ENGINEERING MATERIALS AND METALLURGY

Two mark questions and answers

1. What is Materials Science?

Materials Science is an interdisciplinary subject which is concerned with the study of materials as a whole like behavior of the material, production of the material, applications and study of all properties of the material along with its macro and micro-structures.

2. How do you select a material for the transformer windings?

Oxygen free high conductivity copper is the best material for transformer windings since it has low joule heat losses, high corrosion resistance, high conductivity, high ductility to draw into thin wires and high strength.

3. Mention the required properties of bearing materials.

1. It should have high conductivity.
2. It should have high strength and high impact strength.
3. It should have high fatigue resistance.
4. It should withstand the load without any deformation of friction.

4. What are the required properties of the materials for making thermocouples?

1) The thermocouple material should have larger thermoelectric effect (i.e., produce more voltage or more cooling effect per unit rise of temperature.)
2) It should have high melting point.

Example: Lead telluride semiconductor (where lead is then type and tellurium is The p type semiconductor with 61.9% pb+ 38.1% Te). It has more thermoelectric generators to produce more electric power and thermoelectric refrigerators to produce more cooling effects.

5. What are metallic glasses?

Metallic glasses have the properties of metals and glasses such that they have ductility, malleability and brittleness. Ferromagnetic metallic glasses are in the form of ribbons and are used as light weight magnetic cores having no losses and high energy products.

6. What are advantages of FRP?

i. high strength to weight ratio
ii. high heat resistance
iii. low cost tooling
iv. high electrical conductivity

7. What are SAW materials?

SAW materials are the materials producing surface acoustic waves. The are used in delay lines, filters and oscillators.
Examples : Li Nb O3, Li Ta O3.

8. Mention few biomaterials and their applications.

a. stainless steels (ASTMF – 138) have high tensile strength and high

biocompatibility and are used as steel wires, plates and implant devices.

b. Porous high density polyethylene is used in dental and cortical implants

c. Ceramic implants (Al2 O3 with some Si O2 and alkali metal oxide) are used to make femoral head.

9. Mention few applications of fine ceramics

a. Piezoelectric ceramics are used as SAW devices.

b. Ti2 Ba2 Ca2 Cu3 O3 is a high Tc superconductor.

c. Si C is used as a substrates and varistors.

d. Ba Ti O3 is used as a capacitor dielectric and ferroelectric energy converter.

10. What are cermets?

Cermets are the composite materials having metallic and ceramic properties. Examples : iron, nickel and cobalt carbide ceramics.

Uses : Due to their higher hardness they are used as cutting tools and to shape the Refractories through machining.

11. What are requirements on thermoelectric materials used for power generation?

a. They should have high electrical conductivity

b. They should have low thermal conductivity

c. They should have high thermoelectric power.

12. What are nanophase materials?

Nanophase materials have three dimensional structure having length less than 100nm. They have hybrid properties such that high hardness and high ductility. Further they have nonlinear optical and magnetic properties.

13.What are intermetallic compounds?

Intermetallic compounds have combined properties of metal and nonmetals. Example : Cu Zn alloy. It has ionic bond along with metallic bond. So that it behaves as insulator with high brittleness.

14. What are SMART materials?

SMART materials or intelligent materials are the materials which respond with a change is shape on the application of mechanical stress or a change in viscosity on the application of magnetic or electrical fields.

15. What are the applications of conducting polymers?

Conducting polymers are used to make transistors and diodes, large area light emitting device display and photoconductors. They also act as piezo and pyroelectric materials.

16. What are elastic and plastic materials?

Elastic materials can regain their original shape after removal of the deforming forces and within the elastic limit, the stress is proportional to strain and have high elastic modulus. Example : Steel,Brasses,Gold. Plastic materials can undergo plastic deformation permanently in shape and size by the deforming forces up to the ultimate strength without any fracture. Example : PVC, Polymers.

17. What are true stress and strain?

True stress = l/lo * conventional stress.

Here l = length of wire at any instant while loading and lo = original length of wire before loading and lo = original length of wire before loading Conventional stress = F/Ao = Applied load/Initial cross section area of the wire True stress > conventional strain since l > lo under tension

18. Define ductility and malleability of meterials

Ductility is the wire drawing capacity of the material by plastic deformation without fracture. Copper and platinum are highly ductile materials. Malleability is the sheet form ability of the material by hammering without fracture. Gold and aluminium are the highly malleable materials.

