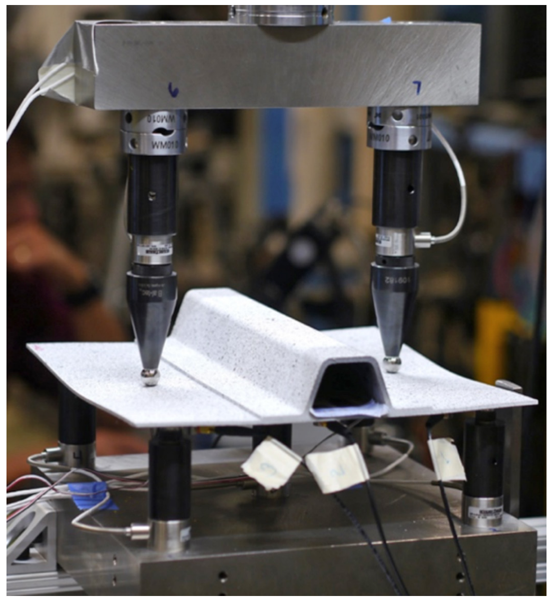
National Aeronautics and Space Administration

NASA facts

AERoBOND Project

Sustainability of the commercial air travel industry requires new aircraft with ultra-efficient structures and designs, which will depend largely on lightweight polymer composites and new assembly methods. Manufacturers of commercial transport aircraft are compelled to install thousands of redundant fasteners into bonded joints to prevent failures due to unpredictable weak bonds.



A seven-point stress test is used to test the bonding of materials.

The Adhesive-Free Bonding of Complex Composites (AERoBOND) process enables re-flow of matrix resin during assembly to eliminate the material discontinuity at the interface, thereby eliminating the dependence of mechanical performance on interfacial adhesion.

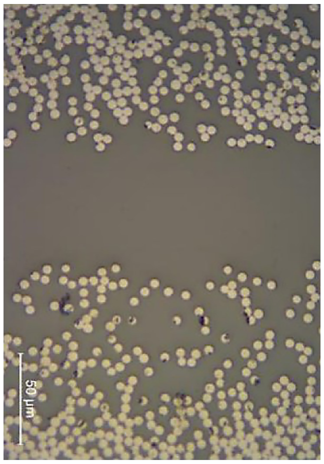
Under NASA's Convergent Aeronautics Solutions project, the AERoBOND project investigated off-stoichiometric epoxy polymers for fast, reliable assembly of epoxy matrix composite structures. The project goal was to demonstrate feasibility of the AERoBOND joining method by demonstrating mechanical properties greater than 80% of conventional co-cured materials while reducing structure weight by 1%. The project consisted of three convergent research areas: material and process development, systems analysis, and material and process modeling. Material and process development was the largest component of AERoBOND in order to formulate and characterize new resins, prepare carbon fiber prepregs, fabricate laminates, measure mechanical properties, analyze failure results, and select material and process improvements.

Rapid Assembly

- Rapid, reliable assembly of composite structures to reduce/eliminate redundant fasteners
- Enables unitization without complex tooling or processing
- Reduce part counts
- Eliminate drilling/installation
- Add no process time/steps
- No performance knockdown

The systems analysis activity estimated the potential reduction in part count and aircraft weight by comparing models of composite wing boxes with no fasteners (co-cured structure), fasteners in major joints (co-cured stringers), and fasteners in all joints. The materials and process modeling activity included a molecular model of the AERoBOND materials system to predict mechanical properties of resins with offset stoichiometry and a process model to predict the effect of resin formulation and processing conditions on the extent of mixing and degree of cure in a finished joint.

The AERoBOND eliminates the potential for weak bond failure mode.



The AERoBOND joint is indistinguishable from the matrix resin of adherends.

The AERoBOND joint is equivalent to the interlaminar region obtained during a co-cure process, so joint performance depends on the cohesive properties of the matrix resin. Conventional co-cured structures, although too costly and complex for large-scale manufacturing, are trusted by manufacturers and regulators, and are certified for flight with few or no redundant fasteners.

The AERoBOND process model is partially validated and available for experimental use. It allows the user to input AERoBOND process parameters such as material composition, laminate configuration, and cure cycle to predict the final cure state of the AERoBOND joint. A preliminary, multi-scale material model was developed to predict AERoBOND joint mechanical properties (stiffness and strength) based on the cure state of the joint provided by the process model.

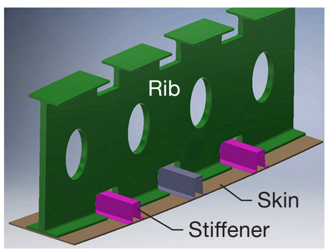
NASA researchers print the experimental adhesive using a special prepegger tape machine.

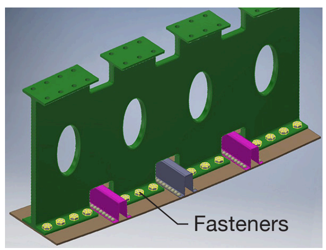
AERoBond Benefits

- Systems analysis performed on a composite wing model at the scale of a single-aisle commercial transport aircraft indicated that more than 20,000 redundant fasteners per wing could be eliminated by implementing the AERoBOND joining method.

- A total weight reduction of 15% was predicted in a wing box by eliminating fasteners and thinning components that must no longer support localized fastener loads and accommodate fastener dimensions.

- Interlaminar shear fracture toughness measured by the end-notched flexure test was greater than 1 kJ/m^2 (nearly 140% of the co-cured benchmark property), which is greatly in excess of the project goals for mechanical properties.





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