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The Shot Peener

Sharing Information and Expanding Global Markets for Shot Peening and Blast Cleaning Industries

Scott Hatfield

2013 Shot Peener of the Year

Laser Peening Is On the Move

An Almen Mini-Strip Validation Study

The "Peenability" of Steel Components

Scott Hatfield is the author of the new SAE medical implant specification and leader of Medtronic's shot peening validation program

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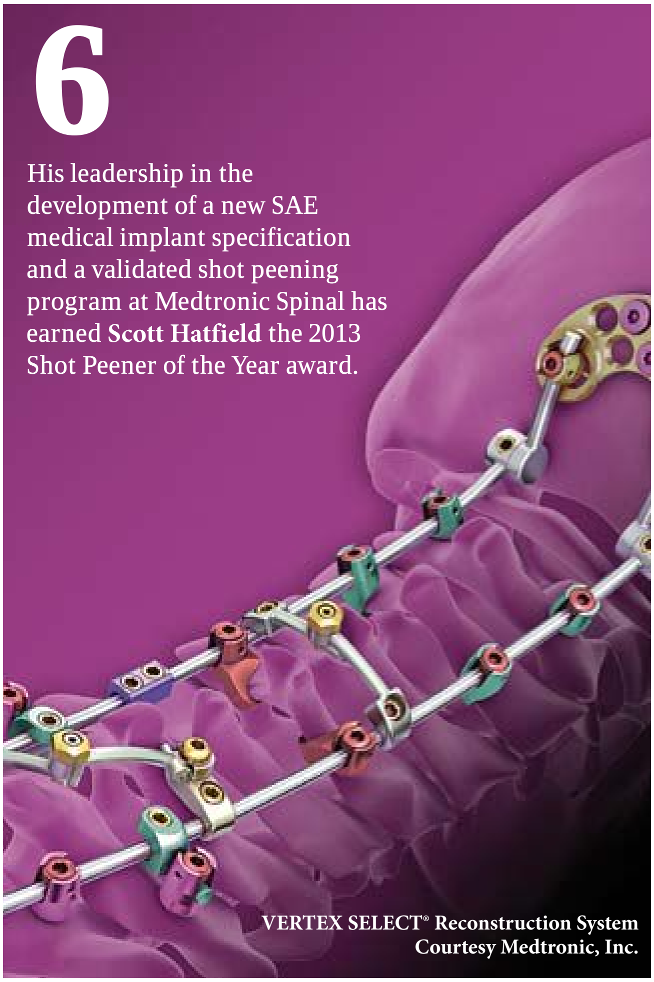

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His leadership in the development of a new SAE medical implant specification and a validated shot peening program at Medtronic Spinal has earned **Scott Hatfield** the 2013 Shot Peener of the Year award.

VERTEX SELECT® Reconstruction System
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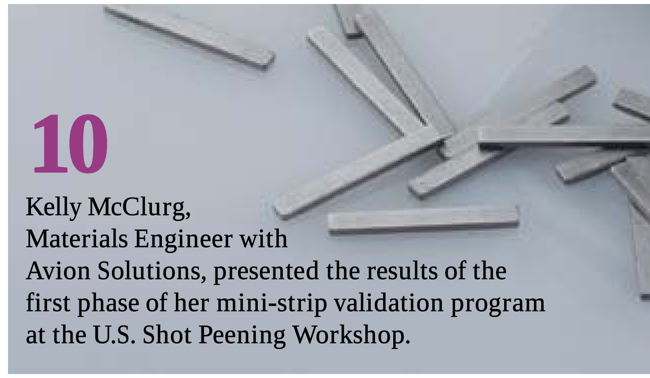

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THE SHOT PEENER

Sharing Information and Expanding Global Markets for Shot Peening and Blast Cleaning Industries

Six Things I Learned While Working on the This Shot Peener

1. Scott Hatfield is a true "Shot Peening Subject Matter Expert." Scott was nominated as our 2013 Shot Peener of the Year because of his work on the SAE Surface Enhancement Committee and his leadership of a shot peening validation project at Medtronic. I've gotten to know and appreciate Scott through our work on the SAE committee, but I didn't understand the depth of his contribution to Medtronic's shot peening program until we interviewed him for the article on page six. Now I'm even more pleased that he was given the award.


JACK CHAMPAIGNE

2. Almen mini-strips and ultrasonic peening are ideal together. I was pleasantly surprised to learn about Kelly McClurg's work with mini-strips and ultrasonic peening (page 10). This is a novel, but ideal, application since both products are well-suited for small, localized repairs in the field.

3. A new use for Almen strips. I have long championed the use of Almen test strips for the abrasive blast cleaning industry as a quality assurance tool. Now a new application is being researched for the High Velocity Oxygen Fuel (HVOF) process (page 12).

4. Researchers at MIT have discovered something surprising that could affect our industry. Is our industry heading for obsolescence? Can self-healing metals replace the need for residual compressive stresses imparted by shot peening? Are we dinosaurs waiting for a meteor impact? Read about the fascinating research done at MIT on page 18.

5. Dr. Kirk never ceases to amaze me. I remember meeting Dr. Kirk in 1993 at the International Conference on Shot Peening which he organized at Oxford University. He was a professor at Coventry University at that time. I was mesmerized by his skill at explaining processes and concepts. His article in this issue of *The Shot Peener* (page 24) serves as yet another example of his ability to explain complex theories to laymen. His explanation of graphs on S-N curves (stress versus number of cycles) and residual stress profiles is particularly informative.

6. I could write an article on intensity and coverage for every issue of *The Shot Peener*. I have a file folder of emails from engineers and shot peening technicians with questions on intensity, coverage, saturation curves and more. The Shot Peener staff likes to share new and different topics but many people struggle with these concepts, especially when they try to put them into practice on the shop floor. I plan to share more of these "problem and solution" articles in the future.

THE SHOT PEENER

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Specification for Success

SCOTT HATFIELD is self-deprecating and quick to give others credit for a job well done. But ask him about his involvement with the shot peening program at Medtronic Spinal and his contributions to its success become evident. His leadership in the development of a new SAE medical implant specification and a validated shot peening program has earned him the 2013 Shot Peener of the Year award.

The Medtronic project began in 2005 when Scott's boss, Mark Pelo, asked Scott to develop a FDA-compliant shot peening process for a new spinal screw. Medtronic was outsourcing most of their shot peening at that time, but they recognized that it would be easier to control the work if it was done on their shop floor. Mark also wanted to duplicate the shot peening operation at their facility in Humacao, Puerto Rico.

Scott had limited knowledge of shot peening having worked in aerospace and automotive machine shops before starting at Medtronic in 2001. While working at a machine shop, he saw the request for "shot peening" on a print and began researching it. When Mark approached him, Scott already knew enough to question if the tumblast machine on the plant floor was the right equipment for the task. In addition to probable limitations in equipment, Scott recognized that engineers and machine operators needed in-depth shot peening training, that he needed to create training documentation, and that the process would need testing. "I wanted a program that I was willing to put my name on," Scott said.

Building the Foundation with Equipment and Education

Scott, Mark, and several other Medtronic engineers went to the 2006 Electronics Inc. (EI) Shot Peening Workshop and Trade Show. Initially, Scott wanted to talk with other workshop attendees to see if he was correct in thinking that a tumblast machine couldn't support a validated shot peening process. Fortunately, at the same time he learned he was right, he and Mark met an OEM at the trade show that was willing and capable of developing a customized robotic shot peening system that could meet the FDA's demands for a controllable and repeatable shot peening process. Another benefit of the workshop was that the Medtronic engineering staff was exposed to every aspect of a controlled shot peening process. Eventually, Medtronic's shot peening technicians and inspectors from the Indiana and Puerto Rico facilities would receive training and earn their Shot Peening Certifications. Scott has achieved EI's Level Three Shot Peening Certification, the highest certification available, and is now a Specialized Instructor for the EI Shot Peening Workshop.

Creating Discipline Through Documentation

At the beginning of the project, Scott started working on a guidance document for the shot peening machine technicians. He began reading shot peening specs for reference. Scott became a regular attendee at the Shot Peening Workshops where he had conversations with Jack Champaigne, President of EI and Chairman of the Society of Automotive Engineers Surface Enhancement Committee (SAE SEC), about how parts of aerospace and automotive specs weren't applicable to medical implant manufacturing. "There were bits and pieces of useful information in aerospace and automotive specs but I wanted a 'one-stop' document," said Scott. "Jack invited me to join the committee and I accepted with the idea that membership could help me improve our internal document and lead to a new SAE standard for our industry." Jack encouraged Scott to write the specification and Scott started on what would become "SAE J3020 for Medical Device Shot Peening." His intent was to write a standard that adequately defined best practice methodology for medical device shot peening.

