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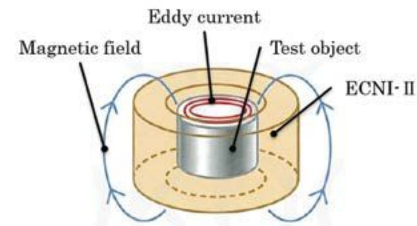
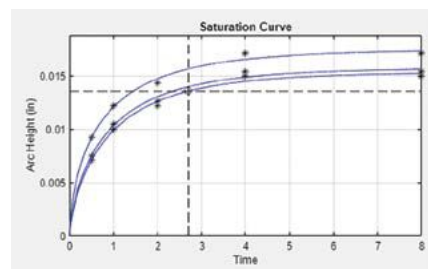
The Shot Peener

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





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

OPENING SHOT

Jack Champaigne | Editor | The Shot Peener

Products, Processes, and Progress

I STARED AT THE COVER of the fall magazine for a while to grasp the significance of this collection of articles. I looked back at older issues to see what was new back then—not much compared to today. Eddy current non-destructive testing was still only a dream. Residual stress determination was available only as a time-consuming laboratory process. Laser shock peening was in experimental stages using Star Wars laboratory equipment. Shot peening machines were automated but today's shot peening systems are sophisticated enough to more than meet the demands of the aerospace industry. Ten years ago, curve solvers allowed compliance with the 10% rule, but today's version brings even more confidence onto the shop floor.

The Almen strip is also in research and development. I always want to learn more about Almen strips. A project to investigate the influence of strip hardness and thickness is starting soon at Purdue's Center for Surface Engineering and Enhancement (CSEE). Why is the "A" strip used only between .004 and .024A intensity? What is the limit for the "C" strip? What is the limit for the "N" strip? How can we design a thinner strip for fine particle shot peening?

A cast steel shot project is underway at CSEE, too. Researchers are evaluating statistical process control limits on cast steel shot to supplement test sieve procedures. I remember talking to a vendor many years ago and I was asked, "Did you want small S-110 or large S-110?" It turns out that is a valid question since there is such a large range of sizes allowed in the sieve analysis.

Another topic that needed to be addressed is the affect of COVID-19 on the USA Shot Peening and Blast Cleaning Workshop and Tradeshow. I wouldn't call these steps "progress" because we would be better off if we never had to adapt to the cruelty of the pandemic. But the actions will make the event productive and safe. (A big thank you to Dave Barkley, Director of Training at Electronics Inc., for designing these programs.)

The first change is in workshop registration that Dave named "Volatile Workforce Accommodations." As Dave wrote in an email, "We recognize many companies are struggling with maintaining a workforce and may be hesitant to register employees for the US Workshop. Maybe an employee will have moved on by November. Maybe you haven't hired anyone yet. Fear not. Sign up employees now to take advantage of the early registration discount. You can make substitutions right up to the last week of October. You can even register a 'to be determined' (TBD) student and let us know the name later."

The second program implements measures for the safety of participants. Student seating will be spaced three feet apart. Exhibition booths will be spaced three feet apart. Breakfast and lunch seating will be spaced appropriately. Face masks are recommended for non-vaccinated individuals coming within three feet of each other. Hand sanitizer will be widely available.

All in all, we are an industry that adjusts to the world around us and we take every advantage of technological advancements. There hasn't been a day when I haven't been proud and grateful to be a part of it.

THE SHOT PEENER

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Introducing the ECNI-II

In-line Eddy Current Non-Destructive Inspection by Sintokogio

1. INTRODUCTION

Special processes such as heat treatment, painting, and welding are difficult to visually inspect. Shot peening (SP) is one of these special processes. SP is a dry method of surface modification. SP improves the fatigue strength by inducing compressive residual stress on the surface of the metal to be processed. Therefore, it is important to measure the compressive residual stress.

Until now, the quality control of the products in the SP processing line has not been performed, but only the process control of the processing machine has been performed. On the other hand, residual stress measurement after the process has been done off-line, if necessary. Generally, the X-ray diffraction method is used for stress measurement of metallic materials; the penetration depth of X-rays is a few micrometers from the top surface. If the stress in the depth direction is needed, it is necessary to measure it step by step by electropolishing. This results in the destruction of the product. Thus, it is a spot check. Therefore, there is a need for a non-destructive method to inspect the compressive residual stress in the depth direction applied by SP.

The inspection unit integrated into the processing machine in the production plant should be established by the processing machine manufacturer who knows the process well. Therefore, we have been developing a system that can perform non-destructive total inspection on SP machines. In this paper, we introduce one of the developed products, the eddy current non-destructive inspection system ECNI-II (Fig. 1).

2. ECNI-II MEASUREMENT PRINCIPLE AND FEATURES

ECNI-II is an inspection system using the eddy current measurement method. Fig. 2 shows an image of the eddy current measurement method. By applying AC magnetism to the specimen, eddy currents are generated on the surface of the specimen. The magnetic field created by these eddy currents changes the current flowing in the coil. The method to measure this change as an impedance change is called the eddy current method. The eddy current changes depending on the magnetic permeability of the specimen. Since the magnetic permeability changes due to elastic strain, plastic strain, phase transformation of austenite, etc., it is possible to inspect surface processing in which the magnetic permeability of the specimen changes.

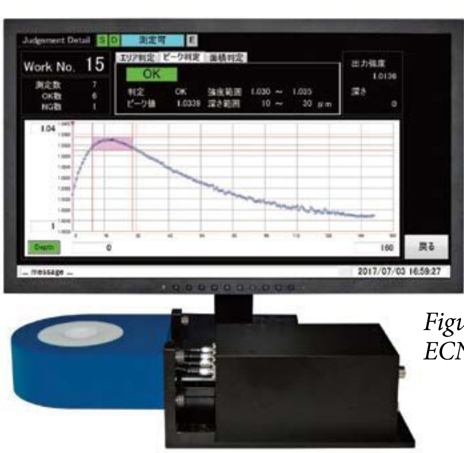


Figure 1. ECNI-II

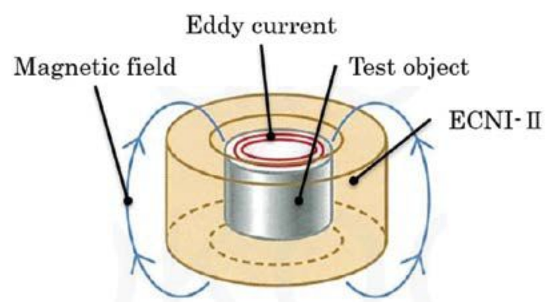


Figure 2. Eddy current method

The depth of eddy current penetration can be changed from 0 μm to approximately 200 μm by changing the excitation frequency of the coil. ECNI-II has a function to graph the processing state inside the specimen by changing the frequency and penetrating eddy currents step by step. This makes it possible to obtain inspection results from the surface to the inside of the specimen at the same time. The measurement results of ECNI-II are shown in Fig. 3. The measurement results of ECNI-II are displayed in a graph. The vertical axis shows the ratio of the eddy current reaction after

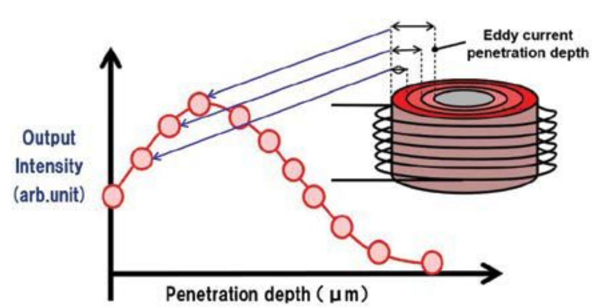


Figure 3. Measurement result

SP to that before SP. The horizontal axis shows the depth of eddy current penetration. The tick width of the measurement can be set to at least every 1 µm.

The measurement result is judged as OK or NG (No Good) by the method of area, peak, and area (Figures 4 A, B, C). After SP, a curve is drawn as shown in Fig. 3. An optimal judgment method is selected for each waveform, and a suitable threshold value is set.

The inspection time from measurement to judgment is as short as one second. These features enable nondestructive inspection of the entire inside of the processed product in the production line.

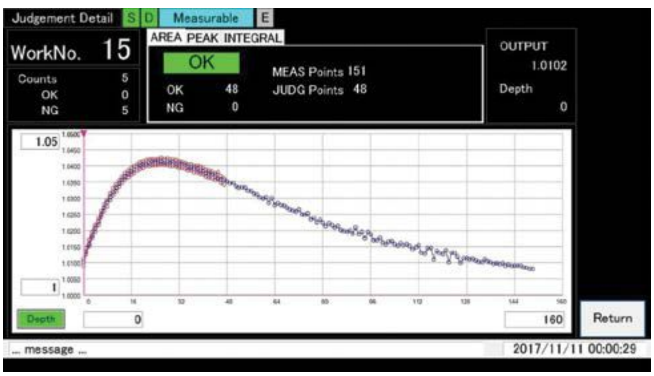


Figure 4 A. Area judgment

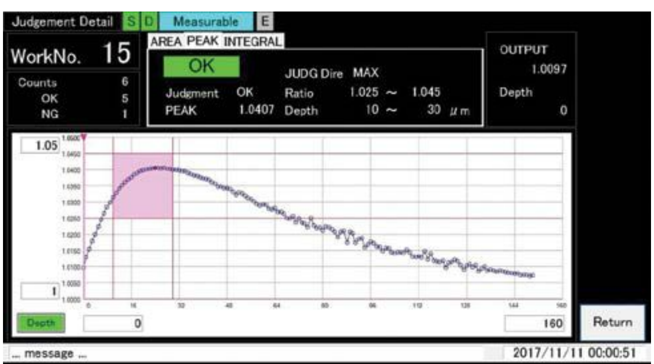


Figure 4 B. Peak judgment

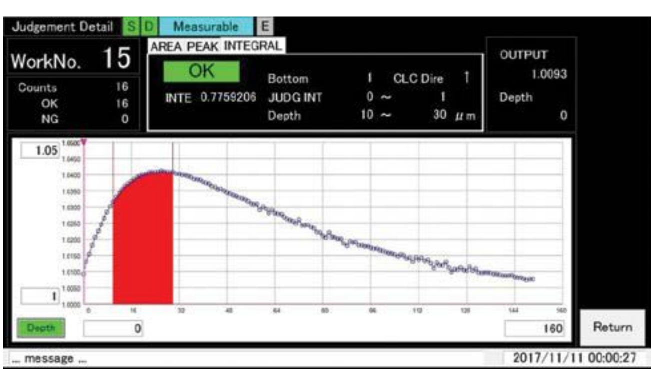


Figure 4 C - Integral judgment

3. ECNI-II MEASUREMENT EXAMPLE

In this paper, we present an example of the evaluation of carburized SCM420H, a typical gear steel, by ECNI-II. In this case, among the SP conditions, only the diameter of the peening media was changed. The measurement results are shown in Fig. 5. As the peening media diameter increased, the eddy currents were distributed from the surface to the deeper position. This is due to the change in permeability caused by the processing-induced martensitic transformation of the austenite retained by the carburizing treatment.

