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UD Researchers Developing New Tool for Testing 21-st Century Aircraft Materials

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Contact: Rosemary Harty or Teri Rizvi

UD RESEARCHERS DEVELOPING NEW TOOL FOR TESTING 21ST-CENTURY AIRCRAFT MATERIALS

DAYTON, Ohio -- University of Dayton and Air Force materials researchers are combining mechanical tests with ultrasound -- the same technology that gives mothers-to-be a look at their developing babies -- to see whether 21st century aircraft materials can withstand the rigors of high-speed flight.

Linking the two technologies -- one destructive, the other non-destructive -- gives researchers a brand-new tool for evaluating advanced materials for such complex, high-performance applications as the Air Force's National Aero-Space Plane (NASP) and NASA's High-Speed Civil Transport (HSCT).

It's a tool that can't come soon enough, according to George Hartman, research engineer in the Structural Integrity Division of the University of Dayton Research Institute (UDRI).

"Because materials don't exist for some of these advanced applications, they have to be invented and evaluated," said Hartman, who's integrating the test methods. "To get better performance, you push materials into new regimes -- higher stress levels or temperatures, for example. We are being pushed extremely hard to produce information as rapidly as possible about how these advanced materials behave under a variety of service conditions. We need every tool we can get because system designers don't want to wait five years; they want answers in six months."

To simulate and study potential damage to aircraft materials in-service, engineers run mechanical tests, which pull or bend a material until it breaks. By running ultrasound tests during mechanical tests, engineers can learn how damage starts and progresses.

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"Until now, ultrasonic methods have been used after mechanical tests, as a sort of post-mortem," said UDRI Materials Researcher Reji John, Ph.D. "While this can tell you what eventually destroyed the material, it won't let you know the sequence of events that led up to the final failure."

The UD research is part of a three-year, $4.9 million Air Force contract directed by the Materials Behavior Branch, and of a five-year, $2.4 million contract directed by the Nondestructive Evaluation (NDE) Branch, both part of the Materials Directorate at Wright-Patterson Air Force Base. Besides Hartman and John, the UD research team includes ultrasonic scientists David Stubbs and Prasanna Karpur, Ph.D., and Pat MacLellan, a graduate student in mechanical engineering.

The researchers say traditional methods for evaluating materials during destructive mechanical tests are insufficient for metal matrix composites--the main candidates for advanced aerospace applications. "The damage is much more complex than what we see in common materials," Stubbs explained.

For example, running non-destructive ultrasound tests during mechanical tests reveals previously undetectable surface and internal damage -- as it occurs -- in the various fibers and matrices that make up metal matrix composites. Damage visible when the material is hot or under stress may not be as evident after the mechanical test is over, Stubbs said.

Knowing how damage progresses means researchers can better predict under what conditions the material and the aircraft components will fail. "We can say to materials designers, 'Here's a class of materials that has potential if you fix the following problem,'" Hartman said. "We can also give feedback about what potential classes of materials they should be looking at for a specific application."

The researchers produce ultrasonic scans in much the same way physicians do--with "belly jelly," Stubbs said. Ultrasonic gel makes the contact between the material and the transducers, which produce and receive the sound.

"We look at how the sound waves change as they travel down the surface or through the material," Karpur said. "All types of damage will change how the sound travels. The trick is to 'read' the ultrasound and know what the changes mean--just as a physician does."

The researchers say the new tool will let them evaluate materials two to 10 times faster because computerized results -- available in real time -- reveal more information about material performance than ever before.

"As it is now, you often don't know when the internal damage starts or some critical event occurs," John said. "By acquiring ultrasonic information during a test, we can put the test on hold if something interesting happens and make informed decisions about how--or if--we should complete the test."

The new tool is becoming a reality because UD and the Air Force have built a team of experts in physics, mechanics, electronics, computer science, metallurgy, mathematics, and software engineering for improving materials-evaluation techniques. "To my knowledge there hasn't been a great deal done in applying ultrasonics to metal matrix composites--not anything of the scope of what we're doing," said Theodore Nicholas, Ph.D., senior scientist at Wright-Patterson's Materials Directorate.

The technology has applications to the auto industry and to civil engineering of roadways and bridges, Hartman said.

"It will become obvious to companies that it's cheaper in the long run to invest a little money upfront to thoroughly understand the materials you are using," the researcher said. "If you don't, you'll waste a lot of time and money using inappropriate materials or designs that don't work."

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For interviews or for more information, contact **George Hartman** or **Dave Stubbs** at (513) 255-1362.