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 A₃)

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 °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.
- less proeutectoid ($\alpha$) in normalized hypoeutectictiode 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 ($\gamma$) 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 °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 °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 (A₁).
  2. Heating & cooling alternatively between a Temp. that just above and just below (A₁).
  3. Heating to a Temp. above (A₁) and then either cooling very slowly in furnace or holding at a Temp. just below (A₁).

Fig. (5): Stages of Spheroidized Annealing.