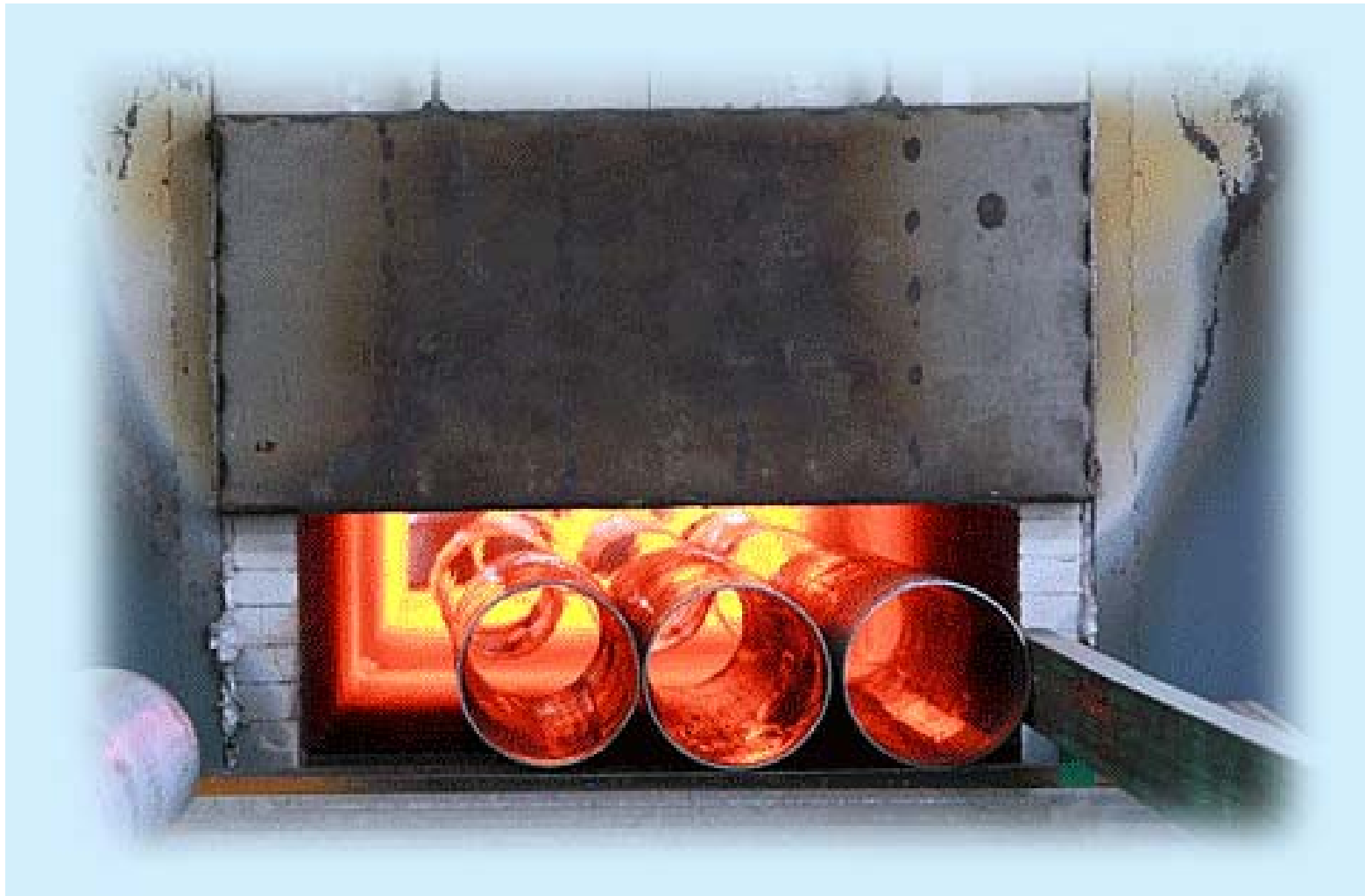


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# Heat Treatment



# Heat Treatment

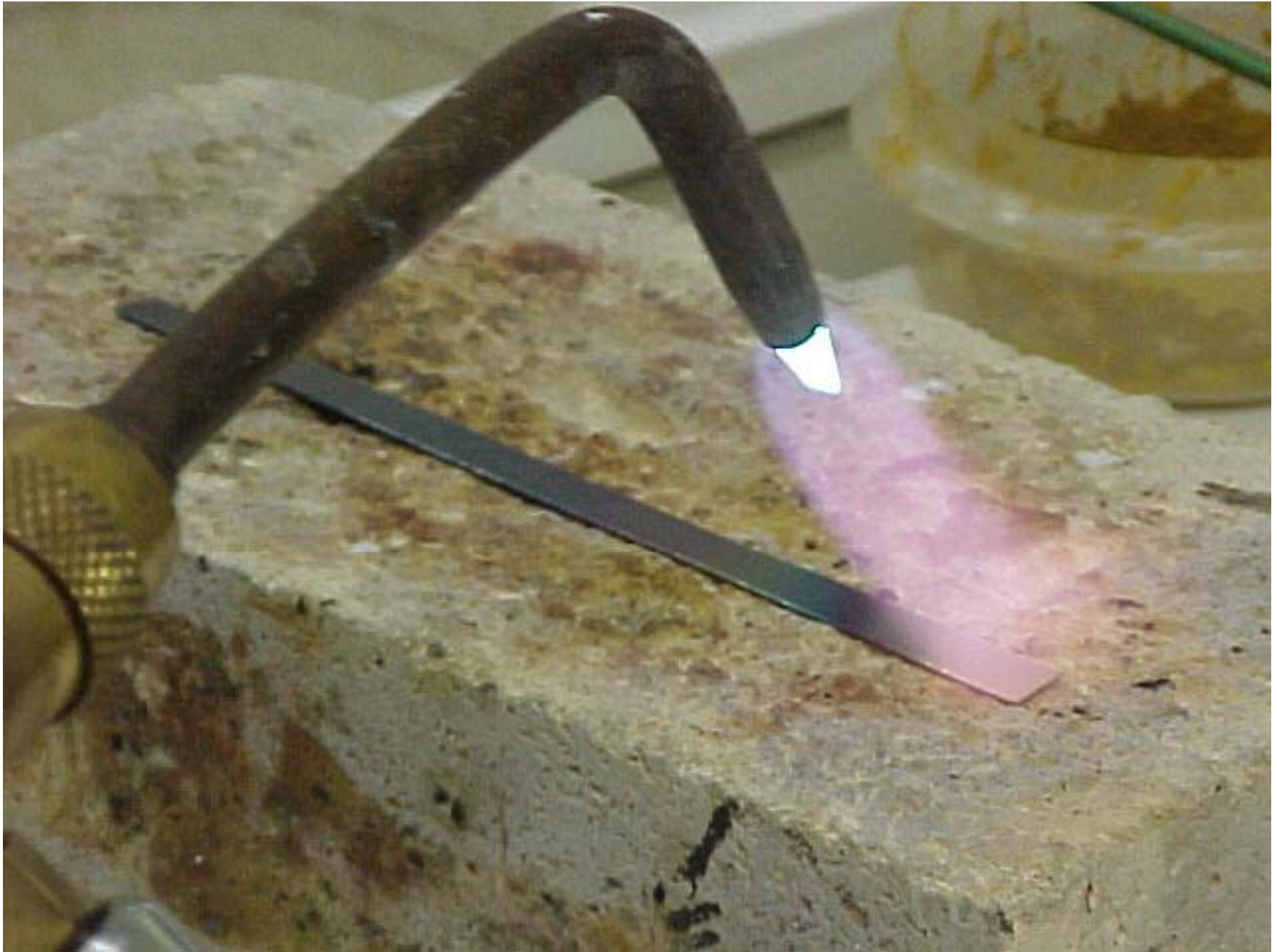
The amount of carbon present in plain carbon steel has a pronounced effect on the properties of a steel and on the selection of suitable heat treatments to attain certain desired properties. Below are some major types of heat treatment processes:

# Types

- *Annealing*
- *Normalizing*
- *Hardening*
- *Carburizing*
- *Tempering*

# Annealing

Steel is annealed to reduce the hardness, improve machine ability, facilitate cold-working, produce a desired microstructure. Full annealing is the process of softening steel by a heating and cooling cycle, so that it may be bent or cut easily. In annealing, steel is heated above the transformation temperature to form austenite, and cooled very slowly, usually in the furnace.



