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Volume 23, Issue 4 **Fall 2009**

The Shot Peener

Dedicated to sharing information and expanding markets for shot peening and blast cleaning industries

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Using Abrasion for Materials Deposition

EnBIO is the developer of CoBlast™; a process that uses abrasive blasting to produce surface modification. Potential applications range from orthopedic prosthetics to stents to dental implants, like those in the photograph.

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Rising to the Challenge

Pangborn needed to overcome seemingly insurmountable challenges to build an one-of-a-kind vertical system to peen Airbus and Gulfstream wing components for Vought® Aircraft. Read how Pangborn's research and development staff and engineers met the challenge.

Photo: Airbus A330/A340 upper panels at Vought

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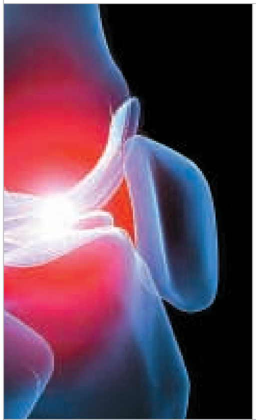

Turning Convention On Its Head

Using Abrasion for Material Deposition

For the first time, it is possible for new and novel functionalities to be added to the surface of metallic implants in a manner devoid of complications. The developers of this abrasion process believe that this capability will lead to the development of new ideas and product concepts not heretofore considered.

John O'Donoghue is the principal founding member of the EnBIO team. He was until recently a Principle Engineer with Guidant/Boston Scientific. There he was responsible for conceptualizing and implementing new approaches to the manufacture of medical devices as well as designing and implementing several product improvement changes. He also has extensive regulatory and medical device validation experience.

Liam O'Neill is the Research and Development Manager for EnBIO. He has 13 years experience in coatings and surface analysis technology, including three years developing coatings for the aerospace industry and six years developing novel plasma-based surface treatments with Dow Corning.

Abrasion is one of the tremendous forces of nature that has helped to shape our world, ranking alongside water and ice in terms of its sheer erosive power. In dry climates, sand-laden winds have sculpted the rock with a raw cutting force, creating shapes and features that awe and inspire. These same forces are often considered to be destructive, defacing the efforts of man to shape his world—literally so in the case of the Sphinx of Giza whose facial features have succumbed to the ravages of erosive sandblasting.

In recent times, abrasion has been tamed and controlled to take its place among the many industrial processes available for the purposes of shaping and fabricating materials into the goods that ease and improve our lives. Abrasive blasting (as distinct from shot peening, which is used primarily to modify the mechanical properties of metals) is used to abrade the uppermost layers from the surfaces of a myriad of metallic and ceramic substrates for the purposes of cleaning, or to prepare the surface for a subsequent process step. It does not logically follow then that abrasion can be used as a means for material deposition on certain select surfaces. Yet EnBIO, a surface modification company based in Ireland, has achieved just that.

CoBlast: A new deposition technique for select metals

EnBIO (an acronym for Enhancing Biomaterials) incorporated in 2006 with a focus on exploiting the use of abrasive blasting to produce surface modifications for the medical device and dental sectors. The company developed a patent-pending technique called CoBlast™ to incorporate dopants (a dopant is a substance which is added to a crystal lattice with the intention of changing its conductive properties) in the uppermost layers of reactive metals like titanium and its alloys, nitinol, cobalt chrome and select stainless steels. These metals, used to manufacture implants for the human body, quickly form a thin protective oxide layer on their surface in air as a result of their inherent reactivity. Ironically, it is this action that renders these metals passive and consequently suitable for use as structural replacements for many diseased body parts. Applications range from commonplace orthopedic prosthetics to stents—tiny scaffolds deployed to hold arteries and ducts open. Also, not surprisingly, the use of titanium in dental implants has led to an explosion of interest from manufacturers in this field.

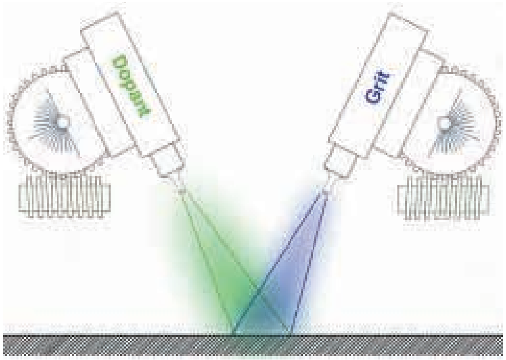

Figure 1: Schematic of the CoBlast process

One of the features of natural oxide formation on reactive metals is the incorporation of airborne contaminants into the newly constructed oxide layer. Carbon and traces of elements deriving from the titanium processing steps are naturally found in the oxide film on the surface. CoBlast exploits this natural effect by loading the immediate atmosphere with appropriate materials when the oxide is forming, thereby incorporating materials of choice into the surface. CoBlast derives its name from the process of simultaneously blasting a surface with two media: one stream is a conventional abrasive jet to disrupt and remove the oxide layer on the immediate surface while the second jet stream delivers the dopant material required in and on the surface. Disrupting and removing the resident oxide layer exposes the underlying metal reactivity; the resulting oxide healing process— which completes itself in a fraction of a second—naturally incorporates the dopant material that is flooding the area. The reconstituted layer is a composite of natural metal oxide and the introduced dopant—usually a bioceramic in the case of an orthopedic implant.

Benefits of CoBlast

In addition to its simplicity (and thus its low cost), the scalable process has many inherent advantages. The main advantage is the room temperature application. As we know, it is extremely difficult to apply a material to the surface of a metal in the adherent manner required for most coatings. High temperature methods such as plasma spray or sputtering are usually used, resulting

in damage to the material being deposited. This has serious implications for the use of such techniques in implant coatings where control of materials is paramount. EnBIO has successfully deposited a range of bioceramics on metal substrates without changing the physical or chemical properties of those materials or the substrate in any way. As well as the obvious regulatory advantages to such a process, the full potency of the material is brought to bear on the surface for its intended function.

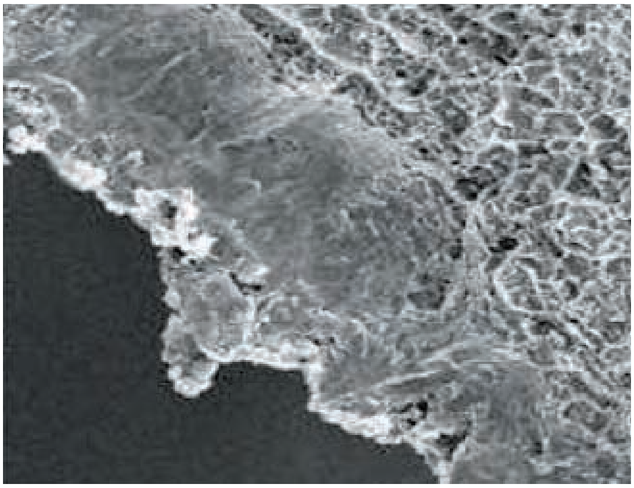

Figure 2: Cross-sectional profile of a surface modified using CoBlast (Hydroxyapatite on Ti)

The straightforward nature of the CoBlast™ process means that it can easily be added to any production process and at a favorable cost relative to conventional deposition techniques in the medical device sector. Abrasive blasting is already well regulated in medical device manufacturing, and this coupled with the fact that all the materials—dopants and substrates—are also well established gives precedence for regulatory approval and hence sector acceptance. It also means that there is already appropriate equipment and expertise available within the industry.

In addition, ceramic materials incorporated via the oxide cannot be delaminated or chipped off as with conventional coatings. In the same way that the natural oxide layer on a metal is considered to be part of the metal, so too is the bioceramic loaded oxide layer resulting from the CoBlast surface treatment. An analogy frequently used by EnBIO is that of the difference between a wood stain and a varnish: the stain is the surface modifying element in the case of wood, while the varnish constitutes the coating that sits on top of the wood. The varnish can be removed off the top but removal of the stain requires removal of wood. Such is the case with reactive metals having undergone the CoBlast process. Removal of the dopant materials is only possible if the uppermost substrate layers are also removed. CoBlast results in a thin layer of incorporated material without adding substantial volume to the part being treated. This adhesion is demonstrated by the superior results of the CoBlast surface to ASTM tensile and shear tests.

