

A Glossary of the terms used in relation to steels and the steel industry.

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ABNORMAL STEELS

- (a) Carbon steels showing relatively poor low deformation creep behaviour usually as indicated by abnormally high creep rates. This usually occurs when high aluminium additions are made and is thought to be associated with removal of nitrogen from solid solution as AlN.
- (b) A name given by McQuaid and Ehn to carburizing steels which tended to show soft spots on quenching after carburizing. The cause is low hardenability associated with fine grain size.

AGEING

(Age Hardening). A process causing structural change which may occur gradually in certain metals and alloys at atmospheric temperature (natural ageing), or more rapidly at higher temperatures (artificial ageing). As a result of ageing, the proof stress, maximum stress and hardness values are increased, with some reduction in ductility. These effects are caused by precipitation from a supersaturated solid solution so that the ageing treatment is usually preceded by a solution treatment at a much higher temperature. The precipitate may be sub-microscopic. There is a tendency to apply the term "ageing" to steels; "age hardening" to non-ferrous alloys. Where the ageing is produced by heating at elevated temperatures, i.e., artificial ageing, the effect is often referred to as precipitation hardening.

AIR HARDENING STEEL

(Self Hardening). Strictly the term refers to a steel which becomes martensitic, i.e., fully hardened, on cooling in air from above its critical point, and does not require rapid quenching in oil or water, but it may also be applied to varying degrees of non-martensitic hardening, e.g., where the steel, although not wholly martensitic, attains adequate hardness on cooling in air. Such steels are produced by the addition of certain alloying elements which lower their critical range on cooling; a typical example contains 0.30% carbon, 1.3% chromium and 4.5% nickel. It should be noted that sufficiently rapid air cooling can be obtained only if the mass of the steel does not exceed a certain section which varies according to the composition.

ALLOY STEEL

A steel to which one or more alloying elements other than carbon have been deliberately added with the object of conferring particular properties upon it, such as strength, ductility and hardenability.

ANNEALING

Heating steel and holding it at a suitable temperature followed by cooling at a suitable rate, with the object of improving softness, machinability, and cold-working properties or of removing stresses and obtaining a desired structure. Usually (full annealing) the steel is heated to a temperature at which the carbide is wholly or partly taken into solution; subsequently the steel is slowly cooled, generally in the furnace. Sub-critical annealing is done at a temperature just below that at which carbide commences to be taken into solution.

AUSTENITE

The allotropic form of iron (gamma iron) which has a face centred cubic lattice, the parameter of which increases with increasing carbon content. Austenite, containing only carbide of iron in solution, is not stable at ordinary temperatures, nor can it be completely retained in solution by quenching, but its stability is greatly increased by the addition of certain alloying elements. (See also Allotropy, Austenitic Steels and Gamma Iron).

AUSTENITIC STEELS

Steels consisting of austenite, which, owing to the presence of high percentages of certain alloying elements such as manganese and nickel, are stable, for most practical purposes, at normal temperatures. Typical examples of austenitic steels include 14% manganese steel, and the corrosion-resistant type containing about 18% chromium and 8% nickel, e.g., Staybrite.

BASIC STEEL

Steel produced in an open hearth or Bessemer or electric furnace in which the hearth consists of a basic refractory such as rammed magnesite or dolomite. A slag, rich in lime, is produced and the sulphur and phosphorus pass into the slag during the working of the charge. The charge of the basic open hearth furnace consists of pig iron and scrap. In the hot-metal process, iron from the blast furnace goes through the mixer to the hearth furnace, and constitutes 75% or more of the charge, the rest being scrap. In the scrap process, the basis of the charge is scrap steel. This may be up to 85% of the charge, the remaining 15% being pig iron. In either case, however, the refining of the metal consists of the removal of some of the carbon and the partial elimination of sulphur and phosphorus, the manganese changes which occur being incidental to the process.

BECKING

Increasing the diameter of a steel ring or drum by forging on a becking bar, or mandrel, the forging being worked radially between the bar and the upper tool.

BLOWHOLES

- (a) Round or elongated smooth walled gas-filled cavities in solid metals formed either by the trapping of gas evolved during solidification of the metal or by steam or gas from the mould surface.
- b) (Gas Pocket). A cavity in a weld caused by the entrapment of gas.

