



دانشگاه صنعتی خواجه نصیرالدین طوسی
دانشکده مهندسی و علم مواد

آشنایی و تاریخچه مهندسی مواد

مدرس: مهدی خدایی

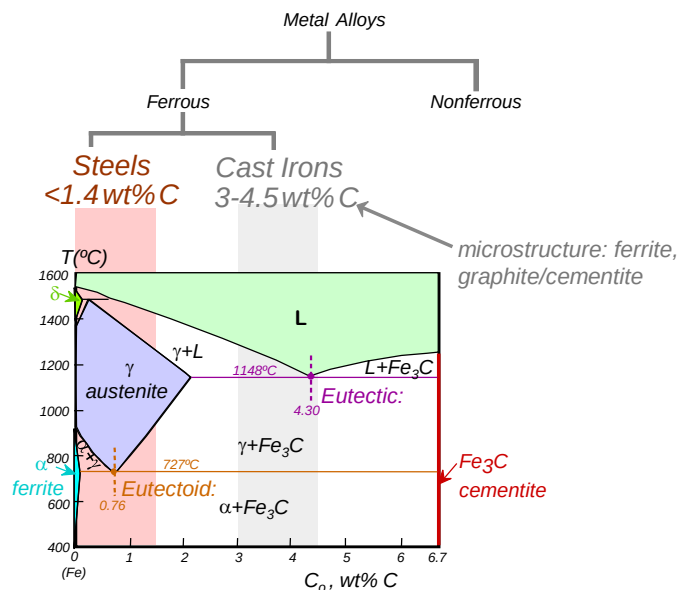
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4-Type of Materials & Processes

Classification of Metal Alloys



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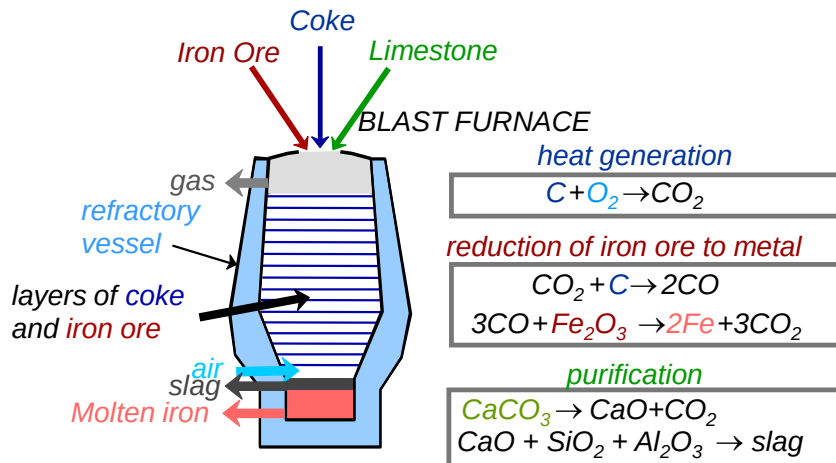
Steels

	Low Alloy				High Alloy		
	low carbon <0.25 wt% C		Med carbon 0.25-0.6 wt% C		high carbon 0.6-1.4 wt% C		
Name	plain	HSLA	plain	heat treatable	plain	tool	stainless
Additions	none	Cr, V Ni, Mo	none	Cr, Ni Mo	none	Cr, V, Mo, W	Cr, Ni, Mo
Example	1010	4310	1040	4340	1095	4190	304, 409
Hardenability	0	+	+	++	++	+++	varies
TS	-	0	+	++	+	++	varies
EL	+	+	0	-	-	--	++
Uses	auto struc. sheet	bridges towers press. vessels	crank shafts bolts hammers blades	pistons gears wear applic.	wear applic.	drills saws dies	high T applic. turbines furnaces Very corros. resistant

increasing strength, cost, decreasing ductility

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TSP-V

Refinement of Steel from Ore



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TSP-V

Ferrous Alloys

Iron-based alloys

- Steels
- Cast Irons

Nomenclature for steels (AISI/SAE)

10xx Plain Carbon Steels

11xx Plain Carbon Steels (resulfurized for machinability)

15xx Mn (1.00 - 1.65%)

40xx Mo (0.20 ~ 0.30%)

43xx Ni (1.65 - 2.00%), Cr (0.40 - 0.90%), Mo (0.20 - 0.30%)

44xx Mo (0.5%)

where xx is wt% C x 100

example: 1060 steel – plain carbon steel with 0.60 wt% C

Stainless Steel >11% Cr



Cast Irons

- *Ferrous alloys* with > 2.1 wt% C
 - more commonly 3 - 4.5 wt% C
- Low melting – relatively easy to cast
- Generally brittle
- Cementite decomposes to ferrite + graphite

