Normalizing Treatment

- **Lec-4**

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Normalizing

Normalizing process consists of three steps. The *first step* involves heating the steel component above the A_3 temperature for hypoeutectoid steels and above A_{cm} (upper critical temperature for cementite) temperature for hypereutectoid steels by 30^0C to 50^0C (*Figure 4.7.5*). The *second step* involves holding the steel component long enough at this temperature for homogeneous austenization. The final step involves cooling the hot steel component to room temperature in still air. Due to air cooling, normalized components show slightly different structure and properties than annealed components. The same are explained in *Table 4.7.1*.

The properties of normalized components are not much different from those of annealed components. However, normalizing takes less time and is more convenient and economical than annealing and hence is a more common heat treatment in industries. Normalizing is used for high-carbon (hypereutectoid) steels to eliminate the cementite network that may develop upon slow cooling in the temperature range from point A_{cm} to point $A_{1.}$ Normalizing is also used to relieve internal stresses induced by heat treating, welding, casting, forging, forming, or machining. Normalizing also improves the ductility without reducing the hardness and strength.

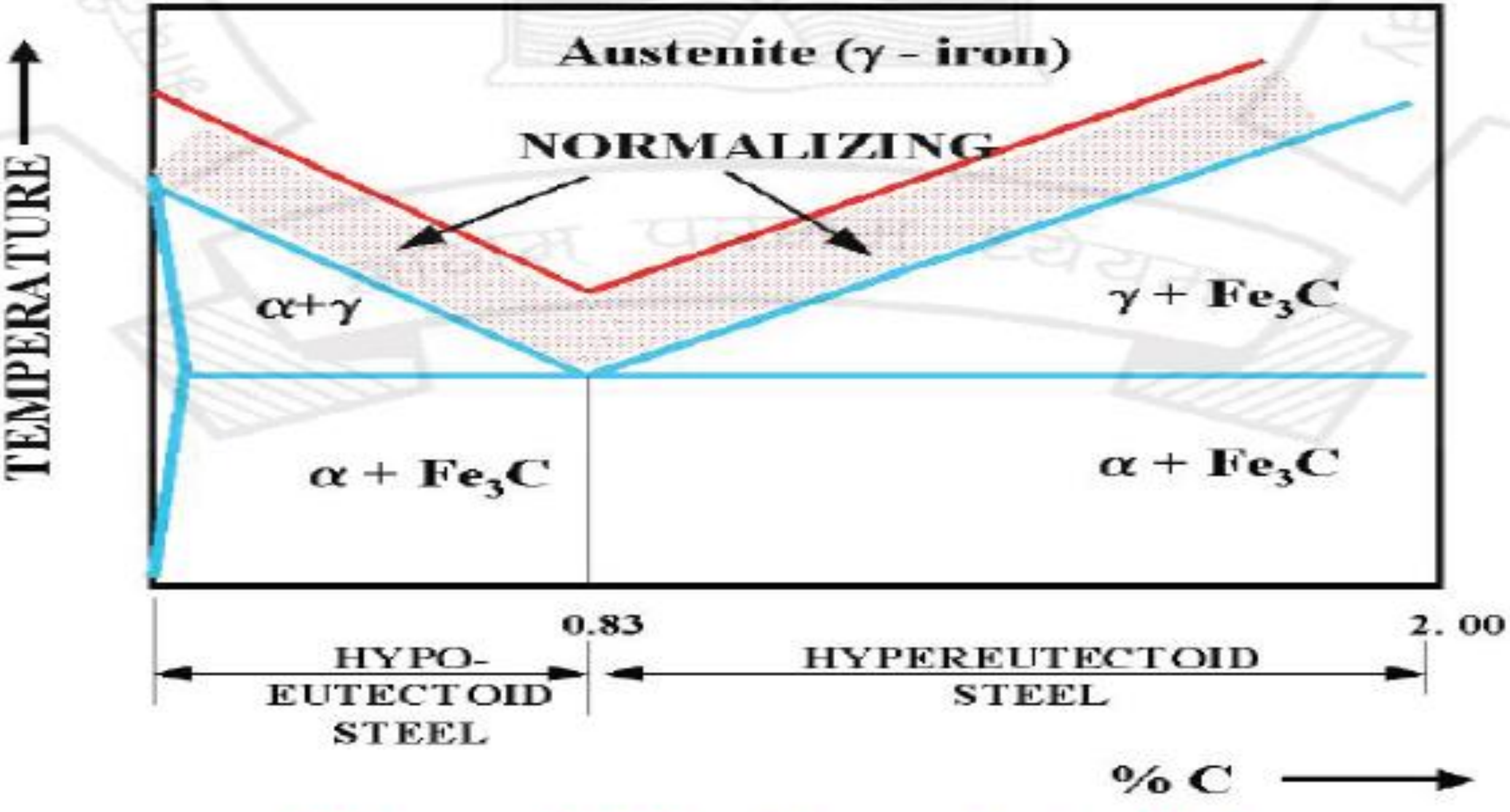


