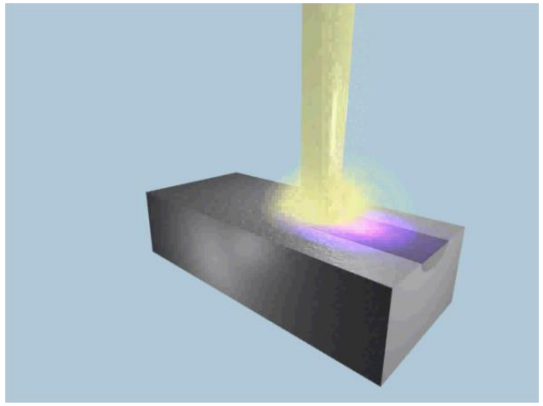
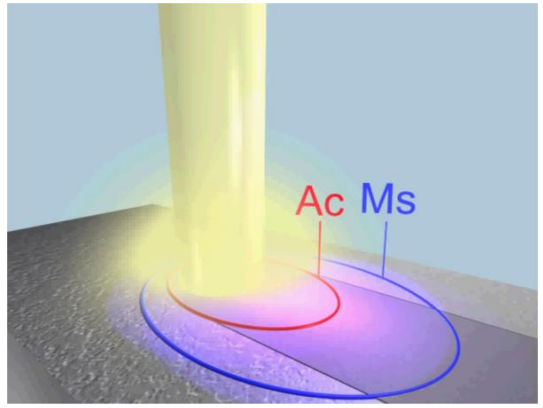
Laser Beam Hardening – Old Laser Technology but Still a Newbee in the Heat Treatment World

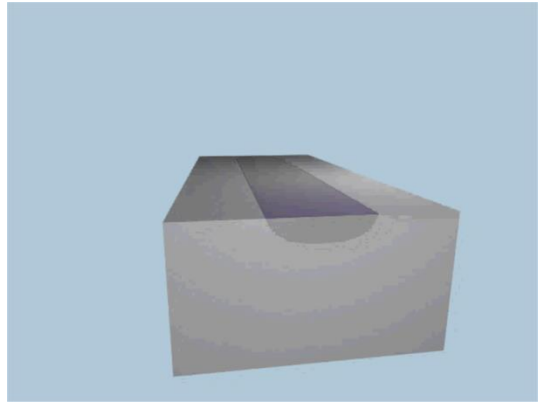
Dr. Steffen Bonss

Principle

- Steel surface is irradiated with laser beam
- Local absorption of laser energy and heating up
- Growing oxide layer on surface
  - absorption increases from 40% to 80 – 90%
- Heat flow into surrounding material, heating up of part
- Local overheating is avoided by temperature control
- Dwell time is controlled by feed rate and lser spot size
- Self quenching by heat conduction into the part





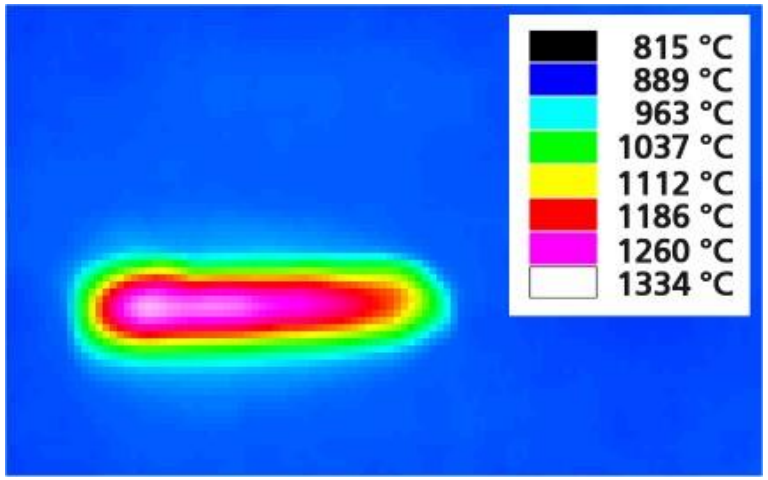


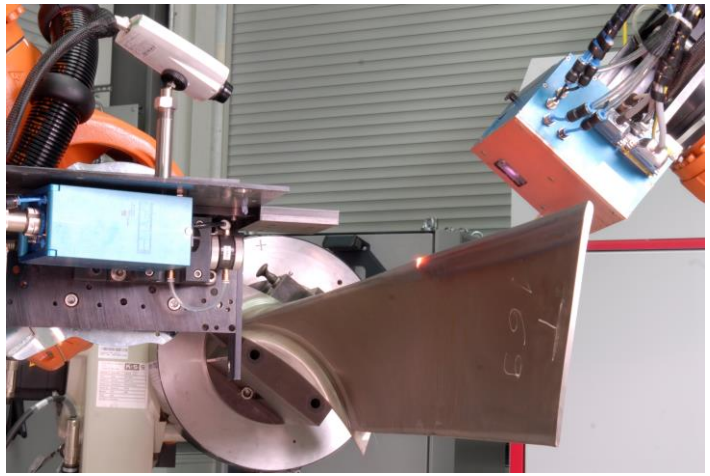
Video and pictures from „Laserlexikon“, Fraunhofer IWS Dresden