Applications: Medical and non-medical

The coating material preferred by the medical device and dental communities is Hydroxyapatite (HA), a bioactive bioceramic used

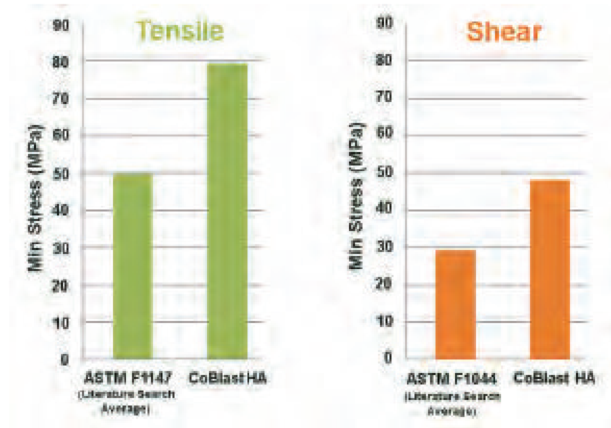

Figure 3: Adhesion of CoBlast HA (measured) vs plasma sprayed HA surfaces for ASTM F1147 tensile test and ASTM F1044 shear test (average from literature search)

mainly in orthopedic and dental applications. XRD analysis of hydroxyapatite (HA) demonstrates that the deposited HA is fully crystalline—an important feature for the implant stakeholders, but indicative of the material-friendly manner embodied by the technique. In vitro and In vivo testing indicates that the CoBlast deposition technique competes favorably with contemporary HA coating methods while offering mid- to long-term benefits due to the highly adherent HA finish. EnBIO has succeeded in depositing HA on Nitinol stents that have successfully survived a 50 million cyclic fatigue test without losing the HA from the surface.

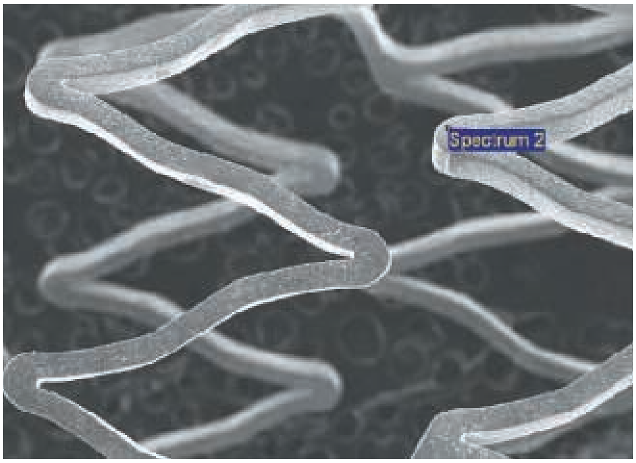

Figure 4: Image of coronary stent with CoBlast modified surface

Other work has demonstrated that using CoBlast to apply various materials to the surface of titanium can significantly improve the hardness and wear resistance of the titanium, which is an inherently soft metal. EnBIO believes that this novel and cost-attractive approach of modifying the surface of titanium will have countless applications as the use of titanium becomes more widespread. EnBIO's focus has expanded into a number of aerospace and military sectors.

With advances in abrasion techniques like these, even the ancient Egyptians would be impressed!

Rising to the Challenge

Vought Aircraft Industries is one of the world's largest independent suppliers of aerostructures and the largest U.S. manufacturer of Airbus aerostructures. Vought has produced more than 10,000 wings and tail sections for a variety of prime aircraft contractors. The company's Nashville, Tennessee location has 70 years of experience in aerospace design, manufacturing and assembly. The site specializes in long and large machining and processing of aircraft parts—the components for the Airbus A330/A340 aircraft measure more than 100 feet long.

Vought's Nashville facility used two horizontal machines to shot peen wing components for Airbus and Gulfstream aircraft: one machine for peening wing panels, one for peening spars. Both parts required multiple passes and time-consuming material handling to complete the peening process. A few years ago, the company considered purchasing a vertical machine to replace both machines and Vought engineers spent eight months working on conceptual design reviews and writing specifications. After review, the company decided to rebuild the existing equipment. Recently, it was determined that the machines, after 37 years of service, were beyond useful life and Vought moved ahead with plans to purchase a vertical machine.

Vought's engineering team needed a unique machine. "We specified a vertical peening system and we wanted to stay away from maintenance issues associated with oscillating panels. We peen large parts and, generally, the surfaces are flat. We wanted to achieve the blast patterns with multiple banks of blast wheels and we wanted to eliminate part manipulation and achieve intensity and coverage requirements in a single pass," said Rick Nicholls, Manufacturing Staff Engineer at Vought Aircraft.

The machine would be a one-of-a-kind vertical shot peening system that must meet Vought's saturation peening specification, must peen in one pass (except for spars with masking that would require a second pass), must have stationary wheels, and the wing panels and spars were not to be rotated, raised or lowered as part of the peening process. Additional challenges were floor space and height limitations. Vought needed to keep one of the horizontal machines operational until the new machine was fully functional and all recipes were approved by Airbus. The older machine required floor space that would have been appreciated by the manufacturer of the new machine. Just as restrictive was the vertical space. The plant had a crane clearance of only 26 feet and because of a high water table, a special pit design with minimal depth was needed.

The company that received the bid would need to overcome seemingly insurmountable challenges to build this system. "We choose Pangborn because they brought more to the table than just a standard machine," said Mr. Nicholls. "Pangborn was willing to invest extensive man hours in their lab to determine the right wheel and line speeds to achieve the saturation curves required."

And so research and development began in the Pangborn lab. The test speciman, a section from one of Vought's most complex aluminum spars, had multiple pockets, thin floors and walls, and enclosed angles. The Pangborn R&D staff mounted 20 Almen strips on all the flats, vertical, horizontal and angled ribs that needed to have saturation peening. The specification required that all of those locations meet saturation within a set range on an "N" Almen strip. The challenge was to determine the quantity of wheels, and most importantly, the wheel positions that would satisfy the saturation requirements. Improper wheel setup would cause some locations to fall within specs while others would be outside of the spec. Wheel rpm and flow entered into the equation and again, all of this must be achieved in one pass.

"We worked seven days a week and many times put in 18 hours a day to find the combination of parameters that met Vought's specifications. We used nearly 3,000 Almen strips during the testing process," said Lynn Keller, a member of Pangborn's engineering staff. Pangborn engineers determined the depth of the machine pit and designed an elevator system that enabled the machine to accommodate large wing components and still not exceed the overall height restrictions.

The final system design included Programmable Logic Controllers (PLC) and a Human Machine Interface (HMI) that were interfaced with an industrial computer to ensure enhanced recipe capability. All motion, travel speeds, travel distances, part position, wheel RPM and flow were monitored with closed loop feedback. Additional components of the system included:

- Twenty-four Rotoblast peening wheels with variable frequency drives and encoders for closed loop feedback
- Twenty-four MagnaValves with closed loop feedback for shot flow control
- Dual shot recovery systems with internal cross-over valves and controls to balance the system
- Monorail system and product load beam for material handling with servo drives and encoder system for closed loop feedback
- Air wash separators and Sweco system for proper fines and shot distribution control

The overall dimensions of the peening cabinet are 5 ft. wide x 46.5 ft. long and 21.5 ft. high (1.5 m x 14.1 m x 6.5 m). The overall dimensions of the system from the bottom of the machine pit to the top of the elevator are approximately 41 ft. high x 60 ft. long x 25 ft. wide (12.5 m x 18.2 m x 7.6 m). A monorail system extends approximately 120 ft. (36.5 m) from each end of the machine.

The system was delivered to Vought in 16 truck loads and reassembled in their facility by Pangborn personnel. Pangborn's field service engineer supervised the set-up, start-up and operator training.

The Pangborn vertical peening system is now fully operational and has successfully met the demands of Vought Aircraft. "We've achieved process improvement with the Pangborn machine. Before, it was very labor intensive to position the large parts and run them through the horizontal machine and then flip them over and run them through again. We eliminated running multiple passes and the time savings have been big," said Mr. Nicholls. ●

A recent research project that compared the effects of shot peening to laser peening on welds is a tribute to Henry O. Fuchs

Weld Fatigue Research

Ralph I. Stephens is a professor of Mechanical and Industrial Engineering at the University of Iowa.

Fatigue and fracture mechanics are two of his special fields of knowledge and he has done extensive research on the fatigue behavior of cast steel, the influence of high mean tensile stress on fatigue life, and the influence of residual stress and mean stress on bolted and welded fasteners.

Professor Stephens is a Registered Professional Engineer, State of Iowa, and a member of the Weld Program in the Society of Automotive Engineers Fatigue Design and Evaluation Committee.

"Effect of Shot and Laser Peening on SAE 1010 Steel Tubes with a Transverse Center Weld Subjected to Constant and Variable Amplitude Loading" is reprinted with permission by ICF12.

