Induction Hardening of Fasteners

by Jozef Dominik

The fasteners of 8.8 to 12.9 strength class has to dispose with mechanical characteristics, corresponding to projected lifetime of the whole construction. In common practice, it indicates refinement which is most frequently realised in continuous belt furnaces. On the other hand, self-tapping and self-drilling screws are gas carburized in multifunctional batch furnaces. Both cases are certified methods of heat treatment. On the contrary, some producers started to use unconventional methods such as induction surface hardening that has a lot of advantages. This contribution will also bring you some information on it.

► The Principle of Induction Hardening

Induction hardening is a part of heat treatment in which the steel is partially inductively heated to austenite temperature and then quenched. Hardening proceeds at the same time either by gradual way with the help of simple inductor and shower **(Fig. 1)** or stationarily in a multiple thread inductor **(Fig. 2)**. In both cases the part is rotating in order to reach uniform heating. The parts complicated in shape require special inductors which are often the object of a trade secret. The important thing is the air gap f, i.e. the distance between the inductor and the surface of hardened part **(Fig. 2)**.

Fig. 1 Gradual induction hardening of a shaft

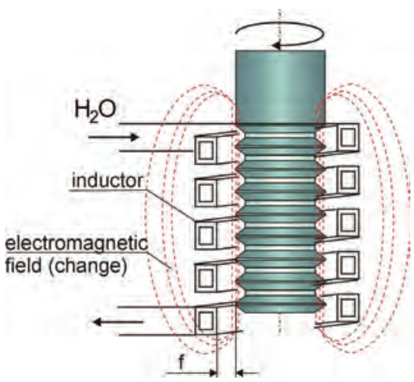

Fig. 2 Multiple thread inductor

All electrically conductive matters like carbon steel or Al-alloys can be inductively heated. Using this way of heating the heat arises directly in the component, as the result of a variable electromagnetic field which goes through the conductive component from the water cooled inductor **(Fig. 2)**. So, it does not spread by conducting as it is done by conventional methods, e.g. in a furnace but so to say in medias res. For parameters of hardened surface layer so called depth penetration δ [mm] of inducted HF (high frequency) - flow is decisive. It is dependent on frequency F and physical characteristics of heated materials as specific resistance ρ and magnetic conduction μ:

$$\delta \approx 503\sqrt{\frac{\rho}{F \cdot \mu}}$$

The result of martensitic transformation is surface layers high hardness of hardened components **(Fig. 3)** while the core remains in the original natural state. The gradient of hardness with maximum on the surface and continuous decrease up to the core hardness is typical for inductively hardened components' surfaces.

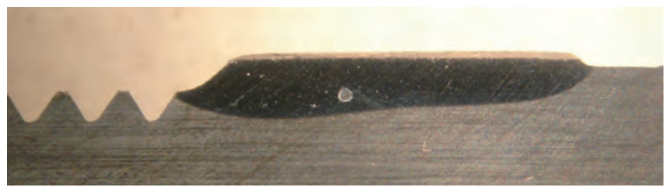

Fig. 3 Inductively hardened layer

► The Comparison with Classical Heat Treatment

The difference between individual ways of heat treatment is demonstrated within **Fig. 4.** While the product of volume hardening in classical furnace aggregates is martensitic microstructure in hardened component's full volume, other two cases are, in their essence, surface technologies with typical surface layer and transition zone. The hardened surface layer after induction hardening does not copy the whole component surface as it is so when carburizing but it is situated into the areas of the inducted flow hugest density. Therefore the induction hardening is appropriate especially for local increase of functional surfaces' hardness, screws for automotive services, heavy trucks, off-road vehicles, construction, etc.

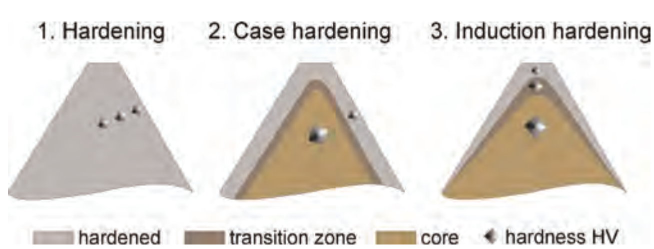

Fig. 4 The comparison of individual ways of hardening

As this calorimetric equation show:

$$Q = m.c.\Delta t,$$

when

Q – heat, m – weight of heated volume, c – specific heat of steel, Δt – temperatures difference

necessary amount of heat energy is dependent mainly on weight of heated volume m, which is in case of partial heating cca 5 or lesser than while heating whole volume. This is a great advantage of induction hardening because it saves energy. Considering annual capacity of induction hardening devices, e.g. 1 million components, it represents appreciable energy saving in total. The next saving arises from the fact that during induction heating the heat is not spreading by transition from surrounding atmosphere but is created directly in the material, which reduces shrinkage.

The main advantage of induction heating is the ability to harden partially chosen functional surfaces. For example, considering self-drilling screws there are so called active threads (Fig. 5), which fulfil the function of cutting tool.

► Conclusion

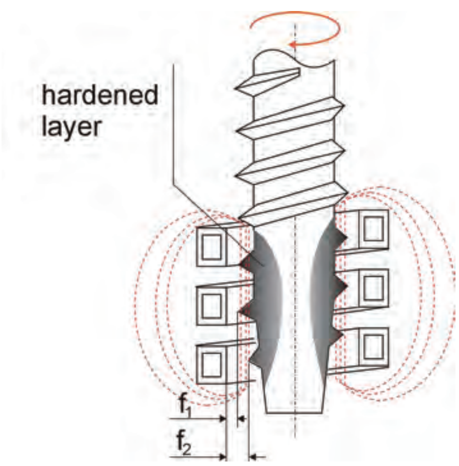

Fig. 5 Partial induction hardening of self-drilling screw thread ($f1$ a $f2$ – vzduchová medzera)

Induction hardening provides wide range of advantages. It enables to harden functional surfaces of components partially. It consumes less energy than classical hardening. It does not need any generator of protection atmosphere. It does not implicitly require continuous operation, etc.

This modern technology cannot be regarded as a universal method of heat treatment of fastening elements. The decision on its application has to be made by a constructor after careful considering all possibilities. Such a decision also often requires cooperation of specialised research departments.