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# EVALUATION OF DIFFERENT NDT TECHNIQUES FOR THE PRODUCTION OF COMPOSITE MATERIALS FABRICATED BY ADDITIVE MANUFACTURING

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## ABSTRACT

In this work we have compared several non-destructive testing (NDT) techniques to evaluate the presence of defects in composite materials fabricated by additive manufacturing. These composite materials had a polymeric matrix and were reinforced by long fibres of Ni-Ti, carbon fibres and fibre glass. Four different NDT techniques were used: transient active thermography, digital radiography, ultrasounds and customized eddy currents.

***Keywords:*** additive manufacturing, non-destructive testing, composite materials.

## INTRODUCTION

3D additive manufacturing (AM) is one of the most exciting manufacturing techniques nowadays. One of the key issues in this field is the development of reliable non-destructive testing (NDT) techniques to evaluate for the presence of manufacturing defects. Defects occurring in AM parts have new morphologies and dimensions when compared to other manufacturing techniques. Some of the typical defects in the production of polymers trough AM are: delamination, lack of bonding between the matrix and reinforcement, porosity, misalignment and excessive surface roughness. Detecting these defects with existing NDT techniques is currently very limited, since conventional NDT procedures were developed for different operation conditions.

To evaluate different NDT techniques in the detection of defects in composite polymers reinforced with long fibres fabricated by AM, transient active thermography, digital radiography, ultrasounds and customized eddy currents techniques were used. Each technique has its own scope of application and limitation and should be used accordingly. However, these NDT techniques can be used in a complementary way.

## EXPERIMENTAL PROCEDURE

Polymeric composite materials reinforced by long fibres were produced by additive manufacturing using a commercial desktop 3D printer.

For the active thermography a Fluke® Ti400 thermographic camera was used. This equipment can measure temperatures between -20 and 1200 °C with ± 2 °C precision. A customized heat system was used, which included a halogen lamp with 400 W. For digital radiography an X-ray generator KODAK 2100 RX was used. The probed area is of 22 × 30 mm and the spatial resolution is of 18,5 µm. Ultrasound inspection was performed using a Krautkramer USM 36. Petroleum jelly was used as coupling agent. This technique was used to evaluate the speed of sound in difference specimens. Eddy currents testing was performed with customized probes and using a Nortec 500C from Olympus. The frequency range varied between 50 Hz and 12 MHz.

## RESULTS AND CONCLUSIONS

Active thermography was seen to be a good option to detect voids and carbon fibres, Figure 1(a). Similarly, with digital radiography it was also possible to detect the same features, Figure 1(b).

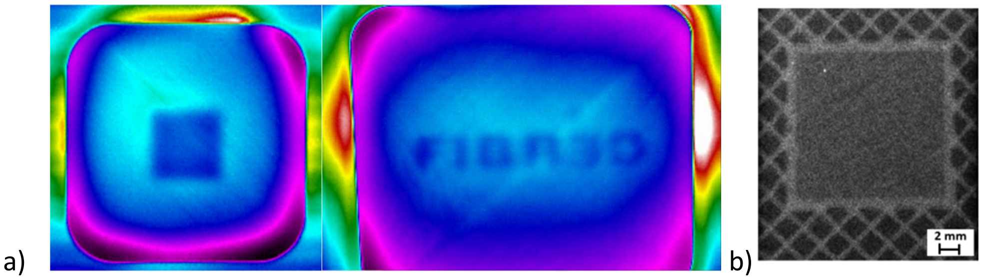


Fig. 1 - Material inspection using: a) active thermography; b) digital radiography.

With eddy currents, it was possible to detect the Ni-Ti reinforcements up to 2 mm deep (Figure 2). With ultrasound testing accurate measurements of the speed of sound in the material and attenuation coefficients were determined. However, this technique is not feasible to employ in polymeric materials due to the high acoustic attenuation of the polymers used.

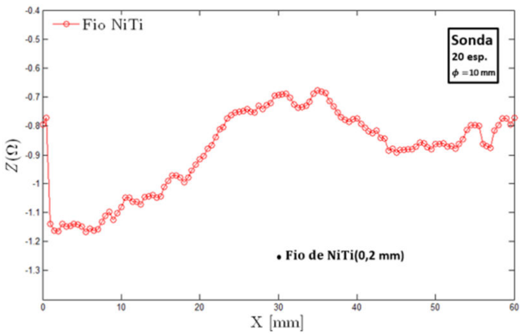


Fig. 2 - Material inspection using Eddy currents inspection.

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