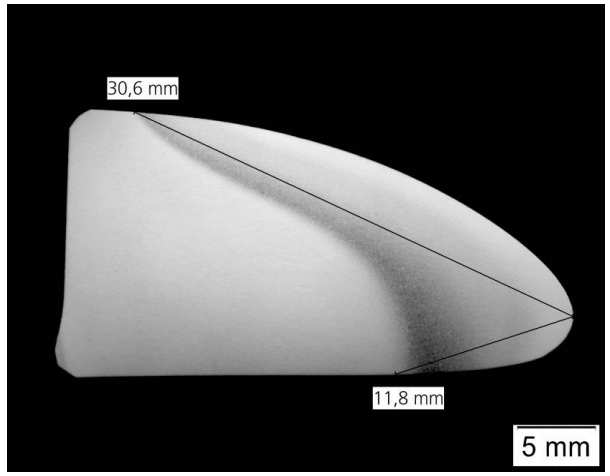
Industrial processing

Process optimization

- Always temperature-controlled processes with pyrometers or cameras and closed loop controls
- Optimum surface temperature is defined by the material
- Width of hardening zone is made by laser spot shape
- Penetration of hardening is optimized by feed rate optimization



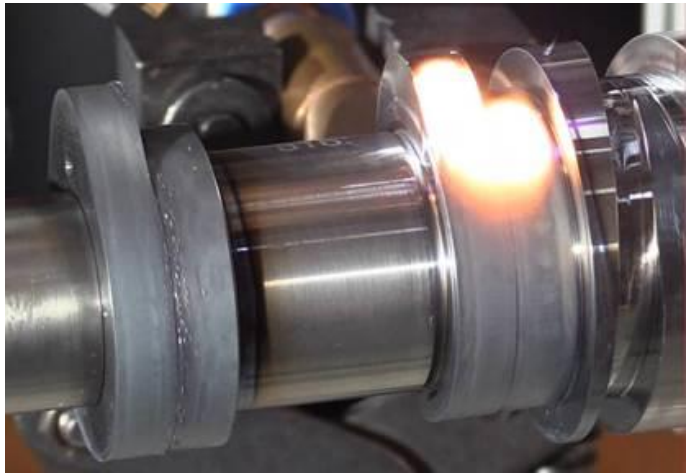




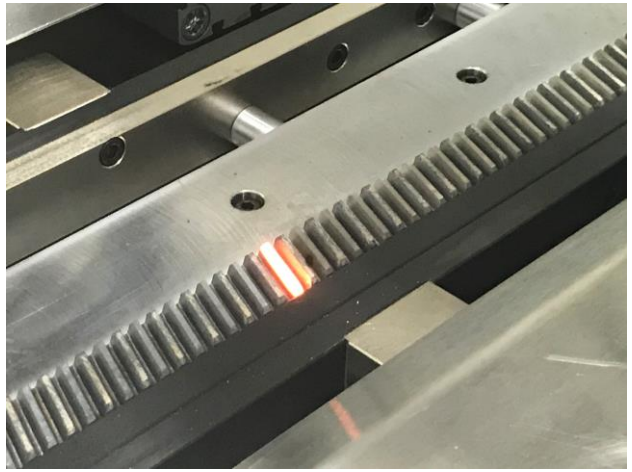
Pictures: Fraunhofer IWS

Different Heat Treatment Procedures

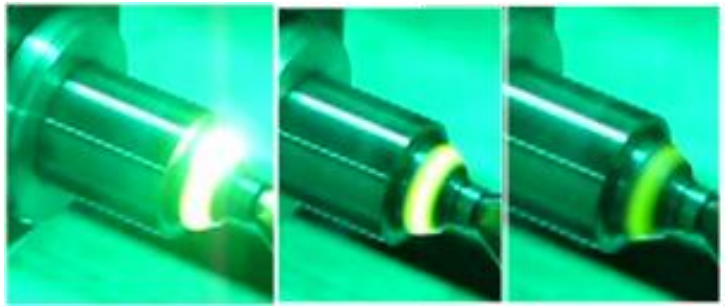
- Feed hardening
  - Example cam piece
    - Rectangular Spot
    - 42CrMo4
    - Process speed about 250 mm/min
    - About 10 kW laser power



- Single shot hardening
  - Example steering rack
    - 2 rectangular spots
    - 0.5%-C-steel
    - Simultaneous process with 2 spots
    - About 1.5 s laser on
    - About 2 x 3500 W laser power



- High speed rotation hardening
  - Example hydraulic valve
    - Rectangular spot
    - C45
    - Fast part rotation
    - About 1.5 s laser on
    - About 2000 W laser power



Pictures: Fraunhofer IWS Dresden

Issues for Technology Transfer

Advantages

- Less distortion, saving of post treatment procedures, saving of costs
- No quenching liquids
- High productivity at integration in manufacturing lines
- Low energy consumption

Disadvantages

- Strong established technologies like induction hardening
- Sometimes material change necessary (replacement of case hardening)
- Lack of heat treatment knowledge if integration in manufacturing lines

Influence of Process Parameters and Necessary Devices

- Shape and size of laser spot at work piece surface
  - width and penetration of hardening zone

  ✓ Optics with specific spot geometry, Zoom-Optics

- Intensity distribution of laser spot
  - adaption to local heat conduction
  - influence on local temperature field and local hardening depth

  × Optics for flexible adjustable 2D-intensity profiles needed for the 2-10 kW cw power range

- Laser power
  - Max. available laser power limits the feed rate (heating rate) or max. temperature

  ✓ Max. cw power of 50 kW available

  × Optics needed for cw power over 20 kW

- Feed rate (or dwell time in case of no movement)
  - hardening depth
  - low feed rates can result in lower hardness because of reduced cooling rate

  ✓ Done by robots or CNC-machines with sufficient precision

- Shielding gas
  - avoids surface oxidation
  - reduces laser absorption from about 80% to about 40%

  ✓ Individual design of device necessary