# Annealing

There are several types of annealing like black annealing, blue annealing, box annealing, bright annealing, flame annealing, intermediate annealing, isothermal annealing, process annealing, recrystallisation annealing, soft annealing, finish annealing and spheroidizing. These are practiced according to their different final product properties in the industry.

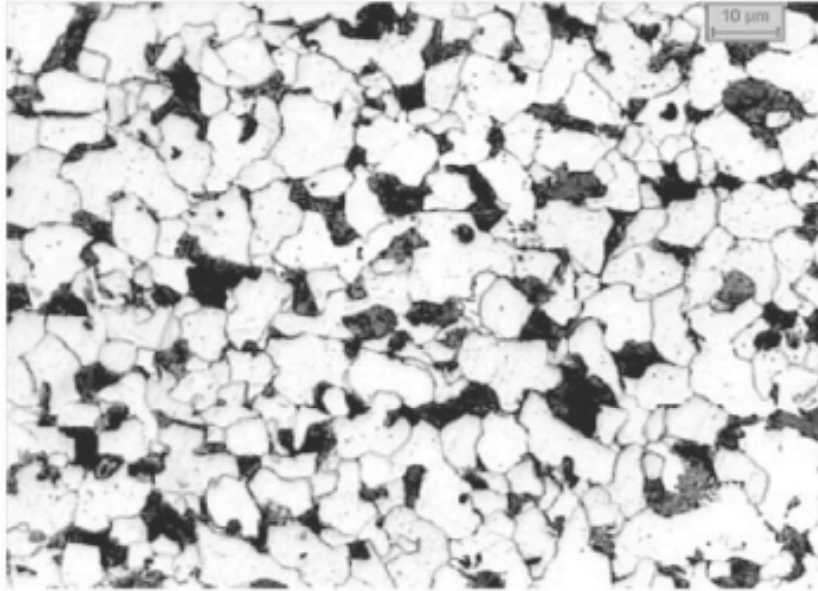
# Annealing

This heat treatment is commonly applied in the sheet and wire industries, and the temperatures generally used are from 1020 to 1200 °F (550 to 650 °C). Full annealing, where steel is heated 50 to 100 °F (90 to 180 °C)

