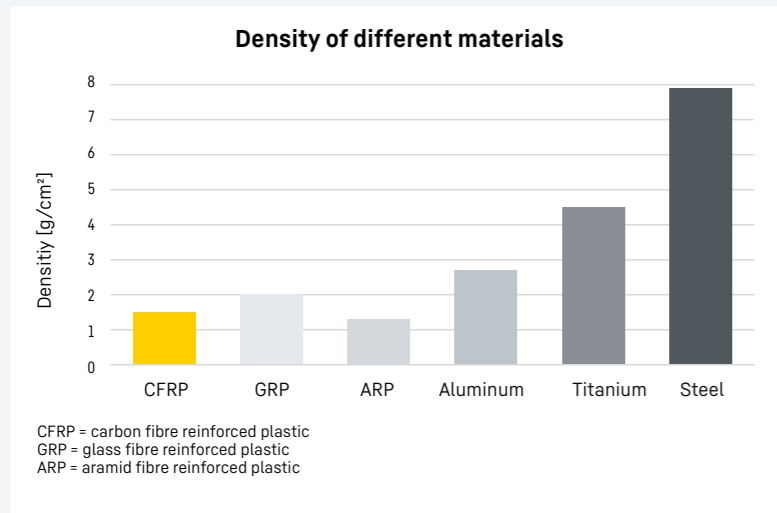
**High stiffness**

**High rigidity**

**Lightweight**

# Strong features

Liebherr selectively substitutes conventional materials to optimise the weight and performance of individual components, assemblies and complete systems. This generates further added value in addition to the static and dynamic performance gains. These include resistance to corrosion, special damping properties or beneficial adjustable thermal expansions.



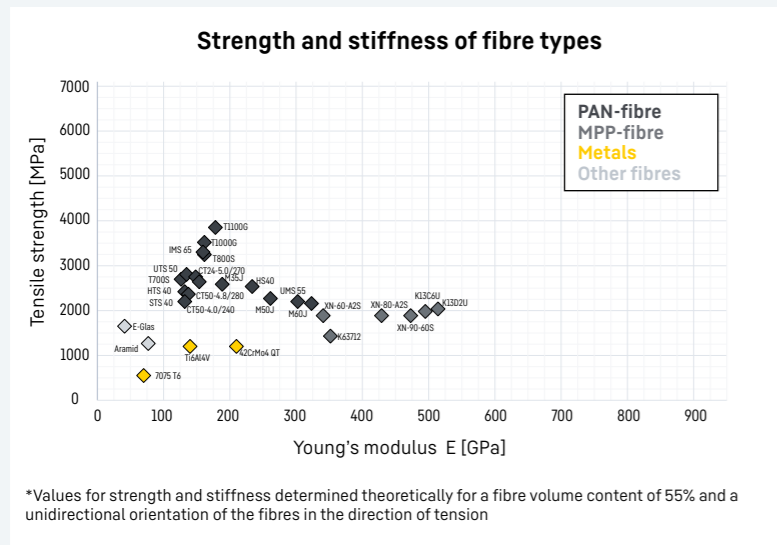
## Density of different materials

Compared to metallic materials, fibre composite materials have a much lower density. A CFRP body with the same volume (1.5 g/cm<sup>3</sup>) weighs only approx. 20% of a steel body (7.9 g/cm<sup>3</sup>). Even compared to lightweight materials such as aluminum and titanium, components made of fibre composite materials can lead to a significant weight reduction.

## Strength and stiffness of fibre types

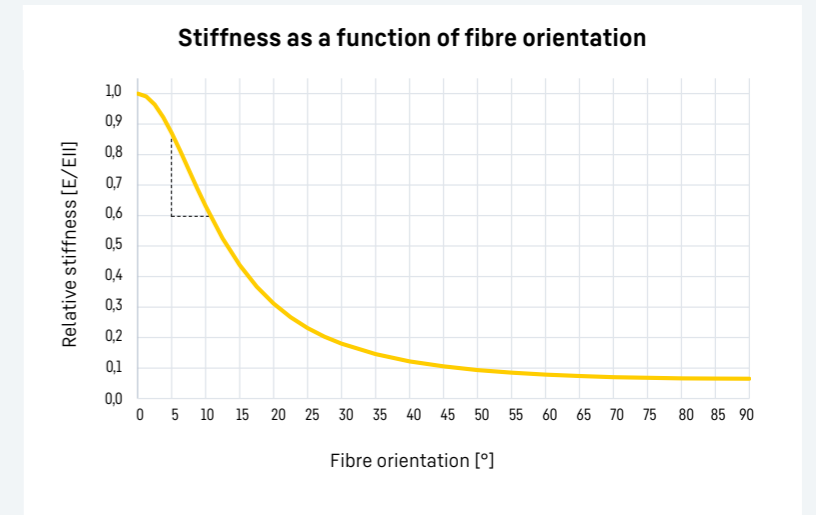
Depending on the application, fibres can be selected that have extremely high strength (HT/UHT) or very high rigidity (HM/UHM) compared to conventional materials. The component can be configured optimally for the load condition through a combination of the layer structure and suitable fibres.