The complete paper (paper number 2009031) is available in the online library at www.shotpeener.com

I presented this paper at ICF12 in July. I chose to work on this project for two reasons: First, the research is part of our SAE Fatigue Design Evaluation (SAEFDE) weld program that holds wide interest in SAE. Second, this is my last research project prior to my phased retirement and I wanted to honor Henry O. Fuchs—my good friend and co-author of our book, *Metal Fatigue in Engineering*.

Henry died in 1989 but his contributions live on in the SAEFDE. He co-led one of most popular short courses in SAE history. The course, titled *Fatigue Concepts in Design*, ran for 30 years and had more than 2,000 participants. His work in fatigue studies was so important that SAE gives the H.O. Fuchs award annually to a deserving student in fatigue research.

Henry's contribution extended beyond the academic. He started Metal Improvement Company in his garage in the 1950s and this company has grown to be one of the largest shot peening companies in the world.

I always considered Henry to be "Mr. Residual Stress," a title I passed down to him after John O. Almen passed away. Thus, based on Henry's strong influence in shot peening and residual stresses, I did this research project to honor my dear colleague and friend. The ICF12 presentation will most likely be my last professional presentation on fatigue.

—**Professor Ralph I. Stephens**

The complete paper is available at the www.shotpeener.com library (paper number 2009031)

Effect of Shot and Laser Peening on SAE 1010 Steel Tubes with a Transverse Center Weld Subjected to Constant and Variable Amplitude Loading

L.D. Vo[1], R.I. Stephens[1]

[1]The University of Iowa, Iowa City, Iowa, USA

INTRODUCTION

Compressive surface residual stresses from shot peening have proven to be extremely beneficial to fatigue resistance of intermediate and high strength metals and alloys. Lower strength materials, including steel weldments, often are believed to not have this significant benefit. This is due to lower yield strengths that restrict the magnitude of induced residual stresses and the relaxation of residual stresses during cyclic loading due to local plasticity. Thus, the application of shot peening, or emerging laser peening, has not been common in steel weldments with yield strengths less than about 400 MPa. The limited research available in the literature concerning these lower strength mild steel weldments, however, has indicated increased constant amplitude fatigue limits at $2x10^6$ cycles of between 10 to 90%.[1-4] Most of these tests were performed with an R-ratio (S_{min}/S_{max}) equal of 0 or 0.1, and included longitudinal and transverse fillet welds, butt welds and bead-on-welds. Intermediate fatigue lives often showed mixed results, whereas at shorter life ($\leq 4x10^4$ cycles), no benefits from shot-peening were obtained. Laser peening produces deeper penetration of compressive residual stresses than shot peening and hence may produce better fatigue resistance than shot peening for mild steel weldments. Laser peening has been very successful in higher strength materials involving aluminum, steel and titanium alloys.[5,6] However, it is significantly more expensive than shot peening. The goals of this research were to compare the fatigue resistance of both shot and laser peened mild steel weldments under constant and variable amplitude loading as part of the Society of Automotive Engineers Fatigue Design and Evaluation (SAEFDE) committee's fatigue of weldments program.

DISCUSSION OF RESULTS

The literature review indicated shot peening of mild steel weldments increased the constant amplitude R = 0 or 0.1 fatigue strength at $2x10^6$ cycles by 10 to 90% with little increase at intermediate or low cycles to failure. However fatigue behavior under variable amplitude or other R ratios was not found. Thus, ambiguity exists as to how beneficial shot peening can be in low strength steel weldments. This research confirmed the beneficial effects of both shot and laser peening on constant amplitude R = 0.1 and 0.5 fatigue strengths at $2x10^6$ cycles, with little benefit at shorter lives. However, under three different variable amplitude spectra little influence on fatigue life was found with either shot or laser peening. This beneficial or little effect is usually attributed to whether or not the desirable residual compressive stresses

are maintained or relaxed during cycling in these low yield strength weldments. The laser peened and shot peened weldments had similar near surface residual compressive stresses, but the laser peened residual stresses remained compressive to much greater depths. This greater depth was only beneficial with respect to shot-peening for the R = 0.1 tests. The macro and micro hardness values indicated surface and depth hardness was greater for the laser peened specimens. All test conditions had little scatter with cracks nucleating at the root of the starting weld area. Fatigue crack growth regions had the same morphology at both the macro and micro levels for the three test conditions as did final fracture regions.

CONCLUSIONS

Both shot and laser peening caused increased fatigue strengths in these mild steel weldments at $2\mathrm{x}10^6$ cycles with R = 0.1 and 0.5, but had little effect at shorter lives and with three different variable amplitude tests. The greater depth of compressive residual stresses and micro hardness from laser peening was beneficial with respect to shot peening for only R = 0.1 tests at long life. The current additional cost for laser peening of mild steel weldments would not yet be justifiable.

ACKNOWLEDGEMENT

The authors want to thank the following people who contributed to this SAEFDE sponsored research program: John Bonnen of Ford Motor Co.; Lloyd Hackel and David Breuer of Metal Improvement Co.,; Kevin Young of Progressive Technology Co.; James Pineault of Proto Manufacturing Co.; Jack Champaigne, John Cammet and Peter Bailey of Electronics Incorporated; SAEFDE committee members involved in debate; and Matt Marquardt, Dan Kinne and Gary Trees of The University of Iowa.

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In part two of a two-part series, learn how using a peening machine for blast cleaning and special applications can give you a competitive advantage over other blast cleaning shops

Switching Over
Cleaning with a Peening Machine

Kumar Balan is a Product Engineer with Norican Group

In my last article, I reviewed the requirements of a shot peening system: Monitor and control media velocity (air pressure or wheel speed), classify shot size and shape (rounds versus non-rounds) and monitor media flow rate. In addition, some aerospace applications need real-time information about the process with alarms and shut-down capabilities when process parameters stray outside of set limits. As a result, the peening process can be expected to deliver intensity within the specified range and the required percentage of coverage on the part on a consistent and repeatable basis.

If your shot peening operations have slowed, you may be able to exploit the sophisticated features of your shot peening machine and market superior blast cleaning services and special applications.

Smart Cleaning

A peening machine, in all likelihood, is equipped with the process control components identified earlier. Why not utilize the machine capabilities to run a "smarter" cleaning operation?

Blast cleaning is defined by momentum of the abrasive, which is mass times velocity. Your peening machine is capable of altering the media velocity since different peening intensities require different velocities.

In a wheel-type blast machine, this is determined by wheel speed and in an air-type machine it's the air pressure. Cleaning a particular part may not always require the maximum velocity that the wheel or the nozzle is capable of delivering. Reduced wheel speeds and air pressure may provide you with equally clean results. More importantly, the resulting reduced momentum means less wear on the machine components and a reduced media breakdown rate. Therefore, smart cleaning lowers operating costs.

Another smart cleaning initiative that can be adopted when using your peening machine for cleaning is to check for process consistency. Shot peening operators run Almen strips at definite intervals, or when changing from one part type to another, as a control test to determine the intensity of the blast spray. A similar process can be followed at regular intervals when cleaning parts, maybe at the start of a shift, to determine whether the machine is performing as it was when the previous batch of parts was cleaned. This not only tests the health of your machine, but also gives you documented proof of your operation. The information provides a credible explanation for your customers regarding the effect of different material, scale or contaminants on blast cleaning quality.

A case study conducted with Almen strips by our company for an airblast cleaning application revealed some interesting results when the stand-off distance (distance from part to nozzle) was changed at different pressures. These results helped determine the optimal distance given the constraints of surface roughness. This also led to the use of fewer nozzles and reduced compressed air, given that nozzle blast patterns flare out with increased stand-off distances. It is important to note that such tests, as in this case, can also be carried out using non-ferrous media such as aluminum oxide. See results in the table below.

When your customer's requirement calls for "contaminant-free" blasting of their critical components, it is advisable to complement a traditional rotary screen and an airwash separator with a media screener such as a vibratory classifier. Larger size contaminants such as nuts and bolts can get into the media stream when not separated from the media in the rotary screen. At a second stage, these will be separated in the vibratory classifier and not clog the pressure pot outlets in an airblast machine or damage wheel parts in a wheelblast machine. These steps will prevent damage to the critical component being cleaned.

	220 AlOx at 20 PSI with N Strip		220 AlOx at 30 PSI with N Strip		220 AlOx at 40 PSI with N Strip	
Stand-Off Distance	Arc Height	Ra Micro Inches	Arc Height	Ra Micro Inches	Arc Height	Ra Micro Inches
3"	0.011	85	0.0146	122.7	0.0153	135.5
5"	0.0088	57.2	0.01205	109.1	0.0127	112.4
7"	0.00755	57	0.01165	105.3	0.0111	88
9"	0.0064	56.1	0.0116	102	0.0107	84.5
11"	0.0064	54.1	0.0109	99.3	0.01065	85


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Once again, a properly designed peening machine is the answer to your smart cleaning application.

