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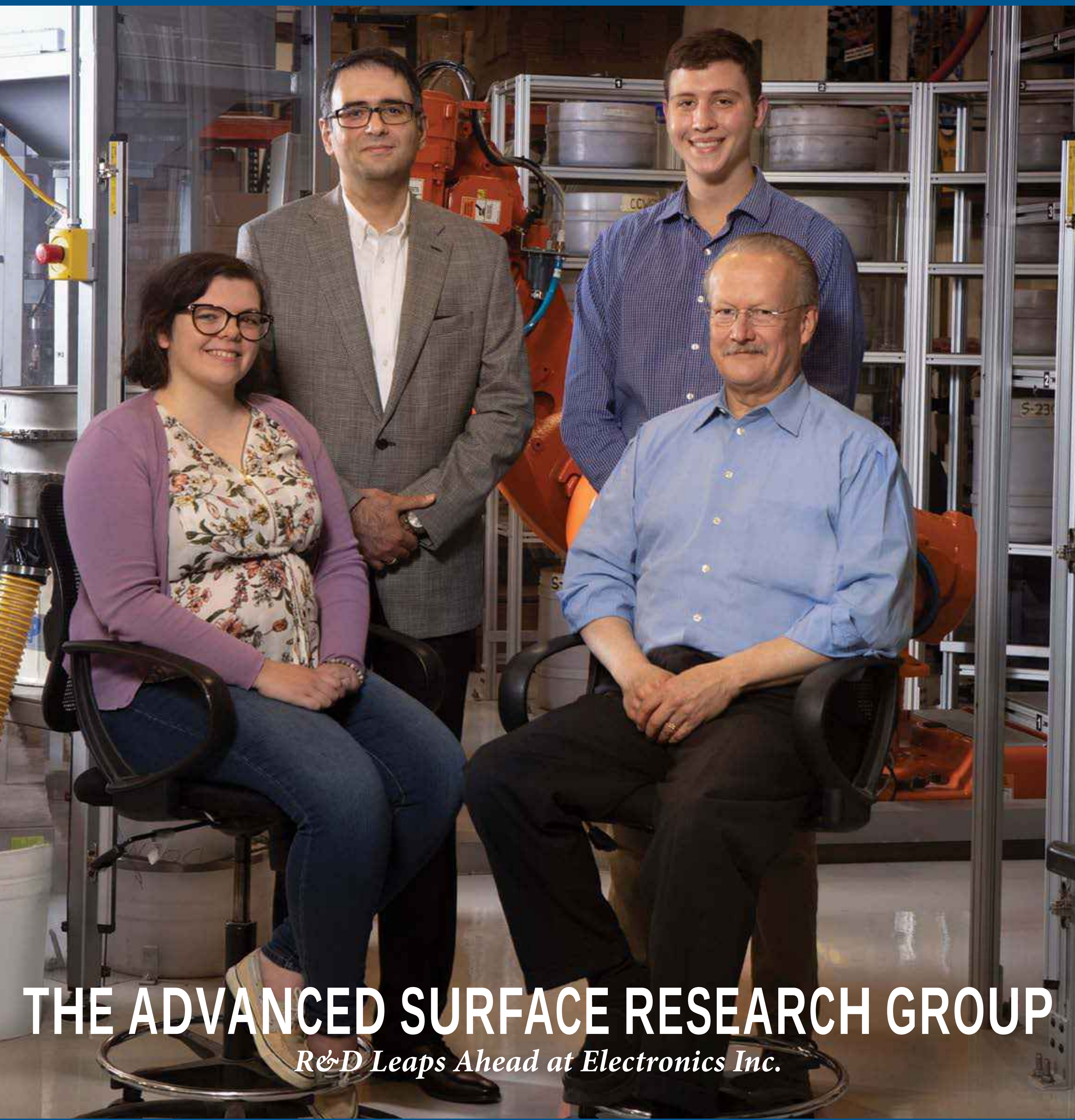
The Shot Peener

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



THE ADVANCED SURFACE RESEARCH GROUP

R&D Leaps Ahead at Electronics Inc.

PLUS: TRIBAL KNOWLEDGE ▌ BACK TO BASICS: COVERAGE ▌ PROCESS DEVELOPMENT SERVICES

Peening Innovation

COVERAGE CHECKER

COVERAGE CHECKER

COVERAGE CHECKER the device for easy and precise coverage measurement

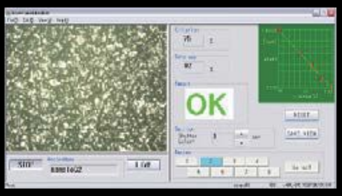
UV Light version

New arrival!

- UV light version Coverage Checker measures coverage by the fluorescent paint peeling rate, using UV light.Therefore, measurement result will not be affected by surface condition.
- UV light version Coverage Checker can measure the coverage even on oxidized surfaces and uneven peened surfaces, which was difficult to measure with normal version.

Coverage Checker (Original)

Easy USB connection to your PC



※PC is not included ※Device image

※Specifications of this device may be changed without notification.

Positron Surface Analyzer

PSA Type L-Ⅱ

PSA Type L-P

Non-Destructive Inspection

by Anti-coincidence System

US Patent : US 8,785,875 B2

Application

- Shot peening inspection (Inspection Depth : Down to 100 micron)
- Evaluation of Fatigue behavior
- Evaluation of sub-nano size defect
- Free volume on Polymer and Glass

Specification

Device size : Type L-Ⅱ W400 X L400 X H358 [mm]
Type L-P W125 X L210 X H115 [mm]

Positron source : Na-22(under 1MBq)

Option : Autosampler function (4 - 8 stage)

Distributor

Country	Company	TEL	E-MAIL
USA	Electronics Inc.	+1 574-256-5001	sales@electronics-inc.com
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THE SHOT PEENER
Sharing Information and Expanding Global Markets for Shot Peening and Blast Cleaning Industries

OPENING SHOT

Jack Champaigne | Editor | The Shot Peener

Patience is a Virtue

- 1997 EI banquet at Purdue celebrating the launch of Shot Peening Program with Dean of School of Technology, Don Gentry
- 1997 Purdue University students visit EI in Mishawaka
- 2001 Contributions from Progressive Technologies, WS Tyler, and Ervin Industries start the Purdue Shot Peening Center
- 2015 Center for Surface Engineering and Enhancement (CSEE) program established at Purdue
- 2019 Media Inspection using image analysis project launched at CSEE
- 2021 Dr. Siavash Ghanbari joins Electronics Inc. as Chief Scientist for Advanced Research

I remember how embarrassed I was in 1996 as the chairman of the International Scientific Committee for Shot Peening in San Francisco. When we reviewed the academic attendees by country, there was no one from the USA. I vowed to change that. I think you can see the long path I traveled.

Dr. Ghanbari brings a lot of talent to our team at Electronics Inc. His education background follows.

Purdue University Doctor of Philosophy PhD, Materials Engineering 2019
Southern Illinois University Edwardsville Master of Science, Mechanical Engineering 2015
Azad University, Science and Research Branch Master of Science, Materials Engineering 2010
Azad University, Science and Research Branch Bachelor of Science, Materials Engineering 2007

Purdue University (Postdoctoral Researcher)
- Design electronic control units and sensors
- Develop software and computational modeling for shot peening process control
- Analyze and characterize flowability of aluminum and copper powders in additive manufacturing process

Purdue University (Graduate Research Assistant)
- Fatigue crack initiation and propagation analysis, residual stresses, yield stress, plastic deformation measurements using nano-indentation and FEM modeling
- Developed Molecular Dynamic (MD) simulation on dislocation nucleation in highly twinned Al thin films
- Designed and developed novel experiments to measure residual stresses after severe plastic deformation using X-ray method and nano-indentation
- Developed numerical and experimental analysis to improve surface roughness and residual stress after plastic deformation
- Developed materials mesoscale simulations Crystal Plasticity Finite Element Method (CPFEM)
- Developed Finite Element Method (FEM), Discrete Element Method (DEM), and Smooth Particle Hydrodynamic (SPH) for elastoplastic deformation analysis
- Developed numerical analysis of hygroscopic swelling cellulose nanocrystal (CNC) film

One of Dr. Ghanbari's assignments at EI relates to a better understanding of intensity and coverage process control of shot peening. My patience has paid off.

THE SHOT PEENER

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Associate Editor
Kathy Levy

Publisher
Electronics Inc.

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THE ADVANCED SURFACE RESEARCH GROUP

R&D Leaps Ahead at Electronics Inc.

INNOVATION WASN'T DORMANT at Electronics Inc. (EI) during the COVID-19 pandemic. EI's Advanced Surface Research Group, comprised of Taylor Bowman, Kenneth Derucki, Siavash Ghanbari, and Erik Waelchli, have been developing new products and technologies that will benefit the shot peening industry. The following are biographies of each team member and the group's contributions to the advancement of surface treatment.

BIOGRAPHIES

Taylor Bowman

Ms. Bowman graduated from Purdue University in 2021 with a Bachelor of Science degree in Electrical Engineering. She minored in creative and technical writing. She began at EI as an engineering intern in 2017 before working at EI full-time as an electrical engineer after graduation. Ms. Bowman's focus is on advanced process control methods for shot peening machines.

Kenneth Derucki

Mr. Derucki graduated from Purdue University in 2020 with a degree in Electrical Engineering. He started at EI as an engineering intern in 2019 before starting to work full-time at EI after graduation. He is an electrical engineer at EI and his responsibilities include working as the primary engineer on a sensor project and coordinating the activities of the production and engineering departments to ensure accurate quality testing.

