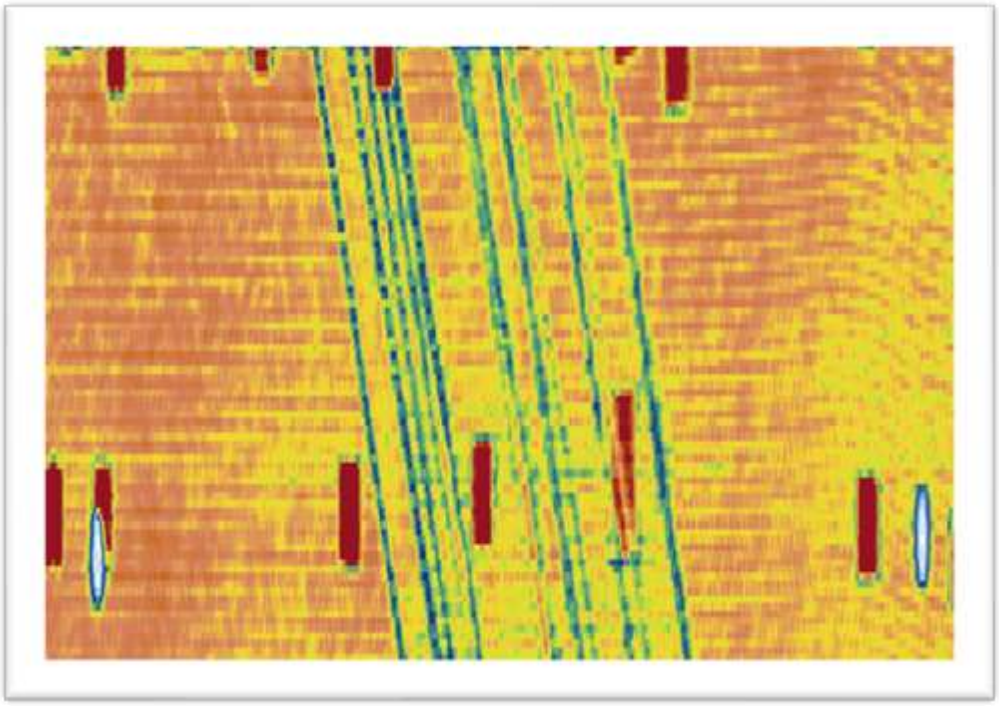


RAPID INSPECTION OF COMPOSITES WITH PHASED ARRAY ULTRASONIC SYSTEM

DHVANI RESEARCH
Making Technology Work

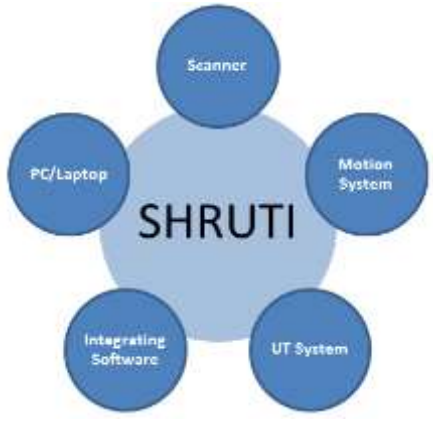
A solution for the rapid inspection of multilayered composites is a long-awaited requirement of the aerospace industry since the widespread inculcation of composites into aerospace structures. The key features in these requirements are speed of inspection, defect detection efficiency, repeatability, and reliability. Conventional ultrasound transducers in arrays are commonly employed for this purpose which has additional complexities like cable routing issues, heavy end manipulators, sophisticated multi-channel ultrasonic pulse receivers, data interpretation and representation difficulties, etc. Phased array ultrasound technology has emerged as a potential solution in the past years to solve the bottlenecks with more efficient emission-reception properties and damping, making it an ideal choice for the application. Phased array transducers, by providing precise time delays and shifts are capable of variable focal lengths, aperture sizes, dynamic depth focusing, electronic angle sweeping, and lots more. These properties enable the scanning of the samples in no time thereby reducing the scanning time by a factor of 1/25. An advanced manipulator capable of maneuvering the PAUT probe in multiple degrees of freedom coupled with advanced and user-friendly software can do wonders, making impossible inspections possible.

SHRUTI® (Scanning High-Resolution Ultrasonic Inspection System) is an indigenously developed customizable, automated, multi-axis robotic scanner. Along with phased array ultrasonic probe, advanced data analysis (***extut®***) and image analysis packages (***imagine®***, ***SimScan®***, ***SimSonic®***), SHRUTI facilitates easy inspection of samples and components. To illustrate the power of PAUT

inspection a composite component with simulated defects is scanned with both conventional ultrasound and phased array ultrasound. For conventional scanning, the same machine **SHRUTI®** can be used which is equipped with an advanced manipulator capable of accommodating both Conventional and PAUT probes.

