NON-DESTRUCTIVE AND NON-CONTACT EVALUATION OF ALUMINUM/ FOAM SANDWICH ELEMENTS USING LASER SHEAROGRAPHY

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ABSTRACT [translated from Spanish]

One of the aircraft industry's main objectives in the manufacturing process is to reduce the weight in aerostructures. In this regard, sandwich structures with foam cores and aluminum laminates fully meets this requirement. However, nondestructive inspection of these components using conventional methods poses some problems. Foam materials display a high degree of attenuation in ultrasound inspections and are insulators in the case of contactless inspections, such as in infrared thermography. Furthermore, the great difference in the absorption coefficient with regard to metallic and foam materials implies that there are contrast limitations for inspections using industrial radiography.

This paper presents a feasibility study on laser shearography (LS) in a sandwich demonstrator element manufactured from an aluminum alloy Alclad 2024 and a ROHACELL® core. It has some artificial defects simulated by inserting TEFLON® into the joining interface between the laminate and core. The results reveal the technique's high level of detection accuracy as well as a simple configuration with reduced inspection times.

ABSTRACT [original in English]

In the manufacturing process at the aerospace industry, one of the main objects is to reduce weight of the aerostructures. In this context, foam core and laminated aluminum structures broadly fulfill this requirement. However, conventional non destructive inspections of these type of component present some disadvantages. Foam materials exhibit high attenuation in the ultrasonic inspection and are insulated for contactless techniques as infrared thermography. In addition, there is a large difference between metallic and foam absorption coefficient, implying limitations in inspections by industrial radiography.

This paper presents a feasibility study for Laser Shearography (LS) in a sandwich demonstrator, manufactured in Aluminum Alclad 2024 and ROHACELL® core. This element contains simulated TEFLON® defects in the core and skin interface.

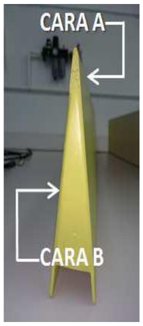
The results demonstrate a high detectability of the technique, reducing inspection time with simple configuration parameters.

Keywords: Laser shearography, sandwich structure, aluminum, foam, non-destructive inspection,

1. INTRODUCTION

The main LS application is non-destructive inspection in composite materials, particularly in sandwich structures and bonded joints. This is why a non-contact technique is involved here, which is also quick, reproducible, easy to interpret and applicable in many industrial sectors where this technique has gained significance, such as inspecting wind turbine blades [1], inspecting cracks in pipes and pipelines [2], inspecting fuel tanks [3], among others. On the other hand, other non-destructive inspection methods do not provide very compelling results whenever the component part consists of a metallic skin (high thermal diffusion for infrared thermography) and a foam core (high attenuation for ultrasound testing and low radiation absorption coefficient for computerized tomography). This paper sets out to evaluate laser shearography's potential in sandwich structure component inspections and to demonstrate the technique's feasibility in elements with a metallic skin and foam core. It further reveals the findings from inspections performed on a component part with an aluminum skin and foam core.

2. EXPERIMENTAL METHODS **[***Cara* = face; *punta* = point]



(**b**)

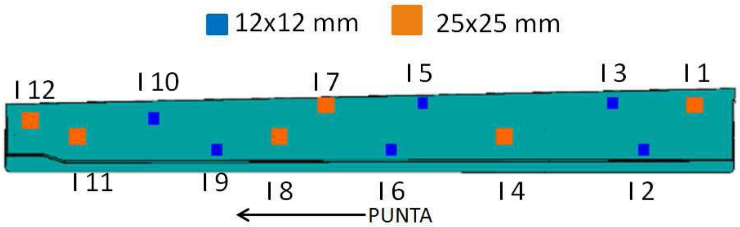


Figure 1. (a) Inspected element profile and (b) component part map indicating insertion sites.

The inspections were carried out in a sandwich type demonstrator element, manufactured with an aluminum alloy Alclad 2024 and a ROHACELL® core. Inside the element 12 artificial defects simulated with 12x12 and 25x25 mm of TEFLON® inserted into the interface joint between the laminate and core. Figure 1 features both a view of the inspected element, as well as the map of the artificial defects introduced.

