THERMAL IMAGING AND THERMAL STRESS ANALYSIS OF THE IMPACT DAMAGE OF COMPOSITE MATERIALS

Lovre Krstulović-Opara[1a], Branko Klarin[1b], Pedro Neves[2] and Željko Domazet[1c]

[1]University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture,

R. Boškovića bb.; HR-21000; Split; Croatia; e-mail: {[a]Lovre.Krstulovic-Opara, [b]Branko.Klarin, [c]Zeljko.Domazet}@fesb.hr

[2]Instituto Superior Técnico; Avenida Rovisco Pais 1; 1069-001, Lisboa, Portugal; e-mail: camone54774@aero.ist.utl.pt

1. Introduction and experimental setup

Composite structures (e.g. wind turbine blades, glider planes) can be damaged due to the impact, or due the transportation and montage mishandling. In the presented work the thermal imaging and the Thermal Stress Analysis (TSA) have been used to observe the impact on a composite material, and to evaluate the resulting damage.

Experimental setup:

1st step: the controlled impact and high frame rate thermal imaging of a four layered 490g/m^2 fiberglass roving for polyester resin impacted with a 19,61 J impactor. Impact is filmed from the opposite side by a cooled IR camera at 360 Hz frame rate.

2nd step: TSA of the cyclically loaded damaged composite (Fig.1). The TSA is based on the infrared camera (IR) and the Lockin.

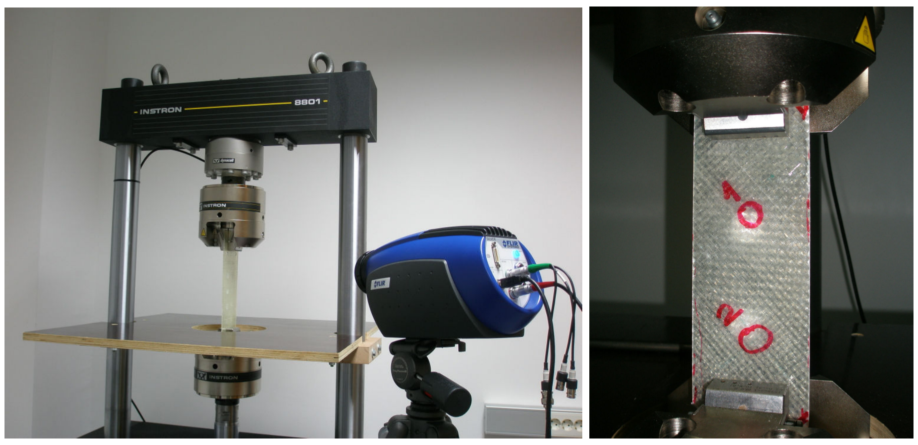

Fig. 1. TSA and damaged specimen

2. Thermal imaging of impact and delamination

Every material in elastic tension cools for a short instant, while heats for the case of elastic compression. For a plastic/damage case, the thermal energy is generated and heat can be observed for a while. Fig. 2a shows the moment before the impact. Fig. 2b shows cooled (elastic tension) zone under the impactor. Fig. 2c shows heated zone where the damage in material occurred surrounded by the cooled elastic zone. The last three figures show generated heat in the damaged area after the impact.

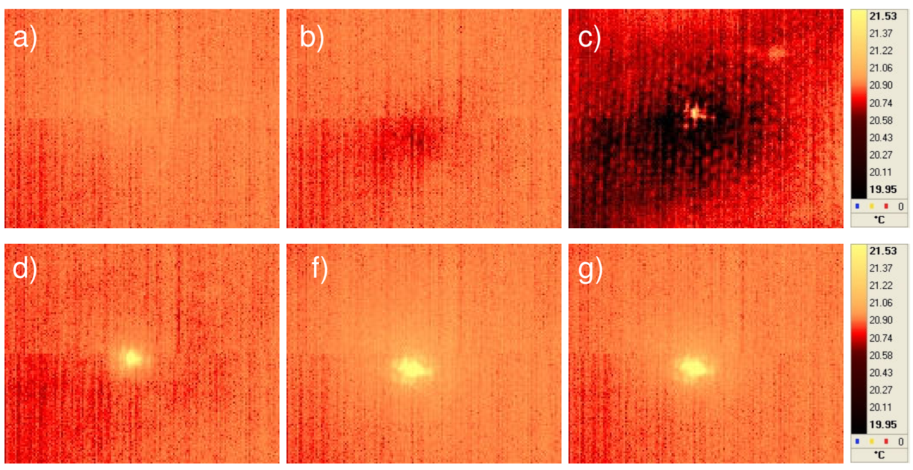

Fig. 1: Consequent images of thermal distribution during the impact at frame rate of 360 Hz

3. Damage evaluation based on the TSA

Fig. 3 shows the stress distribution of damaged and intact specimens. For the damaged specimens, the *0 MPa* stress at the point of impact is caused by the fact that damaged glass fibers cannot carry load.