Figure 4.7.5 Normalizing [3]

Table 4.7.1 The variation in the properties of the annealed and normalized components [7]

Annealed	Normalised
Less hardness, tensile strength and toughness.	Slightly more hardness, tensile strength and toughness.
Pearlite is coarse and usually gets resolved by the optical microscope.	Pearlite is fine and usually appears unresolved with optical microscope.
Grain size distribution is more uniform.	Grain size distribution is slightly less uniform.
Internal stresses are least.	Internal stresses are slightly more.

Example 12.1

An unalloyed steel tool used for machining aluminum automobile wheels has been found to work well, but the purchase records have been lost and you do not know the steel's composition. The microstructure of the steel is tempered martensite, and assume that you cannot estimate the composition of the steel from the structure. Design a treatment that may help determine the steel's carbon content.

Example 12.1 SOLUTION

The first way is to heat the steel to a temperature just below the A_1 temperature and hold for a long time. The steel overtempers and large Fe_3C spheres form in a ferrite matrix. We then estimate the amount of ferrite and cementite and calculate the carbon content using the lever law. If we measure 16% Fe_3C using this method, the carbon content is:

$$\% \mathrm{Fe_3C} = \left[\frac{(x - 0.0218)}{(6.67 - 0.0218)} \right] \times 100 = 16 \ \text{ or } \ x = 1.086\%$$

