Catalog

UNIT – III

FERROUS AND NON- FERROUS METALS.

3.1 PURPOSE OF ALLOYING:

To increase hardenability.

To increase strength at temperature.

To improve high temperature properties.

To increase resistance to corrosion.

To increase wear resistance.

To improve toughness at any minimum hardness.

To improve electrical and magnetic properties.

3.2 EFFECTS OF ALLOYING ELEMENTS :

Solid solution formation.

Carbide formation.

Shifting of critical temperature.

Lowering of critical cooling rate.

Effect on grain growth.

Corrosion resistance.

3.3 EFFECT OF ALLOYING ADDITION ON STEELS :

Carbon (C)

Sulphur (S)

Phosphorous (P)

Silicon (Si)

Manganese (Mn)

Nickel (Ni)

Chromium (Cr)

Titanium (Ti)

Tungsten (w)

Molybdenum (Mo)

Vanadium (V)

Cobalt (Co)

Aluminium (Al)

Boron (Br)

Carbon (c):

It increases hardness and strength.

It increases machinability.

Sulphur (S):

It is hard and brittle.

It increases machinability.

Phosphorous (P):

It dissolves in ferrite solid solution.

It Increases tensile strength and hardness.

It is hard and brittle.

It increases machinability.

Silicon (Si) :

It is a ferrite solid solution.

It reduces losses.

It increases toughness.

It increases strength and hardness.

Manganese (Mn):

It improves Machinability.

It improves strength and toughness.

It dissolves in Ferrite.

Nickel (Ni) :

It is a ferrite solid solution.

It increase tensile strength and hardness.

It increase corrosion resistance.

It reduces co- efficient of thermal expansion.

Chromium (Cr) :

It increases hardenability.

It increases wear resistance.

It increases corrosion resistance.

Titanium (Ti)

It is strong carbide former.

It increases hardenability.

Molybdenum (Mo) :

It increases hardenability.

It makes grain finer.

It forms carbides.

It increases wear resistance.

Grain growth.

Tungsten (w) :

It increases hardenability.

It forms carbides.

It increases wear resistance.

Improves hot hardness.

Vanadium (V) :

It have fine grain structure.

It increases hardenablity.

Forms stable carbides.

Cobalt (Co) :

It reduces hardenability.

It improves strength.

It have fine grained structure.

It improves heat resistance.

Improves hot hardness.

Aluminium (Al) :

It have fine grained structure.

Boron (Br)

It increases hardenability.

It improves wear and fear resistance.

3.4 α AND βSTABILIZERS :

They are :

- alpha stabilizers

β- Beta stabilizers

α- alpha stabilizers increases the temperature at which alpha phase is stable. e.g. : Aluminium, Oxygen, tin .

Beta stabilizers at lower temperature.

e.g. : Copper, Chromium, Vandium, Molybdenum.

Steel consists of two or more phases knower as ferrite, austenite, carbide, graphite.

3.5 STAINLESS STEELS (SS):

Stainless steels are most notable for their corrosion resistance, which increases with increasing chromium content. Additions of molybdenum increase corrosion resistance in reducing acids and against pitting attack in chloride solutions. Thus, there are numerous grades of stainless steel with varying chromium and molybdenum contents to suit the environment the alloy must endure. Stainless steel resistance to corrosion and staining, low maintenance, and familiar luster make it an ideal material for many applications where both the strength of steel and corrosion resistance are required. It is the composition of iron , carbon, and chromium and it contain minimum 12% Chromium. Mo, Ni (Molybdenum, Nickel) is a added as alloying elements.

Types of stainless steel :

Austenitic stainless steel.

Ferritic stainless steel.

Martensitic stainless steel.

i) Austenitic Stainless steel :

Austenitic stainless steel is a specific type of stainless steel alloy.These stainless steels possess austenite as their primary crystalline structure (face centered cubic). This austenite crystalline structure is achieved by sufficient additions of the austenite stabilizing elements nickel, manganese and nitrogen. Due to their crystalline structure austenitic steels are not hardenable by heat treatment and are essentially non-magnetic.

Composition :

C → 0.03 to 0.15 %,Mn →to 10%,Si → 1 to 2 %,Cr→ 16to 26%,Ni → 3.5 to 22%

Properties :

High corrosion resistance.

Non Magnetic.

Good ductility.

High strength.

Application :

Air craft industry.

Chemical processing.

Food processing unit.

Dairy industry.

Transportation industry.

ii) Ferritic Stainless steel :

Ferritic steels are high chromium, magnetic stainless steels that have a low carbon content. Known for their good ductility, resistance to corrosion and stress corrosion cracking, ferritic steels are commonly used in automotive applications, kitchenware, and industrial equipment.

Composition:

C→0.08 to 0.1%,Si→ 1%,Mn→ 1 to 1.5%,Cr→ 12 to 25%

Properties :

They are magnetic.

Good ductility.

High strength.

Soft.

Corrosion resistant.

High toughness.

Application :

Petroleum industry.

Heating element for furnace.

Chemical industry.

Combustion chamber.

This steels can be welded, forged , rolled and machined.

iii) Martensitic stainless steel :

Martensitic stainless steel is a specific type of stainless steel alloy. Martensitic stainless steels can be high- or low-carbon steels built around the Type 410 composition of iron, 12%

chromium, and up to 1.2% carbon. They are hardenable by heat treatment (specifically by quenching, or by quenching and tempering).

Composition:

C→ 0.1 to 1.5%,Si →1%,Mn →1%,Cr→12 to 25%

Properties :

High hardness.

High strength.

Good ductility and thermal conductivity.

Good toughness.

Corrosion resistance.

High magnetic.

Application:

High hardness.

High strength.

Good ductility and thermal conductivity.

Good toughness.

Corrosion resistance.

High magnetic.

Application :

Valves, pumps, surgical instruments, turbine blades.

3.6 STEEL :

Steels are alloy of iron carbon however steel contain other element like Si, Mn, S,P, Ni, (Silicon, Manganese, sulphur, phosphorous, Nickel).

Plain carbon Steel :

Composition :

C→ up to 1.5%,Cu→ up to 0.6%,Mn →upto 1.65%,Si →upto 0.6%

3.6.1 CLASSIFICATION OF PLAIN CARBON STEEL :

Low Carbon steel:

The steel which contain less than 0.2% c is called as low carbon steel.

Medium carbon Steel :

The steel which contain 0.25% to 0.6% carbon content is called as medium carbon steel.

Alloy Steel :

Any steel other than carbon steel is called as alloy steel. Alloy elements are Cr, Ni, Mo, V,W,Co, Cu (Chromium, Nickel, Molybdenum, Vanadium. Tungsten, Cobalt, Copper).

3.6.2 CLASSIFICATION OF ALLOY STEEL :

3.6.2.1 LOW ALLOY STEEL:

This contain up to 3 to 4% of alloying element.

Types of low alloy steel :

AISI Steel (American iron and steel institute).

HSLA Steel (High strength low alloy).

