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DEPARTMENT OF MECHANICAL ENGINEERING

ME 44 ENGINEERING MATERIALS AND METALLURGY

2 MARKS QUESTIONS & ANSWERS

Unit – I

CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS

1. What is an **alloy**?

A metal alloy, or simple an alloy, is a mixture of two or more metals or a metal (Metals) and a non-metal (non-metals).

2. How many components are found in an alloy?

Two or more components are found in an alloy.

3. What is meant by **base metal**?

In an alloy, the element which is present in the largest proportion is called the base metal.

4. What are **alloying elements**?

In an alloy, all elements other than the base metal are called the alloying elements.

5. Differentiate between substitutional and interstitial solid solution.

In a **substitutional solid solution**, the solute atoms (impurities) substitute for parent solvent atoms in a crystal lattice.

In **interstitial solid solution**, the solute atoms fit in to the space between the solvent or parent atoms.

6. State Hume **Ruther's rules** for formation of substitutional solid solutions.

1. Size factor: The atoms must be of similar size, with less than a 15% difference in Atomic radius (in order to minimize the lattice strain).

2. Crystal structure: The materials must have the same crystal structure.

3. Valence: The atoms must have the same valence.

4. Electro negativity: The atoms must have approximately the same electro Negativity.

7. What are **intermediate phases**?

If an alloying element is added in excess of the limit of solid solubility, a second Phase appears along with the primary solution. If the second phase differs in both crystal Structure and properties from primary solid solution, then it is known as an 'intermediate' Phase.

8. What are **intermetallic compounds**?

The compound formed by two or more metals in apparently stoichiometric proportion is called intermetallic compounds.

9. What are **electron compounds**?

If two metals consist of atoms more or less similar size but different valency, then the Compounds formed are called electron compounds.

10. Define '**phase'.** What different kinds of phases are possible?

A phase is defined as any physically distinct, homogeneous and mechanically Separable portion of a substance. Three different kinds of phases are solid, liquid and vapour.

11. What is an **equilibrium phase diagram**?

A phase diagram can be defined as a plot of the composition of phases as a function of temperature in any alloy system under equilibrium condition.

12. What are the advantages of the equilibrium diagrams?

1. To show what phases are present at different compositions and temperature under equilibrium conditions.
2. To indicate the equilibrium solid solubility of one element in other element.
3. To indicate the temperature range over which solidification of a material occurs.
4. To indicate the temperature at which different phases start to melt.

13. State **Gibb's phase rule**?

Gibb's phase rule is given by

$$F=C-P+2$$

Where,

F=degrees of freedom of system or number of variables (such as temperature, Pressure or composition) that may be changed independently without altering the Equilibrium;

C=number of components (usually elements or compounds) forming the system; P=no of phases present in the system

14. What are **cooling curves**?

Cooling curves are obtained by plotting the measured temperatures at equal intervals during the cooling period of a melt to a solid.

15. What is liquids line? A Solidus line? A solvus line?

In a phase diagram, liquidus line is the line or boundary that separates liquid and liquid+solid phase regions. Solidus line is a line or boundary that separate solid and solid liquid phase region.Solvus line separate single-phase solid regions from two-phase solid regions.

16. What pieces of information can be obtained for each point in a phase diagram?

Using a phase diagram, one can obtain at least the following three information.

1. The phases that are present,
2. The composition of each phase, and
3. The amount of each phase present.

17. What is **tie-line**?

A tie line is simply an isothermal line drawn through point of consideration, extending across the two-phase region and terminating at the phase boundary lines on either side.

18. What is the lever-law calculation and what information can it provide?

$$\text{Phase fraction} = \frac{\text{Opposite arm of lever}}{\text{Total length of tie line}}$$

$$\text{and phase percentage} = \frac{\text{Opposite arm of lever}}{\text{Total length of tie line}} \times 100$$

Using the lever law calculations, one can compute the phase fraction and the phase percentage.

19. What is mean by **invariant reaction**?

The eutectic reaction is also called an invariant reaction since it occurs under equilibrium conditions at a specific temperature and alloy composition that cannot be varied.

20. What do you understand by '**allotropy of iron'**?

Allotropy refers to the possibility of existence of two or more different crystal Structures for a substance depending upon temperature.

