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Fiber Glass and Carbon Fiber Laminates

Absolute position encoding manual inspection of fiber glass and carbon laminates using the wheelprobe

Application Note

Carbon Fiber-Reinforced Polymer (CFRP) and Glass Fiber-Reinforced Polymer (GFRP) composite materials are widely used in a variety of applications such as aerospace structures, wind turbine blades, and the automotive industry.

Nondestructive testing (NDT) and inspection of these materials are necessary to control the quality of the parts and inspect for anomalies in the structures given the manual layup work involved.

The most commonly used non-destructive test for composite structures is Ultrasonic Testing (UT), where, by means of a two axis scanner, a two-dimensional C-scan map of the structure can be produced. In composite structures, defects are most often in the form of either disbonds or delaminations in the plane of the material, or porosity.

The reason for favouring ultrasound testing is that it is very sensitive to these types of defect commonly found in composites. It is also one of the few methods available for detecting porosity and it can detect most of the other defects at the same time.

In ultrasonic testing, a piezoelectric transducer is used for generation of compression or shear wave which are propagating through the inspected object. When these waves interact with media boundaries, they face reflection, transmission, and scattering from the boundaries.

Although its considered the "golden standard" test method, in its conventional format it's highly restricted in terms of productivity and flexibility.

Defects in Composites

Defects can inadvertently be produced in composite materials, either during the manufacturing process or in the course of the normal service life of the component.

Type A
Disbonds are separations in a secondary adhesive bond. They will reduce the local stiffness of a component; however, strength is not necessarily affected. Basically, disbonds are delaminations between bonded structures.

Type B
Foreign bodies. Preparation of the resin-impregnated fiber layers (pre-preg), prior to curing, can be by hand or machine. In either case there is the potential for the inclusion of foreign bodies ranging from backing film to just greasy marks from fingers.

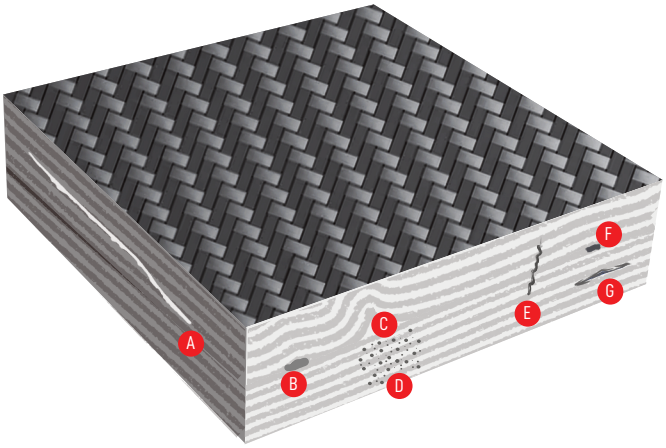
Type C
Wrinkles. More recent low-cost manufacturing techniques, involving the infusion of resin into pre-formed dry fibers in moulds, have introduced other potential defects such as fiber misalignment, or waviness, both in the plane of the material and out-of-plane like wrinckles.

Type D
Porosity does not produce a discrete reflection but scatters the ultrasound in a range of directions, also resulting in a transmission loss. These transmission losses can be detected but in the case of contact methods, where the probe is placed directly on the part and the ultrasonic wave is transmitted through a layer of couplant, careful placement and decent amount of couplant is required to ensure that the loss of signal is not due to these factors.

Type E
Fiber and Matrix Cracks. They are characterized by localized partial through-the-thickness cracking. Many cracklike failures in continuous fiber composites and their laminates are contained within the interface planes, where the matrix material properties dominate the fracture response.

Type F
Voids. Stitching of fiber tows (bunches of fibers), to hold them in place and prevent misalignment during cure, can itself introduce numerous regularly-spaced sites for void formation.

Type G
Delaminations. In service damage is most often caused by impacts. In monolithic composites this results in matrix cracking and delaminations of the ply layers. In some cases the surface is punctured, but often this is not the case, despite the internal delamination damage being extensive.



Our Solution

Phased array ultrasonic testing (PAUT) can overcome conventional ultrasonic method limitations by providing the capability of beam focusing and configurable aperture size. In PAUT, a series of ultrasonic elements in a phased array transducer can provide the option to activate each individual element in a programmed sequence.

Our Roller Probe was designed to inspected composites and other materials with relatively smooth surfaces. The 64 element footprint offers a great coverage that boosts productivity and reduces inspection time.

The phased array unit is capable of driving multiple elements, receiving and digitizing the returning echoes based on the appropriate delay law for firing the elements. This is done by changing the time between the outgoing ultrasonic pulses of each element so that the superimposed wave front effectively shapes the resultant final sound beam.

This capability assists in generating the desired type of ultrasonic signal and improving the wave characteristics in comparison to the conventional single-element ultrasonic transducer.

Instruments

The PragmaPro comes with conventional UT, Time-Of-Flight-Diffraction (TOFD), and all beam-forming phased array UT techniques for single-beam and multi-group inspection.

