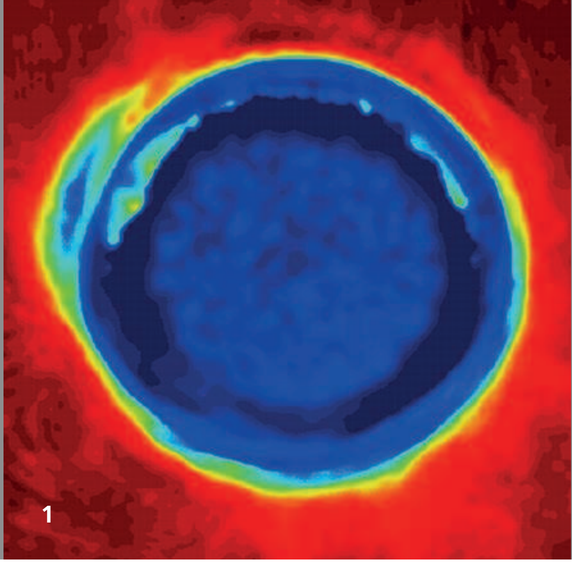

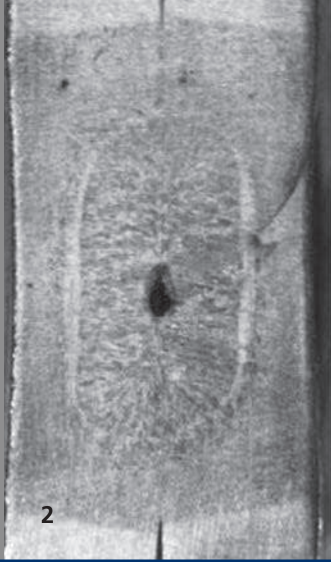

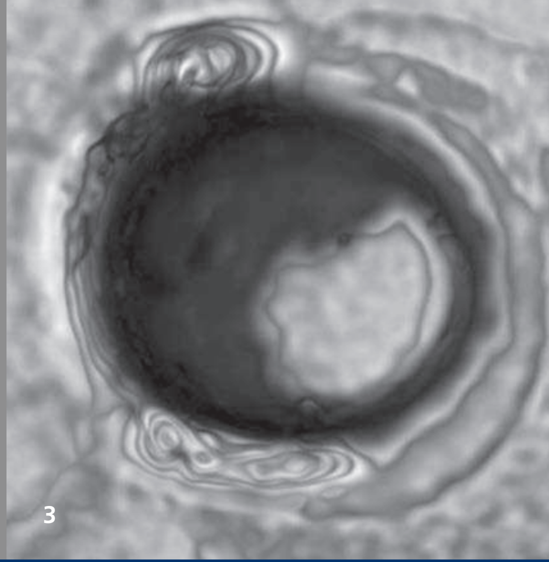

3D WELD NUGGET CHARACTERIZATION BY HIGH-FREQUENCY ULTRASOUND

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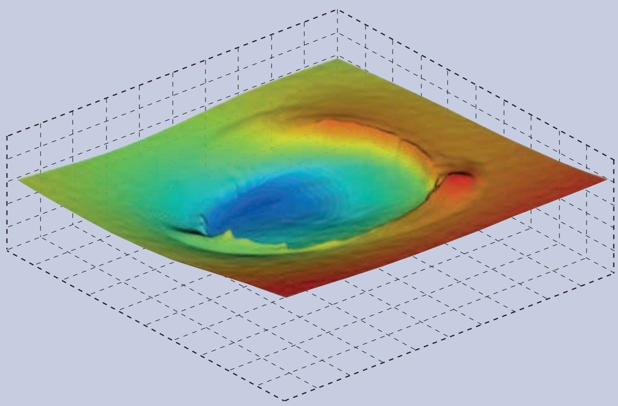
Resistance spot welding represents a well-established industrial joining technology due to its high cost-effectiveness and process reliability. Traditionally, the quality of a resistance spot weld has been tested destructively by the chisel test, in which the button of the weld spot is measured geometrically. Based on the assumption that constant process parameters, such as material type, welding time and electrode force, and other statistically varying parameters lead to similar but not identical results, the process quality can be characterized by the evaluation of random samples. However, for 100 % in-line testing, a non-destructive inspection method needs to be applied. The ultrasonic pulse-echo technique represents such a method. With conventional single-channel transducers, spot welds can be characterized by the evaluation of the echo signals integrated over the aperture of the transducer. However, in order to get a space-resolved evaluation of the spot weld in terms of high-resolution C-scan images, a mechanical scanner or an ultrasonic matrix array is necessary. The latter usually requires high-performance multi-channel electronic measuring equipment. Reference measurements based on high-resolution Scanning Acoustic Microscopy (SAM) showed that with this imaging approach, the lateral size of the weld nugget can be measured precisely. In contrast to conventional single-channel testing, this method also allows imperfections and other discontinuities to be localized and taken into account in the weld assessment. By considering the topography of the weld region and the coarse-grained nature of the microstructure inside the weld nugget, it is additionally possible to estimate the thickness of the weld nugget for full 3D characterization of the nugget. The thickness evaluation is based on the attenuation of the back wall echo caused by ultrasonic grain scattering. In practice, the mechanical scanning of the SAM can be replaced by the electronic scanning of an ultrasonic matrix array. The large number of channels and the high performance of the measuring equipment needed for such an approach are provided by PCUS pro Array II, the newly developed Fraunhofer IKTS in-house hardware platform. It offers 128 transmit and 128 receive channels and is fully cascadable so that even more than 128 channels can be addressed.

Topography of a resistance spot weld caused by indentation of the welding tong



1 Color-coded back wall echo for estimation of the weld nugget thickness, showing the coarse-grained microstructure in the interior of the nugget.

2 Photomicrograph of a resistance spot weld with a coarse-grained microstructure and a void.

3 Typical C-scan of a spot weld with a light area indicative of an incomplete fusion.

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