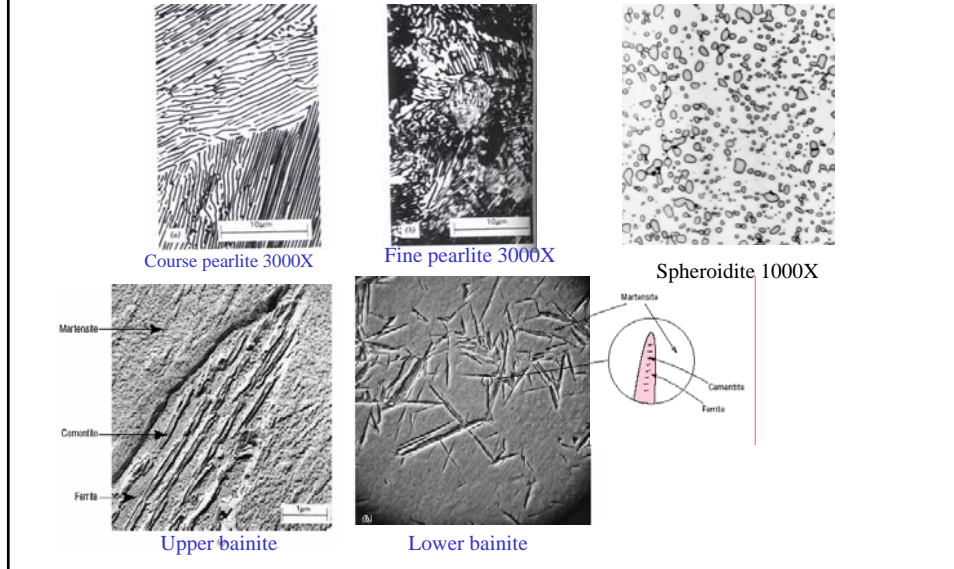
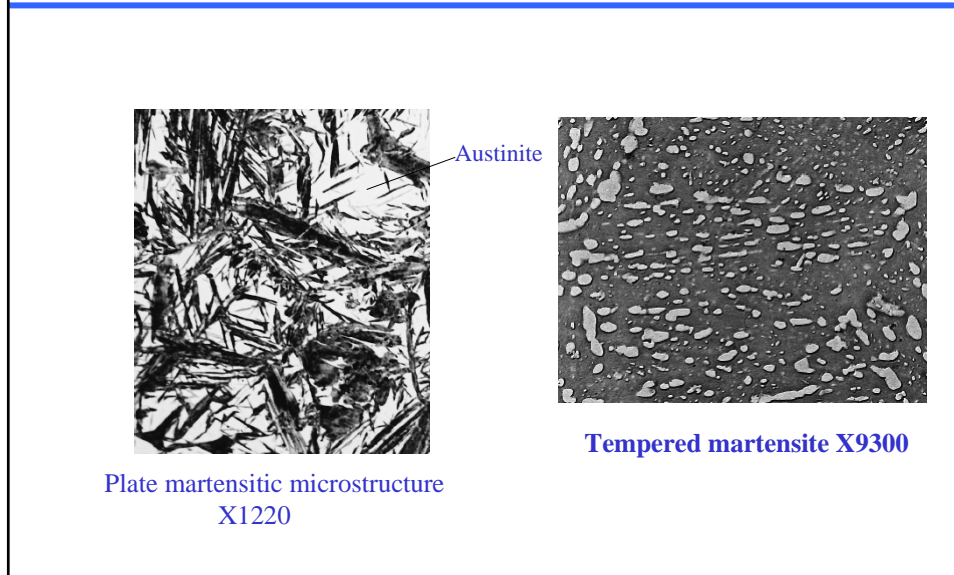


