Surface Modification I *

* Modifications without changing composition of the surface

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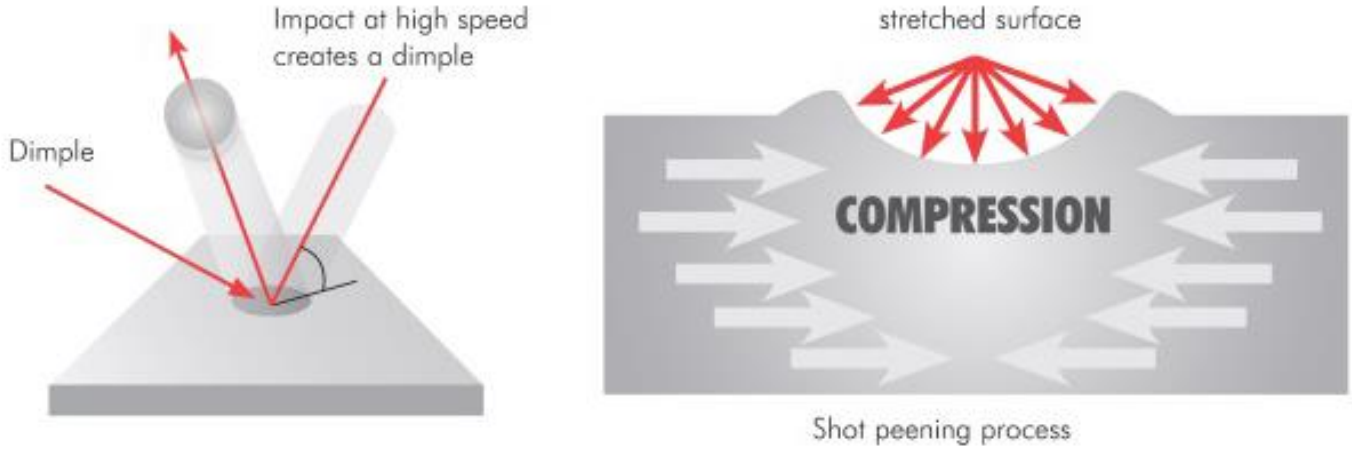
Mechanical surface treatments

Shot peening (bead blasting):

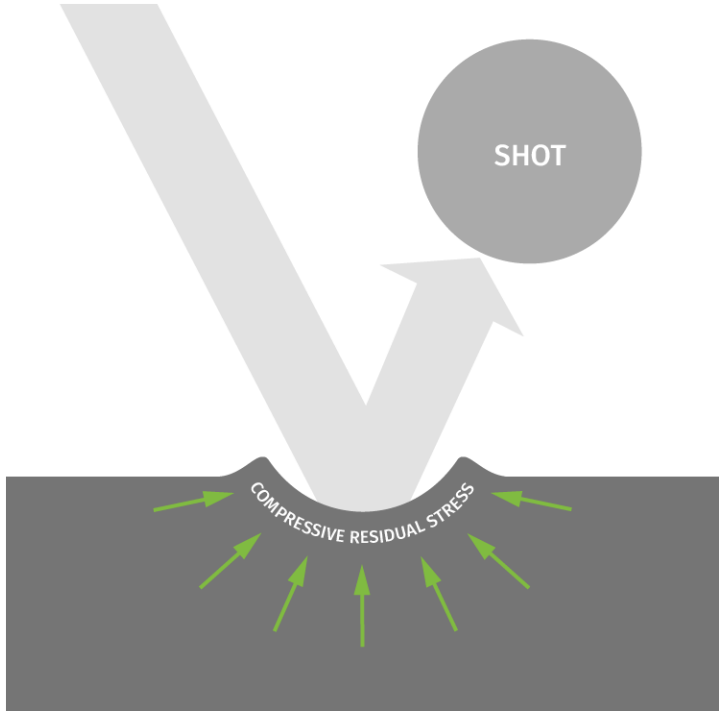
- Shot peening is a cold working process used to provide a compressive residual stress layer.
- Shot peening is similar to sand blasting except that it operates by the mechanism of plasticity rather than abrasion.
- Shot peening is making the material resistant to **fatigue,**

  fretting and

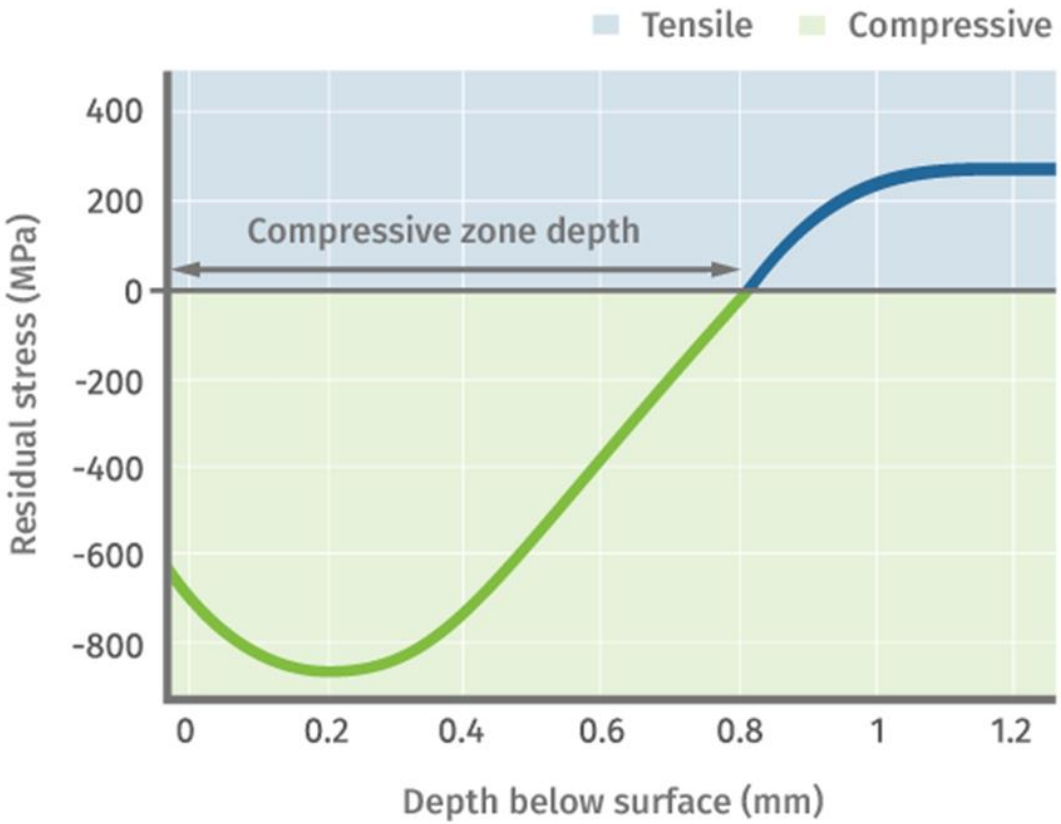
  stress corrosion crack.



