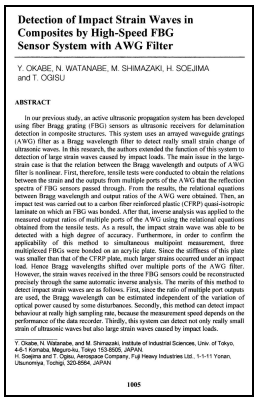
Detection of Impact Strain Waves in Composites by High-Speed FBG Sensor System with AWG Filter

Y. OKABE, N. WATANABE, M. SHIMAZAKI, H. SOEJIMA and T. OGISU

ABSTRACT

In our previous study, an active ultrasonic propagation system has been developed using fiber Bragg grating (FBG) sensors as ultrasonic receivers for delamination detection in composite structures. This system uses an arrayed waveguide gratings (AWG) filter as a Bragg wavelength filter to detect really small strain change of ultrasonic waves. In this research, the authors extended the function of this system to detection of large strain waves caused by impact loads. The main issue in the large-strain case is that the relation between the Bragg wavelength and outputs of AWG filter is nonlinear. First, therefore, tensile tests were conducted to obtain the relations between the strain and the outputs from multiple ports of the AWG that the reflection spectra of FBG sensors passed through. From the results, the relational equations between Bragg wavelength and output ratios of the AWG were obtained. Then, an impact test was carried out to a carbon fiber reinforced plastic (CFRP) quasi-isotropic laminate on which an FBG was bonded. After that, inverse analysis was applied to the measured output ratios of multiple ports of the AWG using the relational equations obtained from the tensile tests. As a result, the impact strain wave was able to be detected with a high degree of accuracy. Furthermore, in order to confirm the applicability of this method to simultaneous multipoint measurement, three multiplexed FBGs were bonded on an acrylic plate. Since the stiffness of this plate was smaller than that of the CFRP plate, much larger strains occurred under an impact load. Hence Bragg wavelengths shifted over multiple ports of the AWG filter. However, the strain waves received in the three FBG sensors could be reconstructed precisely through the same automatic inverse analysis. The merits of this method to detect impact strain waves are as follows. First, since the ratio of multiple port outputs are used, the Bragg wavelength can be estimated independent of the variation of optical power caused by some disturbances. Secondly, this method can detect impact behaviour at really high sampling rate, because the measurement speed depends on the performance of the data recorder. Thirdly, this system can detect not only really small strain of ultrasonic waves but also large strain waves caused by impact loads.

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Ключевые слова:

Содержание.