ARTIFICIAL DEFECTS IN CFRP COMPOSITE STRUCTURE FOR THERMOGRAPHY AND SHEAROGRAPHY NONDESTRUCTIVE INSPECTION

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ABSTRACT

Locating defects in CFRP composite materials is a hot topic in nondestructive inspection (NDI). Beside classical NDI technique, such as ultrasound testing (UT), contactless techniques are actively studied. Generally manufacturers of CFRP structure incorporate artificial defects in the bulk, with different extents and depths, in order to study the performance of a specific NDI technique to detect the defect. One of the most common defects in CFRP is delamination between two layers. This is simulated by inserting teflon sheets which, like air, acts as ultrasound blocker in UT. When such reference part is used to assess NDI performance of thermography or shearography, we only observe respectively the thermal or mechanical response of teflon with respect to external loading used with these techniques. In this work, we assess other possibilities for artificial defects in CFRP matrix. For that a CFRP structure was developed and which incorporates teflon, flat-bottom holes and delamination obtained by the pull-out method. We experimentally studied the signals and we discuss the difference between the various artificial defects methods.

Keywords: Nondestructive inspection, shearography, thermography.

THE CFRP MATRIX

Defects type
Delamination  Flat bottom hole  Teflon insert  Pull-out

CFRP Plate with known defect sizes, depths and positions

Defect positions  Plate back

Comparison with UT C scans

Time of flight (depth map)

Amplitude

No differences between different defect types!

THERMOGRAPHY & SHEAROGRAPHY SETUP

Thermography
- IR camera
- 6000 J flash lamp
- Acquisition rate: 50 Hz
- 1001 frame sequences

Shearography
- Shearography head
- 750 W halogen lamps
- 532 nm extended laser beam
- Acquisition rate: 1 Hz
- 40 s lamp s illumination
- 251 unwrapped difference phasemap sequence

Distance plate-lamps: 1m

DATA PROCESSING AND RESULTS

The sequence is digitally stacked in order to create a 3D cube. A binary mask is applied on each XY plane of the cube. The flash footprint/ overall deformation is remove it using a 3rd degree polynomial fit. A spatial averaging is computed over N by N pixels centered on (x,y) coordinates. A N by N pixels area reference is picked on the object near the area of interest is removed to minimize the influence of the overall heat of the plate.

Thermography

Shearography

Processed phasemap

Temporal evolution of a defect

Corrected Phasemap

Temporal evolution of a defect

FLAT BOTTOM HOLE

In shearography, defects have the same kind of signature with notable differences in amplitude depending on the depth of the defect. The trend seem to be the inverse in thermography.

TEFLON INSERT

In shearography, defects have the same kind of signature with notable differences in amplitude depending on the depth of the defect: the shallower defect seem to have a bigger impact than a deeper one. In thermography, the same trend than the one in shearography.

PULL OUT

No clear trend due to lack of contrast for this kind of defect in shearography.

In Thermography, the difference between defects depth is not as marked as the one with the flat bottom holes. Here it seems only amplitude can be used as a marker of depth

CONCLUSION

A comparison shows some difference in the temporal behaviors of both the techniques. Shearography seems to have different type of response with the type of defect. Temporal signatures can be used as identifier for defect type and depth. Further work will lead toward quantitative comparison of both the techniques.