A

Acicular Ferrite – A highly sub-structured non-equiaxed ferrite that forms upon continuous cooling by a mixed diffusion and shear mode of transformation that begins at a temperature slightly higher than the temperature transformation range for upper bainite. It is distinguished from bainite in that it has a limited amount of carbon available; thus, there is only a small amount of carbide present.

Acicular Ferrite Steels – Those steels having a microstructure consisting of either acicular ferrite or a mixture of acicular ferrite and equiaxed ferrite.

Age Hardening - Hardening by aging, usually after rapid cooling or cold working.

Air-Hardening Steel – A steel containing sufficient carbon and other alloying elements to harden fully during cooling in air or other gaseous mediums from a temperature above its transformation range. The term should be restricted to steels that are capable of being hardened by cooling in air in fairly large sections, about 2 inches or more in diameter. Same as self-hardening steel.

Alloy Steel – Steel containing specified quantities of alloying elements (other than carbon and the commonly accepted amounts of manganese, copper, silicon, sulfur, and phosphorus) within the limits recognized for constructional alloy steels, added to effect changes in mechanical or physical properties.

Alpha Iron – The body-centered cubic form of pure iron, stable below 910 degrees Celsius (1670 degrees F)

Annealing – A generic term denoting a treatment, consisting of heating to and holding at a suitable temperature followed by cooling at a suitable rate, used primarily to soften metallic materials, but also to simultaneously produce desired changes in other properties or in microstructure. The purpose of such changes may be, but is not confined to: improvement of machinability, facilitation of cold work, improvement of mechanical or electrical properties, and/or increase in stability of dimensions. When the term is used without qualification, full annealing is implied. When applied only for the relief of stress, the process is properly called stress relieving, or stress-relief annealing.

In ferrous alloys, annealing usually is done above the upper critical temperature, but the time-temperature cycles vary widely in both maximum temperature attained and in cooling rate employed, depending on composition, material condition, and results desired. When applicable, the following commercial process names should be used: black annealing, blue annealing, box annealing, bright annealing, cycle annealing, flame annealing, full annealing, graphitizing, in-process annealing, isothermal annealing, malleablizing, orientation annealing, process annealing, quench annealing, spheroidizing, sub-critical annealing.

In nonferrous alloys, annealing cycles are designed to: (a) remove part or all of the effects of cold working (re-crystallization may or may not be involved); (b) cause

substantially complete coalescence of precipitates from solid solution in relatively coarse form; or (c) both, depending on composition and material condition. Specific process names in commercial use are final annealing, intermediate annealing, partial annealing, recrystallization annealing, stress-relief annealing, anneal to temper.

Austempering – A heat treatment for ferrous alloys in which a part is quenched from the austenitizing temperature at a rate fast enough to avoid formation of ferrite or pearlite and then held at a temperature just above M until transformation to bainite is complete.

Austenite – A solid solution of one or more elements in face-centered cubic iron. Unless otherwise designated (such as nickel austenite), the solute is generally assumed to be carbon.

Austenitic Grain Size – The size attained by the grains of steel when heated to the austenitic region; may be revealed by appropriate etching of cross sections after cooling to room temperature.

Austenitic Steel – An alloy steel whose structure is normally austenitic at room temperature.

Austenitizing – Forming austenite by heating a ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing). When used without qualification, the term implies complete austenitizing.

B

Bainite – A metastable aggregate of ferrite and cementite resulting from the transformation of austenite at temperatures below the pearlite range but above Ms. Its appearance is feathery if formed in the upper part of the bainite transformation range; acicular, resembling tempered martensite, if formed in the lower part.

Bend Test – A test for determining relative ductility of metal that is to be formed (usually sheet, strip, plate or wire) for determining soundness and toughness of metal (after welding, for example). The specimen is usually bent over a specified diameter through a specified angle for a specified number of cycles.

Blue Brittleness – Brittleness exhibited by some steels after being heated to some temperature within the range of about 200 to 370 degree Celsius (400 to 700 F), particularly if the steel is worked at the elevated temperature. Killed steels are virtually free of this kind of brittleness.

Brinell Hardness Test – A test for determining the hardness of a material by forcing a hard steel or carbide ball of specified diameter into it under a specific load. The result is expressed as the Brinell hardness number, which is the value obtained by dividing the applied load in kilograms by the surface area of the resulting impression in square millimeters.

Brittleness – The quality of a material that leads to crack propagation with appreciable plastic deformation.

C

Carbide – A compound of carbon with one or more metallic elements.

Carbon Steel – Steel having no specified minimum quality for any alloying element (other than the commonly accepted amounts of manganese, silicon, and copper) and that contains only an incidental amount of any element other than carbon, silicon, manganese, copper, sulfur and phosphorus.

