Annealing Treatment

Lec-3

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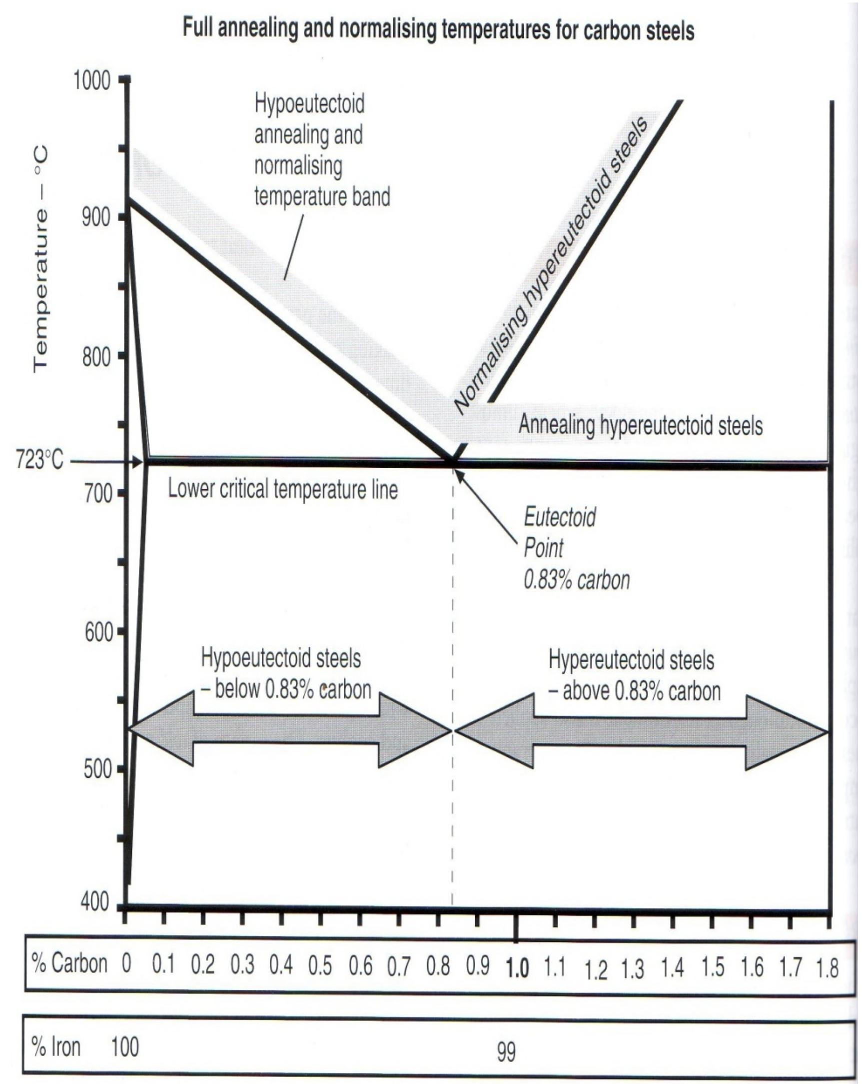
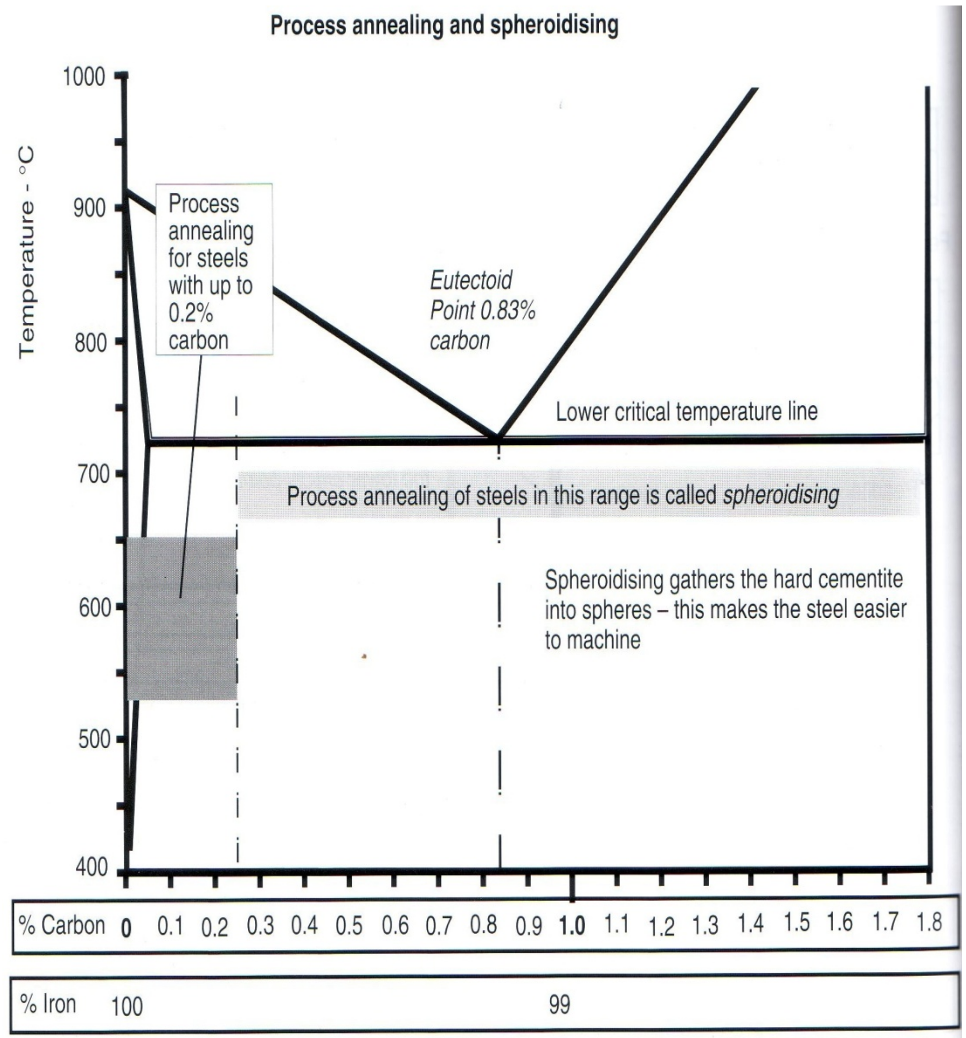
- What does it do?
  1. Reduce hardness
  2. Remove residual stress (stress relief)
  3. Improve toughness
  4. Restore ductility
  5. Refine grain size