Special Applications

Though not driven by specifications as in shot peening, applications other than peening involve an equal amount of process considerations. For example, etching requires a consistent surface finish. Your peening machine is already equipped with components designed to address process consistency. Etching applications are common in the automotive sector for pressure plates, brake liners and any surface that relies on surface roughness to enhance bonding properties. Aircraft engine components are etched prior to the application of thermal coatings to ensure coating efficiency.

Parts that require critical coating applications are good candidates for a converted shot peening machine because an anchor pattern is controlled by consistent media size and velocity. Any change in anchor pattern has a detrimental effect on the coating—deeper patterns will result in greater paint consumption and longer drying times. Shallow anchor patterns will cause thinner paint coats and increase the probability of premature rust-induced failure.

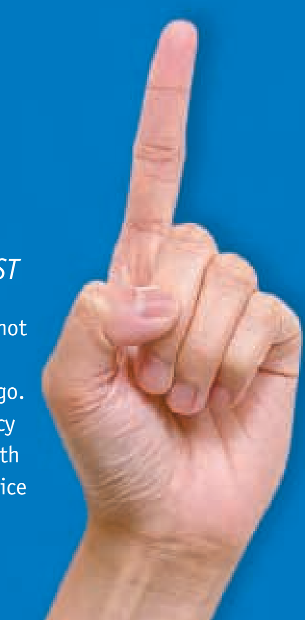
Limitations of Conversion

A partial list of limitations is as follows:

1. Computer-controlled airblast machines that are specifically designed for peening bores, slots, etc., may not render themselves easily for conversion to general cleaning machines.
2. A machine that will be used for occasional peening that requires a different size of media will run the risk of the contamination of media stream with different sizes. The contamination will lead to inconsistent and non-repeatable peening results. This is especially true for customized shot peening machines that are used for demanding applications, like aerospace components. Despite thorough cleaning, the shot peening operator runs the risk of contaminating the peening process when switching over from the cleaning run to peening parts again. However, if the machine isn't needed for shot peening, using it for cleaning projects is a real opportunity.
3. A peening machine that was operated with non-ferrous media can't be used for cleaning with large-sized ferrous media. The media reclaim system in most peening machines operating with non-ferrous media tend to be vacuum style. Such a reclaim system will not be able to reclaim the larger mass of ferrous media. A reclaim system that worked efficiently with a peening machine using glass bead can't be expected to work with S 280 cleaning media.

Summary

You may have the opportunity to keep an idle shot peening machine working. If you have the right conditions to convert the machine to blast cleaning, take advantage of its sophistication. Not only will you run an economical blast cleaning operation, but you can differentiate your blast cleaning and special application offerings by providing superior quality and process control.



ICSP11

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Topics

Applications	Automotive Aerospace Medical Welds Mining Gears Springs
Modeling & Simulation	Lifetime Prediction Load Capability Prediction Stress Profile Surface Characteristics
Alternative Processes	Laser Deep Rolling Ultrasonic-Activated Needle Peening
Fatigue & Fracture	Steel Aluminum Titanium Carburized Steel Stress Relaxation by Tme / Temperature
Technological Aspect	Machines Media Specifications Auxiliary Equipment Devices / Accessories Process Control
Surface Characteristics	Measurement of Residual Stress Stability of Residual Stress Surface Finish
Special Applications	Fine Particle Shot Peening Stress Corrosion Cracking, Fretting Remediation Reduction of Sliding Friction Medical Implant Tissue Adhesion Improvement Medical Implant Peening Special Considerations
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ICSP-11 will be held at the Century Center in South Bend, Indiana

For more information and updates, go to www.shotpeening.org/ICSP-11

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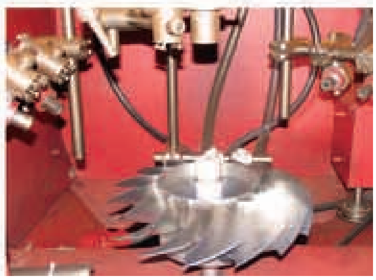

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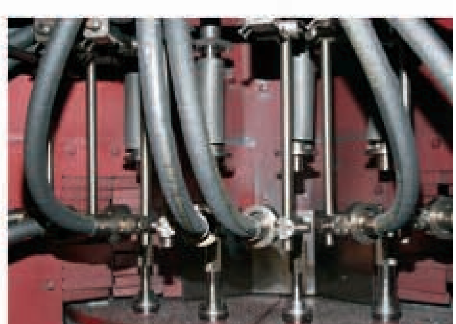

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SPORT has a Mission

SPORT (Shot Peening Operative Resource Team) is a Nordic association for advancing shot peening technology. SPORT creates a forum for the exchange of ideas and experiences related to problems, inventions, and nomenclature in the field of shot peening. Two criteria must be met to be a member of SPORT: Members must be experienced and have an in-depth knowledge in the field of shot peening and they must be working in a Nordic country (Denmark, Finland, Iceland, Norway and Sweden). The restriction to Nordic countries keeps the travel and meeting costs at a reasonable level for all members.

The mission of the group is to:
- influence customers' designs and specifications,
- address development concerns within the field,
- present a unified approach to suppliers,
- and coordinate development and testing in order to reduce costs.

The areas of interest are:
- Media
- Almen strip simulation
- Education
- Specifications
- Machines
- Almen gages, strips and holders
- Residual stress measurement
- Certification
- Future development
- Different shot peening methods

SPORT holds two meetings a year with guest speakers from suppliers, universities and institutes. Topics range from media to residual stresses to the sharing of test results. Recent tests that were shared with the group were the effect of dual shot peening from Therese Brolund at Scania and a stress-relieving procedure by Anna Medvedeva with Uddeholm Tooling AB. Swerea IVF, a research institute based in Sweden, has recently joined SPORT and will offer the ability for the group to coordinate and conduct common tests. The promotion of commercial interests is not allowed within the organization.

Current members come from a wide range of backgrounds such as a shot peening machine operator, a research and development staff member and a PhD student. Membership is limited to 16 people and the roster includes 14 members at this time. Please contact Dan Hoglund at Sandvik AB if you are working in shot peening with a company or university in a Nordic company and are interested in joining (dan.hoglund@sandvik.com). For the rest of us, SPORT is a good example of how to pool resources and knowledge for the advancement of shot peening.

Strip Factors Influencing Almen Arc Height

Dr. David Kirk is a regular contributor to The Shot Peener. Since his retirement, Dr. Kirk has been an Honorary Research Fellow at Coventry University, U.K. and is now Visiting Professor in Materials, Faculty of Engineering and Computing at Coventry University.

INTRODUCTION

Almen arc height is the deflection of the center of an Almen strip. This deflection, when caused by bombarding one face of the strip with high velocity shot particles, is used as a measure of the 'intensity' of the shot stream. Arc height, being such an important factor, is covered by several specifications, e.g., SAE J442 and J443.

Shot-peened Almen strips, on release from their fixture, adopt a curved shape, see fig.1. Arc height increases with the degree of curvature, **1/R**. Shot peening produces a compressively-stressed layer of depth, **d**. The stress in this layer, acting over the strip's cross-section, generates a force, **F**. This, in turn, imposes a bending moment, **M**, on the strip. The strip's resistance to the applied bending moment depends on its elastic modulus, width and thickness, **t**.

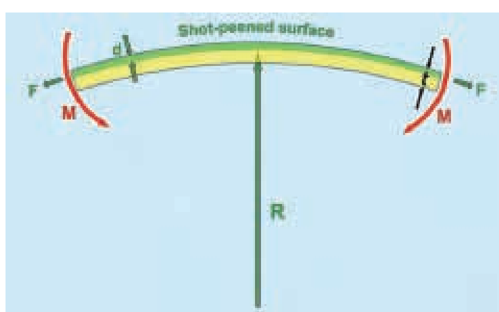

Fig.1. Curving of Almen strips induced by shot peening.

The strip factors that influence Almen arc height fall into two groups:

STRIP BENDING RESISTANCE, **E*I**, where **E** is elastic modulus and **I** is the 'rigidity factor' (technically known as the "second moment of area" of the strip) and

INDUCED BENDING MOMENT, **M**.

The greater the strip's bending resistance, the lower will be the observed arc height. The greater the induced bending moment the greater will be the observed arc height.

This article is an analysis of the several strip factors that affect bending resistance and induced bending moment. The reliability and consistency of Almen strips requires that all of the factors are controlled.