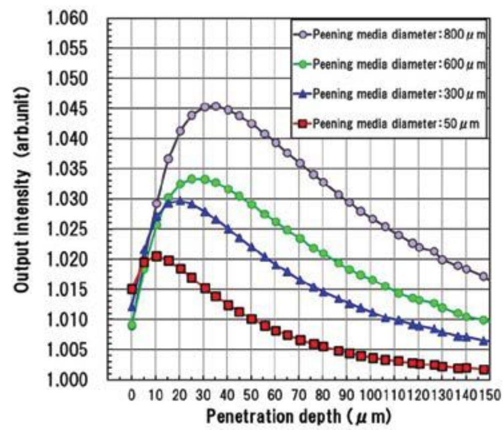


Figure 5. Measurement sample

4. CONCLUSION

In this paper, the functions of ECNI-II are explained and examples of evaluation of materials after SP are introduced. In addition to the examples introduced in this paper, the evaluation of heat treatment and material identification were also performed. We have our own experimental unit, so please contact us if you have any issues about evaluation after surface processing.

AN INSIDER'S PERSPECTIVE

Kumar Balan | Blast Cleaning and Shot Peening Specialist

Laser Shock Peening

Peening Techniques

Rust and fatigue never take a break, and our industry tries its best to get ahead of both miscreants! We blast clean parts to remove the last trace of scale, rust, or any other contaminant to present a clean surface for a downstream coating. We shot peen parts to generate residual compressive residual stress (CRS) that will combat fatigue and enhance the productive life of the component. With peening, we have adopted several other techniques in addition to shot peening using cast steel shot, cut wire shot, glass bead and ceramic shot. Such techniques include Rotary Flapper, Ultrasonic, Needle, Laser, Vibratory, Hammer, and Cavitation peening. Individual techniques continue to be adopted under specific circumstances and to achieve desired end goals.

It is not uncommon that a process engineer encounters a situation where, despite peening the part to the approved parameters, a certain area of the component continues to experience fatigue failure. The nagging issue persists even after altering known parameters in shot peening. FMEA (Failure Modes and Effects Analysis) might reveal other design aspects about the component that may have contributed to this failure. Perhaps, it might benefit from treatment by a different peening technique that can deliver CRS beyond the realms of conventional shot peening. Let us explore one such technique—Laser Shock Peening (LSP).

When discussing LSP, we need to explore beyond our traditional evaluation norms of the process. In addition to intensity and coverage, peening results are also evaluated based on two critical parameters, (a) magnitude, and (b) depth of compression. Each of the processes listed above results in a different achievable value for both parameters. Though largely dependent on the part metallurgy, where conventional peening generates residual compression in the range of 0.002" to 0.020", LSP could generate CRS (Compressive Residual Stress) in depths 0.2" and deeper.

What is Laser Shock Peening?

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. This source of energy is well-utilized in industrial applications such as cutting, welding and common in more mainstream devices such as printers, CD players, barcode scanners, etc. The light emitted by a laser has a coherent property, and different from other sources of light. Coherent light waves have the same frequency (number of occurrences per unit time) and waveform (picture a sine wave or a sawtooth pattern) considered an ideal property for waves.

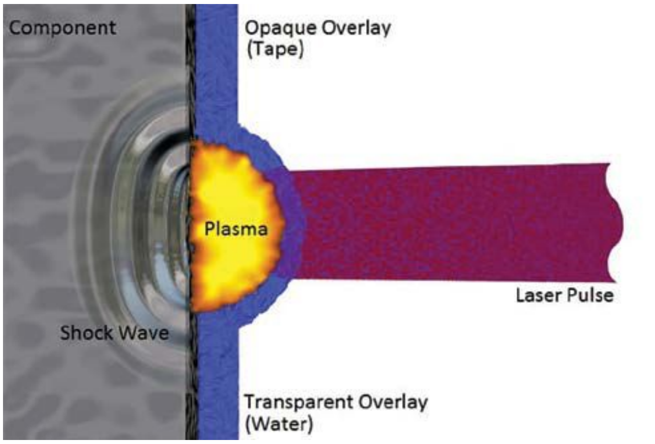
During a condition called spatial coherence, two or more such waves focus on a common spot creating a high quantum of energy that allows for operations such as laser cutting using a *continuous* wave laser. LSP utilizes this phenomenon with a high-energy *pulsed* laser to generate CRS in the component that is laser peened. When a high-energy laser pulse (nominally 10- 20 ns long) hits the surface of the metal, it generates a plasma wave that creates significant pressure to alter or reshape the microstructure (metal grain shapes) in the area. The areas surrounding the impact try to push back this distortion and regain their original shape before the impact. The result is an area of CRS. The net effect of a shot particle impacting the surface and a laser beam is the same—distortion and generation of residual compression.

However, the magnitude and depth are vastly different with both techniques, more of which will be discussed later. Due to laser shock peening's ability to deliver precision protection deep into the surface of metal components, it can result in parts lasting up to 10 times longer.

Mechanism of LSP

During laser peening, the laser pulse created by the incident beam creates an explosive plasma on the process surface that generates a shock wave. Laser peening uses a transparent layer termed "overlay" to confine this explosion and utilize and direct this shock wave energy into the component. Therefore, the term Laser Shock Peening is used to describe the process. Without the transparent overlay, this energy will disperse and not create the intended peening effect.

The most common type of overlay is a transparent overlay (often water) that is presented at an angle of 0 to 30 degrees to the surface of the component. This water is applied at low pressure to a flow that will generate a 0.5 mm - 2 mm thick layer.



Mechanism of LSP – a pulsed laser beam impacting the component with controlled peening results

A second overlay that is sometimes used in LSP is an "opaque overlay". In informal terms, this is an energy absorbing layer that is applied directly over the area being peened to protect the surface of parts made from specific metals and amplify the amplitude of the shockwaves.

Dr. Micheal Kattoura, Materials Research Engineer at LSP Technologies, Dublin, Ohio (USA) explains, "The purpose of the opaque overlay is to protect the surface of the metal part from interacting with the plasma and creating an oxide layer that generates very shallow (few microns) surface tensile residual stresses." When questioned about the processing time involved in applying and removing this layer, Dr. Kattoura added, "With high frequency lasers, typically 20 Hz or higher, the taping process tends to be longer than the actual cycle. Therefore, at LSP Technologies, we conducted several studies on peening without opaque overlay, commonly referred to as bare peening, and concluded that the shallow surface tensile stresses have negligible effects on the parts performance and can be addressed by increasing the overlaps (this term explained later) or by buffing the surface. Bare peening has become more common in the applications we work on." He did note an exception with Titanium alloys which form a brittle layer on the surface when peened without the opaque layer. This layer, also referred to as "Alpha case" contains microcracks that reduces the benefit to the fatigue life of the component from laser peening. Removal of this alpha case is typically through machining or chemical milling which requires high accuracy to continue meeting the part tolerances. Taping (opaque overlay) tends to be a requirement for such metals.

Let us evaluate some of the processing terms used in LSP and contrast them with shot peening to gain a better, comparative understanding. (See Table below.)

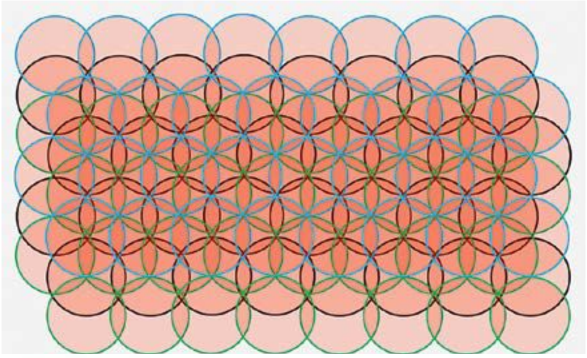
Part Geometry in LSP

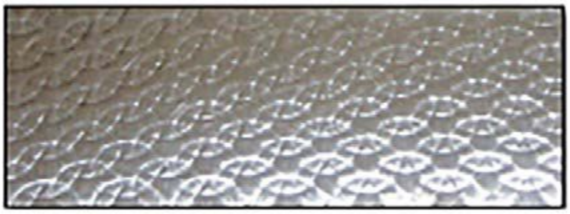
LSP is most effective when there is a direct line of sight between the beam and the area to be peened—unlike shot peening where ricochet peening is a distinct possibility due to the remaining energy in the media particle after its first impact. This presents some unique opportunities for this process that will be discussed later.

Contour (geometry) of the surface being peened influences the character of the shock waves and depth of compressive stress. Concave surfaces cause the shock wave to expand and decrease the magnitude and depth of compressive stress. The opposite is true when peening convex surfaces. LSP presents a unique challenge when peening solid cylinders like shafts. In shafts that are less than 12.5 mm (0.5"), LSP has the potential to create cracking along the center line of the cylinder or a high-core tensile stress that could lower the fatigue strength. This issue diminishes with increasing shaft diameter.

Comparison of Processing Terms

Laser Shock Peening	Shot Peening
Power Density – This is the key to generating CRS. It is directly proportional to the depth of compressive stress generated and determined by the energy of the laser (in Joules), and indirectly related to the pulse width (duration in nano seconds) and laser spot area (in sq. cm). Ideal peening treatment for a material is generally proportional to its yield strength. Strong materials such as high strength steels, Ni and Ti alloys are processed close to maximum power density (7-10 GW/sq.cm) and soft materials at lower power density (2-6 GW/sq.cm). 1 GW = 1 billion watts.	**Impact Energy** – Also referred to as transmitted energy or kinetic energy. Impact energy generated is directly proportional to the mass of the shot particle and velocity of impact (determined by air pressure or wheel speed used to propel the media). Shot size and velocity determine the impact energy delivered. Shot sizes range from 0.007" to 0.078" (SAE sizes). Some applications such as peen forming use even larger size media. Components are shot peened close to or higher than the yield strength (plastic deformation). Impact of shot particle dents the surface and continues to retain energy after the first impact, up to 3-4 impacts.
Overlays – Transparent and Opaque – Transparent overlay is a requirement in LSP to contain the shockwave and allow its propagation into the component. The requirement of opaque overlay is material dependent.	Though masking of components is common in shot peening, neither transparent nor opaque overlays are required when peening the component.
Energy Transmission in LSP is immediate and final. After the component has been impacted in a specific spot, there is no residual energy that a reflected beam will continue to possess.	**Energy Transmissio**n in shot peening is created by the impact of millions of shot particles over a period. Given the right parameters, at process saturation, energy transfer from each media particle is uniform.
Coverage and Overlap - Coverage is achieved through layering. Multiple layers are overlapped on to the target surface to increase the coverage, resulting in a uniform distribution of the residual stress and relatively smoother surface.	**Coverage** on the surface is directly proportional to exposure time and the number of particles that impact the part. Verification of coverage is through visual inspection of the part. Rate of coverage is inversely proportional to the diameter of shot particle.





