Materials Engineering Department
General Materials Branch

Casting Technology

Fourth Class

Lecture Two :Casting Alloys

Class Code :ofp4npn

Casting Alloys

- The most commonly used casting alloy (in tonnage) is gray iron, followed by ductile iron, aluminum, zinc, lead, copper, malleable iron, and magnesium.
- Shipments of castings in the United States are around 14 million metric tons per year

Nonferrous Casting Alloys

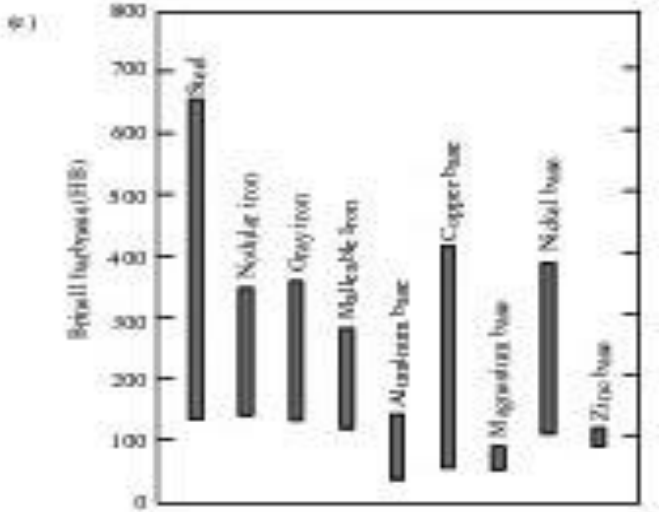
1. Aluminum-based Alloys.
2. Magnesium-based Alloys
3. Copper-based Alloys
4. Zinc-based Alloys. .
5. Tin-based Alloys..
6. Lead-based Alloys.
7. Refractories Alloys..

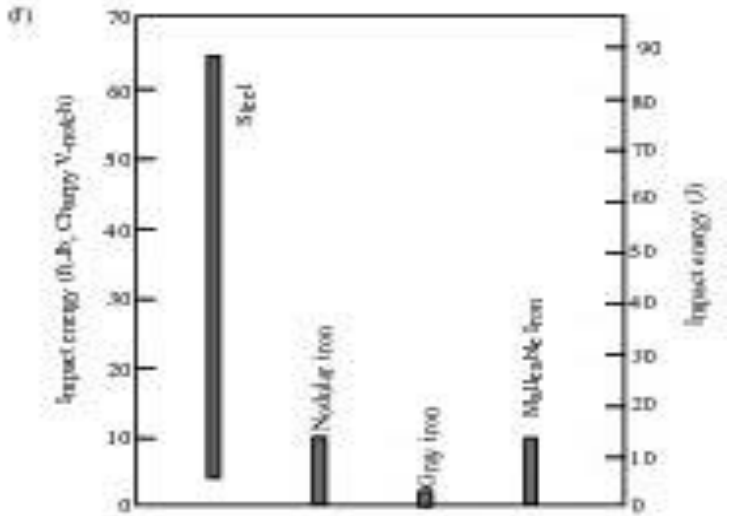
Properties and Typical Applications of Cast Nonferrous Alloys