21. Define: **ferrite** and **austenite.**

Ferrite is a primary solid solution based on iron having BCC structure. Maximum solubility of carbon in iron is 0.025% carbon at 723°C, while its solubility at room Temperature is only about 0.008%.

Austenite is a primary solid solution based on iron having FCC structure. The maximum solubility of carbon in FCC iron is about 2% at 1140°C.

22. Define: Cementite and Pearlite?

Cementite is the name given to the carbide of iron (Fe3C). It is the hard, brittle, intermetallic compound of iron with 6.69% of carbon.

Pearlite is the eutectoid mixture of ferrite (87.5%) and cementite (12.5%). It is formed when austenite decomposes during cooling. It contains 0.8% of carbon.

25. Define: martensite, and bainite?

Martensite is the super saturated solid solution of carbon in iron. It is formed when steel is very rapidly cooled from the austenitic state.

Bainite is a decomposition product of austenite, consisting of an aggregate of ferrite and carbide. Bainite has hardness in between the hardness of pearlite and martensite.

Unit – II

HEAT TREATMENT

1. Define the term '**heat treatment'**.

Heat treatment may be defined as an operation or combination of operations involving Heating and cooling of a metal/alloy in solid state to obtain desirable properties.

2. What are the purposes of the processing heat treatments?

1. To relieve internal stresses.
2. To improve machinability.
3. To refine grain size.
4. To soften the metal.
5. To improve hardness of the metal surface.

3. List the various stages of a heat treatment process.

Stage 1: Heating a metal/alloy beyond the critical temperature.

Stage 2: Holding at that temperature for a sufficient period of time to allow necessary changes to occur.

Stage 3: Cooling the metal/alloy (i.e., quenching) at a rate necessary to obtain the desired properties. That is, cooling at a rate necessary to obtain the desired changes in the nature form, size and distribution of micro-constituents.

4. List some of the important heat treatment operations widely used.

1. Annealing, 2. Normalizing. 3. Hardening. 4. Tempering. 5. Austempering. 6. Mar tempering and 7. Case hardening.

5. What is meant by **annealing?**

Annealing is defined as a softening process consisting of heating the steal to a Temperature at or near the critical point, holding there for a proper time and then allowing it To cool slowly in the furnace itself.

6. What are the purposes of annealing?

1. To relieve or remove stresses. 2. To induce softness. 3. To refine grain structure,
4. To alter ductility, toughness, electrical, magnetic or other properties.
5. To remove gases. 6. To produce a definite microstructure.

7. List the different types of annealing.

a) Full annealing. b) Process annealing. c) Stress relief annealing.
d) Recrystallisation annealing, and e) Spheroidise annealing.

8. What is meant by **normalizing**?

Normalizing is similar to full annealing, but cooling is established in still air rather than in the furnace.

9. What is **quenching**? List some of the quenching medium generally used in industries.

Quenching refers accelerated cooling. Some of the quenching medium that are used generally in industries are: 5-10% caustic soda, 5-20% brine (NaCl), cold water, warm water, mineral oil (obtained during the refining of crude petroleum), animal oil, vegetable oil (such as linseed, cottonseed, and rapeseed).

10. What are the factors should be considered while selecting a quenching medium?

1. Desired rate of heat removal. 2. Required temperature interval.
3. Boiling point. 4. Viscosity. 5. Flash point (if combustible).
6. Stability under repeated use. 7. Possible reactions with the material being quenched. 8. Cost.

11. What are the three stages for quenching?

Stage 1: Vapour-jacket stage.
Stage 2: Vapour-transport cooling stage.
Stage 3: Liquid Cooling stage.

12. What does the term hardening refer? What are the factors affecting the hardness?

Hardening refers to the heat treatment of steel which increases its hardness by quenching.The hardness obtained from the hardening process depends upon the following factors: 1. Carbon content, 2. Quenching medium, 3. Specimen size, and 4. Other factors.

13. Distinguish the work hardening with the age hardening process.

Work hardening also known as strain hardening, is the process of hardening a metal, while working on it (under cold-working conditions).

Age hardening also known precipitation hardening, is the process of hardening a metal when allowed to remain or age after heat treatment.

