ULTRASONIC NDE OF COMPOSITES

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In order to evaluate the reliability of a NDE ultrasonic inspection system, we have analyzed graphite-epoxy plane parallel specimens with artificially made defects (teflon inclusions). Color maps have been produced, which show the cross section and depth of the defects. Reflected ultrasonic amplitude vs. propagation time plots have also been analyzed to establish criteria for an automatic discrimination procedure between real defects and local inhomogeneities and for the inspection of more complex structural components.

INTRODUCTION

Fiber reinforced composites are being increasingly utilized as structural materials, e.g. in the aeronautical industry, due to the possibility of combining together desirable properties, which are usually mutually exclusive in traditional materials, such as a remarkable strength and lightness. Safety and economy considerations require, however, that reliable techniques for their nondestructive evaluation be developed.

Among several available NDE techniques (e.g. radiography with x-rays, γ , neutrons or protons, eddy current testing, liquid penetration, nuclear magnetic resonance, acoustic emission etc.), ultrasonic methods have proved, in many situations, to be most convenient. As an example, the high ultrasonic reflectivity of narrow defects, such as cracks or delaminations, and their accessibility to ultrasound, even deep into the material, are often important factors for choosing an ultrasonic examination.

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Different ultrasonic transmission (1-2) and pulse-echo (3-5) systems have been recently reviewed in Refs (6) and (7), the latter being devoted to the special case of "thick" composites, i.e. specimens with poor S/N ratio of the received propagated signal.

In this contribution we present some results obtained with the Aeritalia F2 system (8), which has been recently developed to perform, in the laboratory or in the airfield, a non-destructive inspection of aerospace composite structures. The F2 system operates in pulse-echo mode and provides in real time a bidimensional representation of the intensity of the ultrasonic signals.

RESULTS AND DISCUSSION

For a description of the F2 system we refer to (8). As it presently operates, it provides, after a scanning of the specimen surface, a color map showing the location and depth of defects. To test this capability, a 240 x 240 x 3 mm specimen was fabricated with 16 teflon inclusions (6 x 6 x 0.13 mm) at different depths and color maps were produced.

However, since color maps require the aid of an operator, it may be desirable to build up a fully automatic procedure, to separate unblemished specimens from flawed ones, using the raw digitized data, upon which a simple accept-reject criterion be implemented. But, if the plate is made of composite materials, partial reflections of the ultrasonic pulse may happen, due to the presence of local inhomogeneities, glued interfaces or other factors, which do not compromise the safety or functionality of the structural components.

In order to build up such an expert system, capable of discriminating between real defects and local imperfections, we are presently studying plots of the reflected ultrasonic amplitude vs. propagation time, such as those shown in Figures 1 (for a point in the specimen where no defect is present) and 2 (on the top of a defect). In both plots the first peak (only partially visible) represents the reflection from the top surface; the other three peaks are successive reflections from the bottom surface (Fig. 1) or from the defect (Fig. 2). Only the envelopes of the curves are meaningful, since, every two points, the lower one is ignored (set to zero) to save data acquisition time. Knowing the thickness of the specimen, from the time difference between two contiguous peaks in Fig. 1, one can determine the propagation velocity. Then the depth of the defect in Fig. 2 can be easily determined.

By analyzing a large number of plots for different known defects, at various positions over the defect (e.g. at its edge) and in regions where no defects but local imperfections are found, we plan to determine specific accept-reject criteria for a fully automatic NDE. We also plan to apply our results to analyze more complex structural elements, such as double curvature wing skin panels, stiffened by cobonded spars, for which simple inspection techniques are lacking.

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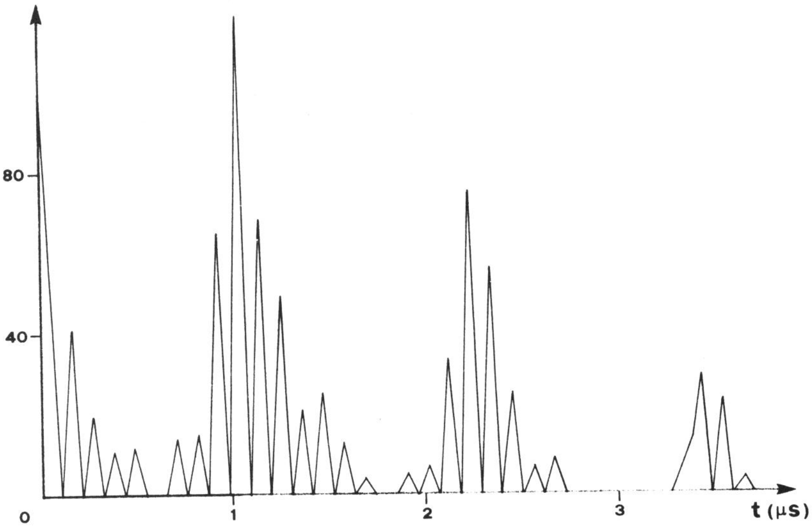

Figure 1 Ultrasonic amplitude vs. propagation time for a point in the specimen where no defect is present.

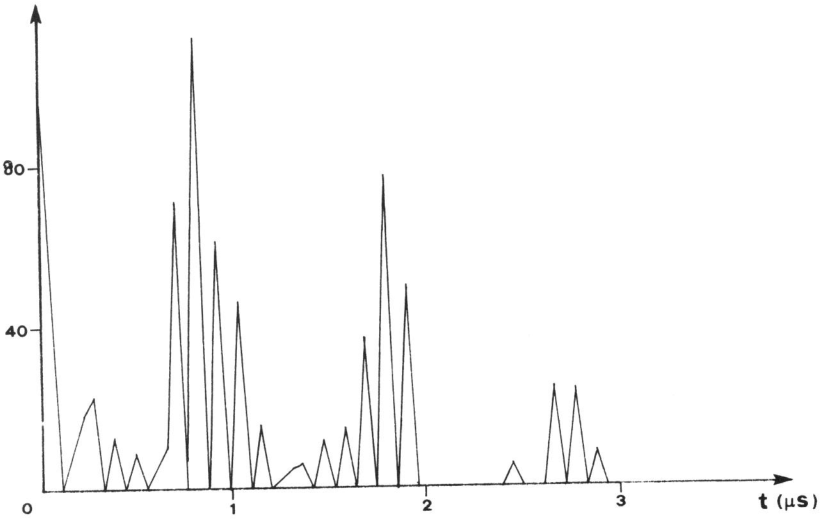

Figure 2 Ultrasonic amplitude vs. propagation time for a point on the top of a defect.