

Electromagnetic Techniques for Nondestructive Evaluation of Durable Materials

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Increased use of integral structures and sensory materials in new aerospace vehicles provides potential to reduce assembly time, reduce damage initiation features, and enhance identification of damage as compared to current built up structures. In this work the nondestructive evaluation requirements of these next generation materials and structures is examined. In particular, electromagnetic methods are explored for the characterization of residual stresses in integral structures and for the characterization embedded sensory alloy particles in an aluminum alloy matrix.

Abstract

(1) Integral structures offer potential improvements in the performance, operational costs, and safety of America's aviation fleets. A common feature of many such designs is an increase in the residual stresses in the materials. While such inherent stresses can be used beneficially to produce damage confinement features, rapid characterization of these stresses in the field requires the development of new tools and techniques.

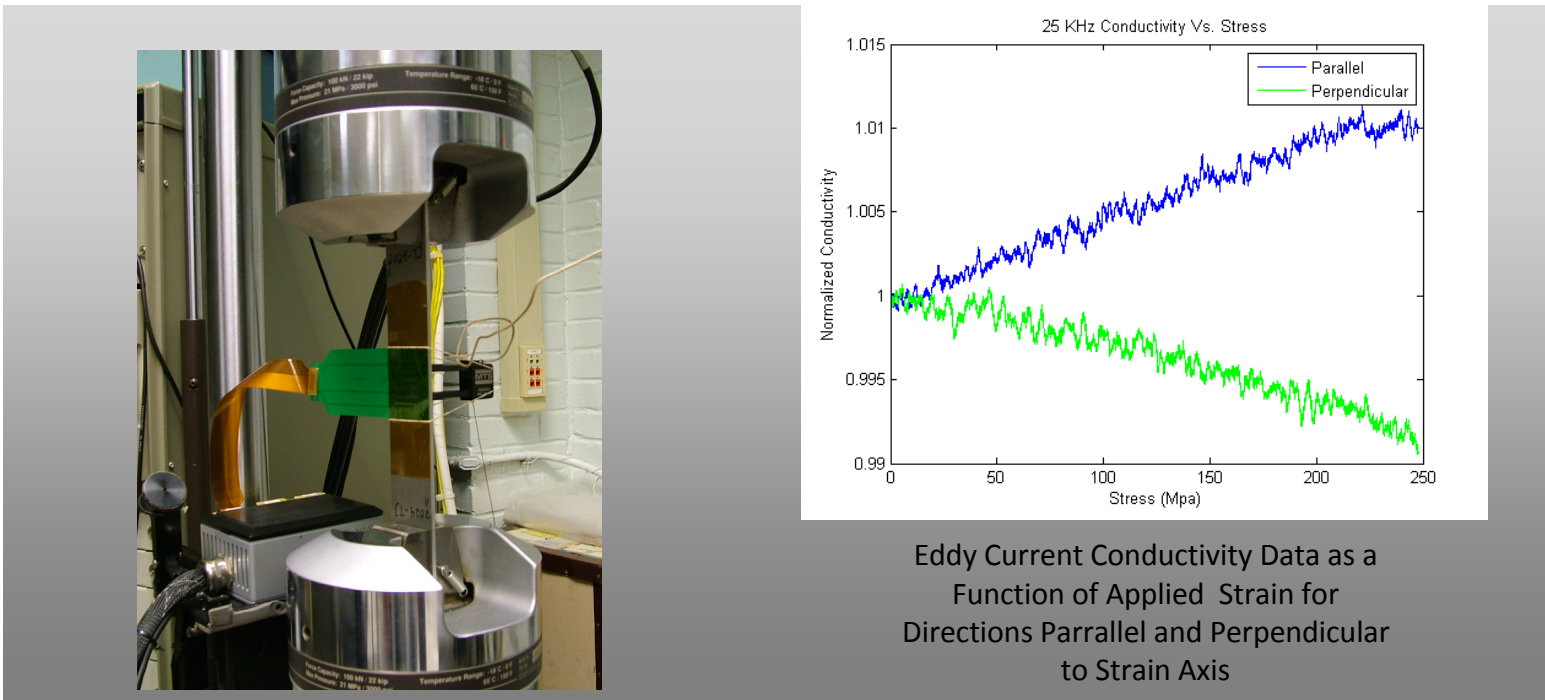
(2) The identification and characterization of potential flaws in a structure often requires detailed and time consuming inspections over large areas of the vehicle due to the relatively small change in measurable material properties.

