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Investigation of a Lock-In Thermography method using embedded piezoelectric transducers into composite plates.

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Abstract

The integration of piezoelectric transducers in composite structures for SHM purposes is a solution that is more and more considered by the aeronautic and aerospace industrials. During maintenance operations, such transducers can be activated to generate guided waves in the structure and interact with possible defects such as impact damage, generating a thermal signature that be spotted by an infrared camera. The aim of the present work is to investigate the relevance of this vibrothermography NDT approach when the transducer is embedded *inside* a laminate composite material.

Introduction

The increase in aircraft availability, the major industrial challenge, the reduction of duration and / or number of maintenance operations. Currently, the control of the state of health of aircraft ending periodically, systematically, which may lead to unnecessary immobilization ground devices in the event that they ultimately prove to be undamaged. The impact of the costs generated by these inspections is reduced to nothing: the controls are then not done periodically but only when they are needed. In order to allow this individualization, it is necessary to embed some transducers into the composite material to control complexes parts of the aircraft and to automate the non-destructive testing procedures. In this work, it has been proposed to embed a transducer inside a laminate composite material to generate guided waves. Depending on the excitation frequency, several Lamb modes can be activated, such as the compressive mode (S0) and the flexural mode (A0). Recent works have shown how the latter could generate significant vibrothermographic effect [1].

In this context, two types of tests are carried out: Laser vibrometry as a tool to validate the generation of guided waves in the composite; lock-in thermography to identify the local heating revealing the defect.

Embedded piezoelectric transducers into composite plate.

The PZT transducer is embedded into a T700-M21 composite plate, constituted of 10 plies: [0,90,0,90,0]s. Its thickness is 2.43 mm and its dimensions are 300x300mm². As can be seen in figure 1 a, the plate contains one embedded PZT sensor of 10 mm diameter and 0.2 mm thickness, and is located between two plies of 0° and 90° directions.

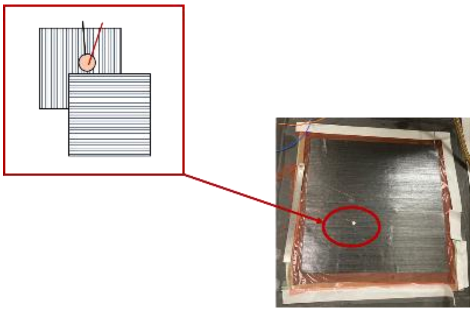

Fig. 1. Schematic representation of the PZT located between two plies of a T700-M21 laminate composite [2]

In order to check the operability of the embedded PZT transducer, a Laser Doppler Vibrometry (LDV) technique is used to measure to the propagation of the generated Lamb waves.

The Laser Doppler Vibrometer (LDV) is an OFV-505 model from Polytech. The sensor head uses a Helium-Neon (HeNe) red laser with a wavelength of 632.8 nm. The measurement of the out-of-plane displacement at that position is based on the Doppler effect. The laser beam is scanned on the specimen surface using a linear stage from Micro Controle. A snapshot of the propagating waves at any given time is obtained by plotting the amplitude of each waveform. The PZT disk is excited by 5-sine burst waves at 25 kHz and 10 Vpp. Figure 2 illustrates the wavefield generated by the PZT in close vicinity.

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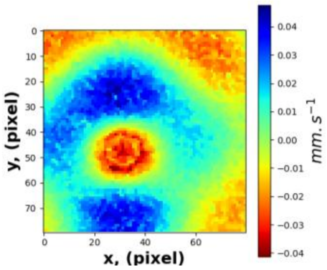

Fig. 2 Velocity map resulting from the Lamb waves generated by the embedded piezoelectric transducer into composite plate.

Lock-In Thermography method

For the investigation, the excitation is sine-cycles at 25 kHz, modulated by sinusoidal window of 0.1Hz the amplitude of this input signal is 30V peak to peak. The IR camera is a FLIR X6540sc MWIR camera (640×512 pixels, NETD 20mK, pitch 15µm, spectral band 3 – 5 µm). The maximum frame rate of the camera was 100 Hz.

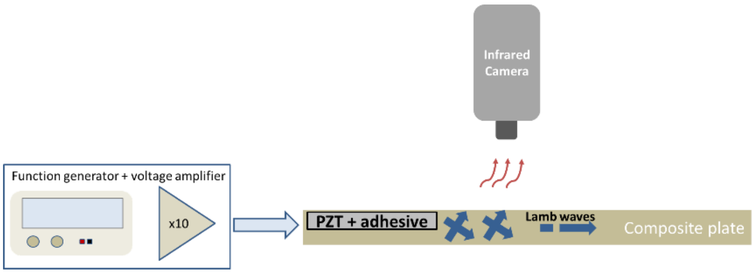

Fig. 3 Vibrothermography bench used to image the thermal response of a defect revealed by Lamb waves excited by a PZT transducer embedded inside a composite plate.

Figure 4-a shows the front-face thermograms allow observing the heating source from PZT embbeded into composite plate at 25 kHz.

The defect that is aimed for detection is a low-velocity impact damage (15 J). A first lock-in thermography experiment is carried out with a PZT transducer bonded to the surface of the composite. As illustrated by figure 4-b, the temperature modulus field allows a definite location of the damage.

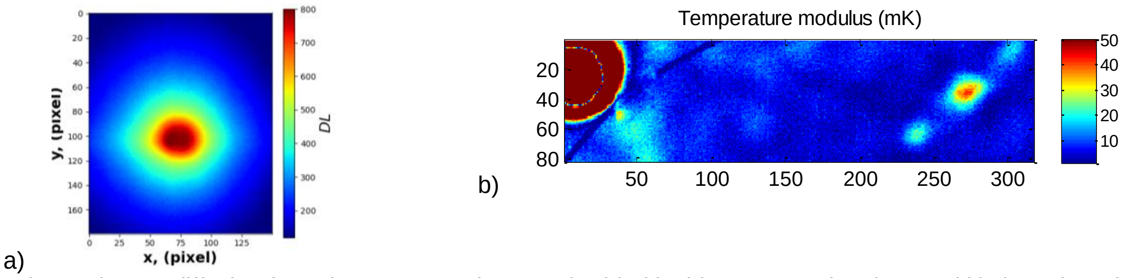

Fig. 4. a) Heat diffusion from the PZT transducer embedded inside a composite plate and b) detection of an impact damage in the laminate composite, by lock-in thermography. The PZT transducer is attached to the surface of the coupon.

In the final paper, similar tests with the embedded PZT transducer will be presented and analysed.

REFERENCES

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