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Date & Time: **Wednesday, October 25, 2017 at 9:00 a.m.**

Location: ME Conference Room

Committee: Dr. Victor Giurgiutiu – Advisor
Dr. Michel van Tooren
Dr. Lingyu (Lucy) Yu
Dr. Lin Bin
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Proposal Title: Non-destructive Evaluation of Composites: Predictive Guided-Ultrasonic Wave Modeling, Non-destructive Material Characterization, and the Application to Aerospace Structures

To predict dispersion curves, it is common to use different solution approaches depending on the material type (isotropic or anisotropic) of the medium in which the wave propagates. The two different solution methods are defined in different domains, frequency-phase velocity domain for isotropic and wavenumber-phase velocity domain for anisotropic materials which can lead to difficulties and unsatisfying results when predicting the dispersion curves for hybrid laminates which contain both isotropic and anisotropic materials. Therefore, a unified formulation defined in the wavenumber-phase velocity domain for both isotropic and anisotropic materials is desired and proposed. The proposed unified analytic method (UAM) is a simple and mathematically straightforward formulation that utilizes Christoffel's equation for a lamina to obtain the eigenvalues and eigenvectors. The eigenvalues and eigenvectors are used to set up the field matrix from which the dispersion curves could be retrieved using the phase approach. As last, the dispersion curves are grouped and sorted using a modeshape analysis.

It is important to realize that predictions depend on the accuracy of the stiffness matrix, input for the UAM. Common practice is to determine the required material properties using destructive mechanical testing procedures in combination with assumption based on the material type. However, the predicted dispersion curves varied significantly from those obtained experimentally; the source of error was identified as the accuracy of the stiffness matrix. A new, non-destructive characterization method based on synergistic combination of several existing ultrasonic immersion techniques is therefore implemented. This LAMSS ultrasonic immersion technique was used to retrieve the stiffness matrix for a unidirectional and woven fabric composite.

The retrieved stiffness matrix using the LAMSS ultrasonic immersion technique was compared to the stiffness matrix reported in the literature. In the case of the woven fabric, in-house mechanical testing was performed as well. Differences between the stiffness matrices retrieved using the different methods were explained.

To validate the UAM predictions, the different stiffness matrices obtained with our methods as well as from literature were used to predict the wavenumber-frequency dispersion curves and compared to the experimentally obtained dispersion curves. The experimental dispersion curves were obtained using a hybrid setup consisting of a piezoelectric wafer active sensor exciter and a scanning laser Doppler vibrometer wave measuring system. A good correlation was observed between the predicted and experimental wavenumber-frequency dispersion curves when using the material properties obtained through the LAMSS ultrasonic immersion approach for both the unidirectional and woven fabric composite material. However, when stiffness matrix values obtained through destructive mechanical testing procedures were used, the error between the predicted and experimental wavenumber-frequency dispersion curves was increased.

Please plan to attend.