Shot peening process

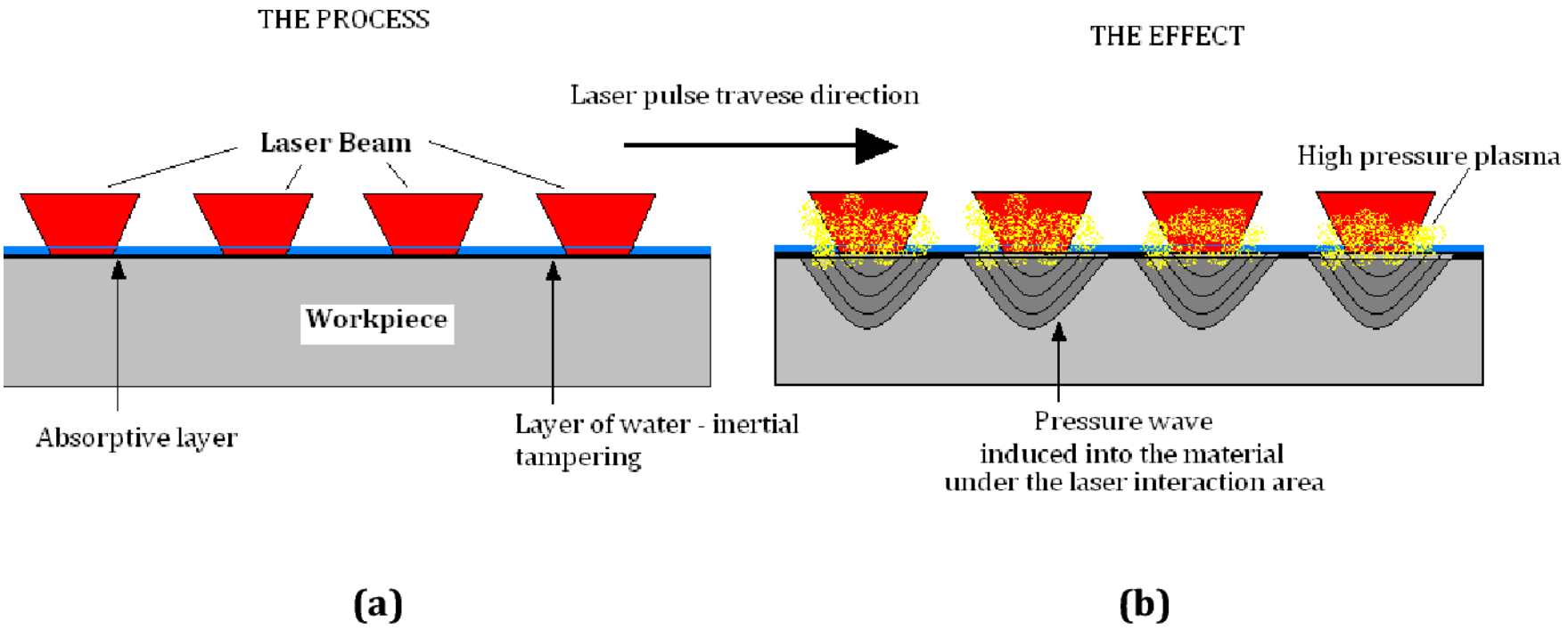


Typical shot peening stress depth profile

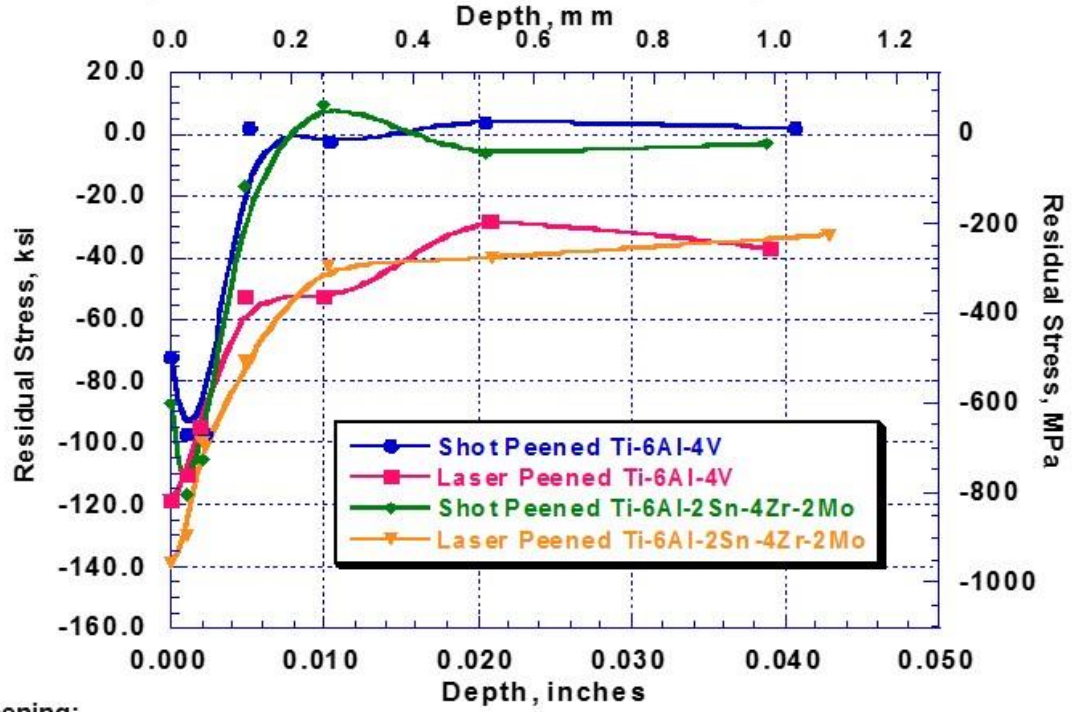


Laser Shock Peening (Laser Peening)

Laser shock peening (LSP) is a process that was developed as a substitution