Thermal-chemical processing

HOMOGENIZING
it is long-term heating in 1000 – 1200 oC in order to homogenize chemical composition and remove or reduce microsegregation and lamellar structure. Homogenizing is applied to billets before plastic working and to castings.

NORMALIZING
it is to heat up steel to the temperature by 30-50°C higher than Ac3 or Accm, heat the steel in this temperature for an adequate period of time and slow, and cool it down steadily in the air. The aim of the treatment is to obtain homogenous fine-grained structure formed due to the re-crystallization of steel.

FULL ANNEALING
it is to heat up an object slightly above Ac or Accm, heat it at this temperature, and cool it down together with a furnace at least to reach the temperature below Ar1 in order to re-crystallize completely and to make more fine the coarse-grained structure of castings, rolled or forged goods. This way the internal stresses and hardness are reduced and the machinability and plasticity of steel are increased.

SPHEROIDIZING ANNEALING (SOFTENING)
it is to heat up an object to the temperature close to Ac1, heat it at this temperature, and cool it down in order to spheroidize the carbides. Grained cementite surrounded by ferrite is obtained in the process. The characteristic feature of such a structure is low hardness, assuring good ability for plastic forming during cold rolling, die stamping, pull broaching, and other operations of that type.

STRESS RELIEF ANNEALING
it is applied in order to relieve the stresses without affecting seriously the structure. It is to heat up steel to a temperature lower than Ac1 (it usually does not exceed 650° C), heat it at this temperature, and then cool it down slowly. This treatment is mostly used to relieve the stresses in castings produced due to solidifying contraction, in welds and in bent materials.

HARDENING
this treatment is to heat up steel to the temperature higher by 30-50° C than Ac3 or Ac1, heat it at this temperature, and then cool it down quickly enough to make martensitic or bainitic structures. Correct hardening temperature produces fine-grained austenite, and after quick cooling down fine-acicular martensite is obtained.

Heating hypereutectoid steels in the temperature above Accm produces coarse-grained austenite which makes coarse-grained martensite after cooling down. The steel hardened that way has lower strength and higher brittleness. After heating the hypereutectoid steels up to the temperature above Ac1 cementite is left in the structure which is a very hard component and if it was made finer before during plastic working and softening it gives advantageous properties to the steel, particularly higher abrasion resistance.

ISOTHERMAL QUENCHING

it is to heat up an object to the temperature higher by 30-50° C than Ac3, heat it at this temperature, cool it down in a bath with the temperature higher than the temperature in which martensite begins to form (Ms), keep it in the bath till the bainitic transformation is finished, and to cool it down in any way to reach the ambient temperature. A bainitic structure is obtained, characterized by reduced stresses, higher ductility, and impact resistance than in the case of the structure obtained after tempering martensite. No tempering is applied after isothermal quenching.

TEMPERING

it is to heat up prehardened steel to the temperature above Ac1, heat it at this temperature, and then cool it down in the air, oil, or water. Cooling down in oil and water is applied for the steels being susceptible to temper brittleness. The stresses created by intensive cooling down are relieved by additional heating in the temperature of 200-300 °C

- low-temperature tempering
  at the temperatures of 150 – 250 °C, it is applied in order to reduce hardening stresses, keeping high strength at the same time.
- medium-temperature tempering
  in the temperature range of 250 – 500 °C, it is applied in order to assure significant strength and elasticity, keeping satisfactory impact resistance and ductility at the same time.
- high-temperature tempering
  in the temperature range 500 – Ac1, it is applied in order to reduce significantly hardness and obtain good plastic properties.

TOUGHENING

it is a combination of hardening and medium-temperature or high-temperature tempering.

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SOLUTION HEAT TREATMENT

it is to heat up steel to the temperature above the boundary solubility of the components to assure uniform solid solution and then to cool it down in order to keep the dissolved component in the solution. The obtained structure of the supersaturated solid solution is unstable and may easily go into the balance state (release of carbides, nitrides, etc.). Solution heat treatment is mostly applied to the austenitic steels at temperatures from 1050 to 1150 °C with cooling down in the water. The effects of the treatment are a slight reduction of strength properties and improved plastic properties. However, the most important result is improved corrosion resistance, particularly intercrystalline corrosion resistance, due to holding the carbides in the solid solution which results in forming a homogenous austenitic structure.

CARBURIZING

this process is to enrich the surface layers of low-carbon steels with carbon. It produces a hard and wear-resistant surface layer, keeping a soft and ductile core at the same time.

NITRIDING

this process is to saturate the steel surface layer with nitride in order to obtain a very hard and wear-resistant surface. Nitriding makes the steel resistant to corrosion. After nitriding, no heat treatment is applied.
Nitriding methods:

- **salt bath**
  the process is to heat a tool up to the approximate temperature of 400° C and to immerse it in the salt bath at the temperature of 520 to 570° C for about 2 hours. The nitriding time depends on the required nitrided layer thickness.
- **gas nitriding**
  it is carried out at the temperature of 480 to 540 °C for 15 to 30 hours. This method allows to exclude some parts of a treated object by covering them with copper or nickel elements or by covering the surface which is not supposed to be nitride with a special compound.
- **ion nitriding**
  it is a thermal-and-chemical process taking place in a vacuum at the temperature of 400 to 600 °C by introducing gases containing nitride. Due to the voltage of an electric field, the gas is transformed into plasma, and electrically charged nitride ions are accelerated towards the object being treated and then they stick to its surface due to diffusion.