EFFECTIVE HARDENING OF SURFACES WITH ROTATIONAL SYMMETRY

THE TASK

Over the past decade laser beam hardening with high power diode lasers became an established industrial surface treatment process. Advantages of the process include the precise control of the hardening zone location, the possibility to treat hard to reach surfaces (e.g. in bores) and the low heat impact of the process, which leads to minimized part warpage.

The typical process hardens tracks on the surface with widths from 1 millimeter to several centimeters. It is difficult to generate closed loop tracks such as rings because tempering effects may occur at the location where start and end points of the track meet. These effects may reduce the hardness at that location and also cause critical stress distributions.

However, surface wear protection is in particular critical for parts of rotational symmetry in the automotive industry and other branches.

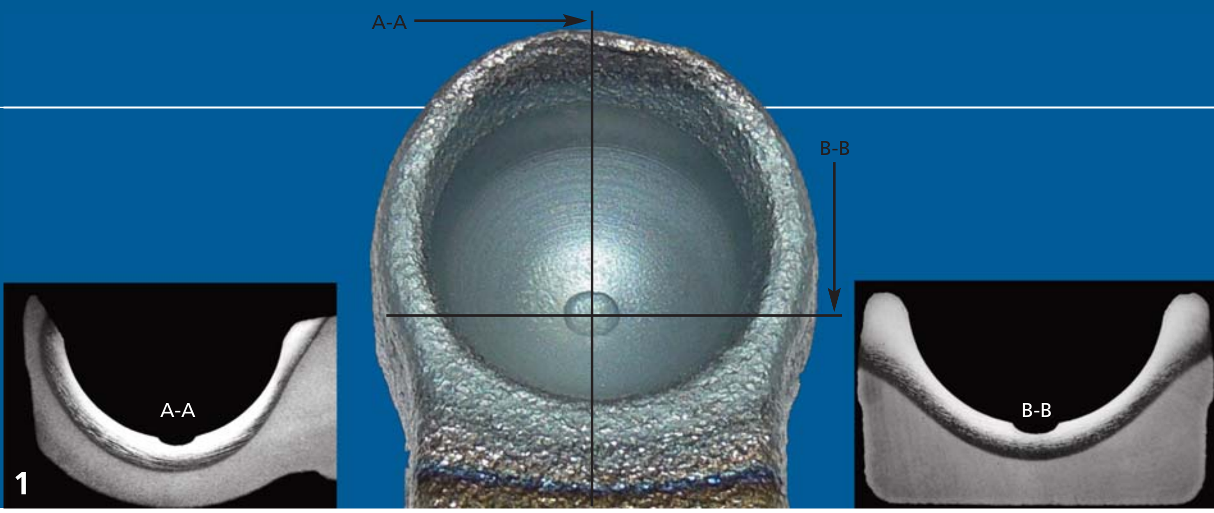
Consequently IWS engineers addressed the development of beam shaping units and process variations to achieve the tempering free surface hardening for such rotationally symmetric parts and other complex surface shapes.

OUR SOLUTION

Large parts of complex shape with 3D hardening zones are, for example, forming tools, turbine blades, angular rings and others. Such parts are processed with two cooperating robots. Each of the robots is equipped with the 1D beam shaping system "LASSY" with integrated temperature controller (also see Annual Reports 2009/2010). In addition the following process variations and corresponding beam shaping systems were developed, tested and implemented in production:

1. Fast part rotation with temperature controlled laser power adjustment
2. Part adapted ring beam optics
3. 2D scanner
4. Rotation mirror optics

The developments provide our customers with specific solutions for a wide selection of parts that can be surface hardened. This capability then enables new designs and products using such parts. In addition the new process variations and system components also help to reduce manufacturing cycle times, costs and energy consumption during surface hardening.



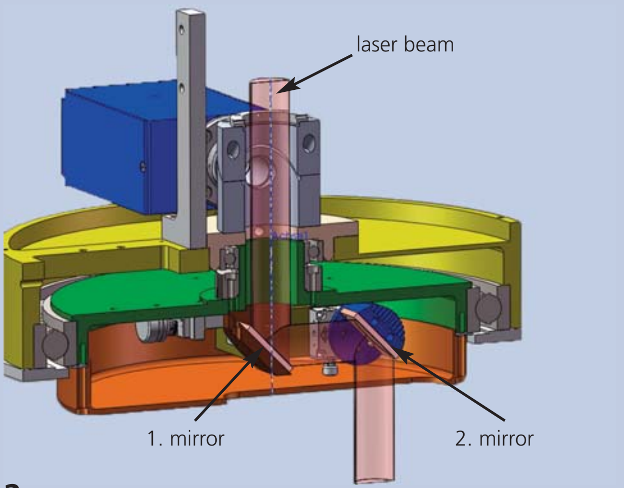
RESULTS

1. A ring shaped region of austenitic steel can be generated by fast rotation of parts such as shafts, shaft shoulders, ring grooves, leading edges or similar. After a brief heating period the glowing ring can be moved along the part using the NC feed.
This simple process variation is very flexible. The NC controller is used to adapt the process to different materials, part diameters, hardening zone depths and transition radii.

2. Especially designed ring optics were developed to perform the hardening of a ring shaped path on flat parts in one shot. This setup is practical for nuts, thrust washers, seat surfaces, valve seat rings or similar and requires only a very simple part fixture. However, the required laser power increases over-proportionally with increasing ring widths.

3. 2D scanners on the other hand allow virtually any shape of closed hardening zones on flat or slightly curved surfaces. Compared to the ring optics approach the 2D scanners require different limits with respect the achievable hardening depths. Typically the required power is substantially lower.

Rotation mirror optics



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4. Rotationally symmetrical parts with strongly curved, convex or concave surfaces require special optics for hardening. This optical system was developed based on rotating mirrors with integrated temperature control. The laser beam is guided by two mirrors, which are rotating around laser beam axis (Fig. 2).

The speed is continuously variable and adaptable to the application. The angle of the second mirror can be adjusted to achieve a sufficiently steep beam impact not only on flat and slightly curved surfaces but also on strongly curved surfaces and even on cylindrical shaft zones. The flexibility of this rotating mirror approach is optimal but it is intrinsically limited to the hardening of rotationally symmetrical surfaces only.

An industrial application example for using the rotating mirror optics is the hardening of ball calottes in suspension components. Here the process has to uniformly harden the entire inner surface of the calotte (Fig. 1). This is in particular difficult due the varying material thickness throughout the desired hardening zone. A compact processing chamber was developed for using the rotating mirror optics in an industrial environment. Due to its compactness it can be easily integrated into existing production lines. It is also possible to use it as a stand-alone unit with its own controller and manual or automated part feed.

1 Longitudinal and cross sections of a laser hardened ball calotte

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