Annealing

- Makes a metal as soft as possible
- Hypoeutectoid steels (less than 0.83% carbon) are heated above upper critical temp., soaked and cooled slowly.
- Hypereutecoid (above 0.83%) are heated above lower critical temp., soaked and allowed to cool slowly.



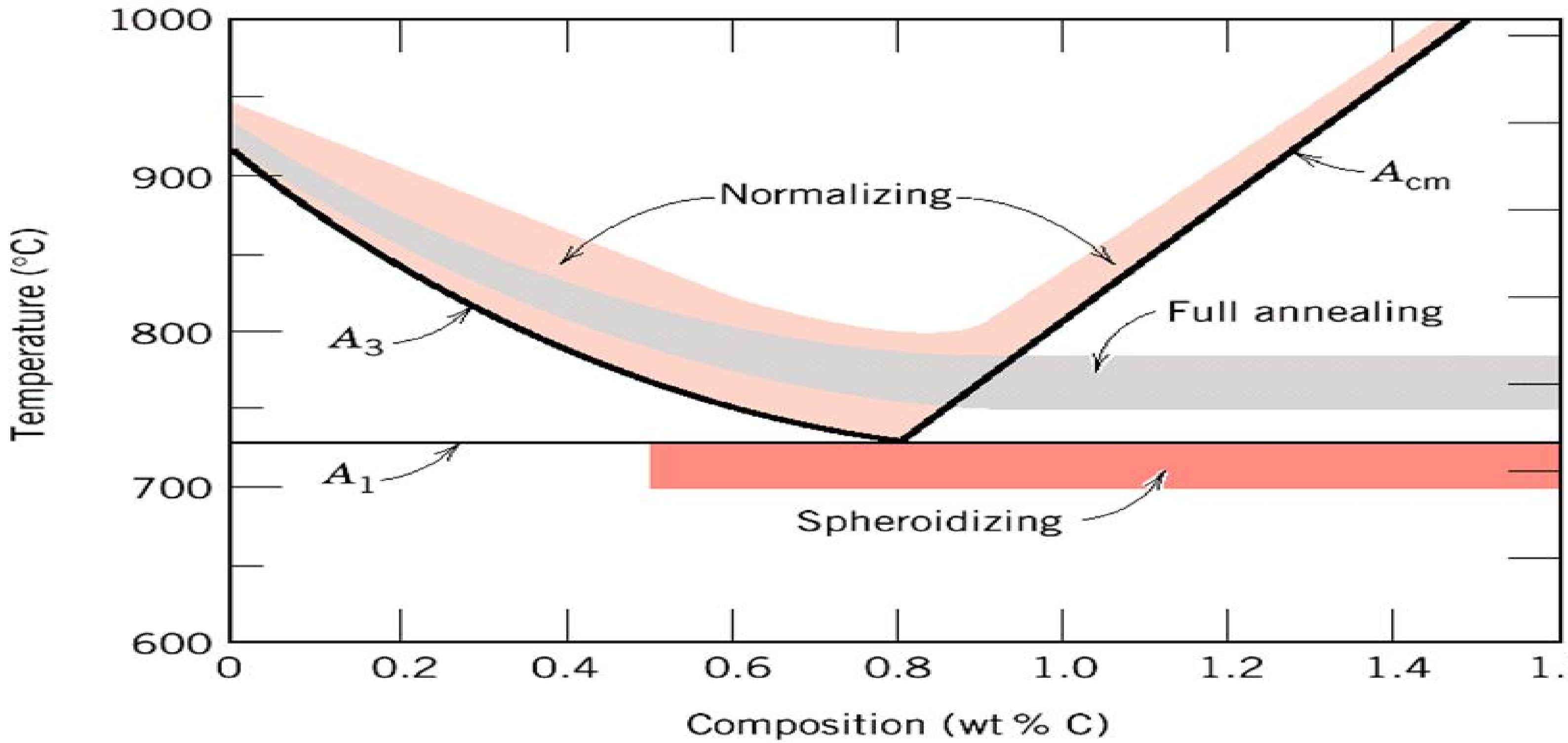
Process Annealing. Low carbon steels may harden through cold working. They can be heated to around 100 degrees below lower critical temp., soaked and allowed to cool in air.

- 

- Recovery - A low-temperature annealing heat treatment designed to eliminate residual stresses introduced during deformation without reducing the strength of the cold-worked material.
- Recrystallization - A medium-temperature annealing heat treatment designed to eliminate all of the effects of the strain hardening produced during cold working.
- Grain growth - Movement of grain boundaries by diffusion in order to reduce the amount of grain boundary area.