for conventional shot peening. It is a surface treatment that is used to improve fatigue life and wear resistance of metallic parts.



Residual Stress Profiles: Laser Peening vs. Shot Peening

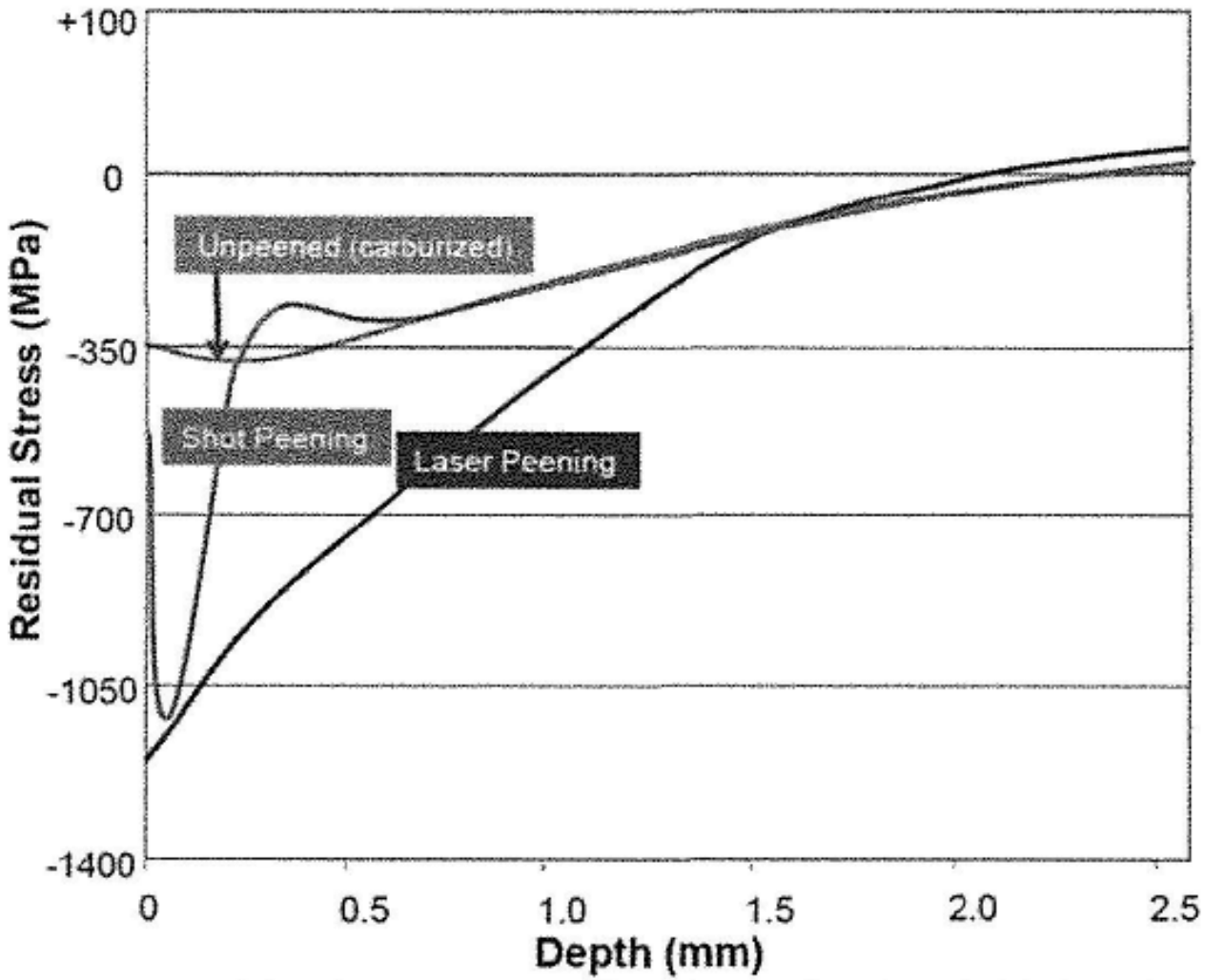


Shot Peening:

