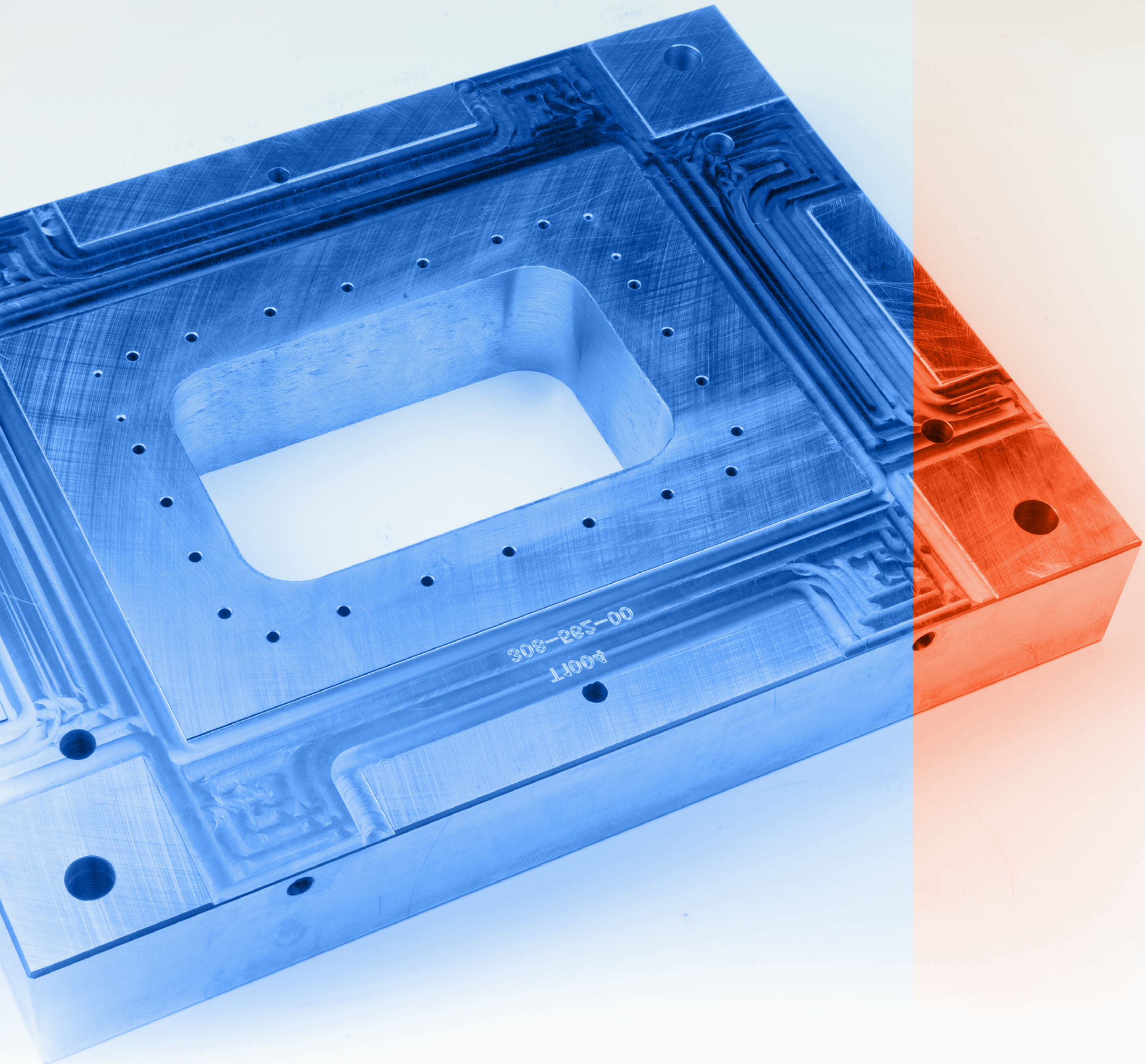
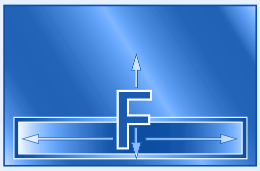
Thermal processes I Heat Treatments



