

## Section 19

### Metallurgical Terms

Terminology used in metallurgy is complex. Some of the more common (and sometimes misunderstood) terms are given below:

**age hardening** Hardening by aging, usually after rapid cooling or cold working.

**ageing** A change of properties that occurs at ambient or moderately elevated temperatures after hot working, heat treating, quenching, or cold working.

**alloy** A substance having metallic properties and composed of two or more chemical elements of which at least one is a metal.

**alloy steel** Steel containing significant quantities of alloying elements (other than carbon and small amounts of manganese, silicon, sulfur, and phosphorus) added to produce changes in mechanical or physical properties. Those containing less than about 5 percent total metallic alloying elements are termed low-alloy steels.

**annealing** Heating metal to a suitable temperature followed by cooling to produce discrete changes in microstructure and properties.

**austenite** A solid solution of one or more alloying elements in the fcc structure of iron.

**bainite** A eutectoid transformation product of ferrite and dispersed carbide.

**beach marks** Crack arrest 'lines' seen on fatigue fracture surfaces.

**billet** A solid piece of steel that has been hot worked by forging, rolling, or extrusion.

**brittle fracture** Fracture preceded by little or no plastic deformation.

**brittleness** The tendency of a material to fracture without first undergoing significant plastic deformation.

**carbide** A compound of carbon with metallic elements (e.g. tungstschromium).

**carbon equivalent (CE)** A 'weldability' value that takes into account the effects of carbon and other alloying elements on a particular characteristic of steel. A formula commonly used is:

$$CE = C + (Mn/6) + [(Cr + Mo + V)/5] + [(Ni + Cu)/15]$$

**carbon steel** A steel containing only small quantities of elements other than carbon.

**cast iron** Iron containing more than about 2 percent carbon.

**cast steel** Steel castings, containing less than 2 percent carbon.

**cementite** A carbide, with composition  $Fe_3C$ .

**cleavage** Fracture of a crystal by crack propagation.

**constitutional diagram** A graph showing the temperature and composition limits of various phases in a metallic alloy.

**crack initiator** Physical feature which encourages a crack to start.

**creep** Time-dependent strain occurring under stress.

**critical cooling rate** The maximum rate at which austenite needs to be cooled to ensure that a particular type of structure is formed.

**crystalline** The general structure of many metals.

**crystalline fracture** A fracture of a metal showing a grainy appearance.

**decarburization** Loss of carbon from the surface of a ferrous alloy caused by heating.

**deformation** General term for strain or elongation of a metal's lattice structure.

**duplex** Containing two phases (e.g. ferrite and pearlite).

**deoxidation** Removal of oxygen from molten metals by use of chemical additives.

**diffusion** Movement of molecules through a solid solution.

**dislocation** A linear defect in the structure of a crystal.

- ductility** The capacity of a material to deform plastically without fracturing.
- elastic limit** The maximum stress to which a material may be subjected without any permanent strain occurring.
- equilibrium diagram** A graph of the temperature, pressure, and composition limits of the various phases in an alloy 'system'.
- etching** Subjecting the surface of a metal to an acid to reveal the microstructure.
- fatigue** A cycle or fluctuating stress conditions leading to fracture.
- ferrite** A solid solution of alloying elements in bcc iron.
- fibrous fracture.** A fracture whose surface is characterized by a dull or silky appearance.
- grain** An individual crystal in a metal or alloy.
- grain growth** Increase in the size of the grains in metal caused by heating at high temperature.
- graphitization** Formation of graphite in iron or steel.
- hardenability** The property that determines the depth and distribution of hardness induced by quenching.
- hardness (indentation)** Resistance of a metal to plastic deformation by indentation (measured by Brinel, Vickers, or Rockwell test).
- inclusion** A metallic or non-metallic material in the matrix structure of a metal.
- initiation point** The point at which a crack starts.
- killed steel** Steel deoxidized with silicon or aluminium, to reduce the oxygen content.
- $K_{IC}$**  A fracture toughness parameter.
- lamellar tear** A system of cracks or discontinuities, normally in a weld.
- lattice** A pattern (physical arrangement) of a metal's molecular structure.
- macrograph** A low-magnification picture of the prepared surface of a specimen.
- macrostructure** The structure of a metal as revealed by examination of the etched surface at a magnification of about  $\times 15$ .

- martensite** A supersaturated solution of carbon in ferrite.
- microstructure** The structure of a prepared surface of a metal as revealed by a microscope at a magnification of about  $\times 15$ .
- micro-cracks** Small 'brittle' cracks, normally perpendicular to the main tensile axis.
- necking** Local reduction of the cross-sectional area of metal by stretching.
- normalizing** Heating a ferrous alloy and then cooling in still air.
- notch brittleness** A measure of the susceptibility of a material to brittle fracture at locations of stress concentration (notches, grooves, etc.).
- notch sensitivity** A measure of the reduction in strength of a metal caused by the presence of stress concentrations.
- nitriding** Surface hardening process using nitrogenous material.
- pearlite** A product of ferrite and cementite with a lamellar structure.
- phase** A portion of a material 'system' that is homogenous.
- plastic deformation** Deformation that remains after release of the stress that caused it
- polymorphism** The property whereby certain substances may exist in more than one crystalline form.
- precipitation hardening** Hardening by managing the structure of a material, to prevent the movement of dislocations.
- quench hardening** Hardening by heating and then quenching quickly, causing austenite to be transformed into martensite.
- recovery** Softening of cold-worked metals when heated.
- segregation** Non-uniform distribution of alloying elements, impurities, or phases in a material.
- slip** Plastic deformation by shear of one part of a crystal relative to another.
- slip plane** Plane of dislocation movement.
- soaking** Keeping metal at a predetermined temperature during heat treatment.
- solid solution** A solid crystalline phase containing two or more chemical species.

- solution heat treatment** Heat treatment in which an alloy is heated so that its constituents enter into solid solution and then cooled rapidly enough to 'freeze' the constituents in solution.
- spheroidizing** Heating and cooling to produce a spheroid or globular form of carbide in steel.
- strain ageing** Ageing induced by cold working.
- strain hardening** An increase in hardness and strength caused by plastic deformation at temperatures below the recrystallization range.
- stress-corrosion cracking** Failure by cracking under the combined action of corrosion and stress.
- sulfur print** A macrographic method of examining the distribution of sulfur compounds in a material (normally forgings).
- tempering** Supplementary heat treatment to reduce excessive hardness.
- temper brittleness** An increase in the ductile–brittle transition temperature in steels.
- toughness** Capacity of a metal to absorb energy and deform plastically before fracturing.
- transformation temperature** The temperature at which a change in phase occurs.
- transition temperature** The temperature at which a metal starts to exhibit brittle behaviour.
- weldability** Suitability of a metal for welding.
- work hardening** Hardening of a material due to straining or 'cold working'.

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