Siavash Ghanbari, PhD

The relationship between Dr. Ghanbari and the EI staff began when Dr. Ghanbari led research projects for EI at the Center for Surface Engineering and Enhancement (CSEE) program at Purdue University. (CSEE was created to assist industry and federal agencies in research, training and information in surface-enhancing processes that optimize material structural performance.) Dr. Ghanbari was a Postdoctoral Researcher at Purdue at that time, specializing in the design of electronics control units and sensors, the development of software and computational modeling for shot peening process control, and analyzing the flowability of aluminum and copper powders in additive manufacturing.

As a Graduate Research Assistant at Purdue, Dr. Ghanbari worked on additional projects related to surface enhancement including fatigue crack initiation and propagation analysis, residual stresses, yield stresses and plastic deformation measurements using nano-indentation and FEM modeling; novel experiments to measure residual stresses after severe plastic deformation using X-ray method and nano-indentation; and numerical and experimental analysis to improve surface roughness and residual stress after plastic deformation. Dr. Ghanbari has also authored and co-authored 14 published papers. (Several of the papers are available for download at www.shotpeener.com.)

The management team at EI was so impressed with Dr. Ghanbari's work at Purdue that they offered him a position to head the EI Advanced Surface Research Group.

Erik Waelchli

Mr. Waelchli has an extensive background in engineering, factory automation, machine-tool manufacturing, and tool and die manufacturing. He holds an MBA from the University of Notre Dame, a Bachelor in Mechanical Engineering from the College of Engineering at HTL Brugg-Windisch in Switzerland, and he is a certified tool-maker. He served as an officer in the Swiss Army at the rank of Lieutenant-Captain of Material Logistics. Mr. Waelchli is fluent in German, Swiss-German, English and French.

Mr. Waelchli works as a liaison between the Advanced Surface Research Group, CSEE at Purdue, and the EI engineering department. His main responsibility is to optimize the production methods of the EI Almen strip.

PRODUCTS AND PROCESSES IN R&D AT ELECTRONICS INC.

Almen Strips

The Almen strip is the most commonly used tool to quantify the intensity of the shot peening process. Dr. Ghanbari and Mr. Waelchli, along with a CSEE research team at Purdue, are studying the interaction between the flatness and hardness of an Almen strip and their effect on the consistency in the shot peening process. Their goal is to develop the next generation of Almen strip that will surpass the needs of critical industries, including medical and aerospace.

Fine Particle Media
Shot peening with fine particle media is widely used in aerospace and automotive applications such as transmission gears for a luxury automobile manufacturer. The EI R&D group, headed by Mr. Derucki, is working with an international partner to develop process controls that will optimize the use of this media.

Velocity Control
Ms. Bowman is developing a new method of gathering shot velocity data that will provide consistent and accurate velocity readings.

Why Our Industry Thrives on Research and Development
Tom Brickley, Vice President at Electronics Inc., said, "We recently got a phone call from a manufacturing company that needs help developing a better shot peening process that will literally save lives. This is just one example of why we formed the Advanced Surface Research Group. We've assembled the best and brightest talent because we are seeing tremendous opportunity from companies that recognize surface technology as a way to improve their products and processes."

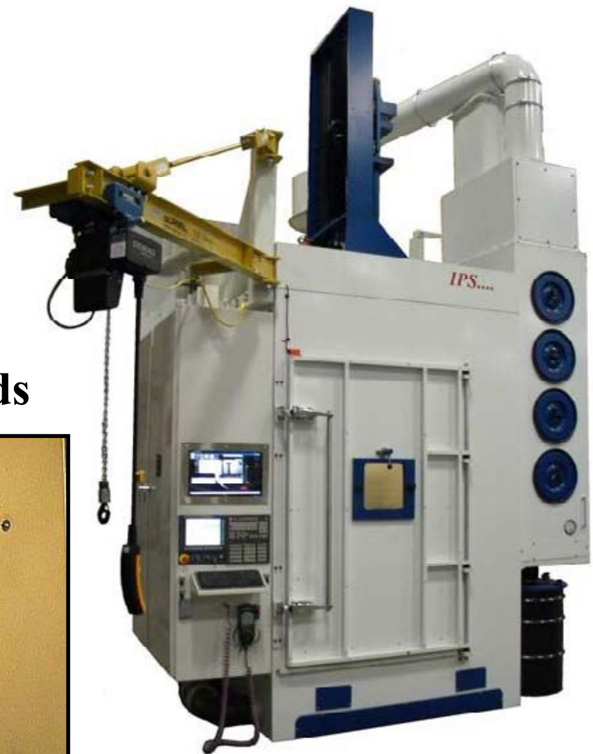
Watch for more information on the progress of the Advanced Surface Research Group in future issues of *The Shot Peener*.

PEENSOLVER

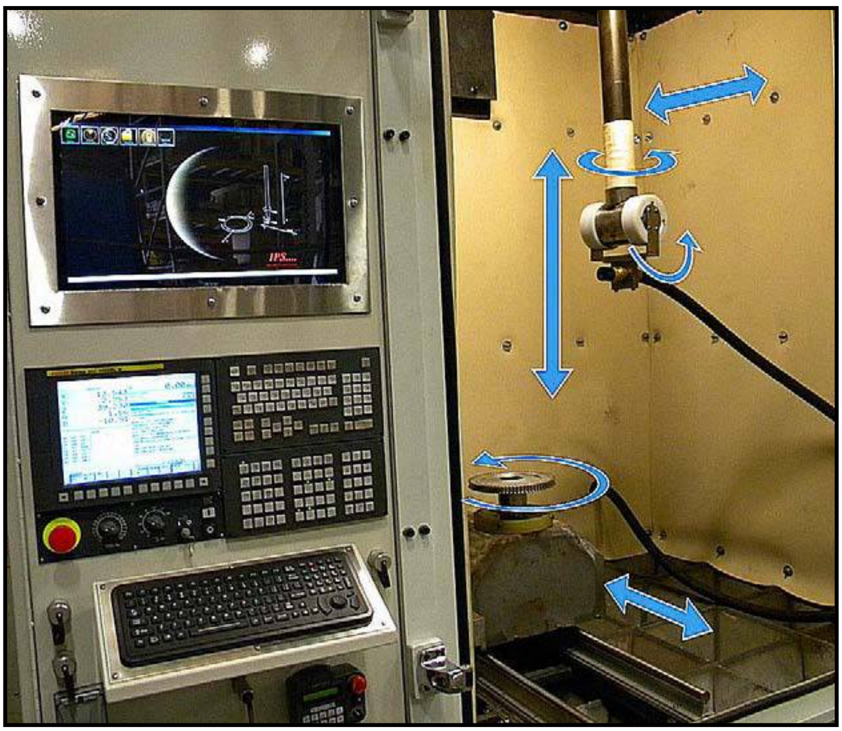
Your Free Curve Solver Web App
Download it at
www.peensolver.com

Peensolver calculates peening intensity as defined in SAE J443. It also conforms to SAE J2597. It evolved from the Curve Solver spreadsheet program developed by Dr. David Kirk that is widely used around the world. Like Dr. Kirk's program, it generates a fitted curve through the given data points. Using the corrected arc heights from the curve, it then locates the one arc height that increases by 10% for the doubling of exposure time. This arc height is the intensity value.

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....

Innovative Peening Systems

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AN INSIDER'S PERSPECTIVE

Kumar Balan | Blast Cleaning and Shot Peening Specialist

Tribal Knowledge in the Blast Industry Part Four

KNOWLEDGE IS UBIQUITOUS

Our discussions here are my attempts at provoking thoughts of operating effectiveness among the most important audience—you, the user of cleaning and peening equipment. Therefore, I start Part Four by acknowledging that in addition to the role played by industry colleagues, end-users too have greatly contributed to the development of tribal knowledge. I share this personal experience to validate my statement. As some of you are aware, the foundry sector uses wheelblast machines quite extensively in their finishing operations. Globally, foundries strive to reach the ultimate (some might even call utopian) goal of minimizing wear rate on blast wheel parts, decreasing their cycle time and maximizing productivity while reining in their operating costs. Unfortunately, the presence of highly abrasive sand in the castings being cleaned makes that task difficult to achieve. Proper design of the airwash separator is one of the critical elements towards reaching this goal. Later in this article, we will discuss the capacity of airwash separators and sand loading.

During a visit to a railway foundry in Southeast Asia that produces passenger and freight railcar wheels, I noticed a custom contraption upstream to their three wheel blast cleaning machine. Upon enquiry, I learnt that the one of the operators, who I am certain was not exposed to formal terms such as "separator lip length" and "abrasive loading," took it upon himself to reduce the machine wear rate. He recognized that substantially high sand content in their wheel castings was rendering their airwash separator ineffective in separating it from the abrasive. So, the solution was to reduce the sand loading before presenting the part to the blast machine. The foundry did not have additional investment earmarked for this task prior to blasting. That did not stop the operator from designing a device which included a spring-loaded paint brush where the soft bristles were replaced with rigid wire brushes. The staging area in this machine was built with a spinning arrangement for the wheel (part), and the operator used this as a pre-cleaning station for the sand by simply having the wire brush scrape against the spinning wheel face, thereby eliminating a large percentage of the sand.

An ingenious idea requiring minimal investment, and likely archived in the future as an equipment manufacturer's patented design!

