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D. Dhital, J.R. Lee, C.Y. Park

Fully Non-Contact Laser Excitation and Reception Ultrasonic Propagation Imaging System with Repeat Scanning Technique

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A reliable nondestructive evaluation technique is essential to detect any possible damage at the initiation phase to allow preventive measures to be taken for failure prevention. Composites are used in aerospace structures e.g., aircraft wing-box, which are highly susceptible to impact damages. Ultrasound has been widely used, but conventional contact ultrasonic inspection techniques are often difficult or not accessible in hard to reach locations and generally require disassembly of the structure for inspection, which limits in-field applicability. A novel fully non-contact hybrid ultrasonic propagation imaging (UPI) system that uses Q-switched laser (QL) ultrasonic scanning excitation and laser Doppler vibrometer (LDV) sensing has been devised and implemented. The problem of the lower sensitivity of LDV than those of contact sensors was solved by time domain averaging through repetitive scanning technique. Since not LDV but QL is used for scanning, LDV can be fixed into its own maximum sensitive status. Multiple 3D imaging processing such as ultrasonic wave propagation imaging (UWPI) and wavelet-transformed ultrasonic propagation imaging (WUPI) algorithms were used to extract reliable damage features without overlook. The pure laser hybrid system enables remote and fully non-contact automatic one-sided inspection for temporal reference-free damage evaluation, and is also applicable to in-field structures. Experimental analyses were conducted for impact damage on carbon fiber reinforced polymer composite wing-box specimen. The proposed laser excitation and sensing UPI system provided enhanced results for damage visibility, and accuracy in determining damage location and size. The results demonstrated the possibility of quantitative, fast and automatic damage evaluation for in-field application as well.

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Ключевые слова:

Содержание