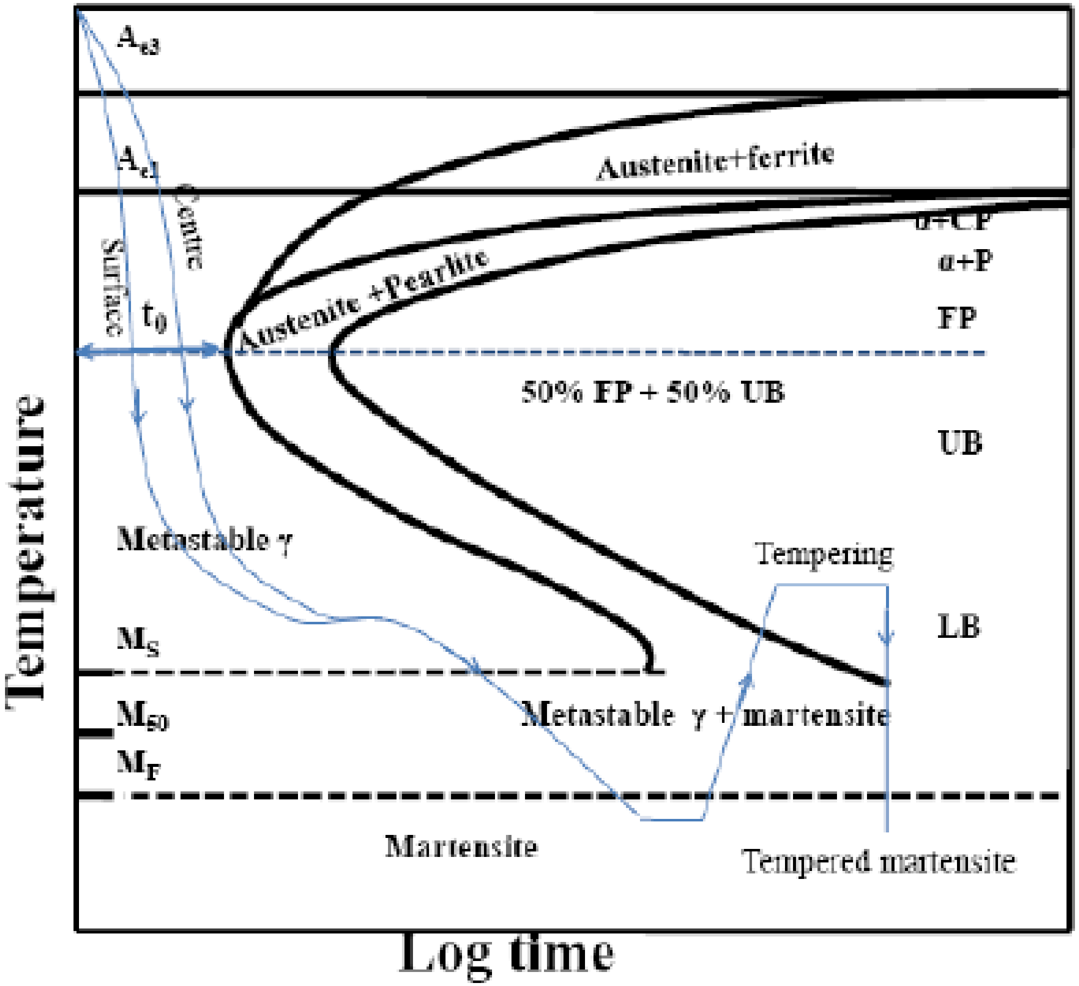
A better approach, however, is to heat the steel above the A_{cm} to produce all austenite. If the steel then cools slowly, it transforms to pearlite and a primary microconstituent. If, when we do this, we estimate that the structure contains 95% pearlite and 5% primary Fe_3C, then:

$$\% \text{ Pearlite} = \left[\frac{6.67 - x}{6.67 - 0.77} \right] \times 100 = 95 \ \text{ or } \ x = 1.065\%$$

Martempering : This heat treatment is given to oil hardenable and air hardenable steels and thin section of water hardenable steel sample to produce martensite with minimal differential thermal and transformation stress to avoid distortion and cracking. The steel should have reasonable incubation period at the nose of its TTT diagram and long bainitic bay. The sample is quenched above M_S temperature in a salt bath to reduce thermal stress (instead of cooling below M_F directly) (**Fig. 44**)

Surface cooling rate is greater than at the centre. The cooling schedule is such that the cooling curves pass behind without touching the nose of the TTT diagram. The sample is isothermally hold at bainitic bay such that differential cooling rate at centre and surface become equalise after some time. The sample is allowed to cool by air through M_S-M_F such that martensite forms both at the surface and centre at the same time due to not much temperature difference and thereby avoid transformation stress because of volume expansion. The sample is given tempering treatment at suitable temperature.

Fig. 44: Martempering heatreatment superimposed on TTT diagram for plain carbon hypoeutectoid steel