In the best case, a body can be created that not only has a lower density, but also a lower volume than a corresponding comparison component made of steel.



## Stiffness as a function of fibre orientation

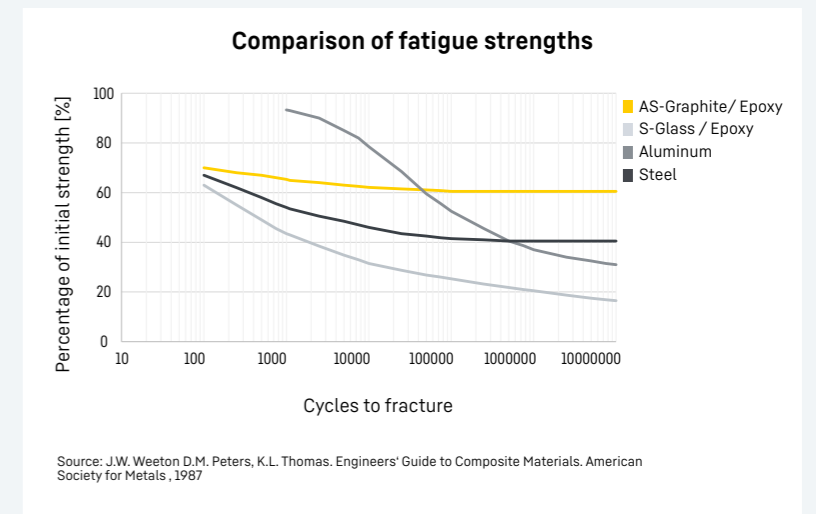
The advantages of higher strength and stiffness can only be fully exploited if the fibres are optimally oriented along the load paths. Exact knowledge of the load conditions, choice of fibres, optimal orientation and highly precise placement of the fibres in the process is required to take full advantage of the material combination. For example, 38% higher stiffness can be achieved by changing the fibre orientation from 10° to 5°.



## Comparison of fatigue strengths

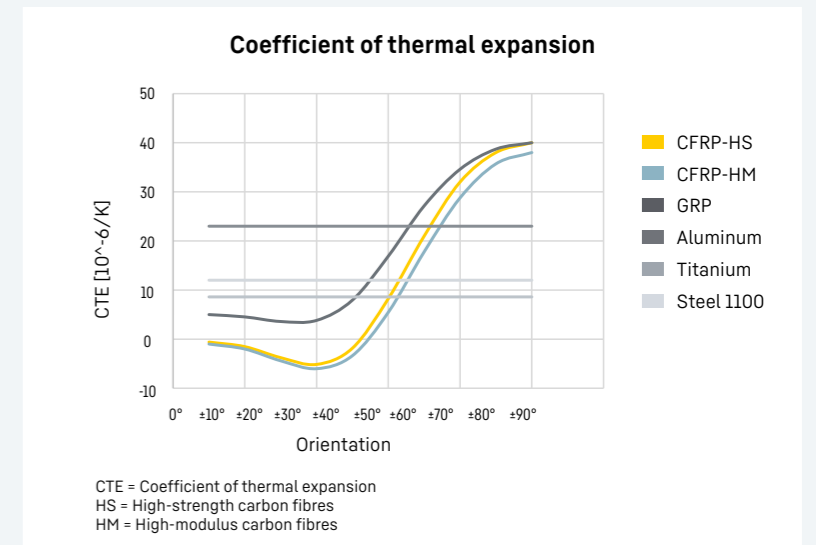
The fatigue behavior of the fibre composite materials is largely dependent on the fibre types used. While glass fibre shows a significant decrease in strength under high cyclic loads, components made of carbon fibres retain their high strength even with extremely frequently changing load intensities. Also compared to steel materials, carbon fibre reinforced plastics show a significantly reduced decrease in initial strength.

