IDEAS

TECHNOLOGY DETECTING AIRCRAFT METAL FATIGUE

Laser Lights Up Flaws

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A small company here is about to make a big impact in aviation around the world.

Laser Technology, a 10-year-old enterprise that employs only 18 people, has developed a camera that can look at a material and see the flaws beneath its surface. That's an exciting prospect to the commercial aviation industry, where metal fatigue of aging aircraft has recently been implicated in a string of accidents.

"I fly 200,000 miles a year," says John Newman, Laser Technology's president. "You just wonder: A lot of these airplanes are 15 or 20 years old. Doing five, six, or 10 takeoffs and landings a day is really pushing these aircraft far beyond the original design life."

The problem, Mr. Newman says, is that the aircraft "run into a bunch of maintenance problems that were never expected." While a host of tests are used today for ensuring aircraft safety, accidents like Aloha Airlines Flight 243 – in which a 20-foot section of a Boeing 737's cabin separated in flight – indicate a need for either better tests or better training for the people performing the tests.

Today a variety of techniques, called nondestructive tests (NDT), are used to check aircraft for airworthiness. "The whole idea is to screen out the things that are going to fail before they fail," says Newman.

The simplest test, termed "direct visual inspection," involves simply looking at surfaces for cracks, says Jim Hoak, Delta Airlines' staff manager of quality control. A more involved test involves spreading a penetrating or fluorescent dye across a piece of metal and then wiping it away: Wherever the metal is cracked, the easily seen dye remains.

Other tests find faults under the surface of the metal. Technicians can use X-rays and ultrasound – two techniques commonly used for looking inside the human body – to look for cracks inside an aircraft. In X-ray tests, radiation sent through a part of the aircraft is used to expose a piece of film: Cracks show up as dark lines. With ultrasound, a high-frequency sound is sent into the part and its echo is listened for. Cracks in the metal can show up as a second echo.

A third technique uses a probe the size of a pencil with a coil in its tip to induce an electrical "eddy current" inside the block of metal to be tested. Cracks in the metal impede the flow of the current and are easily detected.

DIFFERENT tests work best for different parts. The eddy current technique can find a crack as small as a hair, but not if the crack is more than 5/8th of an inch below the surface of the metal. An X-ray provides a picture of the inside of the entire part, but the image can be difficult to interpret.

"When you have cracks and problems with [aircraft aging], there is a whole range of NDT that you can call on. It's a whole bag of tricks. We think that 'electronic shearography' will be a new trick," says Newman, using the name for the process he invented.

So far, his camera has looked at sailboat rudders, aircraft engines, missile casings, and parts of the space shuttle. It displays on its screen a picture of the part being studied, with bright white lines indicating any subsurface flaws.

The electronic shearography camera uses a spread laser beam to illuminate the part being tested. The light reflects off the part, through a special lens which Newman holds a patent on, and into a camera connected to a computer. A speaker inside the camera then transmits a high-frequency tone, which vibrates the part. The computer examines the pictures from the camera and displays them on a video monitor, highlighting the places on the part's surfaces where there are sudden changes in the vibration pattern.

Those changes, Newman says, are indications of shears, cracks, or delaminations underneath the object's surface.

Donald J. Hagemaier, an authority on NDT at McDonnell Douglas, calls the process a "fantastic breakthrough."

"You shine the laser on the surface of the part, you stress the part, and you see the full outline of the flaw itself," he says – much easier to understand than conventional nondestructive tests, and often 10 to 100 times faster. Laser Technology's camera can test a 10-foot-square area in less than a second.

In a demonstration, Newman stabs a wall in his laboratory with the blade of a screwdriver. Damage from the screwdriver can not be seen on the surface of the wall, but when the shearography camera is pointed at the wall, a white line appears on the screen, corresponding to where the tool had struck.

Around the mark is a larger pattern of white and black lines showing the internal stresses in the wall that are the result of the impact.

LASER Technology's initial shearography camera consists of a large tripod with the laser and camera mounted on top and a loudspeaker mounted on the side. The equipment connects to a computer that rests on a cart.

"The initial units are for evaluation and production," Newman says. One has already been delivered to Boeing aircraft, and another to McDonnell Douglas, at a cost of about a quarter of a million dollars each. Laser Technology has also had serious inquiries from four major air carriers.