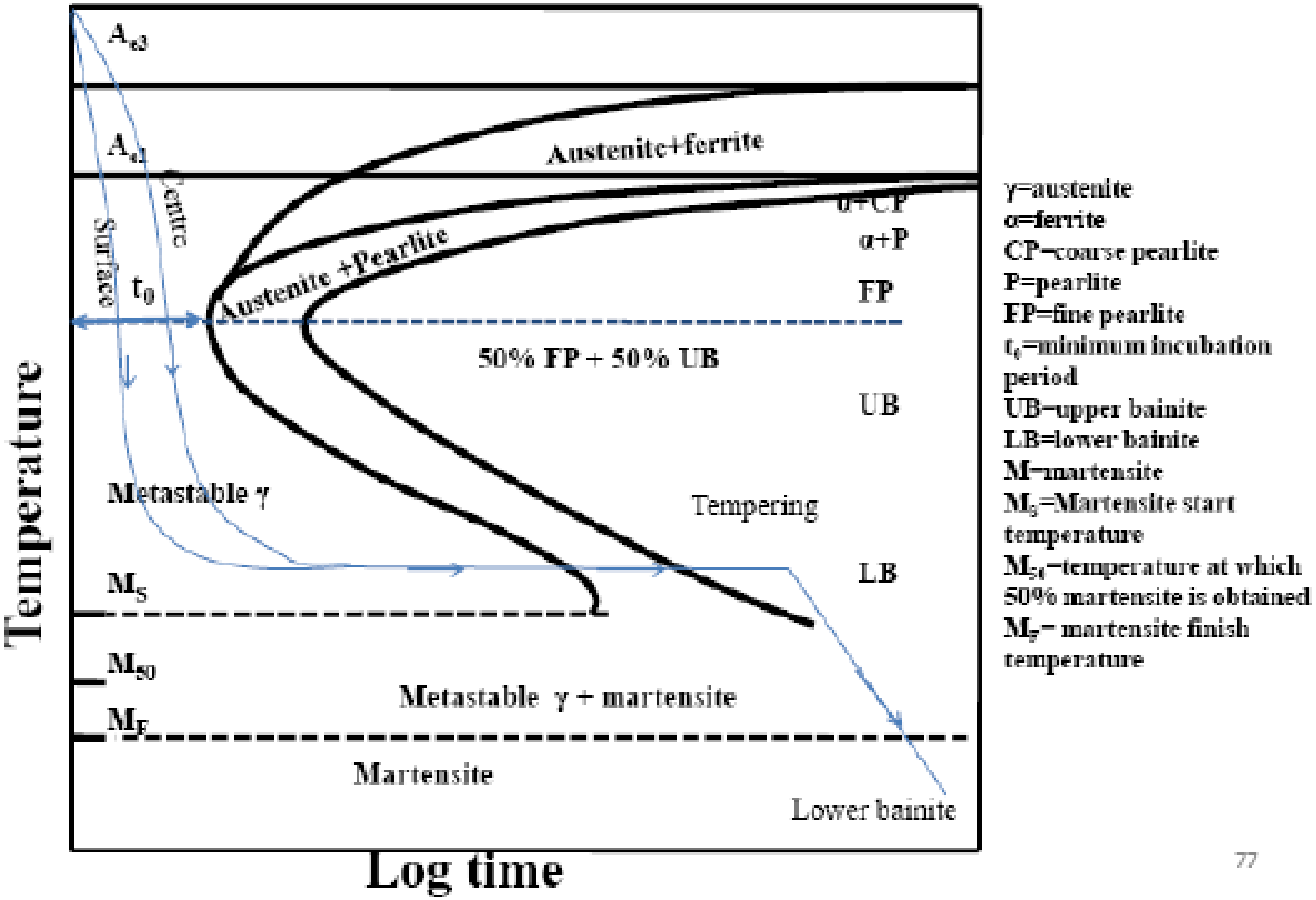


γ=austenite
α=ferrite
CP=coarse pearlite
P=pearlite
FP=fine pearlite
t_0=minimum incubation period
UB=upper bainite
LB=lower bainite
M=martensite
M_s=Martensite start temperature
M_{50}=temperature at which 50% martensite is obtained
M_F= martensite finish temperature

Austempering

Austempering heat treatment is given to steel to produce lower bainite in high carbon steel without any distortion or cracking to the sample. The heat treatment is cooling of austenite rapidly in a bath maintained at lower bainitic temperature (above M_s) temperature (avoiding the nose of the TTT diagram) and holding it here to equalise surface and centre temperature (**Fig. 45**) and . till bainitic finish time. At the end of bainitic reaction sample is air cooled. The microstructure contains fully lower bainite. This heat treatment is given to 0.5-1.2 wt%C steel and low alloy steel. The product hardness and strength are comparable to hardened and tempered martensite with improved ductility and toughness and uniform mechanical properties. Products donot required to be tempered.

Fig. 45: Austempering heatreatment superimposed on TTT diagram for plain carbon hypoeutectoid steel



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