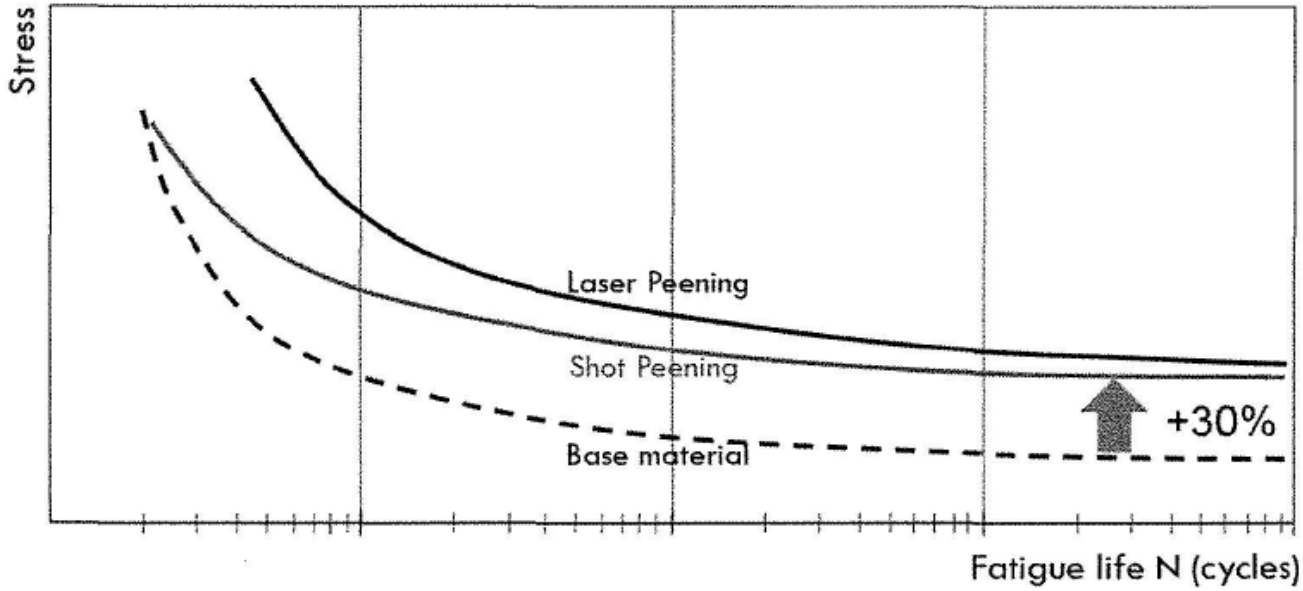
- Residual stress depth 0.1 mm (0.004 in)

Laser Peening:

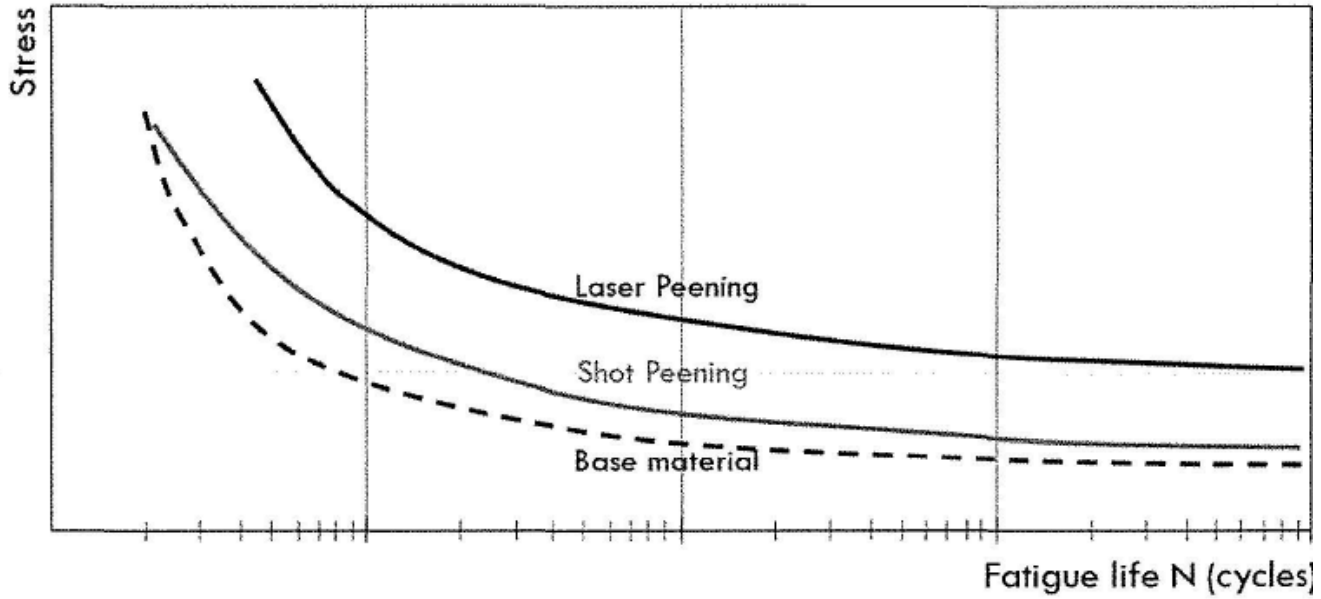
- Residual stress depth 1 – 1.5 mm (0.040 – 0.060 in)



residual stress profiles in carburized 9310 after heat treating, SP and LP



comparison of SP and LP: effect of residual stresses only in non-deteriorating environment



comparison of SP and LP: effect of residual stresses only in deteriorating environment

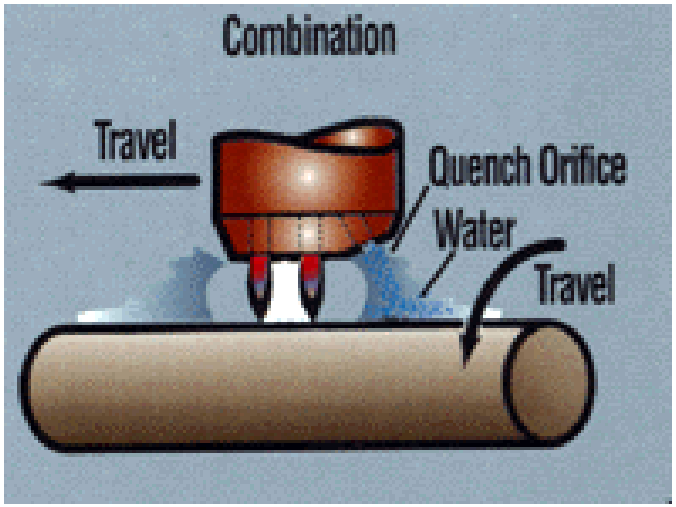
Thermal surface treatments

- **Surface hardening (for steels) (case hardening)**
  - Flame
  - Induction
  - Electron beam
  - Laser

- **Surface melting**
  - Laser

Flame hardening

- It can be applied to hardenable steels.
- Surface of the steel is heated with oxyacetylene or oxyhydrogen flame then quenched.
- Carbon content of the steel must be enough for martensite transformation.
- This technique is applied especially to medium carbon-steels (0.3-0.6 % C).
- Used to treat components such as gears, shafts, cams, crankshafts etc.

