Estimation of Nonlinear Elastic Constants based on the Cross-sectional Resonant Ultrasound Spectroscopy of the Cylindrical Structure under Axial Load

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Nonlinear elastic constants are highly related to degradation and micro-damage of materials. It is also receiving much attention in the field of non-destructive testing as a breakthrough method for improving defect detection. However, it is not easy to apply the nonlinear elastic constants to the field due to its large measurement uncertainty. Therefore, many studies are currently underway for accurate and reliable measurements. In this study, we propose a method for measuring nonlinear elastic constants by observing the variation in the resonant frequency of the cylindrical structure under axial load. Nonlinear elastic materials vary in stiffness with the applied load. These stiffness changes cause variation in wave velocity or resonant frequency. In other words, the nonlinear elastic constants can be estimated by measuring the variation of the resonant frequency. The resonant spectrum detection system of the cylindrical structure has been established, and the temperature was kept constant. Also, a nonlinear elastic constants extraction algorithm from the measured resonant spectrum was developed. Finally, it was applied to the actual cylindrical structure with S20C material. Murnaghan's third-order elastic constants l, m, n were obtained for S20C material. The results show promising feasibility on the measurement of nonlinear elastic constants of the cylindrical structure.