Alloys : Types and uses

Devendra Adhikari*

Introduction

Alloys are metallic materials that include at least one metal and another element. Often, the other components of an alloy are also metals, although various alloys contain non-metallic elements, such as carbon, silicon, sulfur and boron. Common alloys used are stainless steel, which is a combination of iron, chromium and nickel; brass, a combination of zinc and copper; bronze, a combination of tin and copper (sometimes aluminum); and sterling silver, a combination of copper and silver.

Except for native copper and gold, the first metals of technological importance were alloys. Bronze, an alloy of copper and tin, is appreciably harder than copper. This quality made bronze so important an alloy that it left a permanent imprint on the civilization of several millennia ago known as the Bronze Age. Today the tens of thousand of alloys involve almost every metallic element of the periodic table. An alloy is usually harder than a pure metal and may have a much lower conductivity. The Uses for alloys are limitless depending on the materials involved and the complexity of the alloy. The alloys are used in an extensive range of aircrafts, military, commercial, industrial, medical, residential and manufacturing applications. The unit of alloy impurity is commonly expressed in karats, where each karat is 1/24 part. Alloys like Aluminium, Copper, Nickel, Stainless steel, Titanium all have different uses in various application.

Examples

1. **Aluminium** when combined with other metals gives strength and specific characteristics for a particular use. Aluminium alloys are extensively used in the production of automotive engine parts. The Aluminium alloy is used in various applications like transport, packaging, electrical application, medicine, and construction of homes and furniture. The high altitude flying is not possible without the huge pressures and stresses involved in the strong aluminium alloys.

2. **Copper** alloys have excellent electrical and thermal performance, good corrosion resistance, high ductility and relatively low cost. Copper alloy is used in hermetic seals, in automotive heat exchangers

* Reader, Dept. of Physics, M.M.A.M. Campus, Biratnagar, T.U.

and copper tin alloys are primarily used for sleeve bearings due to its stronger and more ductility property. Copper alloys are less expensive than gold or platinum that is why largely utilized in odontological restorations. Due to high strength, electrical and thermal conductivity copper alloys are used in the manufacture of all types of electrical equipment.

3. In order to reduce corrosion losses, there are extensive uses of stainless steels. **Stainless** steel alloys are used for many commercial applications such as watch straps, cutlery etc. Stainless alloys used for making tubes intended for placement on the bottom of the sea. Many stainless steel alloys has improved weldability and corrosion resistance. Stainless Alloys are also widely used in the electronic, agricultural, road and rail industries. Stainless steel grades are used for handling bulk wet materials, tanks, containers, conveyors, chimneys and many others. Whether in the form of element or alloy with other metals, Nickel materials have made significant contributions to present-day society.

4. **Nickel** alloys have good corrosion resistance and heat resistance. Nickel alloys are used for a wide variety of applications like aircraft gas turbines, nuclear power systems and widely used in chemical and petrochemical industries. Several nickel alloys are used in control equipments to determine and control electrical characteristics.

5. **Titanium** alloys have high melting point than stainless steels. Due to high strength, toughness and stiffness, many titanium alloys are used in aerospace structures and other high-performance applications. Titanium alloys are used for different spacecraft parts, jet engines and airframe to save weight and improve aircraft efficiency. It corrosion resistance allow its uses in chemical, petrochemical and biomaterial applications

Types and uses of alloys

1. **Dental alloys**: they contain precious metals. Amalgams are predominantly silver-mercury alloys, but they may contain minor amount of tin, copper and zinc fro hardening purposes. Liquid mercury is added to a powder of a precursor alloy of the other metals. After being compacted, the mercury diffuses into the silver –base metal to give a completely solid alloy. Gold base dental alloys are preferred over pure gold because gold is relatively soft. The most common dental gold alloy contains, silver, and copper. For higher strengthen and hardnesses, palladium and platinum are added and the copper and silver are increased so that the gold content drops.

