

## CHAPTER FOUR

### COPPER AND ITS ALLOYS

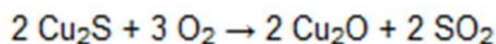
#### COPPER:

- ✓ Copper is a chemical element with the symbol Cu (from Latin: cuprum) and atomic number 29.
- ✓ It is a ductile metal with very high thermal and electrical conductivity.
- ✓ Copper is synthesized in massive stars and is present in the Earth's crust at a concentration of about 50 parts per million (ppm), where it occurs as native copper or in minerals such as the copper sulfides Chalcopyrite ( $\text{CuFeS}_2$ ) and Chalcocite ( $\text{Cu}_2\text{S}$ ), the copper carbonates azurite and malachite, and the copper(I) oxide mineral Cuprite.
- ✓ Pure copper is soft and malleable; a freshly exposed surface has a reddish orange color.
- ✓ Copper forms alloys more freely than most metals, and with a wide range of alloying elements, including zinc, tin, nickel and aluminum.

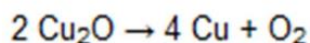
#### Copper extraction techniques

Copper ores are sulfides, especially chalcopyrite ( $\text{CuFeS}_2$ ) and to a lesser extent chalcocite ( $\text{Cu}_2\text{S}$ ). These minerals are concentrated from crushed ores to the level of 10–15% copper.

Heating this material with silica in flash smelting removes much of the iron as slag. The process exploits the greater ease of converting iron sulfides into its oxides, which in turn react with the silica to form the silicate slag, which floats on top of the heated mass. The resulting copper consisting of  $\text{Cu}_2\text{S}$  is then roasted to convert all sulfides into oxides:



The cuprous oxide is converted to *blister* copper upon heating:



It was then electrolytically refined. This step exploits the relatively easy reduction of copper oxides to copper metal. Natural gas is blown across the blister to remove most of the remaining oxygen and electro refining is performed on the resulting material to produce pure copper:

#### **PROPERTIES OF COPPER**

- ✓ Soft and ductile.
- ✓ Highly resistant to corrosion.

- ✓ Excellent electrical & thermal conductivity.
- ✓ Can be alloyed to improve hardness.
- ✓ Cold worked to get the maximum hardness.
- ✓ Ease of fabrication.
- ✓ Has a pleasing color.
- ✓ Can be welded, brazed, and soldered.

## COPPER ALLOYS

### 1. **BRASSES**: essentially alloys of Cu and Zn.

- ❖ Variations in composition will result in desired color, strength, ductility, machinability, corrosion resistance, or a combination of such properties.
- ❖ Best combination of strength and ductility 70Cu-30Zn.



**Brass Components**

### Uses

- The malleability and acoustic properties of brass have made it the metal of choice for brass musical instruments such as the trombone, tuba, trumpet, cornet, euphonium, tenor horn, and the French horn.
  - Brass is often used for decoration, statues and coins for its bright gold-like appearance and its relative resistance to tarnishing.
  - Brass is used for applications where low friction is required such as locks, gears, bearings, doorknobs, ammunition, and valves.
  - It is used for plumbing and electrical applications.
2. **BRONZES**: Bronze is Copper alloyed with Tin – most commonly with 10 percent tin.
- Bronze is hard and brittle.
  - Bronze resists corrosion (especially seawater corrosion) and metal fatigue more than steel.
  - It is a better conductor of heat and electricity than most steels
  -

### Uses

- Bronze is the most popular metal for top-quality bells, particularly bell metal, which is about 23% tin. Nearly all professional cymbals are made from a bronze alloy.
- The alloy used in drum kit cymbal bronze is unique in the desired balance of durability and timbre.
- Phosphor bronze is also used in guitar and piano strings.
- Bronze is used today for springs, bearings, bushings, automobile transmission pilot bearings, and similar fittings, and is particularly common in the bearings of small electric motors.

### 3. **CUPRO-NICKELS**: Alloys of Copper and Nickel. It may be 69.4% to 96% copper.

- ✚ Cupronickel is highly resistant to corrosion in seawater
- ✚ Because of this, it is used for piping, heat exchangers and condensers and sometimes for the propellers, crankshafts and hulls of premium tugboats, fishing boats and other working boats.
- ✚ Cu-Al: Alloys of copper with aluminum (about 7%) have a pleasant golden color and are used in decorations.
- ✚ Cu-Si: Copper - Silicon (90, 10%). This product can be used to improve castability of brass and copper nickel alloys.
- ✚ Cu-Mn: Copper - Manganese (70, 30%). Copper -manganese is used in a number of applications including the improvement of mechanical properties and corrosion resistance of low alloy copper and brass alloys.

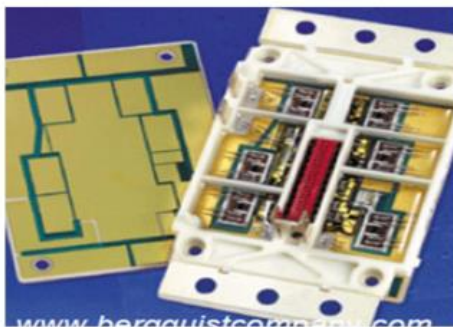
### **APPLICATION OF COPPER AND ITS ALLOYS**

Today, over half of the copper produced is used in electrical and electronic applications and this leads to a convenient classification of the types of copper into:

- ✚ Electrical (high conductivity copper)
- ✚ Non-electrical (engineering copper).

#### 1. **Electrical (High Conductivity Coppers)**

- ✓ Wrought high conductivity copper has excellent ductility and, as a result, is available in forms such as wire, tube, extrusions, bar and sheet.
- ✓ The main grade of copper used for electrical applications such as building wire, motor windings, cables and bus-bars is electrolytic tough pitch copper



Electronic products

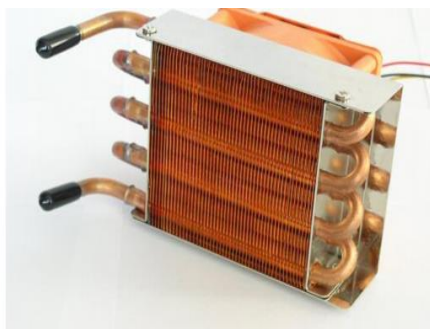
## 2. Non-Electrical (Engineering Copper)

The properties which make copper the standard material for engineering, including are:

**i. Thermal conductivity** - the thermal conductivity of copper is about twice that of Aluminum and thirty times that of stainless steel. This means that copper is used for components where rapid heat transfer is essential. Examples include saucepan bottoms, heat exchangers, car and vehicle radiators and heat sinks in computers, disk drives and TV sets.



Copper plating



Copper as a Heat Exchanger

**ii. High ductility** - Copper is a ductile metal. This means that it can easily be shaped into pipes and drawn into wires.

**iii. Heat resistance** - withstands fire well having melting point of 1083°C.

**iii. Antimicrobial** - copper is a naturally hygienic metal which slows down the growth of harmful germs such as E.Coli, MRSA and legionella. Antimicrobial properties make it ideal for brewing vessels.

**iii. Range of colors and malleability**- widely used by designers and architects for exterior and interior applications. Copper and its alloys, such as brass, are used for Jewellery. They have an attractive golden color which varies with the copper content.

**iv. Corrosion resistance** - copper is non-reactive and does not rust.

**v. Ease of joining** - Copper can be joined easily by brazing or soldering. This is useful for pipe work and for making sealed copper vessels.



**Assorted copper fittings**