Characterization of defects in curved CFRP samples using pulsed thermography and 3D Finite Element Simulation

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Abstract

Active thermography is a technique for non-destructive testing used for a contact-free inspection of components and materials. Thermographic methods are considered as an alternative to the state of the art techniques of ultrasonic- or X-ray-testing. In particular, composite materials like Carbon Fibres Reinforced Plastics (CFRP), are increasingly analyzed by means of Active Thermography in order to detect defects like voids, delaminations or inclusions of foreign materials. Although much progress has been achieved in these fields in the last years, the studies and applications of thermographic detection of flaws are restricted to specimens with simple geometries in most cases found in literature. For industrial applications, however, components with complex geometries are of even prior importance [1]. In complex structures the temperatures after thermal excitation are influenced not only by material and defect properties but also by geometry effects and details of the excitation conditions. Thus the evaluation procedures used in the case of simple geometries cannot be applied in complex structures.

We present results obtained from Pulsed Thermography on curved components made up of CFRP. In the specimens inclusions of Teflon and messing stripes with varying size and orientation are positioned at different depths. All experiments are performed by means of a 320x240 uncooled FPA camera with a frame rate of 25 Hz. As excitation source either flash light or a rotating mechanical shutter system in combination with a high power halogen lamp is used.

In thermographic experiments, for both the reflection as well as the transmission mode, the influence of the conditions of the excitation as well as the algorithms used for the evaluation are studied systematically with respect to the detectability of defects. Especially in the curved regions, it is important to separate defect-related effects on the surface temperature from effects due to the complex sample shape like curvatures or edges. The usage of 3D Finite Element Simulation, taking into account convective heat transfer, radiation, anisotropic heat conduction, inhomogeneous heat excitation as well as orientation dependent heat absorption makes it possible to correct the result with respect to geometry effects (see figure 1). A similar approach has been applied recently in the case of Glass Fibre Reinforced Plastics [2], where the distribution of the density could be determined with spatial resolution in spite of a complex sample shape.

By combining the simulation results with experimental thermographic data we are able to develop algorithms for the detection of inclusions in CFRP-components of complex shape. Further we show that it is possible to determine the size, orientation as well as the depth of the inclusions.

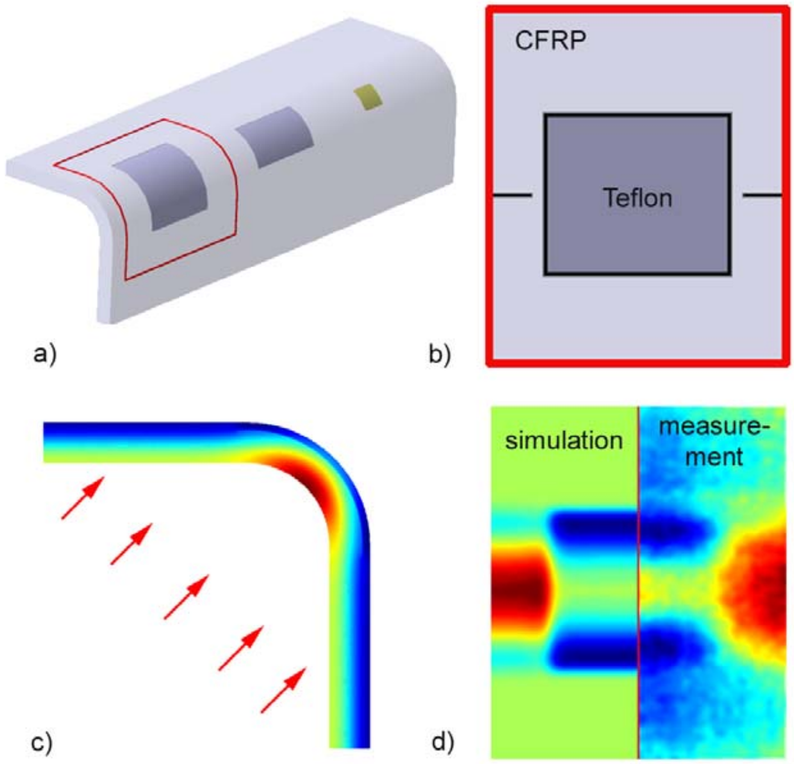

Fig. 1. *Thermographic study of curved CFRP samples: (a) CFRP specimen with Teflon® inserts, (b) Teflon® insert (20x20 mm), (c) Finite Element simulation and (d) comparison of temperature images 15 seconds after flash excitation*

REFERENCES

[1] M. Susa, C. Ibarra-Castanedo, X. Maldague, S. Svaic, A. Bendada, and I. Boras. Pulse thermography applied on a complex structure sample: comparision and analysis of numerical and experimental results, In *IVth Conferencia Panamericana de END*, (2007).

[2] G. Hendorfer, G.Mayr, and E. Schlotthauer. Pulsed thermography applied to components with complex shape. In *Review of Progress in Quantitative NDE, Golden CO* , (2007).