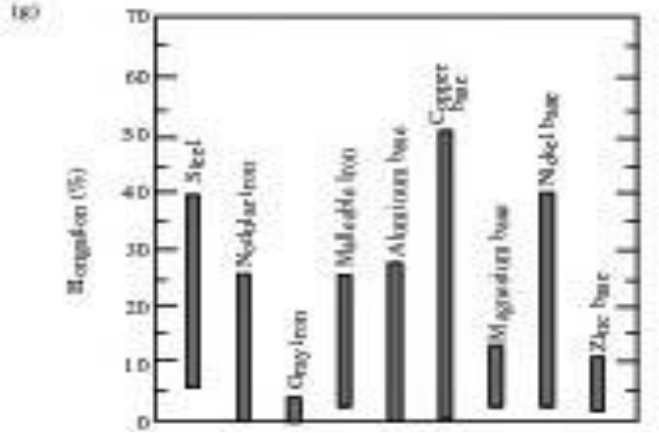
TABLE 12.5

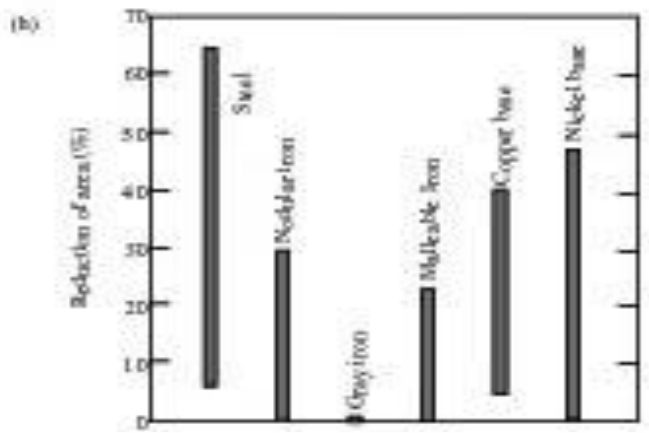
Alloys (UNS)	Condition	Ultimate tensile strength (MPa)	Yield strength (MPa)	Elongation in 50 mm (%)	Typical applications
Aluminum alloys					Sand castings
195 (AO1950)	Heat treated	220–280	110–220	8.5–2	Sand castings
319 (AO3190)	Heat treated	185–250	125–180	2–1.5	Permanent mold castings
356 (AO3560)	Heat treated	260	185	5	
Copper alloys					
Red brass (C83600)	Annealed	235	115	25	Pipe fittings, gears
Yellow brass (C86400)	Annealed	275	95	25	Hardware, ornamental
Manganese bronze (C86100)	Annealed	480	195	30	Propeller hubs, blades
Leaded tin bronze (C92500)	Annealed	260	105	35	Gears, bearings, valves
Gun metal (C90500)	Annealed	275	105	30	Pump parts, fittings
Nickel silver (C97600)	Annealed	275	175	15	Marine parts, valves
Magnesium alloys					
AZ91A	F	230	150	3	Die castings
AZ63A	T4	275	95	12	Sand and permanent mold castings
AZ91C	T6	275	130	5	High strength
EZ33A	T5	160	110	3	Elevated temperature
HK31A	T6	210	105	8	Elevated temperature
QE22A	T6	275	205	4	Highest strength