19. Explain viscoelastic behaviour of the polymers.

The combined viscous and elastic properties give rise to viscoelastic behaviour for the materials. By this phenomenon, a stress is applied there is an immediate increase of strain followed by linear variation in strain even though the stress applied remains constant. When the stress is removed, only the elastic strain is removed but the viscous strain resides permanently producing permanent deformation.

20. What are creep and creep resistance

Creep is the property of a material by which it deforms continuously under a steady load (yielding). The deformation during creep is no recoverable. The creep can produce fracture or rupture even though the applied stress is lower than the Ultimate stress. So the creep in materials should be avoided, particularly at high temperatures.

Creep resistance is the property of the material by which the continuation of creep Is stopped.

21. Define fatigue

The failure of a material under repeated applied stress is called fatigue.

22. What are the factors affecting diffusion?

i) Temperature : increases the rate of diffusion
ii) crystal structure : crystal with low packing factor increase the rate of diffusion
iii)Grain size : fine grain material has more diffusion rate
iv)Concentration : value of diffusion coefficient varies with concentration

23. Distinguish between hardening and annealing.

Hardening gives hardness to a material so that its yield strength, corrosion resistance, war resistance and cutting ability are increased. Annealing gives softness and ductility to the materials and also refines the grain size and removes the internal stresses.

24. What are the uses of Vickers hardness test?

i) The material is tested without any destructions so it's a nondestructive testing. After testing the material or product can be used or sold.

ii) Only smaller loads are applied. That would not produce cracks or fractures inside the specimen.

iii) Micro hardness of the surface hardened materials can be determined accurately.

25. What are the advantages of gamma ray radiography over X ray radiography ?

i) Smaller size and lower cost

ii) Power supply and water supply are not required

iii) A number of castings in one exposure can be inspected can be easily inspected.

26. What are the etchants in the case of microstructural examination of a specimen?

Etch ants are some chemicals which are used on the polished specimen surface to identify the higher energy grain boundaries.

27. Define resolving power of microscope.

Resolving power of a microscope is ability of the microscope to show two closer objects as separated ones. The electron microscope has high resolving power such that can it show the individual images of two objects separated by a distance of 10 A.

28. What are the advantaged of laser welding and cutting ?

i) Heat affected zone is very narrow. So that the surrounding layers are not affected in any way.

ii) the laser welding and cutting can done at room temperature without the preheating vacuum condition.

iii) Titanium, quartz and ceramics can be welded or cut or drilled only by this laser material processing.

iv) Higher welding speed of or cutting speed can be achieved.

29. What are the self lubricating bearings?

Self lubricating bearings are porous bearings mode up of bronze using powder metallurgy. The porosities in the bearings hold the lubricating oil inside and while operation, that oil is coming out automatically to lubricate the parts. When there is no operation of the machine, the oil is stored in the pores.

30. Show that in the case of unary phase diagram the number of degrees of freedom is zero at the triple point.At the triple point where the vapor, liquid and solid coexisting therefore P = 3. No.ofcomponents C = 1.Therefore F = C - P + 2 = 1 – 3 + 2 = 0 Here 2 represents the two variables pressure and temperature of pure metal

31. What are low carbon steels? What are their applications?

Low carbon steels have 0.08% to 0.25% carbon. These are soft, ductile and easy to weld. These are used to make wires, rods and thin heats and boiler plates.

32. What are the effects of addition of boron, chromium and cobalt in steels?

Boron: increase the hardness

Chromium: improves wear and impact resistance and increases its strength.
Cobalt: increase its hardness, coercivity and residual magnetic induction.

33. What is corrosion? How will you control it?

Corrosion means the destruction of materials by chemical and electrochemical reactions. It can be prevented by electroplating, cathodic protection, addition of inhibitors and by proper heat treatment.

34. What is meant by fracture?

Fracture refers to the breaking of a component into two or more pieces either during service or during fabrication.

35. What are the four types of fractures?

Four types of fractures are

i) Brittle fracture
ii) Ductile fracture
iii) Fatigue fracture and
iv) Creep fracture.

36. What is ductile fracture?

Ductile fracture is the rupture of a material after a considerable of plastic deformation.

37. What is fatigue fracture?

Materials subjected to extended cyclic loading may result in delayed fracture called fatigue fracture.

38. What is creep?

Under the influence of a constant applied stress many materials continue to deform indefinitely. This process is called creep.

39. What is brittle fracture?

The failure of a material without apartment plastic deformation is called brittle fracture.