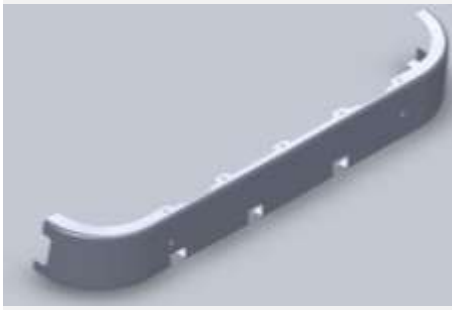
Experimental Parameters	
Conventional Probe	5 MHz 2 inch focused
PAUT Probe	5 MHz 128 element linear array
PAUT Probe	5 MHz 16 element linear array
Machine	SHRUTI

SHRUTI® offers very high-resolution images of the test coupon with very high scanning speeds. The complete instrument control is through the software. Skelton of the system is being built from lightweight aluminum extrusions which are upgraded to



Sample used

The sample used for demonstration is a multilayered composite with tapes and inserts placed between the layers to create delamination. The sample is also cut at places to ensure effective detection of the same.



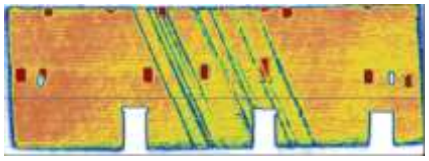
Stainless Steel for heavy-duty applications. All the electrical connections are rugged and properly routed following industrial standards offering very durable and reliable running. Components of flat, cylindrical, and complex shapes can be imaged.

The use of phased array probes instead of conventional ultrasound arrays will give you a quantum leap in terms of efficiency, inspection time, and ease of inspection.

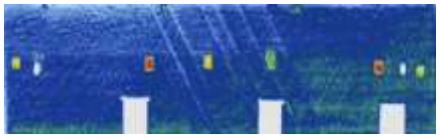
Scanning time comparison	
Conventional UT, Raster mode with resolution 1mm by 1mm at 150 mm/s speed	20 minutes
PAUT one line scan	20 seconds

Inspection Images of the flat face

PAUT one-line scan



Conventional UT raster scan



The above-shown images are for the flat face of the component, to ensure 100% inspection of the components the curved region also needs to be inspected for which the end manipulator needs advanced maneuvering features. For ease, a 16 element PAUT probe is used as shown in the picture

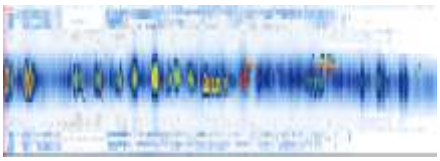
16 element PAUT probe in adapter casing

The end manipulator automatically adjusts itself to the curvature either from a CAD drawing of the component or in teach mode. The phased array is in sectorial mode sweeping electronically from -15 to +15 degrees effectively covering the

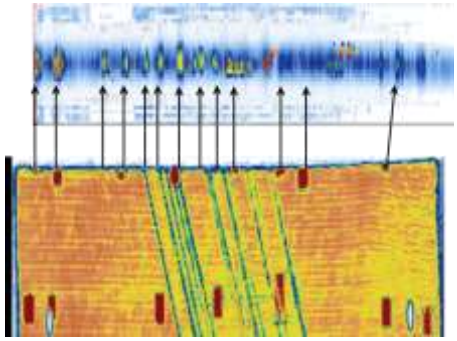
corner regions detecting the defects

Inspection Images of curvature

Sectorial Scan

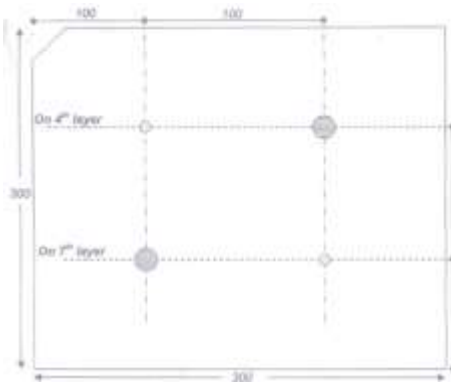


Correlation with a flat face



All the sections are imaged with proper calibration and gates which can be stitched together to display on the surface of the CAD drawing to create a complete picture of the inspection results

The resolution offered by PAUT is comparable to that of conventional UT against the popular myths that as PAUT focus on the near field there are chances that the resolution will be less. For the resolution study, a 300 by 5 mm sample having 33 layers with each layer thickness 0.15 mm is taken, 5 mm and 10 mm Teflon inserts are placed at the 4th and 7th layers.