Carburizing – Absorption and diffusion of carbon into solid ferrous alloys by heating to a temperature usually above Ac3, in contact with a suitable carbonaceous material. A form of case hardening that produces a carbon gradient extending inward from the surface, enabling the surface layer to be hardened either by quenching directly from the carburizing temperature or by cooling to room temperature, then re-austenitizing and quenching.

Case – That portion of a ferrous alloy, extending inward from the surface, whose composition has been altered so that it can be case hardened. Typically considered to be the portion of the alloy (a) whose composition had been measurably altered from the original composition, (b) that appears dark on an etched cross section, or (c) that has a hardness, after hardening, equal to or greater than a specified value. Contrast with core.

Case Hardening – A generic term covering several processes applicable to steel that change the chemical composition on the surface layer by absorption of carbon, nitrogen, or a mixture of the two and, by diffusion, create a concentration gradient. The processes commonly used are carburizing and quench hardening; cyaniding; nitriding,; and carbonitriding. He use of he applicable specific process name is preferred.

Cementite – A compound of iron and carbon, known chemically as iron carbide and having the approximate chemical formula Fe3C. It is characterized by an orthorhombic crystal structure. When it occurs as a phase in steel, the chemical composition will be altered by the presence of manganese and other carbide-forming elements.

Charging – Placing materials into a furnace

Charpy Test – A pendulum-type single-low impact test in which the specimen, usually notched, is supported at both ends as a simple beam and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of the pendulum, is a measure of impact strength or notch toughness. Contrast with Izod Test.

Chevron Pattern – A fractographic pattern of radial marks (shear ledges) that looks like nested letters “V”; sometimes called a herringbone pattern. Chevron patterns are typically found on brittle fracture surfaces in parts whose widths are considerably greater than their thickness. The points of the chevrons can be traced back to the fracture origin.

Conditioning Heat Treatment – A preliminary heat treatment used to prepare material for a desired reaction to a subsequent heat treatment. For the term to be meaningful, the exact heat treatment must be specified.

Continuous Casting – A casting technique in which a cast shape is continuously withdrawn through the bottom of the mold as it solidifies, so that its lengths not determined by mold dimensions. Used chiefly to produce semi-finished mill products such as billets, blooms, ingots, slabs and tubes.

Continuous Mill – A rolling mill consisting of a number of stands of synchronized rolls (in tandem) in which metal undergoes successive reductions as it passes through the various stands.

Controlled Cooling – Cooling from an elevated temperature in a predetermined manner, to avoid hardening, cracking, or internal damage, or to produce desired microstructure or mechanical properties.

Cooling Curve – A curve shoeing the relation between time and temperature during the cooling of a material.

Cooling Stresses – Residual stresses resulting from non-uniform distribution of temperature during cooling.

Critical Cooling Rate – The rate of continuous cooling required to prevent undesirable transformation. For steel, it is the minimum rate at which austenite must be continuously cooled to suppress transformations above the Ms temperature.

Critical Point – the temperature or pressure at which a change in crystal structure, phase or physical properties occurs. Same as transformation temperature.

D

Double Aging – Employment of tow different aging treatments to control the type of precipitate formed from a sub-persaturated matrix in order to obtain the desired properties. The first aging treatment, sometimes referred to as intermediate or stabilizing, is usually carried out at a higher temperature than the second.

Double Tempering – A treatment in which a quench-hardened ferrous metals is subjected to two complete tempering cycles, usually at substantially the same temperature, for the purpose of ensuring completion of the tempering reaction and promoting stability of the resulting microstructure.

Ductitily – The ability of a material to deform plastically without fracturing, being measured by elongation or reduction of area in a tensile test, by height of cupping in an Erichsen test or by other means.

E

Elastic Deformation – A change in dimensions directly proportional to and in phase with an increase or decrease in applied force.

Elasticity – Ability of a solid to deform in direct proportion to and in phase with increases or decreases in applied force.

Elastic Limit – The maximum stress to which a material may be subjected without any permanent strain remaining upon complete release of stress.

Elastic Modulus – Same as modulus of elasticity.

Elastic Ratio – Yeild point divided by tensile strength.

End-Quench Hardenability Test – A laboratory procedure for determining the hardenability of a steel or other ferrous alloy; widely referred to as the Jominy test. Hardenability is determined by heating a standard specimen above the upper critical temperature, placing the hot specimen in a fixture so that a stream of cold water impinges on one end, and after cooling to room temperature is completed, measuring the hardness near the surface of the specimen at regularly spaced intervals along its length. The data are normally plotted as hardness versus distance from the quenched end.