40. What are transgranular and intergranular fracture?

In many brittle crystalline materials, crack propagation occurs along specific crystallographic planes; such a process is termed cleavage. This type of fracture is said to be transgranular in tragranular fracture because fracture cracks pass through grains. The fractured surface looks grainy or granular. In some alloys, crack propagation along grain boundaries is also possible; this is termed Intergranular fracture. This yields a relatively shiny and smooth fracture surface.

41. Distinguish between brittle and ductile fractures

Property	Brittle fracture	Ductile fracture
Deformation	minimum	Large plastic
Indication	No warning and occurrence is sudden	Slow tearing of metals
Location	Occurs at the point where micro crack is larges	Occurs in some localized region when the deformation is very less.
Macroscopic strain appearance of fractured surface	Relatively large sharp planar facets.	Negligible dirty with rough contours.

42. What is fatigue?

Ductile materials may also fracture when subjected to cyclic stresses. The cyclic stresses are considerably lower than the static fracture stress. Such a delayed fracture resulting from extended service is called fatigue.

43. Define fatigue limit or endurance limit.

Fatigue limit or endurance limit can be defined as the stress that would cause failure after a specified number of stress reversals.

44. What are the methods to increase the fatigue resistance?

The fatigue resistance of a component can be increased to improve its life by the following methods:

i) Good design a voiding the sharp corners and thereby eliminating the stress concentration.

ii) Removal of surface irregularities which may initiate a crack by polishing the surface of the component and

iii) Hardening the surface either by carburizing or nitriding to increase the resistance to the crack initiation at the surface.

45. What are the different mechanisms of strengthening of materials?

Different mechanisms of strengthening of materials are:

i) Strain (or work) hardening
ii) Solution hardening and
iii) Precipitation and dispersion hardening

46. What are factors which affect creep resistant materials?

Creep is influenced by minor variations in metallurgical conditions. Some of these affecting variables are:

i) Grain size
ii) Prior strain
iii) Formation of solid solutions and
iv) Precipitation and dispersion hardening

47. What are the characteristics of creep resistance materials?

The characteristics of a creep resistance material are

i) Instantaneous extension produced as soon as the test load is applied.

ii) A steady state or secondary creep during which the work-hardening effect of plastic deformation is balanced by recovery

iii) Primary or transient creep stage during which further work hardening occurs

iv) A period of accelerating or tertiary creep leading to eventual fracture.

48. What important characteristics should the bearing metals possess?

A bearing metal should possess the following important characteristics:

a) It should have enough compressive strength to possess adequate load carrying capacity.

b) It should have good plasticity to allow for small variations in alignment and fitting.

c) It should have good wear resistance to maintain a specified fit.

d) It should have low co-efficient of friction to avoid excessive heating.

49. What is a phase or equilibrium diagram? What information may be obtained from an equilibrium diagram?

Phase or equilibrium diagrams are maps or plots that give the relationships between the phases in equilibrium in a system as a function of temperature, pressure and composition. Information concerning the phase changes in many alloy systems can be had from equilibrium diagram.

50. What is meant by a phase? State Gibb's phase rule.

A physically homogeneous and distinct portion of a material system. The number of phases present in an alloy depends upon the number of elements of which the alloy is composed. From thermo dynamical considerations of equilibrium. Gibbs derived following phase rule:

$$F = C - P + 2$$

Where F = degree of freedom system (temperature, pressures, concentration, composition of phases)

C = number of compounds forming the system (i.e. elements or compounds) P = number of phases in the alloy (in equilibrium state)
2 = number of external factors

51. State lever rule

The lever rule is a convenient method of calculating the relative proportions of different phases (solid and liquid) at any given temperature for a given alloy composition. According to the lever rule the tie-line (horizontal line to a given temperature in a phase diagram) is treated as a lever arm, with the fulcrum at the overall composition. The weight at each end corresponds to the amount of the phase at that end of tie-line phase diagram.

52. What is an alloy?

An alloy is a mixture of two or more metals, or a mixture of metal and a non-metal, with the mixture exhibiting metallic properties.

53. Define eutectic reaction

A reaction wherein, upon cooling, one liquid phase transforms isothermally and reversibly into two new solid phases that are intimately mixed is called utectic reaction.

54. Define eutectoid reaction

A reaction wherein, upon cooling, one solid phase transforms isothermally and reversibly into two new solid phases that are intimately mixed is called utectoid reaction.

55. What do you understand by allotropy?

The possibility of existence of two or more different crystal structures for a substance (generally an elemental solid such as iron) is known as allotropy.