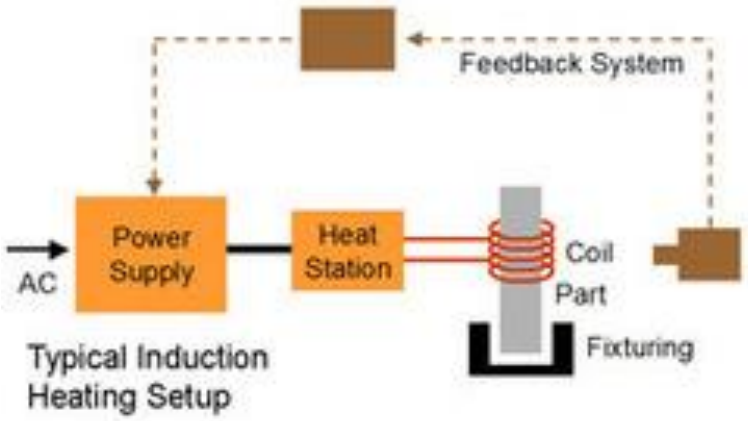


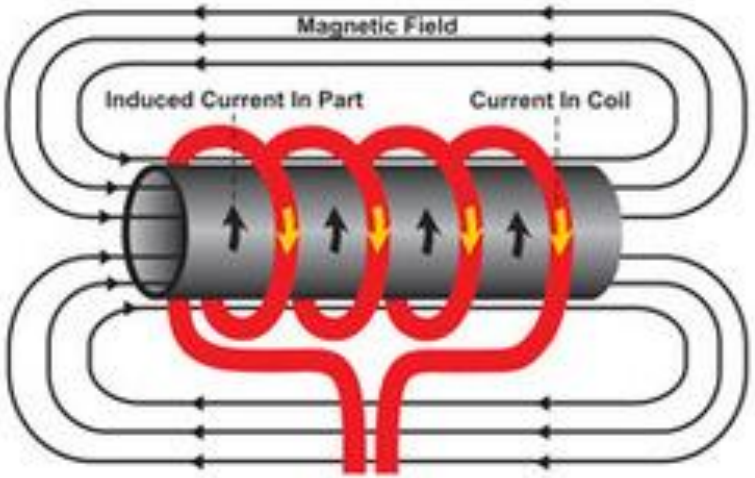
Hardening depth depends on:

- Time
- Speed of travel
- Adjustment of flame intensity

Induction hardening

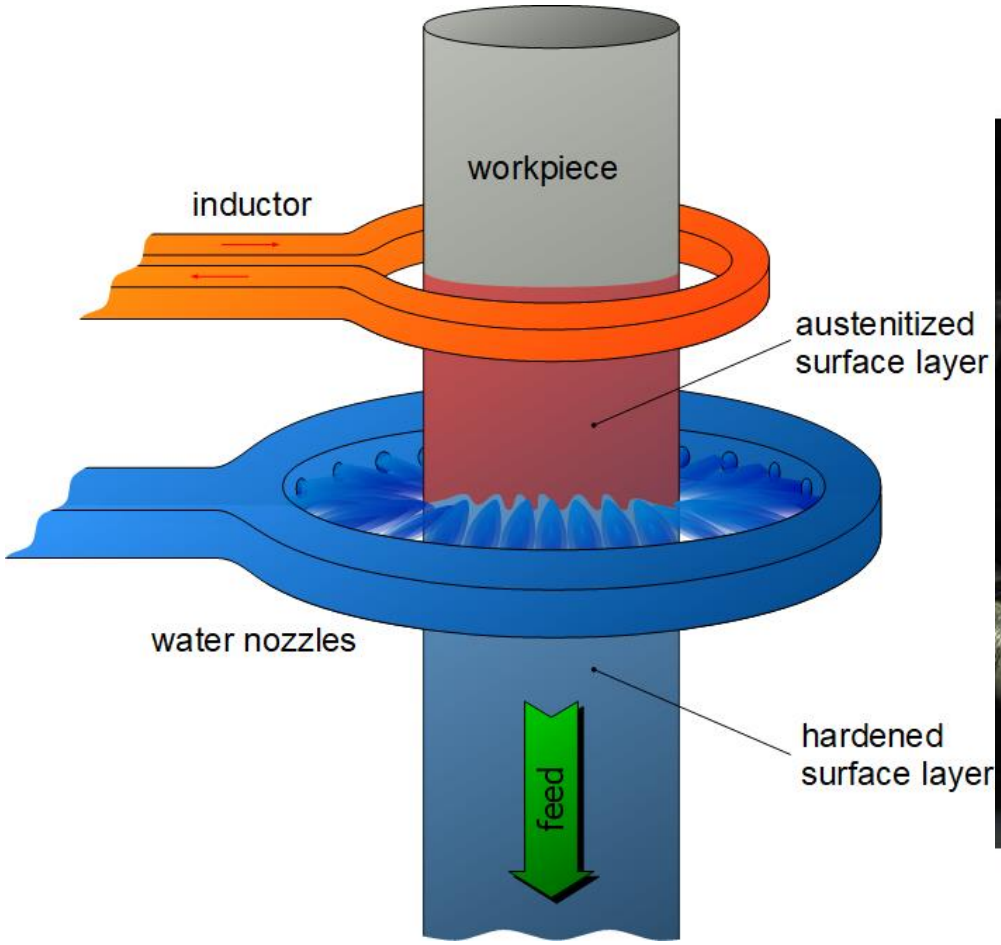
- Use electromagnetic induction.
- Electromagnetic induction is produced with water cooled copper induction coils.
- A magnetic field occurs its inside when high frequency AC (Alternative Current) applied to the coil.
- Resistive heating is proportional to resistance in metal and currents produced.
- Hardening may be done on the surface or throughout entire work piece.





