UNIT – III

FERROUS AND NON- FERROUS METALS.

3.5 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 $\rightarrow$ 12.5% to 14.5% Copper $\rightarrow$ 2.5 % to 3% Nickel $\rightarrow$ upto 1% Magnesium $\rightarrow$ 3% Remaining $\rightarrow$ 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) $\rightarrow$ 3.5 to 4.5 %,Manganese (Mg) $\rightarrow$ 0.4 to 0.7%,Magnesium (Mn) $\rightarrow$ 0.4 to 0.7%,Remaining $\rightarrow$ 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 $\rightarrow$ 92.5% Cu $\rightarrow$ 4% Ni $\rightarrow$ 2% Mg $\rightarrow$ 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

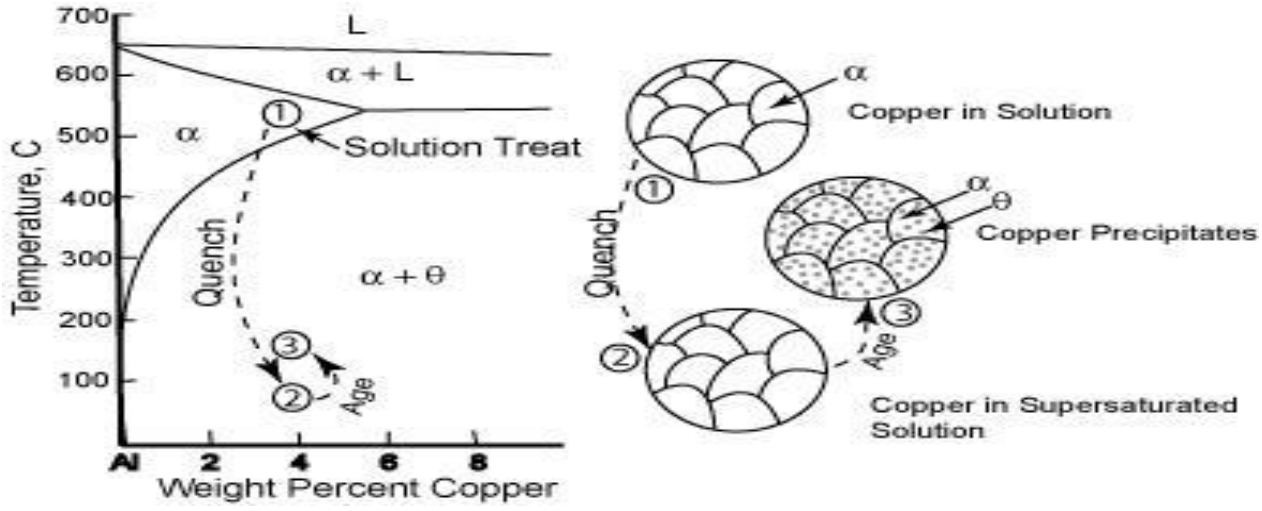

Fig 3.1 Precipitation hardening

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 $\rightarrow$ 20 to 40%,Cu $\rightarrow$ 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 $\rightarrow$ 3 to 4%,Fe $\rightarrow$ 91%,remaining $\rightarrow$ Si, S, P, Mn.

Applications:

Bearings for refrigerators, compressors, railways coaches etc.

6. Porous self – lubricating Bearing:

Copper – Based (Cu $\rightarrow$ 90%, Sn $\rightarrow$ 10%).

Iron – Based (Fe $\rightarrow$ 96%, C $\rightarrow$ 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$\rightarrow$ 94.5%,Mg $\rightarrow$5%,Mn $\rightarrow$ 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.