Description

Process schematic

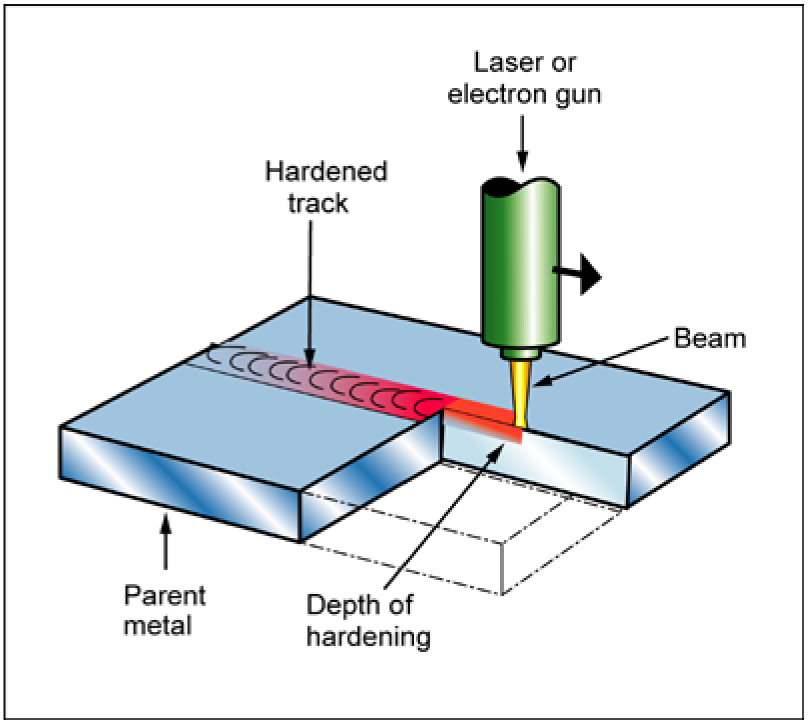

Figure caption

Laser surface

The process

Lasers are a clean, controllable heat source for surface treatment and welding (see also the record for laser welding). The laser beam scans the surface to cause a phase change for localized heat treatment, or to melt it for localized structure-change. This allows three sorts of process: surface transformation hardening, surface shocking, and surface melting and glazing. All can be applied to selected areas of the surface.

In SURFACE TRANSFORMATION HARDENING (limited to carbon and alloy steels) the beam heats a spot on the surface to a temperature above that for the transmission to austenite. As the beam moves on, the hotspot is quenched by conduction of heat into the massive, cold interior of the component, transforming a thin surface layer to martensite. Single, separated tracks give a surface with good wear resistance - the alternating the hard and soft bands contribute to this. Overlapping tracks give a more uniform hardening of the entire surface.

LASER SHOCK HARDENING uses a pulsed, high energy beam to violently vaporize a minute amount of surface material, creating a shock wave that locally deforms the underlying solid, while hardening it like shock peening.

LASER SURFACE MELTING involves the use of a high intensity beam to scan the surface, protected by a shielding-gas, melting it. The subsequent rapid quench by conduction into the interior produces a track with a refined and homogenized microstructure. Laser glazing is a melting process carried out at a high processing speed such as the cooling rates between 10,000 and 1,000,000°C/sec can be achieved. At this cooling rate, metallic glass formation is possible if the alloy composition has a high glass-forming tendency.

Material compatibility

Metals - ferrous	✓
Metals - non-ferrous	✓

Function of treatment

Hardness	✔
Wear resistance	✔
Fatigue resistance	✔
Friction control	✔

Economic compatibility

Relative tooling cost	medium
Relative equipment cost	very high
Labor intensity	low

Physical and quality attributes

Surface roughness (A=v. smooth)	A			
Curved surface coverage	Poor			
Coating thickness	0.394	-	39.4	mil
Surface hardness	420	-	720	Vickers
Processing temperature	1.34e3	-	3.14e3	°F

Process characteristics

Discrete	✔

Supporting information

Design guidelines

Laser treatment can be localized to a required area and very precisely controlled. The heat input is relatively low giving minimum thermal distortion, and the depth can be accurately controlled. Most treatments are rapid and hence suitable for production line incorporation. The laser beam can be directed by mirrors to treat inaccessible areas of components such as automobile cylinder bores. Numerical control allows complex shapes to be treated. Laser source, in decreasing order of importance are : carbon dioxide, neodymium-doped yttrium garnet, neodymium-doped glass, and chromium-doped aluminum oxide. Important factors for selecting a laser for surface alloying are output power, beam diameter, beam configuration, wavelength, pulse length, pulse repetition rate. CO2 lasers are preferred because they are electrically more efficient and produce higher power than other lasers in continuous mode.

Technical notes

The process is usually applied to carbon and tool steels, but aluminum and zirconium can be treated to give a refined surface layer. The laser power for surface alloying of metals must exceed 0.5kW. For ceramics and polymers, low powers are sufficient. The beam size and scan-velocity determine the power-density delivered to the specimen surface.

Typical uses

Laser surface hardening is used to create hard, wear-resistant fencings on tools, rolls for rolling mills, tips of rocker arms and cylinder bores in automotive and marine engines.

The economics

Laser-beam sources of sufficient power to harden or melt the surface of metals are expensive. The beam has to be scanned (or the workpiece translated under the beam) limiting the area that can economically be treated.

Links

MaterialUniverse

Reference