University of Anbar/ Faculty of Engineering

Department of Mechanical Engineering

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Lecture # 17

Heat Treatments for Metal Products

In general, three variables impact the heat treatment of a metal:

1. The heating temperature of a metal.
2. The length of time (holding time) at that temperature
3. The method or rate of cooling

Annealing

Annealing is a general term that refers to heating a material, holding for a certain time, and then cooling to room temperature to improve ductility and reduce brittleness. Annealing include 3 stages: (Recovery – Recrystallization – Grain growth).

Residual stresses are produced because

1) plastic deformation.
2) non-uniform cooling after heating
3) phase transformation after cooling.

Annealing procedures for Ferrous Alloys:

Stress Relief Anneal

- used only to relieve residual stresses produced by (plastic deformation, non-uniform cooling after heating, phase transformation after cooling).
- carried out below the lower critical temperature of carbon steel

Process Anneal

- used to prevent the effects of Cold Working.

- Include recovery and recrystallization but no grain growth
- results in a fine grain microstructure
- heat to just below lower critical temperature and then furnace cooled.

Normalizing

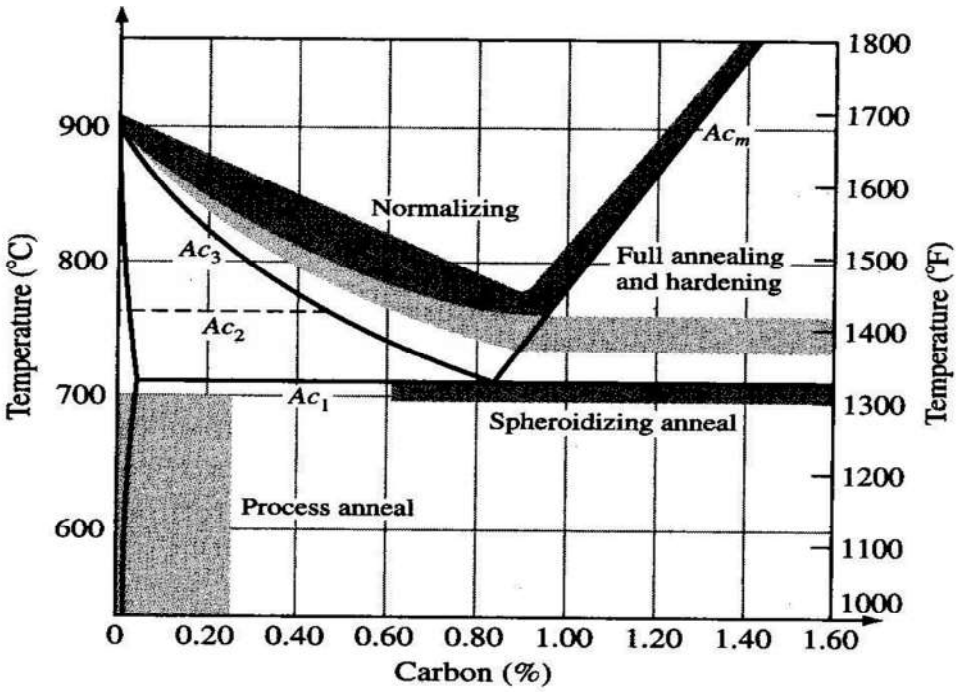
- used to removes internal stresses which caused during hot or cold rolling and forging and refine microstructure.
- heated to $55^{o} – 85^{o}$ above the upper critical temperature then **air cooled**
- results in fine pearlite

Full Anneal

- used to increase ductility of low and medium carbon steels.
- used to on Hypoeutectoid steel castings to treat widmanstatten ferrite (plate-like structure)..
- heated to $15° – 40^{\circ}$ above the upper or lower critical temperature (depending on carbon content) and then **furnace cooled**
- results in coarse pearlite

Spheroidizing Anneal

- the purpose: It is used on medium and high-carbon steels to produce a very soft and ductile steel alloy having a spheroiditic microstructure.
- heated just below the lower critical temperature
- Fe_3C combines to form spherical particles.



H.W. What is the purpose of a spheroidizing heat treatment? On what classes of alloys is it normally used?

H.W. Describe of the following heat treatment processes:

(i) Annealing.
(ii) Normalizing.
(iii) Stress Relieving.

Heat treatment	Method of cooling	Resulting Microstructure	Application
Hardening heating to above the upper or lower critical temperature (depend on carbon content) and then quenched	Quenching (fast cooling) in oil or water	Martensite (very hard and brittle)	Increase hardness
Tempering heating to a temperature below the eutectoid temperature for a period of time and then quenched	Heating from 200-700°C Mostly quenched in water	Tempered Martensite	Increase ductility and reduce brittleness
Full Anneal heating to 15° – 40° above the upper or lower critical temperature (depending on carbon content) and then furnace cooled	Slow cooling in furnace	coarse pearlite	**Used** to increase ductility of low and medium carbon steels. **Used** to on Hypoeutectoid steel castings to treat widmanstatten ferrite
Process Anneal heat to just below lower critical temperature.	Slow cooling in furnace	fine grain microstructure	prevent the effects of Cold Working.
Normalizing heated to 55^{o} – 85^{o} above the upper critical temperature then air cooled.	Cooling in air	fine pearlite	removes internal stresses which caused during hot or cold rolling and forging and refine microstructure.
Spheroidizing heated just below the lower critical temperature	Slow cooling in furnace	Sphere-like particles of Fe_3C	used on medium and high carbon steels to produce a very soft and ductile steel