Microstructures of iron-carbon alloys



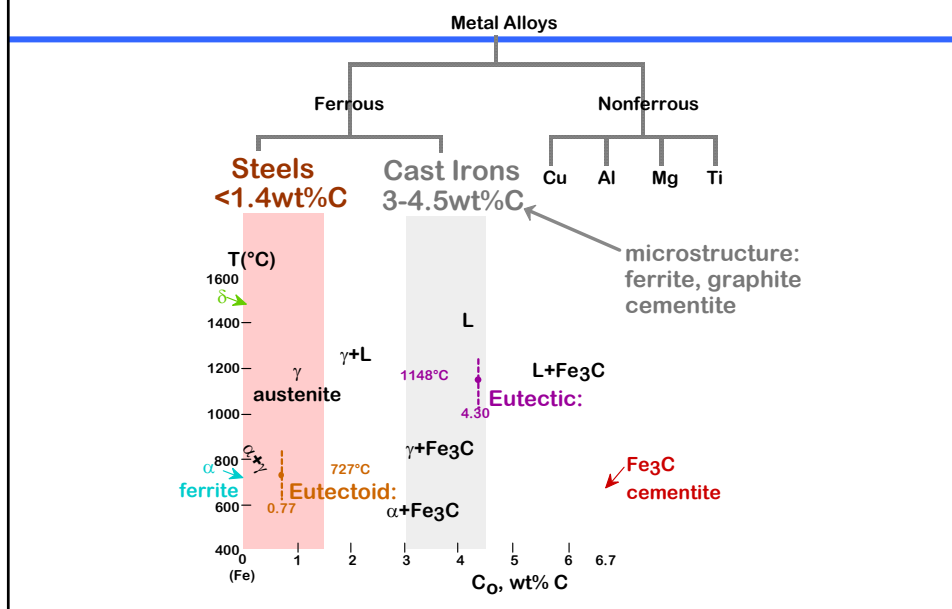
Microstructures of iron-carbon alloys

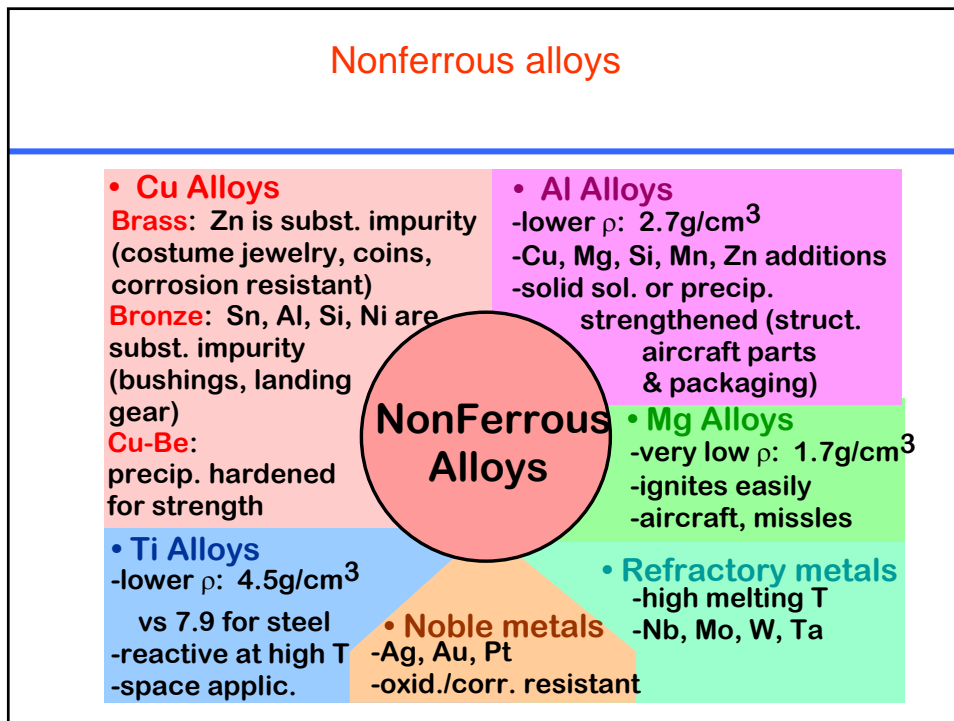
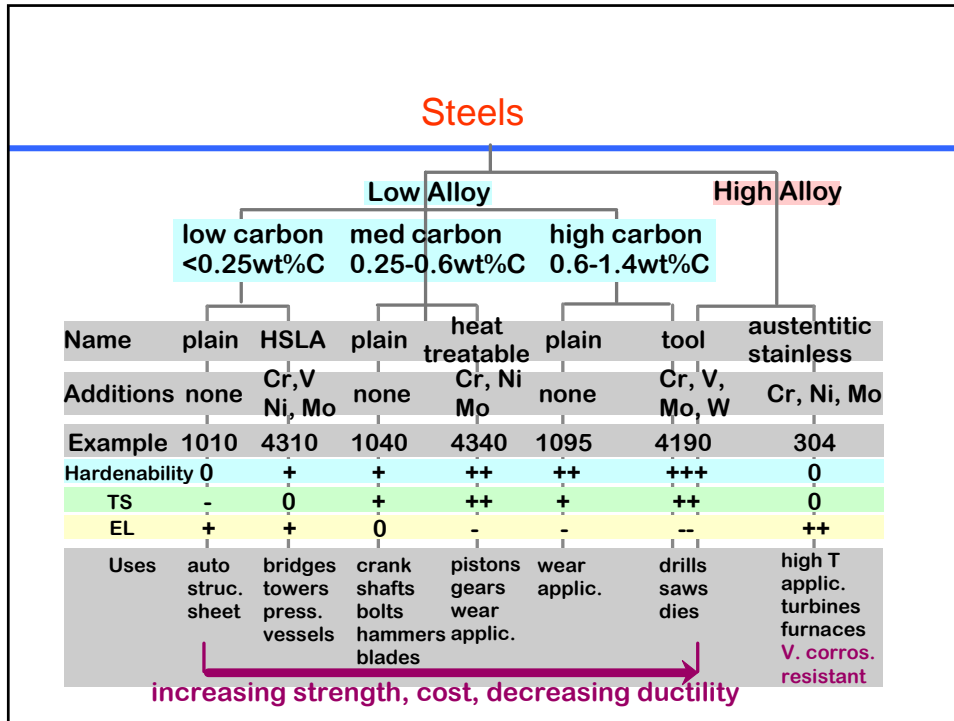