Mechanical Properties for Various Groups of Cast Alloys

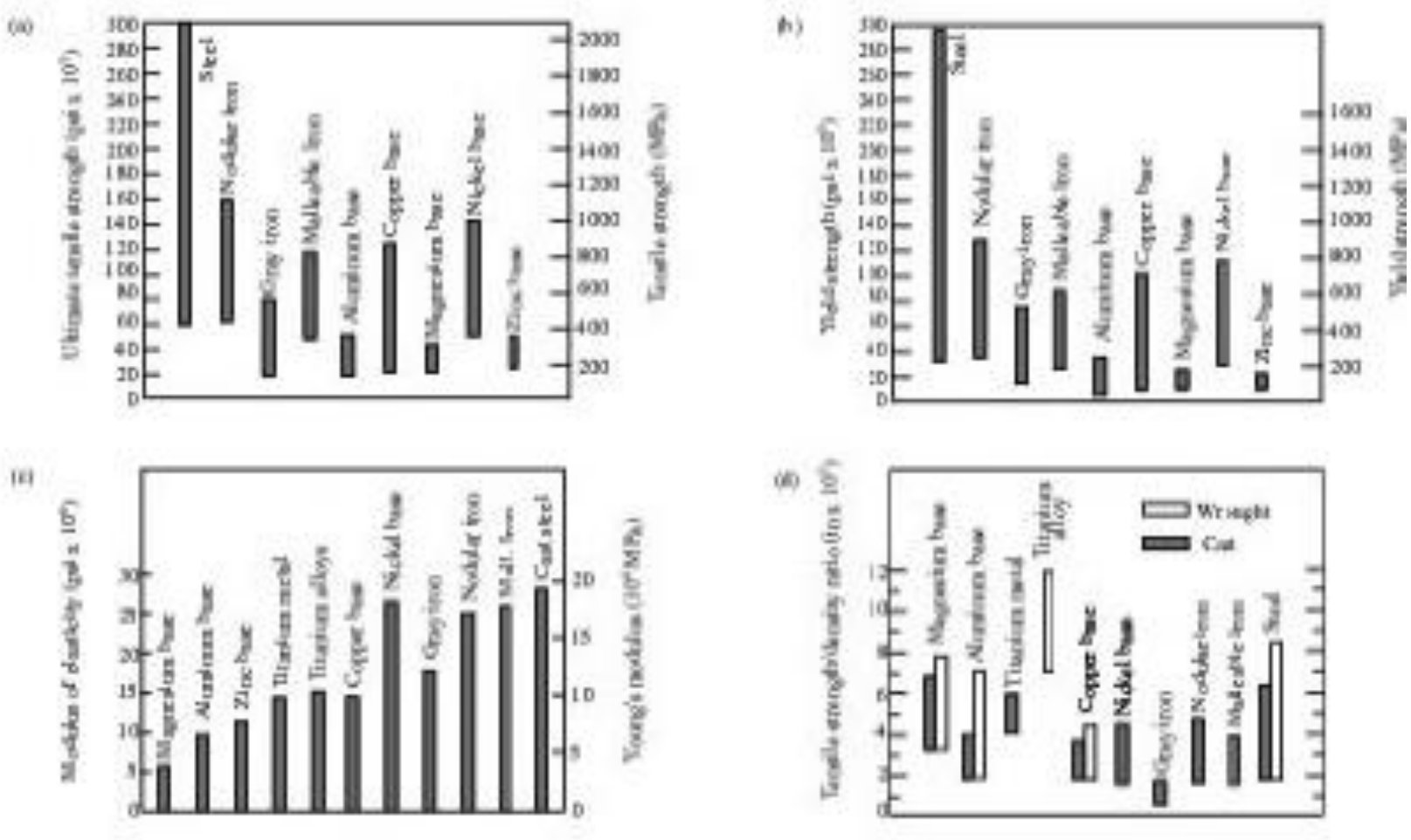








Mechanical Properties for Various Groups of Cast Alloys (cont.)



Al- Alloy Composition(Cast Alloy)

- 1xx.x Controlled unalloyed (pure) compositions, especially for rotor manufacture ·
- 2xx.x Alloys in which copper is the principal alloying element, but other alloying elements may be specified ·
- 3xx.x Alloys in which silicon is the principal alloying element, but other alloying elements such as copper and magnesium are specified ·
- 4xx.x Alloys in which silicon is the principal alloying element ·
- 5xx.x Alloys in which magnesium is the principal alloying element ·
- 7xx.x Alloys in which zinc is the principal alloying element, but other alloying elements such as copper and magnesium may be specified ·
- 8xx.x Alloys in which tin is the principal alloying element ·
- 9xx.x Unused and 6xx.x Unused ·

Mg Alloys Composition

- Magnesium-aluminum-manganese with and without zinc (AM and AZ)
- Magnesium-zirconium (K)
- Magnesium-zinc-zirconium with and without rare earths (ZK, ZE, and EZ)
- Magnesium-thorium-zirconium with and without zinc (HK, HZ, and ZH)
- Magnesium-silver-zirconium with rare earths or thorium (QE and QH)
- Magnesium-yttrium-rare-earth-zirconium (WE)
- Magnesium-zinc-copper-manganese (ZC)

Mg -Alloys Designated

- Magnesium-aluminum-manganese with and without zinc (AM and AZ)
- Magnesium-zirconium (K)
- Magnesium-zinc-zirconium with and without rare earths (ZK, ZE, and EZ)
- Magnesium-thorium-zirconium with and without zinc (HK, HZ, and ZH)
- Magnesium-silver-zirconium with rare earths or thorium (QE and QH)
- Magnesium-yttrium-rare-earth-zirconium (WE)
- Magnesium-zinc-copper-manganese (ZC)

Zinc Alloy composition

- No.3 Zn-4%Al
- No.5 Zn-4% Al-1%Cu
- ZA-8 Zn-8%Al
- ZA-12 Zn-11.5%Al
- ZA-27 Zn-25%Al

Copper Alloy Composition

- C82500 **(97.2Cu-2Be-0.5Co-0.25Si)**
- C83600 **(85Cu-5Sn-5Pb-5Zn)**
- C85800 **(63Cu-1Sn-1Pb-35Zn)**
- C87800 **(82Cu-4Si-14Zn)**
- C87900 **(Silicon yellow brass) (63Cu-1Si-36Zn)**
- C99750 **(White manganese bronze) (**0.25 to 3.0 Al, 55.0 to 61.0 Cu, 0.50 to 2.5 Pb, 17.0 to 23.0 Mn, 5.0 Ni max, 17.0 to 23.0 Zn, 1.0 Fe max, **(***Iron content shall not exceed Nickel content***))**

Die Casting Metallurgy

- Al-Alloys

1. 380 and 383 aluminum–silicon–copper (Al–Si–Cu) system.
2. 413 aluminum–silicon (Al–Si) system.
3. 390 aluminum–silicon.
4. 360 aluminum–silicon–magnesium (Al–Si–Mg) system.
5. 518 aluminum–magnesium (Al–Mg) system.