In 2013, only two years after he started on the specification, Scott presented the final draft of J3020 to the committee and submitted a request for a ballot. "He worked diligently on this

Scott Hatfield

Manufacturing Engineer, Medtronic Technology Engineering Group

Job Responsibilities include:

- Shot Peening and Abrasive Finishing Subject Matter Expert
- Implementation of New Technologies Pertaining to Process Improvements
- New Product DRM Analysis (Design for Reliability and Manufacturability)
- New Product Process Design and Development
- New Product Initial Cost Estimating

spec and it went through SAE in only two years, which is very unusual," said Jack. Scott credits the successful development of the spec to the committee. "The time frame wouldn't have been possible without the dedication of the group and Jack's willingness to allot time in every meeting to work on refining the specification," said Scott. Jack doesn't completely agree with Scott's assessment. "It's great having Scott on our committee. He brings a discipline to our meetings that helps us work on many document topics from media to intensity and coverage," Jack said.

Medtronic has also shown unselfish support for the new document since J3020 will be applicable to all medical implant manufacturing. "I am proud to say that Medtronic is committed to advancing shot peening practices as demonstrated by their continued support of my involvement in SAE," said Scott.

Validation Through Testing

After the shot peening machines were completed (one for the Indiana Medtronic facility and one for the Puerto Rico plant), Scott initiated life cycle testing on shot-peened spinal screws to validate and optimize their shot peening practices. "Validation increased our confidence that the shot peening process and the resulting increase in fatigue resistance was dependable and repeatable and would improve product reliability," said Scott. The testing program has had a "trickle up" effect from the shop floor—design engineers now call Scott and ask him about incorporating shot peening in a part. The design engineers can take advantage of Medtronic's large database of shot peening test results.

Shot Peening: The Highlight of a Medtronic Tour

Shot peening has not only been given a place on Medtronic's shop floor, it's now a highlight of their plant tours. The company is proud of their cost savings from bringing shot peening in-house. "Even with the purchase of two robotic shot peening machines and the time and other resources we've invested in a validated shot peening program, our in-house program is still less expensive than outsourcing," said Scott.

Cost savings aren't the only reasons Medtronic is proud of their shot peening program. "Through Scott's commitment and leadership, Medtronic has a world-class shot peening program that is validated in the medical community," said Mark Pelo. "Clearly, Medtronic and the shot peening industry have benefited from Scott's commitment to shot peening technology," he added.

Scott is still very involved in the day-to-day concerns of shot peening and anything to do with shot peening validation. He plans to continue his involvement with SAE SEC even after the specification is published.

Shot Peener of the Year Award

Since 1992, *The Shot Peener* magazine has given "The Shot Peener of the Year" award to individuals in our industry that have made significant contributions to the advancement of shot peening. We've listed the year of the award, the recipient and their place of employment at the time they received the award.

2013	Scott Hatfield	Medtronic Spinal
2012	Hali Diep	Boeing Research and Technology
2011	James Kernan	U.S. Army Aviation and Missile Research, Development and Engineering Center
2010	Herb Tobben	Clemco Industries
2009	Michelle Bandini	Peen Service
2008	Holger Polanetzki	MTU Aero Engines
2007	Ken l'Anson	Progressive Technologies
2006	Kumar Balan	Wheelabrator Group, Ontario
	Dr. John Cammett	Materials Engineeering Division, Naval Aviation Depot
2005	Marsha Tufft	GE Aircraft Engines
	Helmut Wohlfahrt	Technical University of Braunschweig
2004	Walter Beach	Peening Technologies
	Dr. Katsuji Tosha	Meiji University
2003	Paul Prevey	Lambda Research
	Dr. Niku-Lari	IITT International
2002	David Francis	Metal Improvement Company
	Shaker Meguid	University of Toronto
2001	Dr. David Kirk	Coventry University, U.K.
	Dale Lombardo	GE Aircraft Engines
	Bill Miller	The Boeing Company
2000	Jonathan Clarke	Delta Air Lines
	Lothar Wagner	Technical University of Brandenburg
1999	Andre Levers	British Aerospace Airbus
1998	Wolfgang Linnemann	Kugelstrahlzentrum Aachen
1997	Dr. R. Kopp	Institute Metal Forming of RWTH
1996	Dr. M.C. Sharma	Maulana Azad College of Technology
1995	Dr. Kisuke Iida	Meiji University
1994	Charlie Barrett	Metal Improvement Company
1993	Pete Bailey	GE Aircraft Engines
	Bob Thompson	GE Aircraft Engines
	Jim Whalen	GE Aircraft Engines
1992	Charlie Mason	Menasco Aerospace Ltd.

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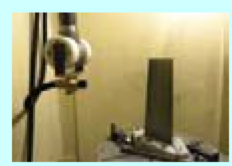

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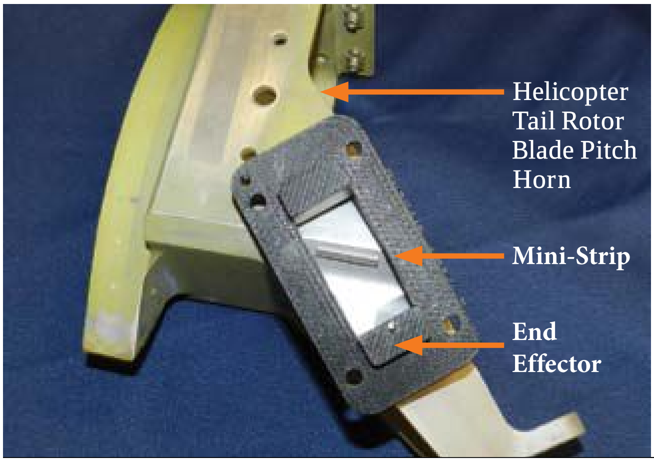
Mini-Strip Research Presented at U.S. Shot Peening Workshop

KELLY MCCLURG presented the results of the first phase of her mini-strip validation program at the 2013 U.S. Shot Peening Workshop. Ms. McClurg is a Materials Engineer for Avion Solutions, Inc. in Huntsville, Alabama. Avion Solutions provides specialized engineering, logistics, software development, and technical services to the U.S. Army's aviation community.

Kelly McClurg
Materials Engineer
Avion Solutions Inc.

Ms. McClurg was introduced to Almen mini-strips when a colleague brought her a sample of the strips from an Army Aviation Association of America convention. Mini-strips are 1" x .125" (25.4 mm x 3.175 mm) Almen strips that can be attached with double-sided tape directly on a test component or simulated fixture. Their size makes them ideal for measuring intensity in small or hard-to-reach areas like dove-tail slots in jet engine disks, gear roots, and the internal bore of springs, without making a complicated test fixture. Avion is currently using shaded strips which involves a laborious masking process. Ms. McClurg recognized that the mini-strip could quickly and accurately obtain intensity measurements. "I conducted this study to get a better understanding of intensities in the small areas of a component. When using shaded Almen strips, we are only getting an arc height. If we change the parameters of the shot peening procedure, then this arc height is no longer a confirmation of intensity as the arc height can fall anywhere along the saturation curve," she said.

Avion utilizes ultrasonic shot peening with the portable SONATS StressVoyager® for small, localized repairs on helicopter components. (Avion Solutions has been validated by the U.S. Army as an Approved Source for the Ultrasonic Shot Peening Process.) Avion creates enclosures called "end effectors" that mate the sonotrode head of the Stresstonic to the section of a component that receives the ultrasonic treatment. The end effector becomes a small peening chamber around the repair area. "We need to make a new end effector for each area of the component to be peened. When we change the design of the end effector, we are changing a shot peening parameter and we need to validate the intensity because of the changed parameter," said Ms. McClurg. "Mini-strips offer a fast and accurate solution."



Ms. McClurg's presentation at the 2013 Electronics Inc. U.S. Shot Peening workshop was titled "Mini-Almen Strips: A Promising New Technology." Her presentation included:

- Development of a correlation between full-size Almen strips and mini-strips arc heights
- Performance comparison between full-size Almen strips and mini-strips
- Intensity validation study along altering geometry (a helicopter tail rotor blade pitch horn was used)
- Mini-strip saturation curve study
- The benefits of using mini-strips including validation of intensity on an angled incline, elimination of complex and costly test fixtures, and intensity confirmation available in areas unattainable with full-size Almen strips

The convenient and easy-to-use mini-strips can be the ideal complement to Avion's portable ultrasonic shot peening processes. "The results of this first study are very promising," said Ms. McClurg. "If we continue to see good results through the conclusion of the study, mini-Almen strips will replace our use of shaded Almen strips and allow for increasingly accurate measurements of intensities in small areas, rather than just arc heights."

Avion Solutions has sent these findings to the U.S. Army for approval to use mini-strips in qualifying intensity on a repair for a Critical Safety Item. ●

MORE INFORMATION

Almen Mini-Strips: Visit www.electronics-inc.com or call Electronics Inc. at 1-800-832-5653 or (574)256-5001

"A Promising New Technology": Download the PowerPoint presentation from the library at www.shotpeener.com

Avion Solutions: Visit www.avionsolutions.com or call (256)327-7144

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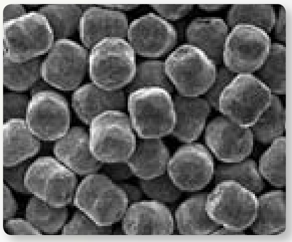

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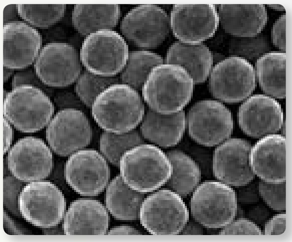

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HVOF Process Control Study with Almen Strips

ALMEN STRIPS are recognized as the industry-standard tools for achieving process control in shot peening. The test coupons are now getting attention in the field of High Velocity Oxygen Fuel (HVOF) coating sprays.