STRIP BENDING MODEL

Basic beam bending theory gives us a simple relationship between the bending moment applied to a beam and its consequent curvature, **1/R** :

$$1/R = M/(E*I) \qquad (1)$$

where **R** is radius of bending, **E** is elastic modulus, **I** is the 'second moment of area' and **M** is applied bending moment.

Equation (1) indicates that curvature (and therefore arc height) increases with increased bending moment but is decreased by increases in either elastic modulus or 'second moment of area'. Bending moment and elastic modulus are familiar parameters. 'Second moment of area' is less familiar. It is simply a quantitative measure of the rigidity of a beam. Fortunately Almen strips, because of their rectangular shape, have a simple relationship between 'second moment of area', **I**, and their dimensions:

$$I = w*t^3/12 \qquad (2)$$

where **w** is strip width and **t** is the strip thickness.

The significance of equation (2) can be appreciated by trying to bend a measuring rule. In one direction the rule bends easily. Turn the rule through 90° and it is virtually impossible to achieve visible bending.

If we substitute the value of **I** given by equation (2) into equation (1) we get:

$$1/R = 12M/(E*w*t^3) \qquad (3)$$

Curvature is not arc height, so that a relationship between them is needed. Use of the 'intersecting chord theorem' gives that:

$$h = s^2/(2R) \qquad (4)$$

where **h** is arc height and **s** is the distance between the support balls of the Almen gage.

Substituting for **R** from equation (4) into equation (3) gives:

$$h = 6s^2*M/(E*w*t^3) \qquad (5)$$

Equation (5) is a 'definitive equation' that indicates the inter-relationship of all of the significant strip factors. **s** is a parameter set by the Almen gage, **M** is a function of both shot bombardment and strip deformation, **E** is a strip function that curiously has attracted little


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attention, **w** the strip width is far less significant than is **t** the strip thickness.

ALMEN STRIP BENDING RESISTANCE

The bending resistance of an Almen strip is directly proportional to **E*I**, see equation (1). Both **E** and **I** are properties that should remain virtually constant from strip to strip – for a given grade of thickness N, A or C. In spite of its fundamental importance the factor **E*I** is rarely monitored directly.

A simple modification to a digital Almen gage allows it to be used to evaluate **E*I**. One such modification is illustrated in fig.2 where 5·5mm diameter steel rods are used to support a strip carrying a load, **P**. The rods prevent contact of the loaded strip with the normal support balls – obviating excessive wear. Deflections of up to 0.700mm can be monitored - before bent strip touches support balls. Rod separation is maximized to 71mm, using spacers at **F**, in order to give greatest deflection sensitivity. The appropriate 'bending of beams' formula is that:

$$h = \frac{P*s^3}{48E*I} \qquad (6)$$

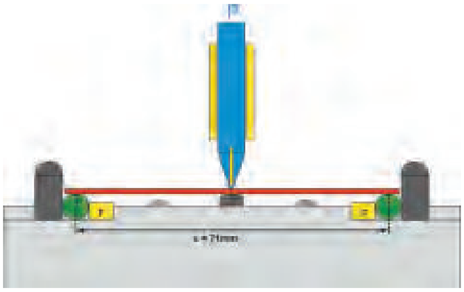

Fig.2. Modification of Almen gage for bending resistance measurements.

Substituting assumed values for **s**, **E** and **I** into equation (6) indicates that a load, **P**, in the range of 1–10N (about 0.1 – 1kg) should be sufficient to give a reasonable amount of N-strip deflection. The load, **P**, in fig.2 can be applied by various means. This modification employed vertical steel bars, of different masses, with chisel ends guided to the central loading line. A particular make of Almen gage needs to be 'propped up' to ensure that the strip is fairly horizontal in both directions.

Equation (6) indicates that there should be a direct correlation between deflection, h, and applied load, P. The modified Almen gage was validated by applying a series of loads to an A strip. Fig.3 shows the excellent linearity between deflection and applied load.

A number of tests can be carried out using the modified Almen gage. The most important commercial test is that for consistency of strip bending resistance. Academic tests include the comparison of bending resistance for the different thicknesses of N, A and C strips and evaluation of the elastic modulus.

Consistency Testing

As an example, a consistency test was carried out on a box of 50 Almen N strips. The same 758g load (7.44N) was applied centrally to each strip. Deflections were recorded using a TSP-3 Almen gage modified as illustrated in fig.2. The collected data is presented in bar chart format as fig.4.

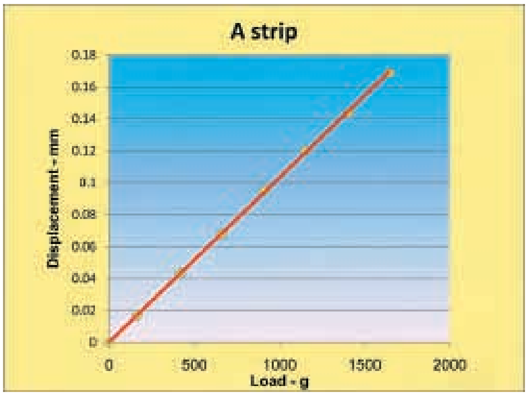

Fig.3 Linear relationship between load and displacement for Almen A strip.

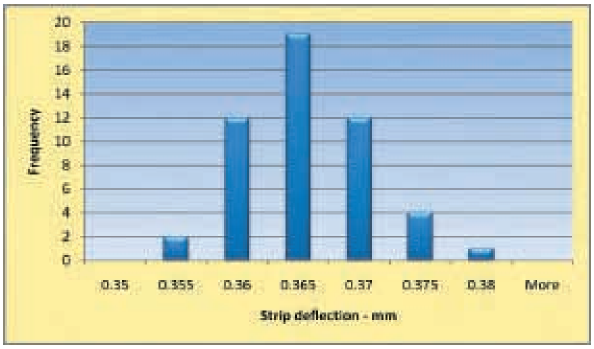

Fig.4 Bar chart showing frequency of deflections for 50 Almen N strips.

For fixed values of **P** and **s** equation (6) shows that there is a direct connection between deflection, **h**, and bending resistance, **EI**. The greater the variability of **h** the greater is the variability of **EI**.

In this test the standard deviation for the 50 deflection values was 0.0052mm, about a mean of 0.3633mm and the range was 0.355 to 0.376mm.

Effect of Almen Strip Thickness on Bending Resistance

The effect of strip thickness can easily be verified **IF** (it is a big "IF") **E**, **P** and **w** are constant. Under those restrictions equation (5) shows that the ratio of deflections h_1/h_2 for Almen strips of thicknesses t_1 and t_2 will be given by:

$$h_1/h_2 = (t_2/t_1)^3 \qquad (7)$$

For a fixed load of 758g the observed deflections for single N and A strips were found to be 0.360 and 0.079mm respectively. Measured thicknesses for the strips were 0.784 and 1.293mm respectively (based on the average of 10 differently located measurements per strip). h_1/h_2 is therefore **4.56** and $(t_2/t_1)^3$ is **4.49**. The difference is 1.5% which is greater than the level of experimental error. Measurements showed that the two strips had precisely the same width. Exactly the same load had been used, so that the only remaining variability was of elastic modulus, **E**.

Effect of Elastic Modulus on Bending Resistance

Bending resistance is directly proportional to the elastic modulus of the strip material. Almen strips are manufactured from rolled SAE 1070 steel strip. The specified elastic modulus is 201GPa which is 4.5% lower than the average published value for ferritic steels of 210MPa. SAE 1070 can

be supplied either as cold-rolled or hot-rolled wide or narrow strip. Published test values for SAE 1070 range from 190 to 219.4GPa.

It is not generally appreciated that the elastic modulus of rolled steels is a vector quantity, i.e., it has both magnitude <u>and</u> direction. Rolled steels are anisotropic - because of the grain preferred orientation that is induced. This anisotropy increases with the amount of rolling and is greater for wide strip than narrow strip. The frequency of intermediate annealing affects the amount of preferred orientation. Hot rolling with multiple passes produces a relatively-negligible amount of preferred orientation. N and A Almen strips are commonly manufactured by slitting and guillotining wide cold-rolled strip prior to heat treatment. Some C strips are manufactured from hot-rolled strip.

Anisotropy of elastic modulus will directly affect bending resistance. A limited test was therefore carried out to determine the elastic modulus of single, randomly-selected, N, A and C strip specimens. The slope of a best-fitting h/p straight line through the origin was used together with equation (6) and careful measurements of strip widths and thicknesses. Corresponding plots of deflection against load are given in figs.3, 5 and 6. Calculated values for the strips were:

N strip: E = 199.9GPa; A strip: E = 204.5GPa and C strip: E = 194.8GPa.

