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

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Institution:

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

Industrial partners:

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

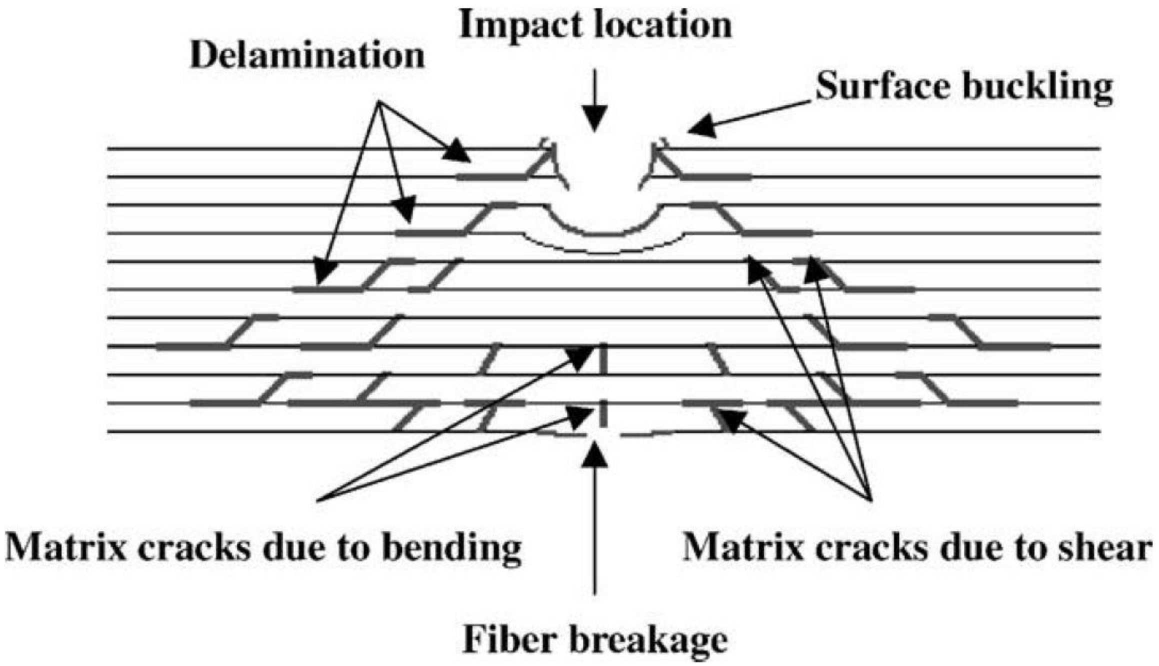
Vulnerable to delamination and impact damage

[1]

[1] www.aerodefensetech.com

Introduction

Impact damage



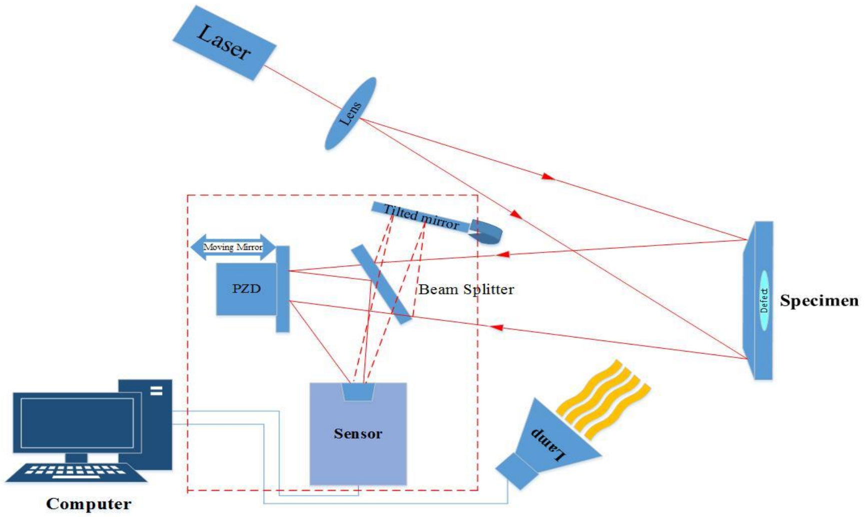
[1]

[1] Impact resistance and damage characteristics of composite laminates. . Shyr, T. W., & Pan, Y. H. Composite structures, 62(2), 193-203.