HVOF utilizes combustible gas and oxygen to produce a flame that is directed at very high velocity through a gun by use of a converging, diverging nozzle arrangement. Powder is injected into the hot gas stream and softened, then impacted with very high kinetic energy onto the work piece layer by layer until the desired thickness is built up. The resultant coatings approach theoretical density and exhibit outstanding performance characteristics. (Source: Cincinnati Thermal Spray, Inc. website: www.cts-inc.net/index.php/resources/thermal-spray-processes)

Because HVOF is used on critical components that are subject to fatigue—for example, landing gear—process control is becoming increasingly important in this thermal spray industry. John Sauer, Sauer Engineering, and Purush Sahoo, formerly with Cincinnati Thermal Spray, published their research with Almen strips in a paper titled, "HVOF Process Control Using Almen and Temperature Measurement." We've reprinted a portion of the paper here; download the complete paper from the library at www.shotpeener.com.

HVOF PROCESS CONTROL USING ALMEN AND TEMPERATURE MEASUREMENT

Abstract

The HVOF process with reduced heat effect on the substrate and therefore minimal degradation of fatigue properties is now finding wide application in fatigue critical applications. The critical parameters for process control are residual stress in the deposit and maximum substrate temperature. Quality control tools for these parameters are deflection of Almen Strips (similar to shot peening) for simulating residual stress and the use of infared pyrometry for temperature measurement. Both of these methods are technique sensitive particularly in spraying of coupons to evaluate the effect of coating on material properties. Lessons learned will be presented and recommendations made for applications of these tools in controlling the HVOF process.

Introduction

With the increased use of thermal spray coatings in more critical applications involving properties like fatigue, the subject of process control is also receiving increased emphasis. In addition to the normal quality control (QC) techniques such as metallography, tensile, and hardness, methods such as Almen strip deflection and infrared temperature measurement are now being implemented to monitor process output.

Although these different tools are not new quality developments, widespread use in the industry is just beginning to occur. The Almen method is used to measure the relative amount of residual stress imparted to the coating/substrate combination during spraying. This is critical for applications where residual stress has a major impact on fatigue properties. Infrared temperature measurement monitors temperature of the part being coated as a non-contact method. This is important where increased heat transfer to the part can affect near surface substrate properties in applications like landing gear fabricated from the family of 4340 materials. Thus, both methods are essential to process control and a final product with the intended properties for the application. As with many of the quality control methods, standard procedures or specifications are not available or do not provide sufficient guidance/identification of the critical variables that govern test performance. Standardization of test procedures across the industry is an important need and is an area of concentration for many companies/industry committees. With the implementation of Almen/temperature measurement, this is an ideal time to consider the standardization issue.

The purpose of this paper is to summarize the same practical testing framework for Almen/temperature measurement as related to thermal spray and identify the critical variables. It is suggested that with the knowledge of the important parameters, procedures can be written that will produce consistent feed back for the thermal spray process. It is recognized that different techniques can and will produce valid results. This article will not endeavor to identify the "best" or "only" test method. General procedural summaries will be given and variables identified. Examples will also be given showing possible process variation and allow people to understand test output when comparing data from different sources/locations.

Again, the complete paper is available for download in the online library at www.shotpeener.com.

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Mobile Laser Peening:
Extending the Service Life of the F-22

METAL IMPROVEMENT COMPANY (MIC), a business unit of Curtiss-Wright Surface Technologies, has developed a mobile laser peening service that is capable of peening large work pieces, such as aircraft, on location at a customer facility. One application of this technology has been the laser peening of the F-22. Since beginning the work in April of 2011, an MIC mobile laser peening system has been used to process the lower wing attachment lugs of 16 in-service fighter jets at the Lockheed Skunkworks in Palmdale, California under a contract with Boeing IDS. In 2014, this work will be moved to Hill Air Force Base in Ogden, Utah.

Technology Overview

MIC is presently conducting commercial laser peening operations at five processing plants: in the U.S. (Livermore and Palmdale, California, and Frederickson, Washington); the U.K. (Earby in Lancashire); and Singapore (Seletar Aerospace Park). The MIC technology has been developed to laser peen components that range in size from small parts, just a few inches in diameter, to large wing skins over one hundred feet long. The laser peening approach relies on flashlamp-pumped glass laser systems that can place high-quality square or rectangular spots onto the treatment surface at a pulse-repetition-frequency of up to 5Hz in continuous operation. High-pulse energies enable the use of spot sizes between 3 and 10 mm, providing up to 10X deeper levels of residual stress than competitive laser peening processes that rely on small spot, low-energy laser systems.

Several methods are used to scan the spots across the surface of the part in precise and repeatable patterns during processing. Smaller parts are manipulated with robotic arms through a fixed laser beam. For larger parts that are not easily moved during processing, the high-power beam can be scanned across a treatment surface while the part is stationary. Complex work pieces often benefit from a hybrid approach where the position of both the part and the beam are actively scanned during processing. Delivery of the water tamping layer is accomplished with a separate robotic arm, through a fixed nozzle attached to the beam scanning tool, or with

Figure 1. This MIC transportable laser system is en route to Palmdale, California for F-22 laser peening. MIC has a fleet of five mobile peening systems that can service marine, offshore oil and gas, petrochemical and aerospace repair and overhaul applications.

computer-activated fixed nozzles attached to the work piece. These approaches have been adapted and are in ongoing commercial production for components such as aircraft engine blades, gas and steam turbine blades, large bladed rotors, and commercial aircraft wing skins.

Challenges of Mobility

The laser peening of a large stationary work piece, such as an F-22 at a customer site, creates a number of significant technology challenges. The first is the need for a mobile, self-contained laser source. The MIC transportable laser system (Figure 1 on page 14) is housed in a trailer which can be located at a customer facility and requires a single 480 VAC power feed and a one gallon/minute tap water source delivered to a conventional garden hose fitting. The system can be parked, self-leveled, and activated in less than one day.

Another challenge is the need for a portable beam transport system between the laser and the work piece and a method of accurately scanning the beam in precise patterns across the component, often following complex surface shapes. Because the laser energy, coherence, and peak power are too great for propagation down a fiber, an automated mirror-to-mirror beam relay and delivery system is used. The MIC mobile beam delivery tool, called the dual-gimbal stinger (DGS), allows a laser spot pattern consisting of hundreds or up to many thousands of spots to be applied from a single robot position (Figure 2). High-speed adjustable optical components are used to direct the beam to each treatment spot rather than robotic motion.

Pattern Registration and Beam Delivery

For smaller work pieces such as turbine blades and rotors, fixed tooling can be used to ensure a precise, repeatable location and orientation between the laser peening system and the part. However, when laser peening a large aircraft such as the F-22, the process cannot rely on each plane being delivered to exactly the same location in the processing cell. For this reason, the DGS uses built-in optical metrology combined with a known surface model of the work piece to register the laser pattern quickly and accurately for each pattern of spots. This eliminates the need for placing the work piece in a known location and orientation with respect to the laser tool and is particularly valuable when laser peening large items such as aircraft.

High speed gimbals under closed-loop control are used to maintain accurate alignment between the mobile laser system and the beam delivery tool, eliminating any beam drift associated with the mechanical stability of the system. A self-contained mobile pallet allows the laser delivery robot to be quickly and easily positioned at locations on either side of an F-22 using an air bearing support system.

Related Applications

In the case of the F-22, the laser trailer is located just outside of the laser safety tent that houses the jet during laser peening operations (Figure 3). In other applications also currently in process, the trailer is located as far as 150 feet from the laser peening work area and the beam is supplied through a series of beam tubes and mirrors. This distance could be increased to well over 500 feet for surface treatment in challenging environments, such as inside of the containment building for a nuclear reactor. MIC has used variants of the mobile laser approach to set up shop-in-shop laser peening operations for original equipment manufacturers. Boeing and Rolls-Royce-Singapore have already realized the benefits from this arrangement, receiving significant savings in non-value-added turn time and cost reduction by eliminating the need for the shipment of parts in and out of the facility.

Figure 2. Mobile beam delivery system. The dual-gimbal stinger (DGS) is held by a robot arm. The entire assembly can be freely moved around the processing cell on air bearings. High speed gimbals maintain the optical path between the laser system and the DGS.

Figure 3. Laser safety tent used for the peening of F-22 fighter jets. The transportable laser system can be seen just to the left of the tent and the mobile beam delivery system is visible inside.

MIT Researchers Discover Self-Healing Metal

The following press release was published by the MIT News Office in October 2103 and it quickly captured the interest of the science community. The process could lead to stronger and safer metal alloys.

