Lecture 23 – Composite Materials

Composite Materials

Reference Text	Section
Higgins RA & Bolton, 2310. *Materials for Engineers and Technicians,* 5th ed, Butterworth Heinemann	Ch 23

Reference Text	Section

Composite Materials *(Higgins 23)*

‘Composites‘ are mixtures of two separate components, one being the matrix (glue), the other giving strength/hardness/stiffness usually as particles or fibres.

This chapter is particle composites, next chapter fibre composites

Moldavite, a natural glass formed by meteorite impact, from Besednice, Bohemia

A modern greenhouse in Wisley Garden, England, made from float glass

Roman Cage Cup from the 4th century CE

23.1 Introduction *(Higgins 23.1)*

23.1.1 Particle composites
Particle-hardened composites
Dispersion-hardened composites
'Filler' composites

To make sure the particle stick (cohesion);
Mechanical bonding (rough surface)
Physical bonding (Van der Waals)
Chemical bonding
Solid-solution bonding

Higgins

23.2 Particle-hardened composites *(Higgins 23.2)*

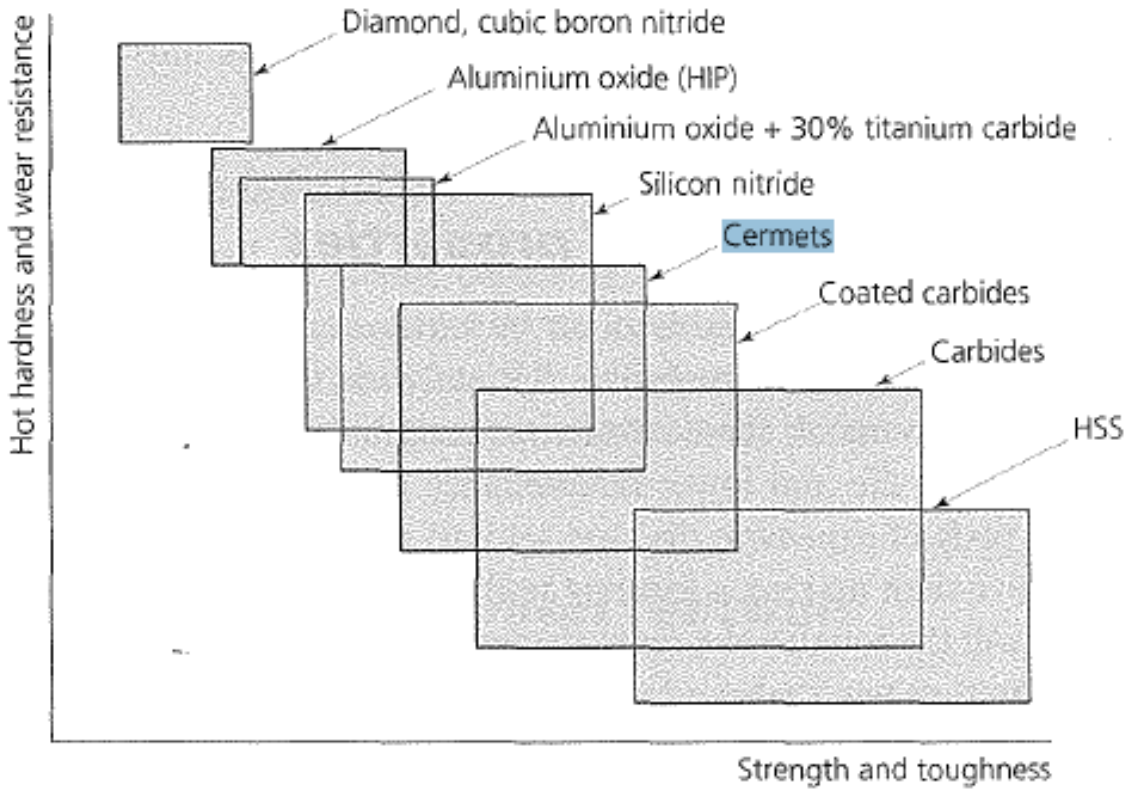
These are generally the products of powder metallurgy in which extremely hard particles of a ceramic material are held in a tough ductile matrix of some metal. Such materials are called *cermets* and are used for cutting tools and die materials.

Figure 23.1 *The type of structure in a tungsten carbide/cobalt cermet. Particles of tungsten carbide (white) in a cobalt matrix (black) (×1000).*

Higgins

23.2 Particle-hardened composites

Range of properties for various groups of tool materials (adapted from Kalpakjian, Manufacturing Engineering and Technology, Addison Wesley)



23.2 Particle-hardened composites *(Higgins 23.2)*

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Table 23.1 *Some cermet materials*

Cermet group	*Ceramic*	*Bonding matrix*	*Uses*
Carbides	Tungsten carbide	Cobalt	Cutting tools.
	Titanium carbide	Cobalt, molybdenum or tungsten	Cutting tools.
	Molybdenum carbide	Cobalt (or nickel)	Cutting tools.
	Chromium carbide	Nickel	Slip gauges, wire-drawing dies.
Oxides	Aluminium oxide	Cobalt or chromium	Rocket motor and jet-engine parts –
	Magnesium oxide	Magnesium, aluminium or cobalt	other uses where high temperatures are
	Chromium oxide	Chromium	encountered. 'Throw-away' tool bits.
Borides	Titanium boride	Cobalt or nickel	Cutting tool tips.
	Chromium boride	Nickel	Cutting tool tips.
	Molybdenum boride	Nickel	Cutting tool tips.