Coupled with very good vibration-damping properties, carbon fibres / carbon fibre reinforced plastics are suitable for highly dynamic, cyclic loads.



## Adjustable thermal expansion for temperature-independent accuracy

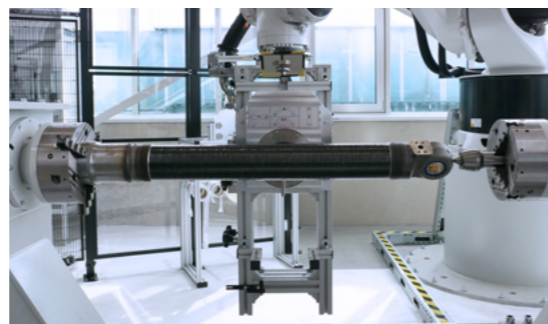
Depending on the layer structure of the fibre-composite materials, the thermal expansion behavior can be individually adapted to the application. With a suitable layer structure, high-precision components can only show very small deformations, even with strong temperature fluctuations. It should be noted that the required mechanical properties for the application must be achieved.



# Focus on CFRP hybrid cylinders

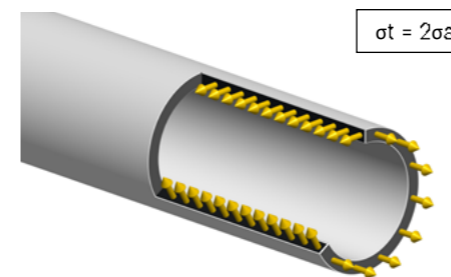
Hydraulic cylinders are used in many areas and are essential for many machines and applications. Due to the extreme power density, high power can be transmitted with little space requirement. This places high demands on the materials used in terms of strength and rigidity. Fibre-composite materials offer great potential in this area due to their outstanding properties.

Many years of experience in the development and production of hydraulic cylinders and expertise in the field of fibre composites are ideal prerequisites for a goal-oriented combination. If weight plays a key role in the end application, the use of hybrid cylinders is the right choice. By using a CFRP winding on the hydraulic cylinder, the weight of the component can be significantly reduced with the same installation situation. This ensures easy interchangeability without changing the device design.



## What do we mean by a CFRP hybrid hydraulic cylinder?

A CFRP hybrid hydraulic cylinder is a material hybrid consisting of a metal base body, which is wrapped with a fibre composite bandage. The boiler formula can be used to gain an understanding of the forces in the hydraulic cylinder. It states that, in an infinitely long pipe subjected to internal pressure, the stresses are distributed in such a way that the tangential stress is twice as great as the stress in the axial direction. We make use of exactly this principle with the CFRP hybrid cylinder.

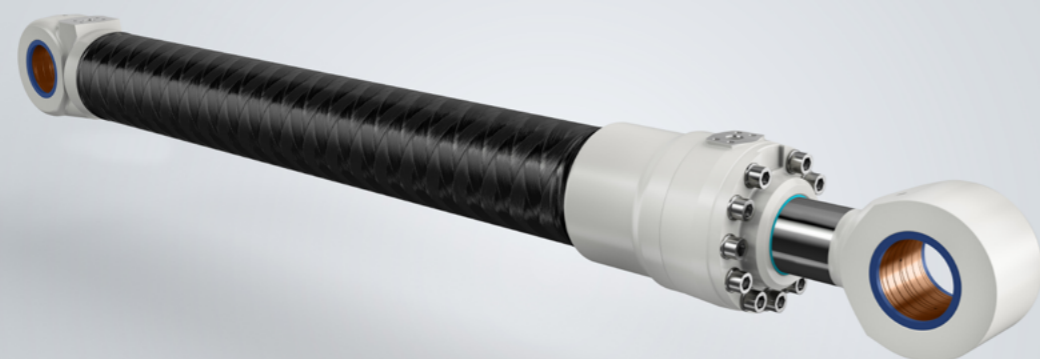


In the simplest case, half of the wall thickness can be substituted with steel and replaced with carbon fibre. The steel continues to absorb the acting axial stresses and half of the tangential stresses. With the CFRP hybrid cylinder concept, we can use existing and proven seals because the functional surface and thus the tribological system remain unchanged. Furthermore, hybrid variants with this design are relatively easy and quick to implement.