Introduction

Shearography

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



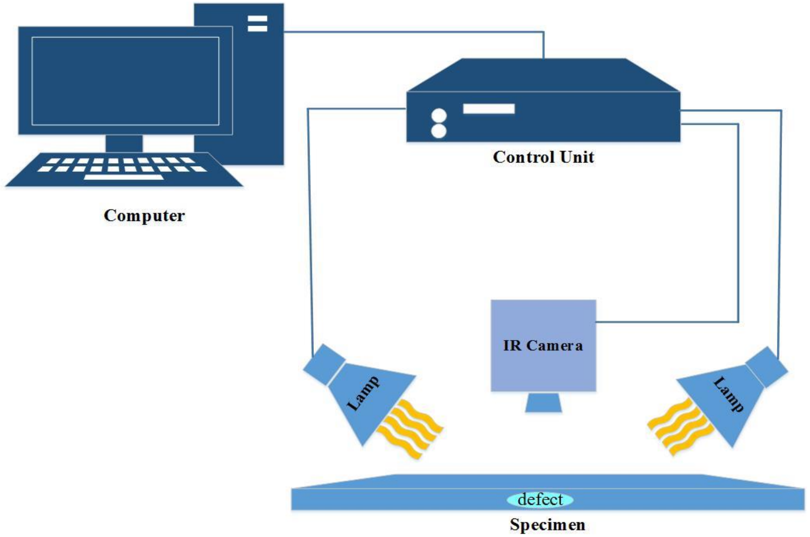
Introduction

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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Literature review

Evaluation the capability of NDT methods to inspect CFRP

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

[1] Růžek, R., Lohonka, R., & Jironč, J. (2006). Ultrasonic C-Scan and shearography NDI techniques evaluation of impact defects identification. NDT & E International, 39(2), 132-142.
[2] Gholizadeh, S. (2016). A review of non-destructive testing methods of composite materials. Procedia Structural Integrity, 1, 50-57.
[3] Amaro, A. M., Reis, P. N. B., De Moura, M. F. S. F., & Santos, J. B. (2012). Damage detection on laminated composite materials using several NDT techniques. *Insight-Non-Destructive Testing and Condition Monitoring*, *54*(1), 14-20.

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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

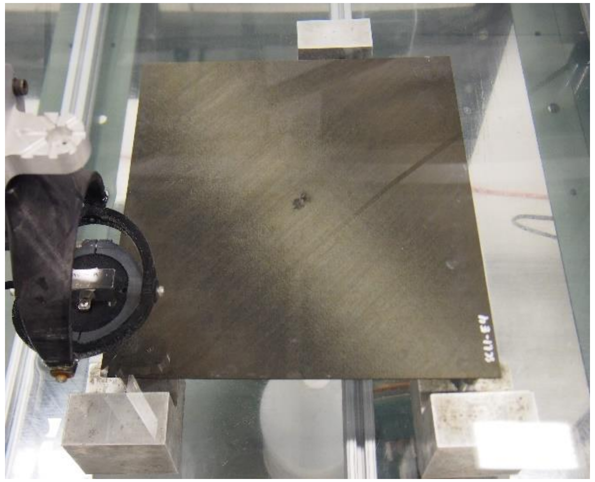
- CFRP laminate, CYCOM 5276, $[45/0/-45/90]_{2s}$
- Size: 30 cm x 30 cm, 2.4 mm
- Impact damages standard: ASTM D7136

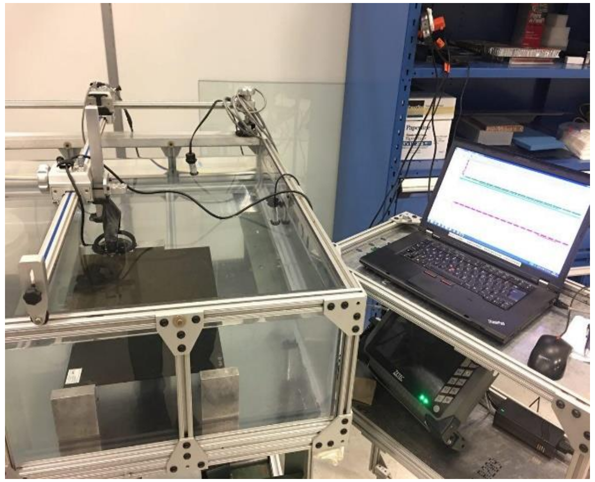
	Coupons	Impact Energy
1	**E1**	**10J**
2	**E2**	**20J**
3	**E3**	**25J**