Technical Challenges

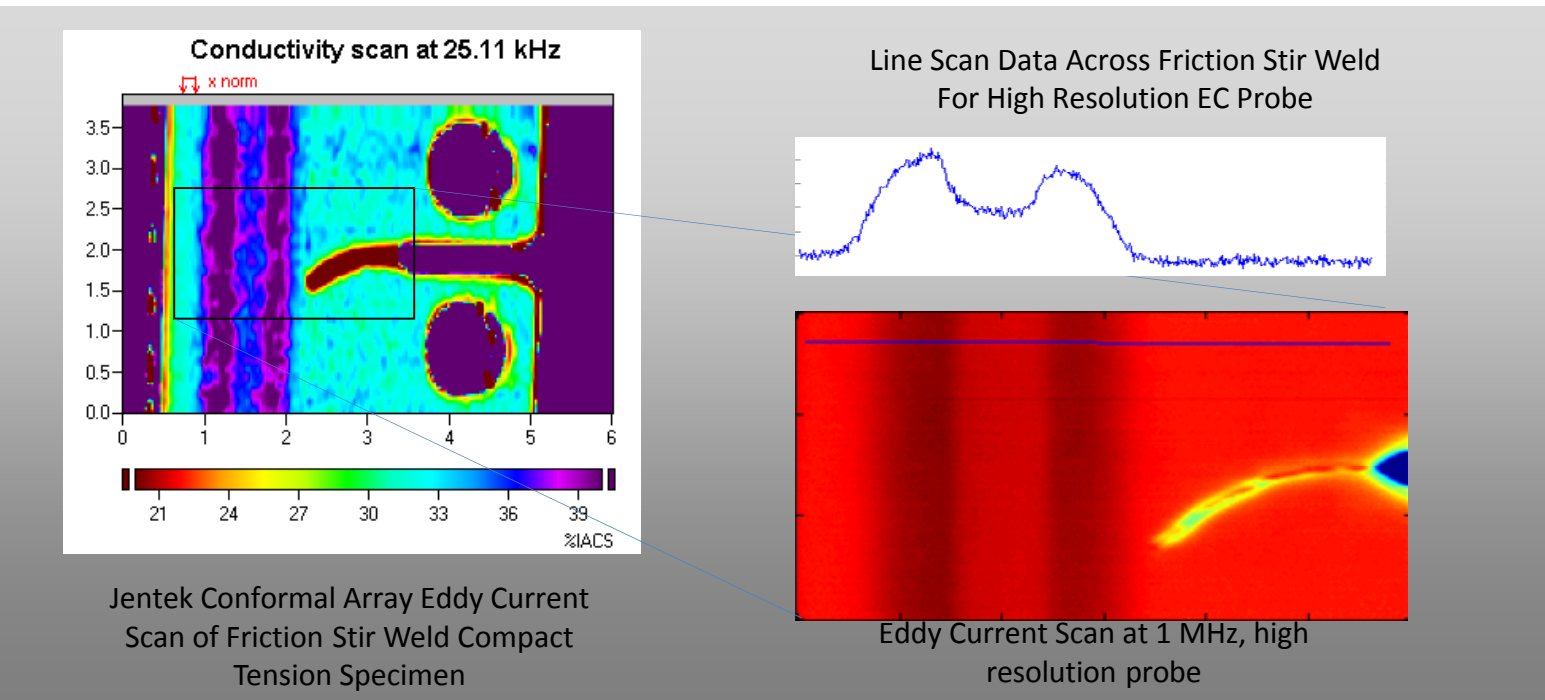
(1) Enhanced eddy current techniques are being explored for characterization of stresses and other material state parameters in a structure. Current research is focusing on analysis of the stress dependent conductivity in aerospace alloys and its impact on the dramatic increase in conductivity near a friction stir weld in aluminum alloys.

(2) Novel structural materials with enhanced response to damage are being studied to improve the identification and resolution of damage in a structure. Characterization of these new materials with prototype NDE sensors is being performed in parallel with material development to optimize improvements in operational safety.

