Heat Treatment of Metals

MSE-S305

Ankur Katiyar

Assistant Professor, MSME Department

UIET, CSJM University

Features of phases present in Fe-Fe_3C Phase Diagram

α-ferrite

- ***α-ferrite* is an interstitial solid solution of *carbon* dissolved in α- iron *(BCC)*.**

- **Maximum solubility of carbon in α-iron is *0.025%C* at *723ºC* and it dissolves only *0.008%C* at *room temperature*.**

- **It is the *softest structure* (fairly *ductile*) that appears on the Fe-Fe_3C phase diagram.**

- **It is a stable form of iron at room temperature.**

Features of phases present in $Fe-Fe_3C$ Phase Diagram

α-ferrite

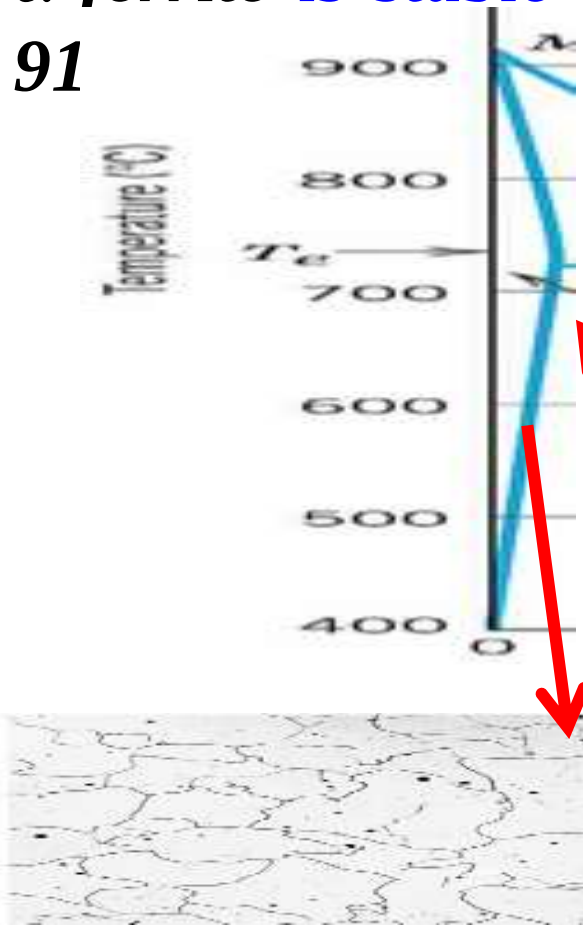
- ***α-ferrite* transforms to *γ-austenite(FCC)* at *912°C*.**

- ***α-ferrite* is ferromagnetic at room temperature and it becomes non-magnetic (paramagnetic) at curie temperature *(768°C)*.**

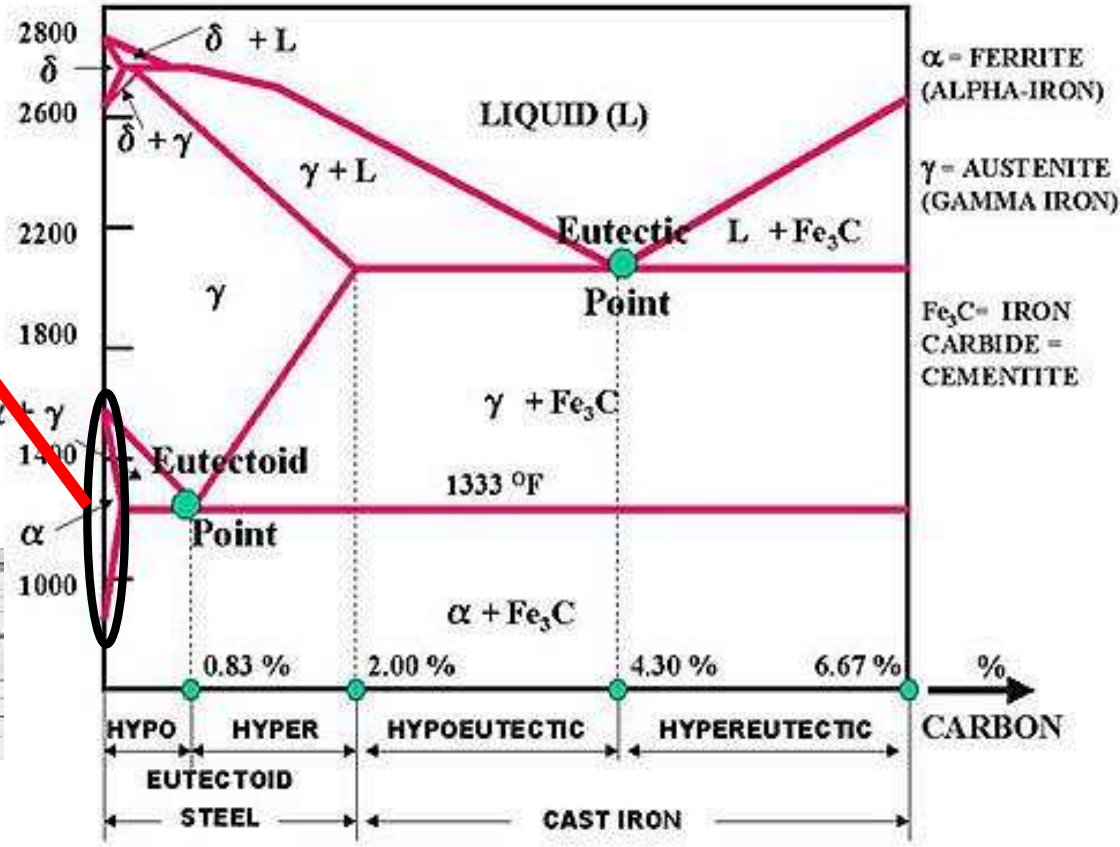
Features of phases present in Fe-Fe_3C Phase Diagram

