The tests validated the use of the ultrasonic inspection method for determining all of the relevant quality characteristics. They also demonstrated the suitability of the ultrasonic inspection for determining typical defects that occur during laser beam welding such as “false friends“, “seam collapse“ and “blow out“ (top left), as well as pores with a minimum diameter of approximately 0.2 millimeters (top right).

Are you familiar with our industrial-grade accredited inspection services?

- Accredited laboratory in line with DIN EN ISO / IEC 17025, to qualify and validate new non-destructive testing (NDT) processes for industrial applications
- Accelerated time-to-market and opportunity for qualified, norm-compliant deployment in industrial applications as well as for complete new in-house developments or custom adaptation of innovative NDT technologies, even in fields where norms have not been established
- Certification of the corresponding quality management system in accordance with DIN EN ISO 9001

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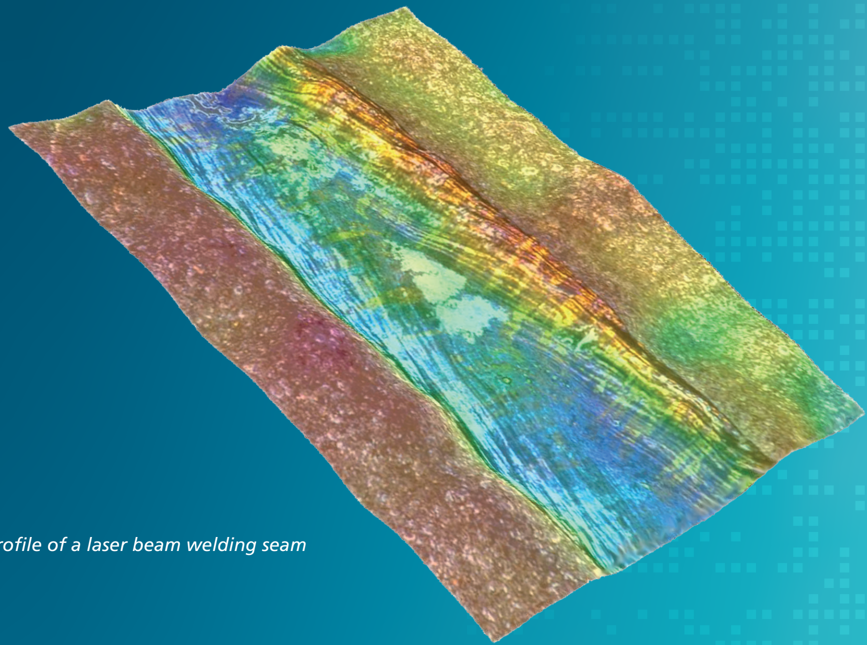
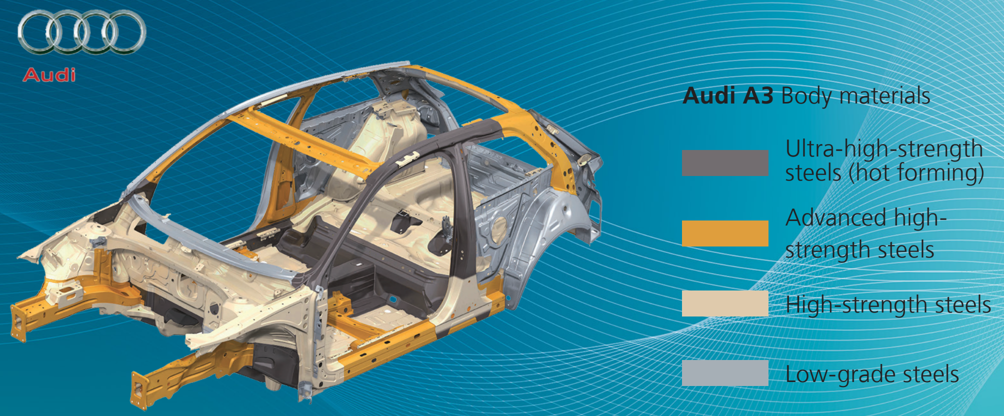
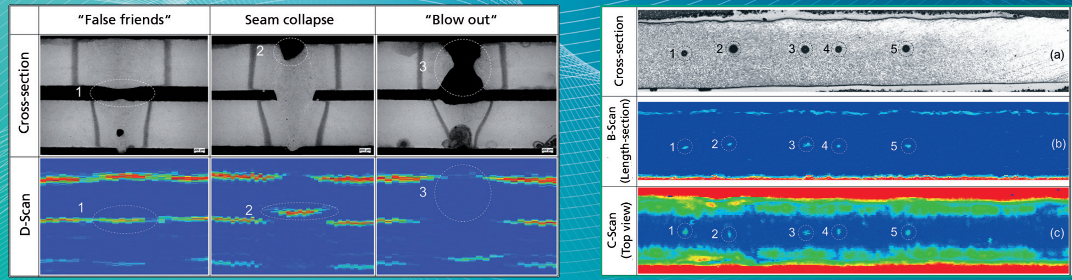


