Heat Treatment

Heat Treatment (H. T.):

A combination of heating & cooling operations, timed and applied to material or alloy in the solid state in a way that will produce a desired properties.

All basic (H. T.) of steel involves the transformation or decomposition of (γ).

H. T. of steel → *1st stage (heat above A_3)*

→ *2nd stage (cool at different cooling rates)*

Types of (H. T.) of steel:

a - Annealing Process.

b - Hardening by Continuous cooling.

c - Isothermal treatment.

The purpose of Annealing Process:

1 - Softening. *2 - Improvement machinability.* *3 - Stress relief.*

4 - Grain refinement. *5 - Homogenizing.*

Steps of Annealing Process

1 - Heating above A_3. 2 - Hold at a temperature for a definite time. 3 - Cooling to the Room Temperature (R. T.) at slow rate.

Types of Annealing Process:

1 - Full Annealing. 2 - Homogenizing. 3 - Normalizing.

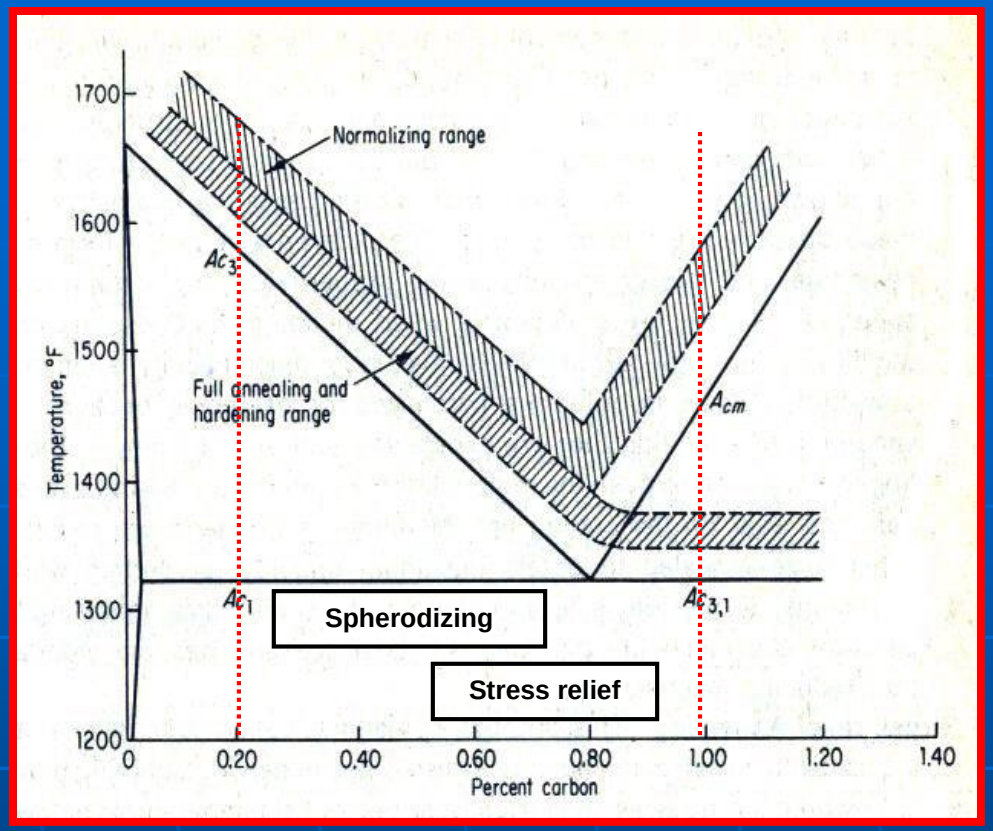
4 - Stress relief anneal. 5 - Process Anneal (Recrystallization – Anneal). 6 - Spherodizing.