IT WAS A RESULT so unexpected that MIT researchers initially thought it must be a mistake: Under certain conditions, putting a cracked piece of metal under tension — that is, exerting a force that would be expected to pull it apart —has the reverse effect, causing the crack to close and its edges to fuse together.

The surprising finding could lead to self-healing materials that repair incipient damage before it has a chance to spread. The results were published in the journal Physical Review Letters in a paper by graduate student Guoqiang Xu and professor of materials science and engineering Michael Demkowicz.

"We had to go back and check," Demkowicz says, when "instead of extending, [the crack] was closing up. First, we figured out that, indeed, nothing was wrong. The next question was: 'Why is this happening?'"

The answer turned out to lie in how grain boundaries interact with cracks in the crystalline microstructure of a metal — in this case nickel, which is the basis for "superalloys" used in extreme environments, such as in deepsea oil wells.

By creating a computer model of that microstructure and studying its response to various conditions, "We found that there is a mechanism that can, in principle, close cracks under any applied stress," Demkowicz says.

A computer simulation of the molecular structure of a metal alloy, showing the boundaries between microcystalline grains (white lines forming hexagons), shows a small crack (dark horizontal bar just right of bottom center) that mends itself as the metal is put under stress. This simulation was one of several the MIT researchers used to uncover this new self-healing phenomenon.

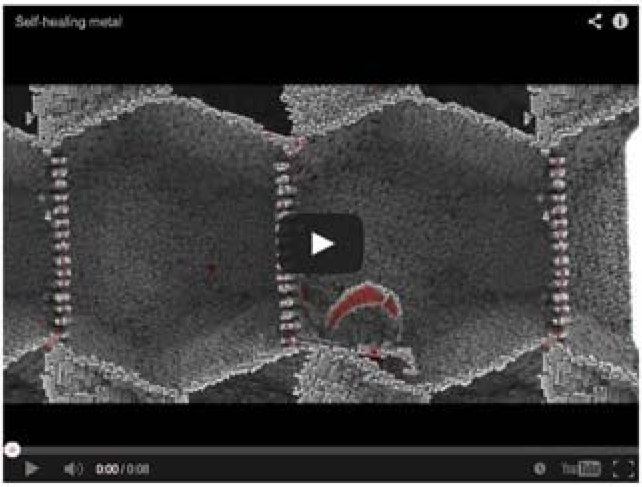
Most metals are made of tiny crystalline grains whose sizes and orientations can affect strength and other characteristics. But under certain conditions, Demkowicz and Xu found, stress "causes the microstructure to change: It can make grain boundaries migrate. This grain boundary migration is the key to healing the crack," Demkowicz says.

The very idea that crystal grain boundaries could migrate within a solid metal has been extensively studied within the last decade, Demkowicz says. Self-healing, however, occurs only across a certain kind of boundary, he explains — one that extends partway into a grain, but not all the way through it. This creates a type of defect is known as a "disclination."

Disclinations were first noticed a century ago, but had been considered "just a curiosity," Demkowicz says. When he and Xu found the crack-healing behavior, he says, "it took us a while to convince ourselves that what we're seeing are actually disclinations."

These defects have intense stress fields, which "can be so strong, they actually reverse what an applied load would do," Demkowicz says: In other words, when the twosides of a cracked material are pulled apart, instead of cracking further, it can heal. "The stress from the disclinations is leading to this unexpected behavior," he says.

Having discovered this mechanism, the researchers plan to study how to design metal alloys so cracks would close and heal under loads typical of particular applications. Techniques



A computer simulation of the molecular stucture of a metal alloy, showing the boundaries between microcystalline grains (white lines forming hexagons), shows a small crack (dark horizontal bar just right of bottom center) that mends itself as the metal is put under stress. This simulation was one of several the MIT researchers used to uncover this new self-healing phenomenon. See the simulation at www.youtube.com/watch?feature=player_embedded&v=E9poznjfOLA
Simulation courtesy of Guoqiang Xu and Michael Demkowicz

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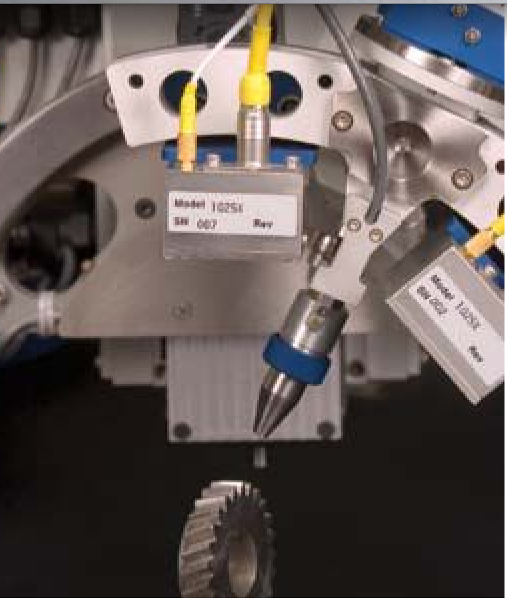

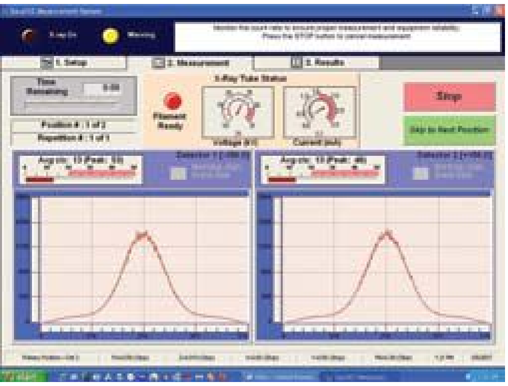

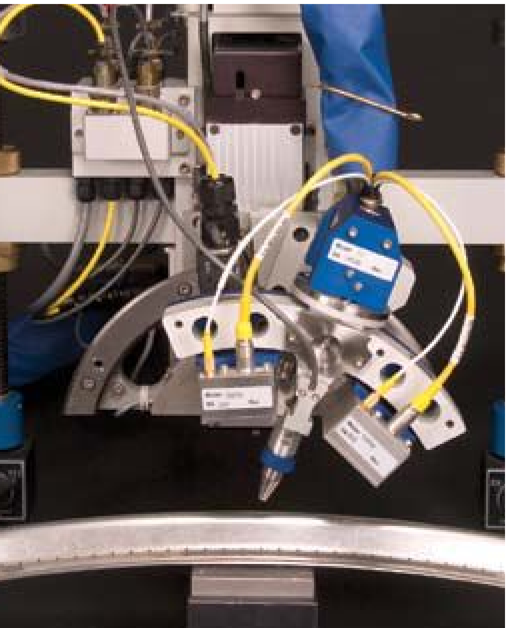

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for controlling the microstructure of alloys already exist, Demkowicz says, so it's just a matter of figuring out how to achieve a desired result.

"That's a field we're just opening up," he says. "How do you design a microstructure to self-heal? This is very new."

The technique might also apply to other kinds of failure mechanisms that affect metals, such as plastic flow instability — akin to stretching a piece of taffy until it breaks. Engineering metals' microstructure to generate disclinations could slow the progression of this type of failure, Demkowicz says.

Such failures can be "life-limiting situations for a lot of materials," Demkowicz says, including materials used inaircraft, oil wells, and other critical industrial applications. Metal fatigue, for example — which can result from anaccumulation of nanoscale cracks over time — "is probably the most common failure mode" for structural metals in general, he says.

"If you can figure out how to prevent those nanocracks, or heal them once they form, or prevent them from propagating," Demkowicz says, "this would be the kind of thing you would use to improve the lifetime or safety of a component."

William Gerberich, a professor of chemical engineering and materials science at the University of Minnesota who was not involved in this research, says that the significance of disclinations in materials was initially reassessed a few years ago. Xu and Demkowicz, he says, "have taken this one step further and suggested that wedge dislocations, in conjunction with stress-driven grain boundary migration, could actually heal cracks. This is indeed provocative [and] may be a plausible and exciting pursuit."

The work was funded by the BP-MIT Materials and Corrosion Center.

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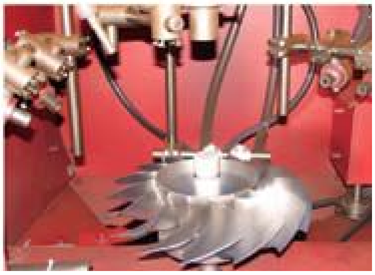

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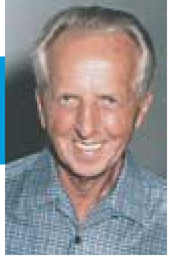

ACADEMIC STUDY

by Prof. Dr. David Kirk | Coventry University, U.K.

'Peenability' of Steel Components

INTRODUCTION

Component designers can assess whether or not their components have the capability for service improvement by shot peening. The extent of such improvement can be termed component 'peenability'. More than 90% of moving engineering components are made of steel.