14. The tempering process usually follows hardening process. Justify.

The martensite which is formed during hardening process is too brittle and lacks good ductility and toughness. Hence, it cannot be used for more applications. Also the internal residual stresses that are introduced during hardening have a weakening effect. The ductility and toughness of martensite can be enhanced and these internal stresses are relieved by a heat treatment process known as **tempering.**

15. What is the effect of: (a) tempering temperature, and (b) tempering time, on the hardness of steels?

a) The hardness gradually decreases as the temperature is increased.

b) The hardness decreases with the increase in tempering.

16. What do you mean by **temper embrittlement**?

The tempering of some steels/steel alloys may result in a reduction of toughness (i.e.,increase in brittleness). This phenomenon is referred as temper embritlement.

17. What is **TTT diagram**?

The TTT diagram is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is a tool used by heat treaters to predict quenching reactions in steels.

18. What is the significance of TTT diagram in the heat treatment of steel?

The TTT diagram is most useful in giving an overall picture of the transformation behaviour of austenite. This enables the metallurgist to interpret the response of a steel to any specified heat treatment.

Using a TTT diagram, one can plan practical heat treatment operations to get desirable microconstituents, to control limited hardening or softening, and the time of soaking.

19. Why are TTT diagrams usually not applicable to industrial engineering practices?

The data for the construction of TTT diagrams are obtained from the isothermal transformation of austenite at differing temperatures. But most industrial heat treatments involve continuous cooling from the austenitic temperature to room temperature. Thus a TTT diagram may not five a fully accurate representation of the temperatures and times of the transformations occurring.

20. What is **CCT diagram**?

The CCT diagram is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to indicate when transformations occur as the initially austenitised material is continuously cooled at a specified rate. In addition, it is also used to predict the final microstructure and mechanical characteristics.

21. Define the term **critical cooling rate**. What are the factors affecting it?

The slowest rate of cooling of austenite that will result in 100% martensite transformation is known as the **critical cooling rate.**

Factors affecting the critical rate are: 1. Chemical composition of steel, 2.Hardening temperature, and 3. Metallurgical nature (i.e, Purity) of steel.

22. What is significance of the critical cooling rate?

The critical cooling rate is most important in hardening. In order to obtain a 100%

martensitic structure on hardening, the cooling must be must be much higher than the critical cooling rate.

23. What is meant by **hardenability**? What are the factors affecting it?

The term **hardenability** refers to the ease with which hardness may be attained. In other words, hardenability is a measure of ease of forming martensite.The factors affecting the hardenability are: 1. Composition of the steel, 2.Austenitic grain size, 3. Structure of the steel before quenching, and 4.Quenching medium and the method of quenching.

24. What is the difference between **hardness** and **hardenability**?

The term **hardness** is the property of a material by virtue of which it is able to resist abrasion, indentation and scratching. It is a mechanical property relatedto strength and is a strong function of the carbon content of a metal.

On the other hand, **hardenability** is the susceptibility of a material to get hardened. It is affected by the alloying elements in the material and grain size.

25. What is martempering and austempering?

Martempering, also known as marquenching, is a interrupted cooling procedure used for steels to minimize stresses, distortion and cracking of steels that may develop during rapid quenching.The **Austempering** is an isothermal heat treatment process, usually used to reduce quenching distortion and to make tough and strong steels.

Unit – III

FERROUS AND NON-FERROUS METALS

1. What are metals? Classify engineering materials.

Metals are elemental substances. Metals are composed of elements which readily give up electrons to provide a metallic bond and electrical conductivity.

Types of metals:

1. Ferrous metals, and
2. Non-ferrous metals.

2. What are ferrous metals? Classify ferrous materials.

The metals, which contain iron as their main constituent, are called **ferrous metals.**

Types of ferrous metals:

1. Steels, and
2. Cast irons.

3. State three reasons why ferrous alloys are used extensively.

1. Iron-based components are relatively abundant and are widely distributed

throughout the world.
2. Ferrous materials can be produced very economically.
3. Ferrous materials are versatile. Therefore wide range of mechanical and physical
properties of ferrous materials can be achieved.
4. State three characteristics of ferrous alloys that limit their utilization.Heavy in weight, Lower electrical and thermal conductivity, and lower resistance to corrosion.