BLUE ANNEALING

A process of softening iron-base alloys in the form of hot-rolled sheet, in which the sheet is heated in the open furnace to a temperature within the transformation range and cooled in air; the formation of a bluish oxide on the surface is incidental.

BLUEING

A treatment of the surface of iron-base alloys usually in the form of sheet or strip, on which, by the action of air or steam at a suitable temperature, a thin blue oxide film is formed on the initially scale-free surface. It is used to improve the appearance and to increase resistance to corrosion.

BRIGHT ANNEALING

A process of annealing which is usually carried out in a controlled furnace atmosphere (i.e., non-oxidizing) so that surface oxidation is reduced to a minimum and the surface remains relatively bright.

CARBON CASE HARDENING

The term is usually applied to the complete process of carburizing or cyaniding low carbon steels, with or without one or more further heatings to promote grain refinement, followed by quenching in order to produce a hard case. The high carbon content of the exterior of the steel so treated renders the surface hard and wear-resistant, whilst the low carbon content of the interior leaves the core tough and ductile.

CARBON STEEL

A steel whose properties are determined primarily by the percentage of carbon present. Besides iron and carbon, such steels may contain a maximum of manganese up to 1.5%, silicon up to 0.5%, sulphur and phosphorus up to 0.1%, nickel up to 0.40%, chromium up to 0.30%, molybdenum up to 0.15%, copper up to 0.25%, tungsten, cobalt, aluminium up to 0.10, and niobium, tantalum, titanium, vanadium, zirconium up to 0.05%. These alloying elements in such quantities are regarded as residual elements, but their deliberate addition in substantial amounts will put the steel in the alloy steel category. (see also Carbon - "Influence of Elements in Steel").

CARBURIZING

The introduction of carbon into the surface layer of a steel having a low carbon content (case hardening steel). It may be effected by heating in a solid, liquid or gaseous carbon-containing medium, which at high temperatures provides a supply of carbon for absorption by the material being carburized. By controlling the temperature and time of treatment, the concentration of carbon in the surface of the steel and the depth of penetration may be varied over wide limits. In the original process of box- or pack-carburizing, the steel is heated to the necessary temperature in a solid carburizing compound, usually a mixture of hardwood charcoal and an oxide or carbonate of the alkalis or alkaline earths. Gas carburizing is finding increasing use because it gives better control over the carbon content of the case. (See Carbon Case Hardening)

CENTRIFUGAL CASTING.

Casting process that consists of pouring molten metal into the cavity of a rotating mould, which can be made of various metals.

CENTRISPINNING

The introduction of liquid metal into a rapidly rotating mould so that the metal is directed by centrifugal force to take up the shape of the mould.

COLD DRAWING

The process of reducing the cross-sectional diameter of tubes or wire by drawing through dies without previously heating the material.

COLD ROLLING

Rolling of metal or steel at room temperature to provide a smooth surface finish and/or enhanced tensile strength. (See Cold-Working).

COLD-WORKING

A method of conferring strength by means of plastic deformation below the annealing or recrystallization temperature. This treatment may consist of cold rolling, hammering, drawing, pressing, heading, spinning, or swaging, usually at room temperature. The hardness and tensile strength are progressively increased with the degree of cold work, whilst the ductility and impact values are lowered. Where this increased hardness is not desired, the material is annealed at various stages between the cold working operations or it may be subjected to a final annealing. Steels containing 0.7-0.85% carbon are often cold worked until they possess a tensile strength of 120 tons/square inch, while piano wires may attain 150 tons/square inch or higher.

CONTINUOUS CASTING

A method of producing cast slabs or billets in long lengths using a single water-cooled copper in crucibles holding about 56 lbs. It was the first process to produce steel in a molten condition, hence the product was called cast steel. It has been replaced by the high frequency process.

CYANIDING

(Cyanide Hardening). The process consists of introducing carbon and nitrogen into the surface of steel by heating it to a suitable temperature (e.g., 760 -845 C.) in a molten bath of sodium cyanide, or a mixture of sodium and potassium cyanide, diluted usually with sodium carbonate, and quenching in water or oil. The process is used where a very thin case of high hardness is required. An immersion of 5 to 10 minutes usually suffices.

DECARBURIZATION

The loss of carbon at the surface of steel as a result of heating in an atmosphere which converts the carbon of the steel to a gaseous form.

DESCALING

- (a) The removal of scale from the surface of steel by mechanical or chemical means, e.g., by sand- or shot-blasting, tumbling, flame descaling, or pickling.
- (b) The removal of scale from the inner surface of boilers and tubes.