The 'peenability' of steel components depends mainly on two factors:

(1) **Service Conditions** and
(2) **Steel Composition**.

Fatigue resistance is the most important service condition and steel is the most important component material. There is, however, a large variety of service conditions and steel compositions that are involved. Service conditions and steel composition often interact with one another. Mild steels generally have the lowest peenability whereas high manganese steels have the highest peenability.

Components that are seriously over-engineered will have zero 'peenability'. Their dimensions (and hence weight) are such that imposed stress levels are well below the component's fatigue strength. Shot peening is mainly applied to what would otherwise be under-engineered components. With under-engineered components there are two alternatives to shot peening: either to increase the dimensions of the component to match the gain achieved by shot peening or to use an inherently stronger, probably more expensive, steel. The greater the possible weight reduction (which can be either direct or indirect), the greater will be the component's peenability.

When service performance is improved we have positive 'peenability'. On the rare occasions when performance is lessened, 'peenability' is negative.

This article describes the basic relationships that exist between service conditions, steel composition and 'peenability'. The subject area is huge so that, of necessity, selected examples are used to illustrate these relationships.

FATIGUE RESISTANCE

Fatigue resistance is the most important service property that can be enhanced by shot peening. Fatigue strength and fatigue limit are terms commonly used to describe fatigue resistance. The ASTM defines **fatigue strength** as: the value of stress at which failure occurs after **N** cycles, and **fatigue limit** as: the limiting value of stress at which failure occurs as **N** becomes very large. Steel composition has a primary effect on fatigue resistance.

Carbon/low-alloy steels exhibit a definable fatigue limit. Virtually all other steels exhibit definable fatigue strength. The difference is illustrated by the hypothetical fatigue curves shown in fig.1, where stress levels are in arbitrary units.

Fig.2 illustrates the general benefit that peening can give to carbon/low-alloy components. The 'peenability' of carbon/low-alloy steel components depends on the level of fatigue

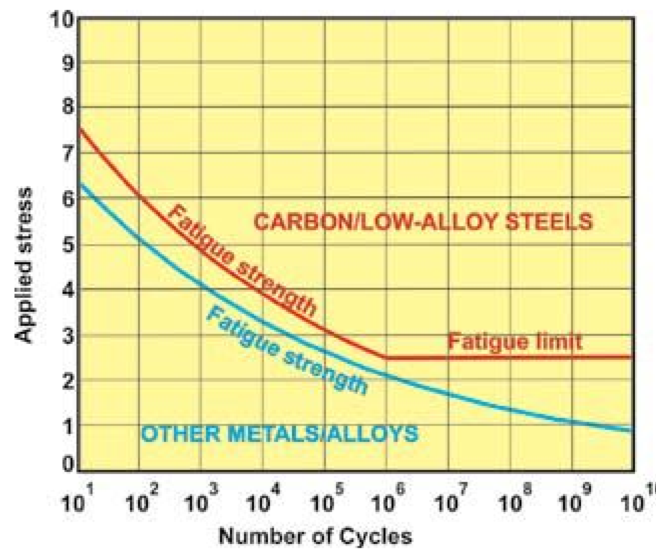

Fig.1 Hypothetical fatigue curves.

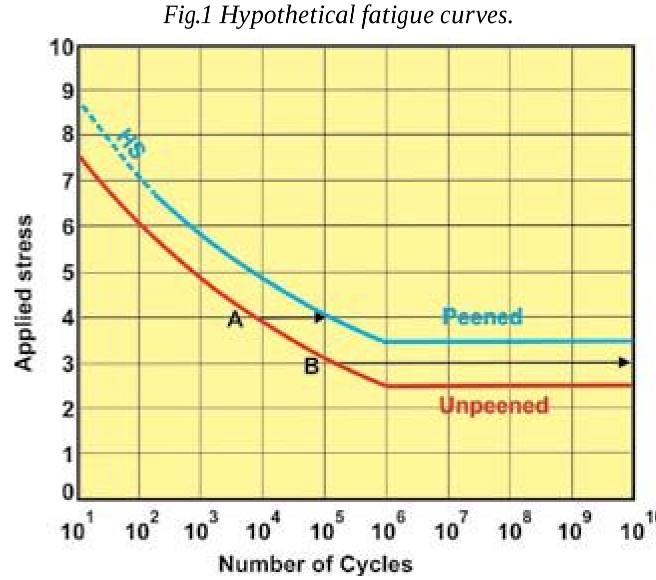

Fig.2 Stylized effect of peening on fatigue curves for carbon/low-alloy steels

stress that is applied. If, for example, the applied stress was **2** (on the arbitrary scale of fig.1) then the peenability is zero! In that situation carbon/low-alloy steels components already have an infinite life - without being shot peened. With higher levels of applied stress then one or other of two benefits can be achieved by shot peening. For a stress level of **4** peening could increase the fatigue life from approximately 10^4 cycles to 10^5 cycles – see **A** in fig.2. Alternatively, for a stress level of **3**, peening could increase the fatigue life from 10^5 cycles to infinity. It should be noted that these values are purely illustrative of the possible effects for a particular component.

Generally speaking, peening increases the fatigue strength and fatigue limit for carbon/low-alloy steel components. This is due to a combination of surface work-hardening and compressive surface residual stress. The region marked as **HS** in fig.2 indicates, however, the potentially-dangerous high-stress region. It has been shown that with very high applied cyclic stresses plastic deformation can occur which changes the surface compressive residual stress into tensile residual stress. That would correspond to negative peenability.

Austenitic steels do not normally show a fatigue limit. The beneficial effect of peening on fatigue, for these materials, is illustrated by fig.3.

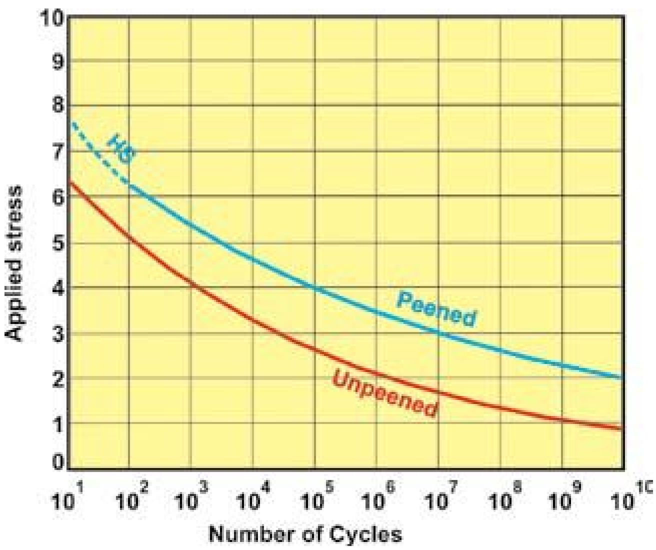

Fig.3 Stylized effect of peening on fatigue curves for austenitic steels.

The usefulness of shot peening for weight saving is a debatable subject. There is very little published information dedicated to the topic. That does not mean that shot peening is not an effective weight-saver. If any given component is 'over-engineered', then it will have an infinite fatigue life. If, however, the service fatigue life is shorter than is required, then shot peening can extend the life to required levels. The alternative would be to increase the dimensions of the component in order to reduce the stress levels – meaning that the weight would have to be increased. Hence we have a situation of indirect weight reduction. With 'cutting-edge' situations, such as Formula 1 racing cars, every tiny amount of weight saving is important. Designers therefore require certain components to be shot-peened, knowing that they would fail in service without the application of shot peening. That corresponds to direct weight saving by shot peening.

COMPRESSIVE SURFACE RESIDUAL STRESS AND WORK-HARDENING

Compressive surface residual stress and work-hardening are of primary importance in gaging peenability. It follows that these two factors relate to peenability. Residual stress and applied stress are additive. Hence compressive surface stress offsets applied surface tensile stress. Work-hardening of the component's surface also improves its fatigue resistance.

In order to be able to generate useful compressive surface residual stress and work-hardening, the component material being peened must have significant ductility. Each indentation stretches the surface material by about 40% - and each point may suffer dozens of indentations. Tensile tests show that different steels elongate within a range of about 10 to 40%. The stressing system in a tensile test is, however, very different from that of a shot impact. That is why localized peen stretching by several hundred percent can occur without fracture. All steels work-harden as a consequence of the localized plastic stretching that occurs on peening. The level of residual compressive stress that can be retained (without self-relief) is a large fraction of the yield strength of the work-hardened surface layer. Peenability of steels is therefore proportional to that of yield strength. This effect is schematically illustrated by fig.4. Steel B has double the yield strength of steel A, allowing doubled residual stress levels. This is not always completely advantageous. The compressed surface layer has a compressive force associated with it. This must be balanced by a sub-surface tensile force – extending deep into the component (as indicated by the red arrow). For steel B the maximum tensile stress in this balancing region is

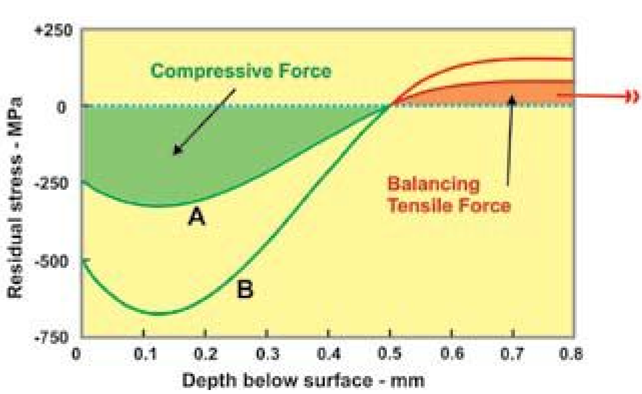

Fig.4. Effect of yield strength on residual stress profiles induced by shot peening.

