University of Anbar/ Faculty of Engineering

Department of Mechanical Engineering

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Course Code: ME2304

Stage: 2nd Year

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Lecture # 14

Cast Irons

- Cast Irons are a class of ferrous alloys contain higher Carbon (2.14 to 6.70 wt% C) (commercial cast irons less than 4.5wt% C), in addition, other alloying elements.
- Very brittle, difficult to deform.
- Easy to cast (due to lower melting point) into complex shapes and cheap.
- With alloying, good foundry practice and heat treatment, properties can be varied over wide range.
- Carbon can found in Cast Iron's as: **combined carbon** (Fe_3C) or **free carbon** (graphite)

- Cementite (Fe_3C) is a metastable compound, and under some conditions it can be made to decompose to form α-ferrite and graphite, according to the reaction;

$$Fe_3C \rightarrow 3Fe\,(\alpha) + C\,(\text{graphite})$$

- Parameters that influence on shape and distribution of free carbon (graphite) in cast irons are:
    1) Carbon content,

2) Alloy and impurity content,
3) Cooling rate during and after freezing,
4) Heat treatment after casting

- Classification of Cast Irons is based on metallographic structure;
  1) White Cast Iron (combined carbon Fe_3C)
  2) Malleable Cast Iron (free carbon as irregular particles)
  3) Chilled Cast Iron (white cast iron at the surface and gray cast iron at the interior)
  4) Grey Cast Iron (Flake Graphite)
  5) Spheroidal Graphite (SG) / Ductile Cast Iron / Nodular Cast Iron (free carbon as spheroids)
  6) Alloy Cast Iron

Factors affect graphitization (form graphite) in Cast Irons:

1) Cooling Rate
2) Carbon Equivalent; which determined as:

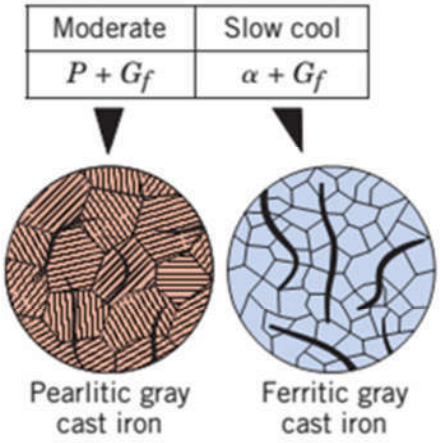
$$CE(\text{wt}\%) = C + \frac{Si + P}{3}$$

White cast iron obtained at: high cooling rate and low carbon equivalent.

Grey cast iron obtained at: low cooling rate and a high carbon equivalent

Grey Cast Iron:

- This type of cast iron is obtained by allowing the molten metal to cool and solidify slowly (at slow cooling rates)
- It contains 2.5 to 3.75% of carbon
- It contains carbon in the form of flake graphite.
- The microstructure of grey cast iron depends upon cooling rate as follow:
  I. At slow cooling — Graphite in ferrite matrix (α +G*f*).
  II. At moderate cooling — Graphite in pearlite matrix (P +G*f*).



- **General characteristics or properties of Grey cast iron:**
  - Cheap
  - Low melting point
  - Fluid – easy to cast, especially advantageous into large complex shapes
  - Excellent machinability
  - Excellent bearing properties
  - Excellent damping properties
  - Excellent wear resistance (hi C)
  - Can be heat treated (surface hardenec
  - Can be alloyed etc.

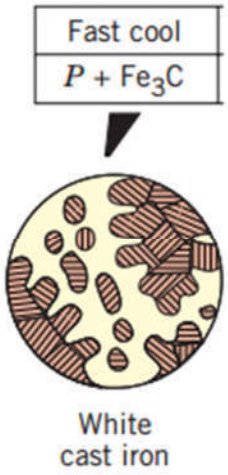
Compressive strength >> tensile strength

Applications of Grey cast iron:

Manhole cover, gas and water pipes for underground purposes, Small cylinder blocks, cylinder heads and block for IC engine, pistons, clutch plates, liners, pulleys, bench, pump body, valve, etc.

White Cast Iron:

- White cast iron is obtained by rapid cooling.
- Due to the absence of graphite, metal has white color at fractured surface.
- It contains 1.75% to 2.3% carbon.
- It contains carbon in the form of cementite.
- The microstructure of white cast iron is



- (White cast iron + annealing heat treatment) form malleable cast iron.