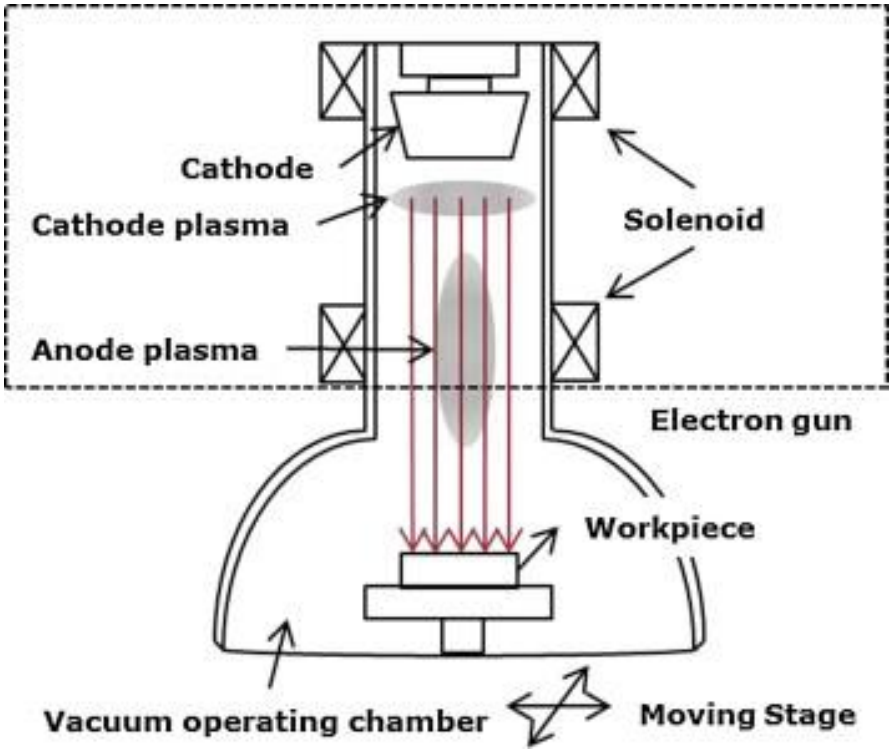
Factors effect hardening depth

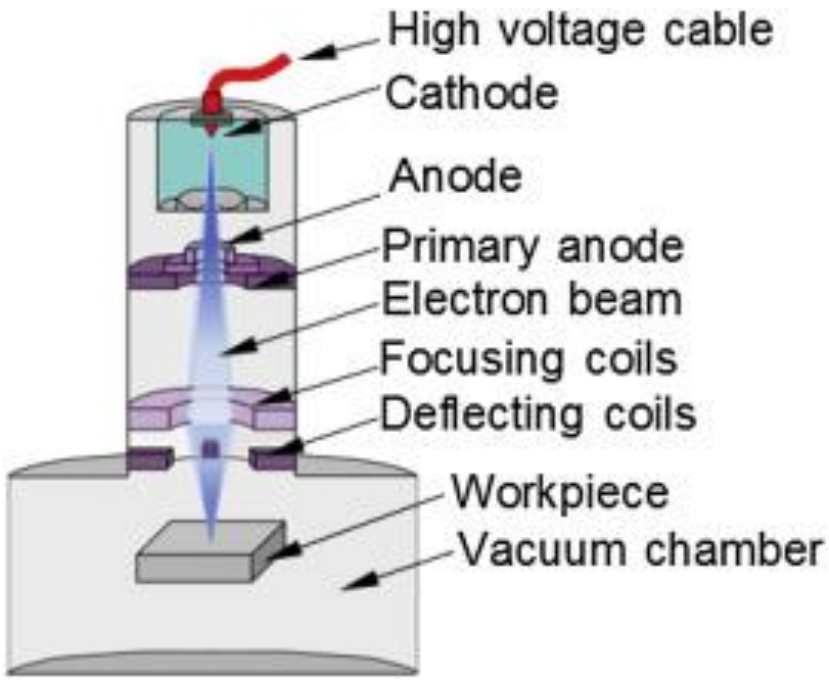
- Current frequency
- Coil current density
- Heating time
- Design of coil


workpiece
inductor
austenitized
surface layer
water nozzles
hardened
surface layer
feed