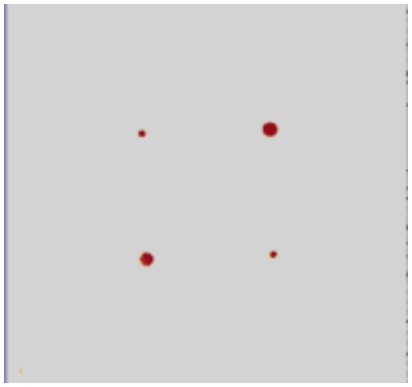


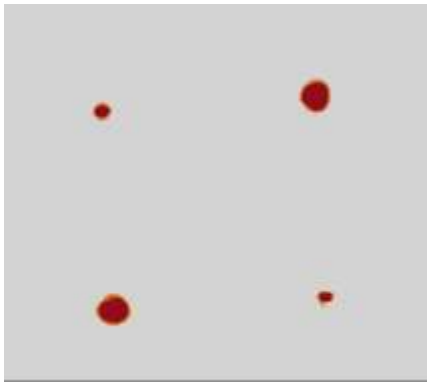
Sample Schematic

The sample is scanned with a 5 MHz 2 inch focused conventional probe and a 5 MHz 128 element linear array probe. Again the same machine SHRUTI is used for the inspection and below is the result.

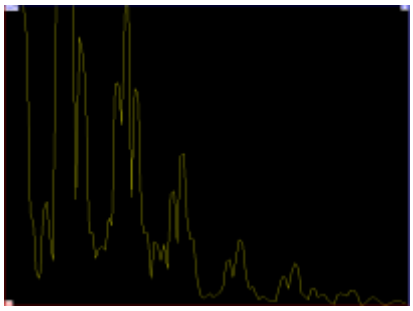
Scan Images

Conventional UT Image





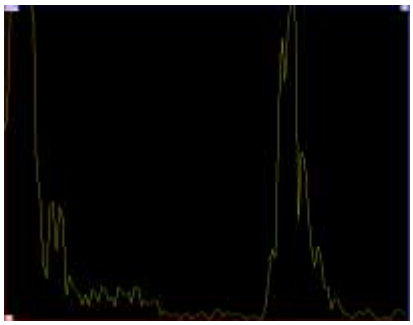
PAUT Image



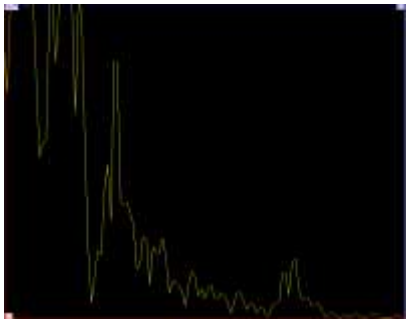
Waveform with defect at 7th layer

The above images show the vertical resolution of the PAUT probes. Phased array probes give added advantages in terms of speed of inspection and ease of operation and are available in a variety of sizes, configurations, and shapes. PAUT inspection coupled with SHRUTI is ideal for aerospace composite component inspection.

Waveform Comparison



Defect-fr waveform

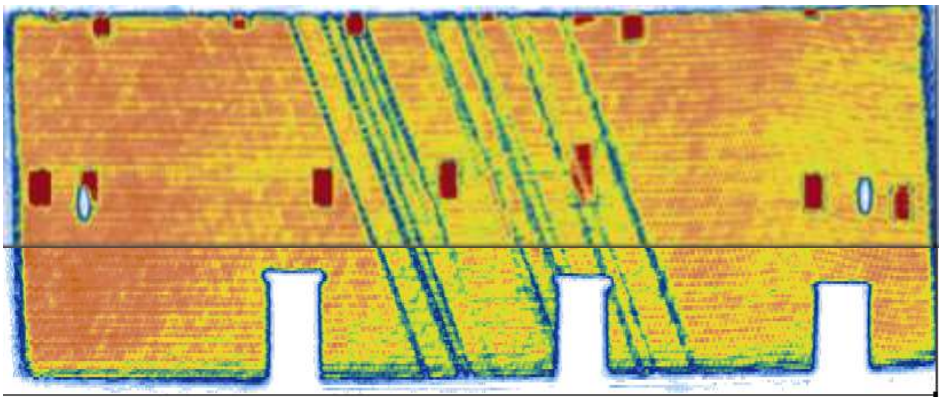


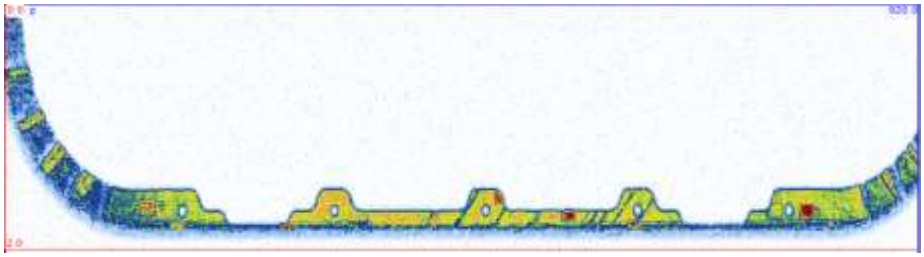
Waveform with defect at 4th layer

Rapid Inspection of Composites with Phased Array Ultrasonic system - Application note

A Dhvani Research Application Note

Chennai, INDIA





PAUT Imaged with 128 elements linear array immersion probe

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