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Integrity Verification of the Hybrid Materials by Using Non Destructive Testing

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Abstract

The paper presents the results regarding the most suitable nondestructive technique, in order to obtain images with high quality, in the case of hybrid material control. The ultrasonic immersion testing, conventional radiography testing and computerizes tomography testing were used to verify the integrity of the hybrid materials.

Key words: *hybrid material, ultrasonic immersion, computerized tomography, radiography*

Introduction

The hybrid materials are mix materials created by blending disparate materials such as plastics with metals. Hybrid materials can create new products with desirable properties, such as being: bioactive, biodegradable, durable, high-strength, intelligent and lightweight. The hybrid materials are used in different field, such us: aerospace, building and construction, cosmetics, textiles, packaging and medicine.

After the manufacturing process it will be possible to appear some defects in these hybrid materials, which are non-detectable with the necked eyes, such us: delaminations, voids, cracks, inclusions, bursts or other types. From this reason it is necessary to control these materials by using the nondestructive testing methods.

Due to the nature of the material it is very difficult to make the right chose regarding the most suitable nondestructive methods (magnetic particle, radiography, ultrasonic testing etc.) in order to obtain images with high quality, in the case of hybrid material control.

This paper presents the experimental results obtained in the case of nondestructive controls made on hybrid material by using Ultrasonic Immersion Testing, Conventional Radiography Testing and Computerized Tomography.

Research Methodology

The specimen used in experimental work is a new hybrid material consists of layers of aluminum sheets bonded together with a fiber composite laminate in between. This material was developed for aircraft use. The tested specimen was designed with a hole, which generated two longitudinal cracks in the specimen. These cracks produced the delamination of the fiber

composite from the aluminum sheets. In figure 1 is presented the specimen tested in the experimental work.

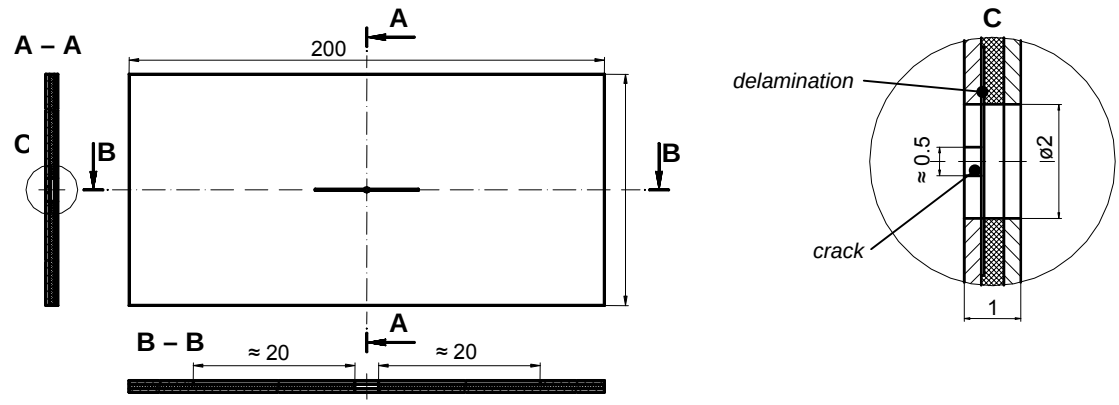

Fig.1. The specimen's profile

This specimen was control in order to determine the delamination occurs by using Ultrasonic Immersion Testing, Conventional Radiography Testing and Computerized Tomography**.**

After the experimental testing, the specimen was investigated to determine the real delamination by using the STERION Microscope. The aluminum sheets were removed from the both side of the specimen. The specimen was immersed in a solution that contains 100 ml H_2O and 200 ml HCl (35%). After 5 minutes the aluminum was totally removed from the specimen.

Ultrasonic Immersion Testing

In the experimental work the NDT system IZOGRAF-4-set was used. The ultrasonic immersion method was utilized and two forms of ultrasonic scanning (A-scan and C-scan) were investigated.

Immersion coupling uses a long fluid delay line. The distance between the transducer and the test object is long enough to separate in the time domain the reflections from the test object front surface and the transducer's excitation signal. In addition, a separation is maintained between the test object's internal reflections and the repetitive reflections in the water path. This adjustment is necessary to avoid interference between the various reflections and to simplify the evaluation of the response.

Figure 2 shows the immersion technique's scheme used in experimental work.

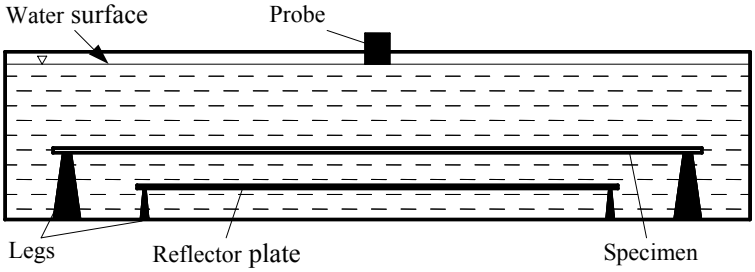

Fig.2. The immersion technique's scheme

The specimen presented in figure 1 was supported by four legs, over a reflector plate. In this technique the battery water was used. The specimen was put in the water and the transducer touch the water.

