논 문

Effect of Ultrasonic Waves on Fiber Orientation in CFRP Laminated Composites

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Abstract

최근에는 탄소섬유복합재료(CFRP)는 우주 및 민간 항공산업분야에 널리 활용이 되고 있는 실정이다. CFRP 복합재는 적층구성에 따라 기계물성치 및 강성에 크게 영향이 미치므로 가장 대표적인 직교이방성 적층재의 적층배향을 비파괴탐상하는 것은 중요하다. 본 연구에서는 CFRP 적층재의 섬유배향에 가장 민감한 초음파 전단파를 활용하기 위해 2개의 종파 초음탐촉자를 이용하는 새로운 기법을 제안 하였다. 또한 초음파 전단파를 발생하기위해서는 탐촉자밑면에 접촉매질인 태운꿀을 사용하는데 초음파시험하는 도중에 물성치중에 하나인 즉 점성이 상당히 변하게 된다. 이러한 문제를 해결하기위해 2개의 종파용 초음파탐촉자를 이용해 전단파를 발생시킴으로써 접촉매질문제를 상당히 경감할 수 있는 것으로 나타났으며 여기에서 발생한 전단파가 CFRP 복합적층판의 섬유배향에 매우 민감함을 알 수 있었다.

Key words : Ultrasonic Waves, Couplant, CFRP, Fiber Orientation

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1. Introduction

Composite laminates help to lighten components because they have the advantage of higher strength-to-weight ratio. Especially, So, ply orientation is an important design parameter for a composite laminate as important as flaw detection [1-6]. Many researchers are investigating on fiber orientation of CFRP composite. An EMAT (electro-meganetic transducer) was used for the various green composite layups in order to change coupling condition during the angular scan was avoided [7].

This paper aimed at alleviating the couplant problems when using a viscous couplant is to eliminate it from the testing. The design and use of a shear wave transducer will be presented for alleviating the couplant problem and the fiber orientation of composite laminates was characterized. Also, a fixture with a new concept was made for characterizing fiber orientation for making transmission measurements. Theory and experimental results were compared for confirming the suggested jig design.

2. Theory and Experimental Method

A model was presented by Hsu at al [9], which model decomposes the transmission of a linearly polarized ultrasound wave into orthogonal components through each ply of a laminate. The input to the first ply is decomposed into one component which propagates through the first ply parallel to the fibers and one component which propagates through the first ply perpendicular to the fibers. This process continues for all remaining plies in the laminate. CFRPs have been made from carbon fibers (CU125NS) by Korea HANKUK Fiber Co.. Its lay-up, stacked with 33plies, indicates that specimen is $[2(90_3,0_3),90_3,\theta_3,90_3,2(0_3,90_3)]$. Here are defect angles (0°, 5°, 10°, 15°, 20° and 45°). One shear wave and two 1MHz, 12.7 mm in diameter transducers in contact transmission mode, two of which serves as a transmitter and the one a receiver, had been used (see Fig. 1). Fig. 1(a) shows schematic mechanism for generating shear waves. The jig is to use two longitudinal wave transducers driven at 180° out of phase to generate a pure shear wave at the bottom base. Here two 1MHz transducers (Panametrics. Co) were used to generate the longitudinal waves. A wedge was fabricated from aluminum such that the cross section consists of an isosceles triangle with two 45° angles show in Fig. 1 (b).

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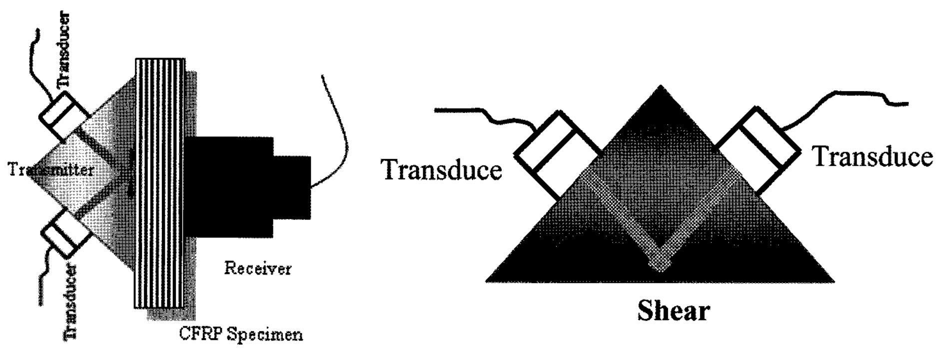

(a)Overview of testing (b) Schematic mechanism for shear waves.