Electron beam (EB) hardening

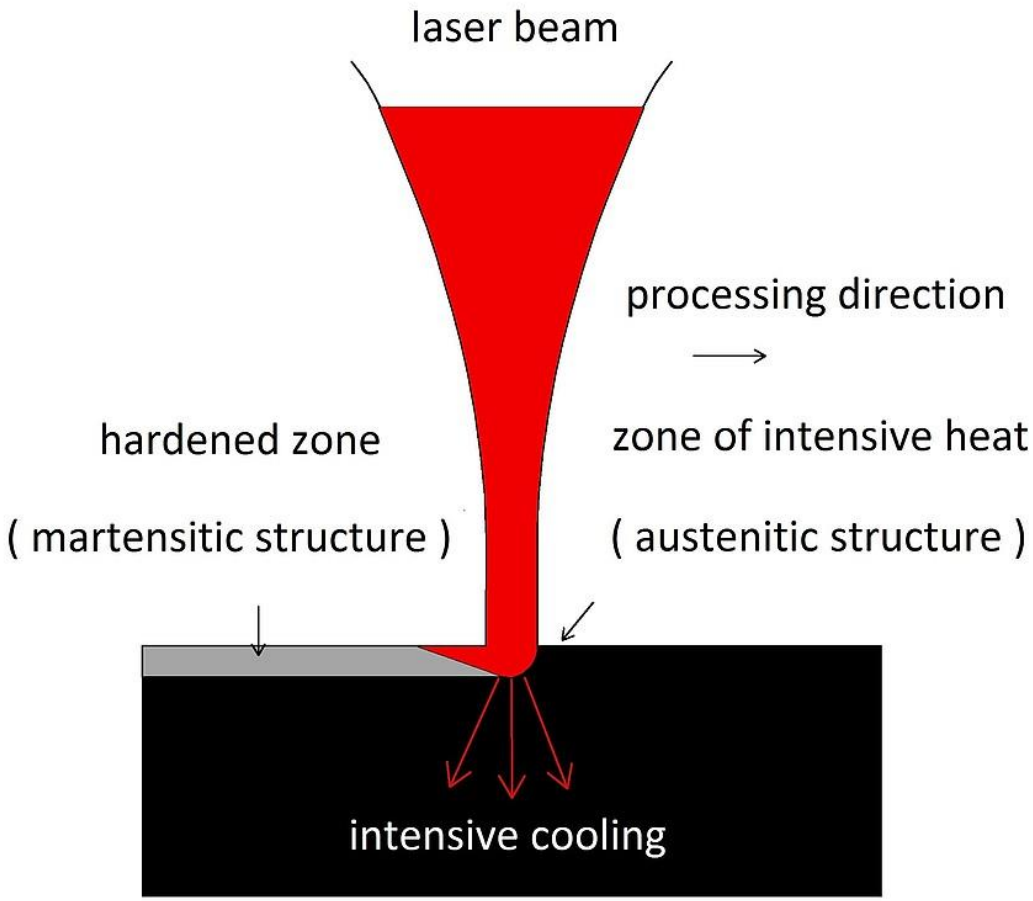
- High velocity concentrated electron beam is used as energy source for heating steel surfaces.
- It can be applied only to chosen fields.
- The rapid cooling of the austenite required for martensite formation occurs through self-quenching.
- Typical hardening depths range from 0.1 to 1.5 mm.
- Vacuum is required to carry out EB hardening

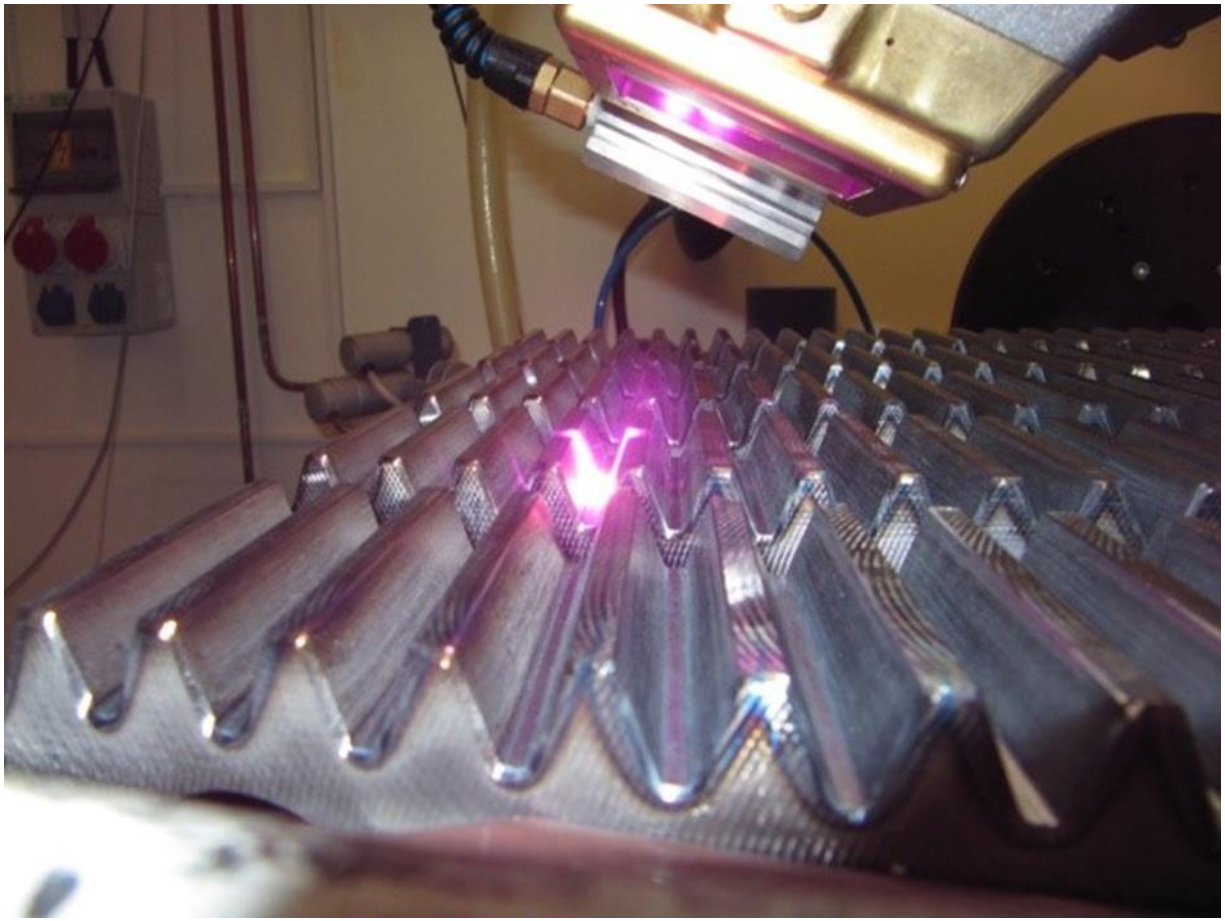

Cathode
Cathode plasma
Solenoid
Anode plasma
Electron gun
Workpiece
Vacuum operating chamber
Moving Stage