A three-layer overlap pattern (top) and an example of laser peen spot pattern (below)

LSP can be used to peen inside holes wherein a series of optics (mirrors) can deflect (bounce) the beam to impact the side walls of the hole without appreciable loss of energy. This works for most hole sizes and is still an effective technique in spite of not having direct line of sight.

Part thickness also plays a crucial role, especially in thin cross-sections, much like in shot peening. Thin-walled sections such as blisks must be peened simultaneously from both sides of the part area to avoid distortion. This is valid when shot peening such parts as well. Dr. Kattoura from LSP Technologies informed me that they had successfully implemented several systems using their Procudo® 200 laser system that were capable of peening both sides of parts simultaneously without distortion.

Beam Delivery in LSP

Delivering peening media to the nozzle or blast wheel in a shot peening machine is through a blast hose in an airblast machine or feed pipe in a wheelblast machine. In comparison, beam delivery systems are of three kinds in a LSP system: Fixed, Articulated Arm and Fiber optics. Keith Glover, Head of Applications Engineering at LSP Technologies provided more insight, "As the names suggest, a fixed beam delivery system is the most straightforward where the part is articulated to expose different areas to a fixed laser beam. With more complicated geometries where manipulating the part is not possible, articulated arms fitted with a series of optics "bounce" the beam to the target when not in direct line of sight. Such systems are highly effective albeit requiring higher capital cost than fixed systems. At LSP Technologies, we have started using fiber optics to streamline this technique." (Fiber optics uses thin strands of glass fibersto transmit information through light pulses over long distances, with minimal loss.)

Shot peening media delivery systems are susceptible to energy losses due to long hose lengths, worn blast hoses and nozzles. Regular monitoring is essential to ensure that the impact energy being delivered is constant and repeatable. This is a stark difference from LSP systems where there is no physical impact or wear from the source that ultimately produces comparable fatigue strength enhancement in the component.

A Synergistic Approach

Our discussion started by introducing the possibility where shot peening alone is not able to counter the effects of fatigue on a component. All identified advantages of LSP, such as resistance to FOD (Foreign Object Damage), improved fatigue strength, increased fatigue life, resistance to crack initiation and propagation, resistance to fretting fatigue, and reduction in stress corrosion cracking, are similar to a list that could be generated for shot peening.

However, there do exist applications in the energy and aerospace sectors which demand a much higher depth of compression in target areas combined with the need to maintain a processing environment devoid of foreign particles. Such applications can greatly benefit from this combined approach.

The industry currently utilizes shot peening machines that take advantage of the increased media flow rate achieved by blast wheels to process large surface areas at high rates of productivity and combine them with nozzles to access those difficult-to-reach spots such as bores and slots, both within the same blast cabinet. Similarly, a hybrid system using both techniques, shot peening and LSP, is entirely possible in specific cases.

Shot peening is not an extension of a blast cleaning process. Whether as a stand-alone process or synergistic to shot peening, the benefits of LSP can only be gained with a higher level approach and understanding relating to materials and their behavior under fatigue-loading conditions. The process approach needs to go beyond deflecting a set of Almen strips and plotting a saturation curve to accomplish a peening operation.

Does LSP Stand on Its Own Merit as a Viable Peening Process?

Yes. LSP is fully mature and thoroughly demonstrated on a variety of metallic aerospace and metal forming components. When fatigue enhancement is mission critical, broad area coverage through shot peening combined with targeted laser peening could be the synergistic service life extension your product may require.

This article was enriched by discussions with various professionals at LSP Technologies in Dublin, Ohio. I would like to acknowledge their interest and efforts in making this an educative and informative document.

Jörg Behler | sentenso | www.sentenso.com

Stress Determination Made Easy

While shot peening intensity verification is the well-established standard in shot peening quality control, the more relevant residual stress determination is mostly caught up in laboratories of a production plant or of external service providers. Until today, the related measurement procedures are complex and time consuming. Fast inspection methods for in line inspections are already available but limited to simple setups. With StressEasy, the new software extension to Pulstec's simple, fast and mobile μ-X360s stress analyzer, sentenso presents a new flexible software tool for the assistance and automation in multiple and complex measurement tasks.

Residual stress determination in the past was time consuming and complex to setup with the need for very precise positioning of the specimen and the need for a mechanically complex goniometer. Starting in the 1970s, Japanese scientists developed a new method to determine stress states in metallic materials using a two-dimensional area detector. The so-called cos-alpha method has several advantages over the standard X-ray diffraction methods. Instead of tilting the X-ray source and detector during the measurement, the method utilizes the complete Debye-Scherrer ring data that is collected on the area detector. Since the stress level can be determined from the ring shift on the detector, movements of X-ray tube and detector are not needed and the measurement time can be reduced to as low as 35 seconds on most ferritic steel samples. Texture and coarse grain conditions can be spotted from only one measurement. These advantages allow for fast, precise and reliable stress determination.

Figure 1: Stress measurement on a gear tooth

The μ-X360s introduced in 2012 by the Japanese Manufacturer Pulstec is utilizing the cos-alpha method to implement the aforementioned benefits into an affordable and fully mobile X-ray diffractometer using a high-resolution image plate (IP) as area detector. The μ-X360s provides fast and stable measurements as well as a lightweight, portable and robust design, while emitting extremely low dose rates. In combination with sentenso's new software extension, StressEasy, stress determination is highly automatized and easy to setup. StressEasy is connecting to the μ-X360s, runs in a web browser and provides the connection to a robot to automatically move the μ X360s sensor unit.

StressEasy provides the following functions:

- Stress limit checks
- Batch measurements
- Stress mappings
- Oscillation methods (linear, circular, ψ-angle)
- Out-of-plane shear stress determination
- Stress matrix determination

StressEasy will be constantly developed further to implement user ideas and additional functions.

Stress Limit Checks in Production

Measuring stress in a production line can be quite challenging due to the required cycle time. A simple and fast solution for inline check of residual stress levels has been presented earlier ("The Shot Peener Magazine", Vol 35, Issue 3, Summer 2021 and Vol 31, Issue 3, Summer 2017). That device, however, is not using an area detector and thus not collecting the complete Debye-Scherrer ring, so the accuracy is reduced. Specific measurement setups and configurations are very limited.

As an example, when stress limit checks would be useful imagine a diaphragm spring that is measured after shot peening. A failure-critical position is chosen to compare the actual value with limits set by engineering. In the software a minimum and maximum stress level expected in the respective measurement spot can be set. Exceeding these limits will cause the software extension StressEasy to give out a signal so further steps can be done—for example, sorting out the part for additional measurements.

Multiple Measurement Tasks

In order to save a lot of valuable operator time, StressEasy provides configurable batch measurement functions to set different measurement tasks and positions beforehand. The measurements are carried out in the order and amount set by the user automatically without the need for additional user input.

Stress Mapping On Critical Surface Areas

Often in stress analysis, not only a single spot on a surface has to be checked but a mapping of the stress distribution in a certain area is required.

Large scale mappings of the residual stress on a surface require a number of single measurements with the following properties:

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- A fast measurement per position is needed since the amount of measurements rapidly grows with the area size.
- The measurements should be easy to setup and easy to configure.
- The measurements should be performed automatically without the need for user input once the measurement has started.

When designing a part and developing the processes needed to manufacture it, the outcome of the residual stress distribution can only be assumed. Instead of destructive cycle tests, stress mapping can be a powerful feature to develop process parameters to get the best possible outcome of residual stress. In Figure 2, an induction heated part is shown with a spot in the middle and around it the heat influenced zone. This 21x21 = 441 was done using the mapping feature of StressEasy. StressEasy is able to create mappings of up to 100 points in just one hour on ferritic steel when used with a robot. A mapping like this provides valuable information about the stress distribution in the part and helps optimizing the manufacturing processes.

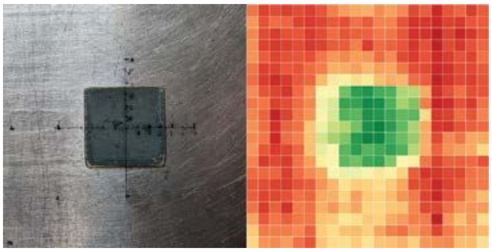

Figure 2: Stress mapping on induction heated part

Measurement Stabilization for Challenging Grain Structures

Even if uncommon with shot peened parts, the grain structure can be coarse—for example in weld beads and additively manufactured parts. Measuring parts under these conditions is challenging since the Debye-Scherrer ring used to determine the stress is missing information in certain areas over its circumference. With a coarse grain structure random grain orientations are missing and can't add a signal to the detector. This leads to a spotty Debye-Scherrer ring difficult to analyze.

To overcome this problem in X-ray stress analysis, oscillation methods are used to "fill the gaps" of the imperfect signal. The automatic oscillation functions of StressEasy provide various options to gather more grain information by either moving or tilting the sensor unit and thus stabilizing the measurement results.

Solution to Complex Stress States

The μ-X360s is determining residual stress by a two dimensional detector as discussed above, but is sensitive not only to the stress in measurement direction σx but also to the out-of-plane shear stress τxz. If τxz is not equal to zero multiple measurements from different measurement, directions are required. This can be easily achieved by rotating the sample or the sensor around the sample surface normal ($\phi 0$).

To determine stress under out-of-plane shear stress conditions, it is sufficient to rotate by 180° and then calculate the mean value of both measurements. If the complete stress matrix (stress tensor) is needed there are several options to perform this measurement. Assuming a stress-free condition in sample normal direction (σz), rotating the sample around $\phi 0$ in 90° steps the residual stress can be calculated from the gathered data.