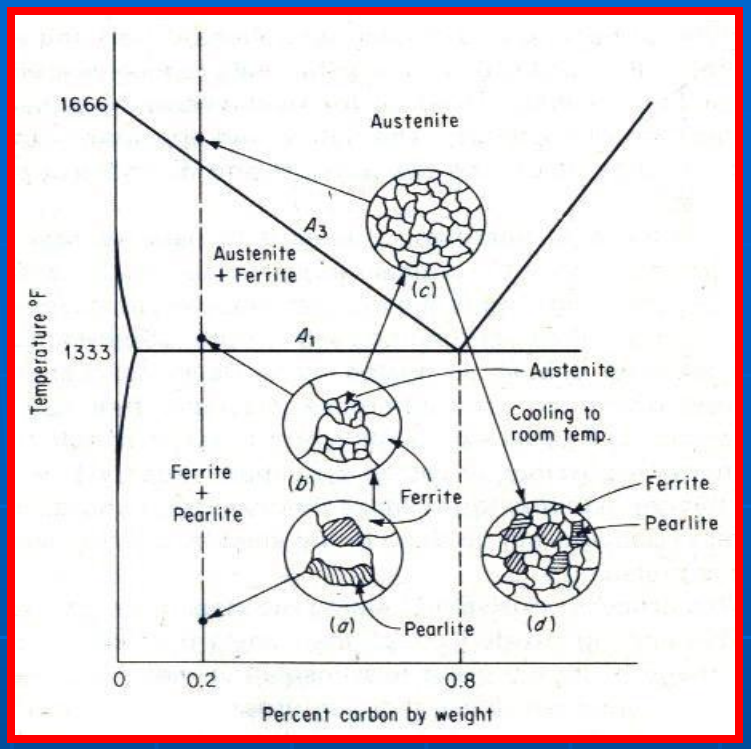
Full Annealing:

❖ *Heating the Steel to the proper temp. and then cooling slowly through the transformation range (in furnace).*

❖ *The purpose of annealing ⟶ (a) - refine the grain. (b) - softness. (c) - improve electrical & magnetic properties. (d) - improve machinability.*

❖ *Refinement of the grain size of hypoeutectiode steel will occur about 50 ^{o}f above the lower critical temp. line ($A_{3,1}$). See fig. 2.*





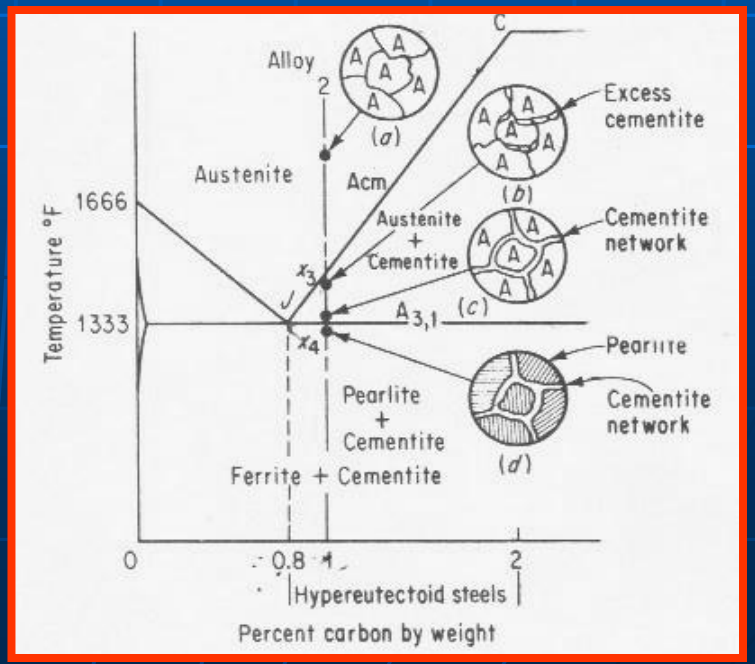


Fig. (2) The Change in microstructure during annealing of:

(a) - 0.2% C.

(b) – 1.0% C.

Homogenizing Treatment:

❖ *A heat treatment of an alloy intended to make it uniform in composition by eliminating Coring & Concentration gradient.*

❖ *It is achieved by heating to a temp. (1100 – 1200 °C) for (10 – 20 hour) followed by slow cooling in air or furnace.*

❖ *Sometimes needed to refine the coarse grains.*

Normalizing:

❖ *It is carried out by heating to (100 °f) above (A_3) or (A_{cem}) followed by cooling in still air to Room Temp. (R_T) to :*

a - produce harder & stronger steel than annealing.

b - improve machinability.

c - modify & refine cast dendritic structure.

d - refine the grain & homogenize the structure.