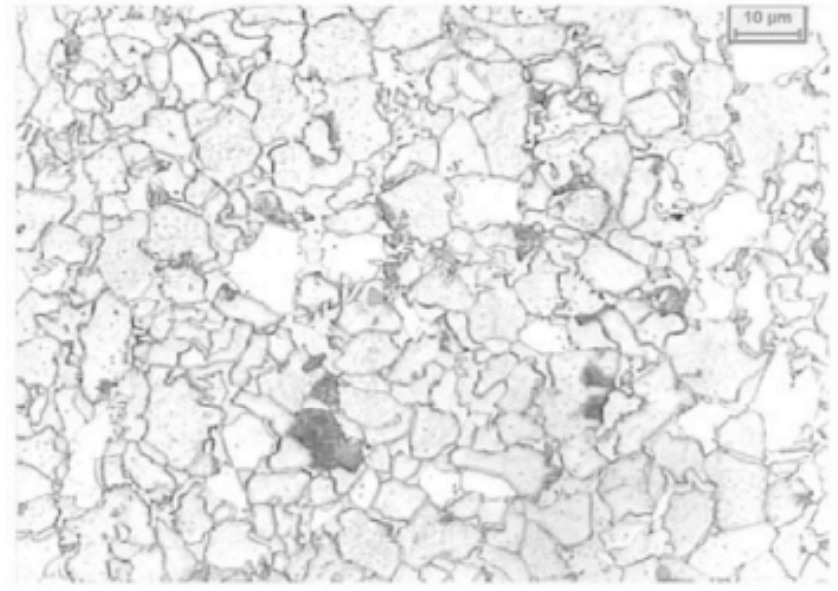


# Normalizing

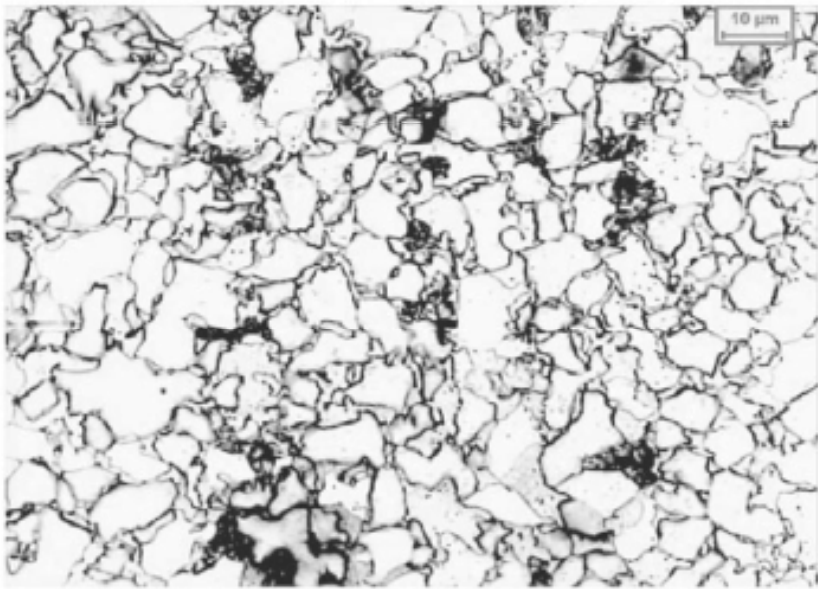
In normalizing steel is also heated above austenitizing temperature, but cooling is accomplished by still air cooling in a furnace. Steel is normalized to refine grain size, make its structure more uniform, or to improve machinability. When steel is heated to a high temperature, the carbon can readily diffuse throughout, and the result is a reasonably uniform composition from one area to the next. The steel is then more homogeneous and will respond to the heat treatment in a more uniform way.



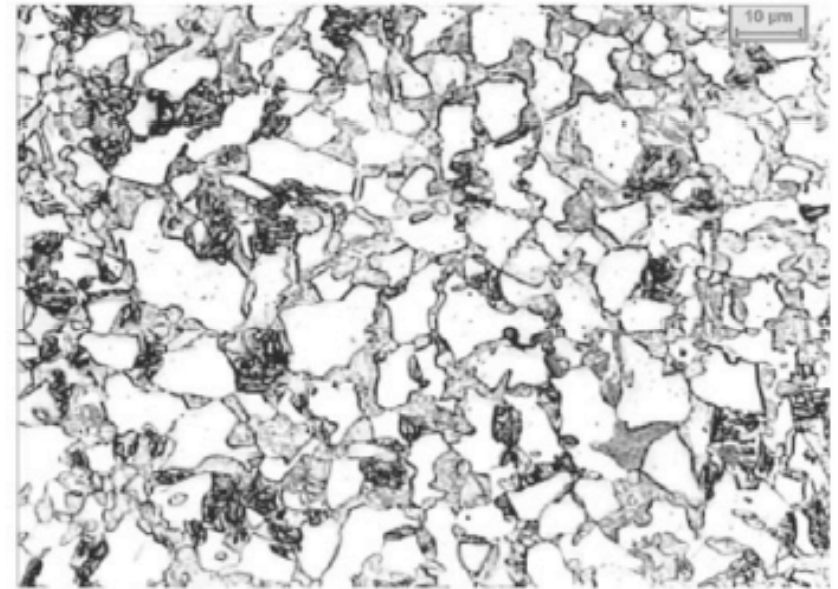
a)



b)



c)



d)

