03 Properties of materials: 1. Metals

Metals: The technological and commercial importance of metals results from the following general properties possessed by virtually all of the common metals:

1. High stiffness, strength and hardness: Metals can be alloyed for high *rigidity*, *strength*, and *hardness*; thus, they are used to provide the structural framework for most engineered products. (Rigidity is measured by finding the Young's modulus).

2. Toughness: Metals have the capacity to absorb energy better than other classes of materials. (Toughness is measured by impact test).

3. Good electrical conductivity: Metals are good conductors because of their metallic bonding that permits the free movement of electrons as charge carriers.

4. Good thermal conductivity: Metallic bonding also explains why metals generally conduct heat better than ceramics or polymers.

Metals are converted into parts and products using a variety of manufacturing processes. The starting form of the metal differs, depending on the process. The major categories are:

(1) cast metal, in which the initial form is a casting;

(2) wrought metal, in which the metal has been worked or can be worked (e.g., rolled or otherwise formed) after casting; better mechanical properties are generally associated with wrought metals compared with cast metals; and

(3) powdered metal, in which the metal is purchased in the form of very small powders for conversion into parts using powder metallurgy techniques. Most metals are available in all three forms.

Metals are classified into two major groups:

(1) ferrous—those based on iron; and

(2) nonferrous—all other metals.

The ferrous group can be further subdivided into steels and cast irons. Most of the discussion in the present chapter is organized around this classification.

Alloys:

An alloy is a metal composed of two or more elements, at least one of which is metallic. The two main categories of alloys are: (1) solid solutions and (2) intermediate phases.

(1) solid solutions and:

(2) intermediate phases.

Solid Solutions: a solid solution is an alloy in which one element is dissolved in another to form a single-phase structure.

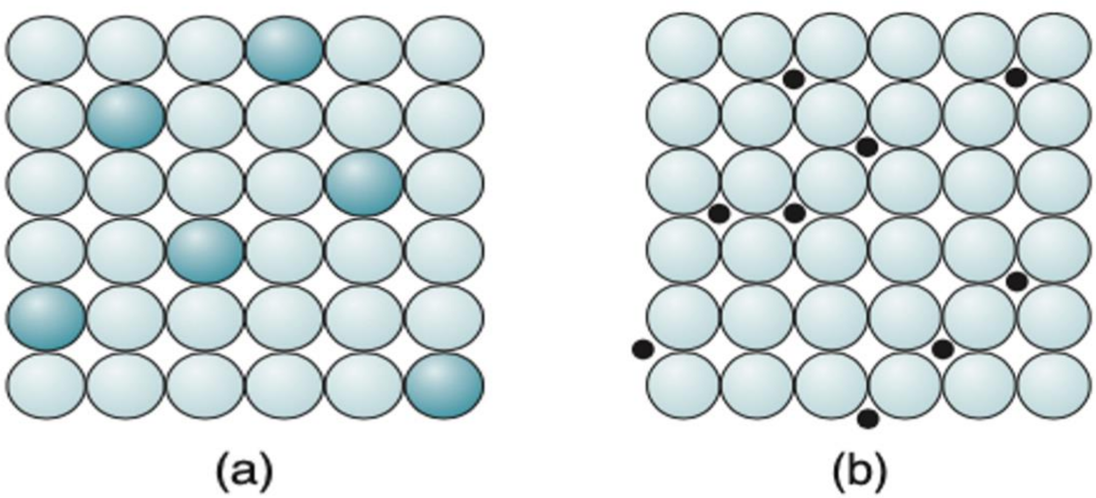

Figure 3.1 Two forms of solid solutions: (a) substitutional solid solution, and (b) interstitial solid solution.

Intermediate Phases There are usually limits to the solubility of one element in another. When the amount of the dissolving element in the alloy exceeds the solid solubility limit of the base metal, a second phase forms in the alloy. The term intermediate phase is used to describe it because its chemical composition is intermediate between the two pure elements.

Its crystalline structure is also different from those of the pure metals. Depending on composition, and recognizing that many alloys consist of more than two elements, these intermediate phases can be of several types, including:

(1) metallic compounds consisting of a metal and nonmetal such as Fe3C; and

(2) intermetallic compounds—two metals that form a compound, such as Mg2Pb.