α-ferrite

α-ferrite is stable over a temperature range of -273ºC to 91



α-ferrite



Features of phases present in $Fe-Fe_3C$ Phase Diagram

γ-austenite

- ***γ-austenite*** **is an interstitial solid solution of carbon dissolved in γ-iron *(FCC)*.**
- **Maximum solubility of carbon in γ-iron is *2.1%C* at *1147ºC*.**
- **Austenite is *soft*, *ductile* and *malleable*.**
- **Austenite is non magnetic *(paramagnetic)*.**

Features of phases present in $Fe-Fe_3C$ Phase Diagram

γ-austenite

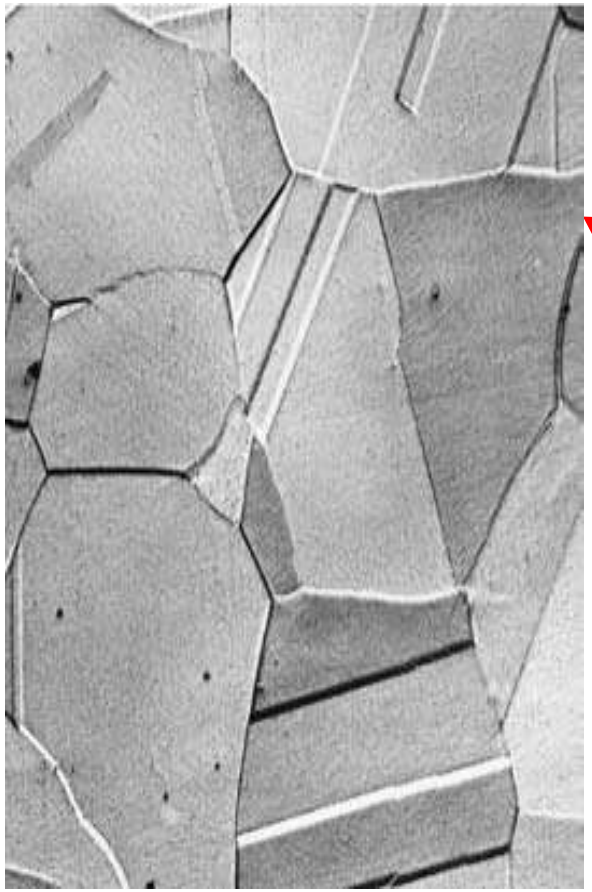
- ***γ-austenite(FCC)*** **transforms to** ***δ-ferrite(BCC)*** **at *1395°C.***

- **Steels are commonly *rolled* and *forged* above about *1100°C*, when they are in austenite state due to its high ductility and malleability, which is also due to its *FCC* crystal structure.**

