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How exclusive 'laser shock peening' technology is improving aircraft reliability and lifetime

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Scientists have long sought to improve human life through lasers—otherwise known as "light amplification by stimulated emission of radiation"—since Albert Einstein first established the theoretical foundation for them in 1917. For years, lasers were the stuff of legend and imagination; just look at "Austin Powers," "Honey , I Shrunk the Kids," "Diamonds Are Forever" and the grandfather of them all, "Star Wars."

The technology has certainly come a long way since Einstein dreamed it. Laser printers, laser cancer treatment, laser pointers ... now ubiquitous with everyday life, the laser is one of the most important and revolutionary inventions of the 20th century.

But just because lasers have become commonplace doesn't mean the innovation has ended. At the University of Cincinnati, in fact, the power of lasers is being harnessed to change the way we fly the friendly skies.

Researchers S.R. "Manny" Mannava and Vijay K. Vasudevan, both professors in the department of mechanical and materials engineering in the College of Engineering and Applied Science, have joined in a unique partnership with Airbus to make airplanes more resilient, longer lasting and more efficient.

In a nutshell, their research uses a laser to alter the physical, mechanical and environmental properties of a metal; making it stronger, more durable, and less sensitive to corrosion, while increasing its longevity.

The process is known as "laser shock peening," or LSP. In layman's terms, that means a sophisticated laser system consisting of several lasers working in tandem to shoot beams of infrared light at portions of a metal, typically aluminum, titanium or nickel-based superalloys that are used in aircraft structures and components. The laser deeply compresses and changes the structure of the metal, fortifying it.

When the metal is processed; a ridged, geometric grid patterns its surface... that's the portion of the sample that is enhanced for fatigue and corrosion resistance. Each sample goes through a rigorous series of manipulations and stress, heat and environmental tests, to name a few—and its structural and chemical properties are assessed right down to its nanostructure.

While the process may sound relatively simple, rest assured: it's not. It's not commonplace, either; UC is the only university in the U.S. to offer LSP for use in research and development and prototyping efforts through the Ohio Center for Laser Shock Processing for Advanced Materials and Devices, which was recently established with a $3 million grant from the State of Ohio Third Frontier Program. General Electric (GE), which developed and patented the process, gifted its original equipment and know-how to the university in 2005.

"Critical aircraft components are made of high-strength materials that are susceptible in service to high stresses, fatigue and corrosion. Should these critical components fail, the reliability of the aircraft would be compromised. We hypothesize that—when we use the LSP processes to impart deep, compressive, residual stresses to these components—we strengthen the metal in a very deliberate way, which makes it less likely to fail. This process can also contain any failures, should they occur," Mannava explains.

"When we have confirmed the metal itself won't fail due to fatigue, cracking or corrosion, we will fortify huge pieces of metal for use in prototypes and, eventually, mass production," says Vasudevan. "We will also conduct basic research to understand the effects of the process on how the material behaves in order to optimize the process for specific, future applications."

The LSP project with Airbus is the latest manifestation of the university's vision to commercialize research and serve as an incubator for innovation. Just over one year ago, UC established the University of Cincinnati Research Institute (UCRI) to connect industry to the resources, labs, faculty and research taking place at UC. UCRI has gone to great lengths to strengthen the university's offerings to industry.

"Working with a university can sometimes be daunting and overwhelming; there are many colleges, faculty, and facilities to leverage. Not to mention the various levels of student experience, from undergraduate through graduate and post doctorate resources," said David Linger, UCRI's CEO. "We eliminate the hassle and make it easier to connect industry to UC smarts. And that's speeding the path to new products, processes and innovations."

Director of research and technology at Airbus Americas, David Hills, is quite happy with the results to date. "If we can improve the properties of our aluminum components and reduce their degradation with time, we can extend both the reliability and life of the aircraft," he says. "It makes good sense on both a human and a business level."

Turning research into real-time industry change is what UC does best. And if the project underway with Airbus is any indication, the path to innovation is moving at quick clip. So far, hundreds of samples have been fortified and tested by Mannava, Vasudevan and many of their graduate students.

The technology is currently being tested for use in passenger aircraft, though the team indicates the technology may eventually make its way to many other high technology product applications. Even deeper research could open up a whole new world for metal-based manufacturers everywhere.

"Medical devices, automobiles, power generation, nuclear imaging components and chemical processing—all of these applications depend on the strength and corrosion resistance of alloys to survive," said Linger. "The possibilities for leveraging LSP across a spectrum of industries are truly endless, proving once again that the collaboration of academia and industry change lives."

Provided by University of Cincinnati