THE LUNG OF YOUR BLAST MACHINE

About 75% of automated blast operations use blast wheels. With greater media flow rates compared to nozzles, the reclaim system needs to not only be designed appropriately, but also requires regular maintenance to work efficiently. Part Four will focus on engineering concepts shared by my respected industry colleague, Mark Lambrix. Mark retired recently after over 45 highly productive years at Wheelabrator in different engineering and product management capacities. With specialized experience in foundry projects, Mark explained the concept of designing an efficient airwash separator. "The airwash separator is essentially the lungs of a blast machine. Without proper sizing and setting, it has the potential to create all sorts of complications leading to process inefficiency and increased operating costs. In terms of sizing, we categorize duty conditions into five types, with each having its recommended rating guideline."

Type 1	Non-abusive (clean)	Light scale with minimal to no sand	@ 70 lb. per inch of lip
Type 2	Moderate (average)	Moderate scale, minimal sand	@ 55 lb. per inch of lip + 0.4 lb. of sand per inch of lip (or less abrasive: more sand)
Type 3	Normal (above avg.)	Normal foundry applications	@ 40 lb. per inch of lip + 0.75 lb. of sand per inch of lip (or less abrasive: more sand)
Type 4	Core Knock-out	Heavy contamination-foundry with max amt of sand	@ 25 lb. per inch of lip + 0.8 lb. of sand per inch of lip *might need a double-lip separator based on cycle time
Type 5	Shot Peening	Light to moderate scale	@ 50 lb. per inch of lip

Shot peening applications fit into Type 5 and are generally considered gentle duty, allowing for up to 50 lb. of media per inch of lip. As we know, contaminant removal is never a goal in peening applications. Mark adds, "Due to the multiple variables in blast machine operation, it is wise to always provide more than adequate separation and eliminate any separation anxiety."

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Langtry Blast Technologies Inc. (L.B.T.I) is a leading manufacturer of automated blast and shot peening systems in North America. We supply all industries worldwide including medical, aerospace, mining, automotive and commercial.

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Double-lip Airwash Separator from Wheelabrator

How does separator efficiency impact shot peening results? Fines and dust that are inadequately separated by the airwash will contaminate the peening media. Not all wheelblast machines are equipped with vibratory classifiers to separate such fine contaminants, and even when provided, though continuously, will only classify a sampling of the total flow. The resulting wear of wheel parts (or blast nozzles) will cause displaced blast patterns, with the media stream no longer impacting the target, leading to insufficient coverage. Wear of wheel parts will also alter media velocity, adversely affecting intensity and necessitate process re-validation.

Mark used to work on difficult foundry installations, and dealt with rectifying initial design flaws by appropriately sizing the separator. Stressing the criticality of separation, Mark adds, "It is imperative that a full length of curtain be maintained at all times. The air stream will use a gap in the curtain when one exists, and short circuit through the gap without carrying out the intended task of cleaning the abrasive."

The airwash separator has a "Swinging Baffle" complete with counterweights on a threaded rod. The swinging baffle is a device/mechanism that helps regulate the flow of dirty abrasive in a thin curtain across the width of the separator at the point of separation. The counterweights on the swinging baffle help obtain a full-length abrasive curtain.

In terms of maintaining a full-length curtain, Mark explains, "These weights should be heavy enough to shut-off the flow when it is low, but light enough to let it open when the flow is sufficient to fill the unit from end to end (full length)." Newer designs of "smart separators" have a sensor-assisted gate to allow the baffle to swing open only when the requisite level of media is built up behind the baffle. A final note of caution from Mark, "Regardless of whether your shot peening machine has a well-designed separator and possibly a vibratory classifier, a wheelblast peening machine should have a Rotary Screen installed as the first check point to eliminate large-sized contaminants and avoid downstream damage from such foreign objects."

VENTILATION IN BLAST MACHINES

Airblast peening machines dominate applications in the Aerospace industry, with a few wheelblast exceptions in structural peening (chords, stringers, etc.) and when processing the entire OD of new landing gear.

In contrast, due to the high-part volume, wheelblast machines dominate applications in the automotive industry. It is quite common to see machines with multiple blast wheels peen components such as leaf and coil springs, connecting rods and transmission components. In an airblast machine, specifically those with up to four (4) blast nozzles, the ventilation system also provides the pneumatic power to reclaim peening media. The ventilation velocity and volume in such cases are designed to mobilize and convey the expected flow rate of media and also ventilate the cabinet of any dust generated during the peening cycle. In a wheelblast machine, due to the high quantity/rate of media being discharged by the blast wheel(s), a mechanical reclaim system is exclusively employed for the same task.

Mark and I discussed the ventilation requirement in wheelblast machines. "The first step in determining the exhaust/ ventilation requirements of a blast machine is to segment the different areas that are going to be your ventilation points. Commonly, they are: (a) blast cabinet exhaust, (b) elevator exhaust, (c) separator exhaust, (d) blow-off exhaust and (e) touch-up exhaust. Not all machines will be provided with (d) and (e). Much like the duty classification with airwash separators, we classify the volume from each of these generation points into three classes: Class 1 (Heavy Duty), Class 2 (Medium Duty) and Class 3 (Light Duty). Heavy duty will include all foundry applications whereas light duty is where shot peening will be categorized. Medium duty typically includes descaling applications."

As a Design Engineer with Wheelabrator back in the 1990s, I recall calculations where the first wheel in the machine was designated a specific CFM based on the above duty classes. The baseline power for this wheel was 30 HP, and a multiplier was applied based on whether a lower or higher power motor operated the blast wheel. For example, a 15 HP blast wheel motor was given a multiplier of 0.85 whereas with a 50 HP motor, the

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multiplier increased to CFM x 1.2. The second, third and every additional wheel accounted for gradually reducing ventilation requirements. The type of cabinet, whether batch type or pass through, also contributed to additional air volumes to be ventilated from the blast cabinet. Different ventilation volumes were assigned to various sizes (capacities) of bucket elevators, airwash separators (lip length). Blow-off exhaust is generally a multiplier applied to the CFM of the blower used. For example, a 3000 CFM blower will require exhaust ventilation of 3000 x 15%. Additional CFM is applied to air cannons that ultimately discharge the blow-off air.

When ventilating touch-up rooms (and manual blast rooms), the type of abrasive, and mode of ventilation (downdraft or cross draft) determine the ventilation volume. Abrasives that contain compounds of high toxicity such as free-silica, coatings containing lead, and chromates, are ventilated at a relatively high velocity (90 feet per minute in a down draft booth). Low-toxicity materials such as steel abrasives and aluminum oxide are ventilated at 40 feet per minute in down draft. In down-draft type of ventilation, the cross-section assumed for calculation of area comprises of the length x width of the cabinet. In cross-draft ventilation, the cabinet width x height is used to calculate the cross-sectional area. Ventilation velocity differs based on the type of draft system being used.

Cross-draft systems are more common in blast applications. A relatively lower ventilation velocity of 50 feet per minute is used for cross draft when shot peening or blasting clean metal with metallic media. Smaller blast cabinets, such as the ones where the operator accesses the parts through handholes, rely on multiple air changes per minute (volume of cabinet x air changes per minute) to provide the ventilation volume. Most manufacturers follow guidelines provided by ACGIH (American Conference of Government Industrial Hygienists) and adapt them to their specific equipment designs.

"Duct Velocity or Carrying Velocity," explains Mark Lambrix, "is the velocity necessary to keep dust airborne in the ventilation duct and avoid settlement. Average duct velocity is in the range of 3000 to 4000 feet per minute." This is altered by adjusting the blast gates in the ductwork. In aerospace applications, it is common to process parts manufactured from titanium or aluminum and their alloys that have a propensity to generate potentially explosive dust. In such cases, the duct velocity needs to be considerably higher (4500 feet per minute) to prevent settlement along the ductwork.

Certain applications that clean or peen with small-sized media such as S-70 and S-110 incorporate an Abrasive Trap or Drop-out Box as part of the ventilation ductwork. Small particles of abrasive could get airborne and travel through to the dust collector. Such particles could be hot and cause damage to the cartridges. At critical temperatures, this could even result in a filter fire. The purpose of the abrasive trap is to reduce the velocity of such particles inside this "box" (due to larger area than the ductwork) and separate it from the ventilation stream.

WHEELBLAST MACHINES AND SHOT PEENING

Earlier in our discussion, I mentioned that 75% of automated blast operations are served by wheelblast machines. However, upon questioning our students at the peening workshops, I often find that very few of them work with wheelblast equipment, and in some cases are blissfully unaware of their existence. I take the opportunity to remind everyone that the origin of shot peening (after the blacksmith and his ball-peen hammer hitting the leaf spring!) was in a wheelblast machine when peening valve springs. High-volume automotive parts can only be peened in a wheelblast machine to keep up with the production requirements. Therefore, it is important to know this type of media propulsion even if your daily work involves peening with blast nozzles. Some useful facts concerning wheelblast peening:

1. Increasing the media flow rate when peening parts with open geometry, where flooding is not a concern, is the fastest way to decrease cycle time and increase productivity. The only limiting factor is the motor power where excessive amps due to high shot load could trip the motor. Therefore, stay within the current (amp) limits.
2. In an airblast peening machine, increasing media flow has a direct effect on peening intensity. Other parameters (air pressure) will need to be adjusted to maintain the original intensity value.
3. Monitoring media quality (size and shape) are equally important in wheel peening as it is with airblast. However, unlike airblast machines where 100% of the media is classified, only a sampling (about 20%) is taken for continuous classification in a wheelblast machine.
4. Wheelblast machines are operated with a single media size at a given time. Use of two media sizes will result in cross-contamination.