3.6.2.2 HIGH ALLOY STEEL :

This contain more than 5% of alloying element.

Types of high alloy steel :

Tool of high alloy steel.

Stainless steel.

3.6.2.3 TOOL STEEL :

This used as material for mechanical working tools. Tool steels are metals used to make tools and dies for cutting, forming and bending operations.

Properties :

Hardness.

Toughness.

Wear resistance.

Red hardness.

Depth of hardening.

Machinability.

Non – deforming.

Types of tool steel :

cold work tool steel :

a) Water hardening steels :

C→0.6 to 1.4 %,balance is iron .

Oil hardening steels:

C→0.6 to 1.4 %,(w + Mn+ Cr+Mo + V) < 5% (Alloys).

Air Hardening steels:

C→0.6 to 1.4%,(W +Mn +Cr+Mo+v) > 5% (Aloys).

High carbon High Chromium steels :

C→>1.5%,Cr →12%,Alloys < 5%,balance is iron.

Hot work Tool Steels :

a) Chromium type (cr):

C→ 0.35 to 0.55%,Cr→ 3 to 7% ,(w + Mo +V) < 5%.

b) Tungsten type : (w)

C→ 0.3 to 0.5%,Cr→ 2 to 12% ,w → 9 to 18%.

a) Molybdenum type (Mo):

C→0.55 to 0.065%,(Mo + Cr+V + w) → 14 to 20%.

High speed tool steels :

a) T – series (Tungsten)

C→ <0.12%,W→ < 20%,Cr , V.

M- Series (Moly bdenum) :

C→ M<0.12%,Mo → <10%,Cr, N.

Special purpose Tool steels :

Shock resisting type :

C→ <0.5%,(Mn, Cr, w, Mo, V, Si).

Low alloy type :

Cr, w, V, Mo, Ni.

Carbon – tungsten type

: C→ > 1% .

d)Mould Steels :

C→ < 0.2 % ,Cr , Ni.

Application :

Taps, drills, reamer, die working, tool, milling cutter, tools, gauges, punches, bearings, dies, blades, Hammers.

3.7 HSLA STEEL : (HIGH STRENGTH LOW ALLOY STEEL)

High-strength low-alloy steel (HSLA) is a type of alloy steel that provides better mechanical properties or greater resistance to corrosion than carbon steel. HSLA steels vary from other steels in that they are not made to meet a specific chemical composition but rather to specific mechanical properties. To improve the strength to weight ratio of steels.0.2 % of Cu is added to improve corrosion resistance. HSLA steels are not hardened by heat treatments.

Composition:

C→0.2 %,Mn→ 1.25%,Si→ 0.3 %,Cr→ 0.01%,V → 0.01 %

Properties :

Good yield strength.

Good corrosion resistance.

High machinability.

High formability and ductility.

Application :

Bridges, towers support, columns in high – rise, buildings and pressure vessels.

3.8 MARAGING STEEL :

Maraging steel is a steel alloy, containing up to 25 per cent nickel and other metals, strengthened by a process of slow cooling and age hardening.

Composition :

Ni → 18%,Co→ 7%,Ti →0.2%,C→0.05%,Al → 0.1 %.

Properties :

High tensile strength.

High toughness.

High impact hardness.

Very suitable for surface hardening by nitriding.

Applications :

Flexible dry shaft for helicopters.

Barrels for rapid firing guns.

Die casting dies.

Extrusion rams.

Pressure Vessels.

3.9 CAST IRON :

The material which contain 2 to 6.67% carbon is called as cast iron. It is obtained by re-melting pig iron with coke and lime stone in a cupola furnace .It is a brittle material.

Properties :

High compressive strength.

High wear resistance.

Good machinability.

Low melting temperature (1250°c).

Good castability.

Low cost.

Ability to make good casting.

Good corrosion resistance.

Composition of Cast iron:

C→ 3-4%,Si → 1-3%,S→ upto 0.1%,P→ upto 0.1%,Mn → 0.5 -1%,Remaining iron.

Applications :

Pipe Fittings.

Farm equipments.

Gears.

Machine tool.

Automobile components.

Dies.

Electrical motors.

3.10 TYPES OF CAST IRON:

Grey cast iron.

white cast iron.

Malleable cast iron.

Nodular cast iron (or) spheroidal (or) Ductile.

Alloy cast iron.

1. Grey Cast iron:

Grey cast iron, is a type of cast iron that has a graphitic microstructure. It is named after the gray color of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight. The carbon is in the free form as "Flakes" of graphite. Ferrite Micro–structure.

Composition:

C → 2.5 – 4%,Si → 1 – 3%,Mn → 0.4 – 1%,P → 0.15 – 1%,S → 0.02 – 0.15%,Remaining – iron

Properties:

Good wear resistance.

Good corrosion resistance.

Good Mach inability.

High tensional, shear strength.

High hardness.

Application:

Machine tool bodies, engine cylinders, brake drums, camshaft, pipe Fitting, rolling mills, agriculture equipment.

White cast iron:

White cast iron is a cast iron without any alloy addition and with low C and Si content such that the structure is hard brittle iron carbide with no free graphite. A fast cooling rate prevents the precipitation of C as graphite. All the carbon is in the combined form as iron carbide. Cementite micro structure.

Composition:

C → 1.8 to 3%,Si → 0.5 to 1.9%,Mn → 0.25 to 0.8%,P → 0.05 to 0.2%,S → 0.1 to 0.3%,remaining – iron.

Properties:

Very hard and brittle.

High wear resistance.

High tensile strength.

Low compressive strength.

High hardness.

Difficult to Machine.

Applications:

Wearing plates.

Road roller surface.

Pump liners.

Grinding balls.

Dies.

Nozzles.

For production of Malleable castings.

3.11 MALLEABLE CAST IRON:

The carbon is in the free forms irregular round particles of graphite known as temper carbon. This is obtained by heat treatment of white cast iron. Cementite in white cast iron Micro structure breaks down into ferrite and graphite.

Composition:

$C \rightarrow 2$ to 3%, $Si \rightarrow 0.6$ to 1.3%, $Mn \rightarrow 0.2$ to 0.6%, $P \rightarrow 0.15\%$, $S \rightarrow 0.1\%$, Remaining – iron.

Properties:

Good ductility and Machine ability.

High yield strength.

High young's Modulus and low – coefficient of thermal expansion.

Good wear resistance.

High tensile strength.

High hardness.

High toughness.

Applications:

Automobile industries.

Farm equipments.

Pipe Fittings.

Chains.

Bearing blocks.

Agricultural machines.

3.12 NODULAR CAST IRONS , DUCTILE CAST IRON (OR) SPHEROIDAL GRAPHITE CAST IRONS:

Nodular Cast Iron, also referred to as ductile iron or spheroidal graphite iron, is a group of irons in which the graphite forms as nodules (spherical) instead of flakes as in normal cast iron. Nodulizing elements, typically magnesium, are used to allow the solidification of the graphite into nodules. The carbon is in free form as nodules of graphite formed directly during the process of solidification.

