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Forging Steel Parts,
Mechanical & Surface Treatment

Comparison of the induction, flame, dip, case and nitride hardening processes

Induction hardening cannot and is not to replace those surface hardening processes being generally in use. It is an additional hardening process which is used for those applications where there is a benefit, both in technical and economic respect. The advantage becomes the more obvious the smaller the surface to be hardened on a workpiece is, compared with its total surface. The following is a summary of the advantages and disadvantages of the different surface hardening processes. The decision which hardening process is advantageous for a specific workpiece can be taken by the processing company only and, in case of doubt, after having consulted experts for such processes.

➢ Induction hardening

Advantages

Uniform heating of the parts of the component to be hardened. Short heating and cooling times and as a result thereof the formation of a minimum amount of scale. In many cases no subsequent work is necessary. Due to short-time heating the formation of coarse grain as a result of overtimes and overheating is avoided. Safe control of heat input. The temperatures required are kept. The distortion is generally low. In comparison with case hardening, expensive alloyed case hardening steels can be replaced by cheap heat-treatable steels. Partial hardening is mostly possible even on most difficult workpiece shapes. The hardening machines and generators can be directly integrated in the production lines. The space requirement is low, easy and clean operation with no health hazards.

The hardening installation is always ready for operation and, with careful routine maintenance, safe in operation. The hardening machines can be manufactured such way to allow for fully automatic operation.

Disadvantages

The purchase costs for a hardening installation are high and can only be amortized through a good utilization and/or major quantities of workpieces to be processed. When hardening heat-treatable steels a zone of low strength (soft zone) might occur between the core and the hardened outer zone. Different inductors have to be used for the different processes. Hardening components with large changes in sections can be difficult.

- **Flame hardening**

Advantages
Low capital costs. The heating times are relatively short. The distortion is low.The minimum hardness depths that can be obtained are more limited downwards than with induction hardening. Within limits, selective hardening of specific areas of the component is possible. The hardening plant and equipment can be installed in a production line. Low space requirements and simple operation. The installation is always ready for operation. The hardening machines can be partly automated.

Disadvantages
Due to variations in the burner gas pressure and mixture the heating flame temperature is not always constant causing the hardening depth to vary. The hardening of bores is difficult and can only be carried out on large diameters. For hardening different components different burners have to be used. When hardening heat treatable steels, a tempering zone (soft zone) occurs between the core and the hardened outer layer.

- **Dip hardening**

Advantages
Low heat treatment costs. Short process times. The distortion is low.

Disadvantages
Selective hardening is only possible in certain instances. The complete component is surface hardened as it is impossible to mask areas which should not be hardened. It is not possible to obtain a perfect hardened layer at points where there is a change in section or notches in the component. The hardening works can only be carried out in a special hardening shop involving additional transportation cost. The fumes of the dip baths are harmful to the health. The hardened components require subsequent work.

- **Case hardening (carbon hardening)**

Advantages
The hardened layer, although relatively thin, is uniform over the component. Selective hardening can be achieved, dependent upon the component shape. The core strength is increased at the same time when the surface is hardened. Higher efficiency in general on parts whose whole surface is to be hardened.

Disadvantages
High operating costs, long annealing times. Severe distortion can occur as the whole component will be heated. Areas which are not to be hardened must be covered or the hardened layer must be removed before the hardening process. The process can only be carried out in a special hardening shop involving additional transportation cost. In order to receive a clean surface the hardened workpieces need subsequent work.

- **<u>Nitride hardening (gas nitriding)</u>**

Advantages
Uniform hardness depth irrespective of the shape of the component. As the process temperature is low (approx. 500 °C), distortion on stress-relieved annealed components is insignificant. No quenching is necessary. Very high hardness values can be achieved and will remain nearly the same at temperatures above 500 °C. The resistance to wear is very high in accordance with the high hardness. Nitrited components do not have to be reworked after hardening.

Disadvantages
High operating costs. Only special steels can be used. The annealing times are very long, depending on the hardness depth between 1 – 4 days are necessary. The whole component is heated through. The hardened layer is thin. The hardness reduces considerably in the zones below 0,2 mm. The surfaces do not withstand high surface pressure as they tend to collapse under pressure. Sections not to be hardened have to be coated by tinning or nickeling. The surface of the component must be perfectly clean before nitriding. The process can only be carried out in a special hardening shop, involving additional transportation costs.