Etching – (1) Subjecting the surface of a metal to preferential chemical or electrolytic attack in order to reveal structural details for metallographic examination. (2) Chemically or electrochemically removing tenacious films from a metal surface to condition the surface for a subsequent treatment, such as painting or electroplating.

Extensometer – An instrument for measuring changes in length caused by application or removal of a force. Commonly used in tension testing of metal specimens.

F

Ferrite – (1) A solid solution of one or more elements in body-centered cubic iron. Unless otherwise designated (for instance, as chromium ferrite) the solute is generally assumed to be carbon. On some equilibrium diagrams, there are two ferrite regions separated by an austenite area. The lower area is alpha ferrite; the upper, delta ferrite. If there is no designation, alpha ferrite is assumed. (2) In the field of magnetics, substances having the general formula:

M++ O2+++ O3

The trivalent metal often being iron.

File Hardness – Hardness as determined by the use of a file of standardized hardness on the assumption that a material that cannot be cut with the file is as hard as, or harder than, the file. Files covering a range of hardnesses may be employed.

Fluorescent Magnetic Particle Inspection – Inspection with either dry magnetic particles or those in a liquid suspension, the particles being coated with a fluorescent substance to increase the visibility of the indications.

Fluorescent Penetrant Inspection – Inspection using a fluorescent liquid that will penetrate any surface opening; after wiping the surface flaws may be detected by the fluorescence, under ultraviolet light, of back-seepage of the fluid.

Forging – Plastically deforming metal, usually hot, into desired shapes with compressive force, with or without dies.

G

Gage Length – the original length of that portion of the specimen over which strain, change of length and other characteristics are measured.

Gamma Iron – The face-centered cubic form of pure iron, stable from 910 to 1400 degrees Celsius (1670 to 2550 F).

Grain Growth – an increase in the average size of the grains in polycrystalline metal, usually as a result of heating at elevated temperature.

Grain Size – (1) For metals, a measure of the areas or volumes of grains in a polycrystalline material, usually expressed as an average when the individual sizes are fairly uniform. In metals containing two or more phases, the grain size refers to that of the matrix unless otherwise specified. Grain sizes are reported in terms of number of grains per unit area or volume, average diameter, or as a grain-size number derived from area measurements. (2) For grinding wheels, see preferred term, grit size.

H

Hardenability – The relative ability of a ferrous alloy to form martensite when quenched from a temperature above the upper critical temperature. Hardenability is commonly measured as the distance below a quenched surface where the metal exhibits a specific hardness (50 HRC, for example) or a specific percentage of martensite in the microstructure.

Hardening – Increasing hardness by suitable treatment, usually involving heating and cooling. When applicable, the following more specific terms should be used: age hardening, case hardening, induction hardening, precipitation hardening, and quench hardening.

Hardness – Resistance of metal to plastic deformation, usually by indentation. However, the term may also refer to stiffness or temper, or to resistance to scratching, abrasion or cutting. Indentation hardness tests, such as Brinell, Rockwell and Vickers.

Heat Treatable Alloy – An alloy that can be hardened by heat treatment.

Heat Treatment – heating and cooling a solid metal or alloy in such a way as to obtain desired conditions or properties. Heating for the sole purpose of hot working is excluded from the meaning of this definition.

Homogenizing – Holding at high temperature to eliminate or decrease chemical segregation by diffusion.

Honing – A low-speed finishing process used chiefly to produce uniform high dimensional accuracy and fine finish, most often on inside cylindrical surfaces. In honing, very thin layers of stock are removed by simultaneously rotating and reciprocating a bonded abrasive stone or stick that is presses against the surface being honed with lighter force than is typical of grinding.

Hooke's Law – Stress is proportional to strain. The law holds up to the proportional limit only.

Hot Quenching – an imprecise term used to cover a variety of quenching procedures in which a quenching medium is maintained at a prescribed temperature above 70 degrees Celsius (160 F)

I

Impact Energy – The amount of energy required to fracture a material, usually measured by means of an Izod or Charpy test. The type of specimen and test conditions affect the values and therefore should be specified.

Impact Test – A test to determine the behavior of materials when subjected to high rates of loading, usually in bending, tension or torsion. The quantity measured is the energy absorbed in breaking the specimen by a single blow, as in the Charpy or Izod tests.

Inclusions – Particles of foreign material in a metallic matrix. The particles are usually compounds (such as oxides, sulfides, or silicates), but may be of any substance that is foreign to (and essentially insoluble in) the matrix.

Indentation Hardness – The resistance of a material to indentation. This is the usual type of hardness test, in which a pointed or rounded indenter is pressed into a surface under a substantially static load.