3D profile of a laser beam welding seam

High-frequency ultrasonic technology for inspecting press-hardened steels

Optimization of the laser welding seam quality





Left: Typical laser beam welding defects: cross-section and ultrasonic D-scan; right: Line of pores at the joint level: cross-section and ultrasonic B- or C-scan

High-frequency ultrasonic technology for inspecting press-hardened steels

Facing conflicting demands for increased safety, reduced CO2 emissions and maximum customer convenience and comfort, today's automobile manufacturers are being compelled to develop individual lightweight construction strategies. One facet of these strategies is the rapidly increasing use of press-hardened steels (22MnB5) for crash-durable structural components (lightweight material design).

To date, resistance spot welding and mechanical spot mating are the established joining techniques. Compared to these methods, laser welding boasts significant advantages, in particular linear joints that simultaneously offer fewer weld flanges and optimized flux. These inherent advantages cannot be fully exploited at the moment. Because of as yet unresolved restrictions, laser-based welding of ultra-high-strength steels is not a fully controllable process. A seamless NDT-based process model to assure the quality of the entire joining process, plus a specific control and regulation concept, could provide a valuable contribution to ensure quality-assured and stable manufacturing processes that allow the potential of lightweight construction to be fully exploited.

With the aim of implementing fully controllable processes, this initial work package is designed to come up with new ways to achieve the rapid and efficient post-process monitoring, documentation and optimization of the laser welding quality by integrating advanced high-frequency ultrasonic inspection technology. The objective is to develop a quality assurance process for laser welds that is much faster and much more efficient than conventional metallographic cross and length sections.

In a first step, a solid state disk laser (see table) was used to produce sample welds of ultra-high-strength auto body steel through a linear I-seam at the overlap joint. A wide range of welding parameters such as laser power, welding speed, focal position, beam angle, shielding gas and the gap between the joined components were varied during the test, which yielded more than 170 individual welding samples.

As part of a second step, destructive inspection methods such as tensile shear strength, hardness profile and metallography testing were utilized to determine the quality of the relevant properties. Quantitative testing was carried out with common reference methods, as well as with the high-frequency ultrasonic inspection technique (75 MHz nominal frequency) which is to be validated.

In a third step, the ultrasonic process enabled the quick and efficient determination of the optimal welding parameters.

Wavelength λ	Laser power P_L	Beam quality SSP	Cable diameter
1030 nm	2000 W	8 mm·mrad	200 µm
Collamination focal length	Lens focal length	Focus diameter d_f	Operating distance
200 mm	200 mm	200 µm	167,5 mm

Data from the laser beam source (top) and laser welding optics (bottom)

Amongst other quality characteristics, the width of the joining cross-section and the length of the welding seam were used to determine the resilience. Other characteristics include the welding seam and root geometry, the existence and position of defects and the welding seam profile.