Rapid materials testing in 3D

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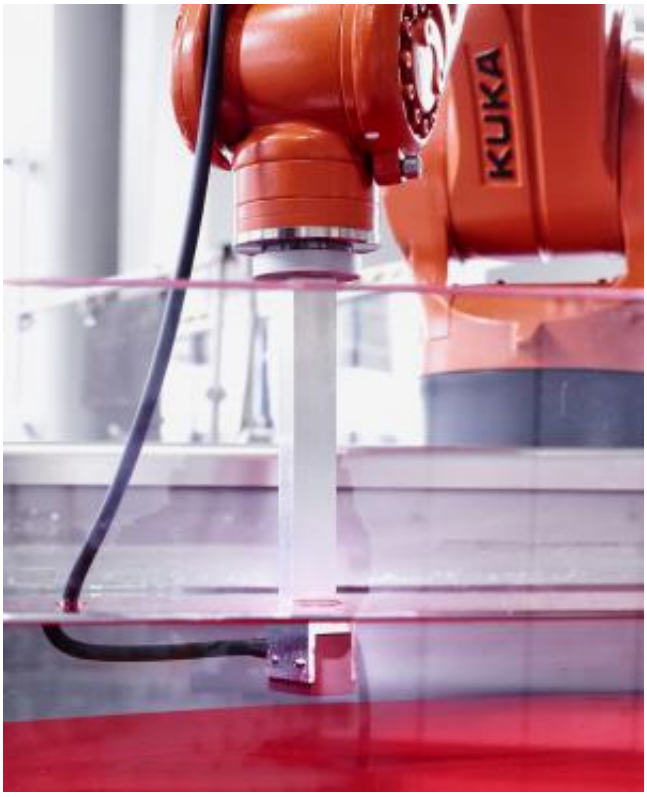

The probe generates ultrasonic waves that penetrate the ma- terial. Credit: Uwe Bellhäuser

Ultrasound is a proven technology in components testing, but until now eva- luating the data has always been quite a time-consuming process. At the Hannover Messe from April 7-11, Fraunhofer researchers will be presenting their optimized ultrasonic testing solution – a method for testing materials quickly and reliably with the help of 3D images.

Bats always know where they are, even in complete darkness. It's not that they have amazing vision: rather, these nocturnal creatures "scan" their surroundings by continually emitting sounds inaudible to humans. Whenever these ultrasonic waves hit an obstacle, they are sent back as an echo. The longer an echo takes to return, the further away the object is. We humans also utilize this echolocation principle; in industry, for example, where ultrasound provides an effective way to test components. Ultrasonic waves emitted from a probe are used to detect the tiniest tears or material flaws that are not externally visible. Until now this process involved an employee guiding the probe along the component by hand, with the reflected signals appearing as curves on the probe's display. Simple cross-sectional images of the area being examined can also be generated, providing experienced examiners with enough information to identify material defects. However, examiners effectively have to create a spatial image in their heads, which is a time-consuming procedure.

All this will be easier and faster in the future. Researchers at the Fraunhofer Institute for Nondestructive Testing IZFP in Saarbrücken have been able to produce high-resolution 3D images from the test signals, just like in medical ultrasound computed tomography. "These pictures reveal any material defects, giving us their size and exact location," says Professor Hans-Georg Herrmann from Fraunhofer IZFP.

Examining fiber-reinforced high-performance polymers for material defects

Fraunhofer's solution builds on phased array technology, which sees several single-element probes arranged side by side into rows or sheets. This allows the ultrasonic waves to be passed through large areas of material at a time instead of only penetrating the subject selectively. Fraunhofer IZFP scientists have developed this idea further by making it possible to control each probe separately, allowing examiners to focus on every part of the area being tested simultaneously. In parallel, they have

developed an algorithm that generates a 3D image from the many individual signals that can then be viewed on a PC. "The spatial resolution of these images is significantly better than in conventional methods. What's more, our reconstruction algorithm is real-time capable, which allows us to significantly speed up the testing process," says Herrmann, summarizing the benefits offered by their new optimized method – sampling phased array technology. Another plus: The new, robot-assisted process can even test materials that have historically been difficult to characterize. Inspecting fiber-reinforced high-performance polymers with direction-dependent fiber orientation is typical of the kinds of application suitable for this new testing technology.

To analyze an abnormality in the material, the examiner can view the pictures from different directions, rotate them or select specific areas. It is also possible to take longitudinal or transverse sections of the images. The objective for industrial applications is to achieve largely automated component testing by enabling an industrial robot, connected to the inspection system via an interface, to carry out complete component scans. The 3D views generated would then be automatically evaluated using specially developed and adapted algorithms, thereby easing the burden on the examiner. In the longer term, this will make the time-consuming manual interpretation of all the data produced entirely unnecessary, speeding up the test process and making it more re-liable.

Quality assurance is only one example of the possible applications for this method. "Our technology is suitable for use over the entire product life cycle – from material characterization to component parts evaluation, from repair services to recycling," says Professor Bernd Valeske of Fraunhofer IZFP. Currently, the new process is being qualified as part of an industrial project and is on the verge of being released. At the Hannover Messe, the Fraunhofer researchers from Saarbrücken will be showcasing a demonstrator of their test system.

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