Physical Properties of Titanium and its Alloys

The physical properties of primary importance in mechanical design are the metal density, 4.51 gm/cc, (.163 lb/cu.in.) which is almost half that of other corrosion resistant alloys, and the modulus of elasticity.

In applications which are weight critical, the weight savings achievable with a properly designed titanium system will be appreciable. Where titanium is used to replace a heavier metal, e.g. retubing of heat exchangers and condensers, it may be necessary to modify the arrangements by which the unit is supported or suspended. (3)

Attention to the modulus is essential for the correct design and application of struts and supports, e.g. heat exchanger baffle spacing, (4) and unsupported pipe spans. The relatively low modulus is however a factor in the substantial resistance to shock which titanium and its alloys possess. Shock resistance is calculated from the maximum allowable stress divided by the square root of the product of the density and the elastic modulus. These two properties are both low for titanium and its alloys, and strengths are relatively high. The shock resistance of titanium is greater than that of most competing copper and nickel based corrosion resistant alloys. (2)

Fatigue, Fracture Toughness and Creep

Fatigue strength of smooth test specimens of titanium and its alloys is typically 50% - 60% of the tensile strength values. Notched specimen tests give lower values. Care is required in design and manufacture to avoid stress concentrating factors where cyclic stress is applied to high levels, or with great frequency. Poor surface finish, sharp sectional transitions, unblended radii and corners are typical conditions to avoid.

Commercially pure titanium and titanium alloys possess a low ductile to brittle transition temperature and have useful levels of impact and fracture toughness even at sub zero temperatures. The ASME Boiler and Pressure Vessel Code allows the rom temperature stress levels of Grades 1, 2, 3, 7 and 11 to be used in design for operational service down to -60°C, (-75°F).

Metallurgical and surface stability of titanium and its alloys is excellent within the working temperature range set by the value of useful strength. Creep values for commercially pure titanium to .1% plastic strain in 100,000 hours are approximately 50% those of the tensile strength at appropriate temperatures up to 300°C. Creep values for welds in commercially pure titanium lie in the same range as for base metal.

Thermal Performance of Titanium and Titanium Alloys

The thermal conductivity of titanium is low, and of the same order as