Composition:

C $\rightarrow$ 3.2 to 4%,Si $\rightarrow$ 1.8 to 3%,Mn $\rightarrow$ 0.2 to 0.5%,P $\rightarrow$ 0.08% Max,S $\rightarrow$ 0.1% Max, Remaining – iron.

Properties:

Good ductility.
Good tensile and yield strength.
Good toughness.
Good fatigue.
Good impact strength.
Good hardness.
High modulus of elasticity.
Good Mach inability.
High Hardness.

Application:

Crank shafts.
Gears.
Sheet metal dies.
Furnace doors.
Cylinder blocks.
Bearing blocks.
Pipes.

3.13 ALLOY CAST IRONS:

Alloy cast irons may be of any of the general types and are modified by the addition of alloying elements to obtain specific properties. Alloying element like Ni, Cr, Mo, Si, Mn.

Composition:

Ni $\rightarrow$ 14 – 36 %,Cr $\rightarrow$ 1.5 %, Cu $\rightarrow$ 5 – 8 %, C $\rightarrow$ 2 to 2.3 %, Si $\rightarrow$ 5 to 6.

Two types of Alloy cast iron:

Ni – resist cast iron.

Ni – hard cast iron.

Properties:

High tensile strength.
More brittle.
Good corrosion resistance.
High wear resistance.

Applications:

Generator, Motor covers, gas turbine, furnace, impellers, cylinder Liners.

Effect of chemical composition in cast irons:-cast irons contain upto 10% of alloying elements like carbon, silicon, Manganese, sulphur and Phosphorus.

Factors affecting structure of cast irons:

Rate of cooling.

chemical composition.

3.14 NON – FERROUS METALS AND ALLOYS:

Non ferrous metals and alloys are those Which do not contain iron, these metals are not iron based metals.

Lighter in weight.

Good resistance to corrosion.

It is having good electrical and thermal conductivity.

Non – Ferrous materials and their alloying elements.

Copper.

Aluminium.

Magnesium.

Lead.

Nickel.

Tin.

Zinc.

Cobalt.

(i) Copper :

It is one of the most widely used non – ferrous metals in industries. Copper alloys cannot be hardened by heat treatment procedures. It may be cast, forged, rolled and drawn into wires.

Properties:

High electrical conductivity.
High thermal conductivity.
Good corrosion resistance.
It is very soft, ductile and malleable.
It can be worked both in hot and cold conditions.
It is light in weight.
Very good machinability.
Non – magnetic properties.

Applications:

It is used to make electrical parts like wire, switches etc.

Heat Exchanger tubes.

It is used to make various copper alloys like brass and bronze.

It is used to make screw machine products.

New grades of copper:-

Arsenial copper

Free cutting copper

Silver bearing copper

Tough pitch copper

Oxygen free copper

De oxidized copper.

3.15 COPPER ALLOYS:

They are classified as:

Brasses (Copper – Zinc alloy)

Bronzes (Copper – tin alloy)

Copper – nickel Alloys (Cupronickel)

Gun metal (Copper – tin – Zinc alloy)

3.15.1 BRASSES (COPPER – ZINC ALLOY) :

Brass is an alloy of copper and zinc sometimes small amount of other metals such as tin, pb, Al and nig are added. upto 36% z_n brass is a single phase solid solution called as α brass. Brass having more than 30% z_n have a twp phases α and β.

Properties:

It is stronger than copper.

Low thermal conductivity.

High tensile strength.

Good surface finish.

Non – magnetic.

Poor conductor of electricity.

Soft and ductile.

Application:

Decorative work, making coins, medals, screws, Bullets, plumbing fittings. Brasses are classified based on the structure as

α - Brasses.

$\alpha - \beta$ Brasses.

3.15.2 BRONZES (COPPER – TIN ALLOY) :

Bronze is an alloy of copper and Tin. Bronze contains silicon, aluminum and nickel.

composition:

Copper $\rightarrow$ 90%,Tin $\rightarrow$ 9 to 10%,Phosphorus $\rightarrow$ 0.1 to 0.3%.

Properties:

High strength alloy.
Good corrosion resistance.
High elasticity.
Hard and brittle.
Good cold working properties.
Low coefficient of friction.
High toughness.

Applications:

Making bells, Boiler parts, Marine components, Die cast parts, pump components, propeller, air pump, gears etc.

Types of Bronze :

Phosphor bronze.
Silicon bronze.
Beryllium bronze.
Manganese bronze.

Phosphor bronze :

Copper → 87% to 90% Tin → 9% to 10% Phosphorus → 0.1% to 0.3%.

Silicon bronze :

copper→ 96%, silicon →3%, Manganese (or) zinc →1% .

Beryllium bronze:

copper→ 97.75% , Beryllium →2.25% Beryllium.

Manganese bronze :

Copper → 60% Zinc → 35% Manganese → 5%.

3.15.3 COPPER – NICKEL ALLOYS (OR) CUPRO NICKEL:

It is an alloy of copper and Nickel. They have better corrosion resistant than any other copper alloys. They can be hot or cold work.

Types of Cupro Nickel:

Cupro Nickel → 70cu, 30% Ni.

Mono metal → 29 cu, 68 Ni, 1.25 Fe, 1.25 Mn.

K – Metal → 29 cu, 66Ni, 2.75 Al, 0.4Mn, 0.6 Ti.

Properties:

Good Mechanical properties.
High corrosion resistant.

Application:

Salt water pipe, condenser tubing, for making propeller, Motor boat propeller shaft, chemical and food handling parts.

3.15.4 GUN METAL :

Gunmetal is a grey corrosion-resistant form of bronze containing zinc. It is an alloy of copper, tin and Zinc.

Composition:

cu – 88%, Zn – 2%, Tin – 10%

Properties:

High corrosion resistant.

Good casting properties.

High strength.

Good machinability.

Application:

Bearing bushes, Boiler fitting, Steam pipe fitting, Marine castings, Hydraulic valves, gears etc.

3.16 ALUMINIUM:

Aluminium is the most abundant metal in the earth's crust and is obtained mainly from bauxite. Its resistance to corrosion, lightness, and strength have led to widespread use in domestic utensils, engineering parts, and aircraft construction It is a silver white metal. Aluminium alloy elements are si, Mg, cu, Ni, Zn, Mn, Fe and Ti.

Composition:

Zinc → 12.5% to 14.5% Copper → 2.5 % to 3% Nickel → upto 1% Magnesium → 3% Remaining → Aluminium.

Properties:

Light weight.

High thermal conductivity.

Good corrosion resistance.

Soft and ductile.

Low specific gravity.

Good tensile strength.

Non – magnetic.

Good formability.

It is brittle.

Application:

Making Aero plane parts, house hold items, electric wires, furniture, surgical Instruments. Chemical plants, food processing equipment.

3.17 AL – CU ALLOYS (ALUMINIUM – COPPER ALLOYS):

They are :

1.Wrought alloy (Duralumin).

2. y- alloy (cast alloy).

