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Lecture # 13

CHAPTER SIX/ Applications and Processing of Metal Alloys

Ferrous alloys

Ferrous alloys are iron based alloys that has extensive use in wide range of industries because of its flexibility to meet strength, toughness, and impact of varied industrial applications. This flexibility depends on the heat treatment procedures, which modifies the final microstructure. **Examples of ferrous alloys** include carbon steels, alloy steels, stainless steels, tool steels, cast iron, cast steel.

On the basis of composition, ferrous alloys fall into three classifications:

1) Iron (< 0.008 wt% C) in α-Ferrite at room temperature
2) Steel (0.008wt%C to 2.14 wt% C); (α-Ferrite+Fe_3C) at room temperature
3) Cast iron (2.14 to 6.70 wt% C) (commercial cast irons less than 4.5wt% C).

Steel can divided into:

1. Plain carbon steel
2. Alloy steel

Plain carbon steel: is a type of steel having a maximum carbon content of 1.7%C. In addition manganese and silicon are almost included to overcome the effects of the two main impurities of sulphur and oxygen.

Plain carbon steels are classified to:

1) **Low-Carbon Steel:** carbon content less than about 0.25 wt% C, microstructures consist of ferrite and pearlite, these alloys are relatively soft and weak but have outstanding ductility and toughness; in addition, they are machinable, weldable, and, are the least expensive to produce.
   Typical applications include: Automobile panels, nails, and wire, structural shapes (I-beams, channel and angle iron), and sheets that are used in pipelines, buildings, bridges, nut, bolts, boiler- plates, ship-plates.

2) **Medium-Carbon Steels:** carbon concentrations between about 0.25 and 0.60 wt%. Additions of chromium, nickel, and molybdenum improve the ability of these alloys for heat-treatment.
   Applications include railway wheels and tracks, gears, crankshafts, bolts and other machine parts.

3) **High-Carbon Steels:** carbon contents between 0.60 and 1.4 wt%, are the hardest, strongest, and yet least ductile of the carbon steels. The tool and die steels are **high-carbon alloys**, usually containing chromium, vanadium, tungsten, and molybdenum. These alloying elements combine with carbon to form very hard and wear resistant carbide compounds.
   Applications include cutting tools and dies for forming and shaping materials, as well as in knives, razors, hacksaw blades, springs, and high-strength wire.

Alloy steels, more alloying elements are purposely added in specific concentrations to steels, such as nickel, chromium, molybdenum, manganese, silicon and vanadium there are three types of alloy steel:

1) **Low alloy steel**: when total amount of alloying element is less than about 2%
2) **Medium alloy steel:** alloying element between (2-10%)
3) **High alloy steel:** alloying element more than (10%)

Stainless Steels

The **stainless steels** are highly resistant to corrosion (rusting) in a variety of environments, especially the ambient atmosphere. Their major alloying element is chromium; a concentration of at least 11 wt% Cr is required. Corrosion resistance may also be enhanced by nickel and molybdenum additions.
Stainless steels are divided into three classes on the basis of the main phase of the microstructure—**martensitic**, **ferritic**, or **austenitic**. A wide range of mechanical properties combined with excellent resistance to corrosion make stainless steels very multipurpose in their applicability.

Classification and Specification of Steels

- The Society of Automotive Engineers (SAE), the American Iron and Steel Institute (AISI), and the American Society for Testing and Materials (ASTM) are responsible for the classification and specification of steels as well as other alloys.
- The AISI/SAE designation for steels is a four-digit number: the first two digits indicate the alloy content; the last two give the carbon concentration. (for example: 10xx, Plain carbon); the first two digits are 1 and 0, mean **plain carbon steels**, the last two give the carbon concentration in weight percent times 100.
  (alloy steels are designated by other initial two-digit combinations (e.g., 13, 41, 43). (for example: 13xx, mean alloy steel containing xx wt% C)
- For example, **AISI 1060**; is a plain carbon steel containing 0.60 wt% C.
  AISI 2340; alloy steel containing 0.40 wt% C.