ENGG*2120 Fall 2011

Chapter 11 Assignment with Answers

1. How are metal alloys classified?

Answer:
Metal alloys are classified as

- <u>Ferrous</u>
    - Steel
    - Cast Irons

- <u>Nonferrous</u>
    - Copper (Cu)
    - Aluminium (Al)
    - Magnesium (Mg)
    - Titanium (Ti)
    - Refractory metals
    - Super alloys
    - Noble metals
    - Miscellaneous alloys

2. Give the classification of steels and briefly describe the properties and typical applications.

Answer:

Steels are classified as

A. Low alloy steels
B. High alloy steels

A. Low alloy steels are further classified as:

(i) Low Carbon Steels: These generally contain less than about 0.25 wt% C.

Properties: nonresponsive to heat treatments; relatively soft and weak; machinable and weldable.

Typical applications: automobile bodies, structural shapes, pipelines, buildings, bridges, and tin cans.

(ii) Medium Carbon Steels: The medium-carbon steels have carbon concentrations between about 0.25 and 0.60 wt%.

Properties: heat treatable, relatively large combinations of mechanical characteristics.

Typical applications: railway wheels and tracks, gears, crankshafts, and machine parts.

(iii) High Carbon Steels: The high-carbon steels, normally having carbon contents between 0.60 and 1.4 wt%, are the hardest, strongest, and yet least ductile of the carbon steels.

Properties: hard, strong, and relatively brittle. Typical applications: chisels, hammers, knives, and hacksaw blades.

B. **High Alloy Steels:** (Stainless and Tool): The stainless steels are highly resistant to corrosion (rusting) in a variety of environments, especially the ambient atmosphere. Their predominant alloying element is chromium; a concentration of at least 11 wt% Cr is required.

Properties: hard and wear resistant; resistant to corrosion in a large variety of environments.

Typical applications: cutting tools, drills, cutlery, food processing, and surgical tools.

3. Briefly describe the types of cast iron.

Answer:

Gray iron: The carbon and silicon contents of gray cast irons vary between 2.5 and 4.0 wt% and 1.0 and 3.0 wt%, respectively. For most of these cast irons, the graphite exists in the form of flakes (similar to corn flakes), which are normally surrounded by α-ferrite or pearlite matrix. They are weak & brittle under tension, stronger under compression have excellent vibrational dampening and are wear resistant

Ductile iron: Adding a small amount of magnesium and/or cerium to the gray iron before casting produces a distinctly different microstructure and set of mechanical properties. Graphite still forms, but as nodules or sphere-like particles instead of flakes. The resulting alloy is called nodular or ductile iron. The matrix phase surrounding these particles is either pearlite or ferrite, depending on heat treatment; it is normally pearlite for an as-cast piece.

White iron: For low-silicon cast irons (containing less than 1.0 wt% Si) and rapid cooling rates, most of the carbon exists as cementite instead of graphite. A fracture surface of this alloy has a white appearance, and thus it is termed white cast iron.

Malleable iron: Generally, white iron is used as an intermediary in the production of yet another cast iron, malleable iron. Heating white iron at temperatures between 800 and 900 ^{o}C for a prolonged time period and in a neutral atmosphere (to prevent oxidation) causes a decomposition of the cementite, forming graphite, which exists in the form of clusters or rosettes surrounded by a ferrite or pearlite matrix, depending on cooling rate.

4. Cite three reasons why ferrous alloys are used extensively

Answer:

- Iron bearing compounds are abundant
- Economic extraction, fabrication and refinement techniques are available
- They can be tailored to have a wide variety of mechanical and physical properties

5. Give three characteristics of ferrous alloys that limit their utilization.

Answer:

- Relatively high density
- Comparatively low electrical conductivity
- Susceptible to corrosion in common environment

6. Briefly explain refractory metals.

Answer:

Metals that have extremely high melting temperatures are classified as the refractory metals. Metals included in this group are: niobium (Nb), molybdenum (Mo), tungsten (W), tantalum (Ta). Melting temperatures range between 2468-3410°C. Inter atomic bonding in these metals are extremely strong, which accounts for the high melting temperature, large elastic moduli and high hardness at ambient as well as at elevated temperatures

7. Give the classification of metal fabrication techniques

Answer:

Metal Fabrication Techniques

Forming operations

1. Forging
2. Rolling
3. Extrusion
4. Drawing

Casting

1. Sand
2. Die
3. Investment
4. Lost Foam
5. Continuous

Miscellaneous

1. Powder Metallurgy
2. Welding

8. Give the difference between hot working and cold working.

Answer:

When deformation is achieved at a temperature above which recrystallization occurs, the process is termed as hot working, otherwise it is called cold working

9. Explain how the deformation is induced in the material during forming operations.

Answer:

In forming operations the shape of the metal piece is changed by plastic deformation, induced through external force or stress. The magnitude of which should be higher than the yield strength of the material.

10. Compare and contrast different casting techniques.

Answer:

For *sand casting*, sand is the mold material, a two-piece mold is used, ordinarily the surface finish is not an important consideration, the sand may be reused (but the mold may not), casting rates are low and large pieces are usually cast.

For *die casting*, a permanent mold is used, casting rates are high, the molten metal is forced into the mold under pressure, a two-piece mold is used and small pieces are normally cast.

For *investment casting*, a single-piece mold is used, which is not reusable; it results in high dimensional accuracy, good reproduction of detail, and a fine surface finish; and casting rates are low.

For *lost foam casting*, the pattern is polystyrene foam, whereas the mold material is sand. Complex geometries and tight tolerances are possible. Casting rates are higher than for investment, and there are few environmental wastes.

For *continuous casting*, at the conclusion of the extraction process, the molten metal is cast into a continuous strand having either a rectangular or circular cross-section; these shapes are desirable for subsequent secondary metal-forming operations. The chemical composition and mechanical properties are relatively uniform throughout the cross-section.