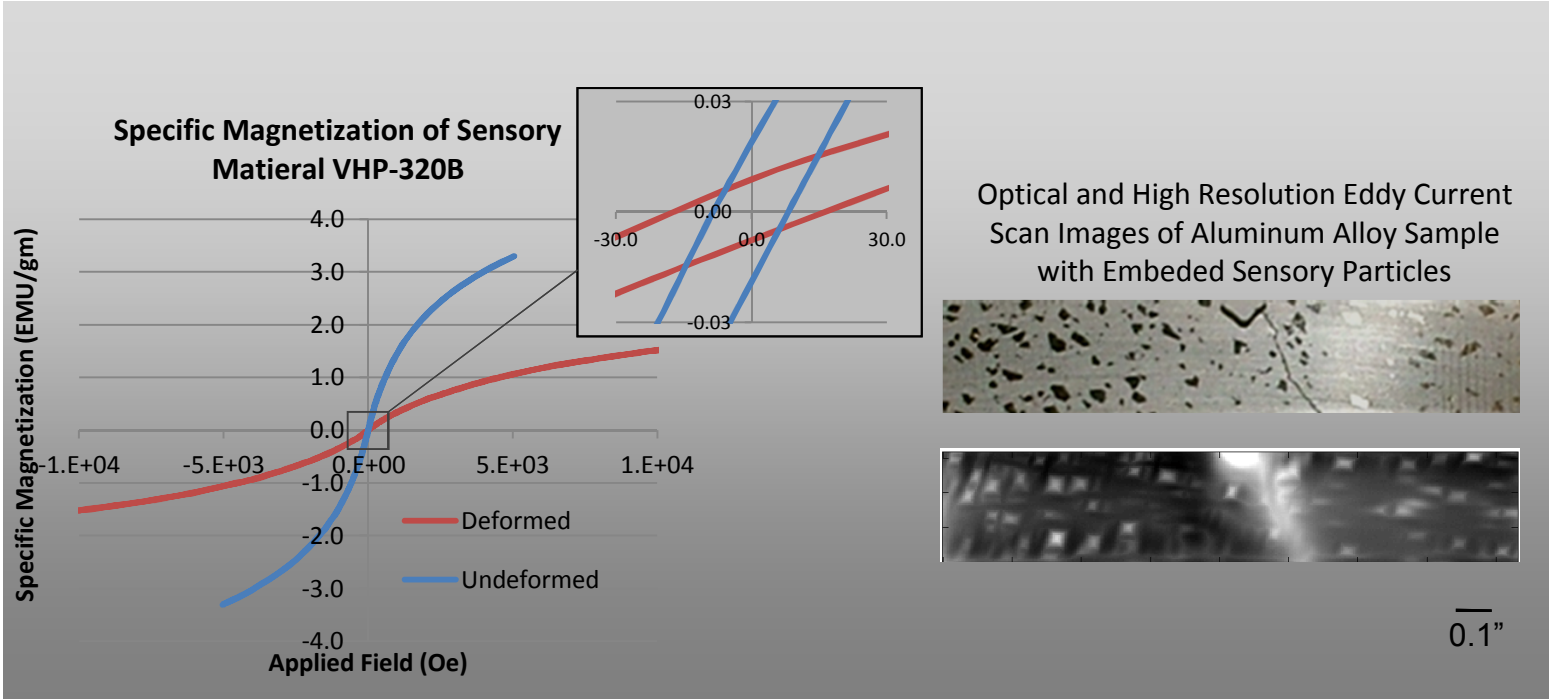
Technical Approach



Calibration of Stress Dependence of Conductivity in Aluminum Alloy Samples



Conductivity Imaging of Friction Stir Weld and Fatigue Crack in Compact Tension Specimen



Magnetic and Eddy Current Characterization of Sensory Alloy

- Calibration of the dependence of conductivity with applied stress using noncontact, bi-directional inductive sensors has been performed.
 - Conductivity variations on the order of 1% have been measure in aluminum alloy samples.
 - Conductivity increases along stress axis while decreasing in the orthogonal direction.
- Analysis of friction stir weld samples shows increase in conductivity on the order of 30% across FSW.
 - Conductivity profile similar to anticipated residual stresses.
 - Study being designed to independently address effects of grain size, phase content, orientation, crystallographic defects and residual stresses.
- Magnetic and eddy current analysis performed on aluminum alloy sample with embedded sensory particles.
 - New eddy current sensor developed to enable tracking of individual sensory particles in the alloy.
 - Study being planned to analyze electromagnetic properties of the particles during fatigue crack growth tests.

Conclusions and Future Directions