56. What is meant by liquidus?

In a constitution or equilibrium diagram, the locus of points representing the temperature at which the various compositions in the system begin to freeze on cooling or to finish melting on heating is called liquidus.

57. What is meant by solidus?

In a constitution or equilibrium diagram, the locus of points representing the temperature at which the various compositions finish freezing on cooling or begin to melt on heating is called solidus.

58. What is ferrite?

Ferrites are body centered cubic solid solutions and body centered cubic allotropes of ά and δ-iron. It is stable over the temperature range from 273^{o} to 908^{o} C in iron

59. What are the possible microstructures of iron and steel?

The possible microstructures of iron and steel which reveal the arrangement, size and shape of the grains and molecules are

a) Ferrite
b) Austenite
c) Cementite
d) Martensite
f) Bainite
g) Sorbite and troostite

60. What is T-T-T diagram?

T-T-T diagram is also called isothermal transformation diagram. It is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to determine when transformation begin and end for an isothermal (constant temperature) heat treatment of a previously austentized alloy.

61. What are the three classes of plain steels?

On the basis of the iron-carbon equilibrium diagram it is possible to describe three classes of plain steels.

i) Hypo-eutectoid steels

These have carbon contents varying from 0.008% to just below 0.83%. ii) Eutectoid steels
These have carbon contents, ideally, of 0.83%
iii) These have carbon contents greater than 0.83%

62. What are the stainless steels and what are the possible classifications based on their microstructure?

The stainless steels are iron-chromium alloys with atleast 11 wt% of chromium. Addition of nickel and molybdenum enhances the corrosion resistance.

Stainless steels are divided into three classes on the basis of the microstructure

a) martensitic stainless steels
b) ferritic stainless steels and
c) austenitic stainless steels

63. What are cast irons and what are their basic types?

Any ferrous alloy made up primarily of iron with about 2% or more carbon is considered to be cast iron. Most commercial alloys contain from about 2.5% to 3.8%
carbon. There are four basic types of cast iron

a) Grey cast iron
b) White cast iron
c) Malleable iron
d) Nodular iron

64. How does the yield strength vary with grain size?

The variation of yield strength σ y with grain size is given by Hall-Petch relation

$$\sigma_y = \sigma_o + k_y d^{-1/2}$$

Where d is the average grain diameter, while σ o and ky are constants for a particular material. Fine grained material is harder and stronger than one that is coarse grained.

65. What is meant by heat treatment? What are the different methods of heat treatment?

Heating and cooling a solid metal or alloy in such a way as to obtain desired conditions or properties is called heat treatment. There are different methods of strengthening and hardening by heat treatment. They are

i) Age hardening (precipitation hardening)
ii) Annealing
iii) Normalizing
iv) Tempering and
v) Case hardening

66. What is age hardening or precipitation hardening?

By uniformly dispersing extremely small particles within the original phase matrix the strength and hardness of metal alloys may be enhanced; this process of heat treatment
is called precipitation hardening or age hardening.

67. What is overaging?

For some alloys, aging occurs spontaneously at room temperature over extended time periods. With increase of time the strength increases and after reaching a maximum a value, if finally diminishes. This type of reduction in yield strength and hardness that occurs after long time periods is known as overaging.

68. What is annealing and what is its purpose?

Annealing means heating the material to and holding at a suitable temperature and then cooling at a suitable rate. Annealing is for the purpose of

i) Reducing hardness
ii) Improving machinability
iii) Facilitating cold working
iv) Producing a desired microstructure and

v) Obtaining desired mechanical, physical and other properties.

69. What is 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 is called normalizing.

70. What is tempering?

Tempering is the process of re-heating the hardened steel to some temperature below its critical temperature in order to impart toughness and to reduce brittleness. This reduces the internal stresses developed during hardening.

71. Explain austempering

The heat treatment for ferrous alloys in which a part is quenching from the autenitizing temperature at a rate fast enough to avoid formation of ferrite or pearlite and held at a temperature just above that of martensite formation until transformation to bainite is complete is called austempering.

72. Explain martempering

The process of quenching an austenitized ferrous alloy is a medium at a temperature in the upper part of the martensite range, or slightly above that range, and holding it in the medium until the temperature throughout the alloy is substantially uniform is known as martempering. The alloy is then allowed to cool in air through the martensite range.

73. What is case hardening?

For many industrial applications, we need a hard wear-resistant surface called yhe case and a relatively soft, tough inside called the core. The process of hardening the surface (case) alone is known as case hardening.

