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Elastic Moduli Identification Method for Orthotropic Structures based on Vibration Data

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Abstract

A novel numerical-experimental methodology for the identification of elastic moduli of orthotropic structures is proposed. Special attention is given to the elastic moduli of laminated electrical steel sheets, which are widely used for the magnetic cores of electric motors and generators. The elastic moduli are determined specifically for use with finite element vibration analyses, such that the dynamic characteristics of such structures can properly be predicted by using the identified elastic moduli. The identification problem is formulated as an inverse problem with nonlinear least squares fit between the measured and computed modal frequencies. The problem is sequentially solved with increasing number of modes that are carefully yet automatically selected based on the analytic sensitivity of the modal frequencies on the elastic moduli. Using the results of numerical experiments, it is shown that the optimal solution obtained by the proposed method converges to the accurate elastic moduli as the number of modes increases. Furthermore, it is also shown that the method not only converges faster but also is numerically more stable than conventional methods. Finally, the method is applied to the experimentally-obtained modal frequencies of the laminated electrical steel sheets, and successfully identifies the elastic moduli where the finite element modal analysis can reproduce accurate modal frequencies.