SUMMARY

What started off as a casual chat with some retired colleagues is now a series on information packets that most likely cannot be located in a formal textbook! However, this may not be all. Though a sequel to this part is not imminent, I am hopeful that this will trigger an interest in friends that wish to contribute and help me continue writing on Tribal Knowledge.

Yuji Kobayashi | SINTOKOGIO, LTD Japan | www.sinto.co.jp/en/index.html

Digital Transformation of Shot Peening Machines Utilizing Total Inspection

INTRODUCTION

Industries are now managing detailed information in order to build production processes that not only improve productivity, but also protect the environment. Shot peening is a process in which shot particles are applied to the surface of a work piece at high velocity. The equipment structure is simple and has been used in a wide range of industries. In particular, Japanese automobile manufacturers have been actively shot peening automobile parts such as gears and springs to improve fatigue life and stress corrosion cracking characteristics. However, if the processing conditions are not controlled, these required effects may not be obtained. Hence, it is vital that these processing conditions are well controlled.

The management of information has become essential for these industrial processes particularly based on the concepts of "IoT" and "DX". As a result, the importance of all kinds of information related to production is increasing enormously.

The current quality evaluation method for the shot peening process is based on the control of processing conditions and intensity. In addition, to evaluating the quality of the product, a sample part is taken out and inspected for roughness, residual stress and/or hardness.

Currently, even if the machining conditions are controlled, it is not possible to control the quality of the product after shot peening. It is also difficult to evaluate the residual stress and hardness required for shot peening on all products. In order to solve these problems, we would like to propose the evaluation of each product after shot peening. In order to confirm the quality of all the products, it is necessary to evaluate all the parts inline and non-destructively to avoid defective products while reducing costly production waste and significantly reducing the impact to our environment.

However, in order to achieve in-line and full inspection, a short, compact, and non-destructive inspection device is necessary. Therefore, we have developed a surface evaluation technology—Sightia™—which can evaluate all the products of shot peening.

NON-DESTRUCTIVE EVALUATION (SIGHTIA™)

As mentioned above, there are several issues in the current management and evaluation of peening. Surface evaluation techniques include:

1. Eddy Current Non-destructive Inspection **(ECNI)** systems and
2. X-ray stress measurement **(PSMX)** systems have been developed to solve these problems

ECNI test equipment

ECNI uses an eddy current measurement method to evaluate the surface, and it can judge whether the peening process is pass or fail.

ECNI consists of a signal processing unit, a display unit, and a probe. Changes in the antimagnetic field created by eddy currents in the conductor due to the magnetic field are measured as changes in the electrical characteristics such as impedance and phase of the coil. The entire treated surface surrounded by the probe can be evaluated.

In addition, it is possible to measure and judge whether the product is good or bad in as little as three seconds. Therefore, if this unit is installed in a shot peening machine, then the quality of each can be compared inline against pass or fail criteria. Also, by changing the eddy current characteristics, the depth direction of the product can be evaluated.

Residual stress measuring unit PSMX

The main purpose of shot peening is to improve fatigue strength by adding residual stress. The X-ray stress measurement device **PSMX-II**, developed by our company, is compact and can measure residual stress values in about 10 seconds. Therefore, it can be integrated into an automated shot peening machine effortlessly if the evaluated products are of the same material and shape.

FROM PROCESS CONTROL TO FULL INSPECTION

In order to achieve the goal of zero outflow of quality defects, we propose a shot peening process that records and utilizes all evaluation and process data which has been difficult in the past.

Full inspection before and after shot peening

In the shot peening process, the one-piece flow process is becoming the mainstream for quality control and traceability. At this time, it is necessary not only to satisfy the quality after the peening, but also to understand the characteristics before the peening. If there is a defect in the product before shot peening treatment, the quality of the product will not be satisfied even if it is processed by a correctly controlled shot peening method.

Again, one-piece flow process represents mainstream quality control and traceability so we believe it is beneficial to not only satisfy the quality after the peening, but also to understand the characteristics before the peening. An efficient automated process eliminates waste while improving value stream and traceability.

The shot peening machine integrated with Sightia™ can evaluate the product even before it is peened to determine if it is unsuitable for peening. Since it can evaluate and record the product after peening, it can easily record the quality of the product after machining. Overall, the reliability of the manufacturing process can be improved more than before.

Combination of evaluations

The above mentioned PSMX measures the local residual stress. On the other hand, ECNI evaluates the finish of peening of the entire surface, although it cannot obtain actual physical quantities such as stress. Therefore, we would like to propose that both measuring devices be integrated into the shot peening machine where possible.

Effects of shot peening machine integrated with evaluation equipment (Sightia™)

Normally the processing conditions are controlled in shot peening machines. Therefore, by using ECNI and PSMX to evaluate the product after processing, the outflow of defective products can be eliminated.

DATA RECORDING AND UTILIZATION IN SHOT PEENING PROCESS

Data recording

When a defect occurs, the stored data can be analyzed to easily identify the cause. If the condition of the product before peening is also recorded, the cause can be more easily identified. In addition to the easy quality control, a large cost reduction can be expected.

Use of measurement data

Feed-forward to peening conditions

If the evaluation before the peening is unacceptable, the product is obviously rejected. We would like to propose that the peening conditions should be automatically changed when the evaluation result is close to the lower limit of the acceptance criteria. (Feed-forward)

Feed-forward conditions provides a method of investigating the impact of shot peening on each product well in advance.

Feedback on shot peening conditions

All data measured after shot peening are used for post-processing trend analysis. If the trend analysis predicts that the material will be out of specification in the near future, the equipment will issue a warning or automatically adjust the peening conditions. (Feedback)

Shot peening machines with these features can not only satisfy the quality after peening, but also eliminate the outflow of product defects.

PROSPECTS FOR DATA UTILIZATION

Traceability

By marking the products with laser markers and linking them with the accumulated data, it is possible to track them later. Thus, it is possible to manage products differently than before.

The Next Generation of Shot Peening Machines

As we have discussed, integrating an evaluation device into a shot peening machine would make it easier to control product quality and prevent defects from leaking out. As a result, it will be possible to save manpower.

The mechanical properties after shot peening change significantly depending on the conditions of shot peening. It is up to the equipment manufacturer to investigate these changes in more detail and to reflect them in the shot peening equipment.

So far, we have mainly discussed the quality improvement after shot peening. On the other hand, the improvement of productivity and the reduction of total running cost are also important themes.

In recent years, data collection and analysis technologies and equipment control technologies have been improving. It will be possible to perform the minimum amount of processing while satisfying the standards required by customers.

In addition, individual shot peening machines will be able to send information to the customer's overall factory management in order to optimize the entire manufacturing process.

In any case, digitalization is required for shot peening machines.

SUMMARY

In this paper, we have proposed a process of total inspection using Sightia™ before and after shot peening.

We believe this process can be applied to various concepts that have been proposed in recent years, such as "Industry 4.0", "IoT", and "Big Data".

We would like to contribute to our customers by analyzing the production processes of individual customers and proposing optimal systems.

Darko Malnarič | Mechanical Engineer, Head of R&D at FerroECOBlast® Europe | www.ferroecoblast.com

Shot Peening and the Dynamic Root Strength of Gears

The effect of shot peening on the dynamic root strength of gears treated with different parameters in different heat treatment methods

WITH MORE than 55 years of experience, FerroECOBlast® Europe, based in Dolenjske Toplice, Slovenia, is one of the global leaders in the field of surface treatment technologies. What makes us stand out from the crowd is our dedication to research and development. The following study, performed by our R&D department, in collaboration with the IMT—The Institute of Metals and Technology from Slovenia—explores the effect of shot peening on the dynamic root strength of gears treated with different parameters in different heat treatment methods.

Gears are commonly exposed to high loads. We therefore decided to choose a gear as the test sample for this particular study. The sample gears were made of standard structural steel typically used in the manufacturing of gears 18CrNiMo7 and, following mechanical treatment, underwent further processing using the three most commonly used heat treatment methods for such parts: cementation (C), nitriding (N) and carbonitriding (NC). After the heat treatment, the gears went through a shot peening process. We opted for a cold and "hot" shot peening process, the latter at an elevated temperature. The purpose of "hot" shot peening is to close the micro-cracks on the surface as much as possible and achieve better tooth micro-hardness as deep into the surface as possible. Two materials were used in the process: S110 and S330. After the basic shot peening, certain samples underwent re-peening using a finer material—Z150 ceramic beads. After the processes were completed, a metallographic analysis of the gears was conducted to measure the tooth's micro hardness and its permanent dynamic strength at two different load levels.

Shot Peening Process

The following abrasives were selected for the shot peening: Steel shot S110, Steel shot S330, and Ceramic shot Z150. The latter was used for the re-peening. By adjusting the angle of the nozzle relative to the gear, we obtained the best possible balanced intensity for the root and top land of the tooth. The process at elevated temperatures (HT) was also carried out on cemented gears, at 180˚C, and nitrided gears, at 320˚C. Carbonitrided gears, however, were not processed at elevated temperatures because this would have neutralized the effect of the preceding heat treatment.

Intensity of Shot Peening

We decided to select different shot peening intensities for different abrasives and did our best to adjust the intensity of the tooth and root of the gear as much as possible. The results of intensity for cold and hot shot peening process have been the same. Table below shows intensity value for each part of the gear with the different abrasive.

