Principles of Metallurgy

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**Introduction**

Overall goal: understand how manufacturing processes enable us to modify mechanical properties of metals.

Cover fundamental metallurgical concepts

Explain methods for strengthening metals
Course Learning Objectives

1. Explain the relationship between a metal's properties and its composition, microscopic structure, and the manufacturing processes used to fabricate the metal.

2. Describe three types of microscopic structures present in metals.

3. Explain how cold working, alloying, and heat treating are used to strengthen a metal.

4. Explain the microstructure and property changes that occur in cold worked metals, steels, and precipitation hardened alloys when they are heat treated.

5. Relate the heat treatment time and temperature to the microscopic structures and properties of precipitation hardened alloys, steels, and cold worked metals.
Course Content

1. Material properties
2. Composition
3. Microscopic structures
   a. Crystal structure
   b. Grains and grain boundaries
   c. Metallurgical phases
   d. Crystal structure defects
4. Diffusion
5. Examples
   a. Cold working
   b. Annealing cold-worked metals
   c. Solution hardening
   d. Steel metallurgy
   e. Precipitation hardening
Concepts applicable to components
Concepts applicable to Non-Mechanical Joints

- Solder and braze joint
- Weld joints
Materials Properties
Module learning objective

Explain the relationship between properties, composition, microscopic structures, and processing.
Metal properties

- Density
- Thermal conductivity
- Melting point
- Strength
- Hardness
- Ductility
- Toughness
- Conductivity
- Magnetic permeability
- Corrosion
- Fatigue
- Creep
- Wear
- Ease of forming
- Machining
- Casting
- Welding
- Brazing
- Strength
- Hardness
- Ductility
- Toughness
- Conductivity
- Magnetic permeability
- Density
- Thermal conductivity
- Melting point

Click Next to continue
Composition refers to elements that make up a metal

**Steel** - iron, carbon, manganese, and silicon

**Brass** - copper and zinc
Microscopic structures

Grains

Phases

Arrangement of atoms

Courtesy of Aston Metallurgical Services

(Courtesy of Aston Metallurgical Services)
Manufacturing defects
Alter metal properties
Try to minimize defects
What manufacturing defects can be tolerated?
How can the level of defects be controlled?

No more discussion of manufacturing defects in this course

Gas porosity in die casting

Forging lap
Composition → Properties → Microscopic structure
Can process an alloy different ways

- Obtain different microscopic structures
- Obtain different properties
Can process a metal different ways
- Obtain different microscopic structures
- Obtain different properties

**Critical concept**
- Alloy and process selection
- Control variation

Harder and stronger
For any particular design, want to

- Select materials that have the desired properties
- Use manufacturing processes capable of transforming a material into desired shape with desired properties.
Questions for further thought

1. What metals are used in your products?
2. What are the desired properties of the metals?
3. What manufacturing processes are used to obtain the desired properties in the metals?

Click Next to continue
End of module