5. How can you specify a steel? What is the difference between 4140 steel and 4340 steel?
The AISI/SAE designation for the steels is a four digit number: First two Digits indicate the alloy content, and Last two digits indicate the carbon concentration. 4140 steels is alloy of Cr-Mo with 0.40% C, where as 4340 steel is an alloy of Mo-Cr-Ni with 0.40% C.

6. What are three primary groups of plain carbon steels?
1. Low-carbon steels: Those contain less than 0.25% carbon.
2. Medium-carbon steels: Those containing between 0.25 and 0.60% carbon.
3. High-carbon steels: Those containing more than 0.60% carbon.

7. What are alloy steels? How are alloy steels classified?
Alloy steels mean may steels other than carbon steels. Alloy steels can be divided into two main groups as:1. **Low alloy steels**: These contain up to 3 to 4% of alloying elements.
2. **High alloy steels**: These contain more than 5% of alloying elements.

8. List four important alloying elements added in alloy steels.
The most commonly used alloying elements are chromium, nickel, molybdenum,
Vanadium, tungsten, cobalt, boron, copper and others.

9. Why is alloying done?
The alloying steel is generally done:
To increase its strength.
To improve hardness.
To improve toughness.
To improve resistance to abrasion and water.
To improve machinability.
To improve ductility.

10. What are the primary effects of chromium, and copper as alloying elements in steel?
Effects of alloying chromium: Increases corrosion and oxidation resistance, increases hardenability, increases high-temperature strength, and resists abrasion and wear (with high carbon).
Effects of alloying copper: Increases strength, and increases corrosion resistance.

11. What are the effects of lead and sulphur on the machinability of steels?

Lead improves the machinability whereas sulphur reduces it.

12. Which alloy elements are basically a) carbide formers, and b) graphite promoters?

a) Carbide formers: Cr, W, Ti, Mo, Nb, V, and Mn.

b) Graphite promoter: Si, Co, Al, and Ni.

13. What makes a stainless steel "**stainless**"?

The chromium oxide (extremely dense-thin) protective layer acts as a barrier to retard further oxidation, rust or corrosion. As this steel cannot be stained easily, it is called stainless steel.

14. Why do stainless steels lose their corrosion resistance when the chromium in solution drops below 12%?

When the weight% of chromium drops below 12% the corrosion rate increases sharply. As the corrosion rate increases, the resultant chromium-oxide protective layer unable
to retard oxidation, rust or corrosion effectively.

15. What determines whether a stainless steel is austenitic ferritic, or martenistic?

The predominant phase constituent of the microstructure present in a stainless steel determines whether a stainless steel is austenitic, ferritic, or martenistic.

16. What are the required properties of a tool steel?

Tool steels should have the following requirements:1. Good toughness, 2. Good wear resistance, 3. Very good machinability,4. Slight change of form during hardening, 5. Little risk of cracking during hardening.5. Resistance to softening on heating.

17. How can you classify tool steels?

1. Cold work tool steels, 2. Shock resisting tool steels, 3. Hot work tool steels, 4. High speed tool steels, 5. Plastic mold tool steels and 6. Special purpose tool steels.

18. What is meant by **18-4-1 high speed steel**?

A widely used high-speed tool steel is 18-4-1 high speed steel. This steel contains
18% tungsten, 4% chromium, and 1% vanadium. It is considered to be one of the best of all purpose tol steels.

19. What are **HSLA** steels? Where are they used?

HSLA steels are nothing but **high-strength low-alloy steels.** HSLA steels, also known as **micro alloyed steels,** are low-carbon steels containing small amounts of alloying elements.These HSLA steels are widely used as **structural or constructional alloy steels.**

20. What are **maraging steels**? Give its composition.

Maraging steels are low-carbon, highly alloyed steels. These are very highstrength materials that can be hardened to obtain tensile strengths of up to 1900 Mpa.

Composition: Maraging steels contain 18% nickel, 7% cobalt, and small amounts of other elements such as titanium. The carbon content is low,generally less than .05%.