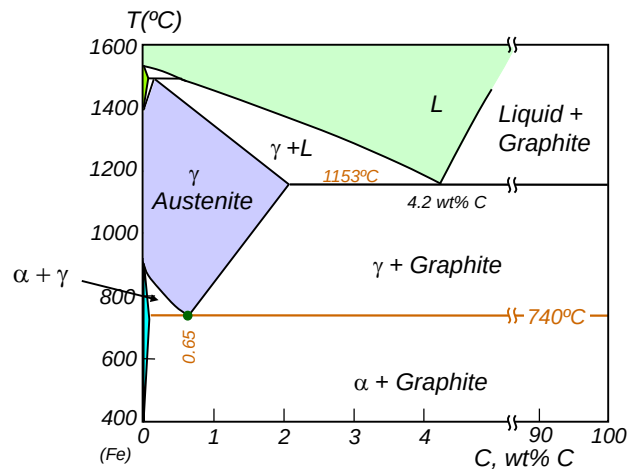
$$\text{Fe}_3\text{C} \rightarrow 3 \text{Fe} (\alpha) + \text{C} (\text{graphite})$$
 - generally a slow process



Fe-C True Equilibrium Diagram

Graphite formation promoted by

- Si > 1 wt%
- slow cooling



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Types of Cast Iron

Gray iron

- graphite flakes
- weak & brittle in tension
- stronger in compression
- excellent vibrational dampening
- wear resistant



Ductile iron

- add Mg and/or Ce
- graphite as nodules not flakes
- matrix often pearlite – stronger but less ductile



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Types of Cast Iron (cont.)

White iron

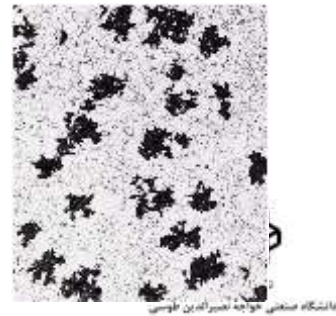
- $< 1 \text{ wt\% Si}$
- pearlite + cementite
- very hard and brittle



HEAT TREAT WHITE IRON ABOVE

Malleable iron

- heat treat white iron at $800-900^{\circ}\text{C}$
- graphite in rosettes
- reasonably strong and ductile

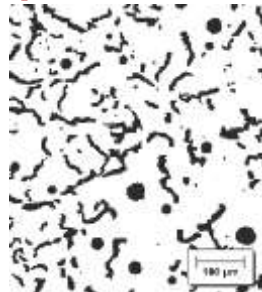


Types of Cast Iron (cont.)

ADD SMALL AMOUNT OF Ce OR Mg TO GRAY CAST IRON

Compacted graphite iron

- relatively high thermal conductivity
- good resistance to thermal shock
- lower oxidation at elevated temperatures