Die Casting Metallurgy

- Mg Alloys

1. AZ91 D Magnesium–Aluminum–Zinc (Lap Top Cover , Cellar Phone Cover).
2. AM60 B Magnesium–Aluminum-Mangaenese (Volkswagen Beetle)
3. ZE41 A Magnesium - Zinc -Rare Earth Elements (Helicopter Engine)

Die Casting Metallurgy

- Zinc Alloys

1. No. 3 and No. 7 zinc–aluminum (Zn–Al) system.
2. No. 2 and No. 5 zinc–aluminum–copper (Zn–Al–Cu) system.
3. ZA8, ZA12, and ZA 27 (Zn–Al) system

Die Casting Metallurgy

1. C83600 **(85Cu-5Sn-5Pb-5Zn)**
2. C85800 **(63Cu-1Sn-1Pb-35Zn)**
3. C87800 **(82Cu-4Si-14Zn)**
4. C87900 **(Silicon yellow brass) (63Cu-1Si-36Zn)**
5. C99750 **(White manganese bronze)**
6. **(**0.25 to 3.0 Al, 55.0 to 61.0 Cu, 0.50 to 2.5 Pb, 17.0 to 23.0 Mn, 5.0 Ni max, 17.0 to 23.0 Zn, 1.0 Fe max, **(***iron content shall not exceed nickel content***))**