High voltage cable
Cathode
Anode
Primary anode
Electron beam
Focusing coils
Deflecting coils
Workpiece
Vacuum chamber

Laser hardening

- Hardening fields and depth are optional like EB technique.
- Hardness can be 60 HRC in 0.75-1.3 mm depth.
- It does not need vacuum like EB (advantage)
- Non-reflective coating can be needed. (disadvantage)
- Self quenching happens in laser hardening processes.


laser beam
processing direction
hardened zone
(martensitic structure)
zone of intensive heat
(austenitic structure)
intensive cooling



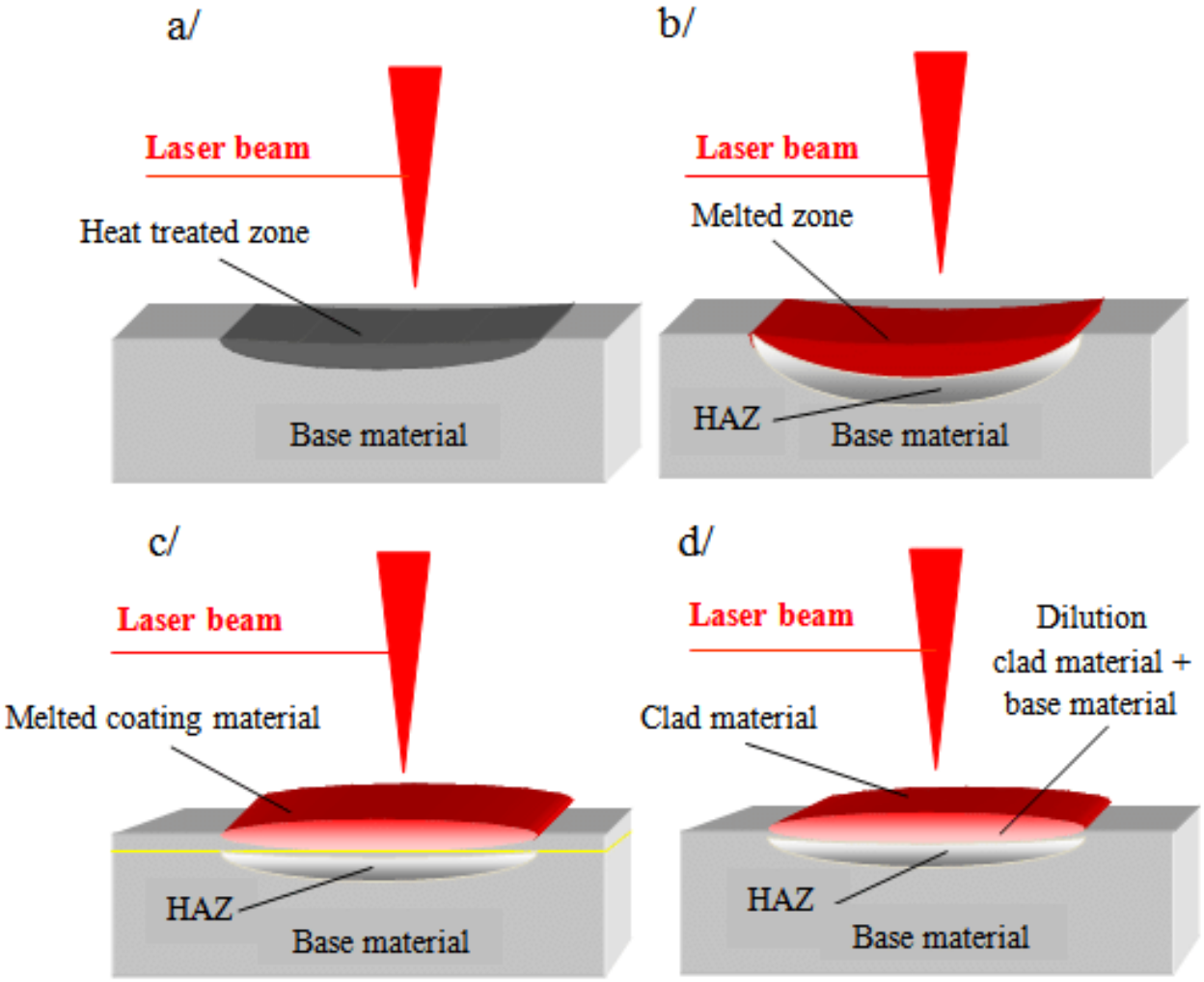
Surface melting

- An amorphous structure in the surface region can be achieved with sudden melting and rapid solidification.
- Commonly it is carried out with laser.
- Power intensity of the laser is higher than laser hardening process.
- Ultra thin melting layer is obtained.
- Refined and metastable microstructures can be produced.

Laser melted structures develops such service properties:

- Wear,
- oxidation
- and corrosion resistance

at high temperatures.



Laser surface treatment techniques; (a) laser transformation hardening, (b) laser surface melting, (c) laser alloying, (d) laser cladding

Video links

- https://www.youtube.com/watch?v=AgPsxoZnEa0
- https://www.youtube.com/watch?v=1DniNil1kVc
- https://www.youtube.com/watch?v=mONGJgdBxtM
- https://www.youtube.com/watch?v=Q7WB5vflsAg
- https://www.youtube.com/watch?v=48jYTRljKPg
- https://www.youtube.com/watch?v=HOREi8_Cgi4
- https://www.youtube.com/watch?v=lJhAQK6xD1g
- https://www.youtube.com/watch?v=CCpaLwPApKE
- https://www.youtube.com/watch?v=fSEv-UI-n_4
- https://www.youtube.com/watch?v=___hCW_EPPg