2. **Ice-casting alloys**: they have melting temperatures low enough so that in liquid form they can be injected under pressure into steel dies. Such casting is used for automotive parts and for office and household appliances which have moderately complex shapes. Most die castings are made from zinc-base or aluminum –base alloys. Magnesium-base alloys find some application when weight reduction is paramount. Low-melting alloys of lead and tin are not common because they lack the necessary strength for the above application.
3. **High-temperature alloys**: They have high strengths at high temperatures. In addition to having strength, these alloys must resist oxidation by fuel-air mixtures and by stream vapour. At temperatures up to about 750^{0}C, the austenitic stainless steels serve well. An additional 100^{0}C may be released if the steels also contain 3% molybdenum. Both nickel-base and cobalt-base alloys, commonly categorized as superalloys, may serve useful functions up to 1100^{0}C. Nichrom, a nickel-base alloy containing chromium and iron, is a fairly simple superalloy.
4. **Superconducting alloys**: These alloys are of great interest in the design of certain fusion reactors which require very large magnetic fields to contain the plasma in a closed system. The advantage of the use of the material with zero resistively approaching zero is obvious. However, two significant problems are involved in the use of superconducting alloys in large electromagnets: the critical temperature, and the fact that above a certain critical current density the superconducting materials tend to become normal conductors with a finite resistance. Serious materials problems still have to be solved before these materials can be used successfully.
5. **Thermocouple alloys**: They include Chromel and Alumel. These two alloys together form the widely used Chromel-Alumel thermocouple, which can measure temperatures up to 1204^{0}C. Another common thermocouple alloy, constantan, is used to form iron-constantan and copper-constantan couples, employed at lower temperature.
6. **Prosthetic alloys**: These alloys are used in internal prostheses, that is, surgical implants such as artificial hips and knees. External prostheses and devices that are worn by patients outside the body; alloy selection criteria are different from those for internal prosthesis. The most widely used prosthetic alloys include high-strength, corrosion –resistant, ferrous, cobalt-based or titanium-based alloys.
7. **Shape memory alloys**: they have very interesting and desirable property. In a typical case, a metallic object of a given shape is cooled from

a given temperature to a lower temperature where it is deformed so as to change its shape. Upon reheating from lower temperature to high temperature the shape change accomplished at the lower temperature is recovered so that the object returns to its original configuration. This thermoplastic property of the shape memory alloy is associated with the fact that they undergo a martenstic phase transformation when they are cooled or heated between certain temperatures. Shape memory alloys are capable of being employed in a number of useful applications.

8. **Light- metal alloys**: Aluminum and magnesium, with densities of 2.7 and 1.75 g/cm^3 respectively, are the bases for most of the light-metal alloys. Titanium (4.5 g/cm^3) may also regard as a light-metal alloy if comparisons are made with metals such as steel and copper.
9. **Low expansion alloys**: they include invar, the dimensions of which do not vary over the atmospheric temperature range, and Kovar, which is widely used because its expansion is low enough to match that of glass.
10. **Fusible alloys**: They generally have melting temperature below that of tin (232^{0}C), and in some cases as low as 50^{0}C. Using eutectic compositions of metals such as lead, cadmium, bismuth, tin, antimony and indium achieves these low melting g temperatures. These alloys are used for many purposes, for example, in fusible elements in automatic sprinklers, forming and stretching dies, filler for thin-walled tubing that is being bent, and anchoring dies, punches, and parts being machined.

Conclusion

Modern alloys can achieve a number of properties not possible even fifty years ago. Even metallic glass alloys can now be produced; the first of these was a gold-silicon alloy produced in 1957, but many new types are now possible, with more on the horizon. Some of the major reasons for the continuing advances in alloys are the availability of materials, new manufacturing techniques, and the ability to "test" alloys before they are ever produced. Most modern alloys are, in fact, preplanned using sophisticated computer simulations, which help determine what properties the alloy will display.

******