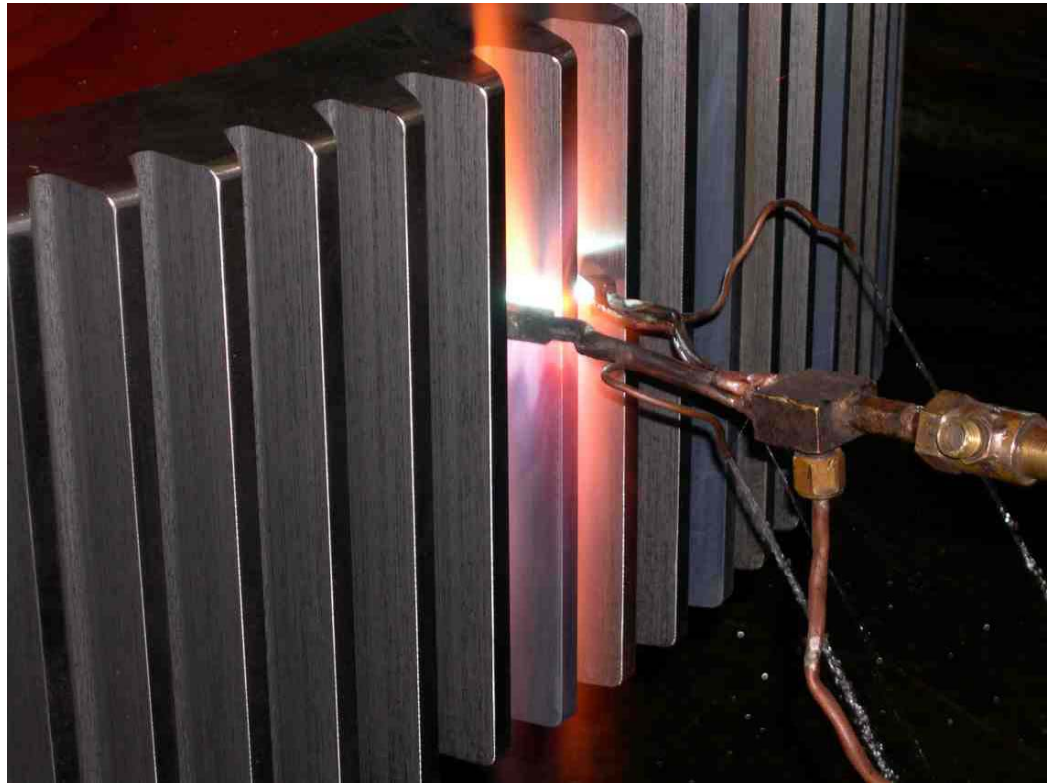
Optical micrographs (1000 ×) of samples after (a) normalization; intercritical at 750 °C for (b) 300s; (c) 600 s, (d) 1800 s.

# Normalizing

The process might be more accurately described as a homogenizing or grain-refining treatment. Within any piece of steel, the composition is usually not uniform throughout. That is, one area may have more carbon than the area adjacent to it. These composition differences affect the way in which the steel will respond to heat treatment. Because of characteristics inherent in cast steel, the normalizing treatment is more frequently applied to ingots prior to working, and to steel castings and forgings prior to hardening.

# Hardening

Hardening is carried out by quenching a steel, that is cooling it rapidly from a temperature above the transformation temperature. Steel is quenched in water or brine for the most rapid cooling, in oil for some alloy steels, and in air for certain higher alloy steels. With this fast cooling rate, the transformation from austenite to pearlite cannot occur and the new phase obtained by quenching is called martensite. Martensite is a supersaturated metastable phase and has body centered tetragonal lattice (bct) instead of bcc. After steel is quenched, it is usually very hard and strong but brittle. Martensite looks needle-like under microscope due to its fine lamellar structure.



# Case Hardening

Case Hardening is a process of hardening ferrous alloys so that the surface layer or case is made substantially harder than the interior or core. The chemical composition of the surface layer is altered during the treatment by the addition of carbon, nitrogen, or both. City Steel Heat Treating provides the most common processes of Carburizing, Carbonitriding, and Gas Nitriding

# Carburizing

Carburizing is a process used to harden low carbon steels that normally would not respond to quenching and tempering. This is done for economical reasons (utilizing less expensive steel) or design considerations to provide a tough part with good wear characteristics.

# Carburizing

Carburizing introduces carbon into a solid ferrous alloy by heating the metal in contact with a carbonaceous material to a temperature above the transformation range and holding at that temperature.



# Tempering

Tempering (formerly called drawing), consists of reheating a quenched steel to a suitable temperature below the transformation temperature for an appropriate time and cooling back to room temperature. Freshly quenched martensite is hard but not ductile. Tempering is needed to impart ductility to martensite usually at a small sacrifice in strength.

# Tempering

The effect of tempering may be illustrated as follows. If the head of a hammer were quenched to a fully martensitic structure, it probably would crack after the first few blows. Tempering during manufacture of the hammer imparts shock resistance with only a slight decrease in hardness. Tempering is accomplished by heating a quenched part to some point below the transformation temperature, and holding it at this temperature for an hour or more, depending on its size.

# Tempering

The micro structural changes accompanying tempering include loss of acicular martensite pattern and the precipitation of tiny carbide particles. This micro structure is referred to as tempered martensite.