21. What are the **heat resisting steels** and **free-machining steels**?

Steels which can resist the creep and oxidation at high temperatures and retain sufficient strength are called **heat resisting steels. Free-machining steels,** also known as free cutting steels, machine readily and form small chips so as to reduce the rubbing against the cutting tool and associated friction and wear.

22. What are the features that make cast iron an important material?

1. It is a cheap metallurgical substance,
2. Good castability,
3. Good mechanical rigidity and good strength under compression.
4. Good machinability cn achieved when a suitable composition is selected.

23. What are the effects of carbon on the properties of cast iron?

If a cast iron contains more of the brittle cementite, then its mechanical properties will be poor.

24. What is the influence of cooling rate on the properties of a cast iron?

High rate of cooling results in a weak and brittle cast iron. Slow cooling rate results in tough and strong cast iron.

25. How can you classify cast irons?

Grey (General-Purpose) White (Hard and wear resistant) Malleable (Heat-treated for ductility)
SpheroidalGraphite (Some ductility) Alloy cast irons (Special-purpose)

Unit – IV

NON-METALLIC MATERIALS

1. What are **polymers**?

Polymers are composed of a large number of repeating units of small molecules called manometers. Polymers may be defined as giant organic, chain-like molecules having molecular weight from 10000 to more than 1,000,000 g.mol-1.

2. List any four attractive characteristics of polymers.

1. Low density.
2. Good thermal and electrical insulation properties.
3. High resistance to chemical attack.
4. Ease of fabrication.
5. Relatively low cost.

3. Classify polymers.

1. Plastics,
2. Elastomers,
3. Adhesives,
4. Coatings,
5. Fibres.

4. Define the following terms: i) Monomer, ii) Homopolymer, and iii) Copolymer.

Monomer is a small molecule consisting of a single mer i.e., a single unit/blocking block.

Homopolymer is a polymer made out of identical monomer.

Copolymer is a polymer which is obtained by adding different types of monomers.

5. What is meant by i**somerism**?

Isomerism is a phenomenon wherein different atomic configurations are possible for the same configuration.

6. What is meant by the term '**unsaturated molecule'**? State its significance in plastics.
A compound in which the valence bonds of the carbon atoms are not satisfied is said to be unsaturated. Such unsaturated molecules are important in the polymerization i.e.,joining together of small molecules into large one having the same constituents.

7. What is **polymerisation**?

Polymerisation is the process of forming a polymer.

8. Define the term '**degree of polymerisation'**?

Degree of polymerisation is the number of repetitive units (or mers) present in one
molecule of a polymer. Mathematically,

$$\text{Degree of polymerisation} = \frac{\text{Molecular weight of a polymer}}{\text{Molecular weight of a single monomer}}$$

9. What is the difference between addition polymerisation and condensation polymerisation?

Addition polymerisation, also known as chain reaction polymerisation, is a process by which two or more chemically similar monomers are polymerized to form long chain molecules. Condensation polymerisation, also known as step-growth polymerisation, is the formation of polymers by stepwise intermolecular chemical reactions that normally involve at least two different monomers
.

10. Why are additives added to polymers?

The various polymer additives include:1. Filler materials, 2. Plasticizers, 3. Stabilizers, 4. Colorants, 5. Flame retardants,6. Reinforcements, and 7. Lubricants.

11. What are the characteristics of plastics which account for their wide use as engineering materials?

Plastics are extensively used in engineering applications due to their important properties such as low price, colour range, toughness, water resistance, low electrical and thermal conductivity, ease of fabrication, etc.

12. Why are the fillers and plasticizers added to polymers?

1. Fillers

To improve tensile and compressive strengths.

To improve dimensional and thermal stability, and other properties.

To reduce the cost of the final product.

2. Plasticisers

To improve the flexibility, ductility, and toughness.

To reduce the hardness and stiffness.

To increase and control the flow of the polymer during molding.

13. Differentiate commodity plastics with engineering plastics.

The plastics which are not generally used for engineering applications are known as commodity plastics. H plastics which are used in engineering applications are known as engineering plastics.

14. Name any four commodity plastics and engineering plastics.

Commodity plastics: i) Polyethylene (PE), ii) Polypropylene (PP), iii) Polystyrene (PS), iv) Polyvinyl chloride (PVC).

Enginering Plastics: i) Ethenic, ii) Polyamides, iii) Cellulosics, iv) Acetals.