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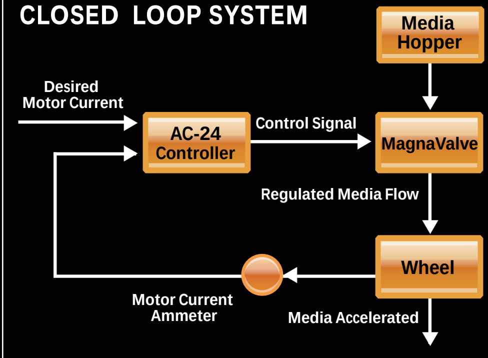

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double that for steel A. This may give rise to sub-surface crack initiation.

Austenitic steels generally work-harden at a faster rate than do ferritic/martensitic steels. Both types of steels reach a maximum level of work-hardening with increase of coverage. This maximum coverage is smaller for austenitic steels because of the greater rate of work-hardening.

In order to retain residual stresses and work-hardening, the component material must be temperature resistant. Steels have substantial temperature resistance when compared with lower melting-point materials such as aluminum. Hence they have greater peenability. Strength combined with ductility equates to toughness of the component's material.

Work-hardening increases the amount of energy stored in the peened metal. The greater the amount of stored energy the greater is the instability of the work-hardened layer. It is a fundamental law of thermodynamics that every system tries to reduce its stored energy level. This tendency is accelerated by increases of temperature. Specifications indicate the maximum temperature at which shot-peened components should be used. Fig.5 illustrates different curve shapes for property decrease with increasing temperature. Type A is characteristic of ferritic steels which show an initial small drop in property value. This is followed by accelerating property reduction, and eventually complete removal of peening enhancement – when the steel either recrystallizes or transforms to austenite. Type B is characteristic of austenitic steels where phase transformation does not occur – but recrystallization of the work-hardened surface will occur at a high enough temperature.

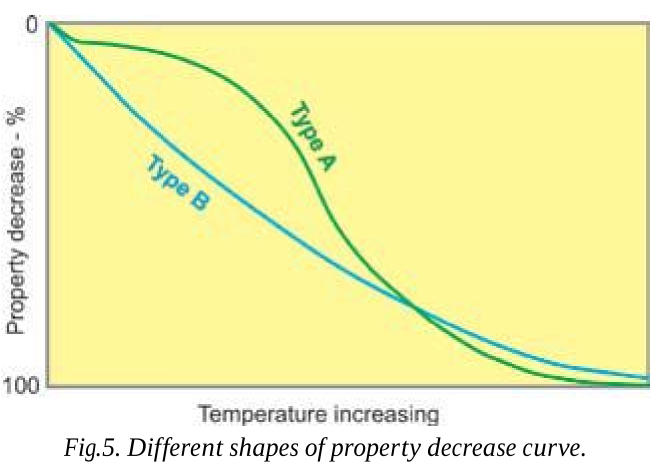

Fig.5. Different shapes of property decrease curve.

PHASE TRANSFORMATIONS DURING SHOT PEENING

Phase transformations can occur during shot peening of steels. Two important examples are those of carburized steels and high-manganese steels.

Phase transformation for carburized steels

Carburization involves diffusing carbon into the surface layer of a component followed by quenching and tempering. This produces a surface layer that is much harder, but less tough, than the core. The quenching process itself introduces a surface layer of compressive residual stress. Shot peening can be applied to further enhance the surface properties. The quenched-and-tempered surface layer consists mainly of martensite/bainite – both of which are based on the body-centered cubic structure of ferrite. An important additional constituent is known as "retained austenite".

When a carburized component is quenched, the surface layer transforms to martensite – to a greater or lesser extent – as illustrated in fig.6. Complete transformation, indicated by A-B, is almost impossible to achieve. Normally there is a significant percentage of retained austenite in the carburized case material, following the path A-C. The retained austenite can be as high as about 30%.

Any form of cold-working introduces energy into steel. It is this energy that retained austenite uses to help it to transform to the more energy-stable phase – martensite.

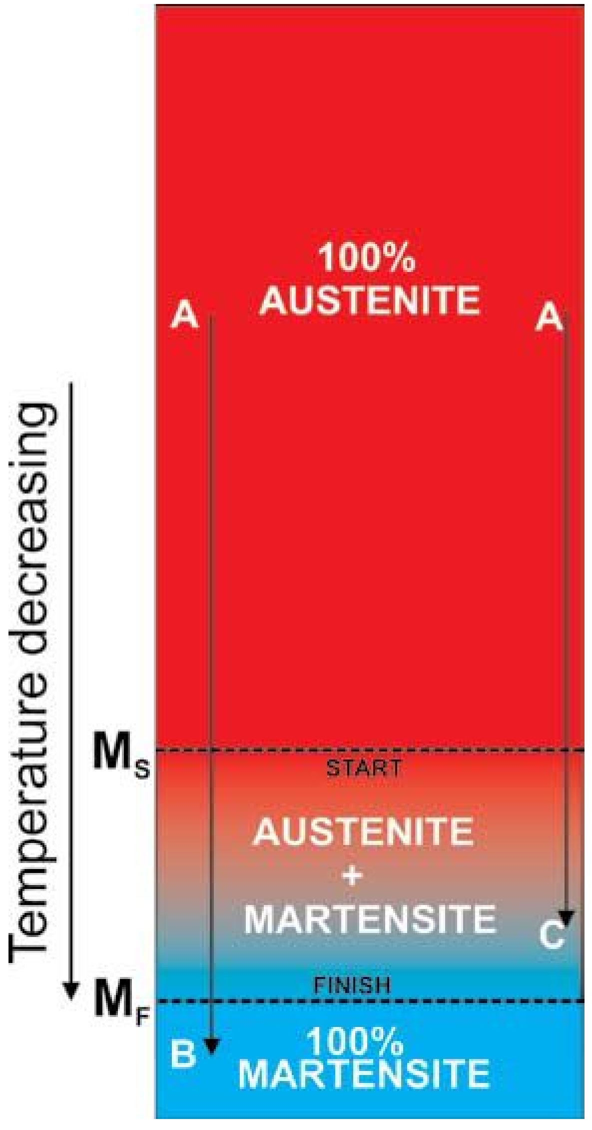

Fig.6. Transformation of austenite on quenching.

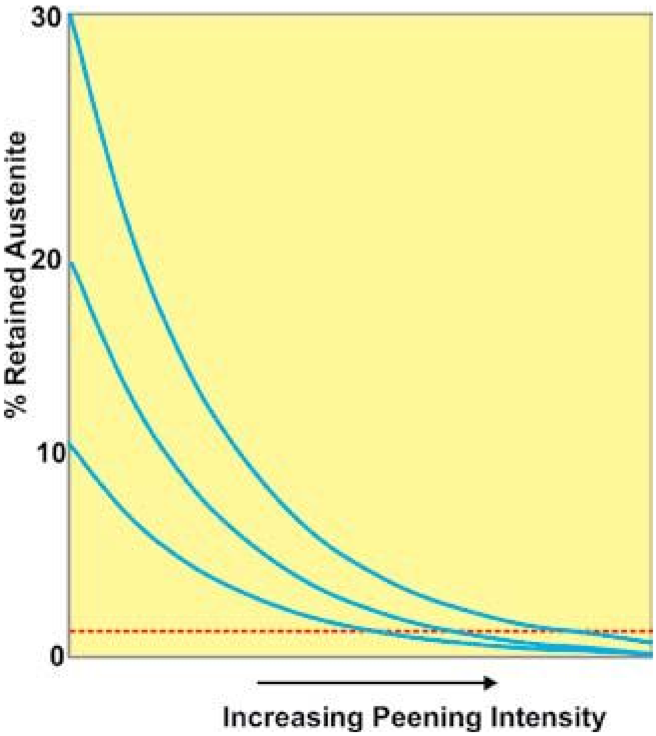

Fig.7. Effect of shot peening intensity on retained austenite content.

The greater the amount of cold-working the greater is the reduction in retained austenite content. This effect is illustrated schematically by fig.7. Steels with as-quenched retained austenite contents of 10, 20 and 30% are shown to have their content reduced to about 1% with increasing shot peening intensity. Retained austenite reduction becomes increasingly difficult – hence the curve shape is roughly exponential. Reduction below the 1% (shown as a dashed red line) would be almost impossible using plastic deformation.

