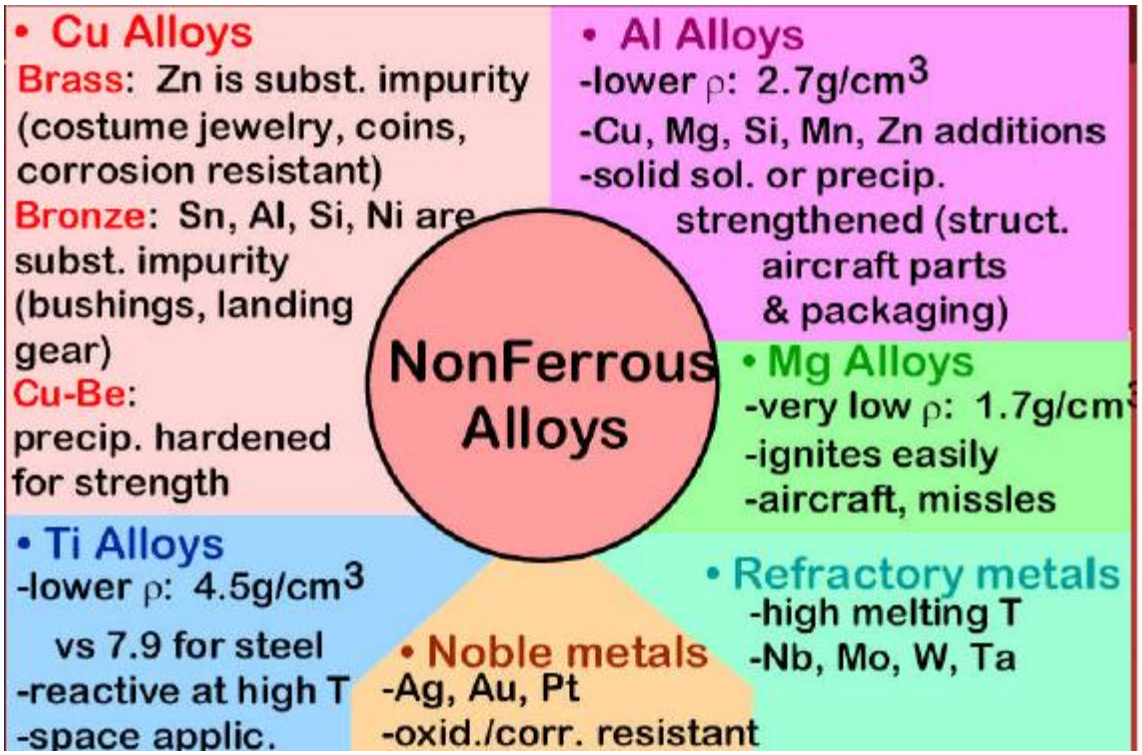
MATERIAL TECHNOLOGY (SPR1201)

UNIT – III (Non Ferrous Alloys)

Nonferrous alloys:



Aluminum and its Alloys:

Pure aluminum is a silvery-white metal with many desirable characteristics. It is light, nontoxic (as the metal), nonmagnetic and nonsparking. It is easily formed, machined, and cast. Pure aluminum is soft and lacks strength, but alloys with small amounts of copper, magnesium, silicon, manganese, and other elements have very useful properties. Aluminum is an abundant element in the earth's crust, but it is not found free in nature. The Bayer process is used to refine aluminum from bauxite, an aluminum ore. Because of aluminum's mechanical and physical properties, it is an extremely convenient and widely used metal. Aluminium alloys can be classified as; cast or wrought alloys, examples are; Al--Li, Al-Cu-Si etc

Properties

 Very lightweight (about 1/3 the mass of an equivalent volume of steel or copper) but with alloying can become very strong.

 excellent thermal conductor

 excellent electrical conductor (on a weight-for-mass basis, aluminium will conduct more than twice as much electricity as copper)

 highly reflective to radiant energy in the electromagnetic spectrum

 highly corrosion resistant in air and water (including sea water)

 highly workable and can be formed into almost any structural shape
 non-magnetic
 non-toxic

Applications
 door and window frames
 high tension power lines, wires, cables, bus bars, components for television, radios, refrigerators and air-conditioners
 beverage cans, bottle tops
 propellers, airplane and vehicle body sheet, gear boxes, motor parts
 Al-Cu food/ chemicals handing and storage equipments.
 Al-Cu-Mn-Zn- Cooking utensils.
 Al-Zn-Mg-Cu-Cr Aircraft structural parts

Copper and its Alloys

Copper alloys are metal alloys that have copper as their principal component. They have high resistance against corrosion. There are as many as 400 different copper and copper-alloy compositions loosely grouped into the categories: copper, high copper alloy, brasses, bronzes, copper nickels, copper–nickel–zinc (nickel silver), leaded copper, and special alloys. The best known traditional types are bronze, where tin is a significant addition, and brass, using zinc instead.

Brasses: Brass A brass is an alloy of copper with zinc. Brasses are usually yellow in color. The zinc content can vary between few % to about 40%; as long as it is kept under 15%, it does not markedly decrease corrosion resistance of copper. Brasses can be sensitive to selective leaching corrosion under certain conditions, when zinc is leached from the alloy (dezincification), leaving behind a spongy copper structure.