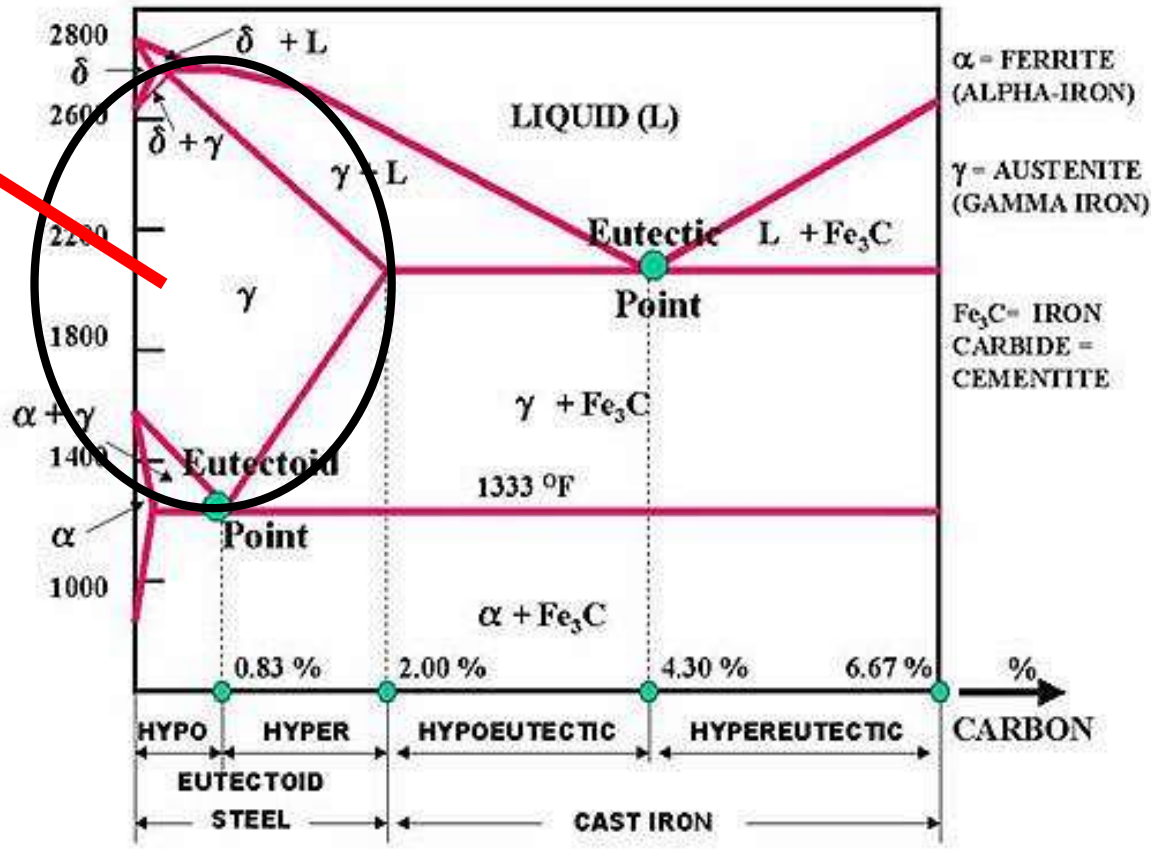
Features of phases present in Fe-Fe_3C Phase Diagram

γ-austenite

➢ *γ-austenite is stable over a temperature range of 912°C.*



γ-austenite



Features of phases present in $Fe-Fe_3C$ Phase Diagram

δ-ferrite

- ***δ-ferrite* is an interstitial solid solution of carbon dissolved in *δ-ferrite(BCC)*.**

- **Maximum solubility of carbon in δ-iron is *0.09%C* at *1495ºC*.**

- ***δ-ferrite* is a high temperature phase and is a high temperature presentation of *α-ferrite*.**