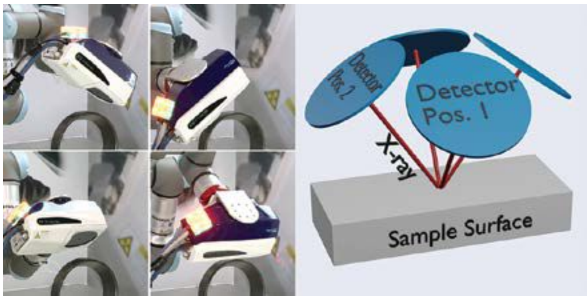

Figure 3: Stress matrix setup

Another option is the tilting of the sensor in four directions to collect the data needed for a stress matrix. Figure 3 shows the principal setup of the four measurements required. Both options can be easily automatized by the use of a six axis robot controlled by StressEasy.

Outlook

One of the future challenges in shot peening process development and control is not only the manufacturer's ability to evaluate his manufacturing processes, but also to understand the influence of different manufacturing parameters on the shot peening and result, resp. the residual stress achieved. Automated stress measurements are not only suitable to check parts in a production line, but also very useful if implemented in an internal research and development project to gain the best possible part performance and lifetime.

In order to achieve this goal in an efficient way it is helpful to move stress determination out of labs remote from production and to avoid major delays between production and quality control. The combination of a fast and easy-to-use X-ray stress analyzer with a flexible and user-friendly software solution like StressEasy is one major step on this way. In contrast to parts with demanding complex material conditions, properly shot-peened surfaces have the advantage to usually provide uniform and isotropic stress states which allow for simplified, accelerated and automatized measurements. Efficiency will further be increased when such standardized measurement tasks are performed under the supervision of material experts but carried out by well-trained operators.

For a StressEasy demo video, visit https://vimeo.com/559910333.


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The New PeenSolver Pro

THE PEENING WORLD needs curve solver programs to make determining intensity easier. Many people use Dr. Kirk's Saturation Curve Solver (SCS) Templates. The newly released Version 10 of Kirk's Solver added some great features but it didn't eliminate the need for Microsoft Excel. Since some people don't have Excel, or only have access to a mobile device, Electronics Inc. (EI) introduced the free-to-use webapp (PeenSolver.com) in 2017. The webapp is great for quickly determining intensity but doesn't have a lot of features and requires access to the internet. Enter the PeenSolver Pro (PSP) Windows 10 curve solver program. Using the powerful MATLAB® engine, it's a full-featured standalone curve solver program.

The experience of seeing many different process setups helped our team develop new exclusive features for the PeenSolver Pro. Process quality can be checked by calculating the percentage between actual arc height measurements and curve values. You can also select which equation the program uses to generate the curve, or let the program decide. Here's a full list of PeenSolver Pro's features.

Conventional Curve Solving

- Provides process intensity and saturation time per SAE J443
- Compliant to SAE J2597 for computer-generated saturation curves
- Selectable 2 or 3 exponent calculations – Exclusive PSP Feature

  PSP will automatically choose between the 2 or 3 exponent equations to generate the curve depending on the number of data points, or the user can select which one to use.
- Timed or feed-rate test strip exposure

  Test strip exposure time can be in seconds, minutes, passes, strokes, or feed rate. Feed rates are becoming more common with robotic motion control in shot peening cabinets.
- Pre-bow compensation

  Test strip pre-bow may be subtracted for more accuracy.

Type-2 Curve Detection

PSP will notify the user if a Type-2 curve is detected and provide the correct intensity value per SAE J443.

Error Checking

- Invalid curve detection

  The user will be notified if the longest peening time input is shorter than the solved 2T value, thus being an invalid curve/solution.
- Process quality detection – Exclusive PSP Feature

  PSP will compare each data point's arc height to the generated curve's arc height. The user is warned if percentage of error exceeds a configurable limit.

Intensity Verification

- Target arc height support

  The user can input a verification exposure time other than the solved saturation time. The PSP will provide the target arc height for the user's time.
- Stored with process file

  Process verification arc height values are logged in a file that can be re-loaded into the program.

Superimposed Curves for Multiple Test Strip Locations

Multiple saturation curves can be displayed with individual verification arc heights based on a single exposure time.

Process Parameter Documentation – Exclusive PSP Feature

Each part process can have a stored file that may be re-opened when the part is run again. Verification values are logged in a continually updated file. The logged data can be cleared if parameters are changed then the file saved as a new process.

- Part name
- Part number
- Machine number
- Solved intensity and saturation time (multiple locations)
- Air pressure or wheel speed
- Nozzle distance
- Impingement angle
- Nozzle details

Rotary Flap Peening Arc Height Conversion

The PSP supports magnetic arc height adjustment.

- SAE 2590(3M), Boeing or Airbus conversion support

Additional Features

- Windows OS Based

  Designed and tested with Windows 10
- Testing Verification integrated into the same screen as intensity calculations, keeping curving solving and testing verification on one print out
- Graphs can be zoomed in and out and rescaled
- Ability to individually chose which graphs are displayed
- Vertical orientation
- File location on printout

PeenSolver Pro is currently undergoing beta testing and is expected to have been released by the time you read this. Visit www.electronics-inc.com for more information. Screenshot on page 22.

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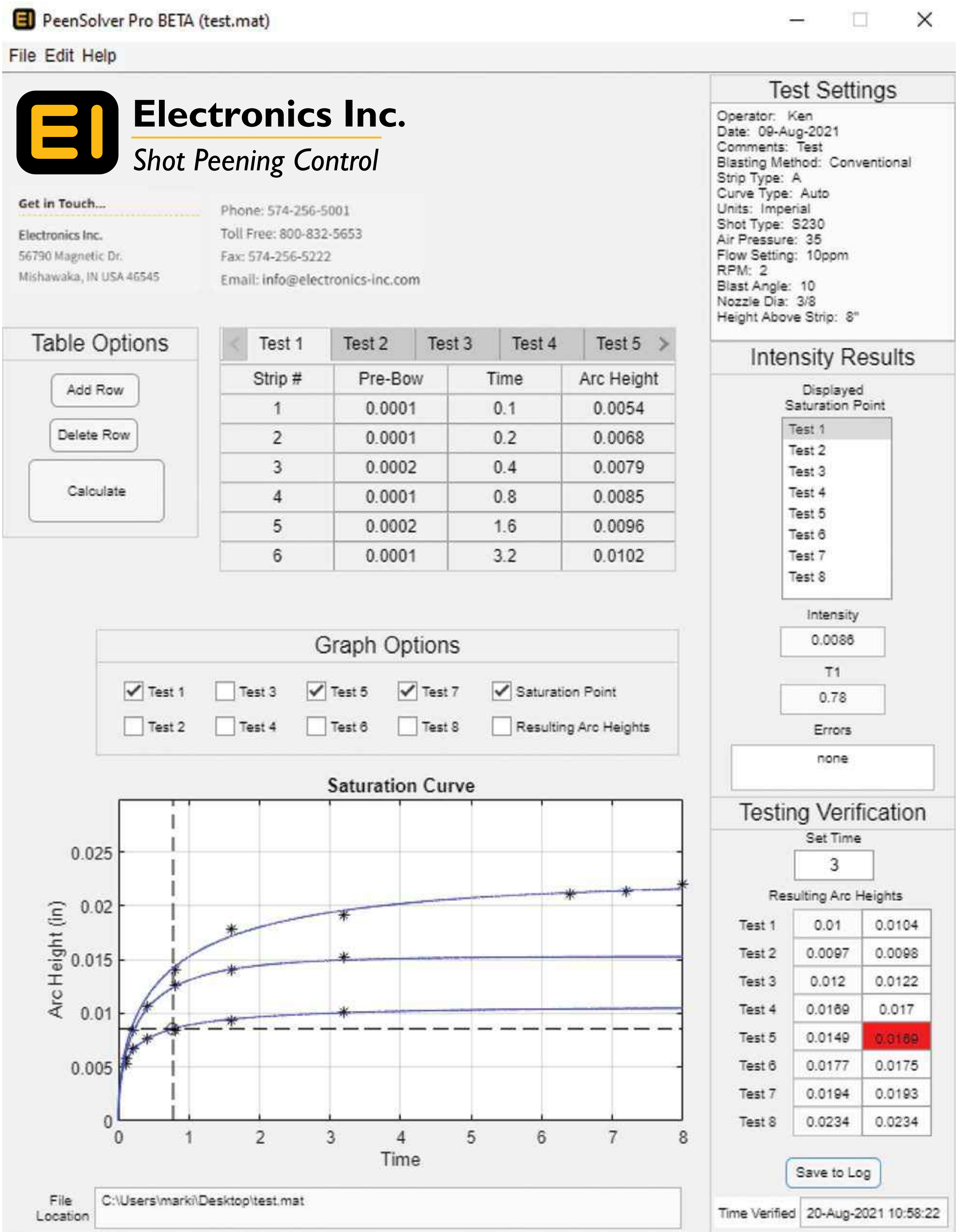
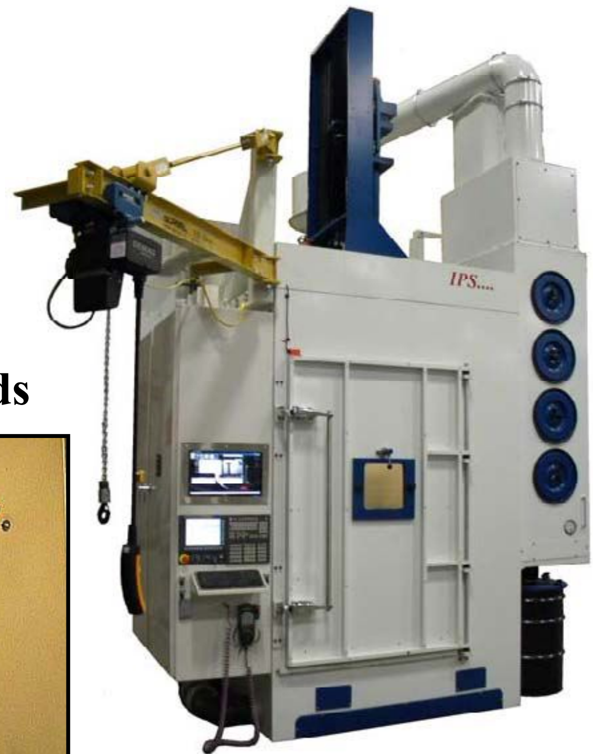
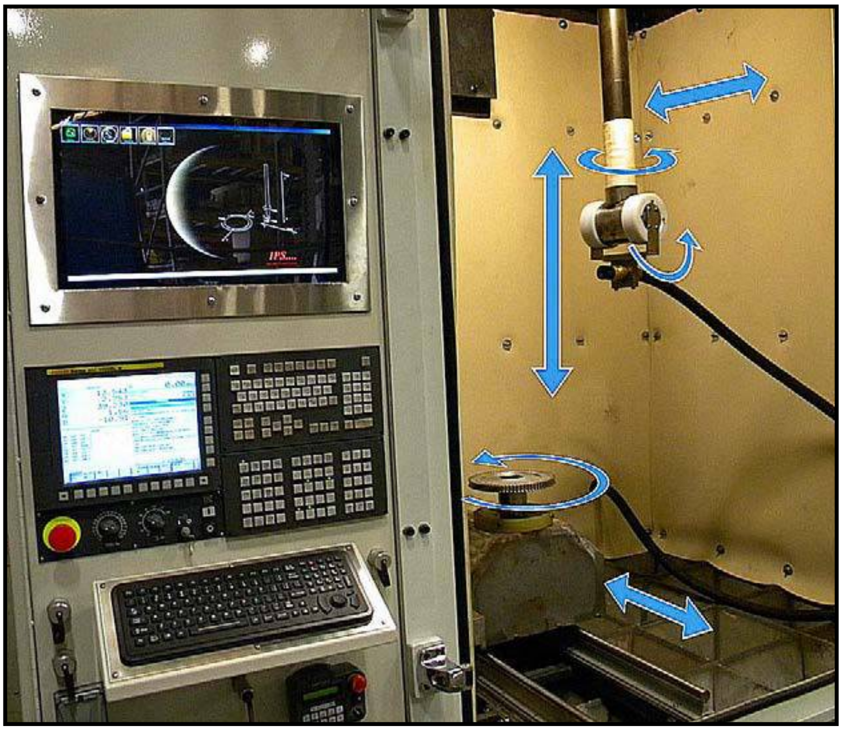


The new PeenSolver Pro is packed with features.