As with all shot peening "more is better" is an illusion. There is an optimum amount of peening, for each steel and component, that maximizes service performance. Maximum performance generally occurs with retained austenite content in the range 1 to 4%.

Phase transformation for austenitic steels

A minority of shot-peened components are made from austenitic steel, which is non-magnetic. Austenitic steels have a face-centered-cubic crystal structure, f.c.c. – as opposed to the normal ferritic/bainitic/tempered-martensite structures. Austenite is promoted by alloying elements such as nickel and manganese and opposed by elements such as chromium, silicon and molybdenum. The most familiar austenitic steels, stainless steels, are based on iron, nickel and chromium. Nickel promotes the non-magnetic f.c.c. structure and chromium imparts corrosion resistance.

A key feature of austenitic steels is that they have a tendency to transform to martensite when subjected to severe plastic deformation. This is the same phenomenon as occurs with the retained austenite of carburized steels. Two common stainless steels, AISI 304 and 316 have been studied in detail (Kirk and Payne, ICSP7). This showed that peening 304 with a variety of intensities always gave approximately 50% of martensite, remainder austenite. No martensite formation was found for the 316 grade – which has 14% of austenite-stabilizing nickel as opposed to only 10.5% in 304. Peened 304 components therefore have a surface layer mixture of magnetic martensite and non-magnetic austenite. Such a mixture destroys a great deal of the corrosion resistance. 'Lean' stainless steels (lean in terms of relatively-low nickel content) can be said to have low peenability.

Less familiar austenitic steels are those termed "high-manganese". The first high-manganese steel was discovered in 1882 by the English metallurgist Sir Robert Hadfield, FRS, First Baronet of Sheffield. Manganese occurs in iron ores used for steelmaking. Some such ores have very high manganese content so that it becomes a very cheap alloying element. Most steels contain about 1% of manganese. As the manganese content is increased, steels become brittle so that at 5% manganese the steel can be pulverized by a hammer blow. This is the reason for manganese contents being normally kept lower than 1.5%. There is an apocryphal story (told to the author as a child by a studious steelmaker) that a trial batch of steel being made for Hadfield was accidently given three 4% additions of manganese separately by three different people. The resulting cast was tested by Hadfield and found to have remarkable properties - though he did not then know why. Production batches were termed "Hadfield High Manganese Steel". The Brodie helmet, introduced in 1915 in World War 1, was a classic application of this steel's properties – it could withstand a bullet fired at a distance of three meters. This helmet is still being manufactured today. Manganese steels are commonly used with manganese content in the range of 11 to 17%. Common applications are for railway crossing points and ore-crusher teeth.

The mechanism of deformation hardening of manganese steels varies with the particular steel and with its heat treatment. Mechanisms are still being investigated and include martensite formation, conventional work-hardening (by dislocation multiplication), twin formation and C-Mn atom pairings in the core of dislocations – very complicated!

The unique property of high-manganese steel components is that a deformation-hardened surface layer will regenerate itself if subjected to wear. This indicates potential applications for shot peening components – particularly surface-hardened steel shot.

Surface Hardening of Steel Shot

Carburized steel shot has been introduced because it combines a hard, wear-resistant, surface layer with a tough core. On quenching, the high carbon surface layer transforms


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Fig.8. Carburized shot particle, before and after wear removal of hard case.

Fig.9. High-manganese shot particle before and after substantial wear.

to martensite – with some retained austenite. Subsequent tempering reduces the brittleness of the surface layer whilst maintaining wear resistance. An alternate approach could be even more effective – using high-manganese steel for shot manufacture.

Figs. 8 and 9 (Page 30) give a schematic comparison of the two approaches (carburized versus high-manganese). Both cast and cut-wire shot can be carburized. Cast high-manganese shot can be surface hardened by plastic deformation – in a similar way to that used for rounding cut-wire shot. With carburized steel shot the hardened case is progressively worn away in use – eventually removing the case altogether, see fig.8.. With high-manganese steel shot the wearing mechanism (high speed impact with components) constantly regenerates surface work-hardening, see fig.9.

DISCUSSION AND CONCLUSIONS

In order to benefit from shot peening, steel components must have certain properties. These include:

Ability to be work-hardened,

Retention of induced compressive residual stresses,

Some degree of under-engineering and

Favorable phase transformations.

The first two properties are well-established. Under-engineering means that the component would, in the absence of shot peening, fail prematurely – particularly in fatigue situations. This leads to the general concept of shot peening being a weight-saving technique. Favorable phase transformations are particularly significant for steel components that contain retained austenite.

Some emphasis has been placed on the possible uses of high-manganese steels. These, in the author's opinion, have not yet received sufficient attention as useful shot-peened products. A great deal of research is currently being carried out to try and solve the mystery of why they develop such substantial, durable, surface hardening.

Joe McGreal Promoted to Vice President of Sales and Marketing

Joe McGreal of Ervin Industries, Inc. has been promoted to Vice President of Sales and Marketing. Mr. McGreal was the General Sales Manager for Ervin and has been with the company for the past 14 years.

Ervin Industries, established in 1920, is a privately held company based in Ann Arbor, Michigan.

Leaders Recognized at Nadcap Meeting

At the October 2013 Nadcap meeting in Pittsburgh, Pennsylvania, the following individuals were acknowledged for their outstanding contribution to quality through participation in Nadcap.

In recognition of service as Chairperson of the Measurement & Inspection (M&I) Task Group: **Phil Bamforth - Rolls-Royce**

In recognition of service as Vice Chairperson of the Aerospace Quality Systems (AQS) Task Group: **Harold Finch - Spirit AeroSystems**

For work on development of Non Metallic Materials Manufacturing fiber and core checklist: **Laura Benedetti - SAFRAN**

In recognition of long-term Non-Destructive Testing (NDT) Task Group support: **David Vaughn - Spirit AeroSystems**

For work on translation of the Conventional Machining checklist into Spanish: **Mario Enriquez, Ken Abram, and the Honeywell Chihuahua Conventional Machining team**

For outstanding support of Sealants Task Group, NMC, and Supplier Support Committee (SSC): **Suzanna DeMoss - 3M**

For contribution and work on Nadcap Management Council: **Amie Emerson - Spirit AeroSystems and Peter Krutoholow - Sikorsky Aircraft**

Joe Pinto, PRI's Executive Vice President & Chief Operating Officer explained "It is only with the support and dedication of aerospace industry leaders that Nadcap can continue to meet their needs in a collaborative, open way. The number of awards given out for so many different reasons to different companies underlines the commitment of the aerospace industry to supply chain quality through Nadcap. I would like to add my personal thanks and congratulations to all award recipients for their well-deserved recognition by their peers."


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by Mara Lee | _ e Hartford Courant

Peening's Value Below the Surface

The Hartford Courant, located in Hartford, Connecticut, recently published an article on Peening Technologies of Connecticut. The nicest aspect of local publicity is the attention it generates from work associates, vendors and friends. "We received phone calls and emails from existing customers, offering their congratulations," said Walter Beach, Vice President of Peening Technologies. "It was especially nice when Ken Jackson, one of our first customers who is now retired from Pratt & Whitney, stopped by. Our father was proud to see the article—he started the original company, Hydro Honing, in 1966."

WHEN YOU USE compressed air to fire millions of tiny BBs at engine parts, it makes the metal more durable for years to come.

It's not really visible, but at 10-times magnification, the metal is dimpled all over.

"The benefit is really below the surface," said Walter Beach, vice president of Peening Technologies, a small service company founded by his father in 1966. "What you don't see."

The same could be said for Peening Technologies, which is in an unassuming brick building on a dead-end street in East Hartford. Inside, the noise is relentless as giant automated machines hurl those balls no bigger than 33/1000th of a inch.

But it's what you don't see that explains why the company has been able to grow, if slowly, in Connecticut — even as more aerospace manufacturing moves to the southern states and to Poland.

Peening President Tom Beach estimates the company has captured about a third of the outsourced peening business for aerospace manufacturers and overhaul plants in the region.

John Tornatore, outside vendor service coordinator at Barnes Airmotive in East Granby, said both the East Granby overhaul facility and the Windsor manufacturing plant have contracted with Peening for more than 20 years.

"I don't think there's anybody that doesn't know the Beach brothers and the quality of work," he said. "They work with us closely, they're very knowledgeable, those boys grew up in the business."

Tornatore has worked at Barnes — and with Peening — for 16 years.

"They have a good team. Their employees, I see the same faces there that I've seen when I started working with them 16 years ago, that says something about them," he said.

Tom Beach said if an employee stays a year at Peening, "he's here five years. If five years, 10."

Walter Beach said their dad's first employee, who is now 70, still works full time. They had a little wave of retirements a couple of years ago, but several of them un-retired.

The company has 45 workers in Connecticut, including 28 machine operators working over two shifts. Machine operators start at $10 to $11 an hour and have opportunities to move up they learn set-up skills or quality inspection. Those who do set-ups can make hourly rates in the high teens, or even over $20 an hour.

"It's a nice little job for a non-skilled person," Tom Beach said of the operator job.