Intensity of shot peening with different abrasives

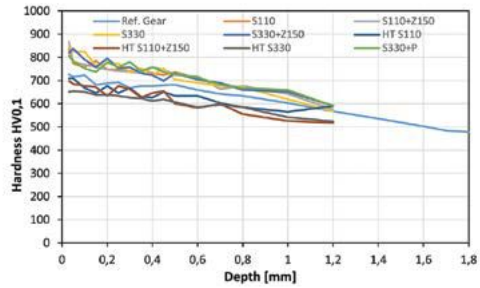
Abrasive	S110		S230		Z150	
Part of gear	Tooth	Root	Tooth	Root	Tooth	Root
Intensity	.007A	.007A	.017A	.014A	.011N	.011N

Testing and Measurements

Dynamic strength testing was performed on a dedicated machine where a gear tooth was put under two different alternating load levels. The load frequency was 15 Hz, while the forces varied: 34 kN in the first run, 40 kN in the second one.

Tooth clamping and loads during testing

After the shot peening, tooth micro-hardness measurements were conducted for each heat treatment and shot peening method combination. This helped identify the effect of shot peening on the tooth's depth from the surface and the effect of the "hot" shot peening. Also identified was the effect of the re-peening using a finer material.



Hardness distribution for cemented gears, with depths (HT – hot peening)

The results have shown the conventional shot peening treatment to increase material hardness by approx. 80–100 HV relative to the reference gear. This difference decreases as the distance from the surface increases. Measured from the surface of the material, the depth of the effect is 1–1.2 mm. "Hot" shot peening, on the other hand, results in hardness reduction by approximately 50 HV.

In the case of carbonitrided gears, shot peening increases material hardness by approximately 100 HV and that this effect decreases as distance from the tooth surface is increased. The effect of the process penetrates up to some 0.3 mm deep in the material.

For the nitrated gears, the same pattern of increasing hardness is detected. The effect of shot peening process penetrates only 0.25 mm deep into the gear tooth.

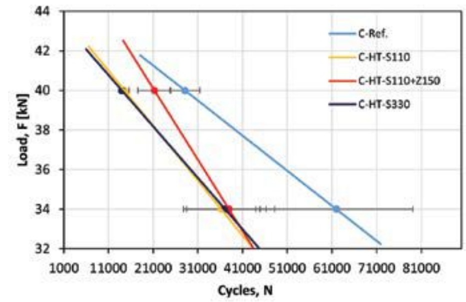
Dynamic Tooth Root Strength Testing

Cemented gears

The impact of the cold shot peening process on the dynamic root strength of cemented gears is shown in the next graph.

As can be observed in the graph, all shot peening methods except for the S110+Z150 combination result in a 10–50% deterioration in the dynamic root strength of the cemented gear. In the case of the S110+Z150 shot peening, too, the root strength at a higher load level has decreased compared to the cemented gear used for reference but, on the other hand, this treatment indicates a significantly improved resistance at lower load levels, where the teeth can withstand >300,000 load cycles without breakage.

In the case of "hot" shot peening, all three operations result in a 30–50% deterioration in the dynamic root strength of cemented gears (next graph), with "hot" shot peening using a combination of steel and ceramic beads (HT-S110+Z150) again being the closest to the reference cemented gear.



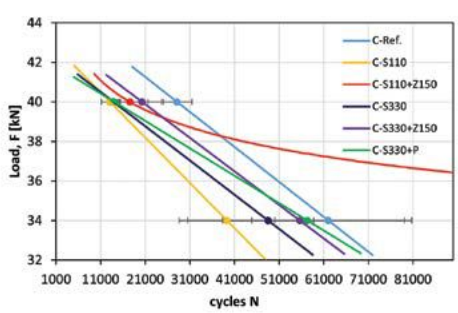
The effect of "hot" shot peening on the dynamic root strength of cemented gears

Carbonitrided gears

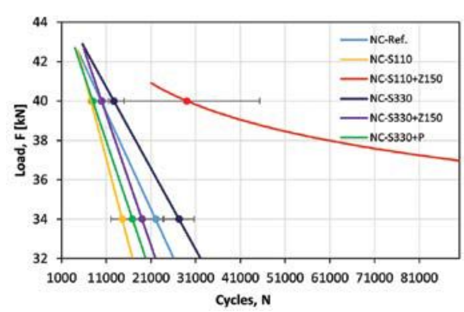
In the case of carbonitrided gears, the shot peening operations with S330 and S110+Z150 show root strength improvement, with the combination of steel and ceramic beads S110+Z150 in particular. Shot peening with S110+Z150 yields a severalfold improvement in the dynamic root strength at both /stress/ load/ levels, whereas with S330, the improvement stands at around 30% (next graph).

Nitrided gears

In the case of nitrided gears, all cold shot peening treatments have a positive impact on the dynamic root strength. The greatest impact was observed in treatments using a combination of steel and ceramic beads (S110+Z150 and S330+Z150), where the latter combination in particular has substantially improved the dynamic root strength at lower loads. "Hot" shot peening, too, has resulted in improved dynamic root strength of nitrided gears, mainly at lower load levels. The improvement ranges from 30–40% to more than a fivefold increase. The most notable improvement was again



The effect of cold shot peening on the dynamic root strength of cemented gears



The effect of cold shot peening on the dynamic root strength of carbonitrided gears

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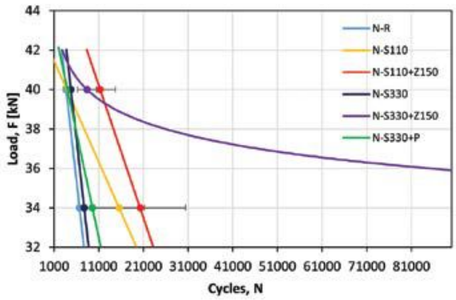
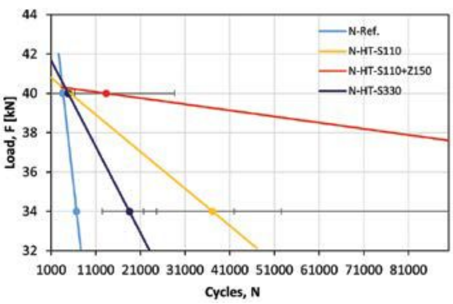


The effect of cold shot peening on the dynamic root strength of nitrided gears



The effect of "hot" shot peening on the dynamic root strength of nitrided gears

achieved using the combination of steel and ceramic beads HT-S110+Z150.

Conclusion

- Shot peening treatment increases the hardness of the surface layer of gears, which holds true for all the three heat treatment methods. The highest hardness measurements have been observed in gears that underwent the S330 and S330+Z150 processes, followed by S110 and S110+Z150. In the case of cemented gears, "hot" shot peening reduces the gears' surface hardness; in nitrated gears, however, it does increase the surface hardness, but to a lesser extent than with cold shot peening.
- A comparison of the gears' dynamic root strength reveals that the highest strength is observed in cemented gears, followed by carbonitrided gears, whereas nitrided gears achieve a mere one-tenth of the dynamic strength of cemented gears. On the other hand, with cemented gears, all subsequent cold shot peening treatments, with the exception of S110+Z150, result in up to a 50% deterioration in dynamic root strength. The S110+Z150 treatment, however, has been shown to provide a substantially improved root strength at lower load levels in particular, as the teeth can withstand more than 300,000 load cycles without breakage. With "hot" shot peening, the dynamic root strength has been shown to decrease as much as twofold.
- In the case of carbonitrided gears, the S110+Z150 and S330 shot peening processes resulted in improved root strength, particularly when using a combination of steel and ceramic beads, where a severalfold improvement has been observed. Other shot peening operations had a negative impact on the gears' dynamic root strength, which decreased by up to 35%.
- In contrast, all the shot peening operations, both cold and hot, on nitrided gears yielded a substantial improvement in the gears' dynamic root strength. Again, the greatest impact can be observed in the treatment with steel beads, followed by shot peening with ceramic beads S110+Z150 and S330+Z150.
- Based on the results, it can be concluded that the best choice of treatment is a combination of cold shot peening using steel and ceramic beads (S110+Z150), which, regardless of the thermochemical treatment, results in improved dynamic root strength of gears. On the other hand, the shot peening process has the greatest effect on improving the root strength in nitrided gears, whereas in the case of cemented and carbonitrided gears the effect is largely negative. This goes to show that the thinner and harder the surface layer is after heat or thermochemical treatment, the more positive effect is achieved with the shot peening process.

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ACADEMIC STUDY
Dr. David Kirk | Coventry University

Back to Basics: Coverage

INTRODUCTION

Coverage and peening intensity are the two major properties for peened components that have to be both measured and controlled. As with all definitions "The Devil is in the Detail." SAE's J2277 does not help clarity of understanding and is somewhat misleading as the following extract indicates: "Coverage is defined as the percentage of a surface that has been impacted by the peening media. The minimum peening time required to obtain 100% coverage is determined by gradually increasing total peening time until the entire surface being peened exhibits overlapping dimpling. Coverages above 100% are multiples of the exposure time required to achieve 100% coverage." Only the first sentence is accurate!

Coverage measurement has to be an average as it is based on being made over a selected area. Coverage varies over the surface of a peened component. Both manual and computer-aided measurement procedures are available. As peening progresses, coverage increases. However, accuracy of coverage measurement decreases as coverage increases. This is so important that an alternative expression to 100% coverage has been coined. "Full coverage" occurs when 98% of the peened surface is covered with dents. The rate of coverage increase is very similar to that of a simple exponential curve. This allows prediction of the coverage achieved using different peening times.