Innovative Peening Systems



High Performance for High Standards



CNC motion allows the nozzle to follow the contour of the part. This motion provides consistent intensities and coverages to occur with optimal speed and precision.

IPS....

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ACADEMIC STUDY

Dr. David Kirk | Coventry University

Back to Basics
Shot Peening Calculations

INTRODUCTION

The ability to quantify its variables has allowed shot peening to evolve into a smart technological process. Calculations are now an unavoidable part of shot peening. Every calculation has two components. The first is an equation and the second is data to substitute into the equation. As a trivial example, consider calculating payment for work done based on a fixed hourly rate. The equation is simply payment equals hourly rate multiplied by the time worked. At $30 per hour, working for 10 hours would earn a payment of $300. This simple example also highlights a very important feature of calculations. The units must balance! Every calculation involves a secondary equation. For this example hourly rate is $30 divided by one hour so multiplying by hours cancels out the hour unit to leave, correctly, payment as only in dollars.

This article collects together many of the large number of equations used in previous Shot Peener articles. The aim being to have them all available in one place. Some of the equations are simple, but some are complicated and were developed by the author. The properties of shot before it strikes a component are dealt with in Part 1 and the effects after striking a component are dealt with in Part 2.

PART 1

SHOT DIMENSIONS

The basic shot dimension is, of course, its diameter, **D**, as described in standard specifications. This allows us to calculate other dimensions. Hence:

$$\textbf{Particle surface area} = \pi D^2 \qquad (1)$$

$$\textbf{Particle volume} = \pi D^3/6 \qquad (2)$$

Particle mass is volume multiplied by density, **ρ**, where density is mass (in kg) per cubic metre, so:

$$\textbf{Particle mass} = \rho\pi D^3/6 \qquad (3)$$

The number of particles per kilogram is 1 kilogram divided by the mass of each particle in kg—note unit cancellation. This yields:

$$\textbf{Particles per kilogram} = 6/\rho\pi D^3 \qquad (4)$$

To illustrate these four basic dimensions, assume that a particular steel particle has a diameter, D, of 1 mm.

Rounding off π to have a value of 3, (1) tells us that this particle's area is 3 mm^2 and (2) tells us that its volume is 0.5 mm^3.

We have to be careful with the units for equation (4). The density of steel is about 7800 kgm^{-3}. 1 mm is equal to 10^{-3} m. Substituting into equation (4) gives, for 1 mm diameter steel particles (about S390): particles per kilogram = $2/7800*10^{-9}$. Using a calculator gives 256,400. Smaller shot, e.g., S110, has more than eleven million particles per kilogram! Knowing the flow rate in kg per minute, particles per kg, and shot stream diameter allows us to estimate the rate of indenting.

SHOT DIMENSION VARIABILITY

Batches of a given grade of shot exhibit a range of diameters. This variability needs to be quantified if we are to keep control of shot quality. Nominal shot sizes are fixed quantities whereas actual samples contain a range of sizes. Cut wire shot has a much smaller range of diameters than has cast shot. The range depends on production variability and associated screening procedures. Batches of shot exhibit variability that approximates to what is called a "Normal Distribution". A typical normal distribution curve is shown as fig.1. The sharper the curve the smaller is the variability. One quantitative measure of sharpness is the curve's width at half of its height (WHH). In order to get a reasonable curve for a sample of shot, we need a very large number of measurements. This is only practicable if we use a technique such as image analysis on a monolayer of shot particles. Diameter estimates are then grouped into "bins"—each bin containing a range of shot diameters. Computer analysis tools for these bin distributions are readily available, e.g., in Microsoft's Excel.

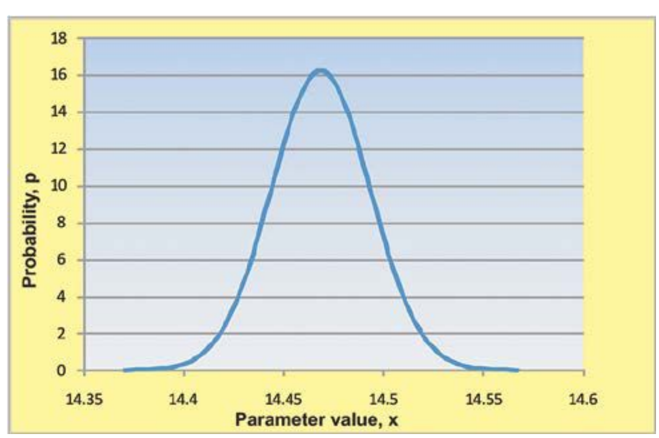

Fig.1. Normal Distribution curve.

Normal distribution curves are particularly relevant to cut wire shot variability. Wire of a fixed diameter is cut up to form cylinders that are then turned into near-spherical shapes using a process called "conditioning". Well-controlled conditioning leads to a narrower curve than does poorly controlled conditioning.

SHOT VELOCITY

The velocity of shot particles is of prime importance for shot peeners. It is the one factor that we can vary directly. Other factors, such as nozzle length, shot and shot feed mechanism tend to be fixed. Because of its prime importance, equations have been developed that show how velocity can be controlled. Different equations apply to air-blast and wheel-blast techniques.

1 - AIR-BLAST SHOT VELOCITY

For a given air-blast peening system, the major velocity control parameter is air pressure. The effectiveness of air-pressure changes depends, to some extent, on the shot feed system being employed—suction, gravity or direct. Compressed air provides the propulsion mechanism that accelerates the shot particles. Compression increases the density of the air. This is illustrated by fig.2. The effect of increasing air pressure can be visualised by the following analogy. Consider walking along into a headwind (density 1 kgm^{-3}) of 10 km/hour. No problem. Now imagine trying to walk into a wall of water (density 1000 kgm^{-3}) moving at 10 km/hour. One would be swept off one's feet. With one's back turned, the propulsive force increases with increasing density.

Air-blast shot velocity is so important that a whole article was devoted to the subject (TSP, Winter, 2007). An equation was presented that allowed us to predict the effects of variables such as shot size and density, imposed air pressure and nozzle length. It is important to remember that applied air pressure at the nozzle should be used rather than that at the air compressor. Pressure drops along the hose because of factors such as hose length, diameter and condition. The easiest way to use the predictive equation is to construct an Excel template, as given in Table 1. Required shot velocity, **v**, in C11, is calculated using the following Excel format formula:

=C9*((1.5*C3*C5*C4*C8)/(π*C6*C7))^0.5/(1+((1.5*C3*C5*C4*C8)/(π*C6*C7))^0.5) **(5)**

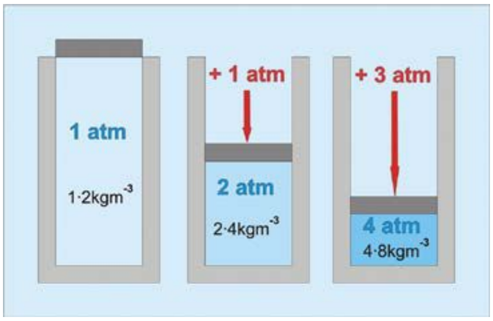

Fig.2. Effect of applied pressure on air density.

Table 1 shows an example of employing equation (5) using Excel. Note that the air velocity is fixed at 200 ms^{-1} for all practical shot peening air pressures. That is because what is called "choked flow" occurs—fixing the air velocity to a maximum value.

Table 1. Specimen calculation using equation (5)

1	B	C	D
2	**Parameter**	**Value**	**Units**
3	Cd	0.5	
4	Air density	1.2	kgm^{-3}
5	Air pressure	9	atm
6	Shot density	7860	kgm^{-3}
7	Shot diameter	0.25	mm
8	Length	50	mm
9	Air velocity	200	$m.s^{-1}$
10			
11	**Shot velocity**	**62.4**	**$m.s^{-1}$**

Fig.3 features the most important factor in air-blast shot peening control. Practical applied air pressures are always at least 2 atmospheres. That means that the average nozzle air velocity is constant at some 200 metres per second. Therefore the only thing being influenced is the density of the air in the nozzle. If both nozzle air velocity and air density varied at the same time we would have to juggle with the duality.

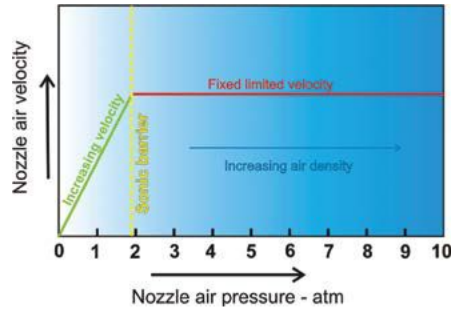

Fig.3. Effect of applied air pressure on nozzle air velocity.

Excel can also be employed to produce graphs of predicted shot velocity such as those in fig.4.

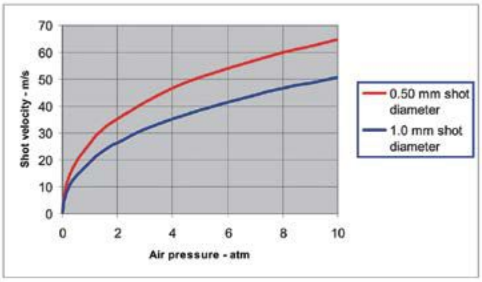

Fig.4. Predicted variation of shot velocity with size and applied air pressure.