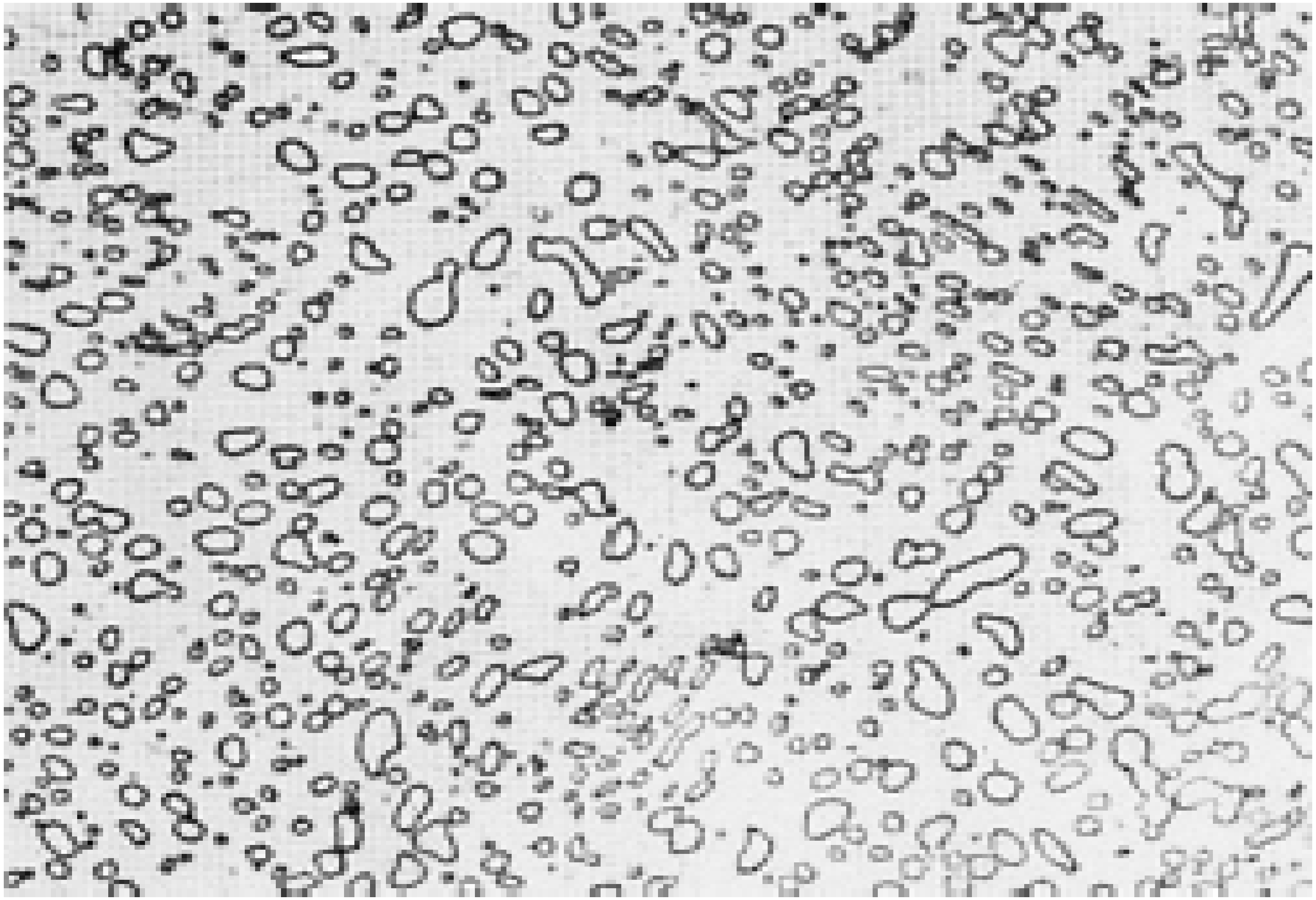
Stress relieving. The component is reheated and held at temperature for a period of time and cooled slowly.

Spheroidising. High carbon steels may be annealed just below the lower critical temp. to improve machinability.



Full annealing: austenizing + slow cooling (several hours) Produces coarse pearlite (and possible proeutectoid phase) that is relatively soft and ductile. Used to soften pieces which have been hardened by plastic deformation, but need to undergo subsequent machining/forming.

Spheroidizing: prolonged heating just below the eutectoid temperature, results in the soft spheroidite structure. This achieves maximum softness needed in subsequent forming operations.



The microstructure of spheroidite, with Fe_3C particles dispersed in a ferrite matrix

Example 12.2 SOLUTION

From Figure 12.2, we find the critical *A*1, A_3, or A_{cm}, temperatures for each steel. We can then specify the heat treatment based on these temperatures.

Steel Type	1020	1077	10120
Critical temperatures	$A_1 = 727°C$ $A_3 = 830°C$	$A_1 = 727°C$	$A_1 = 727°C$ $A_{cm} = 895°C$
Process annealing	727 – (80 to 170) = 557°C to 647°C	Not done	Not done
Annealing	830 + 30 = 860°C	727 + 30 = 757°C	727 + 30 = 757°C
Normalizing	830 + 55 = 885°C	727 + 55 = 782°C	895 + 55 = 950°C
Spheroidizing	Not done	727 – 30 = 697°C	727 – 30 = 697°C