74. What is sub-zero treatment of steel?

Whenever the steel is hardening some amount of austenite is always retained by it. This results in the reduction of hardness, thermal conductivity and wear resistance. The sub-zero treatment of hardened steel reduces the retained austenite. In this process the hardened steel part is cooled to sub-zero temperature (between-30^{o} C to -120^{o} C).

75. What is “patenting”?

A special application of isothermal hardening is called patenting and is used for steel wire. Steel wire with 0.40 – 1.10% carbon is quenched from the hardening temperature in a bath of molten lead to about 400^{o} C to 500^{o} C. A structure results with possesses good ductility in addition to a hardness.

76. Name the industrially important copper alloys.

a) Copper-Zinc (the Brasses)
b) Copper-Tin (the Tin Bronzes)
c) Copper-Tin-Phosphorus (the Phosper Bronzes)
d) Copper-Aluminium (the Aluminium Bronzes)
e) Copper-Nickel (the Cupro-Nickels)

77. What are the uses of high resistivity materials?

High resistivity materials are used
a) In resistor applications
b) As heating elements and
c) In resistance thermometers

78. What is the chemical composition of michrome? Mention its use. The chemical composition of michrome is 80% Ni and 20% Cr. It is used as heating elements in heaters and furnaces.

79. What is the chemical composition of manganin? What are its properties and uses? The chemical composition of manganin is 87% Cu and 13% Mn.
Properties:
It has low temperature coefficient of resistance ($20* 10^{-6}K^{-1}$)
It has high resistivity ($48*10^{-8}\Omega m$)
It has higher ductility
It has good resistance to atmospheric corrosion
Uses:
It is used as standard resistances and shunts.

80. What is the chemical composition of constant? What are its uses?
The chemical composition of constant is 60% Cu and 40% Ni.
It is used for making thermo couples, rheostats and starters for electric motors.

81. Define the term age hardening.

The term as applied to soft or low carbon steels, relates to slow, gradual changes that take place in properties of steels after the final treatment. These changes, which bring about a condition of increased hardness, elastic limit, and tensile strength with a consequent loss in ductility, occur during the period in which the steel is at normal temperatures.

82. What is meant by aging?

Spontaneous change in the physical properties of some metals, which occurs at atmospheric temperatures after final cold working or after a final heat treatment. Frequently synonymous with the term "Age-Hardening."

83. What is air air hardening steel?

Alloy steel which may be hardened by cooling in air from a temperature above the transformation range. Such steels attain their martensitic structure without going through the quenching process. Additions of chromium, nickel, molybdenum and manganese are effective toward this end.

84. What is AISI STEELS?

Steels of the American Iron and Steel Institute. Common and alloy steels have been numbered in a system essentially the same as the SAE. The AISI system is more elaborate than the SAE in that all numbers are preceded by letters: "A" represents basic open-hearth alloy steel, "B" acid Bessemer carbon steel, "C" basic open-hearth carbon steel, "CB" either acid Bessemer or basic open-hearth carbon steel, "E" electric furnace

alloy steel.

85. State the meaning of aluminum killed steel.
A steel where aluminum has been used as a deoxidizing agent.

86. What is an alloy?
Metal prepared by adding other metals or non-metals to a basic metal to secure desirable properties.

87. What is alloy steel?
Steel containing substantial quantities of elements other than carbon and the commonly-accepted limited amounts of manganese, sulfur, silicon, and phosphorous. Addition of such alloying elements is usually for the purpose of increased hardness, strength or chemical resistance. The metals most commonly used for forming alloy steels are: nickel, chromium, silicon, manganese, tungsten, molybdenum and vanadium. “Low Alloy” steels are usually considered to be those containing a total of less than 5% of such added constituents.

88. What is alpha brass?
A copper-zinc alloy containing up to 38% of zinc. Used mainly for cold working.

89. What is annealing?
A heating and cooling operation implying usually a relatively slow cooling. Annealing is a comprehensive term. The process of such a heat treatment may be: to remove stresses; to induce softness; to alter ductility; toughness; electrical magnetic, or other physical properties; to refine the crystalline structure; to remove gases; to produce a definite micro-structure. In annealing, the temperature of the operation and the rate of cooling depend upon the material being heat treated and the purpose of the treatment.

90. State the Abbreviation of A.S.T.M.
Abbreviation for American Society for Testing Material. An organization for issuing standard specifications on materials, including metals and alloys.