Indication – In inspection, indication is a response to nondestructive stimulus that implies the presence of an imperfection. The indication must be interpreted to determine if (a) it is a true indication or a false indication and (b) whether or not a true indication represents an unacceptable deviation.

Induction Furnace – An ac electric furnace in which the primary conductor is coiled and generates, by electromagnetic induction, a secondary current that develops heat within the metal charge.

Interrupted Quenching – A quenching procedure in which the work-piece is removed from the first quench at a temperature substantially higher than that of the quenchant and is then subjected to a second quenching system having a different cooling rate than the first.

Isothermal Annealing – Austenitizing a ferrous alloy and then cooling to and holding at a temperature at which austenite transforms to a relatively soft ferrite carbide aggregate.

Isothermal Transformation – a change in phase that takes place at a constant temperature. The tije required for transformation to be completed, and in some instances the time delay before transformation begins, depends on the amount of super-cooling below (or superheating above) the equilibrium temperature for the same transformation.

Izod Test – A pendulum-type single-blow impact test in which the specimen, usually notched, is fixed at one end and broken by a falling pendulum, is a measure of impact strength or notch toughness. Contrast with Charpy test.

K

Knoop Hardness – Microhardness determined from the resistance of metal to indentation by a pyramidal diamond indenter, having edge angles of 172 degrees 30’ and 130 degrees, making a rhombohedral impression with one long and one short diagonal.

L

Lap – A surface imperfection, appearing as a seam, caused by folding over hot metal, fins or sharp corners and then rolling or forging them into the surface, but not welding them.

Longitudinal Direction – the principal direction of flow in a worked metal.

M

Magnetic-Particle Inspection – A non-destructive method of inspection for determining the extistence and extent of surface cracks and similar imperfections in ferromagnetic materials. Finely divided magnetic, applied to the magnetized part, are attracted to and outline the pattern of any magnetic-leakage fields created by discontinuities.

Maraging – A precipitation-hardening treatment applied to a special group of iron-base alloys to precipitate one or more inter-metallic compounds in a matrix of essentially carbon-free martensite. NOTE: the first developed series of maraging steels contained, in addition to iron, more than 10% nickel and one or more supplemental hardening elements. In this series, aging is done at 480 degrees Celsius (900 F)

Martempering – (1) A hardening procedure in which the austenitized ferrous work-piece is quenched into an appropriate medium whose temperature is maintained substantially at the M3 of the work-piece, held in the medium until the temperature is uniform throughout—but not long enough to permit bainite to form—and then cooled in air. The treatment is frequently followed by tempering. (2) When the process is applied to carburized material, the controlling Ms temperature is that of the case. This variation of the process is frequently called marquenching.

Martensite – A generic term for microstructures formed by diffusion-less phase transformation in which the parent and product phases have a specific crystallographic relationship. Martensite is characterized by an acicular pattern in the microstructure in both ferrous and nonferrous alloys. In alloys where the solute atoms occupy interstitial positions in the martensitic lattice (such as carbon in iron), the structure is hard and highly strained; but where the solute atoms occupy substitutional positions (such as nickel and iron), the martensite is soft and ductile. T he amount of high temperature phase that transforms to martensite on cooling depends on the lowest temperature attained, there being a rather distinct beginning temperature (Ms) and a temperature at which the transformation is essentially complete (Mf).

Martensite Range – The temperature interval between Ms and Mf.

Martensitic Transformation – A reaction that takes place in some metals on cooling, with the formation of an acicular structure called martensite.

Mechanical Properties – The properties of a material that reveal its elastic and inelastic behavior when force is applied, thereby indicating its suitability for mechanical applications; for example, modulus of elasticity, tensile strength, elongation, hardness, and fatigue limit. Compare with physical properties.

Mechanical Testing – Determination of mechanical properties.

Metal – (1) An opaque lustrous elemental chemical substance that is a good conductor of heat and electricity and, when polished, a good reflector of light. Most elemental metals are malleable and ductile and are, in general, denser than the other elemental substances. (2) As to structure, metals may be distinguished from nonmetals by their atomic binding and electron availability. Metallic atoms tend to lose electrons form the outer shells, the positive ions thus formed being held together by the electron gas produced by the separation. The ability of these "free electrons" to carry an electric current, and the fact that this ability decreases as temperature increases, establish the prime distinctions of a metallic solid. (3) From the chemical viewpoint, and elemental substance whose hydroxide is alkaline. (4) An alloy.

Metallography – the science dealing with the constitution and structure of metals and alloys as revealed by unaided eye or by such tools as low-powered magnification, optical microscope, electron microscope and diffraction or x-ray techniques.