- ***δ-ferrite* is non magnetic *(paramagnetic)*.**

Features of phases present in $Fe\text{-}Fe_3C$ Phase Diagram

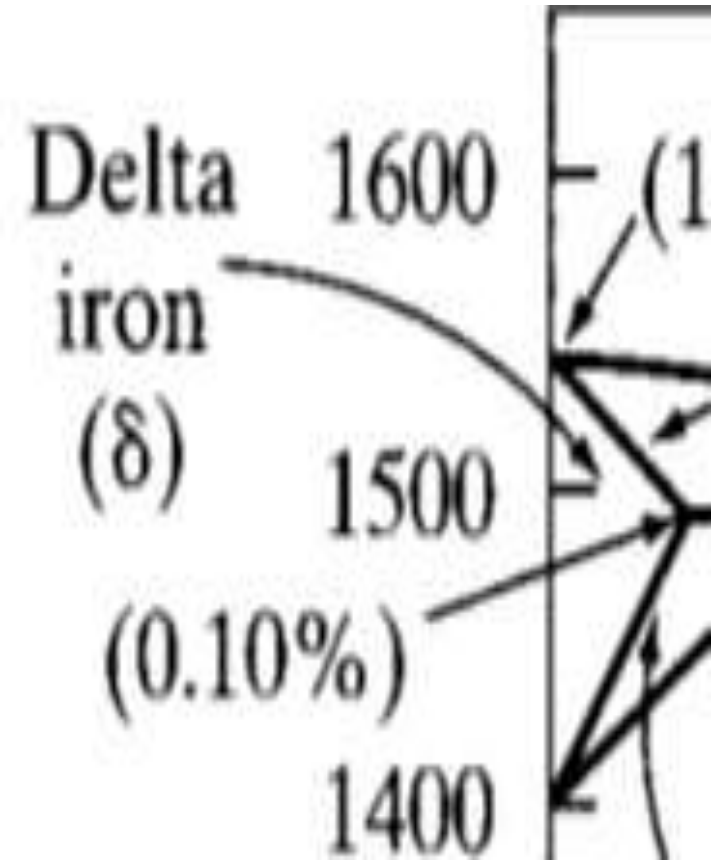
δ-ferrite

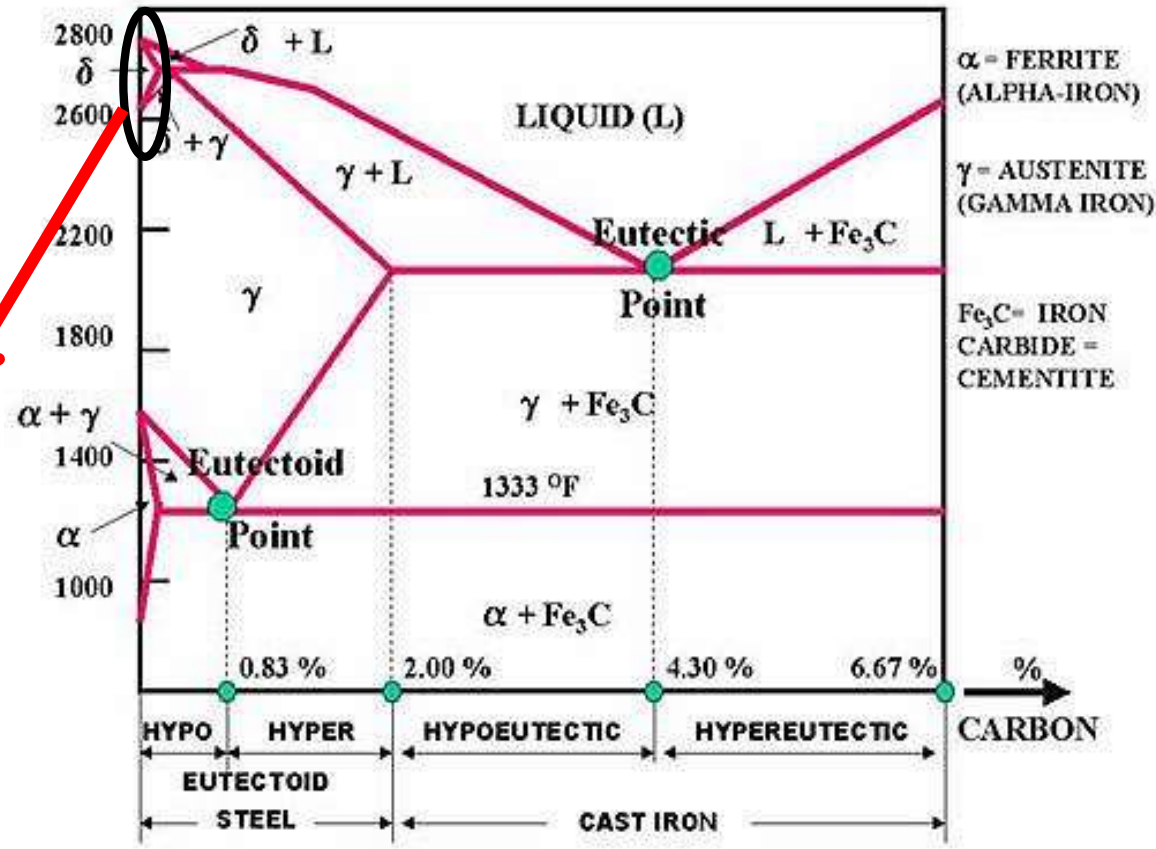
- ***δ-ferrite*** **is not stable at room temperature in plain carbon steel. However it can be present at room temperature in alloy steel specially in duplex stainless steel.**

Features of phases present in $Fe-Fe_3C$ Phase Diagram

δ-ferrite

δ-ferrite is stable over a temperature range of 1394°C to 1538°C.