Methodology

Ultrasonic setup

- Immersion tank technique
- Zetec Topaz, UltraVision software, 64-element 5MHz probe

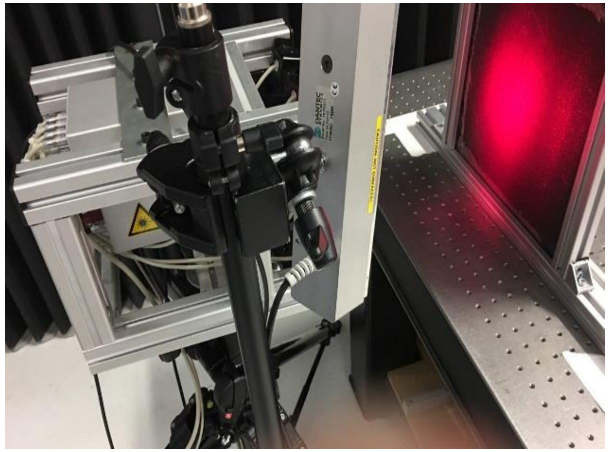


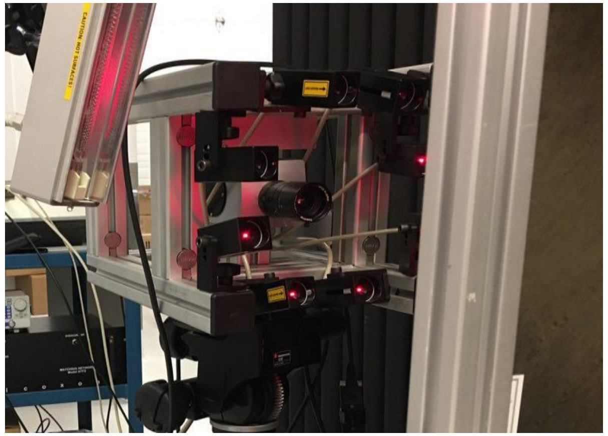


Methodology

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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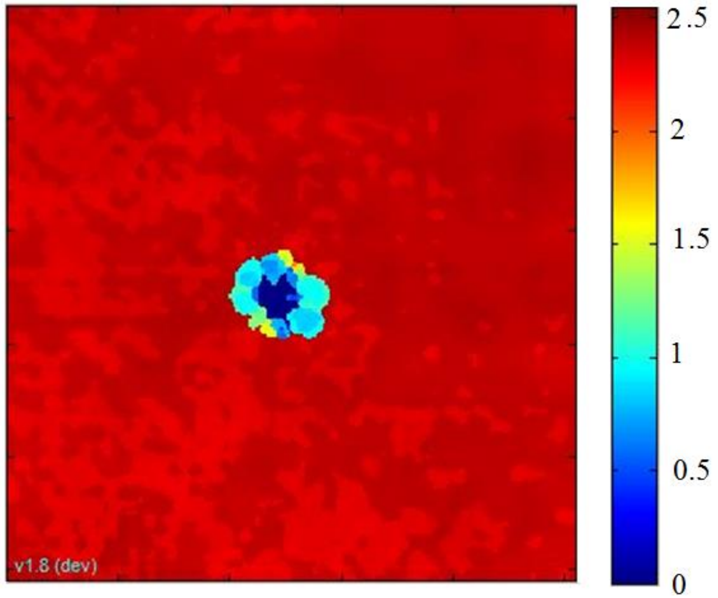
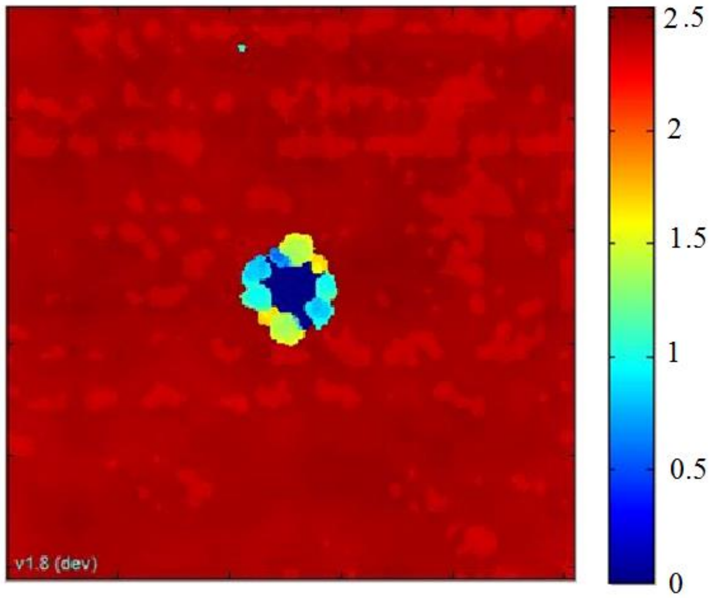
Results