"One thing we are hoping to do further on is looking at the rivet holes on the aging aircraft fleet," Newman says. "We feel that we may be able to look at an area of 2-by-2 feet in one shot with a small hand-held probe."

Newman has also used the electronic shearography camera to find flaws in large foam-core sailboat rudders before they break apart at sea. "They are 7 ft. long, 4 ft. wide, 8 in. thick, with absolutely no other way to test them," he says. "I've done five Atlantic crossings in sailboats. When you lose your rudder, it breaks your day."

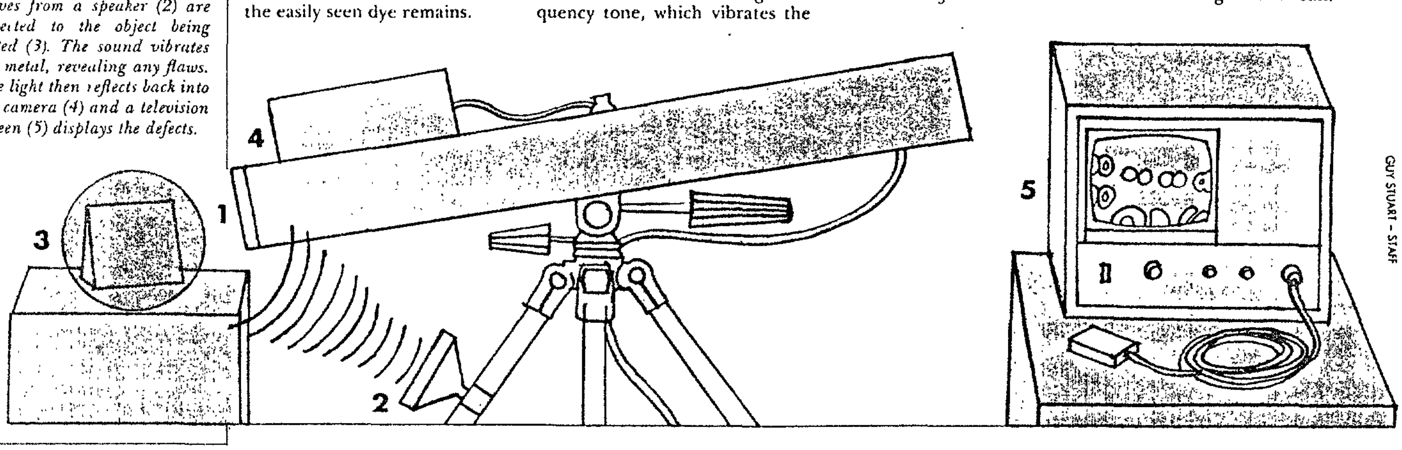
INDEED, the real promise of shearography might not be for testing metals at all, but for testing foam and aircraft made from composite materials, where conventional NDT techniques are often limited.

In one room of Laser Technology's laboratory is a piece from the space shuttle's external liquid fuel tank – a large aluminum plate covered on one side with a layer of insulating foam. In recent shuttle launches, Newman says, that foam has broken loose in flight and damaged the heat-resistant tiles of the spacecraft. With conventional NDT techniques, it is nearly impossible to determine where the foam had adhered properly to the aluminum and where it was loose. Looked at underneath the Laser Technology camera, however, the loose spots show as bright white outlines.

But shearography won't solve all of aviation's problems, Newman says. "When it does a great job, it does a great job, but there are parts you can bring in that we can't test at all."

Typically, shearography fails on thick pieces of steel, like landing gear, where tests such as X-rays and ultrasound will continue to be used.

"What is so satisfying is inventing stuff and seeing it being used," Newman says. But having all the lasers around isn't all work. On Saturdays, he says, he sometimes goes into his laboratory and makes holograms for fun.



CHECKING FOR CRACKS: *In this diagram of Laser Technology nondestructive test equipment, a laser beam (1) and sound waves from a speaker (2) are directed to the object being tested (3). The sound vibrates the metal, revealing any flaws. The light then reflects back into the camera (4) and a television screen (5) displays the defects.*

GUY STUART – STAFF