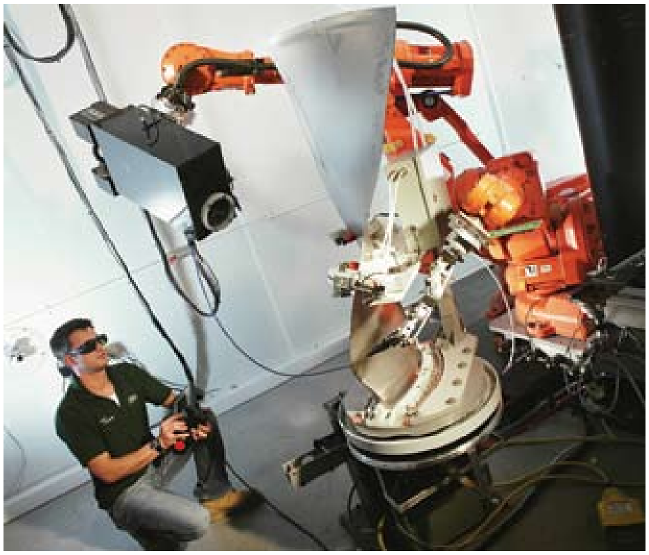
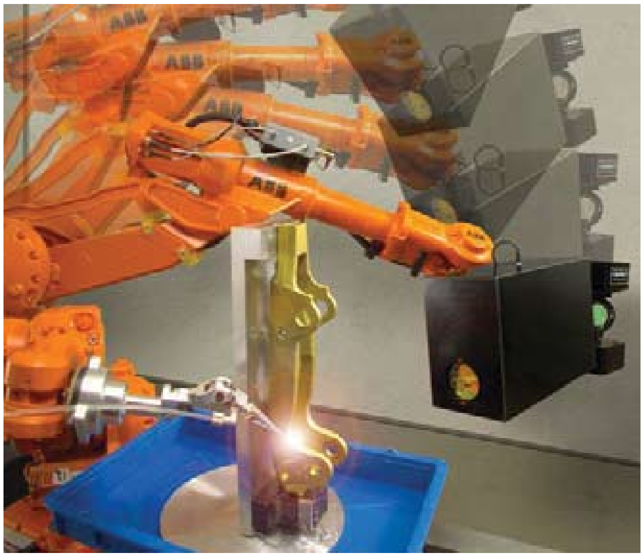
Laser Peening

Boosting Fatigue Properties in High Value Components, Leading to Improved Design





Laser peening systems using a robotically controlled laser beam facilitate uniform peening of large and complex shaped components. Photos courtesy of Metal Improvement Company.

Background

Laser peening is similar to shot peening but imparts compressive stresses much deeper into components with minimal surface deformation. The process replaces the stream of tiny metal or ceramic balls with short blasts of intense laser light, which generates high-pressure plasma, resulting in consistent and deeper compressive stresses in the material near surface, significantly improving performance and fatigue life.

Laser peening technology has been under development since the 1970s at research facilities such as Battelle Laboratories, but only recently has new laser technology developed at the Lawrence Livermore National Laboratory allowed the development of systems that can peen fast enough for industrial use. With the advent of higher output systems, laser peening is now being used in a wide range of industries.

Benefits

Laser peening exhibits substantial advantages over conventional shot peening relative to fatigue strength improvement, depth of compression layer and process control. Each laser pulse creates an intense shock wave over a roughly 5 x 5-millimeter area that drives a residual compressive stress approximately 1- to 2-millimeters deep into the base metal. In conventional peening, this compressed layer is approximately 0.25 millimeters deep. The added depth is key to laser peening's superior ability to prevent cracks from initiating and propagating, which extends the life of parts three to 10 times over that provided by conventional treatments.

Because the fatigue strength of laser-peened parts is significantly increased, components that are processed with laser peening technology often can be produced thinner and lighter, allowing for greater flexibility in the design and operation of systems. Among the other advantages of laser peening over conventional shot peening, laser peening does not require physical contact with treated components and is not limited by surface finish or geometry.

This flyer was prepared by the Navy Metalworking Center, operated by Concurrent Technologies Corporation, under Contract No. N00014-06-D-0048 to the Office of Naval Research as part of the Navy ManTech Program. Approved for public release; distribution is unlimited.

Laser peening processing produces an intense plasma on a protective layer placed on the surface of metals, resulting in a high pressure wave that imparts compressive residual stress deep into the near surface of materials. Photo courtesy of Metal Improvement Company.

Application

Now that laser peening technology and processes have been refined for practical use, commercial applications range from large aircraft components to power generation system parts to knee replacements—anywhere that critical, high-cost components require greater depths of compressive stress.

Mobile systems are also advancing the widespread acceptance and use of laser peening. Transportable laser peening systems, currently in routine operation, facilitate reaching components of arbitrarily large size, such as naval vessels in a shipyard. They are completely self-contained and allow quick setup and teardown on site anywhere laser peening is needed.

Industrial applications either in production or detailed development include components for:

- Commercial wide body aircraft engine blades and discs, drive train components on U.S. Army helicopters, engine components for automobiles and biomechanics
- Energy systems such as steam turbines, power reactors and others
- Naval systems including structural components; propulsion system and hull applications; arresting and launching components; and lightweight alloys
- Laser peenforming of wing skin components of aircraft, especially large wide body aircraft.

The Navy Metalworking Center (NMC) is working with Metal Improvement Company on a NAVAIR-sponsored project that will evaluate the potential benefits of laser peening on selected aircraft components in the Navy inventory. The NMC project will develop and optimize the laser peening process for specific Navy components through material evaluation, demonstration and validation tasks. The project will evaluate the residual stress level and compressive layer depth as a function of laser beam parameters of intensity, duration and number of applications; develop a model that predicts residual stress distribution to include location and distribution of positive stress profiles; and conduct metallurgical evaluations of specimens to determine characteristics after peening and then after surface finishing on critical aircraft components.

In addition to increasing the fatigue strength of metals, laser peening is being used to form large components with complex contours for commercial aircraft. The 8 x 3-foot wing panel represented an initial demonstration of the unique processing capability. The forming process is going into production in the 2nd quarter of 2008 on wing skin panels for the new Boeing 747-8. Photo courtesy of Metal Improvement Company.

NMC Navy Metalworking Center
A ManTech Center of Excellence

www.nmc.ctc.com

Operated by
CTC Concurrent Technologies Corporation

NAVY MANTECH manufacturing technology program

For more information, contact:
NMC Information Services
Concurrent Technologies Corporation
441 Friendship Road, Suite 103
Harrisburg, PA 17111-1204
Phone: 717-565-4405 • Fax: 717-565-4420
e-mail: piastred@ctc.com

2/08