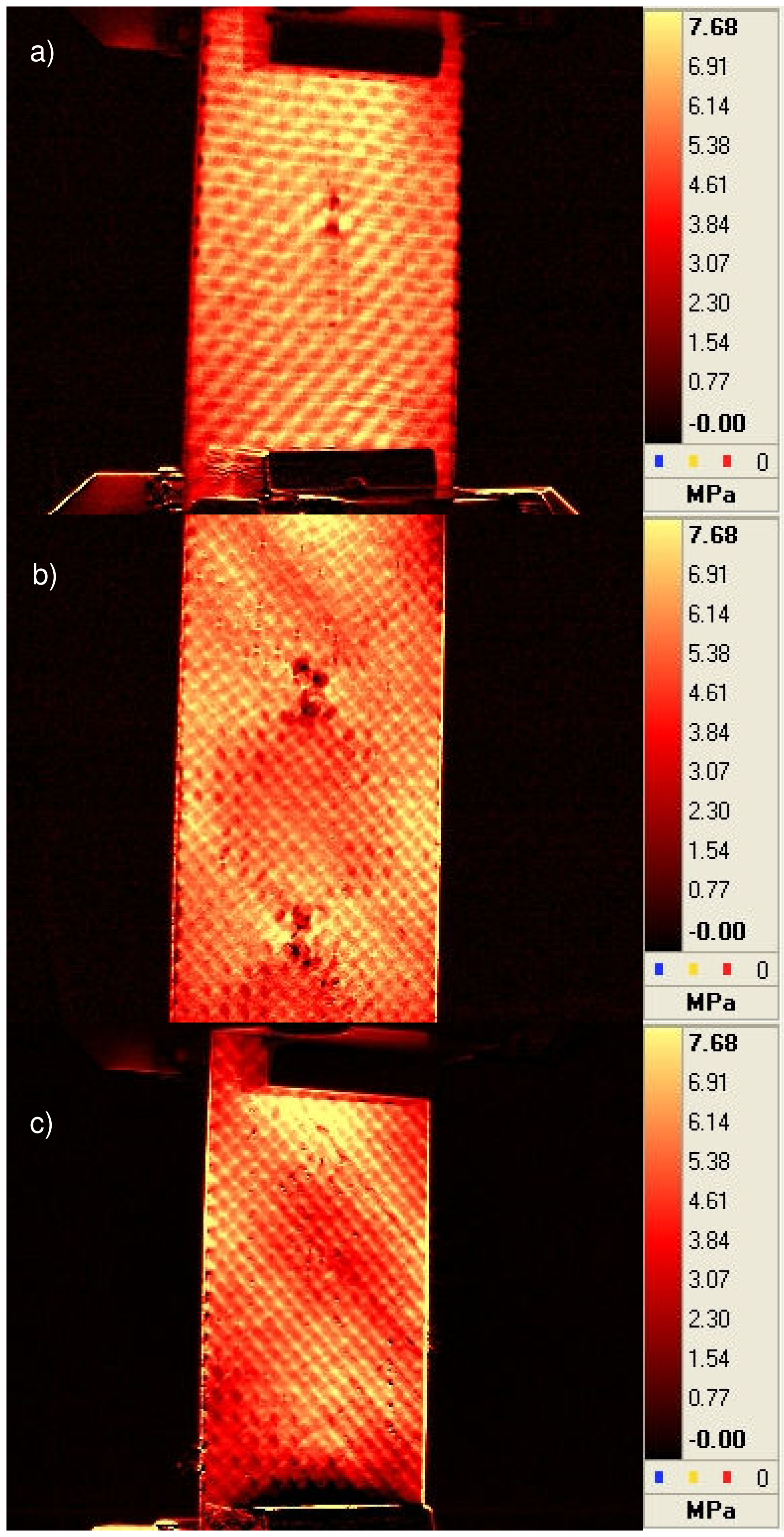

Fig. 2: Stress distribution for a) damaged 0° fibers, b) damaged ±45° fibers and c) intact ±45° fibers specimen

4. Concluding remarks

The presented approach showed good correlation of damage observed during the impact (1st step) and damage observed by the TSA (2nd step). Therefore, the TSA can be used as powerful non destructive method for detecting the level of damage of composite structures. The method requires that the structure is cyclically loaded (approx. 10 Hz). If cyclic loading cannot be applied, the pulse (flesh) thermography should be used.

Acknowledgements

The financial support of the Ministry of Science, Education and Sports project "Fatigue strength of constructions and materials" is gratefully acknowledged.