Metallurgy – The science and technology of metals and alloys. Process metallurgy is concerned with the extraction of metals from their ores and with the refining of metals; physical metallurgy, with the physical and mechanical properties of metals as affected by composition, processing and environmental conditions; and mechanical metallurgy, with the response of metals to applied forces.

Mf Temperature – For any alloy system, the temperature at which martensite formation on cooling is essentially finished. See transformation temperature for the definition applicable to ferrous metals.

Micro-hardness – The hardness of material as determined by forcing an indenter such as Vickers or Knoop indenter into the surface of a material under very light load; usually the indentations are so small that they must be measured with a microscope. Capable of determining hardness of different micro-constituents within a structure, or of measuring steep hardness gradients such as those encountered in case hardening.

Micro-structure – The structure of metals as revealed by microscopic examination of the etched surface of a polished specimen.

Mild Steel – Carbon steel with a maximum of about 0.25% C.

Mill Scale – The heavy oxide layer formed during hot fabrication or heat treatment of metals.

Modulus of Elasticity – A measure of the rigidity of metal. Ratio of stress below the proportional limit, to corresponding strain. Specifically, the modulus obtained in tension or compression is Young's modulus, stretch modulus or modulus of extensibility; the modulus obtained in torsion or shear is modulus of rigidity, shear modulus or modulus of torsion; the modulus covering the ratio of the mean normal stress to the change in volume per unit volume is the bulk modulus. The tangent modulus and secant modulant are not restricted within the proportional limit; the former is the slope of the stress-strain curve at a specified point; the latter is the

slope of a line from the origin to a specified point on the stress-strain curve. Also called elastic modulus and coefficient of elasticity.

Ms Temperature – For any alloy system, the temperature at which martensite starts to form on cooling. See transformation temperature for the definition applicable to ferrous alloys.

N

Nitriding – Introducing nitrogen into the surface layer of a solid ferrous alloy by holding at a suitable temperature (below Ac1 for ferritic steels) in contact with a nitrogenous material, usually ammonia or molten cyanide of appropriate composition. Quenching is not required to produce a hard case.

Nitrocarburizing – Any of several processes in which both nitrogen and carbon are absorbed into the surface layers of a ferrous material at temperatures below the lower critical temperature and, by diffusion, create a concentration gradient. Nitrocarburizing is done mainly to provide an anti-scuffing surface layer ant to improve fatigue resistance. Compare with carbonitriding.

Nondestructive Inspection – Inspection by methods that do not destroy the part nor impair its serviceability.

Nondestructive Testing – Same as non-destructive inspection, but implying use of a method in which the part is stimulated and its response measured quantitatively or semi-quantitatively.

Normalizing – Heating a ferrous alloy to a suitable temperature above the transformation range and then cooling in air to a temperature substantially below the transformation range.

Notch Depth – The distance from the surface of a test specimen to the bottom of the notch. In a cylindrical test specimen, the percentage of the original cross-sectional area removed by machining an annular groove.

O

Offset – The distance along the strain coordinate between the initial portion of a stress-strain curve and a parallel line that intersects the stress-strain curve at a value of stress that is used as a measure of the yield strength. It is used for materials that have no obvious yield point. A value of 0.2% is commonly used.

Over-aging – Aging under conditions of time and temperature greater than those required to obtain maximum change in a certain property, so that the property is altered in the direction of the initial value. See aging.

Overheating – Heating a metal or alloy to such a high temperature that its properties are impaired. When the original properties cannot be restored by further heat treating, by mechanical working or by a combination of working and heat treating, the over heating is known as burning.

P

Partial Annealing – An imprecise term used to denote a treatment given cold worked material to reduce the strength to controlled level or to effect stress relief. To be meaningful, the type of material, the degree of cold work, and the time-temperature schedule must be stated.

Pearlite – A metastable lamellar aggregate of ferrite and cementite resulting from the transformation of austenite at temperatures above the bainite range.

Physical Properties – Properties of a metal or alloy that are relatively insensitive to structure and can be measured without the application of force; for example, density, electrical conductivity, coefficient of thermal expansion, magnetic permeability and lattice parameter. Does not include chemical reactivity. Compare with mechanical properties.

Pitting – Forming small sharp cavities in a metal surface by non-uniform electrode position or by corrosion.

Precipitation Hardening – Hardening caused by the precipitation of a constituent from a supersaturated solid solution. See also age hardening and aging.

Preheating – Heating before some further thermal or mechanical treatment. For tool steel, heating to an intermediate temperature immediately before final austenitizing. For some nonferrous alloys, heating to a high temperature for a long time, in order to homogenize the structure before working. In welding and related processes, heating to an intermediate temperature for a short time immediately before welding, brazing, soldering, cutting or thermal spraying.