As accelerated shot emerges from the nozzle it is always travelling much slower than the air around it. This means that the shot continues to accelerate until it reaches a maximum at about 200 mm from the nozzle. Thereafter the shot is travelling faster than the surrounding air so it slows down. It is therefore the most efficient use of energy to employ the shot stream at its "sweet distance" from a component's surface.

2 - WHEEL-BLAST SHOT VELOCITY

A good understanding of wheel-blast velocity is best based on a knowledge of how the velocity is generated. Fig.5 is a schematic representation of the principal components of a traditional wheel.

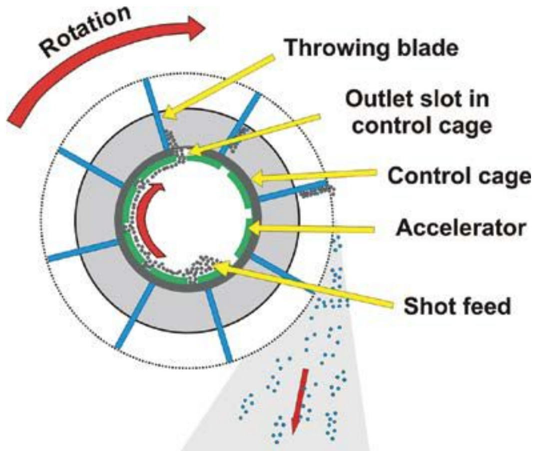

Fig.5. Wheel-blast components.

The late Jack Plaster likened a wheel-blast machine to a giant pepper mill. Expanding that analogy think of peppercorns (shot particles) being feed by gravity into a series of slots in an Accelerator. The Accelerator is rotating at high speed so imposes centrifugal force pressing the shot against a static Control Cage, rubbing them along until they can escape through the Outlet Slot and onto a Throwing Blade.

As a shot particle is thrown off the end of a blade it is given two velocity components: **1. Tangential Velocity Component, V_T** and **2. Radial Velocity Component, V_R**. The two components constitute vectors at right angles to one another so that the combined velocity of the shot particle, **V_S**, is readily obtained using Pythagoras's theorem. Pythagoras's theorem is the one that states: "The square of the hypotenuse is equal to the sum of the squares of the two right-angled sides." So if the two sides had lengths of 3 and 4, the square of the hypotenuse would equal 9 + 16 = 25, yielding that the hypotenuse's length is 5. Fig.6 illustrates the principle involved when applied to wheel-blast shot velocity.

1. Tangential Velocity Component, V_T
In one 360° revolution the tip of the blade will have travelled a distance **π**.2R, the circumference of the circle. We multiply that circumference by **N**, the number of revolutions per

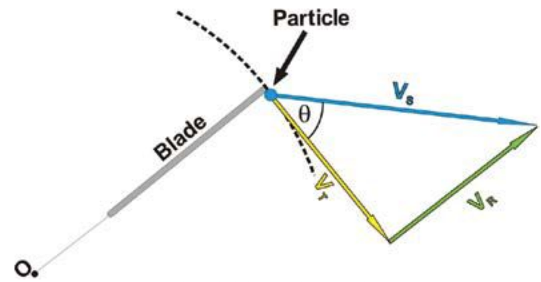

Fig.6. Wheel-blast shot velocity, V_S, based on its two components.

second (r.p.s.) to give the required value of **V_T** as:

$$\mathbf{V_T = 2\pi.R.N} \qquad \mathbf{(6)}$$

As an example, if circumference of blade tip rotation equals 1 m and N = 50 r.p.s., then V_T = 50 m.s^{-1}.

2. Radial Velocity Component, V_R
Centrifugal force pushes cohorts of shot off the end of the rotating blades. The velocity, V_R, imposed on each shot particle is given by:

$$\mathbf{V_R = 2\pi N(2.R.L\text{-}L^2)^{0.5}} \qquad (7)$$

Where **L** is the length of the throwing blade (see fig.5).

Combined Wheel-blast Shot Velocity, V_S
The combined wheel-blast shot velocity is obtained by taking the square root of **V_T^2 + V_R^2**. Hence: **V_S**

$\mathbf{V_S^2 = (2\pi.R.N)^2 + (2\pi N)^2.(2.R.L\text{-}L^2)}$ which simplifies to give

$\mathbf{V_S^2 = (2\pi N)^2(R^2{+}2.R.L\text{ -}L^2)}$ so that

$$\mathbf{V_S = (2\pi N)(R^2{+}2.R.L\text{ -}L^2)^{0.5}} \qquad \mathbf{(8)}$$

For a given blast wheel, **R** and **L** are fixed, known quantities leaving just **N** as our velocity control parameter. For example assume that **R** and **L** are known to be 0.25 m and 0.15 m respectively. Equation (8) then simplifies to: **V_S = 2.13.N**. At 40 r.p.s., that wheel would accelerate shot to 85.2 metres per second.

The angle, θ, at which shot is thrown of the blade's tip is found by knowing that:

$$\mathbf{\tan\theta = V_R/V_T} \qquad \mathbf{(9)}$$

If **V_R = V_T** then **tan θ =1** so that **θ = 45°**.

PART 2

This part considers quantifiable effects of shot striking a component. These are Dent Size, Coverage and Peening Intensity.

DENT SIZE

Shot peening produces dents in the surface of components. The profusion of dents is the most obvious indication that peening has been carried out. Important features are the average dent size and the extent of denting—coverage. Dent

size is directly related to peening intensity and therefore the depth of the work-hardened, compressively stressed surface layer.

An empirical equation has been derived that connects the main variables that affect dent size:

$$\mathbf{d = 1.278.D.P^{0.25}.\rho^{0.25}.v^{0.5}/ B^{0.25}} \qquad \mathbf{(10)}$$

where **d**= indent diameter, **D** = indenting sphere diameter, **P** = proportion of kinetic energy lost on impact, **ρ** = density of indenting sphere, **v** = sphere velocity and **B** = Brinell hardness of component.

In words, equation (10) implies that dent diameter is directly proportional to shot diameter, proportional to the square root of the shot velocity but only proportional to the fourth root of the proportion of kinetic energy absorbed on impact and shot density. Dent diameter reduces with the fourth power of the component's Brinell hardness. Hence, for example, doubling dent diameter requires a fourfold increase of shot velocity and an eightfold increase in shot density.

COVERAGE

(1) Coverage versus Peening Time

The equation for coverage versus peening time is:

$$\mathbf{C = 100(1 - exp((-\pi D^2/4).R.t))} \qquad \mathbf{(11)}$$

Where **C** is the percentage coverage, **D** is the average diameter of each dent, **R** is the rate of impacting (number of dents imparted per unit area of surface per unit of peening time) and **t** is the peening time.

(2) Coverage Rate

Coverage rate is very important for shot peeners because it determines how long a component needs to be peened in order to impart the customer's specified amount of coverage. The coverage rate, **K**, is given by:

$$\mathbf{K =(\pi D^2/4). R} \qquad \mathbf{(12)}$$

For which the π**D²/4** term is the projected area of each dent. If we can assign a value to **K**, we can predict the coverage that will be achieved in any given peening time, **t**. Equation **(11)** simplifies to:

$$\mathbf{C = 100(1 - exp(-K.t))} \qquad \mathbf{(13)}$$

The coverage rate, **K**, is simply the product of the dents' average area multiplied by the rate at which these dents are being produced.

MULTIPLE DENTING

As coverage increases so does multiple denting of the component. At high levels of coverage there is a danger that parts of the component's surface will have its ductility exhausted—leading to crack formation. This topic was dealt with in the previous article in this series. The theoretical basis of multiple denting precision was presented at ICSP6.

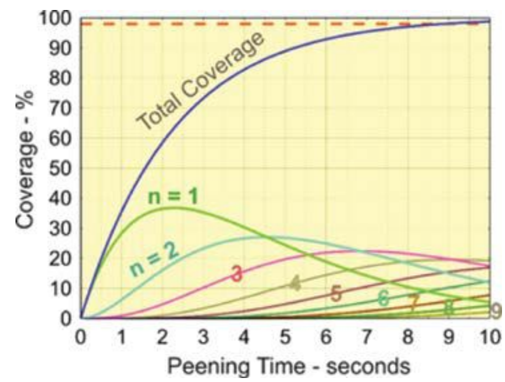

Fig.7. Contribution to total coverage of single and multiple denting.

Fig.7 allows the degree of multiple denting to be calculated graphically. For example, at 89% total coverage doubly-dented areas contribute 27% to the total, single-dented areas 25%, triple denting 20%, quadruple denting 11%, leaving 6% having greater than quadruple denting.

PEENING INTENSITY

Calculation of peening intensity is familiar to all shot peeners. The ready availability of computer-based programs allows unambiguous calculations to be made. There are, however, certain guiding principles that need to be taken on board. These concern both data collection and data analysis.

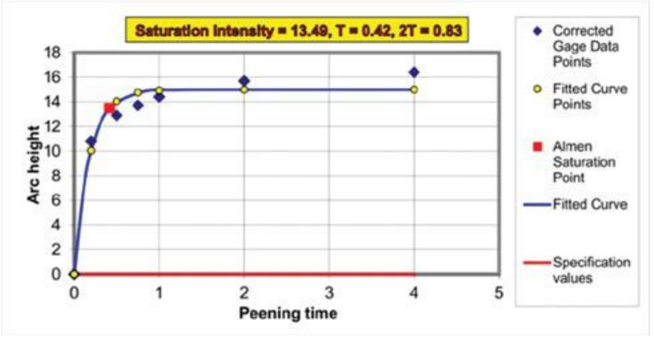

Fig.8. Peening intensity calculation using a two-parameter equation.

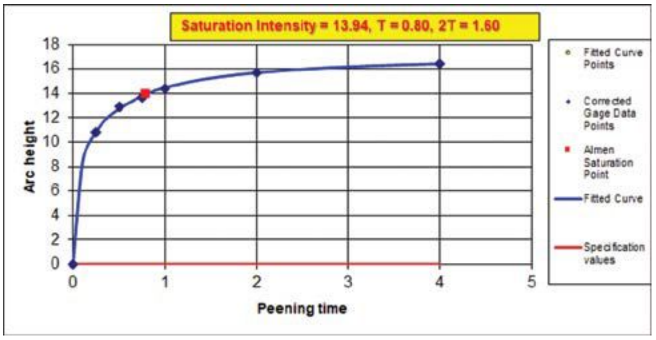

Fig.9. Peening intensity calculation using a three-parameter equation.

