THE APPLICATION OF PULSE HEATING INFRARED THERMOGRAPHY TO THE WIND TURBINE BLADE ANALYSIS

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Summary. The application of infrared thermography based on the pulse heating and gradient filtering approach is demonstrated on examples of wind turbine blades where blade structure and anomalies such as cracks and air pockets trapped in gelcoat are addressed.

1 INTRODUCTION

Glass reinforced polymer structures (GRP), such as wind turbine blades, lightweight airplanes, boat hulls, etc., are often subjected to impacts caused by flying/floating objects or mishandling. Inspection of GRP structures is mostly limited to visual control and more tedious ultrasound gauging or tapping on the surface. A more robust and faster method for detecting potential zones with anomalies, based on the pulse heating thermography (PHT), is presented herein. Advantages of non-destructive testing (NDT) approaches based on the infrared (IR) thermography, e.g. Thermoelastic stress analysis and PHT, are presented for the 900 W wind turbine blade in [1] and the glider plane inspection in [2]. The PHT approach enables clearer distinction between material anomalies such as cracks, fiber delamination, air pockets or debonding in gelcoat protective layer.

2 PRINCIPLES OF PULSE HEATING THERMOGRAPHY

The Pulse Heating or Flash thermography is based on observing the transient cooling process after a heat pulse. The heat pulse is generated by Xenon flash light (for the case of fast cooling material) or Halogen light source (for the case of slower cooling material). For the transient cooling period (Fig. 1), anomalies such as trapped air pockets (Fig. 1b), cracks (Fig. 1c, 1d) or hidden blade structure (reinforcements in clamping region, Fig. 1a) become visible, what was not the case for the “pure” thermograms where no pulse heating was
applied.

Figure 1: Thermograms without and with pulse heating for: a) 0.9 kW blade, b) 1.4 kW blades c) intact and ruptured 1.4 kW blade, and d) detail of ruptured 1.4 kW blade.

3 IMAGE FILTERING BASED ON THE THERMAL GRADIENT APPROACH

There are several very successful approaches of filtering and enhancing anomalies detection, mostly presented for more academic examples. The goal of here presented PHT approach is not to enhance the IR image quality, but to make anomalies more distinguishable from remaining structure. On this real engineering example the gradient method is demonstrated in Fig. 2, where a PHT detail of 1.4 kW blade (depicted in Fig. 1b and 2a) enabled the detection of air pockets in gelcoat layer. The presence of air pocket is proven by ultrasound thickness gauging. Fig. 2b) depicts the PHT of same image like 2a, with the temperature displayed in form of a 3D image. Figure 2c) represents the thermal gradient of the PHT, what enables a distinguishable detection of air pockets. Fig. 2d is thermal gradient of PHT image previously filtered by using a low-pass filter, what enabled stronger distinction of anomalies than in case of thermal gradient only (Fig 2c).

Figure 2: a) PHT thermogram showing air pocket, b) PHT thermogram in 3D view, c) thermal gradient of PHT, and c) thermal gradient obtained from filtered PHT thermogram

REFERENCES
