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MODELING OF GUIDED WAVE INTERACTION WITH DISBONDS IN HONEYCOMB COMPOSITE SANDWICH PLATES SUBJECT TO PZT EXCITATIONS

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ABSTRACT

This study is motivated by the need to understand characteristics of guided wave propagation and interaction with disbonds in Honeycomb composite sandwich plates using built-in piezoelectric (PZT) wafers. A semi-analytical model based on Global matrix method is developed to calculate far-field response in laminated composite plates subjected to high-frequency tone-burst signals generated by a PZT source. The results are compared with those obtained from finite element analysis in ANSYS showing excellent agreement. Disbond is then modeled in ANSYS and their effects on the signal characteristics generated by a variety of transient surface excitations are studied.

Keywords: wave propagation , disbonds, global matrix.

INTRODUCTION

Honeycomb composite sandwich structures (HCSS) are widely used to form major structural components of aerospace structures to achieve high strength to weight ratio. Due to low velocity impact & fatigue loading these materials are susceptible to the sub-surface disbonds/delamination. It is very time consuming and labour intensive process to detect the disbond through traditional nondestructive testing (NDT), such as ultrasonic pulse-echo, C-scans etc, which often require disassembly of structure. Hence efforts have been made to develop an efficient structural health monitoring (SHM) system with built in PZT-wafer that can monitor the structure continuously in-service.

Some publications are available on guided Lamb wave based detection of delamination in laminated composite structures, Guo *et.al*. [1], Hayashi *et. al*. [2], and Palacz *et. al*. [5], but none of these consider the effect of transient surface excitations in the vicinity of the delamination or disbond of HCSS. No literature is available on theoretical modeling of Wave propagation in HCSS.

In this paper, ANSYS is used as a powerful simulation tool to model the disbond in HCSS. A fast and efficient 2D plain-strain theoretical model based on global matrix methods and wave number integral technique is developed to validate and interpret the ANSYS simulation in absence of disbond, Mal [3] and Banerjee et. al.[4] .

THEORETICAL AND FINITE ELEMENT MODELING

The HCSS is used in this study has extremely lightweight honeycomb nomax core of thickness 12.7 mm is sandwiched between thin carbon-epoxy layered skins at top & bottom and the thickness of each composite lamina is 1.78mm. The global matrix method is considered herein to develop a simplified 2D (plain-strain) semi-analytical model for rapid calculations of far-field response due to transient sources on the laterally unbounded HCSS. The displacements and stresses in each layer are 'exactly' represented in the frequency-wave number domain in terms of four unknown constants in each layer, which are then solved by applying the interface continuity conditions and the stress conditions on the free surfaces. Spatial and time domain solution is then obtained after performing a single wave number integral followed by frequency inversion using the fast Fourier transform.

In the FE Model in ASYS, the point source is placed at centre of the surface of HCSS and 200 mm disbond is positioned at the interface of core & top skin . The distance between the source and the center of disbond is 200 mm. 4 noded plane-strain quad elements are used and the element size is controlled so that its dimension does not exceed one-tenth of the minimum wavelength. The time variation of the excitation signal is considered to be a five cycle sine pulse in a Hanning window carrying a central frequency for both the theoretical and FE model.

RESULTS AND DISCUSSIONS

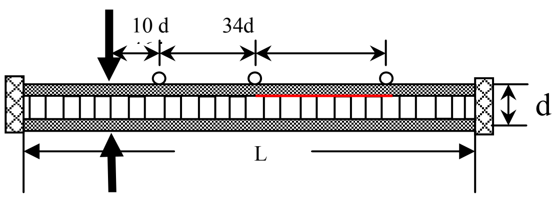

Fig. 1 - Schematic details of typical case of HCSS

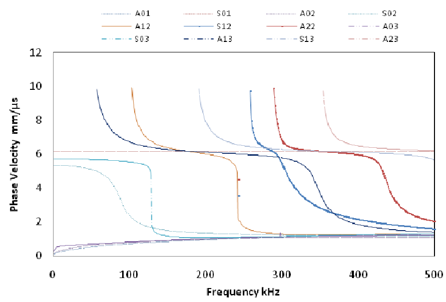

Fig. 2 - Theoretical dispersion curves For Skin,core+ Skin & Skin+Core +Skin

Excellent agreements between the theoretical and simulated results are found for a typical case in absence of disbond. Comparison of results with and without disbond are obtained from FE analysis describing reflections obtained from the exit of the disbond for in-plane & out of plane excitation . In general, guided Lamb wave reflections at disbond occur not at the Entrance of disbond but at exit.

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