Aluminium and its alloys

Objectives : At the end of this lesson you shall be able to
- **state the properties and uses of aluminium**
- **name the commonly used aluminium alloys and their uses**
- **name the ores from which aluminium is produced.**

Aluminium is a non-ferrous metal which is extracted from 'BAUXITE'. Aluminium is white or whitish grey in colour. It has a melting point of 660°C. Aluminium has high electrical and thermal conductivity. It is soft and ductile, and has low tensile strength. Aluminium is very widely used in aircraft industry and fabrication work because of its lightness. Its application in the electrical industry is also on the increase. It is also very much in use in household heating appliances. Some typical aluminium alloys, their composition and applications are given in the table that follows.

Aluminium alloys - Composition - Uses

Composition(%) (Only the percentage of alloying elements is shown. The remaining is aluminium)						**Category**	**Applications**
Copper	Silicon	Iron	Manganese	Magnesium	Other elements		
0.1 max.	0.5 max.	0.7 max.	0.1 max.	-	-	Wrought. Not heat treatable.	Fabricated assemblies, Electrical conductors. Food and brewing, processing plants. Architectural decorations.
0.15 max.	0.6 max.	0.75 max.	1.0 max.	4.5 to 5.5	0.5 Chromium	Wrought. Not heat treatable.	High strength ship building and engineering products. Good corrosion resistance.
1.6	10.0	-	-	-	-	Cast, not heat treatable.	General purpose alloy for moderately stressed pressure die-castings.
-	10.0 to 13.0	-	-	-	-	Cast, not heat treatable.	One of the most widely used alloys. Suitable for sand,gravity and pressure die castings. Excellent foundry characteristics. Used for large marine, automotive and general engineering castings.
4.2	0.7	0.7	0.7	0.7	0.3 Titanium (option)	Wrought. Heat treatable.	Traditional 'Duralumin'. General machining alloy. Widely used for stressed components in aircraft.
-	0.5	-	-	0.6	-	Wrought. Heat treatable.	Corrosion-resistant alloy for lightly stressed components such as glazing bars, window sections and automotive body components.
1.8	2.5	1.0	-	0.2	0.15 Titanium 1.2 nickel	Cast. Heat treatable.	Suitable for sand and gravity die casting. High rigidity with moderate strength and shock resistance. A general purpose alloy
-	-	-	-	10.5	0.2 Titanium	Cast. Heat treatable.	A strong, ductile and highlycorrosion-resistant alloy used for air craft and marine castings, both large and small.

Advantages of using aluminium over steel

Advantages

- lighter
- strength comparable to steel
- corrosion resistance
- good machinability
- can be anodized
- better thermal and electrical conductivity

Disadvantages

- less strength (compared to the higher strength steel alloys)
- not good for threaded fasteners
- more difficult to paint
- weldments require post welding heat treat to recover mechanical properties
- more difficult to weld
- fatigues
- high cost
- lower modulus of elasticity,therefore,increased deformation
- low elongation values

Aluminium and aluminium alloys

Aluminium is one of the most widely used metals in the world. It possesses an exciting range of properties. Moreover,aluminium combines with alloying elements like copper. manganese,silicon,magnesium and zinc,and forms a very useful series of alloys.

Important properties

- Aluminium is a light weight metal. Its density is about 2.7 gm/cm^3. It is about one third as light as steel.
- While pure aluminium has a low strength of 7 kgf/ mm^2, the alloys are moderately strong Some alloys have strength as high as 45 kgt/mm^2 in the heat - treated condition.
- The above two properties together provide it with high strength to weight ratio,which makes it suitable for aerospace application.
- Some of the alloys have excellent toughness at low temperatures,making them suitable for cryogenic (below 0° C) application.
- Some alloys have excellent corrosion resistance.
- Aluminium and its alloys have high thermal conductivity.
- Aluminium and its alloys also have high electrical conductivity.

Applications

- Household furniture and utensils.
- Containers,tanks and vessels.
- Automobile structures,bus bodies,road and railway tankers and wagons.
- Buildings and other architectural structures.
- Portable bridges.
- Aircraft,missiles and other aerospace components.
- Radiators and other heat exchangers.
- Electrical conductor cables and bus bars.

Aluminium alloy system

Aluminium alloys are classified on the basis of the principal alloying element present in a particular alloy.

Lead and its alloys

Objectives : At the end of this lesson you shall be able to
- **state the properties of lead**
- **state the various uses of lead**
- **state the uses of babbit metal.**

Lead is a very commonly used non-ferrous metal and has a variety of industrial applications.

Lead is produced from its ore 'GALENA'. Lead is a heavy metal that is silvery in colour when molten. It is soft and malleable and has good resistance to corrosion. It is a good insulator against nuclear radiation. Lead is resistant to many acids like sulphuric acid and hydrochloric acid.

It is used in car batteries, in the preparation of solders etc. It is also used in the preparation of paints.(Fig 1)

Lead Alloys

Babbit metal

Babbit metal is an alloy of lead, tin, copper and antimony. It is a soft, anti-friction alloy, often used as bearings.