Properties:

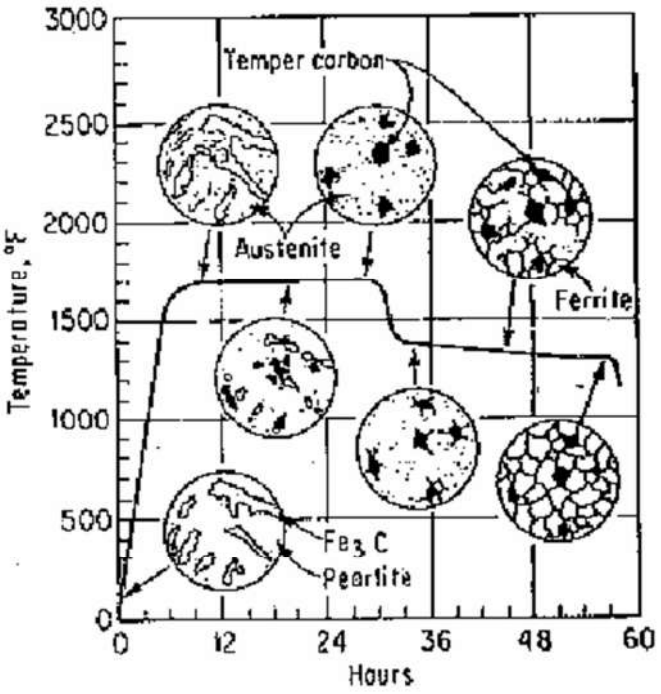
1. White cast iron is very hard and brittle,
2. It is wear resistant and less ductile.
3. Hardness varies from 400 to 600 B.H.N.
4. It can not be machined.

Applications:

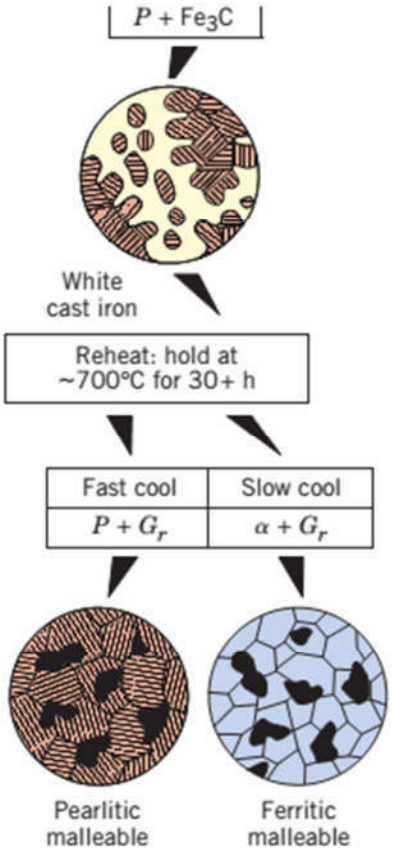
Used for producing malleable iron casting, Grinding balls, dies and extrusion nozzles, and for manufacturing those component parts which require a hard and abrasion resistant material.

Malleable Cast Iron:

- Malleable cast iron is obtained from white cast iron by special annealing process.
- Malleable cast iron contains 2 to 3.6% carbon.
- The microstructure of malleable cast-iron contains graphite in pearlitic matrix at fast cooling or graphite in ferritic matrix at slow cooling.
- The graphite present in the form of small rounded nodules.



The changes in microstructures as a function of malleableizing cycle resulting in temper carbon in ferrite matrix



Microstructure of malleable cast iron at different cooling rates after annealing process.

Properties:

1.It is less brittle.

2. Tensile strength of malleable cast iron is 180 N/mm^2.

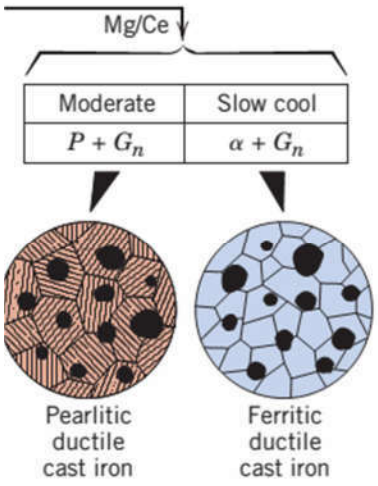
3. Good wear resistance and vibration damping capacity.

Applications:

1. Automobile parts.
2. Sewing machine parts.
3. Bicycle parts.
4. Agricultural equipments.
5. Electrical line hardware.
6. Universal joint yoke.
7. Conveyor chain links.
8. Suitable for small and medium size castings of high strength.

Nodular or Ductile Cast Iron:

- Produced by **inoculation** of grey cast iron; adding a small amount of magnesium and/or cerium (about 0.05%) to the grey cast iron before casting produces a clearly different microstructure and set of mechanical properties.
- Graphite still forms, but as nodules or spherelike particles instead of flakes.
- This is high grade cast iron.
- It is also called ductile cast iron.



