Fraunhofer Institut
Werkstoff- und
Strahltechnik

Laser beam hardening with high power diode lasers

Task

Although there are several proven technologies of surface hardening of steels available (induction hardening, HF-pulse hardening, short-time hardening by electron beam, CO_2-laser, or Nd:YAG-laser) case or bulk hardening in special furnaces is still the dominating technique in the production of small parts, with the drawback of being a discontinuous process. Other disadvantages consist in

- high distortion,
- the often necessary finishing processes in the hardened state,
- annealing of regions where toughness is required.

The reasons for these old-fashioned ways in the supplying industry are found in a few draw-backs of induction, electron beam, and conventional laser beam as heat sources:

- Induction does not well reproduce hardening depths in the range 0.1 ... 0.5 mm.
- HF-pulse hardening is not flexible concerning the shape of the part.
- Electron beam and conventional laser hardening (with CO_2- or Nd:YAG-laser) requires high investment.
- The Nd:YAG laser has low energetic efficiency and high operating cost.
- The CO_2-laser requires absorbent coatings, and its beam is not easily handled.

Fig. 1: Hardening of a curved gripper edge with high power diode laser

Solution

The recently available high power diode laser avoids the drawbacks listed above. It is small and compact (500 · 180 · 130 mm^3 for 4 kW) and hence easily integrated into both simple machines and robots (plug-and-play), distinguished by high energetic efficiency (30 ... 50 % compared to 3 % of the Nd:YAG-laser) and low investment and running cost (low power input, no operating gases).

Its small size allows it to be incorporated into turning and milling processes such that tooling and hardening can be done with one grip. The rectangular beam cross section with nearly constant power density is another feature which turns out advantageous in technological processes.

The following hardening parameters are presently reached:

- track width: 1.5 ... 11.5 mm,
- hardening depth: 0.1 ... 1.5 mm,
- feed rate: 370 ... 24 500 mm min^{-1}.

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Applications

The unique and up to now unmatched properties of this novel beam tool in the power range up to 2 kW justify the assumption that it will be industrially applied for

- hardening depths of 0.1 ... 1 mm,
- thin-walled and warp-prone parts,
- inner surfaces,
- parts with functional faces.

This makes the diode laser beam hardening suitable for

- mechanical precision parts subjected to wear (as in printing, hydraulics, control shafts, miniature support rails),
- small tools (as punches, crimping, bending, and folding tools),
- small textile machine parts (as needles and ears),
- small motor parts (as piston rings, injector needles, injector seats),
- medical instruments, especially for minimal invasive surgery (as pincers, knives, scissors, needles).

This technique is suitable for annealing steels, spring steels, martensite hardening cold heading, cold extrusion, and valve steels, tool steels, cold work tool steels.

Offer

- feasibility studies of laser beam hardening of various materials and parts
- development of technologies
- construction of pilot plants
- system development in cooperation with our corporate partners

Example

Task

The laser beam hardening of a GGG70 cam disk for printing machines is used to demonstrate the possibility of high power diode lasers for hardening. According to the function of the cam disk, only the edges of the curve were hardened. The distortion of the disk due to heat input is only minimal. The surface temperature is kept constant during the process with an accuracy of +/- 5 K by a feedback system involving rapid pyrometry and beam power control. The temperature-conducted laser power control system is a **lasertronic®**-system of the Fraunhofer Institute for Material and Beam Technology Dresden and is managed under this protected brand, because it combines the elements of lasertechnology, electronic and information technology.

Parameters

- beam power 800 - 1000 W
- spot size 8 • 8 mm^2
- feed rate 125 m min^{-1}

Fig. 2: Hardening of a curved gripper edge with high power diode laser

Fig. 3: Laser beam hardened curved gripper edge, hardness 800 HV 0.05, optional hardening depth 0.1

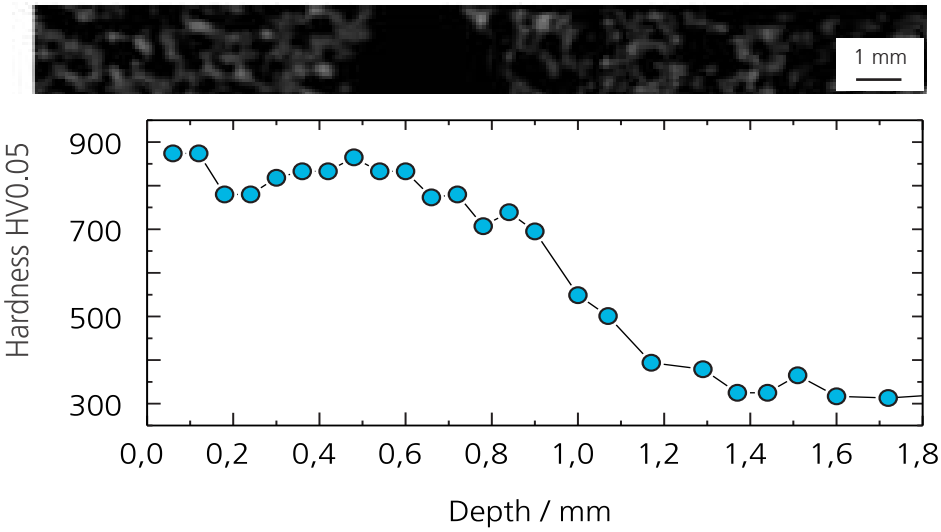

Fig. 4: Cross cut and hardness vs. depth of hardened gripper edge