15. Name any four thermoplastics and thermosetting plastics.

Thermoplastics: Polythenes, Polypropylene, Polystyrenes, PVC.

Thermosetting plastics: Polyesters, phenolics, epoxides, melamine formaldehyde.

16. What advantages do thermoplastic polymers have over thermosetting polymers, and vice versa?

Since thermoplastics have low melting temperature and can be repeatedly moulded and remoulded to the desired shape, they have a good resale/scrap value. The thermosetting plastics are generally stronger, harder, more brittle, more resistant to heat and solvents than thermoplastics.

17. What are the sources of raw materials for plastics?

1. Animal and vegetable by-products,
2. Coal by-products,
3. Petroleum by-products.

18. What do the following ‘acronyms’ refer: PE, PP, PS, PVC, PTFE, PMMA.

PE: Polyethylene; **PP**: Polypropylene; **PS**: Polystyrene; **PVC**; Polyvinyl chloride;
PTFE: Polytetrafluro ethylene; **PMMA**: Polymethyl methacrylate.

19. List the properties and typical applications of PVC.

Properties: Good low-cost, general purpose materials; ordinary rigid, but can be made flexible with plasticizers; susceptible to heat distortion.

Typical applications: Pipes, valves, fittings, floor tiles, wire insulations, toys, phonograph records, safety glass interlayers.

20. What are **acrylic materials**? Name two of them.

Acrylic materials are thermoplastic polymers based on the polymerization of esters of acrylic acid and/or methacrylic acid.The most commonly used acrylic polymers are:

1. PMMA (Polymethyl methacrylate),
2. PAN (Polyacrylonitrile).

21. Write short notes on **nylons**.

Polyamides (PA), also known as **nylons,** are the products of condensation reactions between an amine and an organic acid.There are number of common polyamides. They are usually designated as nylon 6, nylon 6/6, nylon 6/10, nylon 6/12, nylon 11, and nylon 12. These suffixes refer to the number of carbon atoms in each of the reacting substances involved in the condensation polymerization process.

22. What are **bakelites**? Also state their applications.

Phenolics, also known as **Bakelites,** are the oldest family of thermosetting plastics. The most important phenolic materials is the polyformaldehydes.Typical applications include electrical plugs, sockets, switches, telephones,door knobs and handles, adhesives, coatings, and laminates.

23. List the characteristics of **urea-formaldehyde**.

1. They are similar to the phenolics.
2. They are hard and rigid thermosets.
3. They have good electrical insulation properties.
4. They are light in colour.
5. They exhibit good resistance to most chemicals.

24. What are **engineering ceramics**?

Engineering ceramics are also known as **technical/industrial ceramics,** are those ceramics that are specially used for engineering applications or in industries.

25. List some of the distinct characteristics of engineering ceramics.

1. High resistance to abrasion and wear.
2. High strength at high temperature.
3. Good chemical stability.
4. Good electrical insulation characteristics.

Unit – V

MECHANICAL PROPERTIES ANS TESTING

1. What is meant by mechanical properties of materials?

Mechanical properties are those characteristics of material that describe its behavior under the action of external forces.

2. Distinguish between elasticity and plasticity.

Elasticity is the property of a material by virtue of which it is able to retain its original shape and size after the removal of the load.

Plasticity is the property of a material by virtue of which a permanent deformation (without fracture) takes place, whenever it is subjected to the action of external forces.

3. Differentiate between ductility and malleability.

Ductility is the property of a material by virtue of which it can be drawn into wires before rupture takes place.

Malleability is the property of a material by virtue of which it can withstand deformation under compression without rupture.

4. Define the terms brittleness and hardness.

Brittleness is the property of a material by virtue of which it can withstand deformation under compression without rupture.

Hardness is the property of a material by virtue of which it able to resist abrasion, indentation (or penetration), machining, and scratching.

5. What do you mean by toughness and stiffness?

Toughness is the property of a material by virtue of which it can absorb maximum energy before fracture takes place.

Stiffness is the property of a material by virtue of which it resists deformation.