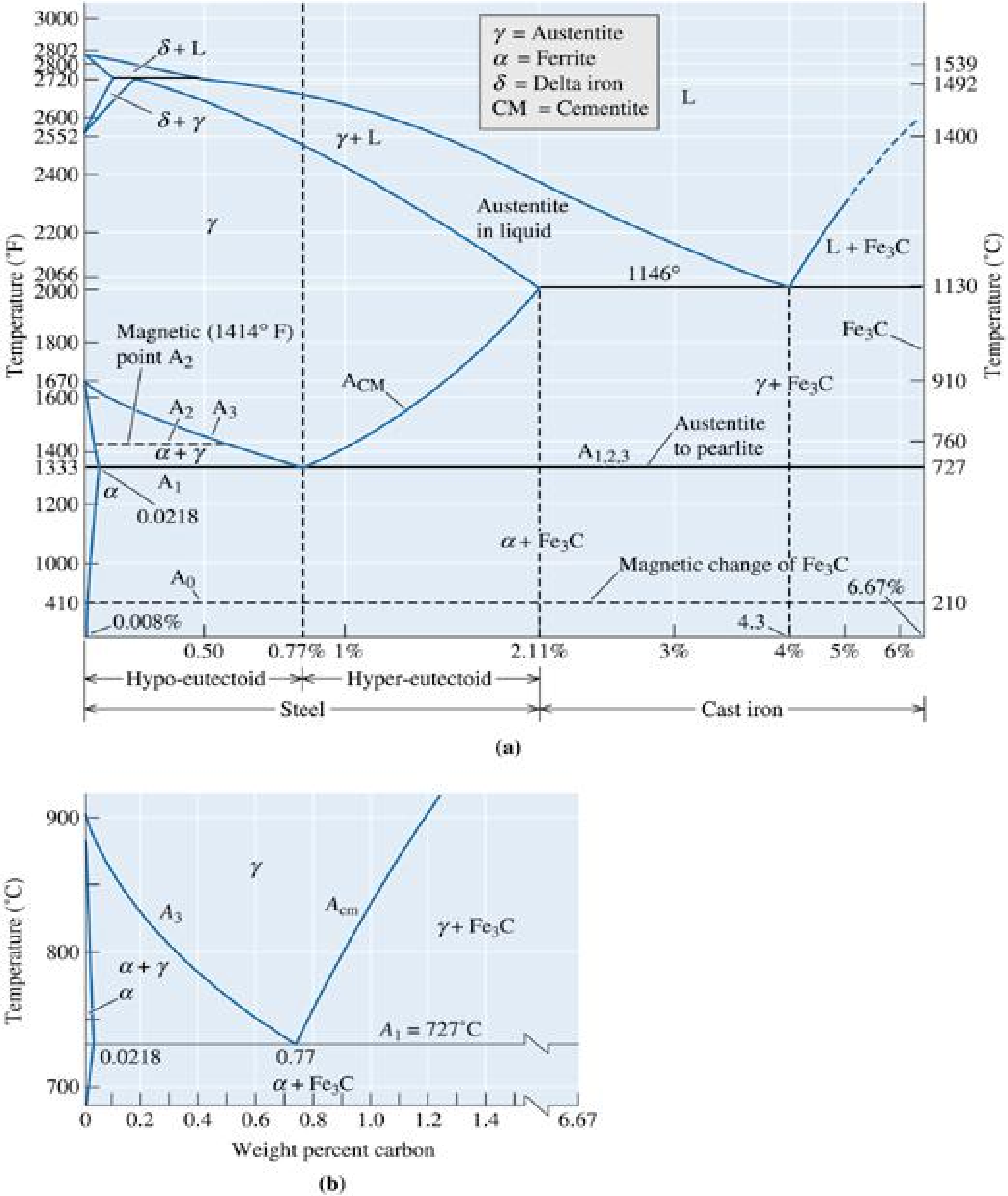


Figure 12.2 (a) The eutectoid portion of the Fe-Fe_3C phase diagram. (b) An expanded version of the Fe-C diagram, adapted from several sources.

Isothermal annealing

Isothermal annealing consists of four steps. The *first step* is heating the steel components similar as in the case of full annealing. The *second step* is slightly fast cooling from the usual austenitizing temperature to a constant temperature just below A_1. The *third step* is to hold at this reduced temperature for sufficient soaking period for the completion of transformation and the *final step* involves cooling the steel component to room temperature in air. *Figure 4.7.3* depicts the heat treatment cycles of full annealing and isothermal annealing. The terms α, γ, P, P_S and P_F refer to ferrite, austenite, pearlite, pearlite starting and pearlite finish, respectively.

Isothermal annealing has distinct advantages over full annealing which are given below.