Proof Stress – (1) The stress that will cause a specified small permanent set in a material. (2) A specified stress to be applied to a member or structure to indicate its ability to withstand service loads.

Q

Quench-Age Embrittlement – Embrittlement of low-carbon steel evidenced by a loss of ductility on aging at room temperature following rapid cooling from a temperature below the lower critical temperature.

Quench Aging – Aging induced by rapid cooling after solution heat treatment.

Quench Annealing – Annealing an austenitic ferrous alloy by solution heat treatment followed by rapid quenching.

Quench Cracking – Fracture of a metal during quenching from elevated temperature. Most frequently observed in hardened carbon steel, alloy steel or tool steel parts of high hardness and low toughness. Cracks often emanate from fillets, holes, corners or other stress raisers and result from high stresses due to the volume changes accompanying transformation to martensite.

Quench Hardening – (1) Hardening suitable alpha-beta alloys (most often certain copper or titanium alloys) by solution treating and quenching to develop a martensite-like structure. (2) In ferrous alloys, hardening by austenitizing and then cooling at a rate such that a substantial amount of austenite transforms to martensite.

Quenching – Rapid cooling. When applicable, the following more specificterms should be used: direct quenching, fog quenching, hot quenching, interrupted quenching, selective quenching, spray quenching and time quenching.

Quench Time – In resistance welding, the time from the finish of the weld to the beginning of temper. Also called chill time.

R

Recrystallization – (1) The formation of a new, strain-free grain structure from that existing in cold worked metal, usually accomplished by heating. (2) The change from on crystal structure to another, as occurs on heating or cooling through a critical temperature.

Recrystallization Annealing – Annealing cold worked metal to produce a new grain structure without phase change.

Recrystallization Temperature – The approximate minimum temperature at which complete recrystallization of a cold worked metal occurs within a specified time

Reduction of Area – (1) Commonly, the difference, expressed as a percentage of original area, between the original cross-sectional area of a tensile test specimen and the minimum cross sectional area measured after complete separation. (2) The difference, expressed as a percentage of original area, between original cross-sectional area and that after straining the specimen.

Refractory – (1) A material of very high melting point with properties that make it suitable for such uses as furnace linings and kiln construction. (2) The quality of resisting heat.

Residual Elements – Elements present in an alloy in small quantities, but not added intentionally.

Residual Stress – Stress present in an alloy in small quantities, but not added intentionally.

Residual Stress – Stress present in a body that is free of external forces or thermal gradients.

Rockwell Hardness Test – An indentation hardness test based on the depth of penetration of a specified penetrator into the specimen under certain arbitrarily fixed conditions.

Rolling – Reducing the cross-sectional area of metal stock, or otherwise shaping metal products, through the use of rotating rolls.

Roll Straightening – Straightening of metal stock of various shapes by (1) passing it through a series of staggered rolls, the rolls usually being in horizontal and vertical planes; or (2) by reeling in two-roll straightening machines.

S

Sample – One or more units of product (or a relatively small quantity of a bulk material) that is withdrawn from a lot or process stream, and that is tested or inspected to provide information about the properties, dimensions or other quality characteristics of the lot or process stream. Not to be confused with specimen.

Scaling – (1) Forming a thick layer of oxidation products on metals at high temperature. (2) Depositing water-insoluble constituents on a metal surface, as in cooling tubes and water boilers.

Sensitization – In austenitic stainless steels, the precipitation of chromium carbides, usually at grain boundaries, upon exposure to temperatures of about 550 to 850 °C (100 to 1550 °F), leaving the grain boundaries depleted of chromium and therefore susceptible to preferential attack by a corroding (oxidizing) medium.

Shear Fracture – A ductile fracture in which a crystal (or a polycrystalline mass) has separated by sliding or tearing under the action of shear stresses.

Shear Strength – The stress required to produce fracture in the plane of cross section, the conditions of loading being such that the directions of force and of resistance are parallel and opposite although their paths are offset a specified minimum amount. The maximum load divided by the original cross-sectional area of a section separated by shear.

Slack Quenching – The incomplete hardening of steel due to quenching from the austenitizing temperature at a rate slower than the critical cooling rate for the particular steel, resulting in the formation of one or more transformation products in addition to martensite.

Snap Temper – A precautionary interim stress-relieving treatment applied to high-hardenability steels immediately after quenching to prevent cracking because of delay in tempering them at the prescribed higher temperature.

Solution Heat Treatment – Heating an alloy to a suitable temperature, holding at that temperature long enough o cause one or more constituents to enter into solid solution, and then cooling rapidly enough to hold these constituents in solution.

