Chart 12: Normalized strength, σ_t/E, against linear expansion coeff., α

The chart guides in selecting materials to resist damage in a sudden change of temperature ΔT. The contours show values of the thermal shock parameter

$$B\Delta T = \frac{\sigma_t}{\alpha E}$$

in °C. Here σ_t is the tensile failure strength (the yield strength of ductile materials, the fracture strength of those which are brittle), E is Young's modulus and B is a factor which allows for constraint and for heat-transfer considerations:

$$B = 1/A \quad \text{(axial constraint)}$$

$$B = (1 - v)/A \quad \text{(biaxial constraint)}$$

$$B = (1 - 2v)/A \quad \text{(triaxial constraint)}$$

with

$$A = \frac{th/\lambda}{1 + th/\lambda}$$

Here v is Poisson's ratio, t a typical sample dimension, h is the heat-transfer coefficient at the sample surface and λ is its thermal conductivity. The contours define the guide line

$$B\Delta T = C \quad \text{(thermal shock resistance)}$$

The value of the constant C increases towards the top left.

12. Strength-Expansion

Metals and Polymers: Ultimate Strength
Ceramics: Modulus of Rupture
Composites: Tensile Strength
Contours: Thermal Shock Resistance
Parameter (See Text)

MFA:88-91

High Thermal Shock Resistance

Low Thermal Shock Resistance

Normalised Strength σ_t/E

Linear Expansion Coefficient ($10^{-6}\,K^{-1}$)