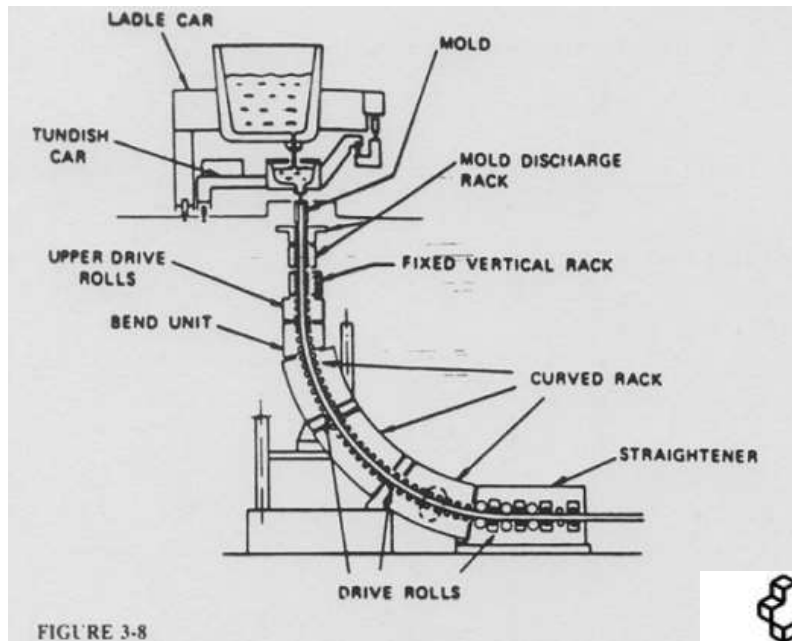
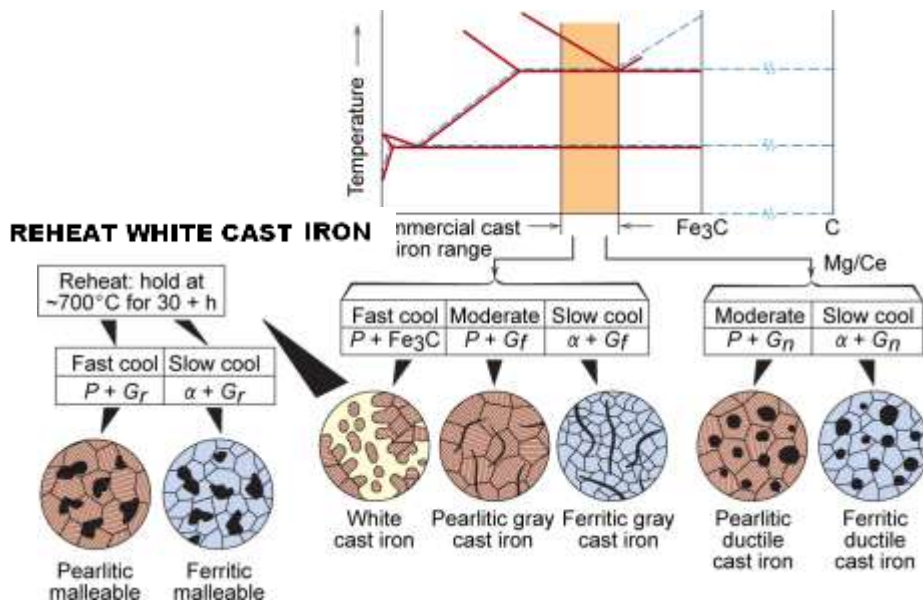


FIGURE 3-8



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Production of Cast Irons



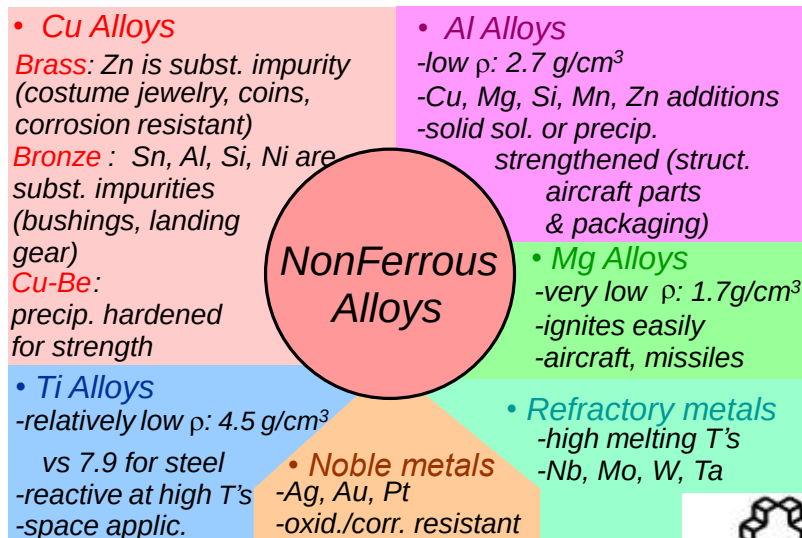
Limitations of Ferrous Alloys

- 1) Relatively high densities
- 2) Relatively low electrical conductivities
- 3) Generally poor corrosion resistance



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Nonferrous Alloys



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Metal Fabrication

- How do we fabricate metals?
 - Blacksmith - hammer (forged)
 - Cast molten metal into mold
- Forming Operations
 - Rough stock formed to final shape

Hot working

vs.

Cold working

- Deformation temperature high enough for recrystallization
- Large deformations
- Deformation below recrystallization temperature
- Strain hardening occurs
- Small deformations



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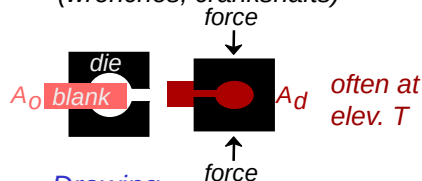
Metal Fabrication Methods (i)

FORMING

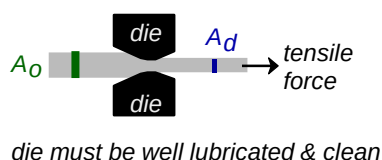
CASTING

MISCELLANEOUS

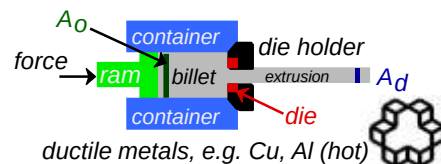
- Forging (Hammering; Stamping) (wrenches, crankshafts)
- Rolling (Hot or Cold Rolling) (I-beams, rails, sheet & plate)