Ken Anderson, the general manager of the plant, started in shipping and receiving, and within five years, he was promoted to his current position, which he's held for more than 20 years.

Connecticut is not the only location for Peening. Tom Beach started out in the early '80s running an outpost on Long Island, which served Grumman and Fairchild Aircraft, but closed after seven or eight years, when "it didn't quite get off the ground."

In 2003, Peening bought a small shot peening company with five employees in Georgia, and it's grown to 30 people over the decade. A cousin, Richard Brooks, runs that facility. The family expanded in the South not because it found Connecticut a difficult place to do business, but because one of the big manufacturers wanted them to move as they shifted work there.

Peening had done a lot of work for Kaman Aerospace's Moosup plant, and when it was closing in 2002, the company asked Peening to open a branch in Florida, where the work was moving.

"We didn't feel it was enough work to set up a dedicated facility," Walter Beach said, but the Georgia plant does serve Kaman, as well as GE, Lockheed Martin and Boeing.

The Connecticut plant serves GE in Lynn, Mass., and about 70 percent of its orders are from Connecticut plants. It does service parts that come from Ohio, California, Poland or China from time to time, via FedEx.

A few years ago, Peening started manufacturing and selling shot-peening machines to large aerospace manufacturers. The machines cost between $225,000 and $900,000, and account for 25 percent to 35 percent of revenues.

The family said the Connecticut branch had less than $10 million in sales last year and this year is expected to be flat. "We're not hearing anything bad, but weren't not hearing anything great," Tom said of the local trends in aerospace.

SHOT PEENING IN THE NEWS

Continued

The Georgia sales are slightly lower, but may pass Connecticut in the next year or two, he said.

While Tornatore said Barnes sends less work to Peening since buying a computer-controlled peening machine, Tom Beach said overall, the equipment sales is not cannibalizing the service contracts.

"We've been able to bill out our process engineering," Walter Beach said. "It allows us to have a few extra people in the job."

The company is slow to hire, preferring to use overtime to meet demands. Nearly all production employees work at least 45 hours a week, and some work as much as 60 hours. Part of that is because the work flow is very unpredictable. Because peening is a quick, low-cost service, customers don't give a lot of advance warning for future orders.

"Boy, do we get busy in December. Everyone wants their parts to make their numbers," Tom Beach said. "We work harder than Santa's helpers in December."

Typically, parts are returned within a week, but customers often pay more for overnight rush orders.

Anderson remembered that two or three times over his 24 years at the company, workers came in on Christmas Day to fulfill a rush order.

"It's always an emergency somewhere," he said.

by Jack Champaigne | President | Electronics Inc. | jack.champaigne@electronics-inc.com

Why Intensity Isn't Dependent on Exposure Time

I RECENTLY RECEIVED an e-mail from someone thanking us for Dr. Kirk's Curve Solver program, followed by several interesting questions. The shot peening technician (let's call him SPT) had a fixture with six Almen holders. He understood how to run the fixture through their machine at four different exposure times, allowing him to construct a saturation curve according to SAE J443. (J443 requires a minimum of four data points on each curve.) He then had six curves, each with intensity value, but at differing T1 times. All of the intensity values were within the tolerance band allowed. SPT wanted to know "if his machine cycle time was set for the longest T1 time, would the intensity be too high for the shortest T1 time?"

The short answer is **NO**. SPT needs to understand why intensity isn't related to exposure time and that he needs to conduct two independent tasks—one to determine intensity and one to determine coverage, which is exposure time dependent. He had already calibrated the machine to a requested intensity. Each Almen holder position was receiving impacts within the requested intensity. The intensity values were not exactly the same but they were all within the tolerance band required. His next task would be to determine exposure time and this would be done by incrementally blasting his target for brief times and inspecting for coverage (surface denting). When the entire part is completely dented, he then has 100% coverage and now the machine cycle time can be established.

What about his concern that the intensity at the location of his shortest T1 time might be "out of spec" or "too high"? The intensity at that location was already proven to be within the tolerance band. Every shot particle is being impacted at that intensity. The intensity does not change with time. The intensity will change if he changes operating parameters like air pressure, nozzle style, shot hardness, etc., but it does not change with time.

If intensity changed with time, then peening a large part, perhaps needing two hours for complete coverage, would suffer from a very high intensity at the end of the cycle. Intensity stays fixed throughout the cycle unless you change an operating parameter.

Since we are talking about intensity checks in six locations, it might be useful to remember that SAE J443 has been updated to accommodate multi-holder situations. Remember, a new setup requires a saturation curve using a minimum of four data points for each holder. Once the machine is accepted and in production, machine operators are required to make periodic intensity confirmation tests. These don't have to be full saturation curves. Run a single strip through the machine using the saturation curve exposure time of T1 and take that arc height as a confirmation of peening intensity. However, in our example, SPT has six locations to check and each location will have its own "T1" time. He needs to decide what time to run the fixture through the machine for the future intensity confirmation checks. J443 now allows using a "target" time with "target" intensities. Let me explain.

Visualize a graph with six saturation curves on it. These curves represent the Almen strip arc heights for six different locations on the fixture. Using Dr. Kirk's Curve Solver, you can find the intensity for each graph and its corresponding T1 time. Earlier specifications required that you run the confirmation tests at the T1 time. What happens if you have six locations and six T1 times? Were you expected to run six different confirmation passes, one for each T1 time? Most people didn't follow that rule.

Thanks to J443 you are now allowed to pick any time you wish, which is within the shortest and longest T1 time for the six curves. Pick a time, draw a vertical line on the graph and see where the line intersects each of the six curves. These points are now your "target" arc heights, one for each location. So if you run your fixture through the machine, you will get six arc heights. If you do this once each day you should get the same "target" arc height for each location. Each confirmation arc height must be within ±0.038 mm or ±0.0015 inch of its corresponding target arc height. If any of the confirmation arc heights is not within this tolerance band, you must make adjustments (perhaps machine maintenance) and then perform a new set of six saturation curves.

Gargi Maheshwari | Surface International | www.surfaceinternational.com

Surface International:
Serving Industries in India and Asia

SURFACE INTERNATIONAL is a rapidly growing company in the city of Jodhpur in Rajasthan, India. We appreciate that Gargi Maheshwari, who works in the marketing department at Surface International, answered a few questions for us about the company.

The Shot Peener: Tell us about Surface International.

Ms. Maheswari: Surface International was founded in 2007 by Mr. Yogesh Maheshwari. He is a technocrat* and holds a bachelor's degree in mechanical engineering and has of over 30 years of experience in the fields of marketing, servicing, designing, manufacturing and management of an engineering company. Before the establishment of Surface International, he was a Technical Partner with Surface Finishing Equipment Company for almost 25 years. Surface International serves India and the Middle East and we manufacture coke injection machines, dust collectors, gunning machines, shot blasting machines, blast rooms, and grout and concrete pumps.

The Shot Peener: Describe your line of blast cleaning equipment.

Ms. Maheswari: We manufacture a complete line of standard designs for batch or continuous/in-line processes. Surface International also provides customized solutions to fit our customer's application. Our blast cleaning products include:

- Batch-type shot blast systems (table type and tumblast)
- Hanger-type shot blast systems
- Roller conveyor type and structural cleaning blasting system
- Robotic shot blast systems
- Air-operated systems
- Special purpose machines
- Blast room system and painting booths

Our typical blast room system is equipped with lighting, dust collector and a portable blast machine. Its recovery system can be a mini-hopper or mechanical recovery system.

*Many of our readers won't be familiar with the word "technocrat." A common definition, and probably the most applicable one in this context, is a technical expert, especially one in a managerial or administrative position. Technocrats are usually scientists, engineers and technologist and are recognized as an elite group in many cultures.

The Shot Peener: Do you manufacture shot peening equipment?

Ms. Maheswari: Yes, we manufacture airless- and air-operated machines for the shot peening of turbine blades, gears, gear shafts, leaf coils and springs, and clutches for automotive, agricultural, and earth moving applications.

The Shot Peener: What makes your machines better than others?

Ms. Maheswari: Basically all reputable manufacturers provide similar features; nevertheless, our machines have robotic material-handling capability, CNC/PLC controls, vibratory shot classifiers and electronic brake system. We are in the process of introducing MagnaValves and spiral separators to achieve precise flow control and shape control in our shot peening machines. We also design our machines to be more user and maintenance friendly than other makes.

The Shot Peener: Please describe a recent installation of a shot peening machine or blast cleaning machine that was unusual or unique.

Ms. Maheswari: A recent installation was a robotic shot peening machine for a job shop. We also have executed a complete project for a railway company where we supplied a roller conveyor-type shot blasting machine with loading and unloading arrangement through a jib crane and electro-permanent magnetic lifter. Both of these machines have PLC controls and touchscreen panels.

The Shot Peener: Do you provide shot peening training for your clients?

Ms. Maheswari: Yes, as a manufacturer of shot peening machines, we feel it is our responsibility to help our customers developing and follow healthy shot peening norms and practices to achieve consistent and uniform results.

For more information on Surface International's products, please contact:

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