91. What is austempering?
A trade name for a patented heat treating process that consists of quenching a ferrous alloy from temperature above the transformation ranges, in a medium having a rate of heat abstraction sufficiently high to prevent the formation of high-temperature transformation products and in maintaining the alloy, until transformation is complete, at a temperature below that of pearlite formations and above that of martensite formation.

92. What is austenite?
Phase in certain steels, characterized as a solid solution, usually off carbon or iron carbide, in the gamma form of iron. Such steels are known as “austenitic”. Austenite is stable only above 1333°F. in a plain carbon steel, but the presence of certain alloying elements, such as nickel and manganese, stabilizes the austenitic form, even at normal temperatures.

93. What is austenitic steel?

Steel, because of the presence of alloying elements, such as manganese, nickel, chromium, etc., shows stability of Austenite at normal temperatures.

94. How bainite is formed?

A slender, needle-like (acicular) microstructure appearing in spring steel strip characterized by toughness and greater ductility than tempered Martensite. Bainite is a decomposition product of Austenite best developed at interrupted holding temperatures below those forming fine pearlite and above those giving Martensite.

95. Which steel is called as carbon steel?

Common or ordinary steel as contrasted with special or alloy steels, which contain other alloying metals in addition to the usual constituents of steel in their common percentages.

96. State the meaning of carburizing.

(Cementation) It is the process of adding carbon to the surface of iron-base alloys by absorption through heating the metal at a temperature below its melting point in contact with carbonaceous solids, liquids or gasses. It is the oldest method of case hardening.

97. What is meant by case hardening?

Carburizing and subsequently hardening by suitable heat-treatment, all or part of the surface portions of a piece of iron-base alloy.

98. What is a cast steel?

Any object made by pouring molten steel into molds.

99. What is cementite?

A compound of iron and carbon known as “Iron Carbide,” which has the approximate chemical formula Fe3C containing 6.69% of carbon. Hard and brittle, it is the hard constituents of cast iron, and the normal form in which carbon is present in steel. It is magnetizable, but not as readily as ferrite.

100. What is meant by cyaniding?

It is the process of Surface hardening of an iron-base alloy article or portion of it by heating at a suitable temperature in contact with a cyanide salt, followed by quenching.

101. What is meant by decarburization?

It is the process of removing the carbon from the outer surface of iron or steel, usually by heating in an oxidizing or reducing atmosphere. Water vapor, oxygen and carbon dioxide are strong decarburizers. Reheating with adhering scale is also strongly decarburizing in action.

102. Sate the composition of duralumin.

The trade name applied to the first aluminum-copper-magnesium type of age-hardenable alloy (17S), which contains nominally 4% Cu, ½ % Mg. The term is sometimes used to include the class of wrought aluminum-copper-magnesium alloys that harden during aging at room temperature.

103. What is ferritic stainless steel?

Has a body centered cubic (BCC) structure. These alloys are the chromium stainless steels containing low carbon levels. They are hardenable primarily by cold working, although some will harden slightly by heat treating. Ferritic stainless steels work harden much slower than austentitic stainless steels

104 What is meant by flame hardening?

A process of hardening a ferrous alloy by heating it above the transformation range by means of a high-temperature flame, and then cooling at the required rate.

105 What is full annealing?

Used principally on iron and steel, means heating the metal to about 100°F. above the critical temperature range, followed by "soaking" at this point and slow cooling below the critical temperature.

106 What is a grain?

A solid polyhedral (or many sided crystal) consisting of groups of atoms bound together in a regular geometric pattern. In mill practice grains are usually studied only as they appear in one plane. (1) Direction of: Refers to grain fiber following the direction of rolling and parallel to edges of strip or sheets. (2) To bend across the grain is to bend at right angles to the direction of rolling. (3) To bend with the grain is to bend parallel to the direction of rolling. In steel, the ductility in the direction of rolling is almost twice that at right angles to the direction of rolling.

107 What is grain boundary?

Bounding surface between crystals. When alloys yield new phases (as in cooling), grain boundaries are the preferred location for the appearance of the new phase. Certain deteriorations, such as season cracking and caustic embrittlement, occur almost exclusively at grain boundaries.

108 What is meant by graphitizing?

A heating and cooling process by which the combined carbon in cast iron or steel is transformed, wholly or partly, to graphitic or free carbon.

109 Define the term hardenability.

The ability of a metal, usually steel, to harden in depth as distinguished from the terms "hardness."

