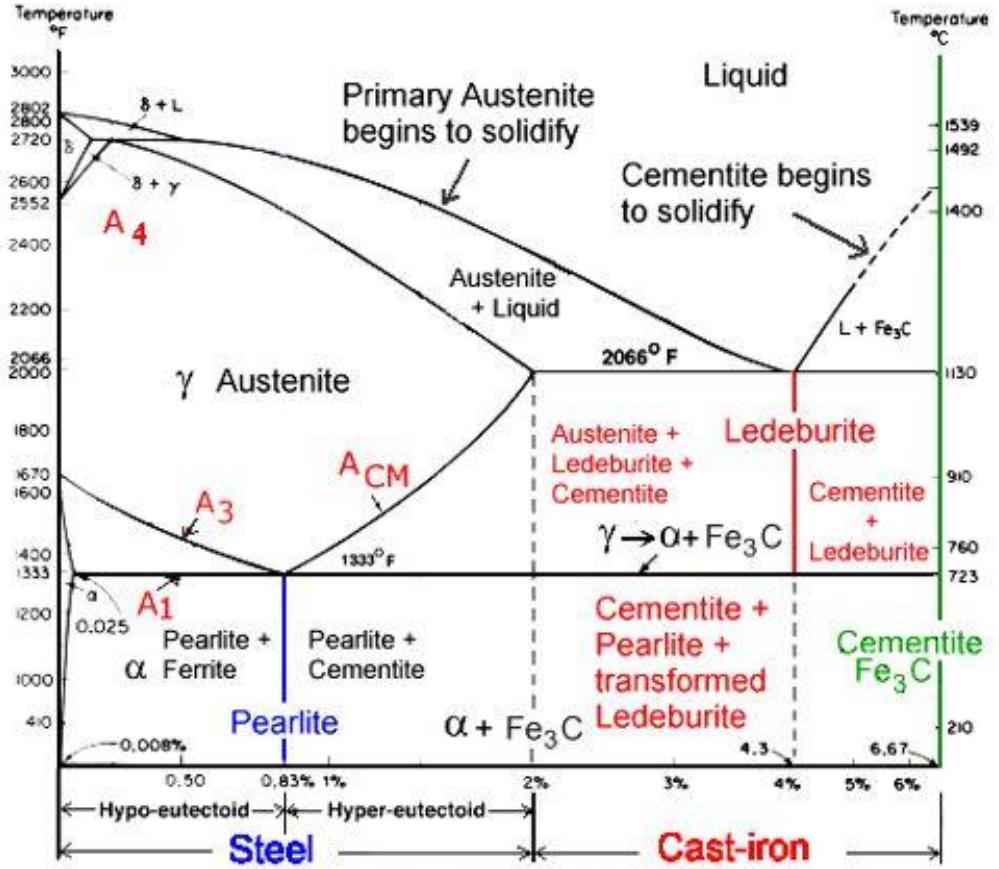
MetallurgyA2Z

C is for Cast Iron

Cast Iron



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Cast Iron

- **Cast iron**, an alloy of iron that contains 2 to 4 percent carbon, along with varying amounts of silicon and manganese and traces of impurities such as sulphur and phosphorus.
- It is made by reducing iron ore in a blast furnace. The liquid iron is cast, or poured and hardened, into crude ingots called pigs, and the pigs are subsequently remelted along with scrap and alloying elements in cupola furnaces and recast into moulds for producing a variety of products.
- **Cast iron** is highly favoured for its ability to be **easily cast into complex shapes when molten and for its low cost**. In addition, its properties can be easily altered by adjusting the composition and cooling rate without significant changes to production methods.

Other alloying elements which are generally used in it are

•**Manganese**: Increases resistance to wear and abrasions

•**Chromium**: Increases hardenability, wear resistance, corrosion and oxidation resistance

•**Nickle**: Increases tensile strength

•**Tungsten**: It increases hot hardness and hot strength

•**Molybdenum**: Increases hardenability

•**Vanadium**: Increases hardenability and hot hardness

•**Silicon**: Increases hardenability and electrical resistivity

•**Aluminum**: Works as deoxidizer in steel

•**Titanium**: Works as deoxidizer in steel

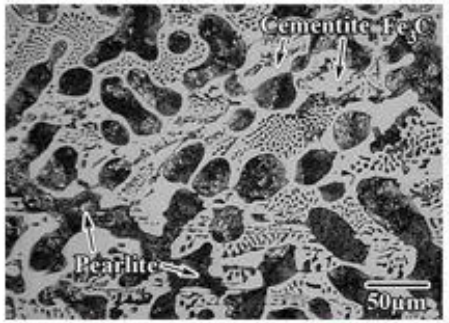
•**Niobium**: It reduces hardenability and increases ductility, which results in increased impact strength

