National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Instrumentation

Fast & Accurate Composite Bond Strength Measurement

Nondestructive Test Compatible with Assembly & Repair Facilities

Innovators at the NASA Langley Research Center, in conjunction with the National Institute of Aerospace and the University of Virginia, have developed a method for evaluation of adhesive bond strength via swept-frequency ultrasonic phase measurements. In recent years, the use of advanced composites has increased as modern designs strive for lighter weight, higher performance, and greater durability. Adhesive bonding is the preferred method of joining composite structures, requiring a nondestructive evaluation (NDE) method for ensuring adequate bonded joint strength. Conventional NDE methods have been used to detect gross bonding defects, but such methods have proven insensitive to weak adhesion. Current NDE methods that claim sensitivity to interfacial bond strength require complex, bulky, and time-intensive measurement procedures that are often not adaptable to the shop floor. NASA's new measurement system quickly and accurately measures interfacial bond strength and is easily compatible with assembly line and repair facilities.

BENEFITS

- Superior method for interrogating bonded joints and detecting weak adhesion: provides a highly accurate and sensitive NDE method with marked improvements over existing technology that can be used for detecting interfacial bond strength after fabrication, following bonded repairs, and throughout a joint's service life
- Lab tested and verified: proven performance using glass adherends, aluminum adherends, and UV curable adhesives
- Shop and production floor friendly: can be built with COTS transducers, enabling a simple, compact measurement device that takes quick measurements and is compatible with assembly line and repair facilities

THE TECHNOLOGY

NASA's Method of Evaluating Adhesive Bond Strength is an accurate, robust, quantitative, and nondestructive bond strength measurement method that meets an immediate need in composite manufacturing. Even with careful control of the bonding procedure, destructive testing has shown that bonded joint strength shows substantial variation. Prior art in the field is insensitive to weak interfacial bonding, which leads to poor service life and potential catastrophic failure. Using NASA's method, phase measurements are acquired at a single frequency and then swept to obtain measurements at other frequencies. Narrowband filtering removes extraneous frequencies, which allows for much lower phase measurement uncertainty than other methods. Digital sine wave generation allows for better phase measurement resolution. The resultant system is a phase-based ultrasonic measurement tool for interrogating bonded joints and detecting weak adhesion with superior sensitivity than the state of the art. This new method models adhesive interfaces as a distributed spring system, where the interfacial stiffness constants of the joint can be determined from the zero- crossing frequency of the phase response and the "sharpness" or slope of the phase response. Previous theoretical research has shown that a linear correlation exists between interfacial stiffness constants and mechanically-measured interfacial bond strength. As such, the ultrasonic phase measurement method identifies intermediate bond strengths, rather than simply detecting good or bad bonds. This technique verifies bond quality in metal and composite joint systems, including those commonly found in aerospace, automotive, and many other transportation and infrastructure designs. The demonstrated ultrasonic phase method is applicable to a variety of bonding material systems.

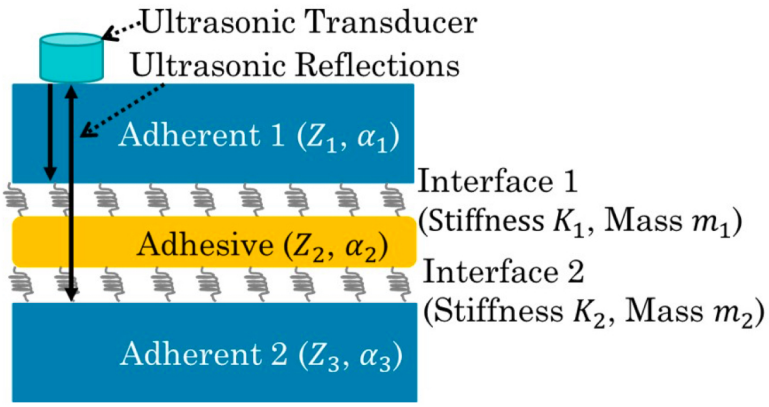

Diagram showing the Method of Evaluating Adhesive Bond Strength using Nondestructive Swept-Frequency Ultrasonic Phase Measurements

APPLICATIONS

The technology has several potential applications:

- Aerospace: aircraft manufacturing (e.g., carbon fiber composites for wing and fuselage surfaces bonded together as well as to aluminum air frames)
- Architecture and construction: building construction
- Automotive: composite parts for automobile manufacturing
- Composites: NDE method for measuring adhesive bond strength
- Electronics: printed circuit fabrication
- Marine: ship building
- Semiconductors: semiconductor fabrication

PUBLICATIONS

Patent No: 11,519,881

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

LAR-19403-1, LAR-TOPS-332

More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Langley Research Center

Mail Stop 020
Hampton, VA 23681
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

NP-2022-11-3091-HQ