Korea Air Force Standard NDE Coupon Test of Full-Field Pulse-Echo Laser Ultrasonic Propagation Imaging System

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***Abstract*— Korea Air force standard NDE coupons which are practical structures used in real aircraft construction were inspected using full-field pulse-echo ultrasonic propagation imaging (FF PE UPI) system. The Korea Air force standard NDE coupons consist of a laminated carbon fiber reinforced plastic (CFRP) step and a CFRP skin/honeycomb sandwich, an aluminum honeycomb sandwich, a bonded aluminum-aluminum coupon, an aircraft magnesium fin including various defects. The FF PE UPI system inspects based on combined generation and sensing laser beams for generating and sensing pulse-echo ultrasound and two-axis transition stage for raster scan. In order to visualize various defects of the coupons, pulse-echo ultrasonic wave propagation imaging algorithm is used after scanning the coupons.**

Keywords—laser ultrasonic; pulse-echo through-the-thickness ultrasound; full-field pulse-echo ultrasonic wave propagation imaging; nondestrutive inspeciton

I. INTRODUCTION

Composite structures have an advantage of weight to strength ratio compared with metallic materials and are extensively applied to aerospace industry. However, composite structure shows complex fracture mechanism and most of defects in compose structure are invisible such as delamination and disbond. C-scan, one of inspection results based on nondestructive ultrasonic testing (UT), shows an excellent result for detecting through-the-thickness defects which are invisible in composite structures. Conventional C-scan techniques have usually used a non-contact inspection method, such as air-coupled ultrasonic transducer [1]. However, the conventional C-scan methods have the limitation of stand-off distance between transducer and structure and the disadvantage of using couplant. Recently, laser ultrasonic generator is widely used as a non-contact nondestructive inspection tool [2] because it generates ultrasounds of diverse modes by thermoelastic mechanism [3]. In addition, many researchers are interested in measuring ultrasound using sensing laser because it has advantage of non-contact sensing in inaccessible area and stand-off distance between laser head and the structure is adjustable within tens of meters.

In this study, standard NDE coupons of Korea Air force which is practically used as real structure in aircraft were inspected using full-field pulse-echo laser ultrasonic propagation imaging (UPI) system. The Korea Air force standard NDE coupons consist of a carbon fiber reinforced plastic (CFRP) step laminate and a CFRP honeycomb sandwich, an aluminum honeycomb sandwich, a bonded aluminum-aluminum coupon, an aircraft magnesium fin. The system consists of generation laser and sensing laser to generate and sense pulse-echo through-the-thickness ultrasound with two axis translation stage for raster scan in scan area. After completing scan, the defects were visualized based on full-field pulse-echo ultrasonic wave propagation imaging (UWPI) algorithm.

II. FULL-FIELD PULSE-ECHO ULTRASONIC PROPAGATION IMAGING SYSTEM

A. Mechanism

Full-field pulse-echo laser ultrasonic propagation system is totally different with conventional ultrasonic testing system which generates C-scan result because this system is fully non-contact non-destructive inspection system using laser excitation and sensing with two-axis translation stage as shown in Fig. 1a. In addition, full-field pulse-echo laser UPI system scans structure along raster scanning pattern at one side of structure through generation and sensing laser beams. As shown in Fig. 1b, generation laser which is Q-switched laser generates diverse mode ultrasounds by thermoelastic mechanism at impinging point of generation laser beam. Among laser-induced ultrasounds, sensing laser captures pulse-echo through-the-thickness ultrasound by impinging the sensing laser beam at the same point as the generation laser beam. This sensing principle is repeated over the scan area thus a full-field ultrasound as large as the scan area can be visualized by full-field pulse-echo ultrasonic wave propagation imaging algorithm.

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