The three calculated values indicate that the elastic modulus, and therefore bending resistance, can vary significantly.

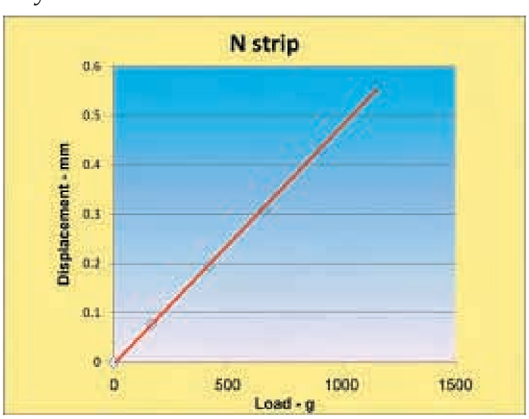

Fig.5 Displacement of N strip versus applied load.

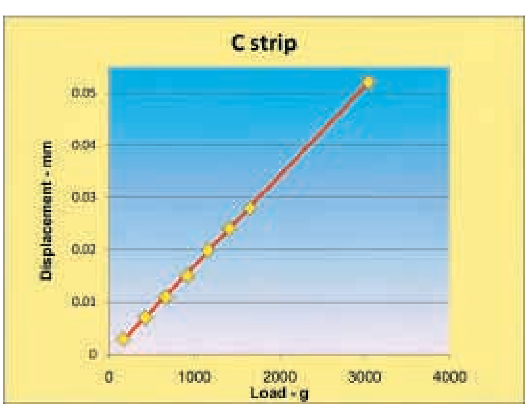

Fig.6 Displacement of C strip versus applied load.

INDUCED BENDING MOMENT

Shot peening of Almen strips produces a compressively stressed surface layer. The stress in this layer multiplied by the area over which it acts generates a force, **F**. This force, in turn, induces a bending moment, **M**. The resulting Almen arc height, h, is directly proportional to the magnitude of the bending moment, see equation (5).

Model of Bending Moment Generation

A simplified model of bending moment generation is shown in fig.7. The bending moment is assumed to be generated by a force, **F**, acting halfway down a compressed surface layer of depth, **d**. This bending moment is then **F(t – d)/2**. The force, **F**, is assumed to be the average stress in the compressed layer, **σ**, multiplied by the area over which it acts (strip width, **w**, times depth, **d**). **F = σ*w*d** so that the bending moment, **M**, induced by peening is given by:

$$M = \sigma * w * d * (t - d)/2 \quad (8)$$

The width, **w**, of Almen strips is virtually constant so that for a given thickness, **t**, of Almen strip there are only two variables in equation (8). Fig.8 shows predicted variations of bending moment with layer depth and stress level for an Almen A strip (width 18.95mm and thickness 1.295mm). The bending moment reaches a maximum when the compressed layer depth is half of the strip thickness. Thereafter the bending moment falls until it reaches zero of the compressed layer occupies the whole of the strip section. It will be shown later that specified restrictions on peening intensity mean that, in practice, the compressed layer would have a maximum thickness of less than 0.2mm. The bending moment is directly proportional to the average level of compressive stress, **σ**.

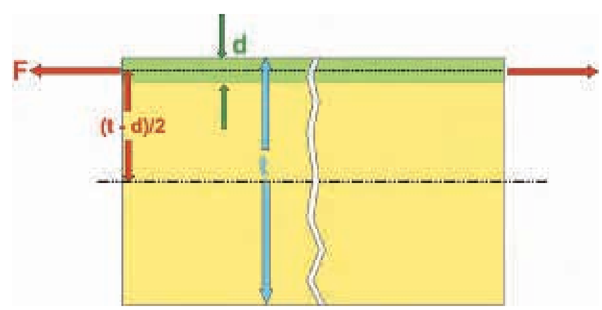

Fig.7 Schematic representation of bending moment generation in an Almen strip.

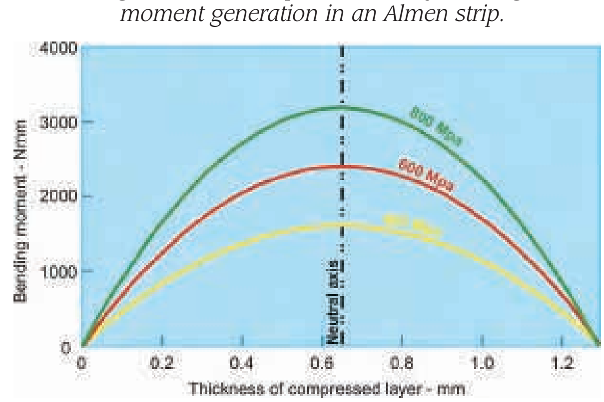

Fig.8 Effects of depth and stress in compressed layer on bending moment.

Effect of Strip Material Properties on Induced Bending Moment

The major property that might be expected to affect the induced bending moment is **hardness**. On the one hand a large hardness will lead to smaller indentations and therefore a smaller depth of compressed layer, **d**. On the other hand a larger hardness would be expected to result in a higher average level of compressive stress, **σ**, in the compressed layer. We therefore have opposing outcomes.

There is strong experimental evidence that the average compressive stress, **σ**, in a shot peened metal increases with increased hardness of the metal. The precise nature of this relationship has not yet been established for as-clamped peened Almen strips. A complication is present because Almen strips have a metastable tempered martensite structure. The greater the hardness the greater is the scope for 'peen tempering' (tempering induced by plastic deformation).

The diameter of shot peening indentations varies inversely with the fourth root of (Brinell) hardness. Depth of compressed layer varies directly with diameter of indentations. Hence it can be assumed that the thickness, **d**, varies inversely with the fourth root of strip hardness.

An empirical approach can be taken to combine the two opposing factors introduced by a strip hardness change. This approach has been used to produce fig.9. The data points are those presented by Champaigne and Bailey at ICSP9 – converted to percentage changes. The equation of a best-fitting straight line for those points has been added to the 'fourth root of hardness' equation to give the line "Increase due to increased layer stress". J442 specifies an allowed hardness range of 44 to 50 HRc. The predicted net change within that range would be 6.3%.

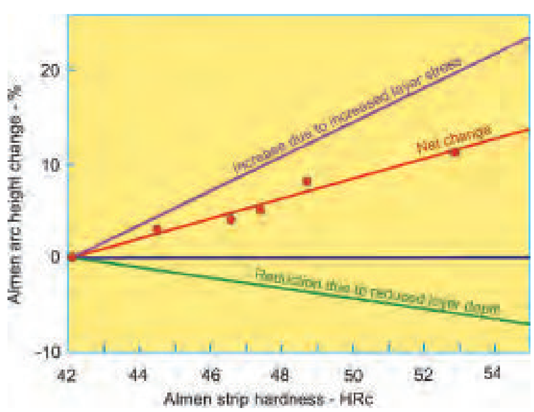

Fig.9 Combination of opposing hardness factors affecting arc height.

COMBINED EFFECTS OF BENDING RESISTANCE AND BENDING MOMENT ON ARC HEIGHT

The arc height, **h**, for a peened strip can be predicted (in mm units) by using equation (9):

$$h = 631 * M/(E * I) \quad (9)$$

The bending moment, **M**, induced by peening is affected by the hardness, width and thickness of a strip - whereas the resistance to the bending moment, **E*I**, is affected by the strip's width and thickness as well as by its elastic modulus.

Equation (9) can be modified using the equations derived for **M** and **I** to give:

$$h = 3786 * \sigma * d(t - d)/(E * t^3) \quad (10)$$

Equation (10) shows that the critical factors governing arc height are hardness (affecting **σ** and **d**), **elastic modulus and strip thickness**. The equation can be used to predict the effects of any of the several factors involved. Assuming, for example, that **σ = 800MPa** and **E = 201GPa**, equation (10) yields the curves shown in fig.10 for N, A and C strips (using average thicknesses). The curves reveal, for example, the virtual linearity of arc height versus layer thickness within the limits prescribed by J443.

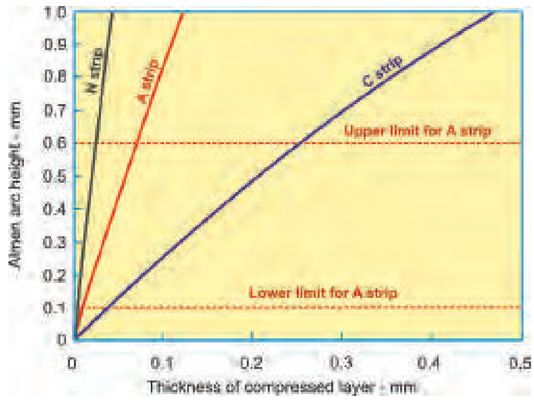

Fig.10 Predicted effects of strip and layer thicknesses on resulting Almen arc height.