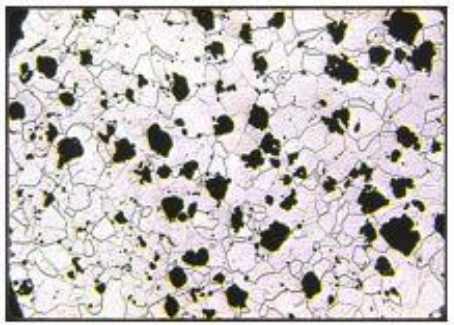
•**Cobalt**: It reduces hardenability and resists softening at elevated temperatures

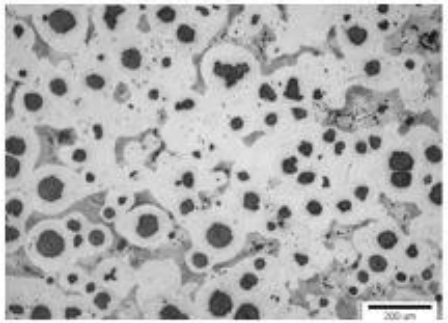
Types of Cast Iron

Cast Iron

- Gray Cast Iron
- White Cast Iron
- Malleable Cast iron
- Ductile Cast iron







Compositions of Cast Iron

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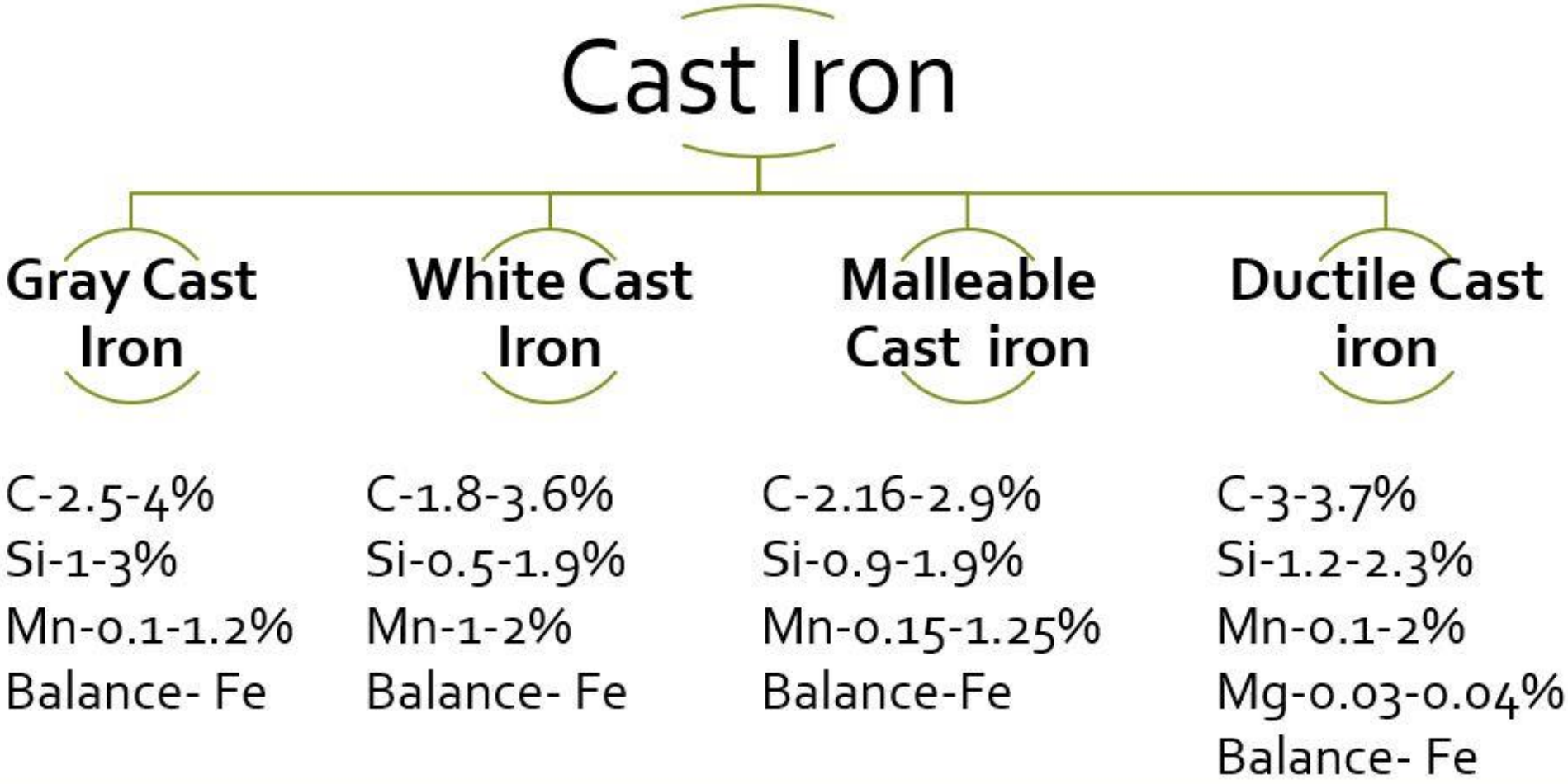
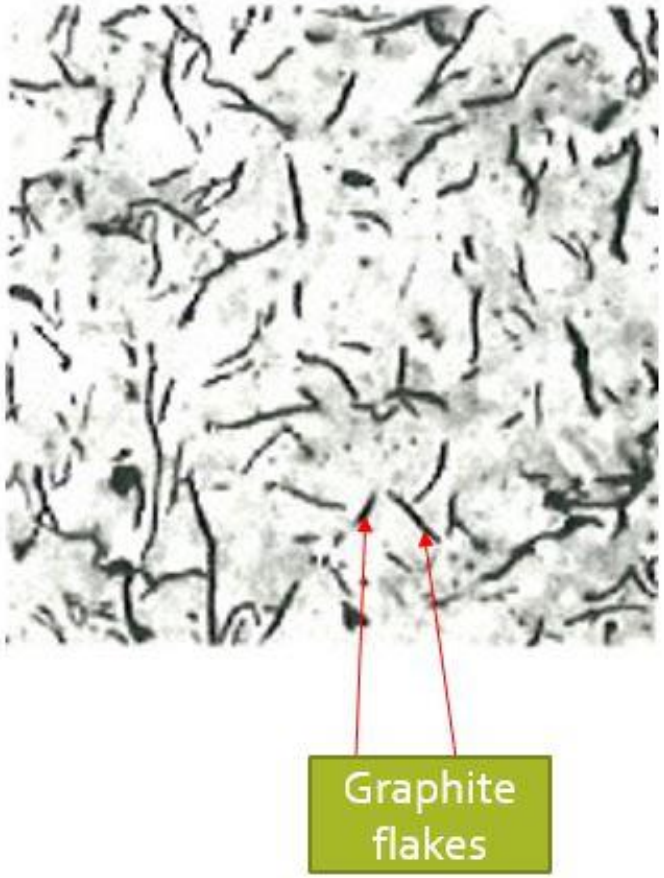