- Drawing (rods, wire, tubing)



- Extrusion (rods, tubing)



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Metal Fabrication Methods (ii)



- **Casting**- mold is filled with molten metal
 - metal melted in furnace, perhaps alloying elements added, then **cast** in a mold
 - common and inexpensive
 - gives good production of shapes
 - weaker products, internal defects
 - good option for brittle materials

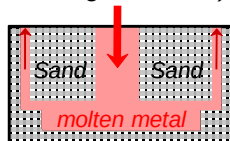


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Metal Fabrication Methods (iii)



- **Sand Casting**
(large parts, e.g., auto engine blocks)



- What material will withstand $T > 1600^{\circ}\text{C}$ and is inexpensive and easy to mold?
- Answer: sand!!!
- To create mold, pack sand around form (pattern) of desired shape



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Metal Fabrication Methods (iv)



- **Investment Casting**
(low volume, complex shapes
e.g., jewelry, turbine blades)
- **Stage I** — Mold formed by pouring plaster of paris around wax pattern. Plaster allowed to harden.
- **Stage II** — Wax is melted and then poured from mold—hollow mold cavity remains.
- **Stage III** — Molten metal is poured into mold and allowed to solidify.

MOLD PLASTER OF PARIS



I



HEAT

II



III



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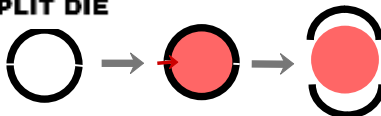
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Metal Fabrication Methods (v)



- **Die Casting**
-- high volume
-- for alloys having low melting temperatures
- **Continuous Casting**
-- simple shapes
(e.g., rectangular slabs, cylinders)

SPLIT DIE

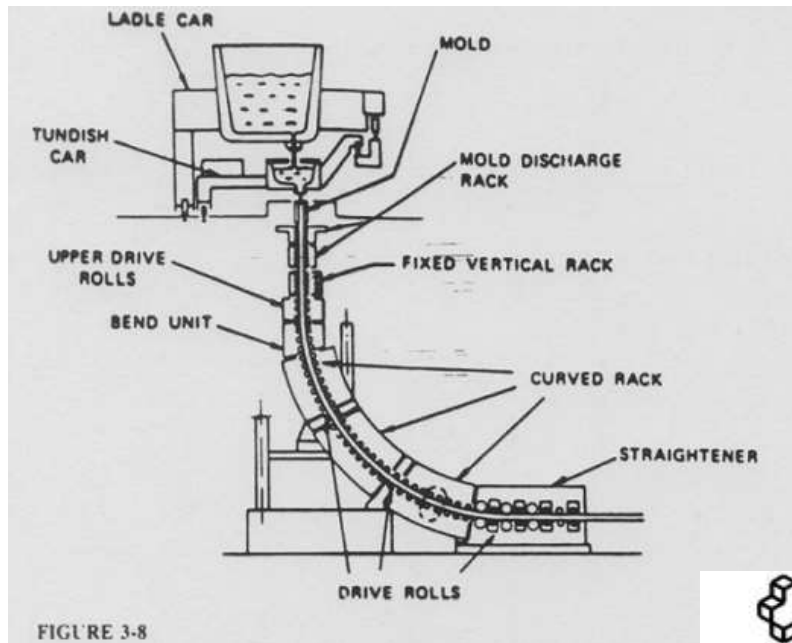


INJECT LIQUID METAL



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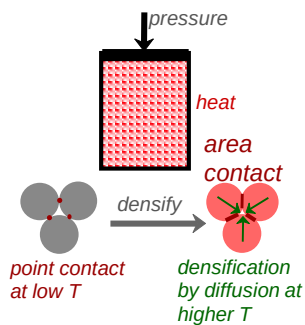


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Metal Fabrication Methods (vi)

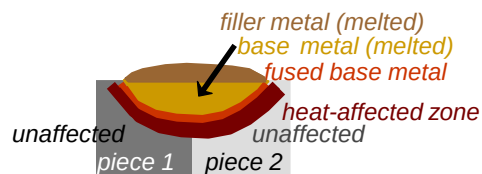
FORMING

- **Powder Metallurgy**
(metals w/low ductilities)



CASTING

- **Welding**
(when fabrication of one large part is impractical)



- **Heat-affected zone:**
(region in which the microstructure has been changed).



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