1. Reduced annealing time, especially for alloy steels which need very slow cooling to obtain the required reduction in hardness by the full annealing.
2. More homogeneity in structure is obtained as the transformation occurs at the same time throughout the cross section.
3. Improved machinability and surface finish is obtained after machining as compared to that of the full annealed components.

Isothermal annealing is primarily used for medium carbon, high carbon and some of the alloy steels to improve their machinability.

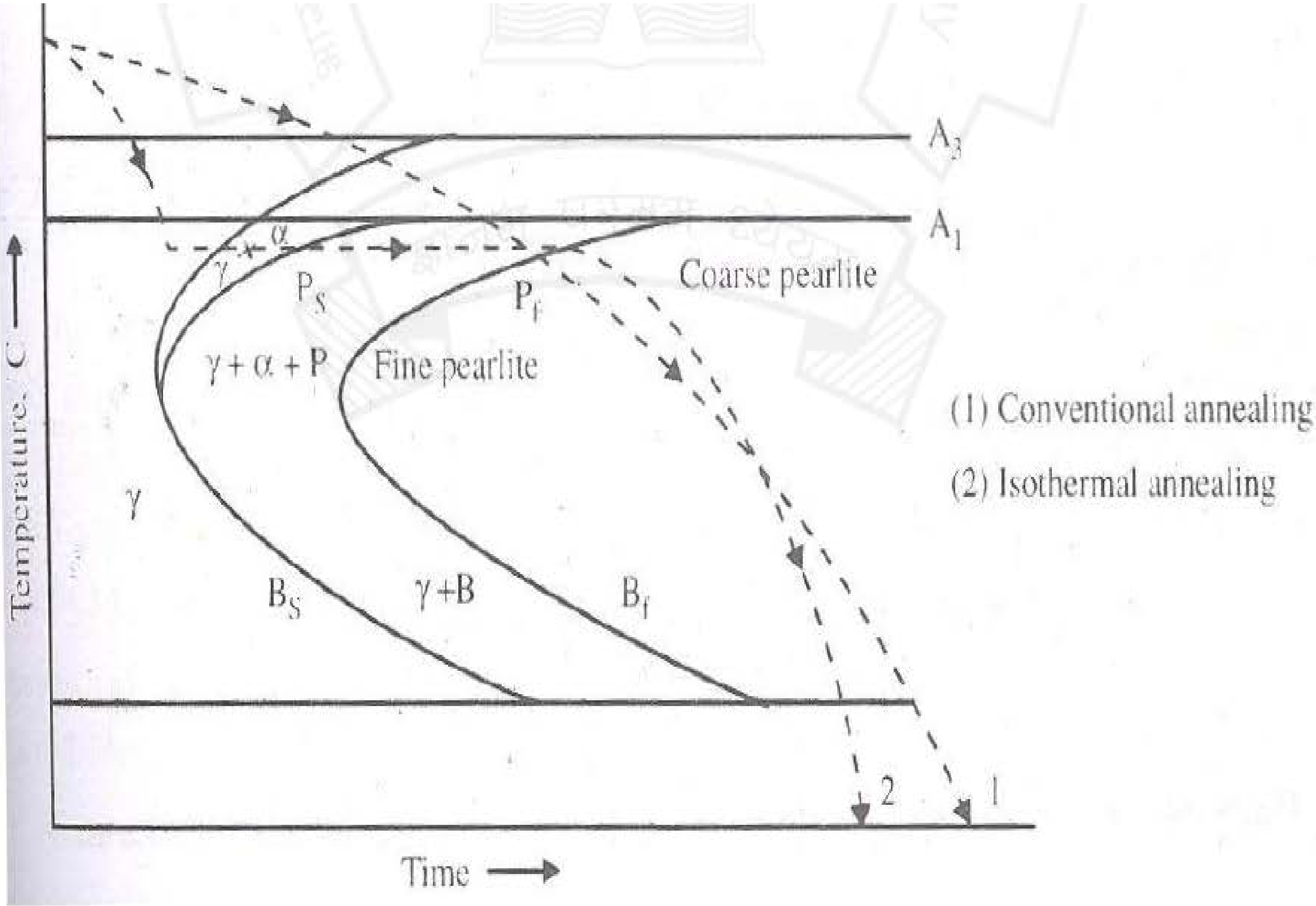


Figure 4.7.3 Heat treatment cycles of full annealing and isothermal annealing [7].