Gray Cast Iron

- Exhibits a gray fracture surface because fracture occurs along the graphite plates (flakes); it is the result of stable solidification (Gr eutectic).
- **Grey cast iron** is a type of iron found in castings known for its grey colour and appearance caused by graphite fractures in the material. Specifically, what makes grey iron "**grey iron**," is the graphite flake structure that is created during the cooling process from the carbon that is in the component.
- **Grey cast irons** are softer with a microstructure of graphite in transformed-austenite and cementite matrix. The graphite flakes, which are rosettes in three dimensions, have a low density and hence compensate for the freezing contraction, thus giving good castings free from porosity.
- The flakes of graphite have **good damping characteristics and good machinability** (because the graphite acts as a chip-breaker and lubricates the cutting tools. In applications involving wear, the graphite is beneficial because it **helps retain lubricants**. However, the flakes of graphite also are stress concentrators, leading to poor toughness. The recommended applied tensile stress is therefore only a quarter of its actual ultimate tensile strength.



2.Gray cast iron

Carbon here is mainly in the form of graphite. It is inexpensive. Its properties are

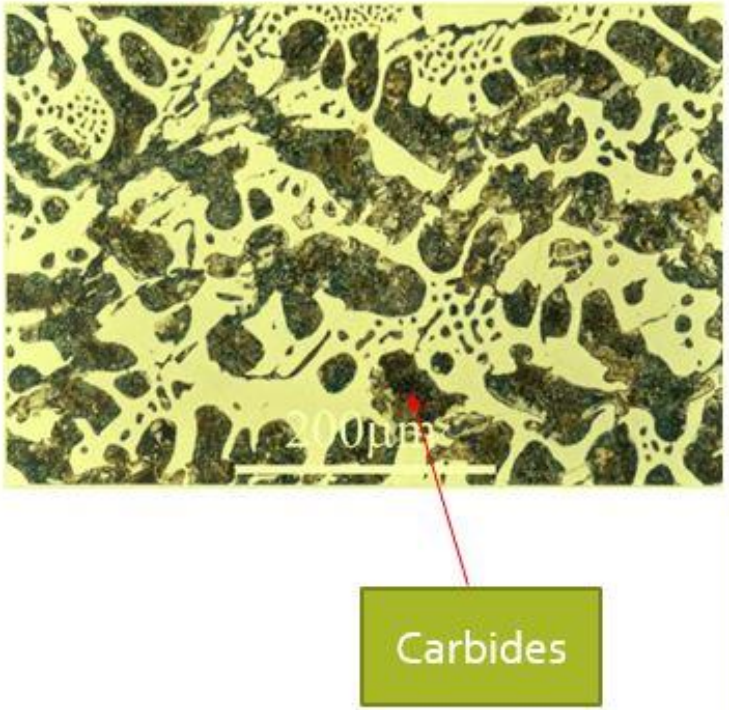
- It has Good machinability
- It has Good resistance to galling and wear
- It has high compressive strength
- It is brittle

Gray iron applications

One of the key characteristics of gray iron is its ability to resist wear even when lubrication supply is limited (e.g. the upper cylinder walls in engine blocks). Gray iron is used to make engine blocks and cylinder heads, manifolds, gas burners, gear blanks, enclosures, and housings.

White Cast Iron

- When the white cast iron is fractured, white coloured cracks are seen throughout because of the presence of carbide impurities. White cast iron is hard but brittle. It has lower silicon content and low melting point. White cast iron contains 1.8 % -3.6 % C, 0.5 % -1.9 % Si and 1 % – 2 % manganese (Mn).
- The carbon present in the white cast iron precipitates and forms large particles that increase the hardness of the cast iron. It is abrasive resistant as well as cost-effective making them useful in various applications like lifter bars and shell liners in grinding mills, wear surfaces of pumps, balls and rings of coal pulverisers, etc.
- It is characterized by the prevalence of carbides, impacting, high compressive strength, hardness and good resistance to wear.
- White cast iron does not have the easy castability of other cast irons because its solidification temperature is generally higher, and it solidifies with C in its combined form as iron carbide



White cast iron

Carbon is present here in the form of Iron carbide (Fe_3C).

Its properties are

- It has High compressive strength
- It is difficult to machine
- It has Good hardness
- It has Resistance to wear

White iron applications

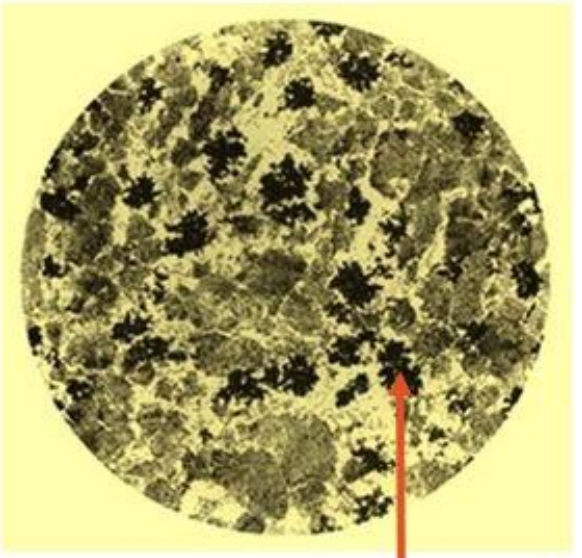
The chilling process used to make white iron results in a brittle material that is very resistant to wear and abrasions. For this reason, it is used to make mill linings, shot-blasting nozzles, railroad brake shoes, slurry pump housings, rolling mill rolls, and crushers.

Malleable Cast Iron

- **Malleable cast iron** is basically white iron that undergoes heat treatment to convert the carbide into graphite. The resultant cast iron has properties that vary from both grey and white cast iron.

- In case of **malleable cast iron**, the graphite structure is formed into irregularly shaped spheroidal particles rather than flakes that are usually present in gray cast iron. This make the **malleable cast iron** behave like low-carbon steel. There is considerable shrinkage that results in reduced production of cast iron as well increased costs. Malleable cast iron can be identified easily by **the blunt boundaries.**

- **Malleable cast irons** are a class of cast irons with mechanical strength properties that are intermediate to those of gray or ductile cast irons. The microstructure provides it properties that make **malleable cast irons** ideal for applications where toughness and machinability are required, and for components that are required to have some ductility or be malleable so that they can be bent or flexed into position without cracking. **Malleable cast iron** besides less sensitive to cracking has a range of features, such as **higher values of tensile strength, rupture strength and elongation, and high resistance to wear and strong shock resistance**. These properties make it useful for a range of commercial purposes. **Malleable cast iron** is often used as an alternative to steel since it is cheaper to produce and use.