An important feature of coverage development is the increasing probability of multiple impacting as illustrated by fig.1 (Fig.6 of *The Shot Peener* article, Spring, 2016).

On a sub-microscopic scale, coverage is either 0% or 100% as can be seen in fig.1. On a macroscopic scale coverage is an average of dented and undented areas.

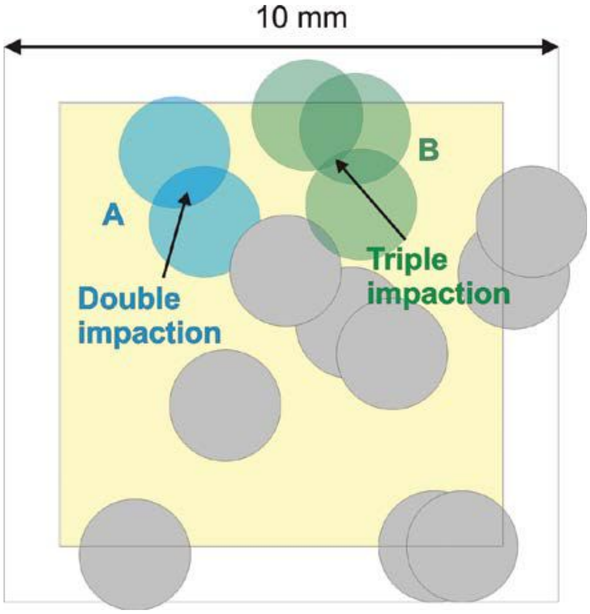


Fig.1. Multiple impactions with 42% coverage.

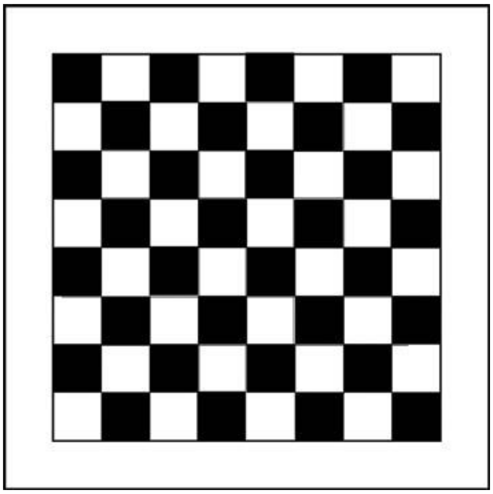


Fig.2. Chess board coverage.

AVERAGED COVERAGE

For sub-microscopic coverage, consider the analogous situation represented as a standard chess board in fig.2. We see that the board contains precisely 50% each of black and white squares—analogous to 100% and 0% coverage of individual squares.

Consider next the coverage if we only sampled part of the board. Fig.3 highlights just nine squares. Black squares occupy five of the nine squares and white the remaining four. The coverage is no longer 50/50. If the sample was of only the top left-hand square the coverage would be 100%. This analogy may seem trivial but it serves to highlight an important feature of coverage estimation. The sample area should (a) be large enough to obviate statistical fluctuation of the average whilst (b) be small enough so as to not mask any true variability of average coverage. Fig.4 illustrates this important principle, using the popular line-intersection measurement technique (described later) and indicating a suggested optimum line length.

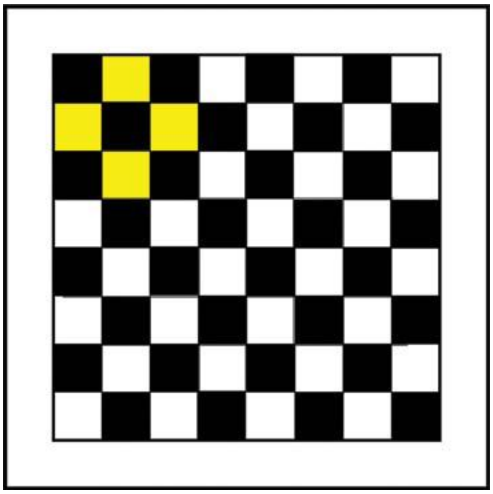


Fig.3. Highlighted area of chess board.

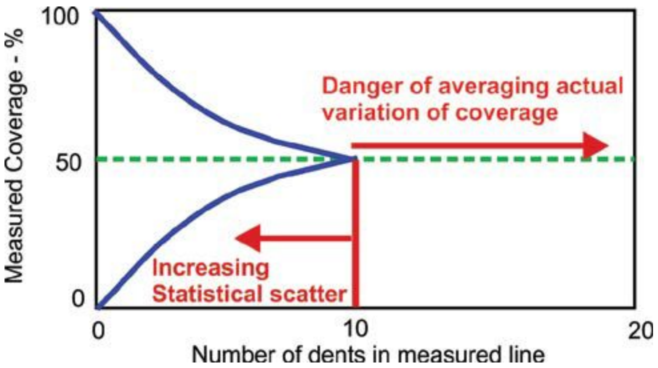


Fig.4. Suggested optimization of selected line length for coverage measurement.

INCREASE OF COVERAGE WITH INCREASE OF PEENING

As peening progresses, the average percentage of the surface containing dents increases. This increase, for a given shot stream, is exponential towards 100%, rather than being linear. Fig.5 illustrates the theoretical shape of a coverage/peening time curve. The peening time scale is arbitrary as it depends on the indentation rate.

Fig.5. Theoretical coverage versus peening time curve.

The equation for coverage versus peening time is:

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

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.

COVERAGE RATE

Coverage rate is 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**, extracted from equation (1) is t given by:

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

For which the $\mathbf{\pi D^2/4}$ term is the projected area of each dent.

Equations (1) and (2) allow us to exercise quantitative coverage control!

If we can assign a value to **K**, we can predict the coverage that will be achieved in any given peening time, **t**. Equation (1) simplifies to:

$$\mathbf{C = 100(1 - exp(-K.t))} \qquad (3)$$

The coverage rate, **K**, is simply the product of the dents' average area multiplied by the rate at which these dents are being produced. Dent diameter can be determined either directly on a peened component or theoretically using a dent diameter prediction equation as published in the Spring, 2004 edition of *The Shot Peener*. The rate of denting can be predicted using the cone area of the shot stream and the shot flow rate. If, for example, 100 shot particles per second are indenting a cone area of 400 square millimetres the rate of impacting is 0.25 dents per square millimetre per second. If the area of each dent is 1 square millimetre then the coverage rate, K, will be 0.25 per second (1 mm^2 times 0.25 $mm^{-2}s^{-1}$).

MULTIPLE DENTING DURING COVERAGE DEVELOPMENT

As indicated in fig.1, multiple denting occurs even at low coverages. Fig.6 illustrates, quantitatively, how multiple

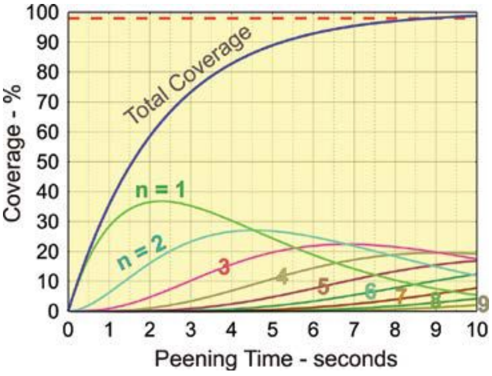
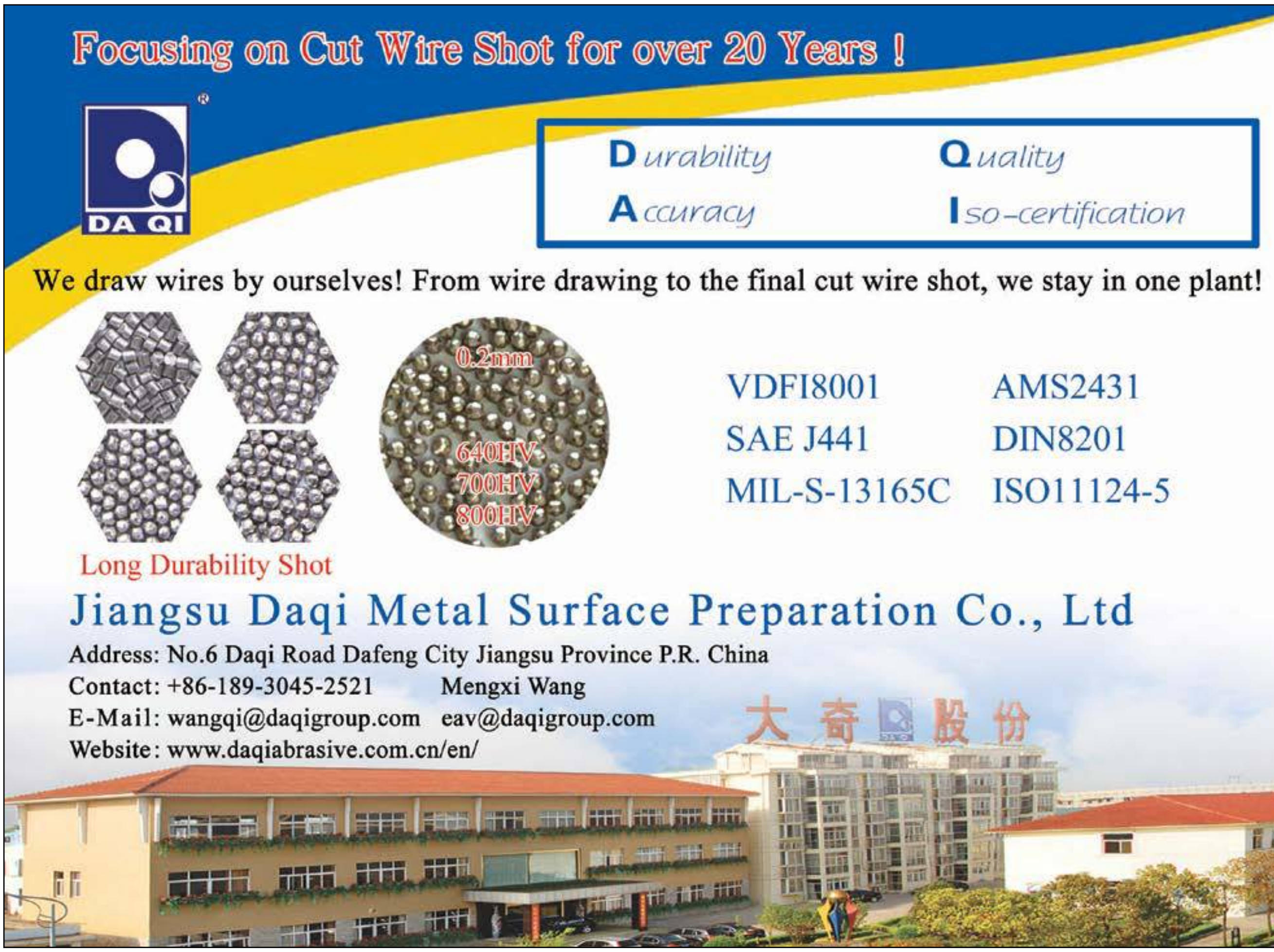


