Heat Treatment

Introduction:
Looking to Fig. (1), it shows 3 (three) lines which indicate isothermal reactions, these lines are:

- HJK line (A₁) lower critical temp. (Eutectiod reaction) at 1333 °f.
- CED line (Eutectic reaction) at 2065 °f.
- MPB line (Peritectic reaction) at 2720 °f.

Fig. (1): The Fe – Fe₃C diagram
Heat Treatment

- Peritectic reaction may be written as:

\[ L + \delta_1 \rightarrow \delta_2 \]
\[ L + \delta \rightarrow \gamma \]

- It is an isothermal reversible reaction in which a liquid phase reacts with a solid phase to produce another solid phase on cooling.

- The maximum solubility of (C) in (\(\delta\)) Fe [b. c. c] is 0.1% C at point M.

- Eutectic reactions may be written as:

\[ L \rightarrow \gamma + \text{Cementite (Fe}_3\text{C)} \rightarrow (L \rightarrow S_1 + S_2) \]

- It is an isothermal reversible reaction in which a liquid solution is converted into two or more mixed solids on cooling, the no. of solids formed being the same as the no. of compositions in the system.

- Eutectoid reaction may be written as:

\[ S_1 \rightarrow S_2 + S_3 \text{ (at 1333 }^\circ\text{F)} \rightarrow \gamma \]
\[ \alpha + \text{Fe}_3\text{C (Cementite)} \rightarrow \gamma \]

- It is an isothermal reversible reaction in which a solid phase (usually a solid solution) is converted into two or more mixed solids on cooling, the no. of solids formed being the same as the no. of compositions in the system.
Heat Treatment

Types of Microstructure in Fe – $\text{Fe}_3\text{C}$ diagram:

1. **Cementite** ($\text{Fe}_3\text{C}$):
   
   It’s a typical hard and brittle interstitial compound of low T. S ($\sigma$) $\approx 5000$ psi, but high Compressive Strength, contains 6.67% C, its crystal structure is Orthorhombic crystal structure.

   \[ E\% \approx 0\% , \quad R_c \approx 72 \]

2. **Austenite** ($\gamma$):
   
   It’s an interstitial solid solution of C dissolved in $\gamma$ (f. c. c) iron. Maximum solubility is 2% C at 2065 °f point (C) in fig. 1. It’s normally not stable at T$_{room}$ (R$_T$), but under certain conditions it is possible to obtain $\gamma$ at R$_T$.

   \[ \text{T. S} \approx 150,000 \text{ psi,} \quad E\% \approx 10\% , \quad R_c \approx 40 \]

3. **Ledeburite**:

   It is a Eutectic mixture of ($\gamma$) and Cementite ($\text{Fe}_3\text{C}$). It contain 4.3% C and it is formed at 2065 °f point (E).
4. **Ferrite (α):**

It’s an interstitial solid solution of small amount of (C) dissolved in α (b.c.c) iron. Maximum solubility is 0.025% C at 1333 °F point (H) in fig. 1. It is the softest structure. The average properties are:

\[ T.S \approx 40,000 \text{ psi}, \quad E\% \approx 4.0\% , \quad R_c \approx 0 \]

5. **Pearlite:**

It is a Eutectic mixture containing 0.8% (C) and is formed at 1333 °F point (J) in fig. 1 on very slow cooling. It is a very fine plate like or lamellar mixture of (α) + Fe₃C. The average properties are:

\[ T.S \approx 120,000 \text{ psi}, \quad E\% \approx 2.0\% , \quad R_c \approx 2.0 \]