An alloy of lead and tin is used as 'soft solder'.(Fig 2)

Fig 1

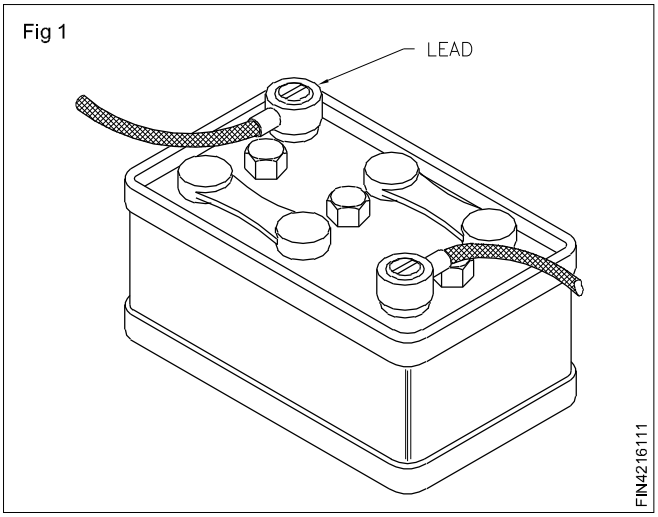
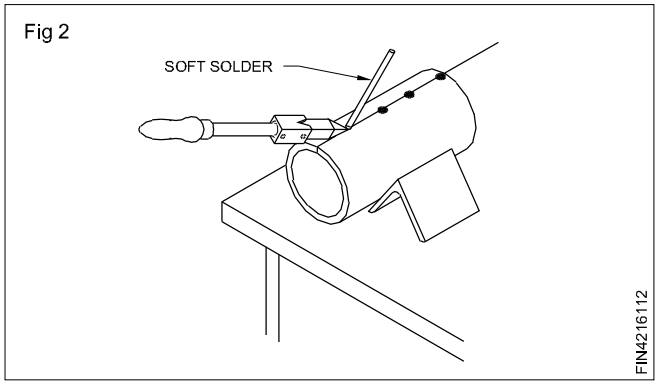


Fig 2



Zinc

Objectives : At the end of this lesson you shall be able to
- **state the properties and uses of zinc**
- **state the uses of zinc alloys.**

Zinc is a commonly used metal for coating on steel to prevent corrosion. Examples are steel buckets, galvanized roofing sheets, etc.

Zinc is obtained from the ore-calamine or blende.

Its melting point is 420°C.

It is brittle and softens on heating; it is also corrosion resistant. Due to this reason it is used for battery containers and is coated on roofing sheets etc.

Galvanized iron sheets are coated with zinc.

Tin and its alloys

Objectives : At the end of this lesson you shall be able to
- **state the properties and uses of tin**
- **name the common tin alloys and state their uses.**

Tin

Tin is produced from cassiterite or tinstone. It is silvery white in appearance, and the melting point is 231°C. It is soft and highly corrosion-resistant.

It is mainly used as a coating on steel sheets for the production of food containers. It is also used with other metals, to form alloys.

Eg. Tin with copper to form bronze. Tin with lead to form solder. Tin with copper, lead and antimony to form babbit metal.

Copper and its alloys

Objectives : At the end of this lesson you shall be able to
- **name the commonly used copper alloys**
- **state the properties and uses of copper**
- **state the composition and uses of different types of brasses**
- **state the composition and uses of different types of bronze.**

Metals without iron (Ferrum) are called non-ferrous metals. Eg. Copper, Aluminium, Zinc, Lead and Tin.

Copper

This is extracted from its ores 'MALACHITE' which contains about 55% copper and 'PYRITES' which contains about 32% copper.

Properties

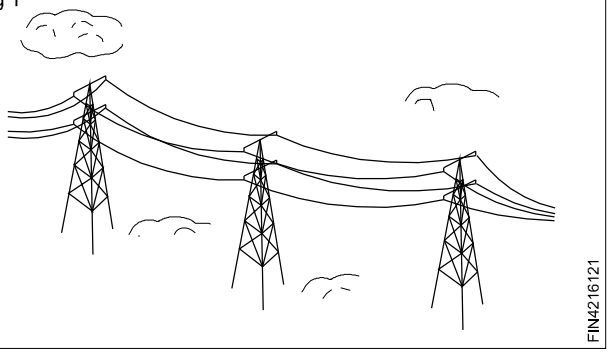
Reddish in colour. Copper is easily distinguishable because of its colour.

The structure when fractured is granular, but when forged or rolled it is fibrous.

It is very malleable and ductile and can be made into sheets or wires.

It is a conductor of electricity. Copper is extensively used as electrical cables and parts of electrical apparatus which conduct electric current. (Fig 1)

Fig 1



Copper is a good conductor of heat and also highly resistant to corrosion. For this reason it is used for boiler fire boxes, water heating apparatus, water pipes and vessels in brewery and chemical plants. Also used for making soldering iron.