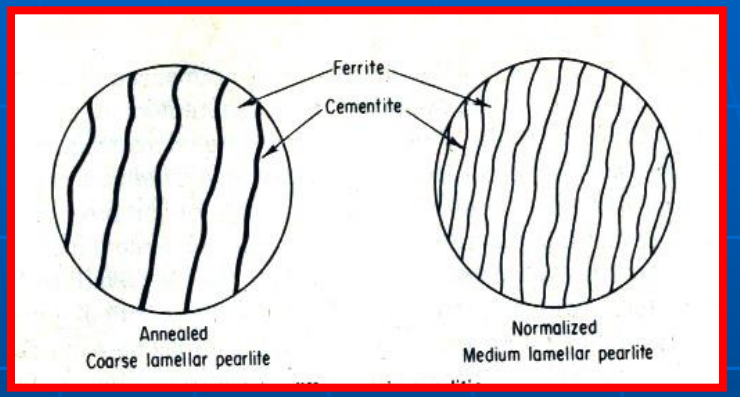


Fig. (3) The difference in P structure due to annealing & Normalizing

❖ *less proeutectoid (α) in normalized hypoeutectiode steel & less proeutectoid Cementite (Fe_3C) in hypereutectoid steel as compared with annealed one because of there is less time for the formation of proeutectoid constituent.*

❖ *The faster the cooling rate, the lower the temp. of (γ) transformation and the finer the Pearlite (see fig. 3).*

Stress relief annealing:

- *It is useful in removing residual stresses due to Cold Work (C. W.) process.*
- *It is carried out at a Temp. below (A_1) (1000 – 1200 ^{o}f).*

Process Annealing (Recrystallization – Anneal):

- *It is used in the sheet & wire industries after (C. W.) see (fig. 4).*
- *It is carried out by heating the steel to a Temp. below (A_1) (1000 – 1250 ^{o}f).*