110 What is meant by hardness?

Degree to which a metal will resist cutting, abrasion, penetration, bending and stretching. The indicated hardness of metals will differ somewhat with the specific apparatus

measuring hardness. (See Brinell Hardness, Rockwell Hardness, Vickers Hardness, Scleroscope Hardness) Tensile Strength also is an indication of hardness.

111. What is heat treatment?

Altering the properties of a metal by subjecting it to a sequence of temperature changes, time of retention at specific temperature and rate of cooling therefore being as important as the temperature itself. Heat treatment usually markedly affects strength, hardness, ductility, malleability, and similar properties of both metals and their alloys.

112. What is high brass?

65% - A copper-zinc alloy containing 35% zinc. Possesses high tensile strength and is used for springs, screws, rivets, etc.

113. What is hydrogen embrittlement?

> Brittleness of metal, resulting from the occlusion of hydrogen (usually as a by-product of pickling or by co-deposition in electroplating). (2) A condition of low ductility resulting from hydrogen absorption and internal pressure developed subsequently. Electrolytic copper exhibits similar results when exposed to reducing atmosphere at elevated temperature.

114. What is a hypereutectoid steel?

A steel having more than the eutectoid percentage of carbon.

115. What is a hypoeutectoid steel?

Steel with less than eutectoid percentage of carbon.

116. What is induction hardening?

A process of hardening a ferrous alloy by heating it above the transformation range by means of electrical induction, and then cooling as required.

117. What is iron?

(Chemical Symbol Fe.) Element No. 26 of the periodic system; Atomic weight 55.85. A magnetic silver-white metal of high tensile strength ductile and malleable. Melting point of pure iron about 2795°F. Chemically iron is chiefly base forming. The principal forms of commercial iron are steel, cast iron and wrought iron.

118. What is meant by ironing?

Thinning the walls of deep drawn articles by reducing the clearance between punch and die.

119. What is isothermal annealing?

A process on which a ferrous alloy is heated to produce a structure partly or wholly austenitic, and is then cooled to and held at a temperature that causes transformation of the austenite to a relatively soft ferrite-carbide aggregate.

120. What is killed steel?

The term "killed" indicates that the steel has been sufficiently deoxidized to quiet the molten metal when poured into the ingot mold. The general practice is to use aluminum ferrosilicon or manganese as deoxidizing agents. A properly killed steel is more uniform as to analysis and is comparatively free from aging. However, for the same carbon and manganese content.

Killed Steel is harder than Rimmed Steel. In general all steels above 0.25% carbon are killed, also all forging grades, structural steels from 0.15% to 0.25% carbon and some special steels in the low carbon range. Most steels below 0.15% carbon are rimmed steel.

121. What is martensite?

A distinctive needle like structure existing in steel as a transition stage in the transformation of austenite. It is the hardest constituent of steel of eutectoid composition. It is produced by rapid cooling from quenching temperature and is the chief constituent of hardened carbon tool steels. Martensite is magnetic.

122. State the percentage of carbon for medium-carbon steel.

Contains from 0.30% to 0.60% carbon and less than 1.00% manganese. May be made by any of the standard processes.

123. What is meant by metallography?

The science concerning the constituents and structure of metals and alloys as revealed by the microscope.

124. What is a metalloid?

(a) Element intermediate in luster and conductivity between the true metals and non-metals. Arsenic, antimony, boron, tellurium, and selenium, etc., are generally considered metalloids; frequently one allotropic modification of an element will be non-metallic, another metalloid in character. Obviously, no hard and fast line can be drawn. (b) In steel metallurgy, metalloid in has a specialized, even of erroneous, meaning; is covers elements commonly present in simple steel; carbon, manganese, phosphorus, silicon and sulfur.

125. What is muntz metal?

(A Refractory Alloy) - Alpha-beta brass, 60% copper and 40% zinc. Stronger than alpha-brass and used for castings and hot-worked (rolled, stamped, or extruded) products. High strength brasses are developed from this by adding other elements.

127. What is meant by nitriding?

Process of surface hardening certain types of steel by heating in ammonia gas at about 935-1000°F. The increase in hardness being the result of surface nitride formation. Certain alloying constituents, principal among them being aluminum, greatly facilitate the hardening reaction. In general, the depth of the case is less than with carburizing.

128. What is meant by normalizing?

A heat treatment applied to steel. Involves heating above the critical range followed by cooling in still air. Is performed to refine the crystal structure and eliminate internal stress.