DIE CASTING

- (a) The process of pouring metals into final shapes in metal moulds. If the metal is forced into the mould the process is known as pressure die casting, but otherwise it is known as gravity- or permanent mould-die casting. The process is usually applied to alloys having relatively low melting points, e.g., tin, zinc, lead and aluminium or magnesium base alloy. The advantages of this process are the high precision of the castings so produced and the high rates of production which may be achieved.
- (b) The product of the die casting process.

DRAWING

- (a) Drawing out metal rods into wire, in the cold state, by pulling through a series of consecutively smaller holes (dies) in steel plates (draw plates).
- (b) Forging to produce the greatest movement in the longitudinal direction.
- (c) In the solidification of castings, the production of shrinkage cavities by reason of improper design, insufficient feeding, too low a casting temperature.
- (d) In the U.S.A. synonymous with tempering.

DROP FORGING

- (a) A forging operation in which a metal shape is formed by repeated blows from a drop or steam hammer on to a bar or billet placed between a pair of dies. The upper die containing half the impression of the desired shape is fixed in the tup whilst the lower die, containing the other half of the impression, is in the stationary anvil. The force exerted by the hammer causes plastic flow in the metal which imparts a tough fibrous structure to the steel, the die being designed to ensure the most advantageous plastic flow of the material so that the grain follows the contour of the forging with as little interruption as possible. The process is economical only when a large number of reproductions are required, as the cutting of the dies is expensive. Where a change, not only of form but of the section of the material takes place, the product is a drop forging; if only a change of form occurs the product is a drop stamping.
- (b) The metal shape made by the drop forging process. In such forgings the grain flow or fibre is of importance.

DRY CYANIDING

A process for case hardening steel by heating it to a temperature of between 625° and 850°C. in an atmosphere containing a carburizing gas with ammonia added in controlled amounts. The combined action of the carbon and nitrogen thus added to the steel permits a wide range of case and core characteristics by direct quenching or by cooling slowly in the atmosphere as required.

EXTRUSION

The term, as applied to metals and alloys, comprises essentially the application to a relatively massive billet or blank, of sufficient pressure to cause the metal to flow through a restricted orifice, thereby forming a greatly elongated section. In hot extrusion, the metal is above its recrystallization temperature and thus continuously recrystallizes and is not work hardened during the process. In cold extrusion, the metal does not reach the temperature of recrystallization and may, therefore, be considerably work hardened by the process. In the production of seamless tubes from a hot billet, the latter is forced to flow through a die over a mandrel positioned centrally in the die.

FERRO ALLOYS

A term used for alloys of iron with another metal such as chromium, manganese, silicon, tungsten, molybdenum or vanadium. These alloys are used as a means of introducing the alloying element into steel or cast iron, or as deoxidisers. Ferro alloys are produced by electric smelting or by reduction with aluminium, an exception being high carbon ferro manganese which is normally produced in blast furnaces.

FORGING

- (a) Working metal parts to a finished shape by means of hammering or pressing after the material has been rendered plastic by heating to a high temperature. Forging may be carried out by hammer forging, press forging and drop forging or stamping. Hammer forging is carried out by steam or pneumatic hammers and deformation is brought about by a number of sharp successive blows of short duration, i.e., by shock. Press forging is done by hydraulic presses and the deforming pressure is applied for longer periods.
- (b) The product of the forging operation. (See also Drop Forging)..

FREE CUTTING STEELS

Steels to which special additions have been made to promote machinability. Sulphur, lead or selenium are elements usually added for this purpose.

FULL ANNEALING

A softening process in which the steel is heated to and held for a suitable length of time at a temperature, which for hypo-eutectoid steel is above the transformation range, and for hyper-eutectoid steel within the transformation range, followed by slow cooling to 600 C. or below.

HARD FACING

A method of improving wear resistance by suitable application of a hard protective coating to a metal. Examples are the deposition by welding of Stellite or metal carbide.

HARD METALS

(Cemented Carbides). Powdered carbides of tungsten, tantalum or titanium, cemented into solid masses by mixing with powdered cobalt or nickel, then compressing and sintering. Used for cutting tools, wire-drawing dies and parts subjected to heavy wear or abrasion.