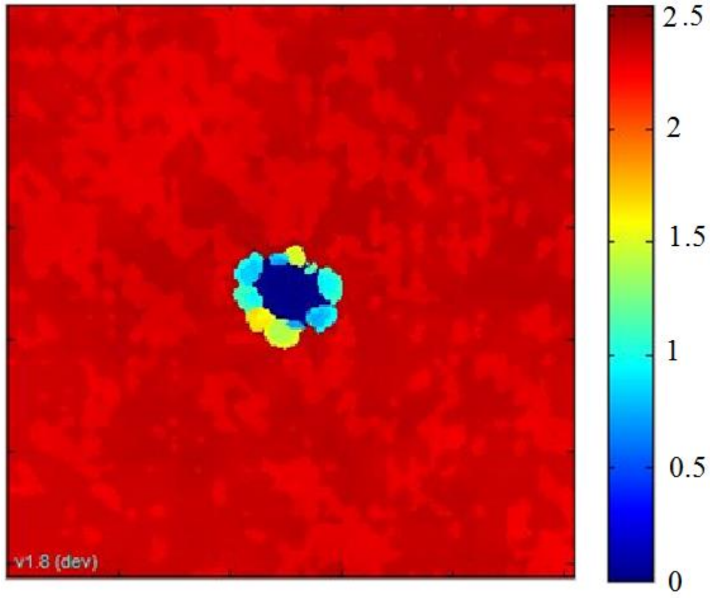
UT results



E2, 10 J



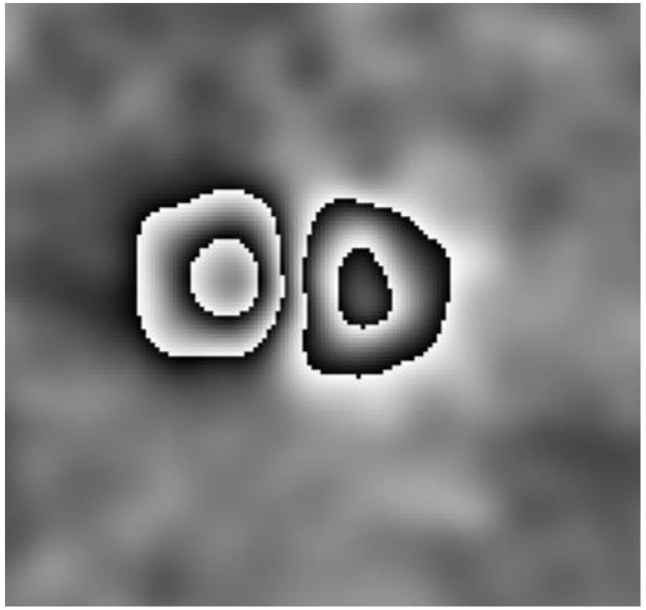
E3, 20 J



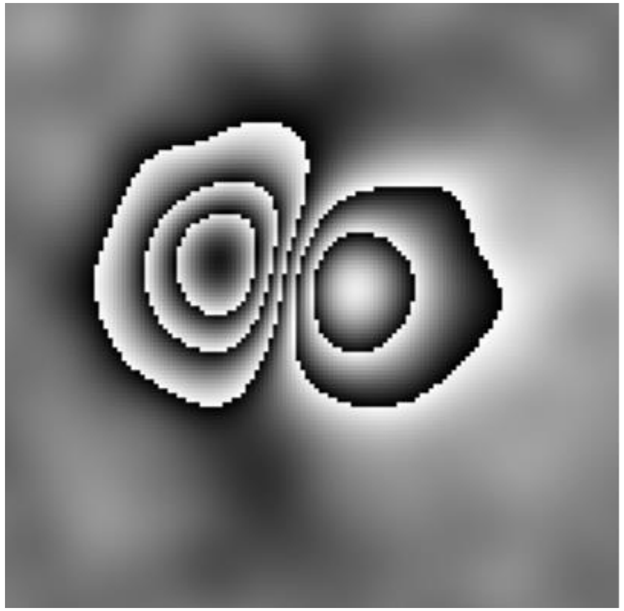
E4, 25 J

Results

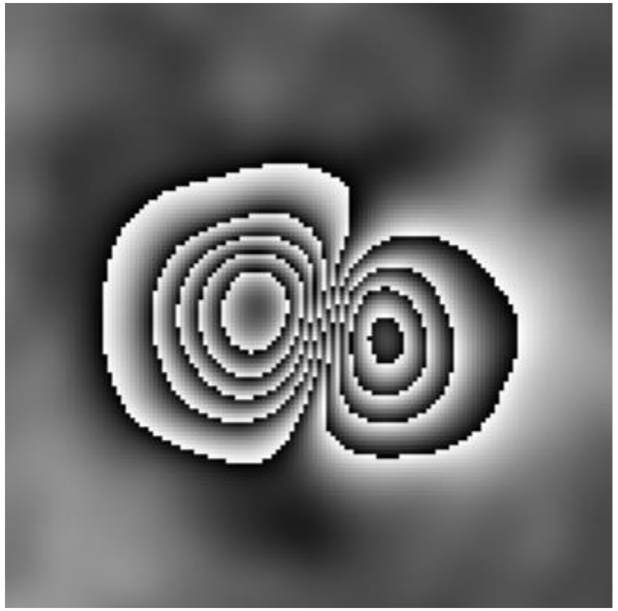
Shearography results



E2, 10 J



E3, 20 J

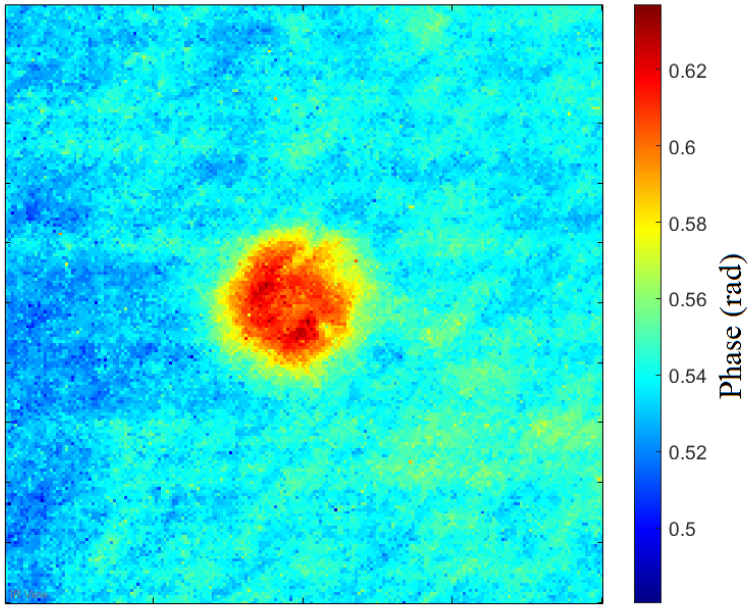