Properties

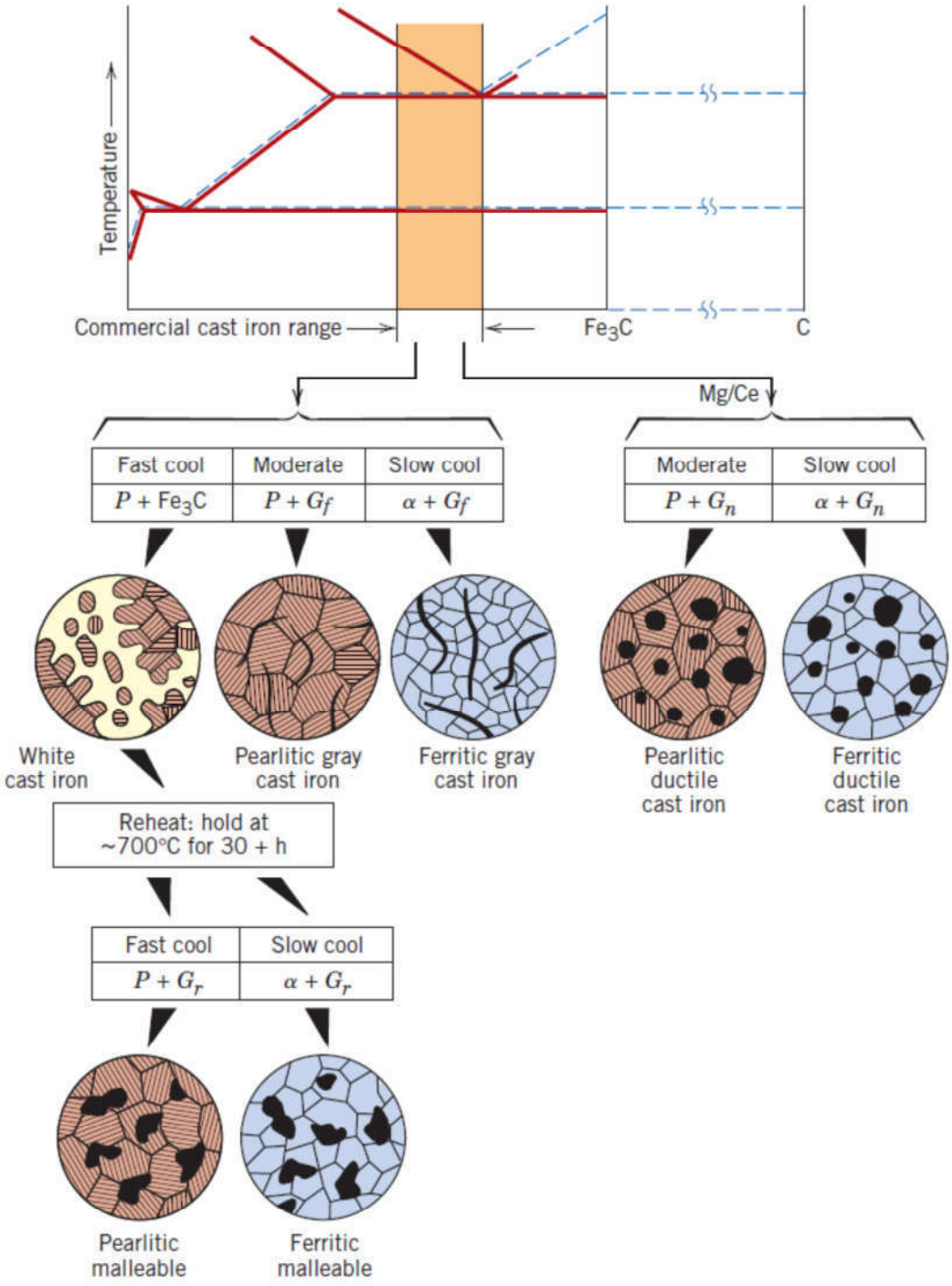
1.It has very good casting properties as high fluidity and low melting point.
2. It produces better machined surfaces.
3. The tensile strength is 330 N/mm^2.
4. High strength and toughness.
5. Good resistance to wear.
6. Higher machinability than grey cast iron.
7. It can be welded well.
8. The value of modulus of elasticity is high.

Typical applications: include valves, pump bodies, crankshafts, gears, and other automotive and machine components.

Chilled Cast Iron:

- white cast iron at the surface (faster cooling rates)and gray cast iron at the interior (slow cooling rates).
- Harder / wear resistant surface
- Depth depends on composition: (C, Si decrease chill depth), Carbide forming elements like Cr, Mo increase chill depth.

Applications: include railway car wheels, crushing rolls, heavy machinery



Schematic microstructures that result from a variety of heat treatments. *Gf*, flake graphite; *Gr*, graphite rosettes; *Gn*, graphite nodules; *P*, pearlite; α, ferrite.