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# HEAT TREATMENT

<sup>S</sup><sub>E</sub> Heat treatment is a procedure of controlled heating and cooling of a metal to alter the physical properties without changing the shape.

Two basic objectives are

**Hardening**

**Annealing**



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# HEAT TREATMENT OF STEELS

**The *elastic limit, ultimate strength and hardness* of carbon steel can be changed by heating and rapid cooling without changing the chemical composition.**

**Higher carbon steel and alloy steel are responsive to heat treatment.**



# Aim of heat treatment

**To increase the hardness of metals.**

**To relieve the stresses set up in the material after hot or cold working.**

**To soften the metal.**

**To improve machinability.**

**To modify the structure of the material to improve its electrical and magnetic properties.**

**To change the grain size.**

**To increase the qualities of a metal to provide better resistance to heat, corrosion and wear.**



# ANNEALING

Heating the metal slowly to a required temperature (below or close to lower critical temp.) and holding it at that temp (1 hour) so that internal changes will take place.

Finally cooling is done slowly (rate of cooling varies from 30 to 200°C/h).

**Complete recrystallisation in steels & new grain structure is formed**

Annealing reduces hardness, increases the ductility and strength

Annealing temperature depends on carbon content

**Lower carbon content higher annealing temperature**

<u>Carbon %</u>	<u>Temp, °C</u>
<b>&lt;0.12 %</b>	<b>875-925</b>
0.12 -0.25	840-970
<b>0.3-0.5</b>	<b>815-840</b>
0.5-0.9	780-810
<b>0.9-1.3</b>	<b>760-780</b>



# QUENCHING

**Heated above the critical temperature and rapid cooling**

**Degree of hardness depends on carbon content and rate of cooling,**

**Oil quenching is slow but prevents cracking**

**Controlled by cooling mediums like water (hot & cold), oil (hot & normal), molten lead**

**Water quenching is used for medium carbon and low carbon steel**

**Increases the strength and wear resistance**



# Tempering

Steel hardened by rapid quenching is hard and brittle and have unequally distributed stresses to give cracks or even rupture

Tempering is a process to soften the steel hardened earlier to reduce *brittleness and internal stresses*.

Additional heating after hardening is a process of tempering

After hardening by heating the metal to critical temperature, the metal is heated again to below critical temperature and cooled slowly in still air.

Reduces ultimate strength slightly.



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# CASE HARDENING OR CARBURIZING

**Prolonged heating of the metal in without air in presence of carbon (charcoal or barium carbonate)**

**Outer layer absorbs carbon**

**When quenched the high carbon steel hardens**

**But the low carbon steel of the core remains soft**

**Applied to soft steel with low carbon content (0.2% carbon)**



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# CYANIDING

Steel is dipped into molten bath of **potassium cyanide** for a short time

**Carbon and nitrogen** is absorbed on the surface

A thin hard surface is formed

Screws, clamps, washers are hardened



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# NITRIDING

**Metal is placed in an airtight box**

**Heating the metal to 1000 ° F**

**Passing ammonia gas through the box**

## INDUCTION HARDENING

❖ **Passing high frequency alternating current**