EFFECTS OF DELAMINATION ON GUIDED WAVE PROPAGATION IN LAMINATED COMPOSITE BEAMS – NUMERICAL SIMULATION

Siavash Shoja, Viktor Berbyuk, Anders Boström

Department of Applied Mechanics, Chalmers University of Technology

Introduction

In composite laminates, delamination is one of the main mode of failure for structures. Detecting the delamination in a structure is usually performed using a non-destructive testing (NDT) methods such as ultrasonic guided waves. Studying the application of guided waves to delamination detection using experimental work is not the most efficient way. The delamination has to be created artificially in the composite structure and experimental measurement has to be done using sensors and transducers. On the other hand, finite element (FE) modelling of guided waves propagating in composite structures is an efficient way of studying their application for delamination detection. The FE model can be validated with both analytical calculations and experimental work.

Methods

Although the FE modelling can create an efficient way of studying the guided waves propagating in composite laminates, in more complicated structures the model becomes too large and computationally expensive. Therefore, the complexity of the model should be reduced by taking care on reasonable accuracy of the model response. The accuracy of the reduced model can be verified, for instance by comparing the results to a full-scale model or an experimental measurement. Some ways of reducing the complexity of the FE model is to use the equivalent single-layer approach instead of a three-dimensional solid model.

Three models have been developed to study guided wave propagation in composite laminates including a delamination. First model is created using 3D solid elements and a delamination is applied between the plies using the duplicate node method (DNM). In the second model, the composite laminate is modelled by homogenizing the material properties into a single layer with 3D shell elements and a delamination is applied between the plies using the DNM. In the third model, the composite laminate is modelled by homogenizing the material properties into a single layer with 3D shell elements and a stiffness reduction method (SRM) is used to model the delamination.

Results

The three models are compared by comparing the wave pattern, signals' time histories and wave velocity. Results show that the SRM based model can be used as the most computationally efficient one and having acceptable accuracy to simulate wave propagation in large and complicated structures.

In order to study the signal in the three models, the signal from a sensor before the delamination location is compared and illustrated in Fig. 1. The comparison shows good agreement between the phase of signal in 3D solid elements model and DNM based shell elements model. However it should be noted that the signal amplitude is better predicted in SRM based model. This means SRM based model can be used as an easy to apply method to model delamination in a shell model with reasonable accuracy.

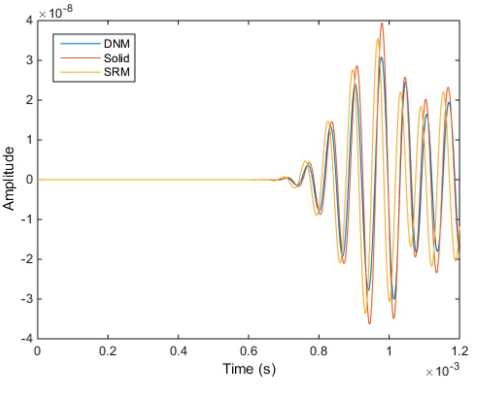

Figure 1: Comparison between the system response between the solid model, DNM and SRM in a sensor before the delamination location.

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