DISCUSSION

A prime consideration for Almen strip manufacturers is that their strips' reaction to peening should be as consistent as is economically possible. Peening induces a bending moment whose magnitude depends on the hardness and thickness of a strip. The strip's resistance to this induced bending moment depends upon its elastic modulus, width and thickness. Measured arc heights, for a given amount of peening depend on five factors: hardness, thickness, elastic modulus length and width of a strip. The critical factors governing arc height are hardness, elastic modulus and thickness. Width and length control are needed in order that the curved strips can be accurately located on a gage relative to the support balls.

Specifications prescribe the allowed ranges of hardness, thickness, length and width for N, A and C strips. Surprisingly there seems to be no restriction on elastic modulus. The modification of a standard Almen gage described in this article allows elastic modulus to be measured with reasonable accuracy.

The analysis predicts that an increase of hardness will result in an increase in arc height – for a given peening treatment. This effect arises because the increased compressive stress level is more significant than the slightly reduced layer thickness. There is, however, a strong case for further experimental work to be carried out on the effect of Almen strip hardness on arc height.

A simplified bending of beams approach has been used for this article. A more rigorous approach would have involved complex mathematical procedures. It is believed, however, that this simplified approach is adequate for the intended purpose. Those strip variables that have a significant effect on arc height have been identified and highlighted.

Back to Basics: Cabinet Selection

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Herb Tobben is Sample Processing Manager for the ZERO and AEROLYTE brands of Clemco Industries Corp., Washington, Missouri. He is a speaker at the EI Shot Peening Workshops.

Especially these days, companies carefully evaluate each and every capital expenditure, hopefully considering value and the long lifecycle of this important industrial product. Many of our cabinets, sold more than 30 years ago, are still going strong and we attribute that longevity to good decision-making on the front end and, of course, to good, consistent maintenance practices. But good maintenance is a topic for another day. Blasting fits into a variety of industrial processes, and its role varies from customer to customer and application to application. Some customers blast a few hours a week; others three full shifts per day. Either way, making the right decision is important. It may not be obvious that buying a blast cabinet can involve a complex decision-making process.

What are the basic decisions in selecting a cabinet? They involve the anticipated use of the cabinet, the parts to be blasted, the size of the parts, the weight of the parts, how frequently the cabinet will be used, the media to be used, etc. You might think that the first consideration is the size of the part and the cabinet to suit it, but that's not really the case. The primary consideration involves the application. It is the application that impacts the size and characteristics of the enclosure in several ways.

The Application

Suction blasting is best for light-duty cleaning, deburring, or deflashing on thin or delicate substrates and for smaller parts that will likely be manually manipulated. Suction blasting involves lower air/media delivery velocity, which makes it suitable for light-duty blast applications with glass beads, aluminum oxide, and other media in finer to medium mesh sizes.

Pressure blasting is best for larger parts or for removing durable, tightly-adhering coatings or heavy corrosion. Pressure is also needed for blasting small, deep holes, often with a probe or side-angle deflection tip. Surface preparation applications, which call for deeper surface profiles for coating, bonding, or plating call for pressure blasting. Pressure blasting is best for these types of applications where the velocity of suction blasting is insufficient.

Enclosure Size

Blast cabinets enclose the blasting environment to provide efficient blasting while maintaining a clean surrounding work area. Production rates are influenced by the size of the nozzle or air jet, compressor output, type and size of blast media, as well as angle and distance of the nozzle from the blast surface. Rules of thumb exist to guide enclosure sizing based upon allocation of free space around the part. That distance surrounding the part allows the operator to have full view of the part and be able to manipulate it as needed to blast and blow off all necessary surfaces. The size of the enclosure depends upon which mode of blasting is chosen: suction or pressure.

How Suction and Pressure Impact Enclosure Size

Once the application considerations are noted, the enclosure size can be determined.

In suction systems, a smaller enclosure compared with the part size can be chosen because the suction blast gun is held relatively close to the part, usually 4 to 6 inches, due to the low air/media velocity. With that distance in mind, we normally suggest that it is most efficient to have a clearance around the part of about 16 inches. With small parts, suction blasting is more forgiving when occasionally blasting the gloved hand, though even suction blasting will wear holes in the gloves over time.

In pressure systems, the nozzle to surface stand off distance must be greater, approximately 12 to 14 inches, to take advantage of the larger blast pattern and increased power generated by greater media velocity. Pressure blast systems use larger hoses and deliver more media, providing 300% to 400% higher production rates compared with suction blasting. We generally recommend a distance of 30 inches around the part when choosing pressure-blast systems.

Other Considerations - Utilities

Suction systems operate using the induction principle, the creation of a vacuum from the movement of compressed air through an air jet and nozzle that draws media through a hose

from a non-pressurized container. These systems are characterized by two hoses connecting to a blast gun, one hose delivers compressed air to the gun; the other transports media from the receptacle. In the gun, the air and media mix and together they exit the nozzle. In suction systems, blast media travels at lower velocity, estimated at 136 mph at 80psi. Along with lower velocity when compared with pressure-blast systems, suction systems consume less compressed air. For example, at 80 psi with a 3/8" nozzle and 3/16" air jet, a suction system consumes 48 cubic feet per minute of compressed air.

Pressure systems utilize a pressure vessel to contain the blast media. When the operator steps on the foot pedal, compressed air enters the blast machine and blasting begins. Theses systems are characterized by a single blast hose with a pressure-blast nozzle as the air and media delivery system. Pressure blasting velocity is averages 450 to 500 mph at 80psi, three to four times that of suction blasting. With the increased velocity and production, the volume of air increases. At 80 psi and a 3/8" nozzle, pressure systems consume 161 cubic feet of compressed air per minute.

Pressure blasting is used for tough cleaning jobs and paint stripping of tightly adhered coatings. Typically, pressure blasting performs four times the work of suction blasting in the same amount of time. But as illustrated in the air consumption examples, pressure systems require a larger compressor, consume more air, more media and consequently require more maintenance.

Shot Peening to a Specification

The considerations for choosing suction or pressure systems in shot peening applications are entirely different. Shot peening in certain industries, such as aviation, automotive, power generation, and others often involves strict adherence to written specifications to achieve exact, consistent, repeatable results. The size of the shot governs which type of system can get the job done. When using up to 230 mesh shot, suction systems will generally be acceptable. When using larger shot sizes, pressure systems will provide more consistent results. Pressure systems are required in shot peening applications involving small holes or restricted areas.

Try Before You Buy

We offer in-house sample processing as do our better distributors. Sample processing is the ideal way to determine which system will be right for your application. Your local distributor can guide you through the decision-making process, taking your application and any budget or location constraints you may have into consideration.

Think Long Term

It's always best to try to anticipate your future; and while that's not always easy or even possible, it is one very important consideration for any investment you make. Rather than live with a hastily-chosen product, take the time to work through the proper decision-making steps. That will pay off for you and your company for a long time to come.


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Industry News

Pirate Brand® Introduces the APVII Premium Metering Valve

Indianapolis, Indiana, USA. The Pirate Brand APVII Metering Valve is an Automatic Plunger Valve for use with your abrasive blasting equipment. It has been designed with 22% fewer parts, and several features that make it better performing, easier to use, and longer lasting than similar models.

The APVII features a solid-machined tungsten carbide plunger and sleeve for longer wear rates. The lower plunger seal design has been improved over previous models for better sealing and longer life. It features our quadruple urethane upper plunger seal arrangement which solves the air and abrasive carry-over problem as well as the plunger and sleeve jamming problem normally associated with regulated low pressure blasting applications and/or the use of steel abrasives. The APVII features a 1" NPT clean out port and a hexagon cast into the cap for easy maintenance. The addition of an anti-vibration disc solves the loose knob adjustment problem and includes adjustment indicators for quick and precise adjustments. The breathing hole has also been relocated and a filter has been added to prevent foreign materials from entering the internal chamber. The finish on the APVII is a super tough, powder-coated black outer shell.

For more information on this product ask your distributor or contact the Forecast Sales / Pirate Brand sales team at sales@forecastsalesinc.com. Pirate Brand Parts and Equipment are sold in North America through distribution only and Direct outside of North America. To access our distributor locator, or to see information on becoming a Pirate Brand distributor, visit our website at www.forecastsalesinc.com.

DISA and Wheelabrator Announce New Name

Herlev, Denmark. The German regulatory agency has officially notified DISA/Wheelabrator Group that it has met all requirements for a legal merger. The merged organisation, becomes the world's leading provider of technology and services to improve metallic parts.

