

Titanium alloys

The material. The alloys of titanium have the highest strength-to-weight ratio of any structural metal, about 25% greater than the best alloys of aluminum or steel. Titanium alloys can be used at temperatures up to 500°C—compressor blades of aircraft turbines are made of them. They have unusually poor thermal and electrical conductivity, and low expansion coefficients. The alloy Ti 6%/Al 4% V is used in quantities that exceed those of all other titanium alloys combined. The data in this record describe it and similar alloys.

Composition

Ti+ alloying elements, e.g., Al, Zr, Cr, Mo, Si, Sn, Ni, Fe, V

General properties

Density	4,400	–	4,800	kg/m ³
Price	57	–	63	USD/kg

Mechanical properties

Young’s modulus	110	–	120	GPa
Yield strength (elastic limit)	750	–	1,200	MPa
Tensile strength	800	–	1,450	MPa
Elongation	5	–	10	%
Hardness—Vickers	267	–	380	HV
Fatigue strength at 10 ⁷ cycles	589	–	617	MPa
Fracture toughness	55	–	70	MPa · m ^{1/2}

Thermal properties

Melting point	1,480	–	1,680	°C
Maximum service temperature	450	–	500	°C
Thermal conductor or insulator?	Poor conductor			
Thermal conductivity	7	–	14	W/m · K
Specific heat capacity	645	–	655	J/kg · K
Thermal expansion coefficient	8.9	–	9.6	μstrain/°C

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	100	–	170	μohm · cm



Adiabatic heating heats the air in the compressor to about 500°C, requiring the use of titanium alloys for the blades (Reproduced with the permission of Rolls-Royce plc, copyright © Rolls-Royce plc 2004)

Eco properties: material

Global production, main component	2.0×10^5			metric ton/yr
Reserves	720×10^6			metric ton
Embodied energy, primary production	650	—	720	MJ/kg
CO ₂ footprint, primary production	44	—	49	kg/kg
Water usage	470	—	1,410	L/kg
Eco-indicator	3,450			millipoints/kg

Eco properties: processing

Casting energy	12.6	—	13.9	MJ/kg
Casting CO ₂	0.9	—	1.0	kg/kg
Forging, rolling energy	14	—	15	MJ/kg
Forging, rolling CO ₂	1.1	—	1.2	kg/kg

End of life

Embodied energy, recycling	78	—	96	MJ/kg
CO ₂ footprint, recycling	4.7	—	5.7	kg/kg
Recycle fraction in current supply	21	—	24	%

Typical uses. Aircraft turbine blades; general aerospace applications; chemical engineering; pressure vessels; high-performance automotive parts such as connecting rods; heat exchangers; bioengineering; medical; missile fuel tanks; compressors; valve bodies; light springs; surgical implants; marine hardware, paper-pulp equipment; sports equipment such as golf clubs and bicycles.