129. What is meant by oil hardening?

A process of hardening a ferrous alloy of suitable composition by heating within or above the transformation range and quenching in oil.

130. What is oil-hardening steel?

Steel adaptable to hardening by heat treatment and quenching in oil.

131. Define the structure of PEARLITE.

Lamellar structure resembling mother of pearl. A compound of iron and carbon occurring in steel as a result of the transformation of austenite into aggregations of ferrite and iron carbide.

132. What is phosphor bronze? State its applications.

Copper base alloys, with 3.5 to 10% of tin, to which has been added in the molten state phosphorous in varying amounts of less than 1% for deoxidizing and strengthening purposes. Because of excellent toughness, strength, fine grain, resistance to fatigue and wear, and chemical resistance, these alloys find general use as springs and in making fittings. It has corrosion resisting properties comparable to copper.

133. What is pig iron?

Iron produced by reduction of iron ore in a blast furnace. Pig iron contains approximately 92% iron and about 3.5% carbon. The balance is largely silicone and manganese with a small percentage of phosphorus, sulphur, and other impurities.

134. What is polymorphism?

The ability of a material to exist in more than one crystallographic structure. Numerous metals change in crystallographic structure at transformation temperatures during heating or cooling. If the change is reversible, it is allotropy. The allotropy of iron, particularly the changes between the alpha body-centered and the gamma face centered form, is of fundamental importance in the hardening of steel.

135. What is meant by precipitation hardening?

A process of hardening an alloy in which a constituent precipitates from a supersaturated solid solution. (See also Age Hardening and Aging)

136. What is meant by precipitation heat treatment?

Any of the various aging treatments conducted at elevated temperature to improve certain of the mechanical properties through precipitation from solid solution.

137. What is process annealing?

In the sheet and wire industries, a process by which a ferrous alloy is heated to a temperature close to, but below, the lower limit of the transformation range and is subsequently cooled. This process is applied in order to soften the alloy for further cold working.

138. What is meant by quenching?

In the heat treating of metals, the step of cooling metals rapidly in order to obtain desired properties; most commonly accomplished by immersing the metal in oil or water. In the case of most copper base alloys, quenching has no effect other than to hasten cooling.

139. What is meant by quench hardening?

A process of hardening a ferrous alloy of suitable composition by heating within or above the transformation range and cooling at a rate sufficient to increase the hardness substantially. The process usually involves the formation of martensite.

140. What is meant by recrystallization?

A process whereby a distorted grain structure of cold worked metals is replaced by a new, stress-free grain structure as a result of annealing above a specific minimum temperature for a specific time.

141. What is sorbite?

Structure of steel, resulting from the tempering of martensite. In a truly sorbitic structure, the cementite is completely dispersed in the matrix. The trend is to call this structure tempered martensite.

142. What is meant by spheroidizing?

Any process of prolonged heating and slow cooling of steel which will convert the carbide content into rounded or spheroid form.

143. What is stabilizing treatment?

A thermal treatment designed to precipitate material from solid solution, in order to improve the workability, to decrease the tendency of certain alloys to age harden at room temperature, or to obtain dimensional stability under service at slightly elevated temperatures.

144. Sate the salient property of stainless steel .

Corrosion resistant steel of a wide variety, but always containing a high percentage of chromium. These are highly resistant to corrosion attack by organic acids, weak mineral acids, atmospheric oxidation, etc.

145. What is a steel?

Iron, malleable in at least one range of temperature below its melting point without special heat treatment substantially free from slag, and containing carbon more than about 0.05% and less than about 2.00%. Other alloying elements may be present in significant quantities, but all steels contain at least small amounts of manganese and silicon, and usually as undesirable constituents, also sulfur and phosphorus.

146. What is strain aging?

Aging induced by cold working

147. What is meant by strain hardening?

An increase in hardness and strength caused by plastic deformation at temperatures lower than the recrystallization range.

148. What is meant by stress relieving?

Reducing residual stresses by heating.

149. State the tempering process.

A process of re-heating quench-hardened or normalized steel to a temperature below the transformation range and then cooling at any rate desired. The primary purpose of tempering is to impart a degree of plasticity or toughness to the steel to alleviate the brittleness of its martensite.

150. What is troosite?

Tempered martensite that etches rapidly, usually appears dark, and is not resolved by the microscope.

151. What is a wrought iron?

Iron containing only a very small amount of other elements, but containing 1-3% by weight of slag in the form of particles elongated in one direction, giving the iron a characteristic grain. Is more rust-resistant than steel and welds more easily.