1. Wrought alloy (Duralumin) :

Duralumin is a hard, light alloy of aluminium with copper and other elements.

Composition:

Copper (Cu) → 3.5 to 4.5 %,Manganese (Mg) → 0.4 to 0.7%,Magnesium (Mn) → 0.4 to 0.7%,Remaining → Aluminium 94.5%.

Properties:

Good strength after age hardening.
Good mechanical properties.
Good corrosion resistance.
High shock resisting.

Applications:

Aircraft industry, Automobile industry, Surgical Instruments.

2. Y– alloy (Cast alloy) :

Y alloy is a nickel-containing aluminium alloy.

Composition:

Al → 92.5% Cu → 4% Ni → 2% Mg → 1.5%.

Properties:

High strength.

Low thermal expansion.

High corrosion resistance.

It can be easily cast and rolled.

Application:

Pistons, cylinder heads of I.C engines, gearbox, blade etc.

3.18 AGE HARDENING (OR)PRECIPITATION HARDENING:

The strength and hardness of non-ferrous alloys may be increased by the formation of small particles within the original solid solution. They are refined and distributed uniformly throughout the matrix by heat treatment. This process is called as Age hardening. Age hardening is also used to mention this because there is a increase in hardness at room temperature.

They are three stages:

Solution heat treatment

Quenching

Aging

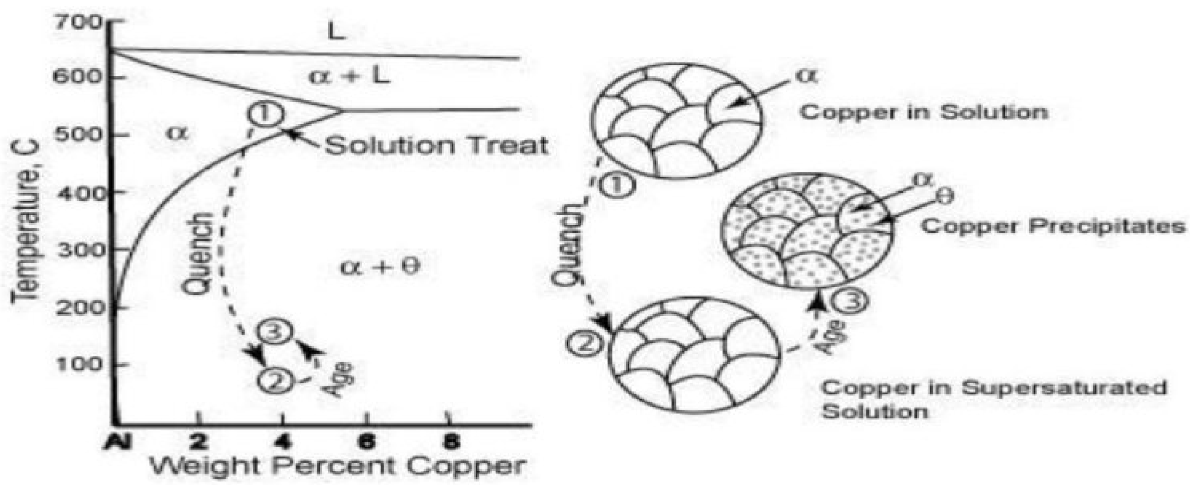


Fig 3.1 Precipitation hardening

Examples of alloys that are age hardness by Aluminum – copper, copper – Beryllium, Copper – tin and Magnesium – Aluminum.The phase diagram of Al – cu alloy. The Maximum solubility of Cu is 5.65% at 548^0C.The solubility of cu goes on decreasing with decreasing temperature.

(a) Solution heat treatment:

The alloy is heated above the solvus line at around 500^0C.It is soaked at this temperature to sufficient time such that the α to phase dissolves to form homogenous α solid solution.

(b) Quenching:

The heated alloy is rapidly cooled in water to around room temperature. The micro structure obtained is super–saturated (α_{ss}).α_{ss} contains excess cu in the Al –base Matrix and hence is not a stable phase.

(c) Aging:

The Unstable super – saturated solid solution (α_{ss}) is heated below the solvus temperature. After sufficient time period at aging temperature, following structural change occurs:

unstable	stable	$CuAl_2$
Super saturated →	Saturated +	Age hardenings
(α_{ss})	(α)	(θ)

The $CuAl_2$ (θ) Aluminium alloy elements are si, Mg, cu, Ni, Zn, Mn, Fe and Ti. Age is hard and thus provides hardness and strength to the Al –Cu alloy system.

3.19 BEARING ALLOYS:

They are anti–Friction alloys.

Properties:

It should be hard to provide longer life.

High wear resistance.

High compressive strength.

High fatigue strength.

Good plasticity.

High thermal conductivity.

High corrosion resistance.

Good mach inability.

Low melting point.

Types of bearing alloys:

White metal alloys (Babbitts)

(a)Tin based bearing alloys.

(b)Lead based bearing alloys.

Copper – lead alloys.

Aluminium alloys.

Silver – lead alloys.

Gray cast iron.

Porous self lubricating bearing.

Non – Metallic bearing.

White metal alloys (Babbitts) :

(a) Tin based bearing alloys:

$Sn \rightarrow 90\%, Sb \rightarrow 5\%, Cu \rightarrow 5\%.$

Applications:

steam turbines, turbo–supercharger.

(b) Lead based bearing alloys:

$Pb \rightarrow 80\%, Sn \rightarrow 10\%, S_n \rightarrow 10\%.$

Applications:

I.C engine, lathe and milling machines, fans, electric motors.

2. Copper – lead alloys:-

Pb → 20 to 40%,Cu → 60 to 80%.

Applications:

Automobile and aircraft industry.

3. Aluminum alloys:

It contains alloying elements such as Sn, cu, Ni, Fe, si and Mn.

Applications:

Connecting rod and main bearings of engine.

4.Silver – lead alloy:

Plated with silver and coating of Lead.

Applications:

Heavy load bearings for air craft industry.

5. Grey cast iron :

C → 3 to 4%,Fe → 91%,remaining → Si, S, P, Mn.

Applications:

Bearings for refrigerators, compressors, railways coaches etc.

6. Porous self – lubricating Bearing:

Copper – Based (Cu → 90%, Sn → 10%).

Iron – Based (Fe → 96%, C → 4%).

Applications:

Food, paper and textile industry.

7. Non – metallic bearing:

Teflon (Poly tetra fluoroethlene), nylon, graphite, Molybdenum disulphide.

Applications:

Food, paper and textile industry.

Bearing are classified as:

1.Sliding bearing.

2.Rolling bearing.

3.Thrust bearing.

3.20 MAGNESIUM ALLOYS (Mg – Alloys):

Magnesium alloys are mixtures of magnesium with other metals (called an alloy), often aluminum, zinc, manganese, silicon, copper, rare earths and zirconium. Magnesium is the lightest structural metal. Magnesium alloys have a hexagonal lattice structure, which affects the fundamental properties of these alloys.

Composition:

Al→ 94.5%,Mg →5%,Mn → 0.5 %.

