Non-destructive evaluation of impact damage in carbon fibre reinforced polymer using infrared thermography and shearography

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Title: Non-destructive evaluation of impact damage in carbon fibre reinforced polymer using infrared thermography, shearography

Industrial partners: CTA
Outline

1. Introduction
2. Literature review
3. Problem statement
4. Objectives
5. Methodology
6. Results
7. Future works
Introduction

Carbon Fiber Reinforced Polymer (CFRP) laminate

Advantages

• High strength to weight ratio
• Corrosion resistance
• Specific thermal properties

Disadvantages

Vulnerable to delamination and impact damage

[1] www.aerodefensetech.com
Introduction

Impact damage

Introduction

Shearography

Measure the spatial derivative of surface displacement (sensitive to surface strain) by using interferometric optical measurement technique.
Introduction

**Infrared Thermography (IRT)**

Analysis of thermal flow which originates from thermal excitation of an object

**Pulse Infrared Thermography (PT)**

Flash heating is applied and thermal images are collected while the specimen is cooling down
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Evaluation the capability of NDT methods to inspect CFRP

<table>
<thead>
<tr>
<th>Methods</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT [1]</td>
<td>• Fast and affordable</td>
<td>• Not able to characterize interior damages</td>
</tr>
<tr>
<td>RT [2]</td>
<td>• Detecting matrix cracks</td>
<td>• Not suitable for laminate with several interfaces</td>
</tr>
<tr>
<td>UT [1]</td>
<td>• Identifying the defect position in plane and through the thickness</td>
<td>• Needs contact medium and point by point inspection</td>
</tr>
<tr>
<td>Infrared  [2]</td>
<td>• Fast inspection rate</td>
<td>• Adequate data processing is needed</td>
</tr>
<tr>
<td>ESPI [3]</td>
<td>• Evaluating the performance of the laminate</td>
<td>• Sensitive to rigid body motion and environmental factor</td>
</tr>
<tr>
<td>Shearography [3]</td>
<td>• Evaluating the performance of the defected laminate</td>
<td>• Hard to detect to defects other than delamination</td>
</tr>
<tr>
<td></td>
<td>• Detecting the defects with smallest values of impact energy</td>
<td></td>
</tr>
</tbody>
</table>

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Problem statement

How features and capabilities of IRT and shearography are evaluated to detect impact damages?
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Objective

To evaluate the detect ability and sizing capability of IRT and shearography methods for different levels of impact damage in CFRP
Methodology

Samples

- CFRP laminate, CYCOM 5276, $[45/0/−45/90]_{2s}$
- Size: 30 cm x 30 cm, 2.4 mm
- Impact damages standard: ASTM D7136

<table>
<thead>
<tr>
<th>Coupons</th>
<th>Impact Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E1</td>
</tr>
<tr>
<td>2</td>
<td>E2</td>
</tr>
<tr>
<td>3</td>
<td>E3</td>
</tr>
</tbody>
</table>
Methodology

Ultrasonic setup

• Immersion tank technique

• Zetec Topaz, UltraVision software, 64-element 5MHz probe
Methodology

Shearography setup

• DANTEC Q-800 portable shearography system

• Eight lasers of 120 mW at a wavelength of 660nm

• Thermal load is applied by a 750W heating lamp

• Data are analysed by ISTRA4D X 86 software
Methodology

Thermography setup

• Telops cooled infrared camera 640 x 512 detectors
• Matlab and IR-view software
• Two 3 kJ Hensel flash lamps
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**Results**

**UT results**

E2, 10 J  
E3, 20 J  
E4, 25 J
Results

Shearography results

E2, 10 J  
E3, 20 J  
E4, 25 J

2.4 mm shearing distance
Results

**IRT results:** Pulse phased thermography

E2, 10 J  
E3, 20 J  
E4, 25 J

minimum available frequency of 0.03Hz
Results

Indication sizing

<table>
<thead>
<tr>
<th>Coupons</th>
<th>C-scan</th>
<th>Shearography</th>
<th>PPT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area(mm²)</td>
<td>Area(mm²)</td>
<td>difference (%)</td>
</tr>
<tr>
<td>E2</td>
<td>441</td>
<td>310</td>
<td>29.7</td>
</tr>
<tr>
<td>E3</td>
<td>522</td>
<td>394</td>
<td>24.5</td>
</tr>
<tr>
<td>E4</td>
<td>547</td>
<td>487</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Method

- Coupons
- C-scan
- Shearography
- PPT
Thank you for your attention!

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