Ultrasonic Transducer Requires No Contact

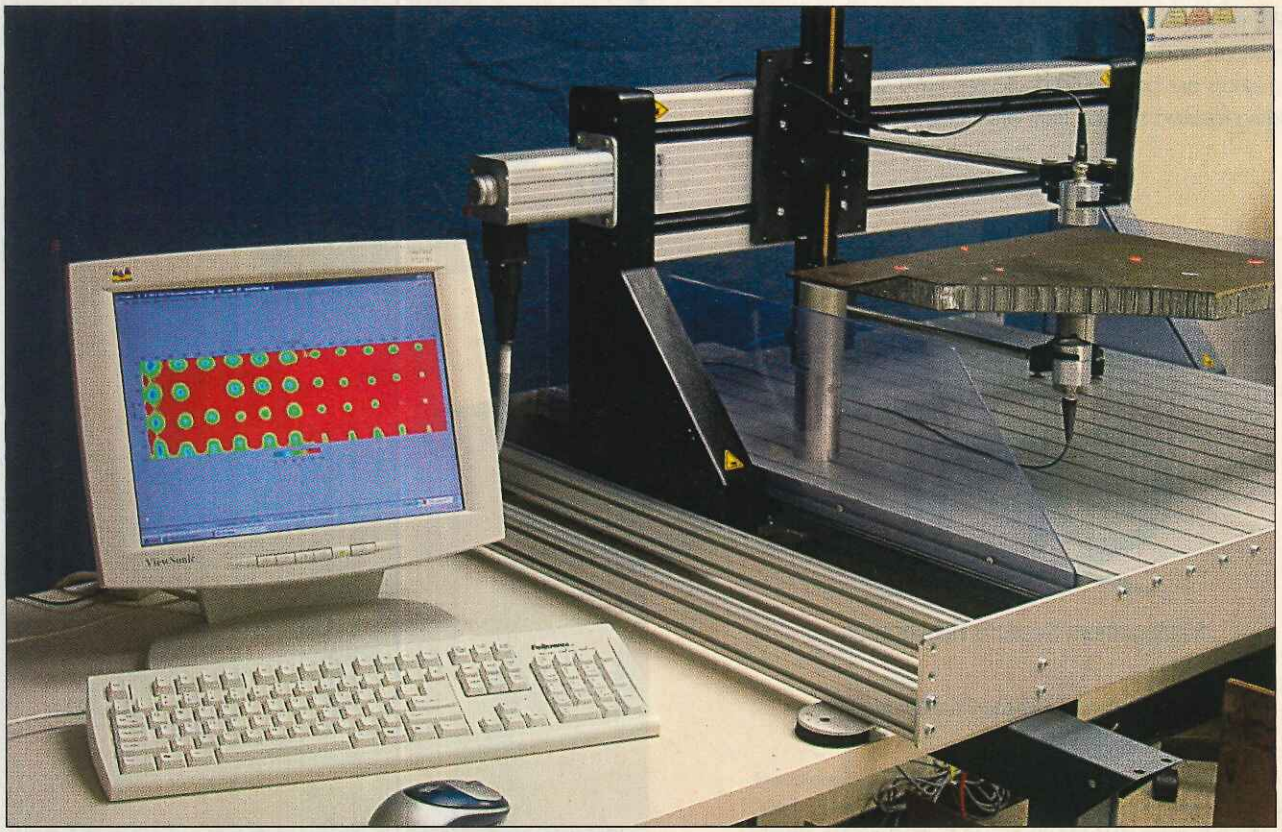
INTEGRATING A GANTRY PLAYS A CRITICAL ROLE IN NONCONTACT ULTRASOUND TESTING. BY STEPHEN GLAD

Ultrasound has been used to determine a range of material characteristics without damage to the test article. But, industrial applications of ultrasound have been limited by the need to physically couple the transducer to the test medium. Recently, this limitation has been overcome by the development of ultrasonic transducers that are capable of transmitting and detecting ultrasound without contacting the test medium.

SecondWave Systems, a division of the Ultran Group (Boalsburg, PA), developed a commercial system that can fully characterize materials by moving the transducer across its length and width while measuring thickness, density, mechanical properties and defects. A computerized numerical control (CNC) gantry from Techno-Isel (New Hyde Park, NY) positions the transducer.

Because of high acoustic impedance mismatch between a non-contacting medium, such as air, and the test media, ultrasound waves can be attenuated by as much as six orders of magnitude when propagated from air to many common materials. As a result, a limitation of this technology has been the need to physically couple the transducer to the test medium. Conventional wisdom dictates that ultrasound cannot be propagated through solids or liquids without physical contact between the transducer and the test medium. This has limited the application of this technology to materials that are not damaged by contact with the transducer and a liquid gel used to couple the transducer to the test medium. So it is normally impossible to test materials that are in the early stages of formation, such as uncured plastics, green ceramics and powered metals; materials that are continuously rolled on a production line or have a large surface area to be scanned. For these reasons, noncontact ultrasound methods that would greatly increase the applicability of this testing method have long been sought.