E4, 25 J

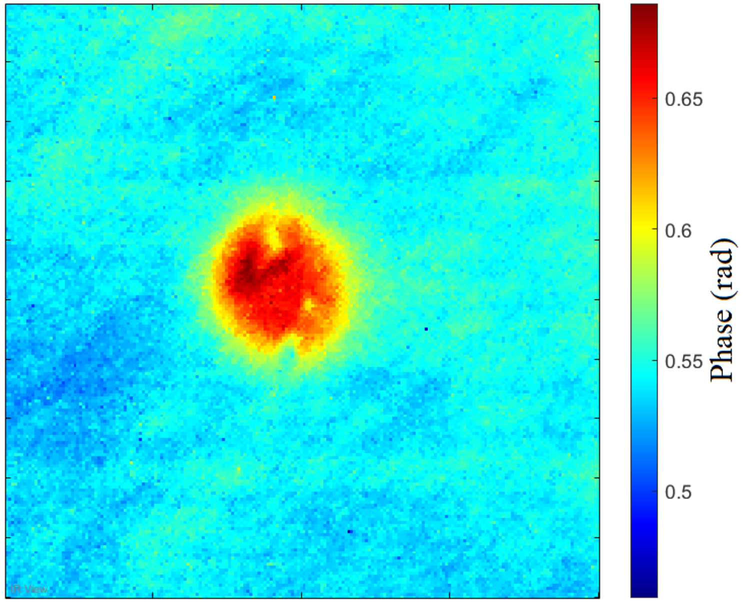
2,4 mm shearing distance

Results

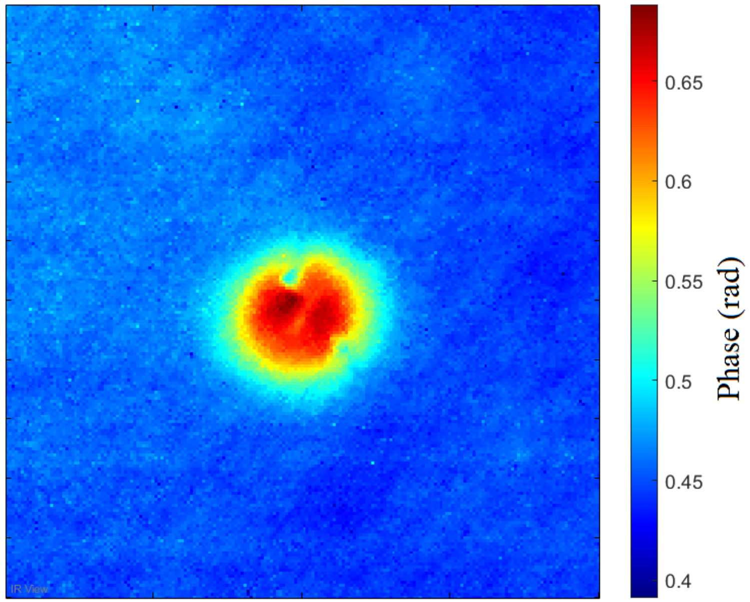
IRT results: Pulse phased thermography



E2, 10 J



E3, 20 J

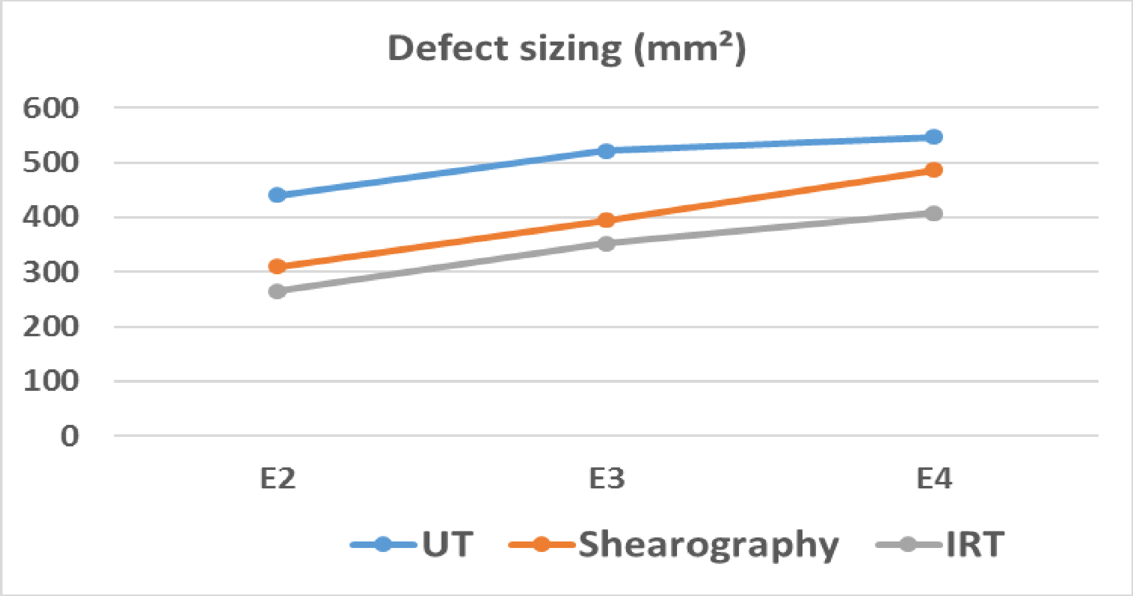


E4, 25 J

minimum available frequency of 0.03Hz

Results

Indication sizing



	Method				
Coupons	C-scan	Shearography		PPT	
	Area(mm²)	Area(mm²)	difference (%)	Area(mm²)	difference (%)
E2	441	310	29.7	265	40
E3	522	394	24.5	352	32.5
E4	547	487	11.5	408	25.4

Thank you for you attention!

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