Chapter 11 Classifications of thermal processing of metal alloys

- Basic concepts
- Annealing process
- Heat treatment of steels
- Precipitation hardening

Taxonomy of metals





Basic concepts

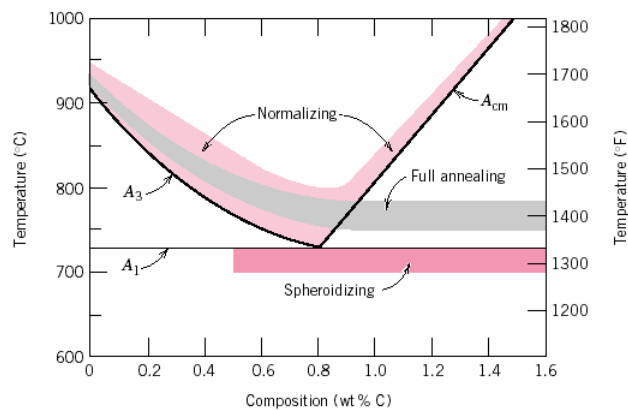
- Annealing: a heat treatment
 - heat up
 - hold for for an extended time period
 - cooling

- Function of annealing:
 - relieve stress
 - increase softness, ductility and toughness
 - produce specific microstructure

Basic concepts

- Lower critical temp:
eutectic temp A_1

- upper critical temp:
 A_3 and A_{cm}



Types of annealing

- Process anneal: negate effect of cold working by recovery/recrystallization
- Stress relief: reduce stresses caused by
 - plastic deformation
 - nonuniform cooling
 - phase transform
- Normalize (steels): deform steel with large grains, then normalize to make grains small-- heat up to above critical temperature followed by cool in air to get fine pearlite

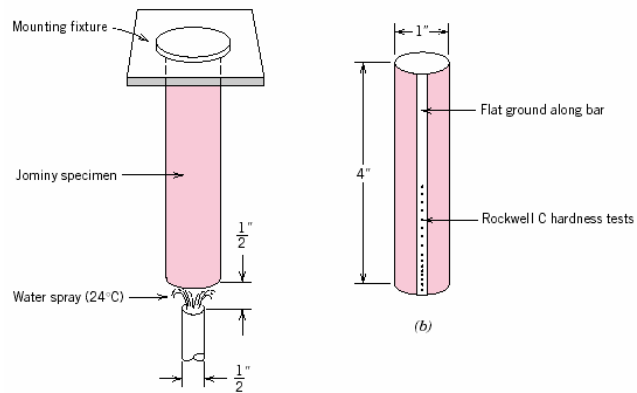
Types of annealing(*continue*)

- Full anneal (steels): make soft steels for good forming by heating to get austenite. Then cool in furnace to get coarse pearlite
- Spheroidizing (steels): make very soft steels for good machining. Heat just below T_E and hold for 15-25h

Hardenability

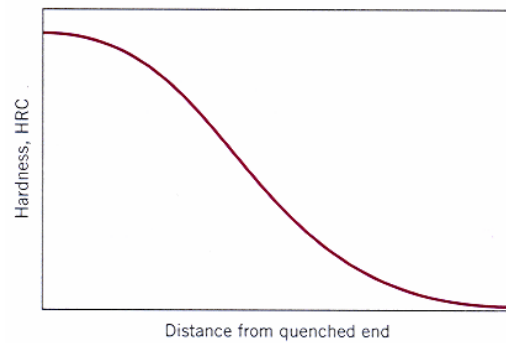
□ Ability of a material of forming martensite