Properties:

High corrosion resistance.
Good Mach inability.
Poor cast ability.
Better finish.

Applications:

Marine, Aircraft, automobile components, Dairy equipment, Architectural work.

3.21 NICKEL ALLOYS (NI ALLOYS) :

Nickel alloys are alloys with nickel as principal element. Complete solid solubility exists between nickel and copper. Wide solubility ranges between iron, chromium, and nickel make possible many alloy combinations.

Properties:

It has F.C.C. structure.

Good ductility.

Good corrosion resistance.

Good electrical conductivity.

Better formability.

High tensile strength.

Applications:

It is used for electroplating.

It is used in production of stainless steel, nickel alloys, permanent Magnets etc.

It is used in radio industries and lamp.

It is used as thermocouple Material.

Low current electrical applications..

Types of Nickel Alloys:

1, Monel Metal → 68% Ni, 30% Cu, 1% Fe, 1% Mn.

Invar→ Ni 36%, Fe 64%.

Inconel → Ni 77%, Cr 15%, Fe 8%.

Nichrome → 80% Ni, 20% Cr.

Constantine → Ni 45%, Cu 55%.

Hast elloy A → Ni 57%, Mo 20%, Fe 20%.

3.22 SUPER ALLOYS:

A super alloy, or high-performance alloy, is an alloy that exhibits several key characteristics: excellent mechanical strength, resistance to thermal creep deformation, good surface stability, and resistance to corrosion or oxidation.

Properties:

High hardness and strength.

High wear resistance.

High creep resistance.

High oxidation resistance.

3.23 TITANIUM ALLOYS:

Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness. They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. It is a highest carbide of all the alloying elements. It improves hardenability. It is added to stainless steels.

Properties:

Light weight and strong.

High corrosion resistant.

High strength to weight ratio.

High Melting point.

Low thermal conductivity.

Low thermal coefficient of expansion.

Good weld ability and formability.

Applications:

Valves, tanks, pipe, aircraft parts, steam turbine, sheet metal parts, forgings.

Types of Titanium alloys:

1.Alpha alloys.

2.Beta alloys.

3.Alpha and beta alloys.

1.Alpha alloys :

$T_i \rightarrow 92\%, A_l \rightarrow 5\%, S_n \rightarrow 2.5\%.$

2.Beta alloys:

$T_i \rightarrow 73\%, A_l \rightarrow 3\%, V \rightarrow 13\%, Cr \rightarrow 11\%.$

3.Alpha – Beta Alloys:-

$T_i \rightarrow 90\%, A_l \rightarrow 6\%, V \rightarrow 4\%.$

3.24 HIGH SPEED TOOL STEELS (H.S.S) :

High-speed tool steels are so named primarily because of their ability to machine materials at high cutting speeds. High speed steel has unusually high resistance to softening at temperatures up to 600C. It is called, red hardness. It is known as Tungsten High speed Tool steel.

Composition:

$C \rightarrow 0.7\%, W \rightarrow 18\%, Cr \rightarrow 4\%, V \rightarrow 1\%$

Properties:

High hardness.
High wear resistance.
High cutting ability.
Temperature upto 600^0C

Applications:

Cutting tools, dies, blanking tools, gears.

UNIT – 3: FERROUS AND NON-FERROUS METALS

PART: A

1. What are HSLA steels?[A/M'15]

HSLA steels are High- Strength Low – Alloy steels. HSLA steels are low carbon steels containing small amounts of alloying elements.

What are the required properties of tool steel?[N/D'16]

Good toughness
Good wear resistance
Very good machinability

What are Gun metals?

What are the applications of plain carbon steels?

Plain carbon steels are used for mass – production products such as automobiles and applicance.

They also find applications in the production of ball bearings, base plates, housings, chutes, structural members, etc.

What are the applications of high carbon steels?

Typical applications of plain high-carbon steels include cutting tools and dies, knives, razors, hacksaw blades, springs, and high-strength wires, etc. these are the application of high carbon steels.

6. What are the types of aluminium alloys?

The alloys of aluminium may be subdivided into two groups as:

Heat –treatable aluminum alloys, and
Non-heat treatable aluminum alloys.

List two factors that affect hardenability of steels.

composition of steel
austenite grain size
structure of steel before quenching
the quenching medium and the method of quenching.

What are bronzes? List some use of bronzes.[N/D'16]

Bronzes are alloys of copper and any other major alloying element but not zinc. (eg – Al, Be,Sn, etc.)

Uses of bronzes: jewellery, condenser tubes, marine applications, cigarette cases, pump casting parts, etc.

9.What is the difference between white cast iron and gray cast iron ?

In white cast iron all the carbon is present in the combined form i.e , cementite and there is no free carbon (graphite) because of which the fractured surface appears white, hence called white cast iron.

gray cast iron consist of graphite in the form of flakes and appear gray hence called gray cast iron.

10. What are the effect chromium and molybdenum in low alloy steel ?

The effects of alloying elements are follows:

Chromium

It forms chromium carbides with increase hardenability. It increase wear resistance. It also increase corrosion and oxidation resistance.

Molybdenum

It increase hardenability. It forms carbide and increase wear resistance, reduce decarburization. it increase high temperature creep resistance.

11. What is bearing alloy? [N/D'15]

Materials which are used for making bearings are known as bearing materials. White metals, copper base alloys, aluminium base alloys are examples

PART: B

1) (i) Enumerate the composition and applications of following alloys. (1)Cupronickel [N/D'16]

Bronze

State the effects of the following alloying elements in steel bearing alloy.

CUPRONICKEL

Cupronickel, any of an important group of alloys of copper and nickel; the alloy containing 25 percent nickel is used by many countries for coins.

Applications:

Cupronickel is used in:

tubes for light-duty condensors, feedwater heaters and evaporators used in power stations and desalination plants

pipes carrying seawater to fire mains, cooling water systems and ship sanitary systems

sheathing for wooden piles

underwater fencing

cabled tubes for hydraulic and pneumatic lines

fasteners, crankshafts, hulls and other marine hardware used in boats

silver-coloured circulation coins

BRASS

Brass is an alloy of copper and zinc; the proportions of zinc and copper can be varied to create a range of brasses with varying properties. In comparison, bronze is principally an alloy of copper and tin.

Applications:

It was used to create more powerful and long-lasting weapons, tools, and farm implements. Craftworkers also used it to make intricate castings—objects made by pouring melted bronze into a mold.

EFFECTS OF ALLOYING ELEMENTS IN STEEL Alloying elements are added to effect changes in the properties of steels. The basis of this section is to cover some of the different alloying elements added to the basic system of iron and carbon, and what they do to change the properties or effectiveness of steel.

MANGANESE

Manganese slightly increases the strength of ferrite, and also increases the hardness penetration of steel in the quench by decreasing the critical quenching speed. This also makes the steel more stable in the quench. Steels with manganese can be quenched in oil rather than water, and therefore are less susceptible to cracking because of a reduction in the shock of quenching. Manganese is present in most commercially made steels.