A key to overcoming this limitation is a piezoelectric transducer that has a high level of sensitivity. For example, one comparison of these new transducers in air and conventional contact sensors in water shows that the sensitivity



The Airtech 4000 with the gantry system generates ultrasonic images in the c-scan mode. The two-axis linear motion-control platform provides a scanning area of 50 by 54 centimeters. ***Photo: Techno-Isel***

QUALITY SPECS

- An ultrasonic transducer is capable of transmitting and detecting ultrasound without contacting the test medium.
- The system can fully characterize materials by moving the transducer across its length and width while measuring thickness, density, mechanical properties and defects.
- A key to the success of this application is a computer numerical control (CNC) gantry that positions the transducer.

of the former is only between 12 decibels (dB) to 40 dB less than the latter in a frequency range of 50 kilohertz to 5 megahertz. The ultrasound transduction efficiency of new transducers is sufficient to break the massive acoustic impedance mismatch barrier between air and most materials.

SecondWave Systems integrated the noncontact ultrasonic transducers with the new generation of ultrasonic instruments and mechanical transducer translational systems. The two newest systems are the AirTech 4000 that uses the Techno Gantry, and the iPass which works statically or in a scanning configuration. The analyzer is normally operated in direct transmission mode to characterize a sample for thickness, velocity, density, defects and microstructure. When the material surface needs to be evaluated, it can be operated in direct reflection mode because reflectivity of ultrasound is directly related to surface roughness. For example, when ultrasound encounters a discontinuity in its path of propagation, the amount of energy transmitted is reduced, relative to that from a defect-free region.

One function of the iPass System is it can monitor the trend of any measured parameter such as thickness, velocity, time-of-flight, attenuation or density as a function of its variation from one point to another. This feature is particularly beneficial for linear imaging or for on-line applications where the product is in motion. The system provides two trend plots, thus facilitating two independent measurements of a material, or from two different locations on it. The speed of a trend plot can be synchronized with that of the moving object or the material.

Noncontact ultrasound measuring technology has been successfully applied for the analysis of a wide range of materials. This includes aircraft and aerospace composites, space shuttle thermal protection tiles; green ceramics and powder metals; light metals; porous materials and foams; rubbers, tires and plastics; wood, lumber and construction materials; asphalt and reinforced concretes; food and pharmaceutical products, level sensing and proximity analysis; bone density (osteoporosis) measurements, and several other materials and applications. Noncontact

ultrasonic transmission and reflection signals are monitored in real time and are related to significant material characteristics, such as defects, texture, density and porosity.

Neeraj Bhardwaj, director of sales and marketing for SecondWave Systems, identified the need for a noncontact ultrasound device capable of accurately measuring and inspecting large surface areas. "To bring the new product to market, we needed a motion control system with a high level of accuracy to move the transducer over the test materials while accurately recording its position," he says. "Cost was also a major consideration because the manufacturing market is price-sensitive." Bhardwaj discovered the Techno-Isel stepper-motor-controlled gantry system that has a 0.0005-inch resolution and repeatability, 0.003 inch per foot absolute accuracy and travel ranging from 8 by 10 by 5 inches to 56 by 96 by 20 inches.

This stepper-motor-controlled gantry system is constructed on steel stress-relieved bases with hardened steel linear ways. Its shaft-and-bearing system produces smooth, play-free motion and is a rigid system that produces high-accuracy positioning. The gantry's design includes heavy cast-aluminum side plates supporting the Y-axis, giving extra stiffness for accuracy in positioning. Anti-backlash ball screws and nuts are standard. SecondWave Systems interfaced the Airtech 4000 with the Techno-Isel Gantry system to create a system capable of generating ultrasonic images in the c-scan mode. The Airtech 4000 is a general-purpose two-axis linear motion-control platform. It provides a scanning area of 50 by 54 centimeters. The drive mechanism consists of 16-millimeter ball screws and 4-millimeter double re-circulating ball bearings. The analyzer also includes 15-centimeter posts, two precision transducer alignment holders, a serial interface cable, MATLAB ready scripts for data presentation and a power cord.

"The gantry rapidly moves over the test materials while the transducer fires off signals that evaluate parameters of interest at every point in the test item," Bhardwaj says. "Our customer obtains a comprehensive record of the material properties. Customers in the ceramics, paper, composites and other industries are using it for automated, nondestructive testing that couldn't be performed in any other way."

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