

**Category:** Materials, Coatings & Processes

**Reference:** TD-DE-1055

### TMC - Titan Matrix Composite

Immense demands are placed on materials, especially in the aerospace sector; in addition to low weight, they must have high stiffness and strength.

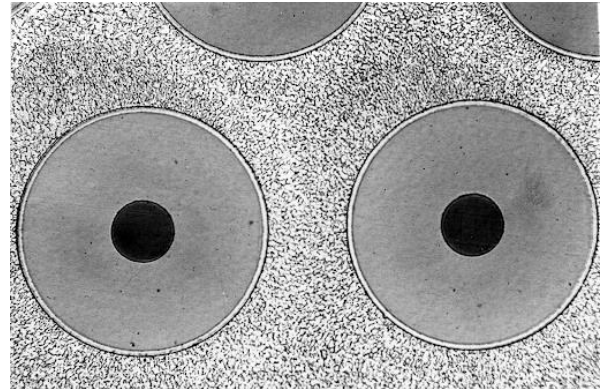
Fiber-reinforced titanium (TMC) was developed for use in space propulsion systems.

Titanium Matrix Composite (TMC) is a fibre-reinforced composite material in which SiC fibres are inserted into a metal matrix of titanium and form a unit via a gapless form closure (quasi-material closure). Due to the special features of the magnetron sputtering process, any titanium alloy can be used as a metal matrix.

Component design is crucial

The material properties of the TMC require a specific component design:

- Homogeneous distribution of SiC fibres across the component cross-section
- Compliance with defined fibre density parameters (fibre content to metal matrix)
- Alignment of the fibre bundles to the main load directions
- Avoidance of fibre interruptions
- Closed titanium outer skin of the component (even after any mechanical finalisation)
- Design maximum bending radiuses



Characteristics	TMC	High-strength Steel	Ti-alloy
Density [g/cm <sup>3</sup> ]	4	7,8	4,6
Strength [Mpa]	2200	1700	1100
Strength at 600°C [Mpa]	1400	800	650
Stiffness [Gpa]	210	190	115
Elongation [%]	1,3	6	15
Thermal expansion [K <sup>-1</sup> ]	5 x 10 <sup>-6</sup>	12 x 10 <sup>-6</sup>	8,5 x 10 <sup>-6</sup>

#### Innovative Aspects:

The titanium convinces with its low specific weight. The SiC fibres provide the high tensile strength and stiffness. In contrast to many lightweight materials, TMC retains its material properties even at high temperatures of up to 600 °C. Since the SiC fibres do not come to the surface, the material retains its corrosion resistance and biocompatibility.

## Benefits of Titan Matrix Composites

### *Significantly Increased Load Capacity in Comparison to Steel*

At the same dimensions, KTW Titan Matrix Composites possess 75% higher tensile strength and a 10% increase in stiffness than equivalent high-alloy steel components. This also means that, at consistent load, a significant reduction of component size is possible. In addition, TMC components show the same or better performance at high temperatures than their steel-alloy counterparts.

### *50% Weight Reduction*

When compared with components made of high-alloy steel, TMC-built components on average weigh half as much at higher levels of rigidity. This allows fabricating large machinery such as plane turbines and other heavy duty appliances at a much lower weight, leading to great savings in energy and fuel in the final application.

### *Versatile Applications*

The process is suitable for many kinds of components from all kinds of industries and processes. It delivers perfect and repeatable quality thanks to a high level of automation. Machining and 3D-printing allow the production of many desired shapes. Low reactivity and high biocompatibility also allow for usage in the medical field, for example, in artificial joints.

## Application Areas:

### Areas of Application for This Lightweight Material

Titan Matrix Composites are employable in a wide range of industries and fields:

- General mechanics – The material is able to replace a great number of parts in different kinds of machinery. Examples include connection rods, bolts, valves, and other components with high demands for performance.
- Aerospace – Here, the process can provide lighter and more stable turbine/fan blades, inlet/outlet valves, rods, bolts, pins, shafts, and more. For example, due to the material's minimal thermal expansion, turbine blades made from TMC can greatly increase the efficiency of plane engines.
- Cars/motorsports – TMC components are already in use in Formula 1 Toyota engines. In general, they are able to increase the power density of electric motors by reducing the moving mass e.g. of the rotor or stator.
- Medical field – Low reactivity and high biocompatibility make Titan Matrix Composites perfect material for orthopedic implants.

## Cooperation:

There is interest in material sales as well as the development of TMC components to specific requirements.