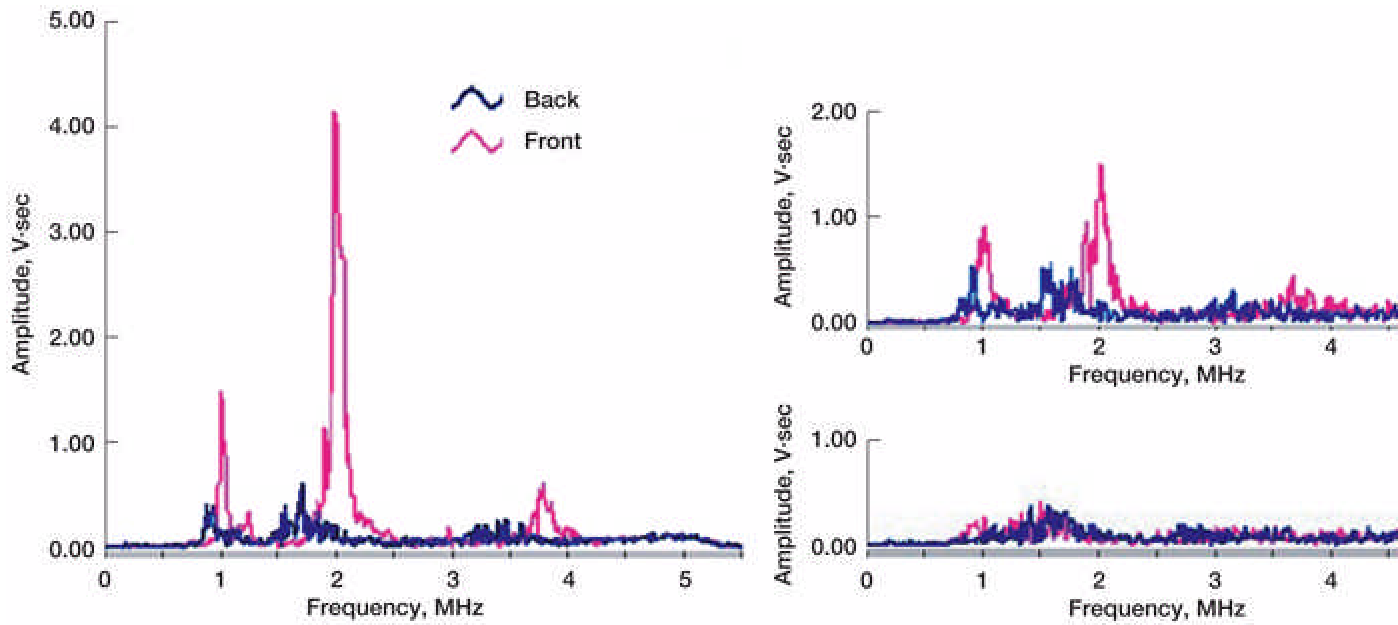
Sandwich Panels Evaluated With Ultrasonic Spectroscopy

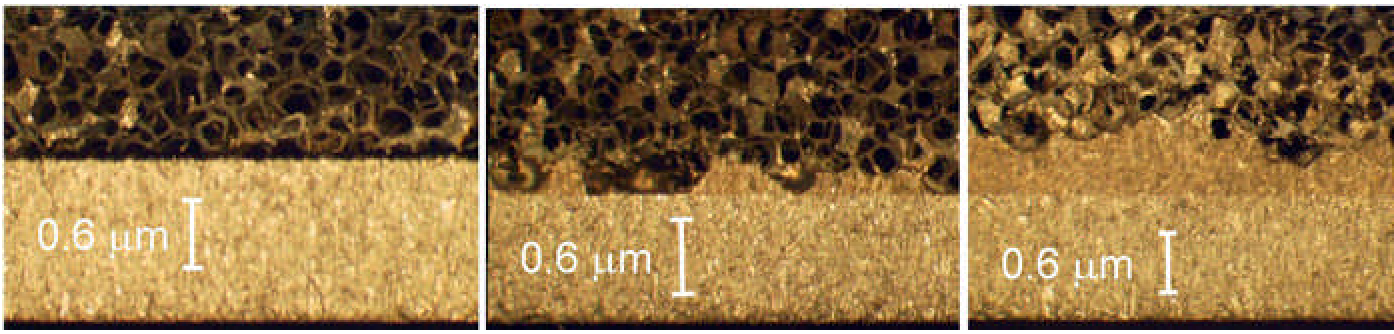
Enhanced, lightweight material systems, such as 17-4PH stainless steel sandwich panels are being developed for use as fan blades and fan containment systems for next-generation engines. The bond strength between the core and face sheets is critical in maintaining the structural integrity of the sandwich structure. To improve the inspection and production of these systems, researchers at the NASA Glenn Research Center are using nondestructive evaluation (NDE) techniques, such as ultrasonic spectroscopy, to evaluate the brazing quality between the face plates and the metallic foam core. The capabilities and limitations of a swept-frequency approach to ultrasonic spectroscopy were evaluated with respect to these sandwich structures (ref. 1). This report discusses results from three regions of a sandwich panel representing different levels of brazing quality between the outer face plates and a metallic foam core. Each region was investigated with ultrasonic spectroscopy. Then, on the basis of the NDE results, three shear specimens sectioned from the sandwich panel to contain each of these regions were mechanically tested.