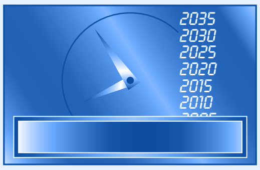
Hardening / Tempering

Making steel hard and wear resistant

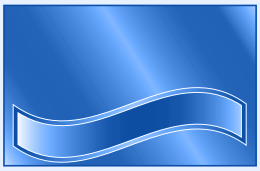
High wear resistance



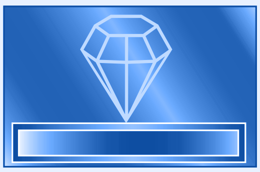
Increased mechanical properties



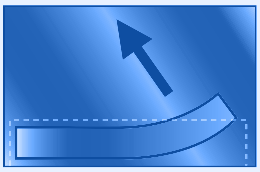
High stability



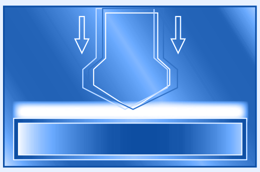
Improved fatigue strength



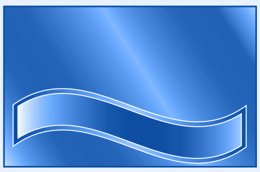
High hardness



Improved ductility



Increased impact resistance



Increased bending fatigue strength

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Hardening / Tempering

Making steel hard and wear resistant

What is hardening?

Hardening is heating and then cooling at such a rate of steel alloys so that a significant increase in hardness occurs. In most cases, hardening is performed in connection with a subsequent new heating, the tempering. If, after hardening at a high temperature, tempering is performed and then a relatively low hardness combined with high toughness is achieved, this process is called hardening and tempering.

How does hardening take place?

The hardening process of workpieces can be divided into three technical steps. First, the workpiece is heated so that the output structure transforms into an austenitic structure. This austenitizing temperature depends on the material used (750 °C – 1210 °C). Then the workpiece is maintained at this temperature so that alloying elements can be incorporated homogenously in this austenitic structure. The final step is quenching the workpiece at such a cooling rate that a so-called martensitic structure is originated.

The heating and temperature maintenance should be performed in a protective atmosphere to protect the material from oxidation and decarburization. Cooling can be performed in different media. The most common are: water, saline water, hardening oils, polymers, salt bath, nitrogen or argon.

After hardening steel has a relatively high brittleness and so it usually cannot be case-hardened in this condition. Therefore, directly after hardening it must be tempered at least once, however, more times is better. Tempering is an annealing treatment at lower temperatures, when the largest internal stresses that arose during the hardening, decrease. This decreases the hardness in most cases, but on the other hand, the toughness increases significantly.

The Theory behind Hardening

Steel has in an unhardened state a body centered cubic (BCC) structure, in which it can only dissolve very little carbon. After warming up over approx. 720 °C austenite is originated that has a body face centered (BFC) crystal structure (and occupies a smaller volume). It can dissolve considerably more carbon, which occurs at hardening temperature. By cooling the material then rapidly enough, converting it from a cubic face centered crystal structure back into a cubic spatially centered structure, oversatured carbon remain and martensite is originated. Due to the presence of supersaturated carbon, the BCC (body centered cubic) lattice is stretched out to a tetragonal lattice. The martensite thus possesses high internal stresses and a larger volume than non-hardened steel at room temperature. As a consequence, the high internal stresses have a high hardness of the material.

Upon tempering, a little carbon will be diffused from the tetragonal cube. Consequently stress and volume, but also hardness decrease and the toughness increases significantly.

Hardening Processes

The Heat & Surface Treatment and hardening process applied by Mamesta are hardening under protective gas and vacuum hardening. Hardening under protective gas is hardening of a workpiece in an inert gas atmosphere. This process serves to protect the surface of the component against oxidation as well as against decarbonizing and carbonizing. By an adjustable carbon potential of the protective gas atmosphere, decarbonizing and carbonizing can be undone.
Vacuum hardening is the hardening of components in a vacuum atmosphere (in a controlled vacuum) in which temperatures up to 1300 °C can be achieved. Purpose of this treatment is to prevent any oxidation or to avoid other reactions on the surface of the workpiece. The advantage of vacuum hardening is that metals remain white and a further mechanical treatment is usually unnecessary.
Also isothermal hardening, a special hardening technique is applied by Heat & Surface Treatment and Mamesta.

Properties

- Higher wear-resistance
- Higher hardness
- Improved resistance to deflection
- Improved resistance to fraction/tearing
- Improved resistance to chipping
- Improved ductility

Hardenable steels

Hardenable steels contain at least 0.3% carbon. Examples of steels that can be hardened are: spring band steel, cold work steel, high-grade steel, roller bearing steel, hot work steel and tool steel. A large number of high-alloy, stainless steels and alloys of cast iron can be hardened