Features of phases present in Fe-Fe_3C Phase Diagram

Cementite (Fe_3C)

- ***Cementite (iron carbide), chemical formula Fe_3C, contains 6.67%C by weight and it is metastable phase at room temperature.***

- ***Cementite (Fe_3C) is an intermetallic compound.***

- **It is typically *hard* and *brittle* interstitial compound of *low tensile strength* but *high compressive strength* and *high hardness*.**

Features of phases present in Fe-Fe_3C Phase Diagram

Cementite (Fe_3C)

- **Iron carbide is the *hardest structure* that appears on the Fe-Fe_3C phase diagram.**

- **It is slightly *ferromagnetic* up to *210°C* and *paramagnetic* above it.**

- ***Cementite (Fe_3C)* has a complex orthorhombic crystal structure with *12 iron atoms* and *4 carbon atoms* per unit cell.**

Features of phases present in Fe-Fe_3C Phase Diagram

Cementite (Fe_3C)

Cementite (Fe_3C) is a metastable phase at room temperature but the decomposition rate of cementite is small and included in a phase diagram. Hence, we typically consider the Fe-Fe_3C part of the Fe-C phase diagram.

Cementite (Fe_3C) decomposes (very slowly, within several years) into α-Fe and C (graphite) at 650 - 700°C.

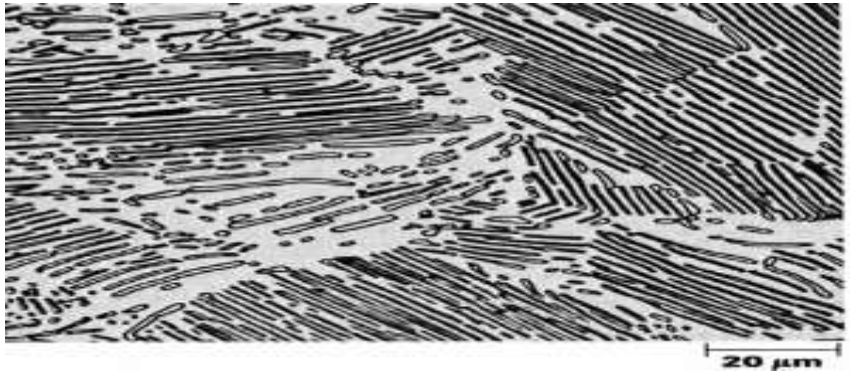
Melting point of *Cementite (Fe_3C)* is around *1227°C.*

Features of phases present in Fe-Fe_3C Phase Diagram

Pearlite (α+Fe_3C)

- ***Pearlite (α+Fe_3C)* is an alternate layered structure of two phases: *α-ferrite* and *cementite (Fe3C)*.**

- ***Pearlite (α+Fe_3C)* is very fine *plate like* or *lamellar* mixture of ferrite and cementite.**



Features of phases present in Fe-Fe_3C Phase Diagram

Pearlite (α+Fe_3C)

- ***Pearlite (α+Fe_3C)*** **is the eutectoid mixture containing *0.80 %C* and is formed at *723°C* on very slow cooling.**

- **The weight fraction of these two phases (*α-ferrite* and *cementite*) are thus in the ratio of *8:1*.**

Features of phases present in Fe-Fe_3C Phase Diagram

Ledeburite (γ+ Fe_3C)

- ***Ledeburite (γ+ Fe_3C) is the eutectic mixture of austenite (γ-ferrite) and cementite (Fe_3C).***

- ***Ledeburite (γ+ Fe_3C) contains 4.3%C and is formed at 1147°C.***

- **Structure of *ledeburite* contains *small islands* of *austenite (γ-ferrite)* are *dispersed* in the *carbide phase*.**

- ***Ledeburite* is not stable at room temperature.**

Features of phases present in $Fe\text{-}Fe_3C$ Phase Diagram

Ledeburite (γ+ Fe_3C)

- ***Ledeburite* is not a type of steel as the *carbon level* is *too high*.**

- ***Ledeburite* may occur as a *separate constituent* in some *high carbon steels*.**