Inspection of CFRP- and GFRP- Sandwich Components

1. Introduction

High-performance materials such as sandwich components are attractive materials for lightweight constructions in aerospace, naval and automotive engineering. Their application to primary aircraft structures requires the knowledge of damage incurred after fabrication or in service. Typical damages to be detected are: cracks and delaminations in the skin, debondings between skin and core and defects in the core (crushing), of which only a small part is visible from the outside. The ultrasonic technique is principally able to indicate internal defects. Honeycomb sandwich components are inhomogeneous and anisotropic materials with an extremely high sound damping. Through-transmission techniques with separate receiver and transmitter transducers on opposite sides of the component, is often used for their testing. This method is much easier than the echo technique because the sound has to travel only once in the thickness direction. However, through transmission technique is not practicable for in-field inspections because of the access is limited to one side of the components.
Special developments for the ultrasonic echo technique were necessary in order to obtain a high degree of evidence. This report describes the optimizations of pulse parameters for the ultrasonic imaging of internal defects in sandwich specimens with Nomex cores, and the results of laboratory and in-field inspections.

2. Optimization of Pulse Parameters

Different test frequency spectra have to be used for the skin inspections and for testing of the whole sandwich thickness. The skin thickness is only 0.5 to 1.0 mm, so that high frequencies in the range of 15 to 35 MHz are required to separate interface and backwall echoes. The skin inspections provide no information about core defects. Therefore the investigations were focused on the inspection of the whole sandwich thickness by the echo technique [2] (see Fig. 1).

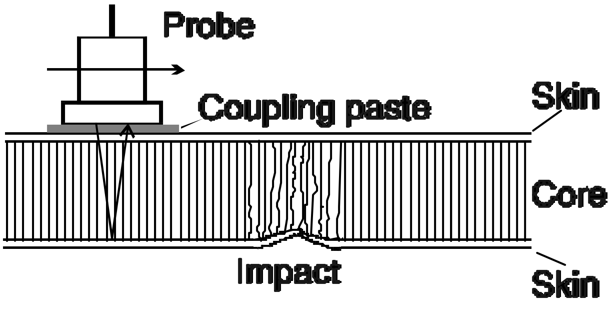

Fig. 1:
Ultrasonic Inspection of sandwich components in echo-technique

Best results were obtained with a broadband ***transducer 0.8-3 MHz*** with an aluminium oxide protective layer. Water split coupling was used.

Different types of ultrasonic pulsers were investigated for sandwich components. Best results delivered the rectangular pulser board ***HILL-SCAN 3100***. In comparison with the normally used broadband spike pulser (useful for high frequency ultrasonic testing of the skin) the frequency spectrum is more concentrated in a smaller range which is adjustable by the pulse width.

The ultrasonic hardware for sandwich components consists of HILL-SCAN 3100, HILL-SCAN 3010 and the ADC-board 20520 built-in an **USPC 3010 Portable** or **USPC 3010 Industrial**. The pulser-/receiver-board ***HILL-SCAN 3010*** is used as an receiver with low pass filter. The application of the echo technique opens the possibility to a powerful ultrasonic imaging of defects in sandwich components not only for laboratory use but also for field-inspections.

3. Inspections of skin and core

Fig. 2 shows a comparison of three C-scans and their echo-dynamic curves below of an impacted sandwich component (impact energy levels of 4 and 18 Joules) with 1 mm thick CFRP fabric skins and a 15 mm thick Nomex core. The left C-scan relates to the skin (in echo-technique), the one in the centre to the whole sandwich thickness in through transmission technique and the C-scan on the right also of the whole thickness but recorded in echo-technique with one transducer.

The identified defect sizes are quite different: the 18J- impact damage identified by skin inspection shows an area of 644 mm^2, the inspection of the whole thickness delivers areas of 2574 mm^2 (through-transmission technique) and 2435 mm^2 (echo-technique). The C-scan of the skin only shows portions of the defect areas which are equal to the sizes visible from outside. A comparison of the horizontal echo dynamic curves (whole thickness) of the 18 Joule impact indicates a -20dB drop of the amplitude (through transmission technique), and a -10 dB drop in echo technique.

The results show that the echo technique with optimized pulse parameters provides a precise identification of defects in the skin and in the core. Additional imaging is possible with B-scans which clearly show the defects in different depths of the specimens. An example is given in Fig. 3 in the form of two B-scans. The 18 Joule impact causes many echoes in the core region which are impressively displayed in the horizontal B-scan.