2.2. Methodology and arrangement

During the component part inspections the surface of the item is lit up by four expanded laser beams and the element's state of surface deformation after thermal stimulation is compared with its original condition. The inspection area was 200x200 mm^2 for each test (Figure 2).

Figure 2. Test set-up, including inspection area.

Table 1. Laser shearography inspection parameters

STIMULATION PARAMETERS	**Warming time [s]**	2
	Cooling time [s]	10
CAMERA PARAMETERS	**Scanning angle [º]**	45
	Scanning range [pixels]	6
	Wavelength [nm]	658
GEOMETRIC CONFIGURATION	**Lamp angles [º]**	0
	Camera distance [mm]	450

The inspections were carried out by using a Dantec Dynamics Q-800 system (4 laser diodes 70 mW / 658 nm, CCD camera image sensor- 1392x1040 $pixels^2$), thermal stimulation by means of two 750W quartz lamps.

The variables used during the laser shearography tests are indicated in Table 1, which provides details on the stimulation and camera parameters, as well as the geometric configuration used.

3. RESULTS AND DISCUSSION

Figure 3 provides an overview of the results obtained from inspecting the element by using laser shearography. It is remarkable how this technique is capable of detecting the greater part of the Teflon inserted (I1-I12) and also locating in the item other anomalies.

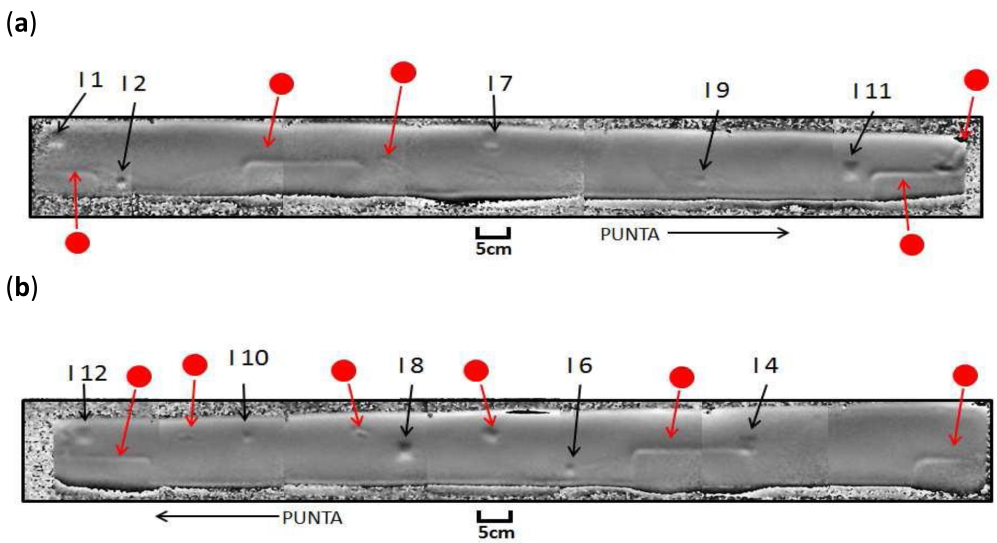


Figure 3. Inspection results obtained by laser shearography for (a) Face A and (b) Face B.

4. CONCLUSIONS

The inspection results yield a very high rate of detection accuracy by allowing for visualization of 10 out of the 12 simulated insertions. It is felt that the 2 defects that remained undetectable by the technique may have experienced shifting while the element was being manufactured. In addition, 11 other anomalies are detected, which presumably are structural in nature and from lack of adhesion between the laminate and the core. There would have to be a subsequent study to determine if these 11 anomalies may be isolated by using conventional non-destructive testing methods prior to the inspection by means of laser shearography or by destructive methods such as dissection of the element in order to determine the type of discontinuity that gave rise to the anomaly. Also it would be advisable to look into the reason why 2 of the 12 insertions remain undetectable.

At any rate, after the results obtained in this study, the laser shearography technique appears to be a very interesting prospect for inspecting structures of this type when other non-destructive inspection techniques, such as ultrasound testing or infrared thermography, prove to be not very compelling.

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