CHROMIUM

As with manganese, chromium has a tendency to increase hardness penetration. This element has many interesting effects on steel. When 5 percent chromium or more is used in conjunction with manganese, the critical quenching speed is reduced to the point that the steel becomes air hardening. Chromium can also increase the toughness of steel, as well as the wear resistance. Probably one of the most well known effects of chromium on steel is the tendency to resist staining and corrosion. Steels with 14 percent or more chromium are referred to as stainless steels. A more accurate term would be stain resistant. Stainless tool steels will in fact darken and rust, just not as readily as the nonstainless varieties. Steels with chromium also have higher critical temperatures in heat treatment.

SILICON

Silicon is used as a deoxidizer in the manufacture of steel. It slightly increases the strength of ferrite, and when used in conjunction with other alloys can help increase the toughness and hardness penetration of steel.

NICKEL

Nickel increases the strength of ferrite, therefore increasing the strength of the steel. It is used in low alloy steels to increase toughness and hardenability. Nickel also tends to help reduce distortion and cracking during the quenching phase of heat treatment.

MOLYBDENUM

Molybdenum increases the hardness penetration of steel, slows the critical quenching speed, and increases high temperature tensile strength.

VANADIUM

Vanadium helps control grain growth during heat treatment. By inhibiting grain growth it helps increase the toughness and strength of the steel.

TUNGSTEN

Used in small amounts, tungsten combines with the free carbides in steel during heat treatment, to produce high wear resistance with little or no loss of toughness. High amounts combined with chromium gives steel a property known as red hardness. This means that the steel will not lose its working hardness at high temperatures. An example of this would be tools designed to cut hard materials at high speeds, where the friction between the tool and the material would generate high temperatures.

COPPER

The addition of copper in amounts of 0.2 to 0.5 percent primarily improves steels resistance to atmospheric corrosion. It should be noted that with respect to knife steels, copper has a detrimental effect to surface quality and to hot-working behavior due to migration into the grain boundaries of the steel.

Bearing alloy:

The widely bearing materials are

White metals
Copper bare alloy
Aluminimum base alloys
Plastic materials and
Creamics

The selection of a particular bearing material depends upon types of loading running speed and service conditions.

State the effects of following alloying elements:

Chromium:

Typical ranges in alloy steel 0.3-4
Increases corrosion and oxidation resistance.

- Increases hardenability.
- Increase high temperature strength.
- Resists abrasion and wear.

Molybdenum:

Typical ranges in alloy steel 0.1-0.5
Improves high temperature creep resistance. ○ Reduces temper brittleness in Ni-Cr steels. ○ Stabilizes carbides.

- Increases hardenability.

State objectives:

The properties of all steels are determined by the kind and amounts of phases of which they are composed by the properties of the phases and by the way in which these phases are distributed among one another.

Steel consists of two or more phases known as ferrite austenite carbides and graphite.

Write short notes on: [A/M'15]

High speed steel
HSLA steel
Marageing steel
Tool steel

High speed steel:

- First produced in 1900s. They are highly alloyed with vanadium, cobalt, molybdenum, tungsten and chromium added to increase hot hardness and wear resistance.

Can be hardened to various depths by appropriate heat treating up to cold hardness in the range of HRC 63-65.

The cobalt component gives the material a hot hardness value much greater than carbon steels.

The high toughness and good wear resistance make HSS suitable for all type of cutting tools with complex shapes for relatively low to medium cutting speeds.

The most widely used tool material today for taps, drills, reamers, gear tools, end cutters, slitting, broaches, etc.

High-strength low-alloy steel (HSLA) is a type of alloy steel that provides better mechanical properties or greater resistance to corrosion than carbon steel.

HSLA steels vary from other steels in that they are not made to meet a specific chemical composition but rather to specific mechanical properties. They have a carbon content between 0.05–0.25% to retain formability and weldability.

Other alloying elements include up to 2.0% manganese and small quantities of copper, nickel, niobium, nitrogen, vanadium,chromium, molybdenum, titanium, c alcium, rare earth elements, or zirconium, Copper, titanium, vanadium, and niobium are added for strengthening purposes.

These elements are intended to alter the microstructure of carbon steels, which is usually aferrite-pearlite aggregate, to produce a very fine dispersion of alloy carbides in an almost pure ferrite matrix.

This eliminates the toughness-reducing effect of a pearlitic volume fraction yet maintains and increases the material's strength by refining the grain size, which in the case of ferrite increases yield strength by 50% for every halving of the mean grain diameter. Precipitation strengtheningplays a minor role, too.

Their yield strengths can be anywhere between 250–590 megapascals (36,000–86,000 psi). Because of their higher strength and toughness HSLA steels usually require 25 to 30% more power to form, as compared to carbon steels.

Maraging steel:

- Maraging steels (a portmanteau of "martensitic" and "aging") are steels (iron alloys) that are known for possessing superior strength and toughness without losing malleability, although they cannot hold a good cutting edge.

Aging refers to the extended heat-treatment process. These steels are a special class of low-carbon ultra-high-strength steels that derive their strength not from carbon, but from precipitation of intermetallic compounds.

The principal alloying element is 15 to 25 wt.% nickel. Secondary alloying elements, which include cobalt, molybdenum, and titanium, are added to produce intermetallic precipitates, Original development (by Bieber of Inco in the late 1950s) was carried out on 20 and 25 wt.% Ni steels to which small additions of Al, Ti, and Nb were made; a rise in the price of cobalt in the late 1970s led to the development of cobalt-free maraging steels.

The common, non-stainless grades contain 17–19 wt.% nickel, 8–12 wt.% cobalt, 3–5 wt.% molybdenum, and 0.2–1.6 wt.% titanium. Addition of chromium produces stainless grades resistant to corrosion.

This also indirectly increases hardenability as they require less nickel: high-chromium, high-nickel steels are generally austenitic and unable to transform to martensite when heat treated, while lower-nickel steels can transform to martensite.

Tool steel:

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools.

Their suitability comes from their distinctive hardness, resistance to abrasion and deformation and their ability to hold a cutting edge at elevated temperatures. As a result tool steels are suited for their use in the shaping of other materials.

With carbon content between 0.5% and 1.5%, tool steels are manufactured under carefully controlled conditions to produce the required quality.

The presence of carbides in their matrix plays the dominant role in the qualities of tool steel. The four major alloying elements in tool steel that form carbides are: tungsten, chromium, vanadium and molybdenum.

The rate of dissolution of the different carbides into the austenite form of the iron determines the high temperature performance of steel (slower is better, making for a heat resistant steel).

Proper heat treatment of these steels is important for adequate performance. The manganese content is often kept low to minimize the possibility of cracking during water quenching.

There are six groups of tool steels: water-hardening, cold-work, shock-resisting, high-speed, hot-work, and special purpose.

The choice of group to select depends on, cost, working temperature, required surface hardness, strength, shock resistance, and toughness requirements. The more severe the service condition (higher temperature, abrasiveness, corrosiveness, loading), the higher the alloy content and consequent amount of carbides required for the tool steel.