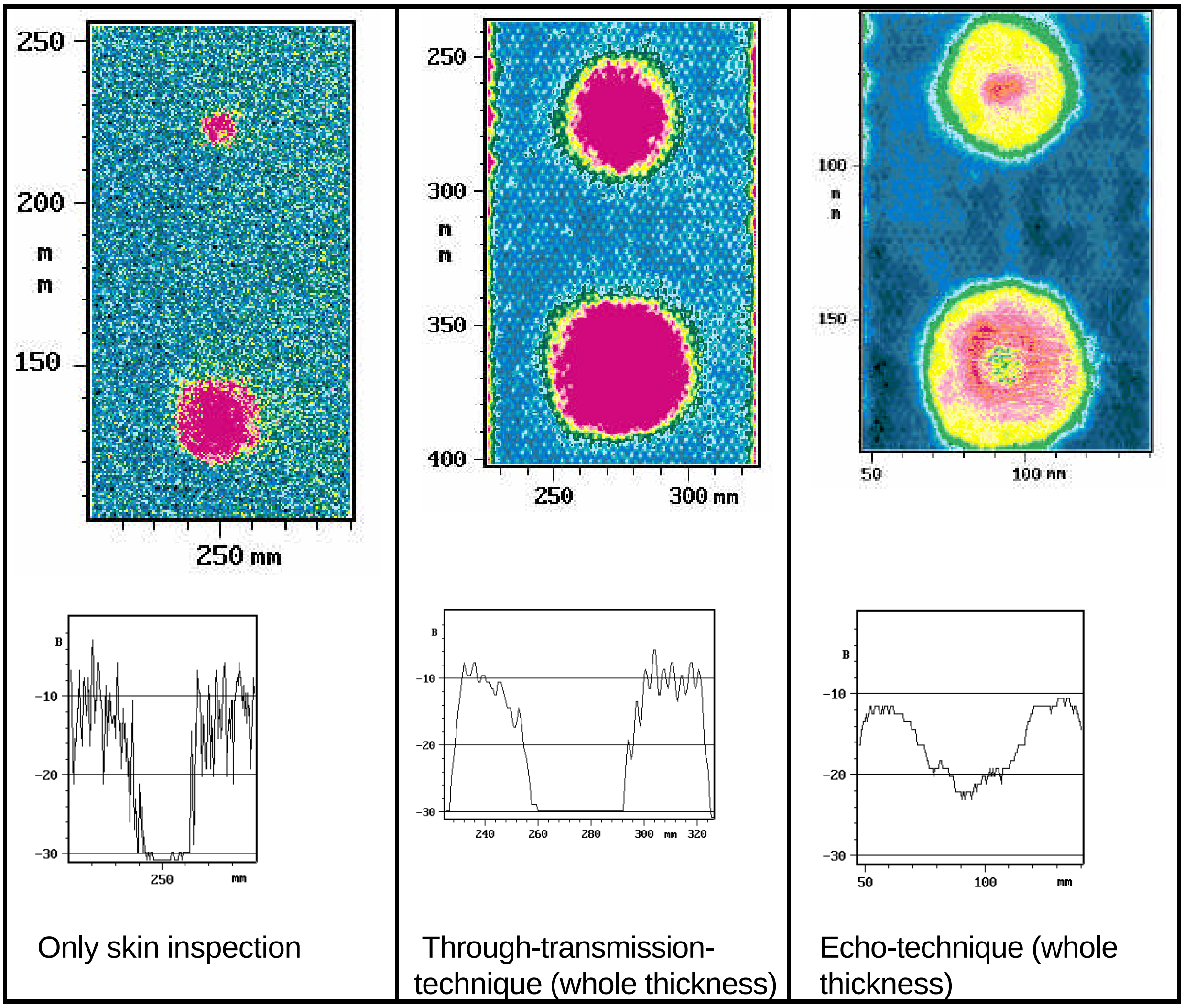

Fig. 2: C-scans and echo-dynamics of specimen 39/4 with impact energy levels of 4J and 8J (DLR Braunschweig, Germany)

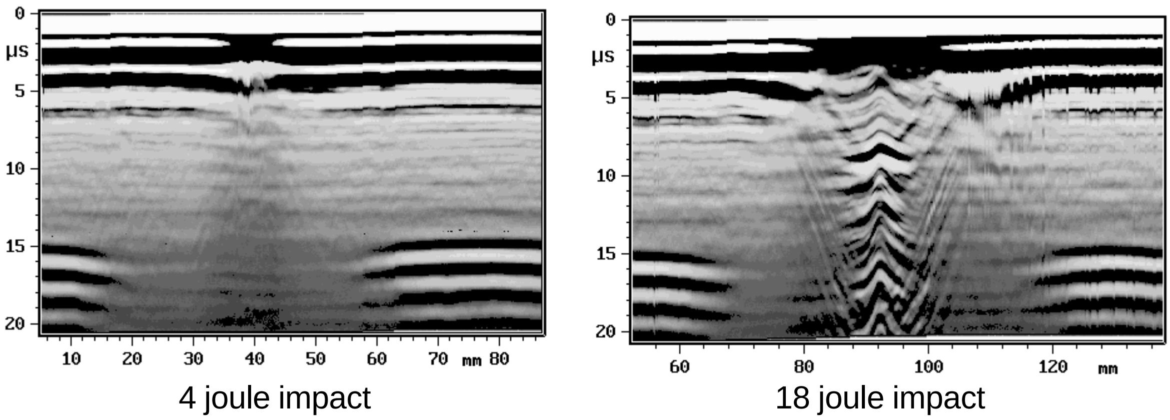

Fig.3: B-scans of the whole sandwich thickness (DLR Braunschweig, Germany)

4. References

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