The melting temperature of copper is 1083°C.

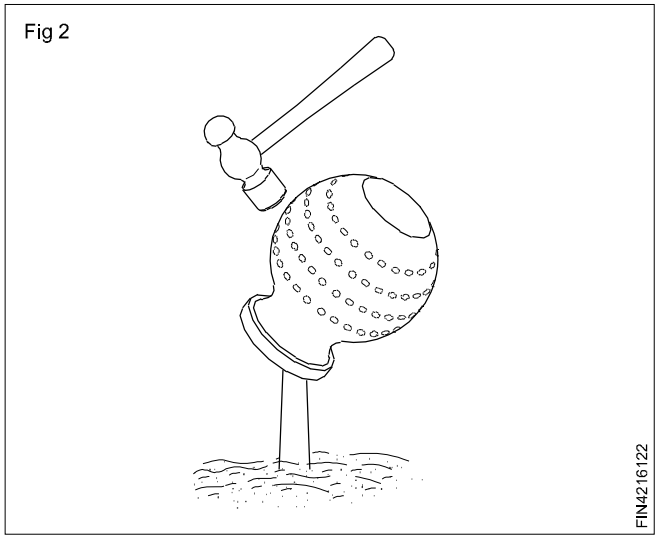
The tensile strength of copper can be increased by hammering or rolling. (Fig 2)

Copper alloys

Brass

It is an alloy of copper and zinc. For certain types of brass small quantities of tin or lead are added. The colour of brass depends on the percentage of the alloying elements. The colour is yellow or light yellow, or nearly white. It can be easily machined. Brass is also corrosion-resistant.

Fig 2



Brass is widely used for making motor car radiator core and water taps etc. It is also used in gas welding for hard soldering/brazing. The melting point of brass ranges from 880 to 930°C.

Brasses of different composition are made for various applications. The following table-1 gives the commonly used brass alloy compositions and their application.

Bronze

Bronze is basically an alloy of copper and tin. Sometimes zinc is also added for achieving certain special properties. Its colour ranges from red to yellow. The melting point of bronze is about 1005°C. It is harder than brass. It can be easily machined with sharp tools. The chip produced is granular. Special bronze alloys are used as brazing rods. Bronze of different compositions are available for various applications. Table-2 gives the type compositions and applications

Table 1 - Composition of different types of brass

Name	Composition (%)			Applications
	Copper	Zinc	Other elements	
Cartridge brass	70	30	-	Most ductile of the copper/zinc alloys. Widely used in sheet metal pressing for severe deep drawing operations. Originally developed for making cartridge cases, hence its name.
Standard brass	65	35	-	Cheaper than cartridge brass and less ductile. Suitable for most engineering processes.
Basic brass	63	37	-	The cheapest of the cold working brasses. It lacks ductility and is only capable of withstanding simple forming operations.
Muntz metal	60	40	-	Not suitable for cold working, but suitable for hot-working. Relatively cheap due to its high zinc content. It is widely

Muntz metal	60	40	-	Not suitable for cold working, but suitable for hot-working. Relatively cheap due to its high zinc content. It is widely used for extrusion and hot-stamping processes.
Free-cutting brass	58	39	3% lead	Not suitable for cold working but excellent for hot working and high speed machining of low strength components.
Admirality brass	70	29	1% tin	This is virtually cartridge brass plus a little tin to prevent corrosion in the presence of salt water.
Naval brass	62	37	1% tin	This is virtually Muntz metal plus a little tin to prevent corrosion in the presence of salt water.
Gilding metal	95	5	-	Used for jewellery.

Table 2 - Composition of different types of bronze

Name	**Composition (%)**				**Applications**
	Copper	Zinc	Phosphorus	Tin	
Low tin bronze	96	-	0.1 to 0.25	3.9 to 3.75	This alloy can be severely cold-worked to harden it so that it can be used for springs where good elastic properties must be combined with corrosion resistance,fatigue-resistance and electrical conductivity. Eg.Contact blades
Drawn phosphor/ bronze	94	-	0.1 to 0.5	5.9 to 5.5	This alloy is used for turned components requiring strength and corrosion resistance, such as valve spindles.
Cast phosphor/ bronze	89.75 to 89.97		0.03 to 0.25	10	Usually cast into rods and tubes for making bearing bushes and worm wheels. It has excellent anti-friction properties.
Admirality gun-metal	88	2	-	10	This alloy is suitable for sand casting where fine-grained, pressure-tight components such as pump and valve bodies are required.
Leaded gun-metal (free cutting)	85	5 (5%lead)	-	5	Also known as 'red brass' this alloy is used for the same purposes as standard, admirality gun-metal. It is rather less strong but has improved toughness and machining properties.
Leaded (plastic) bronze	74	(24%lead)	-	2	This alloy is used for lightly loaded bearings where alignment is difficult. Due to its softness, bearings made from this alloy 'bed in' easily.