Ferrous Casting Alloys

Cast iron :-

1. Gray cast iron
2. Ductile (nodular) iron
3. White Cast Iron
4. Malleable iron
5. Compacted-graphite iron

Properties and Typical Applications of Cast Irons

TABLE 12.3

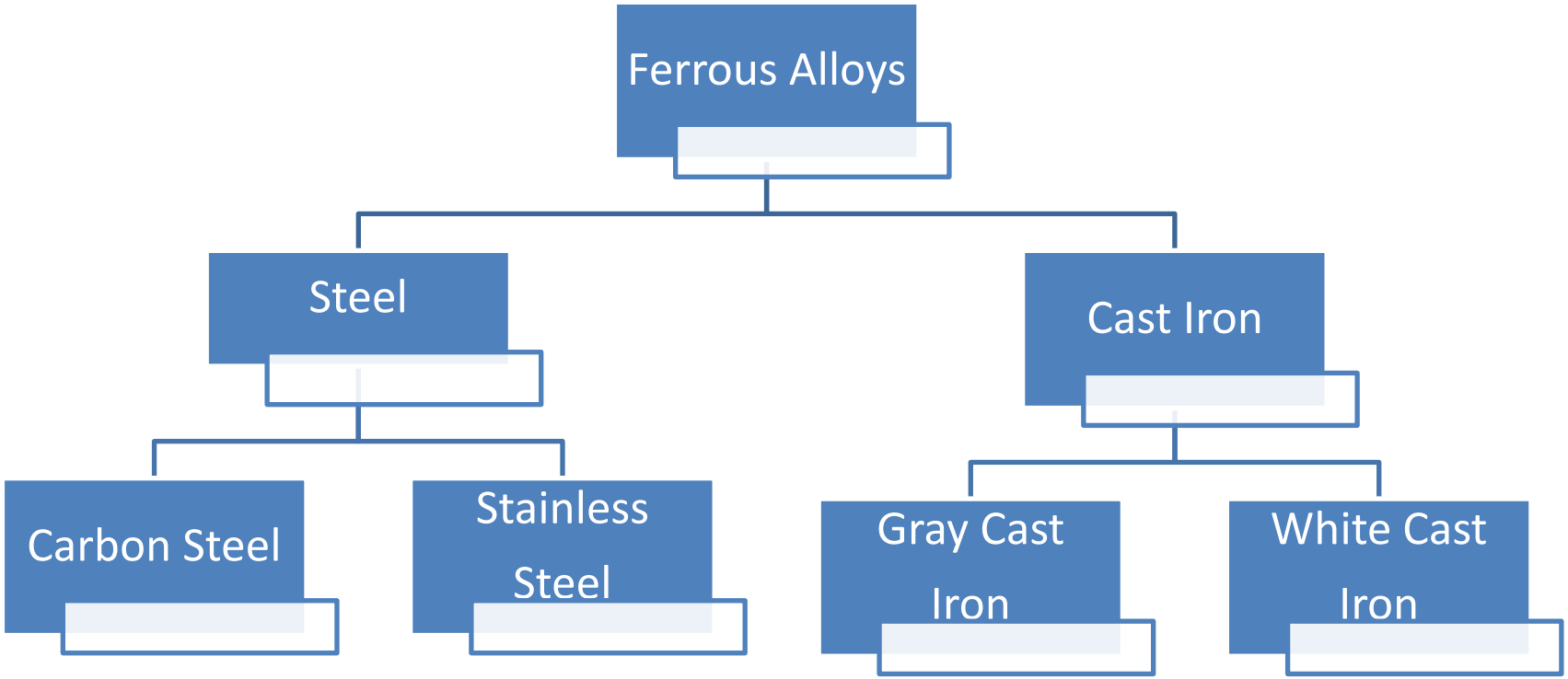
Cast iron	Type	Ultimate tensile strength (MPa)	Yield strength (MPa)	Elongation in 50 mm (%)	Typical applications
Gray	Ferritic	170	140	0.4	Pipe, sanitary ware
	Pearlitic	275	240	0.4	Engine blocks, machine tools
	Martensitic	550	550	0	Wearing surfaces
Ductile (Nodular)	Ferritic	415	275	18	Pipe, general service
	Pearlitic	550	380	6	Crankshafts, highly stressed parts
	Tempered martensite	825	620	2	High-strength machine parts,wear-resistant parts
Malleable	Ferritic	365	240	18	Hardware, pipe fittings, general engineering service
	Pearlitic	450	310	10	Railroad equipment, couplings
	Tempered martensite	700	550	2	Railroad equipment, gears, connecting rods
White	Pearlitic	275	275	0	Wear-resistant parts, mill rolls

Mechanical Properties of Gray Cast Irons

TABLE 12.4

ASTM class	Ultimate tensile strength (MPa)	Compressive strength (MPa)	Elastic modulus (GPa)	Hardness (HB)
20	152	572	66 to 97	156
25	179	669	79 to 102	174
30	214	752	90 to 113	210
35	252	855	100 to 119	212
40	293	965	110 to 138	235
50	362	1130	130 to 157	262
60	431	1293	141 to 162	302

Ferrous Casting Alloys



Major Steel Classifications

Major classifications of steel[2]

SAE designation	Type
1xxx	Carbon steels
2xxx	Nickel steels
3xxx	Nickel-chromium steels
4xxx	Molybdenum steels
5xxx	Chromium steels
6xxx	Chromium-vanadium steels
7xxx	Tungsten steels
8xxx	Nickel-chromium-molybdenum steels
9xxx	Silicon-manganese steels

Typical Applications for Casting and Casting Characteristics

TABLE 12.2

Type of alloy	Application	Castability*	Weldability*	Machinability*
Aluminum	Pistons, clutch housings, intake manifolds	E	F	G–E
Copper	Pumps, valves, gear blanks, marine propellers	F–G	F	F–G
Ductile iron	Crankshafts, heavy-duty gears	G	D	G
Gray iron	Engine blocks, gears, brake disks and drums, machine bases	E	D	G
Magnesium	Crankcase, transmission housings	G–E	G	E
Malleable iron	Farm and construction machinery, heavy-duty bearings, railroad rolling stock	G	D	G
Nickel	Gas turbine blades, pump and valve components for chemical plants	F	F	F
Steel (carbon and low alloy)	Die blocks, heavy-duty gear blanks, aircraft undercarriage members, rail-road wheels	F	E	F
Steel (high alloy)	Gas turbine housings, pump and valve components, rock crusher jaws	F	E	F
White iron	Mill liners, shot blasting nozzles, railroad brake shoes, crushers and pulverizers	G	VP	VP
Zinc	Door handles, radiator grills,	E	D	E

*E, excellent; G, good; F, fair; VP, very poor; D, difficult.