The Solver Suite equations used for figs. 8 and 9 were, respectively:

$$h = a^*(1 - EXP(-b^*t)) \tag{14}$$
$$h = a^*(1 - EXP(-b^*t^C)) \tag{15}$$

where **a**, **b** and **c** are parameters.

Additional calculations are present when using Solver suite programs. Fig.10 is an illustrative example. **SUM** indicates the goodness of fit— smaller values equate to better fit. The **Residuals** column shows how the data deviates from the selected equation and by how much.

SATURATION CURVE SOLVER, PROGRAM SCS1
EXP2P STANDARD vers.09

Strip No.	Time	Arc Height	Pre-bow	Corrected Height	Calc. Y	Residuals	Res. Sqrd	Parameters	Values
								a	8.65
	0	0	0	0	0	0	0	b	0.53
1	1	4	0.2	3.8	3.53419	-0.265813	0.070657	Start value for a=	9
2	2	6.3	0.5	5.8	5.62433	-0.175672	0.030861		
3	4	7.5	0.2	7.3	7.5915	0.2915015	0.084973	Sat. Intensity =	7.35
4	6	8	0.1	7.9	8.27954	0.3795433	0.144053	T =	3.61
5	8	8.3	0.1	8.2	8.52019	0.320194	0.102524		
6	13	8.8	0.3	8.5	8.64027	0.1402742	0.019677		
7	18	8.9	0.1	8.8	8.64896	-0.151038	0.022813		
8	22	9.2	0.2	9	8.64956	-0.350444	0.122811	If WARNING or ERROR appear	
9	26	9.4	0.4	9	8.64963	-0.350371	0.12276	above, read note below graph.	
			Lower Spec.=			SUM =	0.72113	RMS-R=	0.2831
			Upper Spec.=						

STEP 1 Enter data values within blue frame after deleting previous values.
Arc heights to be in thousandths of an inch or micrometers.
STEP 2 Enter largest CORRECTED arc height as a start value for "a" in J4 (required value appears in J6).
STEP 3 Select box containing Sum of Residuals squared, H16, click Data (on Excel toolbar),
select SOLVER, click on SOLVE, press OK.
STEP 4 Enter required Lower and Upper specification values in
red frame above - if you wish to, otherwise delete previous values.

Fig.10. Example of a Solver program's calculations. A four-parameter equation is available but its use is only recommended for research purposes.

DISCUSSION

An attempt has been made to cover the main types of calculation that are now encountered by shot peeners. The focus has been to base calculations on a combination of data and selection of an appropriate equation. Normally, we can predict the type of equation that will be appropriate. Having fitted the equation to the data we can then examine its significance. If the equation is not a good fit to the data, we have to consider why and consider alternative equations.

Previous calculations should always be stored for comparison purposes. For example, we may find that there is a general drift downwards in calculated peening intensity, even if precisely the same peening parameters have been applied. This can then be related to possible causes such as reduction of shot size.

Finally, it is worth repeating the opening sentence: "The ability to quantify its variables has allowed shot peening to evolve into a smart technological process."


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Shot Peening's Vital Role in the Aerospace Industry

BEFORE THE COVID-19 EPIDEMIC, airplanes transported 4.5 billion passengers and 57.7 million tons of freight every year. To keep them moving safely and fast, airplanes are equipped with turbojet engines that need to withstand extremely high loads.

One of the processes aimed at keeping the engine running safely at such loads is the shot peening process which improves mechanical properties by inducing residual compressive stress and prevents fractures on practically every component of a turbojet engine. Taking in consideration that the most powerful turbojet engine produces up to 115.000 pounds of thrust, this process is crucial for every component.

Originating in the heart of Europe, FerroECOBlast® Europe develops solutions and manufactures machines for surface treatment processes, shot peening included. With expertise in this area since 1964, FerroECOBlast® Europe has made a name for itself among aircraft manufacturers and repair shops all around the world. The company's FAA-approved Shot Peening experts provide consultation, testing and solutions for any workshop—whether specializing in engines, landing gear, structural components, or composites and increasingly for the additive manufacturing industry. Additive manufacturing has become very popular in aviation in recent years. The company's presence in Europe, the Middle East, Asia-Pacific, the United States, New Zealand and Australia goes to show that distance is no obstacle for their clients when it comes to choosing a reliable solution and quality support.

Also, during the COVID-19 epidemic, FerroECOBlast® Europe has successfully completed all its pending projects with the help of its local partners and through virtual support. As Charles Darwin put it: "It is not the strongest of the species that survives, nor the most intelligent. It is the one that is the most adaptable to change." And FerroECOBlast® Europe did exactly that—it adapted to changes to support its partners.

The ARSP 1000 ECO DUAL was developed for the application of the shot peening process on turbojet engines and gas turbine components, with a particularly strong focus on process repeatability and traceability. Manufacturers of jet engines know full well how important it is to apply the shot peening process on components like discs, blisks, blades, shafts—essentially almost every single component of a turbojet engine. Therefore, machines need to be designed with the utmost precision and attention to every little detail in order for them to provide repeatable and traceable results.

Mr. Aljaž Molek, FerroECOBlast's Certified shot peening expert

Working area of ASRP 1000 ECO DUAL

FerroECOBlast® Europe carries out five important steps to make its solution match the customer's needs and expectations as closely as possible. Robotic, automatic, or manual testing is carried out at the company's on-site testing facilities, during which process parameters are identified by R&D and FAA-approved Shot Peening personnel. The results obtained are then submitted to the customer for confirmation. Once this stage is finished, the second stage is engaged—technical design. The technical design is developed in cooperation with the customer in order to meet their expectations either in terms of the machine's capabilities, layout, complexity, component selection, or any other. This is also submitted to the customer for confirmation. The technical evaluation and final confirmation are followed by production and assembly. The manufacturing and assembly of machinery is carried out at the company's headquarters, and the machinery is tested together with the customer before being shipped out.

Next up is step number 4: installation and training. FerroECOBlast® Europe experts come to the installation site together with their local support team to install the machine, perform the start-up and repeat the testing at the customer's location. Once this is completed, training is provided to operators, technicians and maintenance staff so as to ensure smooth operation of the machine and prevent any downtime. And finally, the last, fifth step, aftersales activities. FerroECOblast® Europe and their local support are dedicated to providing quality aftersales support, which is oftentimes even more important than the solution itself. Consultation, support, and fast response times are their principal values that help keep their customers satisfied.


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In this particular case, the ARSP 1000 ECO DUAL was designed to use two robots and a synchronized turntable, which allows 13 different axis manipulations in one single machine. Each robot is equipped with two peening nozzles, which can be adjusted to allow the use of only one nozzle for smaller parts depending on the job or the part currently being processed by the machine.

The most important things in the shot peening process are process repeatability and traceability, so the recycling of media needs to be done with precision. First, the peening media is extracted and transported from the bottom of the hopper to a dust extraction unit called "air-wash", where dust is removed from the shot peening media. The peening media is then fed into a vibration sorting machine where it gets sifted by size, making sure that only correctly sized media can be used back in the system. But before being used, the media needs to pass through a spiral sorting machine to eliminate all broken particles that are not round anymore. This way, shots always have the same size and shape inside the operating mix.

Once the media is properly recycled and ready to use, the work process needs to be precisely and carefully controlled. In a properly conducted shot peening process, media flow, air pressure, nozzle angle, clearance between the nozzle and the part, turntable movement and ventilation need to be controlled with ultimate precision in order to ensure process repeatability. Electromagnetic valves are therefore used for every single nozzle so as to keep the tolerance levels below ±3% and the air pressure within the deviation range of ±1%. This requires the use of special valves and program in the backend that control every component. To check the quality of the process, intensity tests are conducted on Almen strips. Intensity tests show the operator whether the given parameters are in range and free from any deviations.

Double-chamber pressure peening generator of ARSP 1000 ECO DUAL

This is done by a PLC operated via the FerroSmartPanel interface. Good machines deserve good interfaces which is why FerroECOBlast® Europe developed its own user-friendly interface to allow machine control and visual observation of machine parameters and the whole process. In the designing of such an interface, a lot of focus was placed on delivering the best user experience for operators. In an industry as demanding as aviation, all processes need to be traced back so the user-friendly controller allows the logging of full process and machine history which can be exported onto a USB key or SD card for every individual part or batch. FerroECOBlast® Europe offers a system developed in-house that controls, tracks, and stores all the relevant data, making sure the design and production processes are always traceable. Furthermore, the touchscreen panel also allows the creation of peening saturation curves for the operator to print out and enclose with the shot peening report. The machine interface includes connectivity with the internal process control protocol, allowing the machines' parameters and status to be displayed in the engineers' offices for the purpose of tracking every step or printing out the entire process for each batch in order to monitor the trace of the process.

Universal Almen strip holder for intensity check during Factory Acceptance Testing of the ARSP 1000 ECO DUAL machine

User-friendly FerroSmartPanel

FerroECOBlast® Europe machines boast the following key features: **Repeatability** - to always carry out the selected shot peening process with the same parameters and level of precision and to ensure identical results on every single part, eliminating any possibility of mistakes. **Flexibility** - to be able to quickly adjust parameters and the shot peening process to different parts in order to minimize machine downtime. **Traceability** - the second most important feature after repeatability, it allows the tracing back of the process for each individual part. And finally, **Durability** - to reduce the machine's downtime during maintenance and to extend its lifespan. As mentioned above, this process allows no margin for error. If errors begin to mount up in the aviation industry, the most important thing is to have access to the full history of the aircraft manufacturing process because this is the only way to go back and check out why something happened and be able to improve or change when necessary.

As is often heard in aviation circles, "Failures don't just happen, they are triggered by a chain of critical events," which is why traceability in such an industry is an inevitable must.


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Empire Introduces One-Piece Flow Systems

EMPIRE ABRASIVE EQUIPMENT has launched two automated blast systems—the SPF 3830 System and the SPF 2424 System—that offer the benefits of automated air blasting at an attractive price.

