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Damage localization on hot and curved structures based on ultrasonic propagation imaging technology

C.C. Chia[1], S.G. Jang[1], J.R. Lee[2], D.J. Yoon[2]

Summary

An ultrasonic propagation imaging (UPI) system consisted of a Q-switched Nd-YAG pulsed laser with 20 Hz-repetition rate and a motorized tilting mirror system for rapid scanning of target was developed. The system which requires neither reference data nor fixed focal length could be used for health monitoring of curved structures. If combined with a fiber acoustic wave PZT (FAWPZT) sensor, it could be used to perform inspection on hot target structures, which present formidable challenges to the usage of contact piezoelectric transducers mainly due to the Curie temperature limitation of transducers and debonding problem due to the mismatch of coefficient of thermal expansion between the target, transducer and bonding material. The inspection of a stainless steel plate with a curvature radius of about 4 m, having 2×1 mm open-crack was demonstrated at 150˚C with the use of a FAWPZT sensor welded on the target structure. In addition, highly-curved surfaces scanning capability was demonstrated on a stainless steel cylinder with a 2×1mm open-crack. The adaptivity of the system for large laser incident angle up to $\pm70^{\circ}$ was demonstrated. The imaging results were presented in ultrasonic propagation movie which was a moving wavefield emerged from an installed ultrasonic sensor. Damages were localized by the scattering wavefields. The result images enabled easy detection and interpretation of structural defects as anomalies during ultrasonic wave propagation.

keywords: Ultrasonic propagation imaging, structural health management, Q-switched pulsed laser, laser ultrasonics, hot and curved structures.

[1]Department of Aerospace Engineering, Chonbuk National University, 664-14, Duckjin-dong, Jeonju, 561-756, Korea.

[2]Safety Metrology Center, Korea Research Institute of Standards and Science, Daejon, 305-340, Korea.