23.3 Dispersion-hardened materials *(Higgins 23.3)*

Small particles impede slip in the matrix.

23.3.1 Sintered aluminium powder (SAP)

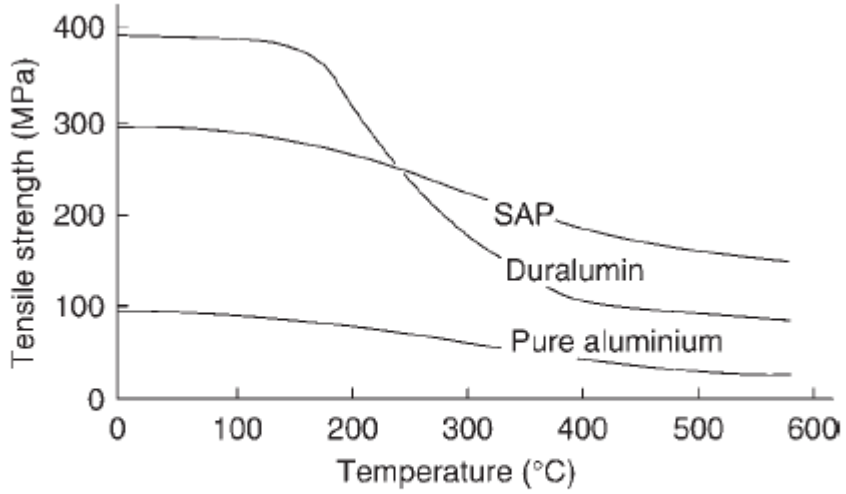

Figure 23.2 *The relationship between tensile strength and temperature for duralumin, SAP and pure aluminium.*

Higgins

23.3 Dispersion-hardened materials *(Higgins 23.3)*

23.3.2 Manufacturing processes
23.3.3 Modern superalloys

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23.4 Mortar and concrete *(Higgins 23.4)*

23.4.1 Mortar
23.4.2 Concrete

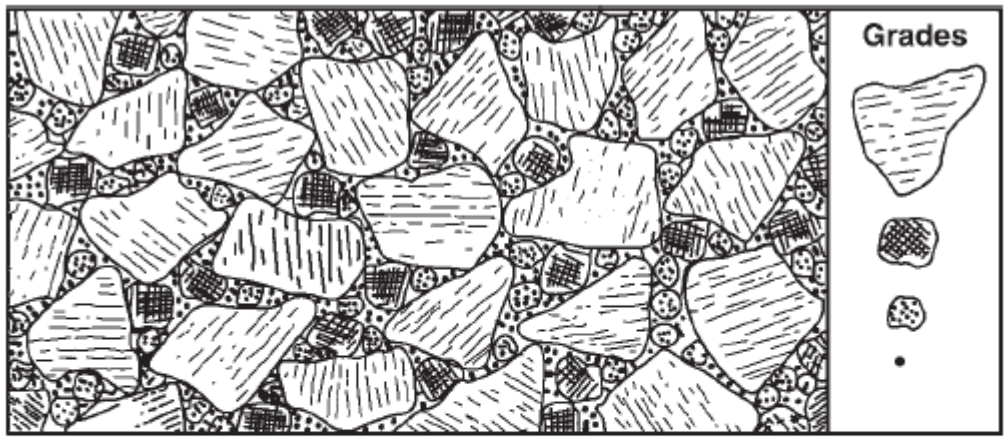

Figure 23.3 *A satisfactory concrete structure: the aggregate consists of different grades (or sizes) in the correct proportions so that the smaller particles fill the spaces between the larger ones, whilst particles of sand occupy the remaining gaps, and all are held together by a film of cement.*

Higgins

23.5 Tarmacadam *(Higgins 23.5)*

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Resources.

Wikipedia: Concrete

Glossary

Cohesion
Mechanical bonding
Physical bonding
Chemical bonding
Solid-solution bonding
Cermets
Sintering
Matrix
Mechanical alloying
Aggregate
Rich and lean
Cement/aggregate ratio
Portland cement
Dispersion hardened material

QUESTIONS

Higgins Ch23, Newell, Timmings, Sheedy, Callister, Ashby

1. Define all glossary terms
2. Explain the issues of making strong concrete regarding water ratio, cement ratio, aggregate and sand, curing time and temperature, curing humidity. Explain what would be done to achieve high strength and low shrinkage.
3. What is a cermet and what are they used for? Give some examples of cermets and explain what properties they have that make them suitable for their purpose.
4. Give five reasons for a particle to be added to a matrix – include a range of different types of particle composites.
5. Explain how small particles can strengthen a ductile metal matrix even when the particles are rounded. (Dispersion hardened material).