- C26800, Yellow brass, is the single phase alpha brass with the lowest content of copper. It is used where its deep drawing properties and lower cost give an advantage. When welded, particles of beta phase may form, reducing ductility and corrosion resistance.

3.) Discuss different types of copper alloys and their properties and applications.

Copper and copper alloys are some of the most versatile engineering materials available. The combination of physical properties such as strength, conductivity, corrosion resistance, machinability and ductility make copper suitable for a wide range of applications. These properties can be further enhanced with variations in composition and manufacturing methods.

Copper is the oldest metal used by man, its use dates back to prehistoric times. Copper has been mined for more than 10,000 years with a copper pendant found in current day Iraq being dated to 8700BC.

Copper is found as native metal and in the minerals cuprite, malachite, azurite, chalcopyrite and bornite. It is also often a by-product of silver production. Sulfides, oxides and carbonates are the most important ores.

Copper and copper alloys are some of the most versatile engineering materials available. The combination of physical properties such as strength, conductivity, corrosion resistance, machinability and ductility make copper suitable for a wide range of applications. These properties can be further enhanced with variations in composition and manufacturing methods.

APPLICATIONS OF COPPER

Copper and copper alloys can be used in an extraordinary range of applications. Some of these applications include:

Power transmission lines
Architectural applications
Cooking utensils
Spark plugs
Electrical wiring, cables and busbars
High conductivity wires
Electrodes
Heat exchangers and refrigeration tubing
Plumbing
Water-cooled copper crucibles.

The largest end use for copper is in the building industry. Within the building industry the use of copper-based materials is broad. Construction industry related applications for copper include:

Roofing
Cladding
Rainwater systems
Heating systems
Water pipes and fittings
Oil and gas lines
Electrical wiring.

TYPES OF COPPER ALLOYS

Commercially pure coppers are very soft and ductile, containing up to about 0.7% total impurities. These materials are used for their electrical and thermal conductivity, corrosion resistance, appearance and color, and ease of working. They have the highest conductivity of the engineering metals and are very ductile and easy to braze, and generally to weld. Typical applications include electrical wiring and fittings, busbars, heat exchangers, roofs, wall cladding, tubes for water, air and process equipment.

High copper alloys contain small amounts of various alloying elements such as beryllium, chromium, zirconium, tin, silver, sulphur or iron. These elements modify one or more of the basic properties of copper, such as strength, creep resistance, machinability or weldability. Most of the uses are similar to those given above for coppers, but the conditions of application are more extreme.

Brasses are copper zinc alloys containing up to about 45% zinc, with possibly small additions of lead for machinability, and tin for strength. Copper zinc alloys are single phase up to about 37% zinc in the wrought condition. The single phase alloys have excellent ductility, and are often used in the cold worked condition for better strength. Alloys with more than about 37% zinc are dual phase, and have even higher strength, but limited ductility at room temperature compared to the single phase alloys. The dual phase brasses are usually cast or hot worked.

Typical uses for brasses are architecture, drawn & spun containers and components, radiator cores and tanks, electrical terminals, plugs and lamp fittings, locks, door handles, name plates, plumbers hardware, fasteners, cartridge cases, cylinder liners for pumps.

Brasses are divided into two classes. These are:

The alpha alloys, with less than 37% Zinc. These alloys are ductile and can be cold worked.

The alpha/beta or duplex alloys with 37-45% Zinc. These alloys have limited cold ductility and are typically harder and stronger.

There are three main families of wrought alloy brasses:

Copper-Zinc alloys

Copper-Zinc-Lead alloys (Leaded brasses)

Copper-Zinc-Tin alloys (Tin brasses)

Cast brass alloys can be broken into four main families:

Copper-Tin-Zinc alloys (red, semi-red and yellow brasses)

Manganese Bronze alloys (high strength yellow brasses) and Leader Manganese Bronze alloys (leaded high strength yellow brasses)

Copper-Zinc-Silicon alloys (Silicon brasses and bronzes)

Cast Copper-Bismuth and Copper-Bismuth-Selenium alloys.

Bronzes are alloys of copper with tin, plus at least one of phosphorus, aluminum, silicon, manganese and nickel. These alloys can achieve high strengths, combined with good corrosion resistance. They are used for springs and fixtures, metal forming dies, bearings, bushes, terminals, contacts and connectors, architectural fittings and features. The use of cast bronze for statuary is well known.

Copper nickel are alloys of copper with nickel, with a small amount of iron and sometimes other minor alloying additions such as chromium or tin. The alloys have outstanding corrosion resistance in waters, and are used extensively in sea water applications such as heat exchangers, condensers, pumps and piping systems, sheathing for boat hulls.

Nickel silvers contain 55–65% copper alloyed with nickel and zinc, and sometimes an addition of lead to promote machinability. These alloys get their misleading name from their appearance, which is similar to pure silver, although they contain no addition of silver. They are used for jewelry and name plates and as a base for silver plate (EPNS), as springs, fasteners, coins, keys and camera parts.

PROPERTIES OF COPPER ALLOYS

Corrosion Resistance of Copper. All copper alloys resist corrosion by fresh water and steam. In most rural, marine and industrial atmospheres copper alloys are also resistant to corrosion. Copper is resistant to saline solutions, soils, non-oxidizing minerals, organic acids and caustic solutions. Moist ammonia, halogens, sulfides, solutions containing ammonia ions and oxidizing acids, like nitric acid, will attack copper. Copper alloys also have poor resistance to inorganic acids. The corrosion resistance of copper alloys comes from the formation of adherent films on the material surface. These films are relatively impervious to corrosion therefore protecting the base metal from further attack.

With part of phase diagram and relevant sketches, explain the precipitation hardening treatment of Al-Cu alloys. [M/J'16]

PRECIPITATION STRENGTHENING TREATMENT:

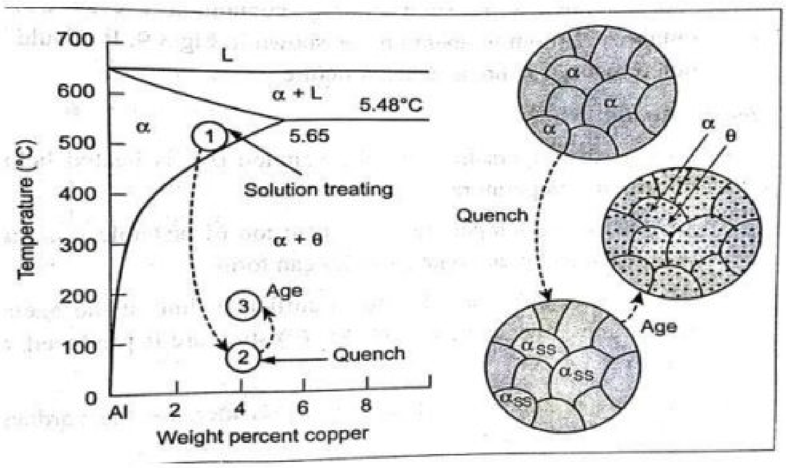
In designing alloys for strength an approach after taken is to develop an alloy with a structure that consists of particles dispersed in a ductile matrix. Such a dispersion can be obtained by choosing an alloy that is single phase at elevated temperatures but on cooling will precipitate another phased in the matrix, when alloy is strengthened by this thermal treatment, it is called precipitation strengthening or hardening.