HARDENABILITY

The property that determines the depth and distribution of hardness induced by quenching, i.e., it represents the resistance to transformation. It is generally expressed in relative terms and is related to the critical cooling rate, i.e., the rate at, or above which wholly martensitic structures are formed. This critical cooling rate, or hardenability, is largely a function of composition, although steels of apparently similar composition can have different hardenabilities and the same cast of steel may show fairly wide variations. There is a limit to the section size which can be completely hardened upon quenching. Plain carbon steels are shallow hardening, and alloy additions increase the depth of hardening. The Jominy Test is a method of assessing hardenability.

HARDENING

Increasing the hardness by heat treatment. This usually implies heating to a temperature slightly above the critical range, i.e., for hypo-eutectoid steels above the AC₁ point and for hyper-eutectoid steels above the AC_{cm} point, maintaining at that temperature until diffusion is complete, and by quenching in water, oil or air cooling at a rate sufficiently rapid to prevent or retard the austenite-pearlite transformation, and to form a martensitic or bainitic structure.

HEAT TREATMENT

A process in which steel in the solid state is taken through one or more temperature cycles for the purpose of obtaining certain desired properties. Heating for the sole purpose of hot-working is excluded from the meaning of this definition.

HIGH SPEED STEEL

A high alloy steel, capable of intense hardening, used for metal-cutting tools. It retains its hardness at a low red heat, and hence the tools can be used in lathes, etc., operated at high speeds. It usually contains 12-22% tungsten, up to 5% chromium, up to 1% carbon, and varying amounts of other elements (vanadium, cobalt, etc.). Part or all of the tungsten may be replaced by half its weight of molybdenum.

HOLLOW FORGING

A method of producing hollow bodies, e.g., steel tubes or pressure vessels, in which a comparatively small hole, trepanned in a solid forging, is expanded on a mandrel under a forging press or on a becking bar.

HOT WORK

The mechanical working, by rolling, forging or extruding, of a metal or alloy at a temperature above its recrystallization point. This temperature varies according to the composition of the material.

NITRIDING

A process for producing a hard surface on special types of steel by heating in contact with partly dissociated ammonia or other suitable medium for periods of 10 to 90 hours at a temperature of about 500 C. A hard surface can be obtained on steels containing elements such as Al, Cr, Mo, V, W, etc., which form stable carbides. The original Nitralloy steels range between 0.50 and 0.20% carbon, with about 1.5% chromium, 1.10% aluminium and 0.2% molybdenum, but other grades have been developed which contain no aluminium and are characterized by possessing a case of lower intrinsic hardness and greater ductility and toughness. Together, the various types of Nitralloy steel embrace, when nitrided, a range of surface hardness from 600-1100 diamond number.

NOBLE METALS

Metals such as gold and platinum which are resistant to corrosion by all but the most powerful acids, such as aqua regia, i.e., a mixture of 3 parts hydrochloric acid and 1 part nitric acid.

NON-AGEING STEEL

Low carbon steel to which is added an element (usually aluminium, less commonly titanium or vanadium) which stabilizes the active nitrogen or carbon to prevent strain ageing.

NON-DESTRUCTIVE TESTING

Any form of testing which does not result in permanent damage or deformation to the part being tested. Examples are ultrasonic inspection, X-ray inspection, gamma radiography, magnetic crack detection and dye penetrant inspection.

NON-MAGNETIC STEELS

Austenitic steels, such as 14% manganese-, 25% nickel-, and 18/8 chromium-nickel steels, under normal conditions.

NORMALIZING

Heating to, and if necessary holding at, a suitable temperature, i.e., about 50 C. above the transformation range followed by cooling in still air so that moderately rapid cooling occurs, the object being to eliminate internal stresses, refine the grain size, render the structure more uniform, and improve the mechanical properties. It is used specially for large forgings or castings which cannot be quenched and tempered, and to produce a more uniform structure than exists in untreated pieces.

ORANGE PEEL EFFECT

An effect which arises from the roughening of the surface due to the coarse grain size, when steel sheets are stretched beyond their elastic limit. Also applied to the roughening of the surface of hard rolls arising from differential wear.

PEELED BAR

A round bar that has been centreless machined to remove its outer surface. The peeling process takes less than one-fourth the time of conventional lathe turning operations.

PICKLING

The process of chemically removing scale or oxide from metal objects to obtain a chemically clean surface. This is usually effected by immersion in an acid bath. For steel, the acids generally employed are sulphuric and hydrochloric to which is added an inhibitor (restrainer).