Specimen – A test object, often of standard dimensions or configuration, that is used for destructive or nondestructive testing. One or more specimens may be cut from each unit of a sample.

Spheroidite – An aggregate of iron or alloy carbides of essentially spherical shape dispersed throughout a matrix of ferrite.

Spheroidizing – Heating and cooling to produce a spheriodal or globular form of carbide in steel. Spheroidizing methods frequently used are:

1. Prolonged holding at a temperature just below Ae1

2. Heating and cooling alternately between temperatures that are just above and below Ae1

3. Heating to a temperature above Ae1 or Ae3 and then cooling very slowly in the furnace or holing at a temperature just below Ae1

4. Cooling at a suitable rate from the minimum temperature at which all carbide is dissolved, to prevent the reformation of a carbide network, and then reheating in accordance with method 1 or 2 above. (Applicable to hypereutectoid steel containing a carbide network.)

Stabilizing Treatment – (1) Before finishing to final dimensions, repeatedly heating a ferrous or nonferrous part to or slightly above its normal operating temperature and then cooling to room temperature to ensure dimensional stability in service. (2) Transforming retained austenite in quenched hardenable steels, usually by cold treatment. (3) Heating a solution-treated stabilized grade of austenitic stainless steel to 870 to 900 degrees Celsius (1600 to 1650 F) to precipitate all carbon as TiC, NbC, or TaC so that sensitization is avoided on subsequent exposure to elevated temperature.

Stainless Steel – Any of several steels containing 12 to 30% chromium as the principle alloying element; they usually exhibit passivity in aqueous environments.

Steel – An iron base alloy, malleable in some temperature ranges as initially cast, containing manganese, usually carbon, and often other alloying elements. In carbon steel and low-alloy steel, the maximum carbon is about 2.0%; in high-alloy steel, about 2.5%. The dividing line between low-alloy and high-alloy steels is generally regarded as being about 5% metallic alloying elements.

Steel is to be differentiated from two general classes of “irons”: the cast irons, on the high carbon side, and the relatively pure irons such as ingot iron, carbonyl iron, and elecrtrolytic iron, on the low-carbon side. In some steels containing extremely low carbon, the manganese content is the differentiating factor, steel usually containing at least 0.25%; Ingot iron, considerably less.

Step Aging – Aging at two or more temperatures, by steps, without cooling to room temperature after each step.

Strain – a measure of the relative change in the size or shape of a body. Linear strain is the change per unit length of a linear dimension. True strain (or natural strain) is the natural logarithm of the ratio of the length at the moment of observation to the original gage length. Conventional strain is the linear strain over the original gage length. Shearing strain (or shear strain) is the change in angle (expressed in radians) between two lines originally at right angles. When the term “strain” is used alone it usually refers to the linear strain in the direction of applied stress.

Strain-Age Embrittlement – A loss in ductility accompanied by an increase in hardness and strength that occurs with low-carbon steel (especially rimmed or capped steel) is aged following plastic deformation. The degree of embrittlement is a function of aging time and temperature, occurring in a matter of minutes at about 200 degrees Celsius (400 F) but requiring a few hours to a year at room temperature.

Strain Aging – Aging induced by cold working.

Strain Energy – (1) The work done in deforming a body. (2) The work done in deforming a body within the elastic limit of the material. It is more properly termed elastic strain energy and can be recovered as work rather than heat.

Strain Rate – The time rate of straining for the usual tensile test. Strain as measured directly on the specimen gage length is used for determining strain rate. Because strain is dimensionless, the units of strain are reciprocal time.

Stress – Force per unit area, often thought of as force acting through a small area within a plane, called normal stress and shear stress, respectively. True stress denotes the stress where force and area are measured at the same time. Conventional stress, as applied to tension and compression tests, is force divided by the original area. Nominal stress is the stress computed by simple elasticity formulas, ignoring stress raisers and disregarding plastic flow; in a notch bend test, for example it is bending moment divided by minimum section modulus.

Stress Relieving – Heating to a suitable temperature, holding long enough to reduce residual stresses and then cooling slowly enough to minimize the development of new residual stresses.

Sub-Critical Annealing – a process anneal performed on ferrous alloys at a temperature below Ac1.

Surface Hardening – A generic term covering several processes applicable to a suitable ferrous alloy that produces, by quench hardening only, a surface layer that is

harder or more resistant than the core. There is no significant alteration of the chemical composition of the surface layer. The processes commonly used are induction hardening, flame hardening and shell hardening. Use of the applicable specific process name is preferred.

