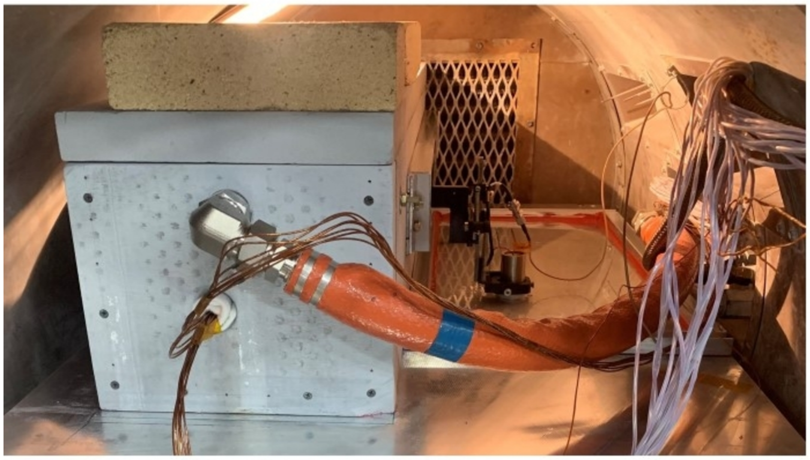


Image Credit: NASA

National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Manufacturing

System for In-situ Defect Detection in Composites During Cure

Enhance processing via real-time, non-destructive defect tracking

Innovators at the NASA Langley Research Center, in collaboration with Analytical Mechanics Associates, have developed an automated ultrasonic scanning system for in-situ cure monitoring and defect detection of composites in an autoclave or an oven. This non-destructive evaluation system is based on an ultrasonic contact scanner enclosed in an insulated vessel placed inside of the autoclave. The system actively scans for any defects that may form in composites during the cure process and tracks movement of defects originating during layup or cure. Typically, non-destructive evaluation of composites, by ultrasound or other means, is conducted either before or after the cure process, but many defects vanish and form during cure. NASA's in-situ cure monitoring system, by contrast, provides real-time monitoring of defect formation and movement during cure. This not only offers a better understanding of defect sources and sinks, but also the ability to more accurately validate process models for the prediction of cure process defects.

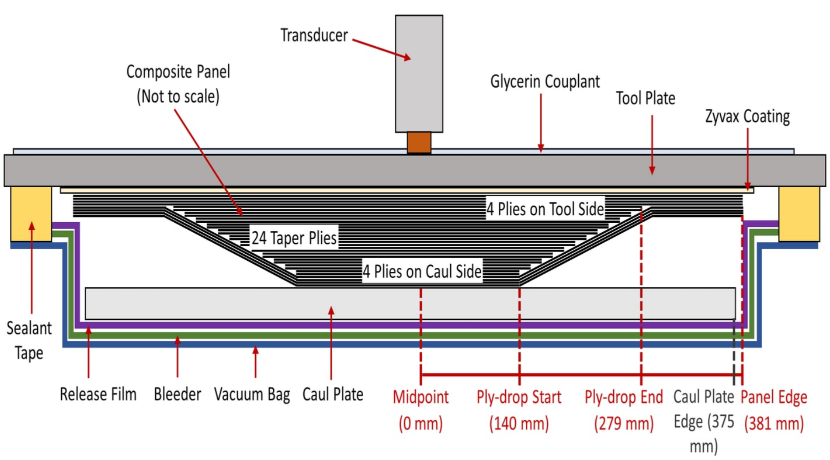
BENEFITS

- Substantial advantages over traditional techniques: The system provides a real-time, non-destructive means of monitoring defect formation and movement during composite cure and delivers higher resolution data to find, characterize, and track defects better than other cure monitoring techniques
- Ease of implementation: The ultrasonic scanner can be placed in an oven or autoclave without the need to attach any sensors that may affect the parts structure, such as embedded fiber Bragg gratings (FBGs), piezoelectric transducers, or temperature sensors
- Optimization of composite cure processes: Cure process parameters can be dynamically tuned based on inspection results to reduce defects (e.g., lower porosity level)

THE TECHNOLOGY

NASA's System for In-situ Defect (e.g., porosity, fiber waviness) Detection in Composites During Cure consists of an ultrasonic portable automated C-Scan system with an attached ultrasonic contact probe. This scanner is placed inside of an insulated vessel that protects the temperature-sensitive components of the scanner. A liquid nitrogen cooling systems keeps the interior of the vessel below 38°C. A motorized X-Y raster scanner is mounted inside an unsealed cooling container made of porous insulation boards with a cantilever scanning arm protruding out of the cooling container through a slot. The cooling container that houses the X-Y raster scanner is periodically cooled using a liquid nitrogen (LN2) delivery system. Flexible bellows in the slot opening of the box minimize heat transfer between the box and the external autoclave environment. The box and scanning arm are located on a precision cast tool plate. A thin layer of ultrasonic couplant is placed between the transducer and the tool plate. The composite parts are vacuum bagged on the other side of the tool plate and inspected. The scanning system inside of the vessel is connected to the controller outside of the autoclave. The system can provide A-scan, B-scan, and C-scan images of the composite panel at multiple times during the cure process.

The in-situ system provides higher resolution data to find, characterize, and track defects during cure better than other cure monitoring techniques. In addition, this system also shows the through-thickness location of any composite manufacturing defects during cure with real-time localization and tracking. This has been demonstrated for both intentionally introduced porosity (i.e., trapped during layup) as well processing induced porosity (e.g., resulting from uneven pressure distribution on a part). The technology can be used as a non-destructive evaluation system when making composite parts in in an oven or an autoclave, including thermosets, thermoplastics, composite laminates, high-temperature resins, and ceramics.



NASA's In-situ Defect Detection in Composites During Cure system. Image Credit: NASA

APPLICATIONS

The technology has several potential applications:

- Aerospace and Aviation: parts for spacecraft (e.g., satellites, landers), launch vehicles, and aircraft (e.g., fuselage, wing, etc.)
- Architecture and Construction: building sections
- Automotive: composite components in vehicles
- Composites: high-performance structural parts
- Marine: hull sections
- Transportation: high-speed rail sections
- Turbines: wind turbine blades
- Unmanned vehicles: parts for UAVs

PUBLICATIONS

Patent No: 11,360,053

"Design of an Automated Ultrasonic Scanning System for In-Situ Composite Cure Monitoring and Defect Detection," Hudson, Tyler B. et al., May 20, 2019, https://ntrs.nasa.gov/search.jsp?R=20200002665

"In-Process Ultrasonic Cure Monitoring System for Defect Detection and Localization in Composites," Hudson, Tyler B. et al., To be published (paper accepted) in SAMPE Technical Conference Proceedings, Long Beach, CA, May 24-27, 2021

"In-Situ Detection of Process-Induced Porosity During Cure of Out-of-Autoclave Composites" & "In-situ Inspection of Reflowable-Interface Composite Joints During Cure in an Autoclave," Hudson, Tyler B. et al., To be published in AIAA SciTech Forum 2021 Conference Proceedings, Nashville, TN, Jan. 15-19, 2021.

"Porosity Prediction and Detection During Composite Cure Using Simulation and Ultrasonic In-situ Inspection Inside an Autoclave," Hudson, Tyler B. et al., Journal Paper (Draft in progress).

More Information

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