Remote Imaging of Local Resonance for Inspection of Honeycomb Sandwich Composite Panels

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***Abstract*—We have developed and tested a new ultrasonic technique for rapid, remote inspection of honeycomb and similar sandwich composites based on imaging of local resonance behavior. A single pristine honeycomb cell can be approximately modeled as a hexagonal plate with appropriate boundary conditions on its six sides. With this in mind, we excite the entire honeycomb panel continuously with a single, steady tone at the resonance frequency of the single pristine cell using a fixed-position transducer. We then measure and visualize the full-field amplitude and phase response over the inspection area using a scanning laser Doppler vibrometer. We applied the technique to two imperfect aluminum honeycomb panels. By imaging the magnitude of the response at each pixel, we found that one can simultaneously visualize the high-amplitude response of the pristine cells, the lower-amplitude response of the out-of-spec cells, the near-zero response near the cell boundaries, and the non-zero response in the damaged cell walls.**

***Keywords*—Nondestructive Inspection, Laser Ultrasound**

I. INTRODUCTION

Ultrasonic inspection of honeycomb is typically done using C-Scans either in a pulse-echo or pitch catch mode. In these modes, time of flight or energy transmission information is then used to assess the condition of the composite facings and core. However, in order to image the shape and bonding condition of the core, the effective raster pixel size of the scan must be on the order of the thickness of the material constituting the core, which is usually only a few hundred microns thick. This is paired with the relatively long per-pixel scan time associated with transient excitation, which often necessitates performing many averages per pixel and waiting for reverberations to die out in between averages. In this work we sought to circumvent these limitations by instead relying on measurable secondary effects of cell geometry, namely, the transverse resonance. By exciting with one tone, the scan has a significantly higher SNR, only needs to measure a few cycles of the response per pixel, and does not have pause between pixels [1], [2].

Using resonance for detecting out-of-spec parts has its origin in the field of resonant ultrasound spectroscopy [3]. These techniques, however, are limited to whole-part resonances, and provide very little local information. Using

Fig. 1. Custom scanning laser Doppler vibrometer system. Visible is the Polytec laser head, the 2D galvo mirror system, and a projector system for displaying inspection results back on to the inspected part.

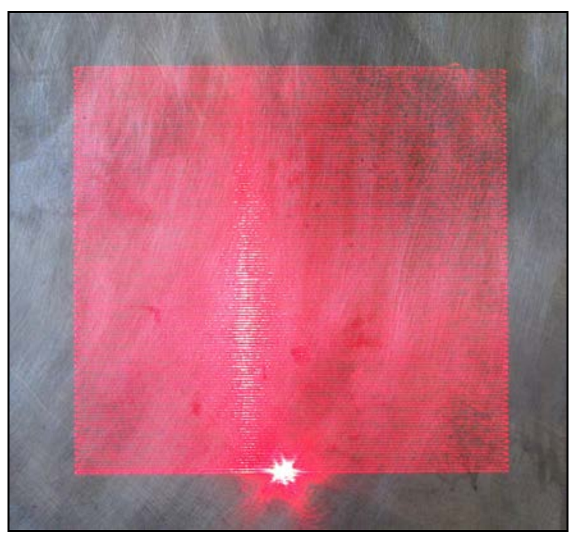

Fig. 2. Extended-exposure photograph of a raster scan on an aluminum plate.

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