T

Temper – (1) In heat treatment, reheating hardened steel or hardened cast iron to some temperature below the eutectoid temperature for the purpose of decreasing hardness and increasing toughness. The process also is sometimes applied to normalized steel. (2) In tool steels, temper is sometimes used, but inadvisedly, to denote the carbon content. (3) In nonferrous alloys (steels that cannot be hardened by heat treatment), the hardness and strength produced by mechanical or thermal treatment, or both, and characterized by a certain structure, mechanical properties, or reduction in area during cold working. (4) To moisten sand for casting molds with water.

Temper Brittleness – Brittleness that results when certain steels are held within, or are cooled slowly through, a certain range of temperature below the transformation range. The brittleness is manifested as an upward shift in ductile-to-brittle transition temperature, but only rarely produces a low value of reduction area in a smooth-bar tension test of the embrittled material.

Tensile Strength – In tensile testing, the ratio of maximum load to the original cross-sectional area.

Thermocouple – A device for measuring temperatures, consisting of lengths of two dissimilar metals or alloys that are electrically joined at one end and connected to a voltage-measuring instrument at the other end. When one junction is hotter than the other, a thermal electromotive force is produced that is roughly proportional to the difference in temperature between the hot and col junctions.

Tool Steel – Any of a class of carbon and alloy steels commonly used to make tools. Tools steels are characterized by hardness and resistance to abrasion, often accompanied by high toughness and resistance to softening at elevated temperature. These attributes are generally attained with high carbon and alloy contents.

Toughness – Ability of a metal to absorb energy and deform plastically before fracturing. It is usually measured by the energy absorbed in a notch impact test, but the area under stress strain curve in tensile testing is also a measure of toughness.

Tramp Alloys – Residual alloying elements that are introduced into steel when unidentified alloy steel is present in the scrap charge to a steel-making furnace.

Transformation Ranges – Those ranges of temperature within which a phase forms during heating and transforms during cooling. The two ranges are distinct, sometimes overlapping, but never coinciding. The limiting temperatures of the

ranges depend on the composition of the alloys and on the rate of change of temperature, particularly during cooling.

Transformation Temperature – The temperature at which a change in phase occurs. The term is sometimes used to denote the limiting temperature of a transformation range. The following symbols are used for iron and steels:

· Accm – In hypereutectoid steel, the temperature at which the solution of cementite in austenite is completed during heating.

· Ac1 – The temperature at which austenite begins to form during heating.

· Ac3 – The temperature at which transformation of ferrite to austenite is completed during heating.

· Ac4 – The temperature at which austenite transforms to delta ferrite during heating.

· Aecm, Ae1, Ae3, Ae4 – The temperatures of phase changes at equilibrium.

· Arcm – In hypereutectoid steel, the temperature at which precipitation of cementite starts during cooling.

· Ar1 – The temperature at which transformation of austenite to ferrite or to ferrite plus cementite is completed during cooling.

· Ar3 – The temperature at which austenite begins to transform to ferrite during cooling.

· Ar4 – The temperature at which delta ferrite transforms to austenite during cooling.

· Ar' – The temperature at which transformation of asutenite to pearlite starts during cooling.

· Mf – The temperature at which transformation of austenite to martensite finishes during cooling.

· Ms (or Ar") – The temperature at which martensite starts during cooling.

NOTE: All these changes except the formation of martensite occur at lower temperatures during cooling than during heating, and depend on the rate of change of temperature.

Transverse – Literally, "across", usually signifying a direction or plane perpendicular to the direction of working. In rolled plate or sheet, the direction across the width is often called long transverse, and the direction through the thickness, short transverse.

Trepanning – A type of boring where an annular cut is made into a solid material with the coincidental formation of a plug or solid cylinder.

U

Ultimate Strength – the maximum conventional stress (tensile, compressive or shear) that a material can withstand.

Ultrasonic Testing – A nondestructive test applied to sound-conductive materials having elastic properties for the purpose of locating in homogeneities or structural discontinuities within a material by means of an ultrasonic beam.

Uniform Strain – The strain occurring prior to the beginning of localization of strain (necking); the strain to maximum load in the tension test.

V

Vicker's Hardness Test – An indentation hardness test employing a 136 degree diamond pyramid indenter (Vickers) and variable loads enabling the use of one hardness scale for all ranges of hardness from very soft lead to tungsten carbide.

Y

Yield Point – The first stress in a material, usually less than the maximum attainable stress, at which an increase in strain occurs without an increase in stress. Only certain metals exhibit a yield point. If there is a decrease in stress after yielding, a distinction may be made between upper and lower yield points.

Yield Strength – The stress at which a material exhibits a specified deviation from proportionality of stress and strain. An offset of 0.2% is used for many metals. Compare with tensile strength.