Fig.6. Increase of multiple denting with peening time.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denting increases as peening progresses. After some five seconds (for this example) total coverage is about 90% but more of the surface has received two dents than has received a single dent. Twenty percent of the surface has received triple denting.

Again we must appreciate that the predicted multiple denting is only the average value for a peened component. Some parts of the peened surface will experience more than the average multiple denting and some parts less.

In one sense, we are "Caught between the Devil and the Deep Blue Sea." If we try to get close to 100% average coverage, we run the risk of exceeding the component's tolerance for massive plastic deformation. On the other hand, if we reduce the amount of peening to avoid that danger, we run the risk of leaving large islands of undented component surface. This leads to a consideration of what should be the optimum average coverage.

OPTIMUM AVERAGE COVERAGE

The optimum coverage of a component, for a given peening intensity, varies according to material and service conditions. Experience has shown that the optimum coverage can be as low as 50% but rarely exceeds 90%. Fig.7 is a graphical representation of one particular set of conditions. It is worth noting that when maximum improvement is being indicated there is only a tiny reduction on either side of the optimum coverage.

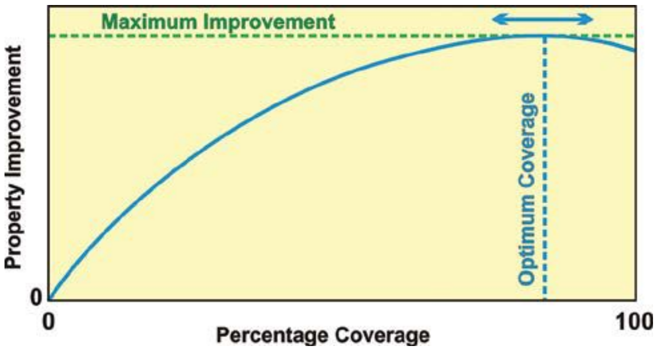

Fig.7. Example of a coverage optimization curve.

MACRO VARIATION OF AVERAGE COVERAGE

Another basic feature of a shot stream's coverage is that it varies considerably. This variability is curiously under-publicized. In order to appreciate variability, consider the following analogous situation.

Squaddies in training
A drill sergeant, having a warped sense of humor, decided to organize his squad into an unusual formation. Instead of their normal rectangle, they had to adopt a near-circular array. Then they were marched across a wet, soggy, rectangular field leaving clear bootprints as they marched in unison. The result is represented as a cartoon in fig.8.

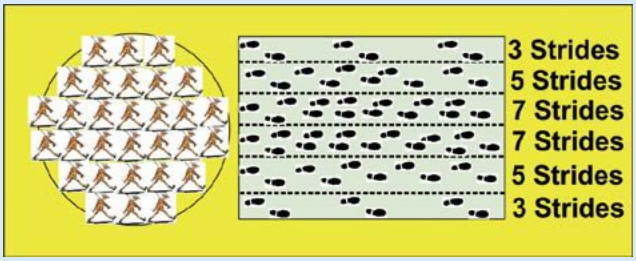

Fig.8. Analogous variation of bootprint coverage.

The coverage of bootprints varies from three to seven for this small squad analogy. For a squad more equivalent to a shot stream, the squad would have to number in the thousands. For that size, the effect could be represented as an aerial photograph of the field as in fig.9.

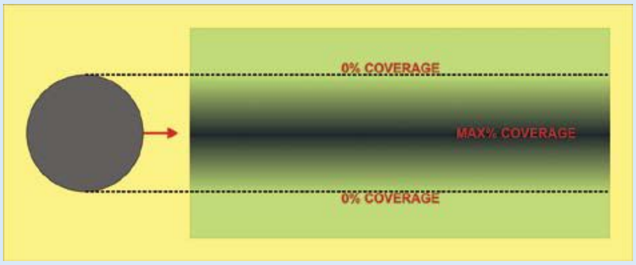

Fig.9. Imagined aerial photograph of bootprints left by huge squad marched across a field.

As alternatives to the squaddie analogy, consider the following analogies:

(1) Painting a barn door. Would you use a round or a flat brush? The relative effects are illustrated in fig.10.

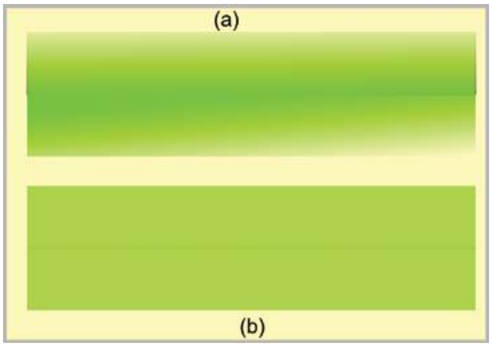

Fig.10. Paint stripes using (a) round brush and (b) flat brush.

(2) Try using an aerosol spray, moving quickly over a sheet of cardboard. The effect is very similar to that of a shot stream, as well as to (a) in fig.10.

COVERAGE CONTROL

It must be stressed that:

Coverage achieved is the product of coverage rate multiplied by the actual time of peening.

As already pointed out, the coverage rate varies because of its macro-variation. Coverage rate control depends upon the offset of repeat passes. Fig.11 illustrates the stripe effect of offsetting by an amount equal to the shot stream's diameter. Fig.12 illustrates the reduction in stripe severity due to reducing the offset.

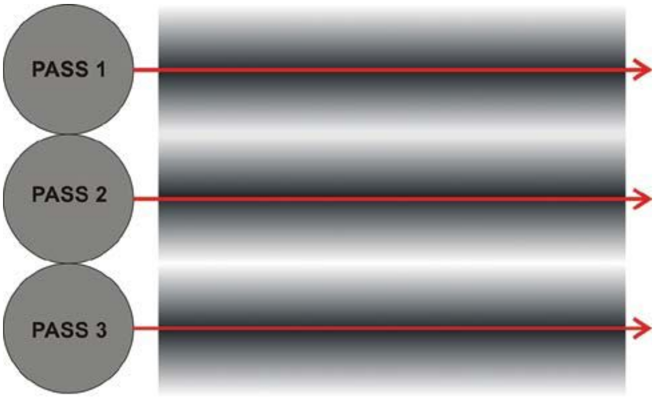

Fig.11. Stripe effect produced by an offset equal to the shot stream's diameter.

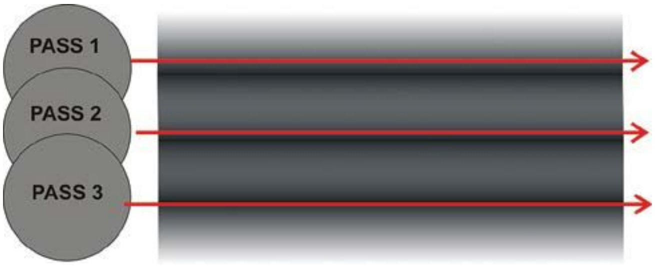

Fig.12. Reduced stripe effect by reduced offset.

Fig.13 indicates that optimum coverage uniformity would result from using an offset half of the shot stream's indenting area diameter, D.

