Copper Alloys

Copper alloys are commonly used for their electrical and thermal conductivities, corrosion resistance, ease of fabrication, surface appearance, strength and fatigue resistance. Copper alloys can be readily soldered and brazed, and a number of copper alloys can be welded by arc, and resistance methods. Color of copper alloys is a significant reason for using them for decorative purposes. For decorative parts, conventional copper alloys having specific colors are readily available.

Copper is used extensively for cables and wires, electrical contacts, and a wide variety of other parts that are required to pass electrical current. Coppers alloys are used for automobile radiators, heat exchangers, and home heating systems. Because of copper alloys corrosion resistance they are used for pipes, valves, and fittings in systems carrying potable water, process water, or other aqueous fluids.

Along with ease of fabrication, some of the principal selection criteria for copper alloys are:

- Corrosion resistance
- Electrical conductivity
- Thermal conductivity
- Color and surface appearance

Corrosion resistance of copper alloys is good in many environments, however copper alloys may be attacked by some common reagents and environments. Pure copper resists attack under some corrosive conditions. Some copper alloys, on the other hand, sometimes have inadequate performance in certain environments.

Stress corrosion cracking most commonly occurs in brass. Brasses containing more than 15% Zn are the most susceptible.

Dealloying is another form of corrosion that affects zinc containing copper alloys. During dezincification of brass, selective removal of zinc results in gradual replacement of sound brass by weak, porous copper. Unless stopped the metal is weakened and liquids or gases may be capable of leaking through the porous structure.

Electrical and thermal conductivity of copper and its alloys are relatively good. This is why copper is the most commonly used electrical conductor. Alloying decreases electrical conductivity to a greater extent than thermal conductivity. This is why copper and high-copper alloys are preferred over other copper alloys when high electrical or thermal conductivity is required.

Common Copper Alloys

Name	Alloying elements
Coppers	Cu
Brasses	Cu-Zn
Leaded brasses	Cu-Zn-Pb
Tin brasses	Cu-Zn-Sn-Pb
Phosphor bronzes	Cu-Sn-P
Leaded phosphor bronzes	Cu-Sn-Pb-P
Copper-phosphorus and copper-silver-phosphorus alloys	Cu-P-Ag
Aluminum bronzes	Cu-Al-Ni-Fe-Si-Sn
Silicon bronzes	Cu-Si-Sn
Copper-nickels	Cu-Ni-Fe
Nickel silvers	Cu-Ni-Zn

Titanium

- **Titanium Alloys**
- The density of Titanium is roughly 55% that of steel. Titanium alloys are extensively utilized for significantly loaded aerospace components.Titanium is used in applications requiring somewhat elevated temperatures. The good corrosion resistance experienced in many environments is based on titanium's ability to form a stable oxide protective layer. This makes titanium useful in surgical implants and some chemical plant equipment applications.
- Unalloyed (commercially pure) titanium can be found in two crystallographic forms:
- Hexagonal close-packed (hcp) or alpha (α) phase is found at room temperature
- Body centered cubic (bcc) or beta (ß) phase is found above 883 °C (1621 °F)
- The control of alpha (α) and beta (ß) phases through alloying additions and thermomechanical processing is the basis for the titanium alloys used by industry today. It is also the primary method for classifying titanium alloys. Titanium alloys are categorized as either alpha (α) alloys, beta (ß) alloys, or alpha+beta (α+ß) alloys. One of the primary effect of alloying elements used in titanium production is the affect on the alpha to beta transformation temperature. Some elements raise the alpha to beta transformation temperature thereby stabilizing the alpha crystal structure. While other elements lower the alpha to beta transformation temperature thereby stabilizing the beta crystal structure. The effect of some elements is shown below:
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temperature thereby stabilizing the beta crystal structure. The effect of some elements is shown below:

- Element Effect Aluminum alpha stabilizer Tin alpha stabilizer Vanadium Beta stabilizer Molybdenum Beta stabilizer Chromium
- Beta stabilizer Copper
- Beta stabilizer Alpha alloys commonly have creep resistance superior to beta alloys. Alpha alloys are suitable for somewhat elevated temperature applications. They are also sometimes used for cryogenic applications. Alpha alloys have adequate strength, toughness, and weldability for various applications, but are not as readily forged as many beta alloys. Alpha alloys cannot be strengthened by heat treatment.
- Beta alloys have good forging capability. Beta alloy sheet is cold formable when in the solution treated condition. Beta alloys are prone to a ductile to brittle transition temperature. Beta alloys can be strengthened by heat treatment. Typically beta alloys are solutioned followed by aging to form finely dispersed particles in a beta phase matrix.
- Alpha + beta alloys have chemical compositions that result in a mixture of alpha and beta phases. The beta phase is normally in the range of 10 to 50% at room temperature. Alloys with beta contents less than 20% are weldable. The most commonly used titanium alloy is Ti-6Al-4V, an alpha + beta alloy. While Ti-6Al-4V is fairly difficult to form other alpha + beta alloys normally have better formability.
- Alpha + beta alloys can be strengthened by heat treatment. When strengthening alpha + beta alloys the components are normally quickly cooled from a temperature high in the alpha-beta range or even above the beta transus. Solution treatment is then followed by aging to generate an proper mixture of alpha and transformed beta. Heat treatment is dependent on the

cooling rate from the solution temperature and can be affected by the size of the component.

Some of the uses of titanium alloys:

- Surgical Implants
- Prosthetic devices
- Jet engines
- Chemical processing plants
- Pulp and paper industry
- Marine applications
- Sports equipment