Bronzes: A bronze is an alloy of copper and other metals, most often tin, but also aluminium and silicon. Aluminium bronzes are alloys of copper and aluminium. The content of aluminium ranges mostly between 5-11%. Iron, nickel, manganese and silicon are sometimes added. They have higher strength and corrosion resistance than other bronzes, especially in marine environment, and have low reactivity to sulfur compounds. Aluminium forms a thin passivation layer on the surface of the metal. Example: Bell metal Phosphor bronze Nickel bronzes, e.g. nickel silver and cupronickel Speculum metal

Properties
 Good thermal and electrical conductivity
 Ease of forming, ease of joining, and color.
 However, copper and its alloys have relatively low strength-to-weight ratios
 Low strengths at elevated temperatures.
 Copper is resistant to corrosion in most atmospheres including marine and industrial environments. It is corroded by oxidizing acids, halogens, sulphides and ammonia based solutions
 Copper and its alloys -- the brasses and bronzes -- are available in rod, plate, strip, sheet, tube shapes, forgings, wire, and castings.

Applications

 Pure Cu Electrical and thermal conductors (cast Cu), transistor components, coaxial cables rectifiers, lead in wires (cold--worked Cu)
 Cu- Be- Co moulds for plastic parts, bearings, valves, gears(cast Cu)
 Cu--30Zn & Cu --40Zn (cold --work brass) fasteners, locks, heal exchange components, large nuts and bolts, plumbing accessories, pints and rivets.
 Cu--4Si bearing, belts, marine fittings

Titanium and its Alloys

Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials and processing limit their use to military applications, aircraft, spacecraft, medical devices, highly stressed components such as connecting rods on expensive sports cars and some premium sports equipment and consumer electronics. Although "commercially pure" titanium has acceptable mechanical properties and has been used for orthopedic and dental implants, for most applications titanium is alloyed with small amounts of aluminium and vanadium, typically 6% and 4% respectively, by weight.

Titanium alloys are generally classified into four main categories:

[1] Alpha alloys which contain neutral alloying elements (such as tin) and/ or alpha stabilisers (such as aluminium or oxygen) only. These are not heat treatable. Examples include: Ti-5AL-2SN-ELI, Ti-8AL-1MO-1V.

[2] Near-alpha alloys contain small amount of ductile beta-phase. Besides alpha-phase stabilisers, near-alpha alloys are alloyed with 1–2% of beta phase stabilizers such as molybdenum, silicon or vanadium. Examples include: Ti-6Al-2Sn-4Zr-2Mo, Ti-5Al-5Sn-2Zr-2Mo, IMI 685, Ti 1100.

[3] Alpha and beta alloys, which are metastable and generally include some combination of both alpha and beta stabilisers, and which can be heat treated. Examples include: Ti-6Al-4V, Ti-6Al-4V-ELI, Ti-6Al-6V-2Sn.

[4] Beta and near beta alloys, which are metastable and which contain sufficient beta stabilisers (such as molybdenum, silicon and vanadium) to allow them to maintain the beta phase when quenched, and which can also be solution treated and aged to improve strength. Examples include: Ti-10V-2Fe-3Al, Ti-13V-11Cr-3Al, Ti-8Mo-8V-2Fe-3Al, Beta C, Ti-15-3.

Properties

 Low density metal (4.5 g/cm cm3)
 High melting point = 1668oC
 elastic modulus = 107MPa
 Chemical reactivity with other material at elevated temperatures
 Corrosion resistance
 Ti—alloys ,very high elastic modulus ~1400MPa, easily forged and machined, high ductility

Applications

• Pure Ti - Jet engine cases and airframe skins, corrosion--resistance equipment for marine's applications chemical processing, industries.
• Ti--5Al--2.55Sn – Gas turbine engine casing
• Ti--6Al-4V – High strength prosthetic implants, orthopedics, airframe structured components

Nickel and nickel alloys

Nickel is a versatile element and will alloy with most metals. Complete solid solubility exists between nickel and copper. Wide solubility ranges between iron, chromium, and nickel make possible many alloy combinations. It has strength, toughness, and corrosion resistance to metals. It is used in stainless steels and nickel-base alloys. Nickel alloys are used for high temperature applications, such as jet-engine components and rockets.

Types of resistance alloys containing nickel include:

Cu-Ni alloys containing 2 to 45% Ni Ni-Cr-Al alloys containing 35 to 95% Ni Ni-Cr-Fe alloys containing 35 to 60% Ni Ni-Cr-Si alloys containing 70 to 80% Ni

Types of resistance heating alloys con-taining nickel include:

Ni-Cr alloys containing 65 to 80% Ni with 1.5% Si Ni-Cr-Fe alloys containing 35 to 70% Ni with 1.5% Si + l% Nb

Soft Magnetic Alloys.

Two broad classes of magnetically soft materials have been developed in the Fe-Ni system. The high-nickel alloys (about 79% Ni with 4 to 5% Mo; bal Fe) have high initial permeability and low saturation induction.

Shape Memory Alloys:

Metallic materials that demonstrate the ability to return to their previously defined shape when subjected to the appropriate heating schedule are referred to as shape memory alloys. Nickel-titanium alloys (50Ni-50Ti) are one of the few commercially important shape memory alloys.

Superalloys: *Superalloys* are high-temperature alloys use in jet engines, gas turbines and reciprocating engines.

Nickel and nickel alloys are used for a wide variety of applications:

The majority of which involve corrosion resistance and/or heat resistance. Some of these include: Aircraft gas turbines Steam turbine power plants Medical applications Nuclear power systems Chemical and petrochemical industries

A number of other applications for nickel alloys involve the unique physical properties of special-purpose nickel-base or high-nickel alloys. These include: Low-expansion alloys Electrical resistance alloys Soft magnetic alloys Shape memory alloys