"This is a great day for the company," said Robert E. Joyce Jr. president and chief executive officer, "as we can now begin the business of bringing the combined value of these two great companies to our customers." Following an internal competition within DISA and Wheelabrator, a new name was chosen for the parent organisation: Norican Group. The name Norican is derived from Noricum, an ancient Celtic kingdom that existed in the Austria/Bavaria area circa 15BC – 500AD. The region was famous for its high quality Norican steel, which was widely used within the Roman Empire.

The strength of Norican Group lies in its two industry leading brands:

DISA – the brand for moulding technology, and Wheelabrator – the brand for surface preparation technology. The company will continue to build, develop and promote these brands, and will use Norican Group for its corporate functions.

Currently the offer includes all forms of parts formation (horizontal, matchplate and vertical moulding) and surface preparation technologies (airblast, wheelblast and mass finishing). The organization represents over 200 years of expertise and experience, and employs 2200 people over 5 continents, with major operations in Canada, China, Czech Republic, Denmark, France, Germany, India, Poland, Switzerland, UK and USA. Norican Group works with the industry's leading representatives and business partners in serving its customers throughout the world.

Mr. Joyce said, "The creation of Norican Group heralds the start of a new, exciting global business. DISA and Wheelabrator combined have the strength, innovation, products and force to shape industry in the future, so we have incorporated "Shaping industry" into the Group's logos. The company's newly merged knowledge, experience, cultures and ideas will have a positive, influential effect on the industries that we touch, and I look forward to witnessing the great achievements that lie ahead for Norican Group."

Almen Strips Consistency Test Results Available from Electronics Inc.

Mishawaka, Indiana.Saturation curves are only as dependable as the strips used to perform the test. If your strips are not consistent in hardness and thickness, your tests won't be accurate. That's why, before we launched our Electronics Inc. brand of strips in 2007, we began consistency testing on our Almen Strips to track their performance and to document that our strips were manufactured under conditions more stringent than SAE J442 specifications. Our tests prove that EI strips are consistent in hardness and thickness from lot to lot, from year to year. Email us at lori.bonk@electronics-inc.com and we will send our our performance data in easy-to-read histograms for Almen strips produced in 2007, 2008 and 2009.

Shock Peening of Engineering Ceramics Using Contact-Less Energy Beams

Coventry, United Kingdom. Pratik P. Shukla, a research student at Coventry University, has completed a research project on laser peening. The paper's introduction are reprinted here; the paper in its entirety is available at the online library at www.shotpeener.com (paper number 2009023).

Research Background

Laser Shot (Shock) Peening is a comparable process to the conventional shot peening technique applied on various types of metal surfaces. Commercial advantages offered by the laser systems such as flexibility, deep penetration (precise control of the thermal input), shorter process times, high speeds, accuracy and aesthetics are attractive in comparison with the conventional peening technique. Laser peening in the recent years has developed and proven its success with steels, aluminium and titanium surfaces, although, minimal research has been conducted on laser shock peening and conventional shot peening of engineering ceramics [2, 4, 5]. The aim of this investigation is to begin the process of addressing the gap in knowledge by applying industrial lasers to hot pressed silicon nitride (HP Si3N4) in particular as a typical engineering ceramic. This investigation is highlighted on the feasibility of shock peening Si3N4 using contactless energy beams such as industrial lasers and investigates a change in the significant mechanical property; fracture toughness (K1c) of the Si3N4 ceramics. A 2 Kw pulsed Nd: YAG laser is used assisted by an industrial robot to conduct experimentation on the HP Si3N4 ceramics.

Introduction

Applications of ceramics have been limited due to their crack sensitivity and low fracture toughness (K1c), however, the use of ceramics have advanced over the years. They are now considered as the new age material used to manufacture components for the aerospace, automotive and military sectors. Engineering ceramics offer exceptional mechanical properties, which allows them to replace the more conventional materials currently used for high demanding applications. The mechanical property under investigation was fracture toughness (K1c), since it is a very important property of any material and especially ceramics in particular due to their brittle nature. Ceramics in comparison with metal/ alloys have a low K1c, hence it would be an advantage if the K1c of ceramics could be improved using a laser shock peening technique. This can open avenues for ceramics to be applicable to high demanding applications where metals/ alloys fail due to their low thermal resistivity, coefficient of friction, wear rate and hardness in comparison with ceramics. In all cases a comparison was made with the characteristics of the conventional shot peening process to assess the feasibility of surface treating engineering ceramics by the aid of energy beams, to identify if a similar outcome is obtained to that of the conventional mechanical technique [1].

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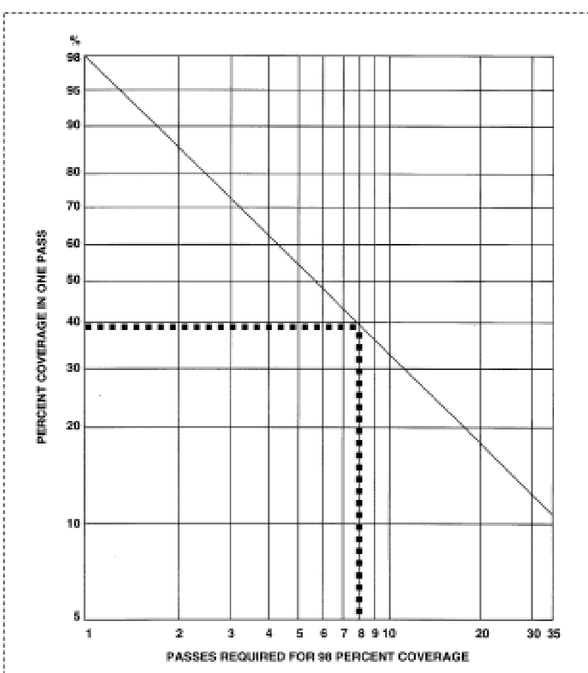
AMEC Shot Peening Committee Updates

Changes to the SAE "J" Standard Practices are again under way. Our last meeting on May 12 in Troy, Michigan resulted in changes to several documents. The word "Determination" was added to SAE J2277 so that it now reflects more accurately its intension "Peening Coverage Determination." A nomograph was added to provide estimates of number of passes required for 98% coverage when the percentage of coverage of a single pass is estimated. Several illustrations were added to show the concept of percentage of coverage and there is now more information on how to document and verify coverage.

SAE J2597, Computer Generated Saturation Curves, will soon be published. This document describes how computer algorithms can be employed in spreadsheets to generate the saturation curve and identify "Intensity" (the arc height value (T1) and its corresponding 10% higher value at twice the T1 time). A table of sample arc heights Vs exposure time values is included to assist users wishing to develop their own algorithms. The use of SAE J2597, Computer Generated Saturation Curves, is recommended but not required for previously approved technical plans.



Nomograph added to SAE J2277

Some very important changes were made to SAE J443. The use of computer generated saturation curves (SAE J2597) is emphasized in an effort to improve consistency of declaration of intensity. Also, a new method of determining intensity when a fixture has multiple holders is introduced. This technique allows a great reduction in time required to both determine intensity and later to confirm that intensity is still maintained.

The graph depicting arc heights Vs exposure time was redrawn and the terminology for the intensity value was changed from "10% or less" to "10%". Allowing the "or less" provision offered too much leniency in interpretation. A second saturation curve was added to the document to illustrate the interpretation of saturation curves where the exposure time is shown as number of passes or table rotations etc. There are situations, such as use of very small media, when the first strip presented to the shot stream is, in essence, saturated. Additional exposure to more table rotations or passes reveals essentially the same value. The method of interpreting this condition is now explained in the document.

The next meeting of the Surface Enhancement Committee will be held on the Monday before the annual EI Shot Peening Workshop in Albuquerque, New Mexico on October 26. Please contact me if you would like to attend this meeting (9:00 AM to 5:00 PM on Monday). Also, the next meeting of the AMEC Shot Peening Committee will be January 26-27 at the Asilomar Conference Center in Pacific Grove, California. ●

We note with sadness the passing of two long-time friends and work associates: Bob Ford with Abrasive Blast Systems and Greg Rabel with Midwestern Industries. Both will be deeply missed by friends, family and colleagues.

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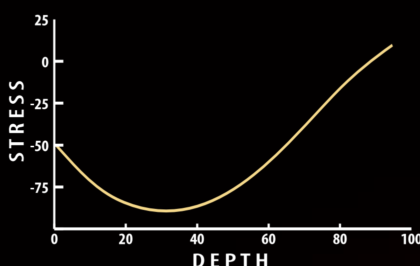

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