The SPF 3830 System

- Powers Part Rotation (3 to 30 rpm)
- Oscillates 4 Blast Guns up to 24"
- Automates Air Blasting Economically

With its roomy enclosure, adjustable blast envelope and multiple processing controls, the SPF 3830 outperforms manual air-blasting in applications requiring consistent, repeatable results. The multi-tasking SPF 3830 often processes a variety of parts within a single production facility, making it ideal for companies with short runs on many parts. Additional features include:

- **Cartridge Dust Collector** contributes to a clean work environment by capturing fines and other unwanted debris.
- Optional **Pneumatically Powered Vertical Door** speeds part loading and conserves floor space. An electric interlock switch prevents blasting with the door open.
- **Four MH-2 Suction Blast Guns** oscillate up to 24", creating a large blast envelope. A DC drive, mounted on cabinet rear, includes variable speed and adjustable stroke length.
- Optional: **1/4" Ultrawear Curtains** protect cabinet walls and door from abrasives or **1/8"-thick curtains** in black.
- **Rugged 38" Deep x 30" Wide x 65" High Cabinet**, constructed with 11 gauge steel, handles a wide range of parts.
- **900 CFM Tunable Reclaimer** reduces media loss, cuts operating costs and improves finishing results.
- Optional **Infrared Light Curtain** prevents vertical door from closing if curtain area senses an obstacle.
- **Bolt-On Access Panel** includes its own electric interlock switch.
- Optional **PLC** controls the number and length of guns oscillations. (Standard control panel mounts on the left side of the cabinet in place of the viewing window.)

The SPF 2424 System

- Powers Part Rotation (3 to 30 rpm)
- Great Buy for Simple Air-Blast Automation

Like the SPF 3830 System, the 2424 Model delivers the repeatability of automated air blasting, but in a simpler design and at a lower price without compromising on essentials such as media reclamation and dust collection. Additional features include:

- Optional **Pneumatically Powered Vertical Door** speeds part loading and conserves floor space. An electric interlock switch prevents blasting with the door open.
- **24" Deep x 24" Wide x 30" High Cabinet** constructed with rugged 14 gauge steel handles a wide range of parts.
- Optional **1/4" Ultrawear Curtains** protect cabinet walls and door from abrasives; **1/8"-thick curtains** in black also available as an option.
- **Three MH-3 Blast Guns** equipped with long-lasting boron nozzles and supplied by a one-cubic media hopper, creating a versatile blast envelope.
- Optional **Infrared Light Curtain** prevents vertical door from closing if curtain area senses an obstacle.
- 600 CFM Tunable Media Reclaimer
- SEM-2 Dust Collector with Manual Pulse Jet Cleaning
- DC Drive Part Rotation Assembly, Variable 3 to 30 rpm

Both systems can be upgraded with many factory options to meet specific production needs.

For more information on the SPF 3830 and 2424 Systems, contact Empire or your local Empire distributor, or visit www.empire-airblast.com.

Grand Opening of New Toyo Seiko North America Facility

TOYO SEIKO NORTH AMERICA celebrated the opening of their 25,200 square foot facility this July. The company has been located in South Bend, Indiana, USA for several years but due to its growth in North America, Toyo Seiko needed a larger facility. The new distribution and manufacturing center has an inventory of all Toyo Seiko shot peening media.

South Bend is at the junction of three interstate systems and four national highways. The area is served by all national motor freight carriers and is a regional hub for UPS, FedEx, and USPS. Toyo Seiko North America Inc. utilizes this strategic location to provide exceptional service in distributing the superior quality Toyo Seiko shot peening media.

Toyo Seiko North America Inc. is the direct distributing arm of Toyo Seiko Ltd Co., a manufacturer of superior quality cut wire and conditioned cut wire shot. Toyo Seiko products are specified by all major automotive and aerospace companies.

If you are a current Toyo Seiko cut shot wire consumer, we look forward to continuing to meet and exceed your expectations. If you are interested in becoming a valued customer of Toyo Seiko North America, our knowledgeable staff will explain in detail the benefits and advantages of Toyo Seiko shot peening products.

Please contact us by telephone at (574) 288-2000 or send email to sales@toyoseiko-na.com.

Joe Leatherman, CEO of Cadet Construction, and Shota Watanabe, Vice President of Toyo Seiko North America. Cadet Construction was the General Contractor on the project.

The event opened with a flag-raising ceremony for the Japan, Indiana, Toyo Seiko, and United States flags.

Coffee cups and chocolates for the Grand Opening attendees.

The lobby of the new facility.

Clemco Employee Refurbishing a Half-Century-Old ZERO Blast Cabinet

Cabinet used at a high school career center since 1969

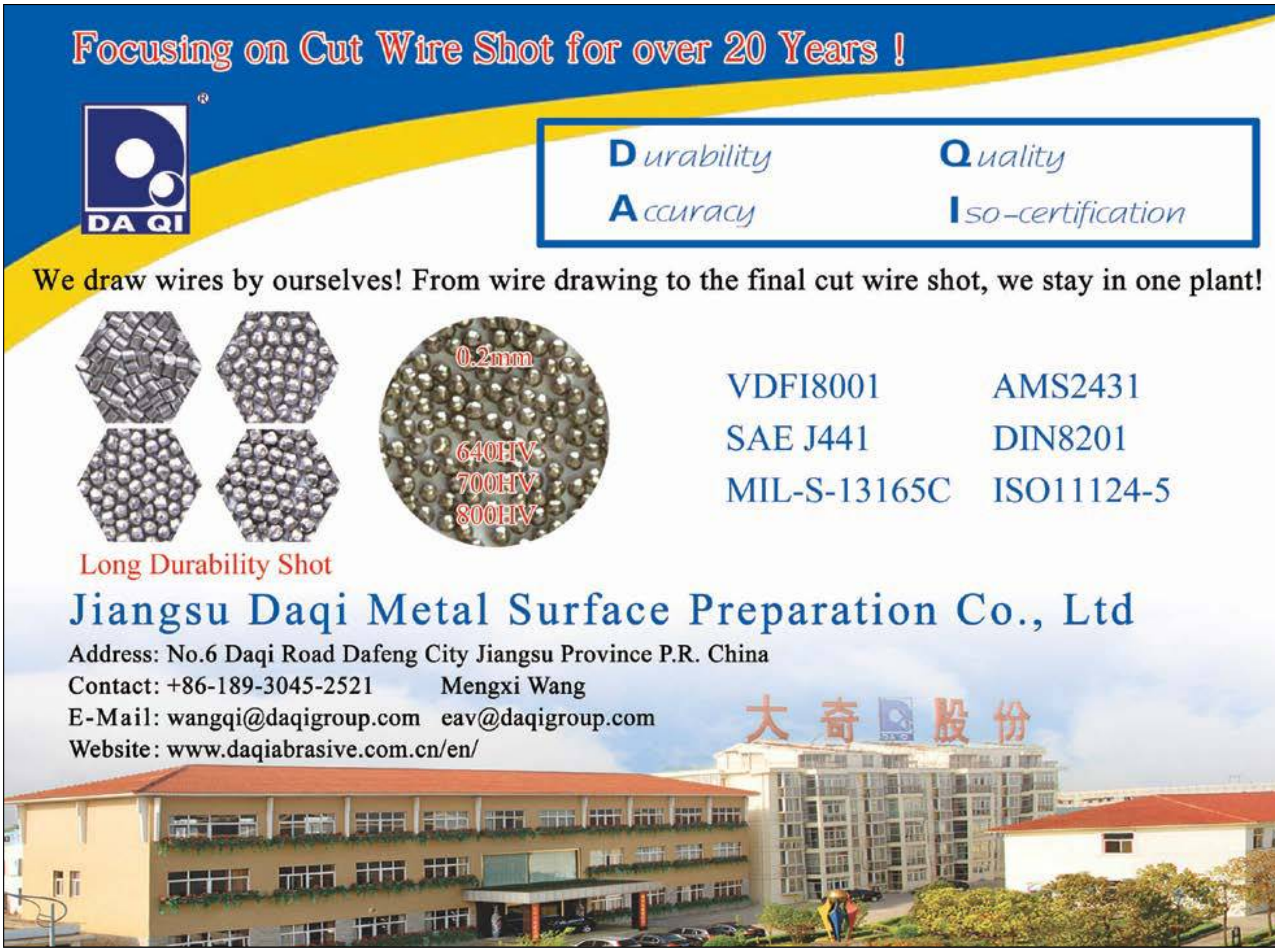
"It needs a makeover, new gloves, and a new view window," says Clemco Quality Assurance Inspector Eric Brukerhoff of his new ZERO® BNP-270 Blast Cabinet, "but then it will be ready to go."

Since 1969, students at a Missouri career center had been blasting with the cabinet as part of their coursework. The school, however, recently purchased two ZERO BNP-220s and no longer needed the 51-year-old cabinet, so Eric inquired about the school's plan for it.

"They said if I wanted it, all I had to do was haul it away," Eric shares. "I had made donations to the school of blast cabinet gloves and replacement view windows. I didn't expect anything in return, but was pleasantly surprised after they offered me the cabinet."

Eric plans on refurbishing the cabinet with his son who is a mechanic at a Ford dealership. His son works on cars in his spare time. "My son will use the cabinet to resurface and clean auto parts," Eric explains. "The cabinet is in much better shape than it looks and won't need much work—but did I mention it needs a makeover?"

Eric Brukerhoff, Clemco's Quality Assurance Inspector, will refurbish this ZERO® BNP-270 Blast Cabinet with his son.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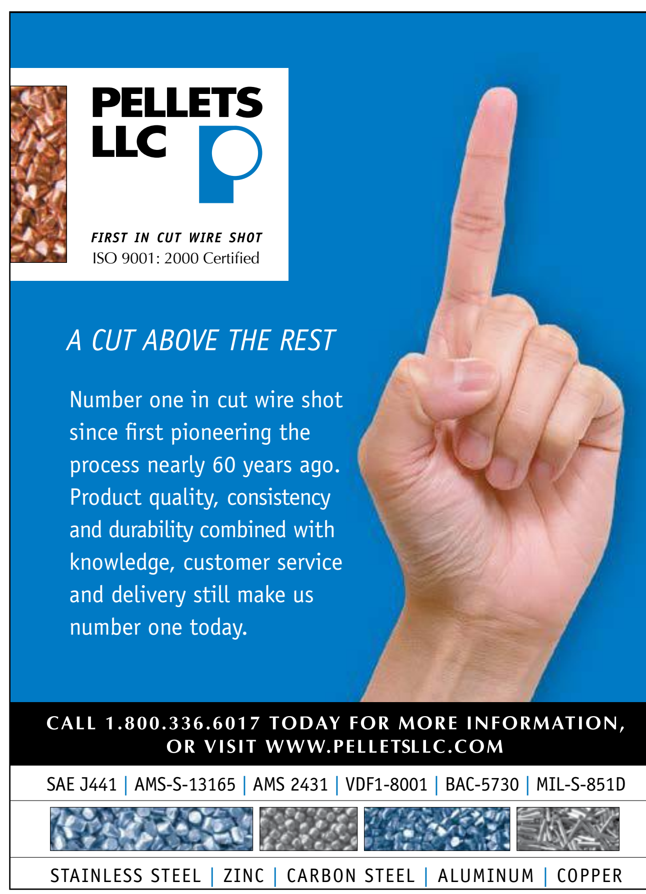
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