Frequency spectra plots from the front and back of regions A, B, and D. Left: Region A with poor brazing on the front face plate and presumed good brazing on the back face plate. Top right: Region B with intermediate brazing on the front face plate and presumed good brazing between the back face plate and the foam core. Bottom right: Region D with good brazing conditions between both face plates and the foam core.

Each plot compares the ultrasonic spectroscopy response from the front and back of each region. The response for the front of region A with poor brazing produced a resonance peak corresponding to the thickness of the plate, whereas the response for the back of region A with better brazing produced a very low, attenuated signal. The response for the front of region B with intermediate brazing produced a low-amplitude resonance peak, whereas the response from the back of region B with better brazing produced a very low amplitude signal. The responses for both the front and back of region D with good brazing were very low amplitude, attenuated signals. Neither signal produced a resonance peak

The preceding graphs depict the ultrasonic spectroscopy responses from the front and The preceding graphs depict the ultrasonic spectroscopy responses from the front and back of each of the three regions. After the sectioning, optical photographs illustrating the braze conditions investigated (see the following figure) were taken from the gauge region of each of the shear specimens. When braze did not wet the surface of the plate (left photograph), a resonance corresponding to the thickness of the face sheet was produced, as in the ultrasonic spectroscopy response from the front of shear specimen A (left graph). Intermediate brazing conditions (center photograph) produced a resonance with much lower amplitude, as shown in the top right graph. With the presence of good braze between the face sheet and the metallic foam (right photograph), the ultrasonic spectroscopy signal was attenuated so that no resonance was produced, as in the responses depicted in the bottom right graph).



Optical photographs of three brazing conditions investigated in this study. Left: Front of shear specimen A with poor brazing. Center: Front of specimen B with intermediate brazing. Right: Front of specimen D with good brazing between the outer face plate and the foam core.
Each photograph shows the braze interface between the metallic foam and the face sheet.

Ultrasonic spectroscopy successfully characterized each of the braze conditions shown in the optical photographs. However, the results of the shear tests indicated that possible cracks in the foam near the braze interface or small amounts of braze wetting the surface of the face sheet, but not the foam core, represented more critical manufacturing defects than having very little or no braze wet the surface of the plate. This conclusion came from the actual failures of shear specimens A and B, which occurred near the interfaces with good brazing conditions instead of at the interfaces with poor or intermediate brazing conditions. Shear specimen D failed through the foam thickness as expected.

Ultrasonic spectroscopy demonstrated capabilities in examining braze quality between stainless steel foam cores and face sheets at the panel level. These results can be extended to the evaluation of manufactured components made from these sandwich structures because ultrasonic spectroscopy signals corresponding to various levels of brazing quality were identified. However, the technique demonstrated limitations with respect to evaluating the condition of the metallic foam beyond the braze interface. To further improve the manufacturing and inspection methods, we need a better understanding of the failure mechanisms occurring in these sandwich structures. Additional NDE techniques are being investigated to further understand these sandwich structures and their failure mechanisms.

Reference

1. Cosgriff, L.M., et al.: Ultrasonic Spectroscopy of Stainless Steel Sandwich Panels. To be published in the proceedings for the 35th International SAMPE Technical Conference, SAMPE, Covina, CA, 2003.

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