Irregularly shaped spheroidal shaped graphite

Malleable cast iron

They are made malleable with the help of annealing. They are used to make parts where forging is expensive like, brake supports, hubs of wagon wheels etc. They are in expensive.

Its properties are

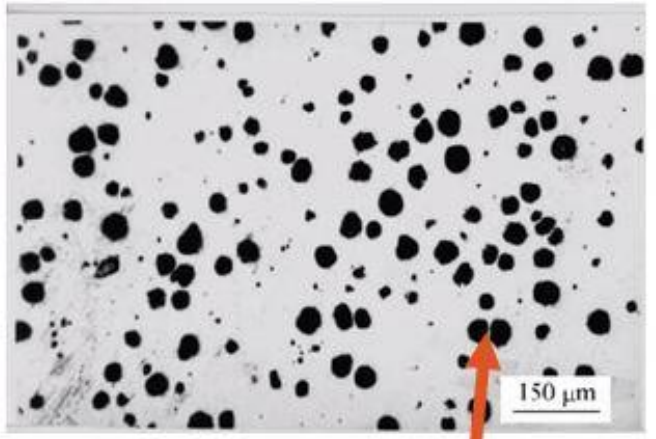
- They have High ductility
- They are tougher than gray cast iron
- They can be twisted or bent without fracture
- They have excellent machining capabilities

Malleable iron applications

Different grades of malleable iron correspond to different microcrystalline structures. Specific attributes that make malleable iron attractive are its ability to retain and store lubricants, the non-abrasive wear particles, and the porous surface which traps other abrasive debris. Malleable iron is used for heavy duty bearing surfaces, chains, sprockets, connecting rods, drive train and axle components, railroad rolling stock, and farm and construction machinery.

Ductile Cast Iron

- **Ductile cast iron** is yet another type of ferrous alloy that is used as an engineering material in many applications also known as **Nodular cast iron, spherodised cast iron.**
- To produce **ductile iron**, small amount of magnesium is added to the molten iron, which alters the graphite structure that is formed. The magnesium reacts with oxygen and sulphur in the molten iron leading to nodule shaped graphite that has earned them the name-**nodular cast iron**. Like malleable iron, **ductile iron** is flexible and exhibits a linear stress strain relation. It can be casted in varied sizes and into varying thickness.
- Gray iron with small amounts of **magnesium and cesium** which nodulates the graphite, resulting **high strength and high ductility**
- There are several advantages that **ductile iron** provides designers: **Ductile iron** can be easily cast and machined. It has an **excellent strength to weight ratio**. **Ductile iron** can be made for a much lower cost than steel. It has **superior castability and machinability**. **Ductile iron** provides a designer with an exceptional combination of toughness, low cost manufacturing, and reliability.



spheroidal shaped graphite

Ductile cast iron

Its properties are

•It has High ductility

•It has High strength

Ductile iron applications

Ductile iron itself can be broken down into different grades, each with their own property specifications and most suitable applications. It is easy to machine, has good fatigue and yield strength, while being wear resistant. Its most well-known feature, however, is ductility. Ductile iron can be used to make steering knuckles, plow shares, crankshafts, heavy duty gears, automotive and truck suspension components, hydraulic components, and automobile door hinges.

Advantages of cast iron

•It has Good casting properties
•It is available in large quantities, hence produced in mass scale. Tools required for casting process are relatively cheap and inexpensive. This results into low cost of its products.
•It can be given any complex shape and size without using costly machining operations
•It has three to five times more compression strength compared to steel
•It has Good machinability (gray cast iron)
•It has excellent anti-vibration (or damping) properties hence it is used to make machine frames
•It has good Sensibility
•It has excellent resistance to wear
•It has constant Mechanical properties between 20 to 350 degree Celsius
•It has very low notch sensitivity
•It has Low stress concentration
•It bears Low cost
•It has Durability
•It has Resistance to deformation

Disadvantages of cast iron

- It is Prone to rusting
- It has poor tensile strength
- Its parts are section sensitive, this is due to slow cooling of thick sections.
- failure of Its parts is sudden and total, it does not exhibit yield point.
- It has poor impact resistance
- Compared to steel it has poor machinability
- It has High weight to strength ratio
- It has High brittleness
- It is Non machinable (white cast iron)