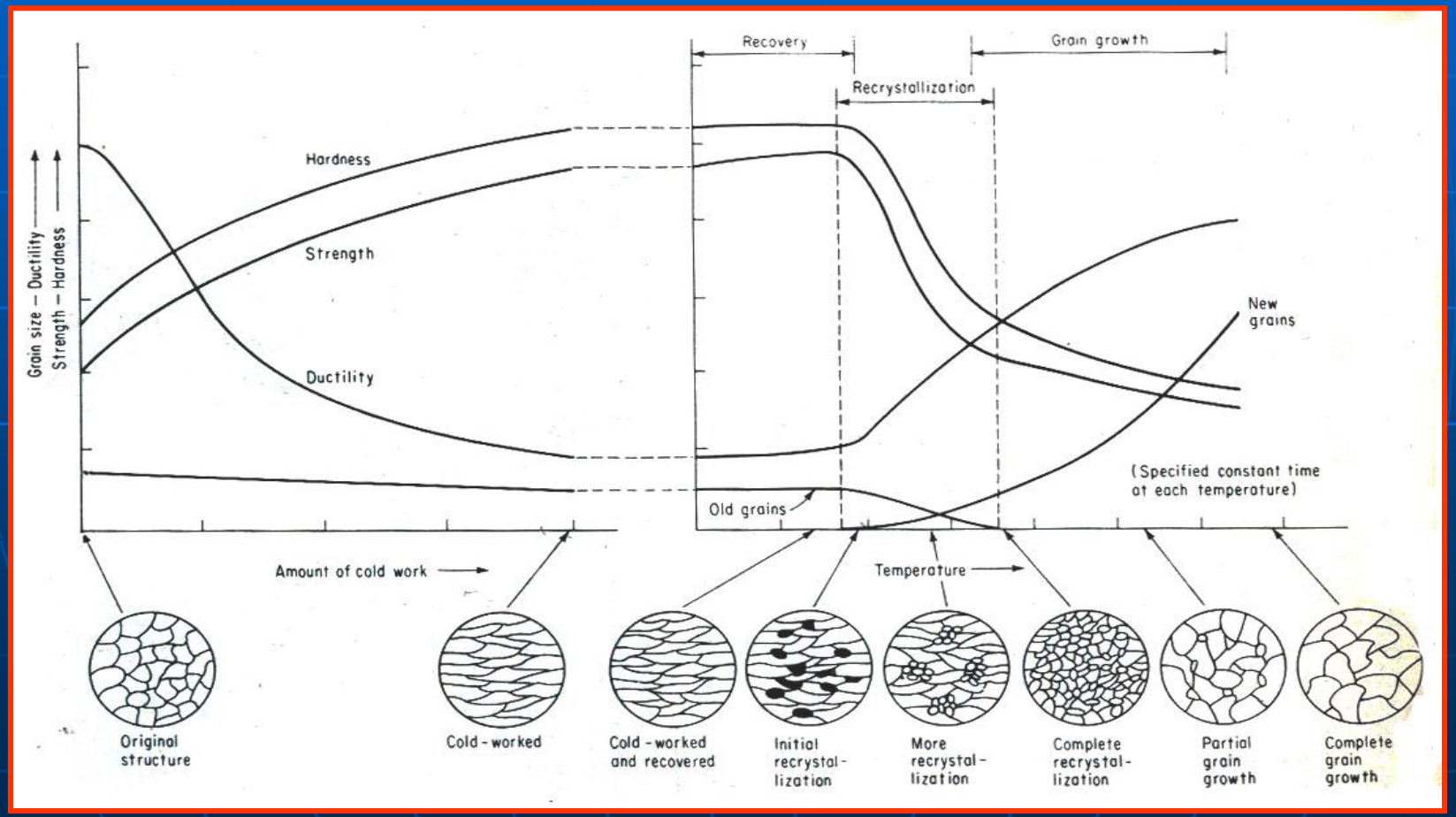


Fig. (4) The cold – work cycle & Recrystallization diagram

Spherodizing:

- *This process will produce a Spheroidal or Globular form of carbide in (α) matrix (as shown in fig. 5) to improve machinability.*
- *One of the following methods may be used for Spherodizing:*

1 - prolonged holding at a Temp. just below (A_1).

2 - Heating & cooling alternatively between a Temp. that just above and just below (A1).

3 - Heating to a Temp. above (A_1) and then either cooling very slowly in furnace or holding at a Temp. just below (A_1).

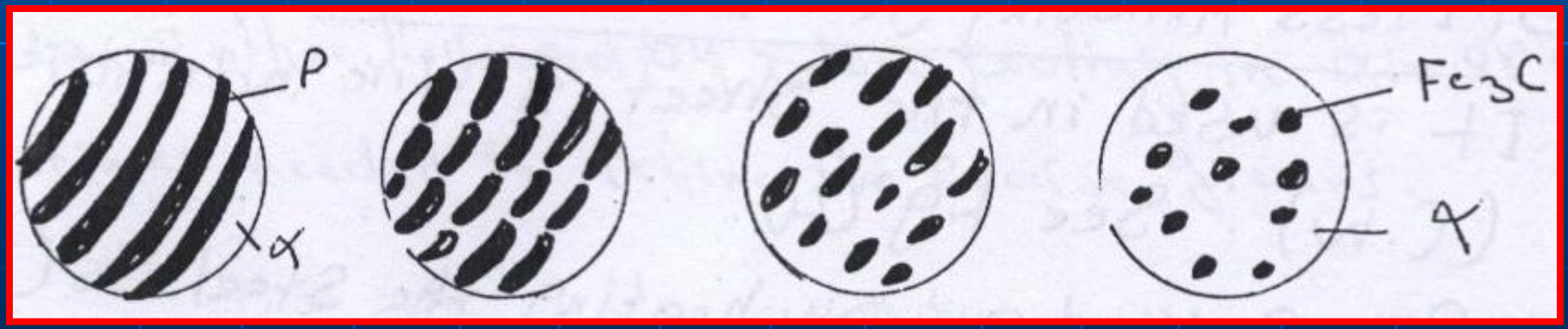


Fig. (5): Stages of Spheroidized Annealing.