### Features of the CFRP hybrid cylinder:

- Weight reduction on the cylinder tube: 30 - 60%
- Weight reduction on the hydraulic cylinder: 10 - 25%

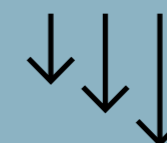
With an individual design and construction, the CFRP bandage can also absorb axial forces, which further reduces the weight of the component.



## Advantages of weight saving



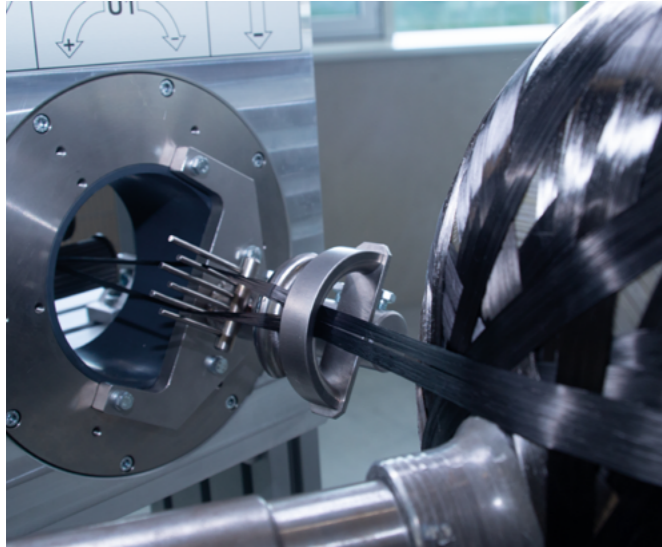
Increased efficiency



Reduced emissions



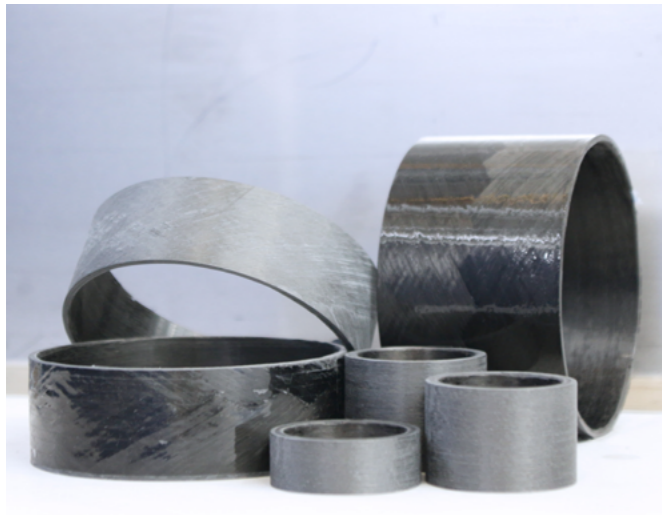
Increased life expectancy



CFRP winding on the piston accumulator



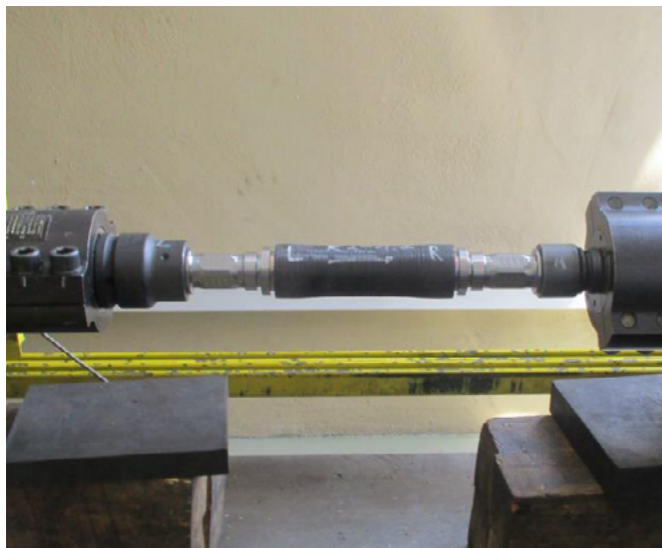
CFRP hybrid cylinders



CFRP tubes and bandages



Tool extension drive shaft



Test specimen in the torsion test rig



Individual test plate

# CFRP hybrid cylinder - and much more

In addition to hydraulic cylinders, many other component classes and products can be manufactured using winding technology. Drive shafts, for example, should be emphasised here, in which both the torsional rigidity and the bending rigidity can be individually adjusted. In addition, CFRP can also be successfully integrated in many other applications.