Conventional Radiography Testing and Computerized Tomography

In order to detect the delamination occurs in the specimens were used conventional radiographic and computerized tomography testing methods.

The equipment used for both methods is presented schematically in figure 3.

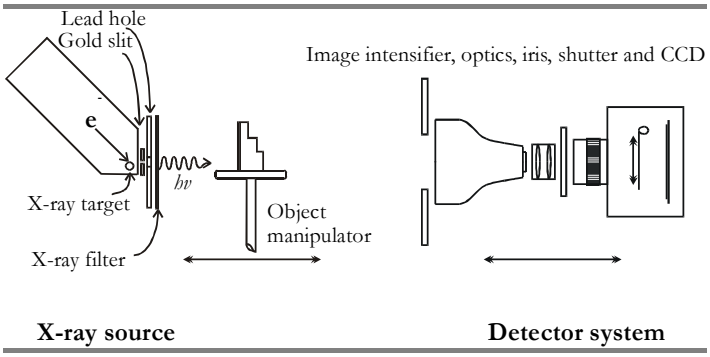

Fig.3. Schematic description of the experimental arrangement

In order to apply the computerized tomography method, the specimen was divided in equal parts and these parts were superposed (in order 1, 2 … 6) to obtain a tri-dimensional piece having the dimensions requested by the testing equipment (fig.4 a). Nine slices of the specimen were investigated (fig.4 b).

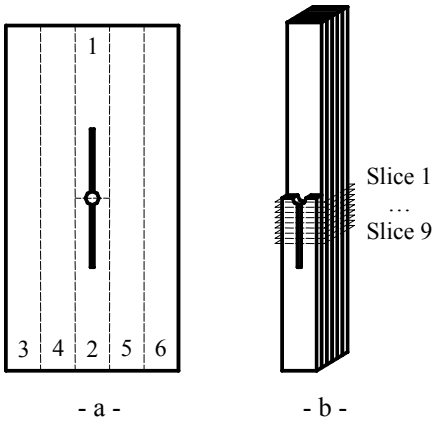

Fig.4. . The specimen's profile used in the computerized tomography testing:
a – cutting plane, b – work piece and slice of investigation.

In conventional radiography only one view of the sample was collected, resulting in a project two dimensional view of the sample. The conventional radiography was taken from the one half surface of the specimen. In order to visualize the delamination it was used a contrast liquid. The composition of the contrast liquid was isopropanol, H_2O and zinc iodide.

In the computerized tomography testing the specimen was rotated in steps between the X-ray source and the detector until the whole specimen volume was scanned. After a complete rotation, the data was processed in a computer in order to build an image of a thin slice of the specimen, cut along the plane of the detector array, of thickness equal to the thickness of the detectors. With mathematical algorithms it was possible to reconstruct a two dimensional image of a plane in the sample.

Experimental Results

The ultrasonic immersion testing, in A-scan and C-scan mode, allowed to determine the delamination area occurs in the specimen.

Figure 5 present the A-scan of one specimen for different delay Z coordinate control. When the A - scan mode is used two types of signals are registered by the ultrasonic immersion device: pulse echo signal and through transmission signal (figure 5). Pulse echo signal occur due to the reflection of the ultrasonic waves by the delamination. Through transmission signal occurs due to the reflection of the ultrasonic waves by the reflector plate, when the specimen is travel by these.

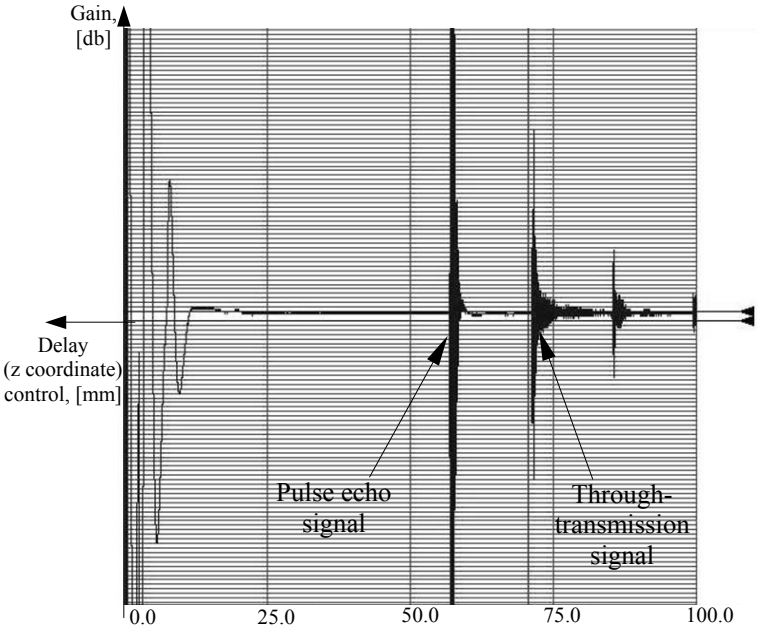

Fig.5. A-scan of one specimen

The C - scan mode was used in order to obtain images with high quality. These images give information regarding the specimen, the delamination and the crack. When the through transmission signal is investigated in the C-scan the dark area is given by the delamination and the with area is given by the specimen without any defects (figure 6).When the pulse echo signal is investigated in the C-scan the white area is given by the delamination and the dark area is given by the specimen without any defects (figure 7).