6. List any four technological properties of metals.

1. Machinability,
2. Castability,
3. Weldability,
4. Formability or workability.

7. What are the factors affecting mechanical properties?

1. Grain size,
2. Heat treatment,
3. Atmospheric exposure, and
4. Low and high temperatures.

8. What is the effect of the grain size on the mechanical properties of the materials?

The materials having smaller grains (i.e., fine grained structure) have high yield strength, high tensile strength, and more hardness. Also fine grain results in better resistance to cracking and better surface finish.

9. What is the effect of heat treatment on the mechanical properties of the materials?

The heat treatment improves mechanical properties like tensile strength, toughness, hardness, ductility, shock resistance and resistance to corrosion. It also improves workability, forgeability and machinability of metals.

10. Define the terms slip and twinning.

Slip may be defined as the sliding of blocks of the crystal over one another along definite a mirror image of the other part.

Twinning is the process in which the atoms in a part of a crystal subjected to stress, rearrange themselves so that one part of the crystal becomes a mirror image of the other part.

11. State the **Schmid's law**.

The stress required at a given temperature to initiate slip in a pure and perfect single crystal, for a material is constant. This is known as Schmid's law.

12. What are the causes of twins?

1. Mechanical twins: Twins that are produced by mechanical deformation are calledmechanical twins.

2. Annealing twins: Twins that are produced by annealing are called annealing twins.

13. What is meant by fracture?

Fracture is the mechanical failure of the material which will produce the separation or fragmentation of a solid into two or more parts under the action of stresses.

14. List the different types of fracture in a material.

1. Brittle fracture,
2. Ductile fracture,
3. Fatigue fracture,
4. Creep fracture.

15. What is brittle fracture?

A brittle fracture may be defined as a fracture which takes place by a slow propagation of crack with appreciable plastic deformation.

16. What is ductile fracture?

Ductile fracture may be defined as the fracture which takes place by a slow propagation of crack with appreciable plastic deformation.

17. How can you prevent the ductile fracture?

In order to prevent the ductile fracture, the material should have the following characteristics:

The material should have fine grains.
It should have higher hardness value.
It should have higher Young's modulus and cohesive energy.
It should not have any defects/dislocations.

18. What is meant by **fatigue fracture**?

A fatigue fracture is defined as the fracture which takes place under repeatedly applied fatigue stresses.

19. What is S-N diagram? What is the significance of it?

The S-N diagram is a graph obtained by plotting the number of cycles of stress reversals (N) required to cause fracture against the applied stress level (S). Using S-N diagram, the fatigue life of a material can be determined.

20. What are the factors affecting fatigue strength?

1. Fatigue strength is influenced by many factors such as chemical composition, grain size, and amount of cold working.
2. Fatigue strength is high at low temperatures and gradually decreases with rise in temperature.
3. Environmental effects such as corrosion of the product by moisture decreases The fatigue strength.
4. The design of the product also influences the fatigue strength.

21. How can you prevent fatigue fracture?

The following methods can be adopted to prevent the fatigue failure.

1. Use of good design to avoid stress concentration by eliminating sharp recesses and severe stress raisers.
2. Control of the surface finish by avoiding damage to surface machining, punching, stamping, shearing, etc.
3. Reduction of corrosion environmental effects by surface heat treatments like polishings, coatings, carburizing, nitriding, etc.

22. What is meant by creep fracture?

The creep is defined as the property of a material by virtue of which it deforms Continuously under a steady load.

23. What are the factors affecting creep?

1. Grain,
2. Thermal stability of the micro-structure,
3. Chemical reactions,
4. Prior strain.

26. How can you prevent the creep fractures?

The following methods can be adopted to prevent the creep failure.

1. Use of coarse grained materials will avoid creep fracture.
2. Strain hardening can be done to avoid creep fracture.
3. The material should be free from any residual stresses and dislocations.
4. Precipitation-hardened alloys can be used to avoid creep fracture.

24. Differentiate between destructive and non-destructive tests.

In destructive type of testing, the component or specimen to be tested is destroyed and cannot be reused.In non-destructive type of testing, the component or specimen to be tested is not destroyed and can be reused after the test.

25. List some important destructive tests carried out on a material.

1. Tensile test, 2. Impact test, 3. Bend test,
4. Fatigue test, 5. Torsion test, and 6. Creep test.

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