Precipitation strengthening consists of three main steps.

Solution treatment
Quenching
Aging

SOLUTION HEAT TREATMENT:

To take advantage of precipitation hardening reaction, it is necessary first to produce a solid solution. The process by which this is accomplished is called solution heat treating and its objective is to take into solid solution the maximum practical amounts of soluble hardening elements in the alloy. The processes consist of soaking the alloy at a temperature sufficiently high and for time long enough to achieve a nearly homogenous solid solution.



QUENCHING:

Quenching is in many ways the most critical step in the sequence of heat treating operations. The objective of quenching is to preserve the solid solution formed at the solution heat treating temperature by rapidly cooling to some lower temperature usually near room temperature.

In most cases, the solid solution formed during solution heat treatment must be quenched rapidly enough to produce the supersaturated solution at room temperature the optimum condition for precipitation hardening. Quenching rapidly cools the solution and frees the atoms in solution. In more technical ters, the quenching cools the material so fast that the atoms of the alloying elements do not have time to diffuse out of the solution. Most frequently parts are quenched by immersion in cold water or in continuous heat treating of sheet plate or extrusions in primary fabricating mills by progressive flooding or high velocity spraying with water.

AGING OR AGE HARDENING:

Aging is the process where the solute particles diffuse out of solution and into clusters that distort and strengthen the material. After solution and quenching, hardening is achieved either at room temperature or with a precipitation heat treatment. In some alloys, sufficient precipitation occurs is a few days at room temperature to yield stable products with properties that are adequate for many applications.

These alloys sometimes are precipitation het treated to provide increased strength and hardness in wrought or cast products other alloys with and hardness reaction at room temperature are always precipitation heat treated before use precipitation heat treatments generally are low temperature, long term processes and temperatures range from 1115oC to 190oC times vary from 5 to 48 hours. The precipitation hardening process for a copper aluminium alloy is shown graphically on the right is a phase diagram which is very useful tool for understanding and controlling polyphone structures. The phase present as the temperature and over all composition of the alloy are varied.

PART-C

Write short notes on:

Austenitic stainless steel (5)
Ferritic stainless steel (5)
(iii) Martensitic stainless steel (6)

(i)**Austenitic Stainless Steel:**

Austenitic stainless steels are a class of alloys with a face-centered-cubic lattice structure of austenite over the whole temperature range from room temperature (and below) to the melting point.

In ferritic steels there is a transformation from the body-centered-cubic lattice structure of ferrite to the face-centered-cubic lattice structure of austenite.

The temperature of this transformation depends upon the composition but is about 1340^{o} F for a plain-carbon steel similar to the SA178 or SA210 grades.

When 18% chromium and 8% nickel are added, the crystal structure of austenite remains stable over all temperatures.

The nickel-based alloys with 35-70% nickel and 20-30% chromium, while not strictly steels (a steel must have at least 50% iron), do have the face-centered-cubic lattice arrangement and are also called austenitic materials.

Ferritic stainless steel:

Ferritic stainless steels have a "body-centred-cubic" (bcc) crystal structure, which is the same as pure iron at room temperature.

These steels contain less than 0.10% carbon and are magnetic. The fact that they can't be hardened via heat treatment and don't weld to a high standard limits the use of these metals somewhat, but they are still suitable for a wide range of applications.

The main alloying element is chromium, with contents typically between 11 and 17%, although higher a chromium content of about 29% is found in one specialised grade.

Carbon is kept low which results in these steels having limited strength. They are not hardenable by heat treatment and have annealed yield strengths in the range of 275 to 350 MPa.

(iii)**Martensitic stainless steel:**

Martensitic stainless steels are similar to low alloy or carbon steels. They have a structure similar to the ferritics with a 'body-centred tetragonal' (bct) crystal lattice.

Due to the addition of carbon, they can be hardened and strengthened by heat treatment, in a similar way to carbon steels. They are classed as a "hard" ferro-magnetic group.

The main alloying element is chromium, with a typical content of 12-15%. In the annealed condition, they have tensile yield strengths of about 275 MPa and so they are usually machined, cold formed, or cold worked in this condition.

The strength obtained by heat treatment depends on the carbon content of the alloy. Increasing the carbon content increases the strength and hardness potential but decreases ductility and toughness.

The higher carbon grades are capable of being heat treated to hardnesses of 60 HRC. Optimum corrosion resistance is attained in the heat-treated i.e. hardened and tempered condition.

Martensitic grades have been developed with nitrogen and nickel additions but with lower carbon levels than the traditional grades. These steels have improved toughness, weldability and corrosion resistance

What are the types of titanium alloy, their composition properties and applications? [N/D'15]

Titanium and its alloys are new engineering materials that possess an extraordinary combination of mechanical properties. Titanium alloys are extremely strong, room temperature tensile strengths as high as 14000MPa are attainable yielding remarkable specific strengths, highly ductile, easily forged and machined.

ALLOY NAME & COMPOSITION	MECHANICAL PROPERTIES	APPLICATIONS
Commercially Pure-99.1%Ti	Tensile strength (MPa)-484 Yield strength (MPa)-414 Ductility (% elongation in 50 mm)-25	Jet engine shrouds, cases and airframe skins, corrosion resistant equipment for marine and chemical processing industries
Alpha alloy 5% Al,2.5% Sn, balance Ti	Tensile strength (MPa)-826 Yield strength (MPa)-784 Ductility (% elongation in 50 mm)-16	Gas turbine engine casings and rings, chal processing equipment requiring strength to temperatures of 480 degree Celsius
Near alpha alloy 8%Al, 1%Mo, 1%V, balance Ti	Tensile strength (MPa)-950 Yield strength (MPa)-890 Ductility (% elongation in 50 mm)-15	Forgings for jet engine components (compressor disks, plates and hubs)
Alpha Beta alloy 6%Al, 4%V, balance Ti	Tensile strength (MPa)-947 Yield strength (MPa)-877 Ductility (% elongation in 50 mm)-14	High strength prosthetic implants, chemical processing equipment, airframe structural components.

b

Alpha Beta alloy 6%Al,2% Sn, 6%V,0.75%Cu, balance Ti	Tensile strength (MPa)-1050 Yield strength (MPa)-985 Ductility (% elongation in 50 mm)-14	Rocket engine case airframe applications and high strength airframe structures
Alpha alloy 10%V, 2% Fe, 3%Al, balance Ti	Tensile strength (MPa)-1223 Yield strength (MPa)-1150 Ductility (% elongation in 50 mm)-10	Aircraft tailpipe assemblies, missile fuel tanks and structural parts operating for short times upto 593 degree Celsius.