PROCESS ANNEALING

A process, commonly applied in the sheet and wire industries, in which an iron-base alloy is heated to a temperature close to, but below, the lower limit of the transformation range, and subsequently cooled. This process is applied for the purpose of softening for further cold-working.

QUENCHING

Rapid cooling from an elevated temperature, generally carried out by immersion in a liquid bath of oil or water. The usual effect is to confer hardness as the sudden abstraction of heat suppresses the phase transformation of austenite to pearlite, forming instead the harder constituents bainite and/or martensite. The austenitic steels such as Staybrite and 14% manganese steel are not hardened by quenching.

ROLLING

- (a) The process of shaping steel by passing it between two rolls revolving at the same peripheral speed and in opposite directions.
- (b) The preparation of a cylindrical forging by rounding stock between swaging tools prior to the drop forging operation.
- (c) An operation similar to tumbling, in that the metal parts and abrasives are loaded in a barrel or similar mechanism, but differing in that the work and abrasives are rolled in such a way that the load rolls over and over upon itself in a continuous flowing motion in relation to the rotating barrel. Such rolling removes flash, rough spots and scale, and cuts down a metal surface to an even and uniform condition.

ROTARY FURNACE

A furnace having a hearth, circular in plan view, which is slowly rotated, the walls and roof being stationary. The workpieces are charged through a door on to the hearth and are carried round for one revolution during which they pass various burners adjusted to complete the required temperature cycle.

SHOT-BLASTING

A method of cleaning the surface of metals by abrasion, as in sand-blasting, the sand being replaced by broken shot or steel grit. It is less effective than sand-blasting, as the peening effect of the shot tends to drive the unwanted deposit, e.g., oxides, into the surface of the metal.

SHOT PEENING

Superficial cold working by directing a stream of metal shot on to the surface of a metal article. The fatigue strength is improved since the surface becomes slightly work hardened and acquires a residual compressive stress.

SILVER STEEL

A name given to bright drawn carbon steels, containing about 0.95-1.25% carbon with low sulphur and phosphorus and normal silicon and manganese. It has no silver in its composition.

STABILIZERS

Elements added to austenitic stainless steels, of the type containing 15 to 20% chromium and 12 to 8% nickel, for the purpose of forming a stable carbide, thus preventing any tendency to intercrystalline corrosion or weld decay. The stabilizers in most common use are titanium and niobium. (The titanium should be added to the extent of 4 to 5 times, and niobium 8 to 10 times, the carbon content.)

STRESS RELIEF HEAT TREATMENT

(Stress Relieving). A process of reducing residual stresses in a metal object by heating to a suitable temperature, e.g., 600° to 650° C. and holding for a sufficient time for the internal stresses to be released by creep. After soaking, the structure is allowed to cool slowly. This treatment may be applied to relieve stresses induced by casting, quenching, normalizing, machining, cold-working or welding.

SUB-CRITICAL ANNEALING

(Process Annealing). Heating to, and holding at, some temperature below the transformation range. Subsequent cooling may be in air.

SWAGING

A process by which metal is worked into the desired shape by a series of blows rapidly applied by suitably shaped dies in order to produce close tolerances in cylindrical or tapered bars or tubes. In hand swaging, the bar or tube is rotated whilst the dies are stationary. In machine or rotary swaging, the dies, usually two in number but sometimes four on large machines, reciprocate rapidly as the spindle on which they are mounted rotates. This means that the finished work must be round, but within this limitation swaging can be applied to a wide variety of pointing, tapering, sizing and reducing operations.

TEMPER

- (a) The operation of tempering.
- (b) The degree of hardness left in a steel after quenching and tempering.
- (c) The amount of carbon present in a steel, e.g., razor temper 1.5% C., file temper 1.3%C., die temper 0.75% C.
- (d) The percentage increase in length of a sheet after cold rolling.
- (e) The degree of hardness of cold rolled low carbon steel strip as controlled by heat treatment and cold deformation. Strip is produced in a series of tempers from full hard or hard temper (in the U.S.A No.1 temper), which is the most heavily cold rolled condition, to soft or dead soft (No.5 temper U.S.A.) which is the annealed condition.
- (f) The moisture content of a sand at which any certain maximum physical test value is obtained.
- (g) (verb) The process of mixing sand with sufficient water or other liquid to develop its moulding properties.