#### Example applications for fibre composites:

- Pressure tank
- Piston accumulators
- CFRP hybrid cylinder
- Pull/push rods
- Bandages and wraps
- Feathers
- Tools and tool extensions
- Tubes and profiles
- Machine carrier
- Measuring equipment

# Unlimited possibilities



## 1 Earthmoving & Mining

- Enlarged attachment tools
- Reduced emissions
- Increased efficiency through higher digging performance
- Lower energy consumption and less drive power required

## 2 Material handling technology

- Improved corrosion resistance
- Greater reach of the outriggers
- Outstanding cushioning properties
- Higher throughput
- Lower energy consumption

## 3 Crane construction

- Increased payloads
- Larger deployment altitude or range
- Improved work speeds
- Compliance with the permissible axle loads
- Easier assembly

## 4 Agriculture

- Larger working width due to low weight and high rigidity at the same time
- High precision thanks to vibration-damping properties

# Better together

From the first stroke of the brush to the finished solution in series production, Liebherr is at your side in the development process. Experienced colleagues take charge of all necessary steps from requirements analysis through to production-capable solution, and always with an eye on customer needs.

## With us you get the entire solution from a single source:

- Support throughout the entire development process
- A solution that fits your application perfectly
- Adaptation and adjustment based on empirical values in close cooperation
- Products manufactured in-house, without further interfaces
- A wide range of materials, depending on the requirement
- High quality down to the last detail
- Services in the form of material tests

### Your challenge



### Solution in series



#### Requirements analysis

Comprehensive analysis of the customer application and consideration of the overall system and its environment.



#### Design & calculation

Visualisation of a requirement-based and specific end product. From rough dimensioning to a fibre-specific construction, Liebherr offers a detailed components analysis to optimise the fibre-composite laminate using FEM.



#### Material & process selection

Selection of the appropriate fibre/resin combination and the manufacturing processes, taking into account costs, performance and quantity (economy).



#### Prototype & component tests

Provision of individual pieces and prototypes in order to gain knowledge from trials and based on field tests.



#### Quality assurance

Liebherr also has the highest quality standards in the field of fibre-composite materials. Continuous monitoring of the process parameters ensures a consistently high level of quality.



# In-house competence

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CFRP products are manufactured in house. Liebherr relies on automated production processes and state-of-the-art systems that allow for efficient and careful processing of raw materials. The focus is on safety for people and products.

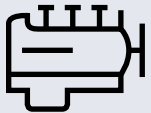
# Components

From A to Z – the components product segment of the Liebherr Group offers a broad range of solutions in the area of mechanical, hydraulic, electric and electronic drive system and control technology. The efficient components and systems are produced at a total of ten production sites around the world to the highest standards of quality. Central contact persons for all product lines are available to our customers at

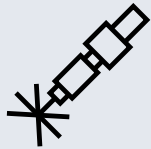
Liebherr-Components AG and the regional sales and distribution branches.

Liebherr is your partner for joint success: from the product idea to development, manufacture and commissioning right through to customer service solutions like remanufacturing.

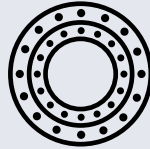
[components.liebherr.com](http://components.liebherr.com)



Engines



Fuel injection systems



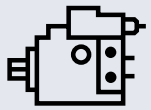
Slewing bearings



Gearboxes



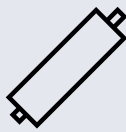
Winches



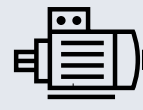
Hydraulic pumps and motors



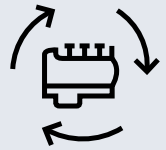
Hydraulic cylinders



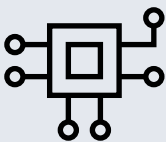
Piston accumulators



Electric machines



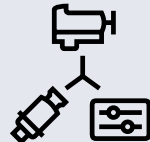
Remanufacturing



Industrial electronics



Electrical drive and control technology



Drive systems



Aerospace electronics



Fibre composite

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