- Battery operated portable instrument.
- 32 channels. Multiplexing up to 128 elements
- Best in class waveform signal
- Variety of 6 Degree of freedom encoding solutions

Wheel Probe

The probe consists of a phased array probe that is 51.2 mm (2 in.) long with 64 elements immersed in a water tire and requires minimum pressure to couple to the part.

- 1-5 MHz depending on the thickness of the material and layup.
- Tire's material has an acoustic impedance that is closely matched to water.
- Built-in encoder for simple line scans. Ability to index multiple line scans to form a C-Scan map.
- Optional laser guides can be added for guidance.

Hexagon Absolute Arm

This 7 axis absolute arm lends its ultra-high precision to probe position over any given surface. Using the RSW Probe adaptor, the probe is mounted in the arm's handle. The laser and structured light scanners allow for surface scanning and in the automotive world these are typically used to measure the gaps between panels.

- Metrology grade positioning device.
- High-tech carbon-fibre tube construction ensures strength and thermal stability.
- A wide range of touch probes and high-speed 3D scanners.
- Range varying from 2 and up to 4.98m depending on the length of the model.

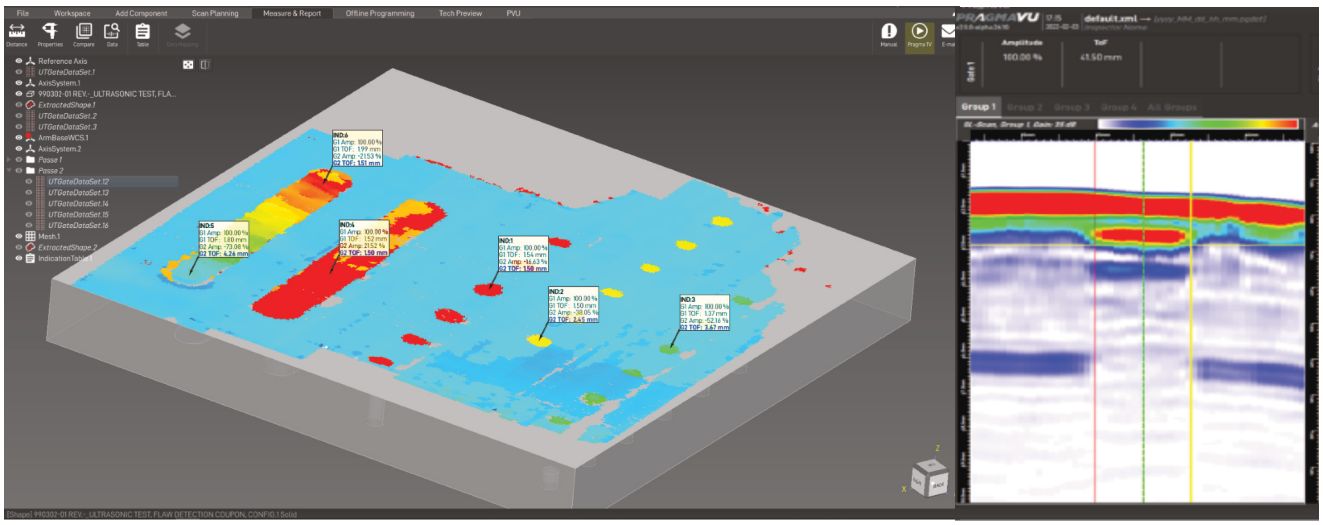
Software

A 6DOF position encoding system creates a challenge on how to record data since most PAUT software only account for 3 axis. Pragma3D was developed to tackle such issue and to enable UT technicians to visualize data in a true 3D environment.

UT data can be acquired in the same workspace with an embedded version of PragmaVU, the software responsible for that.

Composite laminates are subjected to a variety of possible defects which may be located in the various plies of the composite. Depending on the depth of the flaw, amplitude compensation is required to ensure that the signal response is constant across the plies.

This is ensured by means of a TCG (Time Corrected Gain) curve that is generated within PragmaVU



Conclusion

To demonstrate the potential of PAUT for flaw detection on CFRP/GFRP laminates, a coupon with flat bottom holes at different depths was used. A linear scan was set using all 64 elements of the probe with a 8 element active aperture. All simulated flaws were detected effectively, including the near surface ones (depth >1mm)

Reviewing the acquired data is done in the same 3D workspace of the acquisition process. Sizing of the suspected flaws is done effortlessly using the auto-sizing feature of Pragma3D. After evaluating the registered flaws, a report can be rapidly generated and sent to the interested parties within Pragma3D.

Ordering Info

SKU	Description
PRG-PRO-900	PragmaPro NDT Instrument Platform
PRG-PRO-KIT0	PragmaPro Convenience Kit
PRG-PAUT-32/128	PAUT 32/128 Cartridge
PRG-3D-COMP	Pragma3D | Composer, Data Acquisition and Analysis Software for Windows PC, Version 2.x, Free Updates and Support for 1 Year
PRG-PAUT-SPOT-20M121	PragmaSpot, Aqualene delay line, 20 MHz, 121 Elements, 11x11 Matrix
PRG-SCAN-CMM-ADAPT2	PragmaSpot Adaptor for CMM Arm

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