



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

HEAT TREATMENT OF CASTINGS

Heat treatment of cast iron and non ferrous metals and alloys

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Heat Treatment of Cast Iron

- **Benefits of Heat Treatment of Gray Cast Iron**
 - Improved machinability
 - Improved wear resistance
 - Improved strength
 - Dimensional stability and stress removal

Improvement in machinability of Gray CI

- Subcritical annealing may be done which promotes spheroidization of pearlite and some degree of graphitization.
- Complete annealing results into complete graphitization and softening of iron.
- Permanent mold castings are fully annealed.
- Normalizing at high temperature retains pearlite and gives high strength and hardness as compared to that from annealing

Improvement in wear resistance and strength

- By hardening and tempering
 - Heating to $\sim 910-925^{\circ}\text{C}$, subsequent quenching in oil/water produce a martensitic structure
 - Quenched iron may be tempered at various temperature ($\sim 200-210^{\circ}\text{C}$ for cylinder liners).
 - Flame/induction hardening may also be carried out.
- For improving strength, hardening followed by tempering at $425-430^{\circ}\text{C}$ produces optimum tensile properties.

Stress relief

- Desirable when castings are found to change dimensions (during machining or use)
- Annealing or normalizing operation may be carried out to alleviate the stress.
- Heating slowly to $\sim 480-590^{\circ}\text{C}$, holding for an hour or more and cooling slowly to $\sim 200-300^{\circ}\text{C}$.

Heat Treatment of Malleable iron

- **Annealing heat treatment in three steps**
 - Step 1: Nucleation of graphite
 - Occurs during heating to high holding temperature and very early during holding period.
 - Step 2: First stage graphitization (holding at $\sim 870-950^{\circ}\text{C}$)
 - Step 3: Second stage graphitization (Slow cooling through allotropic transformation of iron)

Heat Treatment of Malleable iron

➤ **Pearlitic malleable iron**

- Matrix consists of pearlite (spheroidized pearlite or temper martensite) and temper carbon
 - Mn maintained at 0.5-0.9% to retain pearlite
- Complete SSG is prevented by adding alloying elements like Mn, Mo or Cr
- By arresting anneal during SSG

Heat Treatment of Ductile iron

- **Annealing for improved ductility and machinability**
 - Matrix consists of ferrite and spheroidal graphite
 - (Mn,P,Cr,Ni,Mo etc should be as low as possible as they retard the process)
 - Shorter, subcritical annealing cycle may be used when very high impact properties are not desired.

➤ **Normalizing of ductile iron** results into homogeneous structure of fine pearlite and improvement in tensile properties.

- Temperature at which casting is removed for air cooling affects hardness.
- Heavier sections should contain alloying elements like Ni, Mo and additional Mn for satisfactory normalizing.
- Alloying elements also have important role in normalizing. (they increase hardenability).
- Normalizing is commonly followed by tempering.

➤ **Hardening and tempering of ductile iron: Gives very high hardness.**

- Oil preferred medium of quenching (water/brine is also used)
- After quenching, castings are usually tempered.

➤ **Surface hardening**

- By flame or induction process
- Pearlitic types of ductile iron are preferred, because of short heating cycles of these processes.
- Irons without free ferrite respond instantly to flame/induction heating and require no holding time at austenitizing temperature for getting fully hardened.

➤ **Stress relieving**

➤ At $\sim 500-600^{\circ}\text{C}$

➤ **Austempered ductile iron**

➤ Possess very good toughness with high strength.

➤ Structure consists of two phase mixture of acicular bainitic ferrite and austenite.

➤ Austempering reaction proceeds in two stages:

➤ Stage 1: Austenite decomposes to bainitic ferrite and carbon enriched austenite

➤ Stage 2: on prolonging the austempering reaction, carbon enriched austenite decomposes to ferrite + carbide.

Heat Treatment of Non ferrous metals and alloys

➤ Homogeization

- Removes coring and dendritic segregation. (common in isomorphous alloys like Cu-Ni, Au-Ag etc)
- Alloy is heated to elevated temperature for several hours during which homogenization of composition occurs through the action of diffusion.
- The choice of suitable homogenizing temperature is limited by solidus line as well as retardation of the process.

Solutionise-quench-age treatment

- This treatment is given to alloys with solute components having decreasing solubility with decrease in temperature. Ex: Al-Cu, Al-Ag, Al-Mg, Al-Si, Al-Zn, Al-Mg-Cu, Al-Mg-Si, Al-Mg-Zn, Cu-Be etc.
- Strength and hardness of alloys are improved.
- Alloy heated to a temperature (where homogeneous single phase is formed), followed by quenching and further ageing in temperature range 100-200°C.

THANKS