Fig. 1. Schematic for contacting transducer with through-transmission mode.

3. Results and Discussion

All tests utilized a through-transmitted ultrasonic pulse which was generated and received by pyramid jig with two longitudinal transducers and a 1 MHz shear wave transducers. To verify that the suggested model worked at various transducer angles, the first set of experiments were performed using one specimen of 33 aligned plies. Also, a fiber orientation error was confirmed using a C-scanner shown as Fig. 2. This good agreement between the C-scan experimentation and sample was observed using a gate technique. For the CFRP composite material, this test will produce a null, or zero received signal at any transmitter orientation based on the peak-to-peak amplitude. For a laminate consisting of orthotropic plies, this test is very sensitive to fiber orientation and ply sequence. So it was desired to determine if the test had the sensitivity to determine an orientation error of one ply in the laminate. Results from Figs. 3 and 4 indicate that the test has the sensitivity to detect an error of one ply in 33 piles. Specimens with 5°, 10° defect angles were compared to demonstrate the test's capability and sensitivity in determining a misoriented ply as a symmetrical layup with the experimental and theoretical results as shown in Figs. 3 and 4. Especially, peak values between theory and experimentation were corresponded with at 5 and 10 degree respectively. So it is found that the peak points well agreed with those of experimental and theoretical solutions for the peak-to-peak amplitude and angle of function.

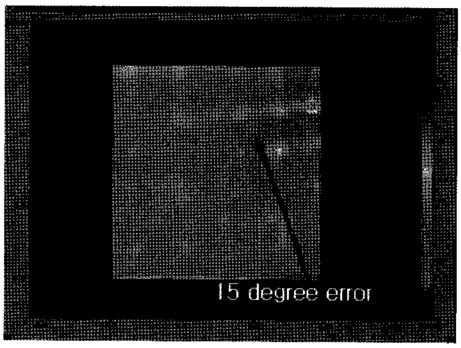

Fig. 2. A C-scan image with fiber orientation error.

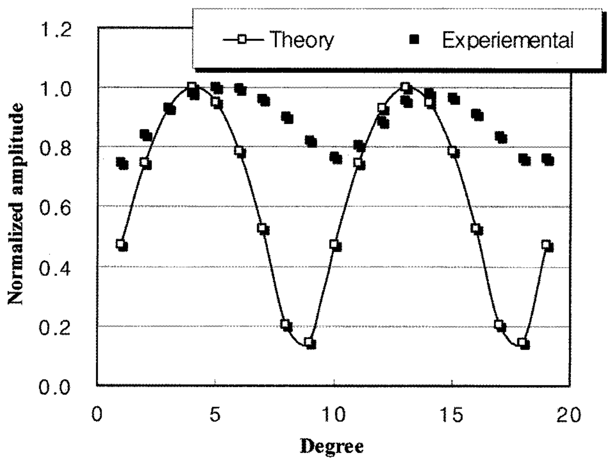

Fig. 3. Modeling and experimentation with 5° defect angle.

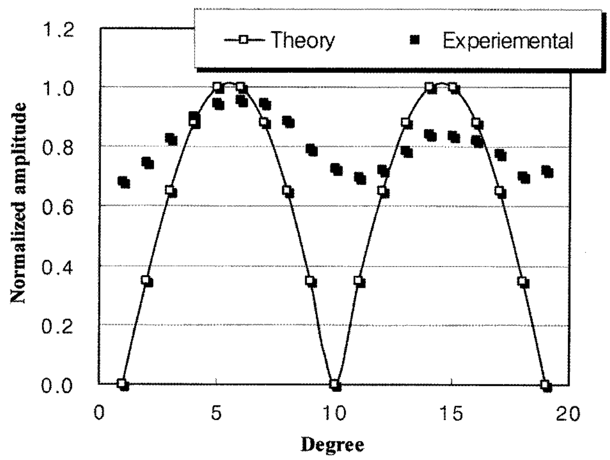

Fig. 4. Modeling and experimentation with 10° defect angle.

4. Conclusions

In this paper, a jig with a new concept was adopted in order to inspect effect of fiber orientation of CFRP laminated and the conclusions obtained in this study as follows; 1) It is demonstrated that shear waves of newly-proposed mechanism have highly sensitivity for inspecting error ply in fiber orientation of laminates. 2) By performing the shear wave testing with an new design jig, the fiber orientation effect of the plies can be nondestructively characterized out. And a model has been successfully utilized in order to compare the experimentation.

Acknowledgements

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