LOCK-IN THERMOGRAPHY ANALYSIS OF WOVEN CFRP DAMAGED BY DRO-WEIGHT IMPACT

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Introduction

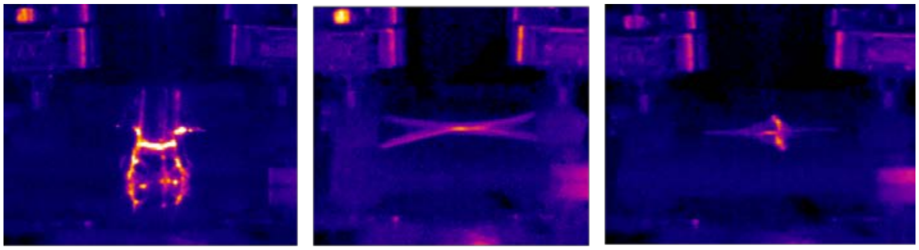
CFRPs have high specific strength and specific stiffness and are mainly used as lightweight structural material. Nondestructive inspections are mainly used to check pores and cracks in CFRPs that occurred processing. Among them, the infrared ray image inspection has an advantage that the internal defect of the composite materials can be confirmed without damaging the specimen. In this study, the Drop-Weight Impact test was performed on the carbon composite material with three lamination angles, and the internal damage of the specimens after impact was analyzed by the lock-in thermography method. An infrared thermal image refers to the converted image through the detecting the radiant energy on the surface of the object by a thermal imaging camera and then convert that energy into temperature for visually confirmation [1].
The Lock-in thermography method is the system of conversion that maximizes the defects by synchronizing the pulse energy of the heat source with the detection signal of the thermal imaging camera [2].

Materials and Methods

The test specimens used in the experiments were formed into woven carbon prepregs, and the molded specimens were subjected to a Drop-Weight Impact test according to ASTM D 7136 specifications. During the Drop-Weight Impact test, the radiant energy generated by the impact was confirmed by the thermal imaging camera. After the test, the lock-in thermography analysis was carried out to check the internal damage of the specimens.

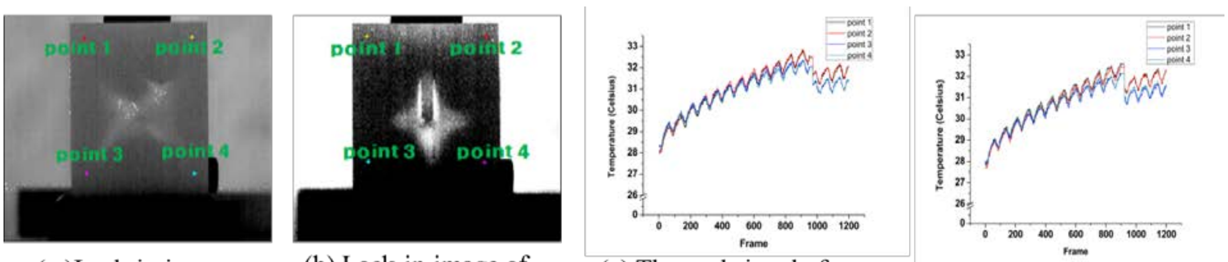
Results and Discussion

The test specimens used in this experiment were molded into three types of unidirectional carbon prepregs at $0°_{[30]}$, $+ 45°_{[15]}$ / $- 45°_{[15]}$ and $0°_{[15]}$ / $90°_{[15]}$. The drop impact test was performed on the specimens according to ASTM D 7136 [3]. As shown in Figure 1, the occurred thermal energy during the impact testing was observed using thermographic camera. After the test, the lock-in thermography analysis was carried out to check the internal damage of the specimens. Figure 2(a)-(b) shows the image and Figure 2(c)-(d) shows the temperature signals at different points that were acquired through lock-in non-destructive inspection. All cracks propagated from the impact part to the fibers direction and could be confirmed through the thermal image. The mode of failure was confirmed by thermal imaging camera, and the failure factors such as fiber failure and peeling were confirmed through lock-in thermography. In case of $0°_{[30]}$ lamination, the specimen was completely broken in the direction perpendicular to the fiber during the drop test, and the non-destructive test could not be performed.



(a) 0°[30] (b) +45°[15]/-45°[15] (c) 0°[15]/90°[15]

Figure 2 Drop-weight Test of each specimen



(a)Lock-in image of +45°[15]/-45°[15] specimen

(b) Lock-in image of 0°[15]/ 90°[15] specimen

(c) Thermal signal of +45° /-45°[15] specimen

(d) Thermal signal of 0°[15]/ /90°[15] specimen

Figure 3 Results of Lock-in non-destructive Testing

Conclusions

The non-destructive testing was performed on the CFRP composites subjected to drop-weight impact. Both normal thermal imaging and lock-in non-destructive inspection showed that the failure modes were dependent on the angle of the fiber. However, the lock-in testing showed fiber breakage and interlaminar exfoliation that could not be seen in the standard thermograph imaging. Our future work will focus on the comparison of the experimental results with the numerical analysis.

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