□ The Jominy end-quench test



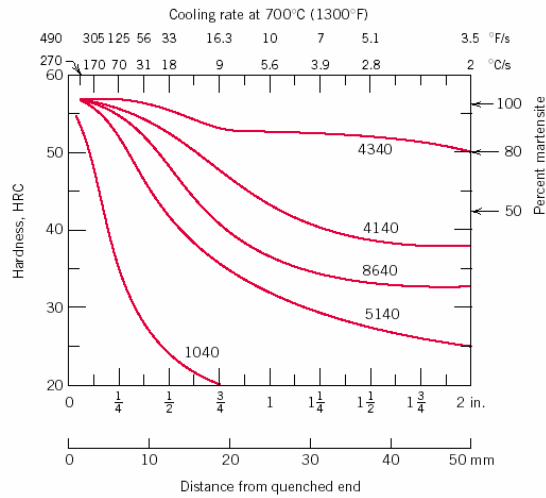
Hardenability (*continue*)

□ Hardness vs distance from quenched end



Hardenability vs alloy content

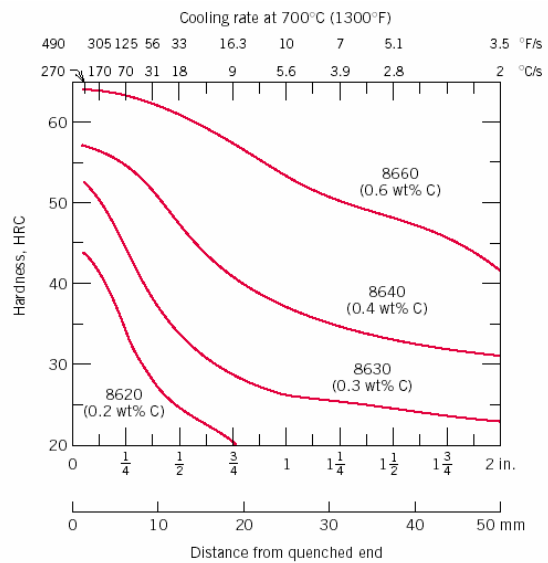
□ Jominy end quench results, c=0.4wt%C



Hardenability vs carbon content

□ Jominy end quench results, 8600 series

□ Hardenability increases as wt%C increase



Quench medium and geometry

□ Effect of quenching medium

- air, small severity, small hardness
- oil, moderate severity, moderate hardness
- water, large severity, large hardness

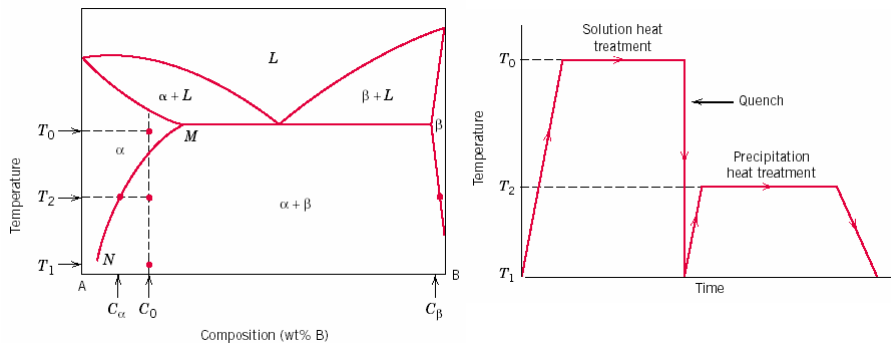
□ Effect of geometry

-When surface-to-volume ratio \uparrow , cooling rate \uparrow , hardness \uparrow
-Typical results



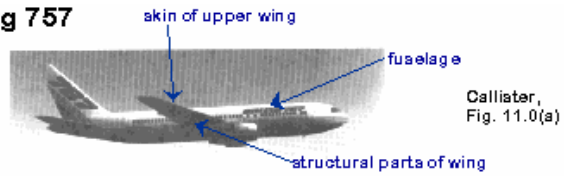
Precipitation hardening

□ Particles impede dislocations



Example: 7150-T651 Al alloy

- **Boeing 757**



- **Microstructure: MgZn₂ particles**