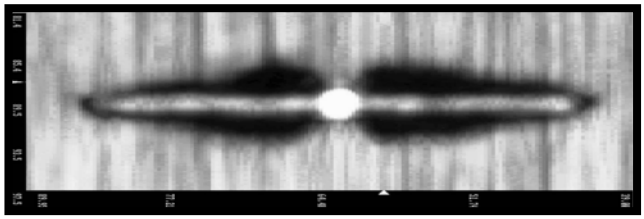

Fig.6. C-max plot scans for through-transmission signal

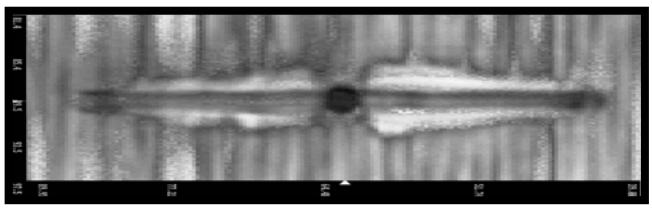

Fig.7. C-max plot scans for pulse echo signal

By using this nondestructive testing a delamination propagated unequal around the crack was clearly observed (the white area observed in figure 7 and the dark area in figure 6). This method is very suitable to determine this kind of defect in hybrid materials.

Figure 8 present the specimen's image determinate by using the conventional radiography. The delamination was not observed in this case.

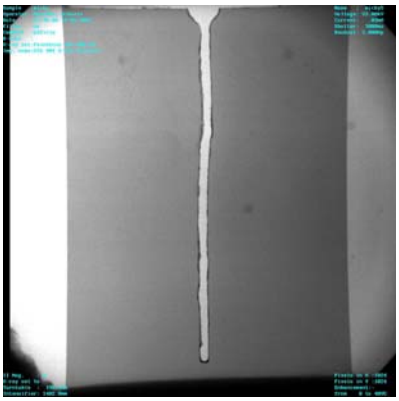

Fig.8. Conventional radiography of the specimen.

By using the computerized tomography the delamination was not observed, too. With mathematical algorithms it was possible to reconstruct two dimensional images of nine slices (planes) cut along the plane of the detector array. Figure 9 presents the images obtained in the case of three slices investigations. In no one of these images the delamination didn't show up.

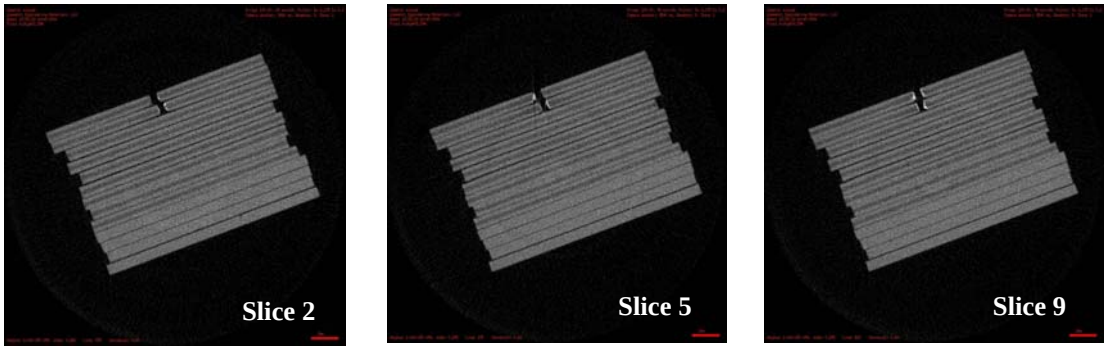

Fig.9. Images of slices investigated

The real delamination, when the aluminum sheets were removed from the both side of the specimen, is presented in figure 10. The dimensions and the design of the delamination observed is the same as that observed in the ultrasonic immersion testing.

Fig.10. Real delamination

Conclusions

The focus of this research was to choose the suitable nondestructive technique, comparing radiography and computerized tomography testing with ultrasonic immersion testing, in order to obtain images with high quality.

The experimentally results, using the computerized tomography and radiography testing, do not allow to identify the delamination occurs inside the hybrid materials.

The ultrasonic immersion testing is the most suitable method in order to detect the delamination occurs inside the hybrid materials.

Due to the high performances obtained in the case of using the ultrasonic immersion nondestructive testing, this method is recommended to be use to investigate the integrity of the hybrid materials.

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Verificarea integrității materialelor compozite prin tehnici de control nedistructiv

Rezumat

În lucrare se prezintă metodologia şi rezultatele încercărilor experimentale privind determinarea celei mai adecvate metode de control nedistructiv a materialelor hibride. Pentru verificarea integrității materialelor hibride au fost folosite mai multe tehnici de control, cum ar fi: controlul cu ultrasunete în imersie, controlul radiografic convențional şi tomografia computerizată.