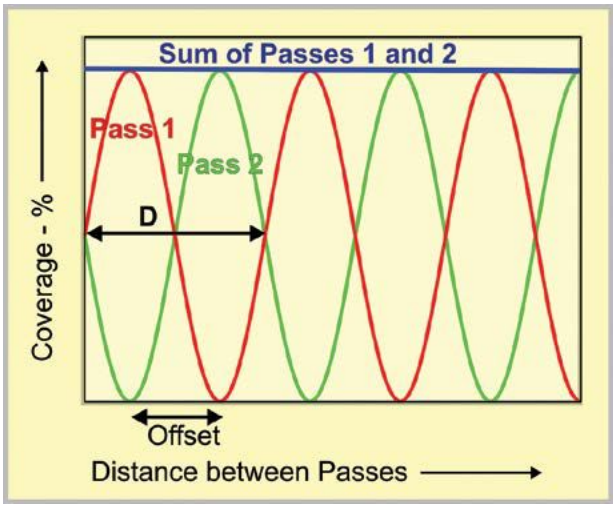

Fig.13. Prediction of uniform coverage using an offset of half of the shot-stream's diameter, ***D****.*

The effects just shown have been applied to the simple case of peening flat surfaces. Controlled offset should be applied to more complex components and is particularly important when peening holes.

COVERAGE MEASUREMENT

Coverage measurements can be made either manually, using the naked eye, or by employing computer-based image-analysis software.

(a) Manual Coverage Measurement

The most commonly-used manual method is to compare a magnified image of the shot-peened surface with "standard" images, such as those in fig.14. There is, however, a subjective element in this procedure. On the other hand, the human brain can act as a marvellous computer. Indeed, in many areas of image analysis, manual measurement is still considered superior to computer-based measurement.

Often overlooked is the lineal analysis method for quantifying coverage. It is similar to computer-based methods insofar as lines on an image are divided into dent and non-dent lengths. The principle involved is illustrated schematically by fig.15.

As an exercise, printing fig.15 allows the "dent lengths" to be measured using an office ruler. The sum of the "dent lengths" on each line is then divided by the "100%" length. By way of illustration, on a print of fig.15 and using 170 mm lines the author found the total "dent lengths" to be 137, 140,120 and 140 mm for lines 1, 2, 3 and 4 respectively. Dividing these by 1.7 (in order to arrive at coverage percentage) gave values of 80.6, 82.4, 70.6 and 82.4 respectively. The average is 79.0%. The variation of the values reflects the variability of coverage that occurs, on a micro scale, for actual peened components. In practice, a high-resolution photograph of a peened area can be enlarged and printed for lineal examination. On real peened components the author aims for making about 20 measurements of dent lengths per line on up to 10 lines (it comes quicker with practice!).

Fig.15 is schematic, being designed solely to illustrate the principle of the lineal analysis method when applied to coverage measurement. Real peened surfaces are, of course, much less clearly defined. That is where the human eye can score over one aspect of computer-based image analysis. An experienced observer can distinguish dent edge borders individually with reasonable accuracy. The human visual cortex is an excellent image analysis apparatus.

(b) Computer-based Image Analysis of Coverage

This method is based on exactly the same principle as the manual lineal analysis technique. The main differences are that: each computer scan line normally embraces far more dents and far more scan lines are involved. One major problem, however, is the difficulty of identifying dent edges.


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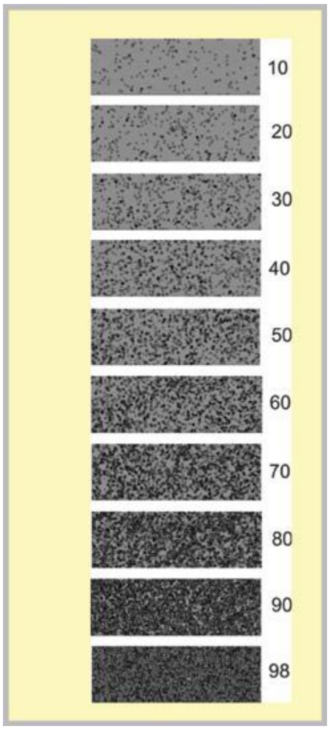


Fig.14. Standard Comparison images for Coverage Assessment.

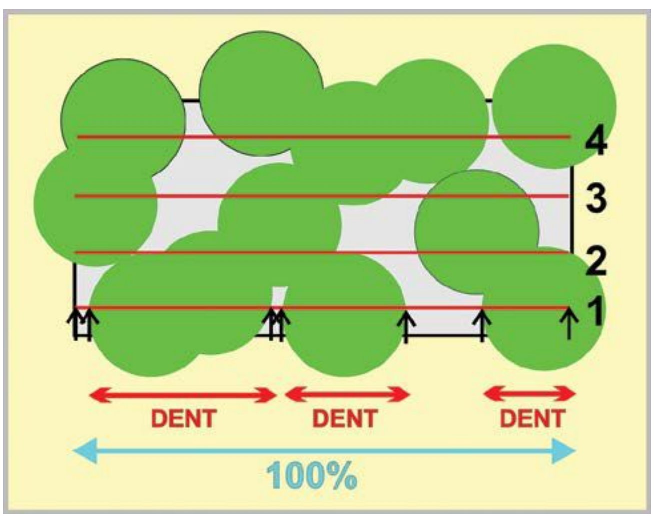


Fig.15. Identifying "Dent" lengths for a fixed length of measurement.

This does not arise when computer-based image analysis is being employed to study shot size and shape variation. "Image Analysis and Computer Microscopy of Shot Particles" was the very first article that I submitted to *The Shot Peener* (Vol.15, Issue 3, Fall 2001).

DISCUSSION

Coverage is very important and warrants very serious consideration. At least nine of the author's Shot Peener articles have been devoted to the topic.

Coverage measurement is, of course, a primary consideration. It is needed in order to confirm the satisfying of customer requirements. Other relevant factors need to be understood. Only the basic principles governing these factors have been presented in this article. Attached is a chronological list of *The Shot Peener* articles that give expanded treatments of those factors.

***The Shot Peener* Articles**

1. Coverage – Development, Measurement, Control and Significance. Fall, 2002.
2. Theoretical Principles of Shot Peening Coverage. Spring, 2005.
3. Shot Peening Coverage: Prediction and Control. Spring, 2009.
4. Non-uniformity of Shot Peening Coverage. Summer, 2009.
5. Shot Peening Coverage Requirements. Summer, 2012.
6. Quantification of Shot Peening Coverage. Fall, 2014.
7. Optimization of Shot Peening Coverage. Spring, 2010.
8. Coverage Variability. Winter, 2017.
9. Coverage Science. Fall, 2019.

GelSight – Enabling 3D Measurement for Shot-Peened Surface Characterization

GELSIGHT, INC. is a startup commercializing a unique imaging technology invented at MIT. The technology uses an elastomeric pad that conforms to any surface and enables 3D measurement of precise surface topography. Dr. Kimo Johnson, co-founder of the company and co-inventor of the technology, spoke with our team to explain how measurements of 3D surface topography can be used for shot-peened surface characterization.

What was the concept or challenge that led to the founding of GelSight?
Johnson: The driving concept behind the technology was to turn tactile interaction into an image. Our soft elastomeric pad is similar to human skin in that it deforms when it presses against objects. The early research on the technology demonstrated that it could be used to measure detailed 3D surface geometry of any material, which has broad applications across many industries.

What are the main application areas for GelSight's technology?
Johnson: GelSight technology is primarily used for non-destructive inspection in aerospace and automotive industries but can be utilized across many others where precise measurement is required. The technology has been developed into a handheld tool that can quickly measure 3D surfaces and provide critical dimensional information such as the depth of a scratch, the diameter of a hole, or the angle of a chamfer. GelSight systems are actively used for quality control applications, mass production inspection, and both academic and industrial research.

GelSight Mobile System

What makes it relevant to the shot peening industry?
Johnson: As you and your audience know, shot peening is a process of altering the surface of an object to change its mechanical properties. The ability to quickly measure the shot peening process on the component itself, rather than by viewing an Almen strip, can provide a more accurate assessment of shot peening coverage, rate, and other process parameters.

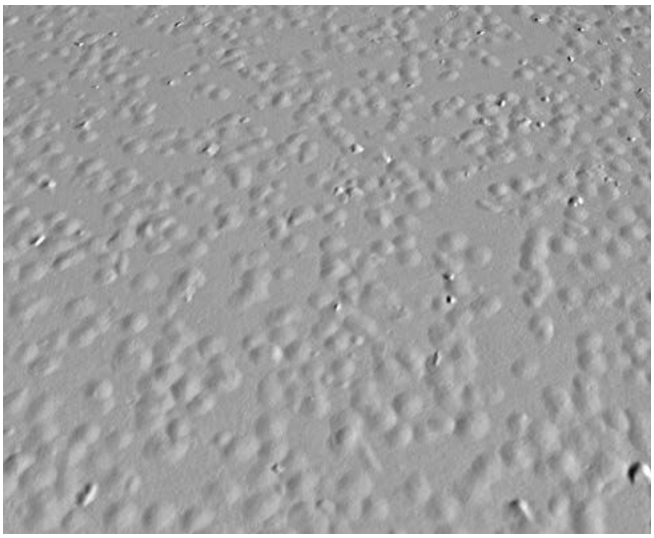
What are the benefits of your technology over others in the market?
Johnson: The unique property of our technology is the elastomeric pad that enables precise surface measurements of any material, independent of the material's reflective properties. Many other technologies struggle to accurately measure reflective metals or require significant training to configure the system parameters for the material being measured. The GelSight measurement probe has a single button, similar to a camera, and touchscreen software that can be used effectively with little training.

What kind of surfaces does GelSight work on?
Johnson: The GelSight system can be used on any rigid surface, including glass, metals and composites. For deformable materials, it is possible to use a softer elastomeric pad to reduce deformation of the material during measurement.

What are you working on today that you are most excited about?
Johnson: We are deploying measurement systems into different industries and finding new opportunities where the technology can provide value. The company is also developing

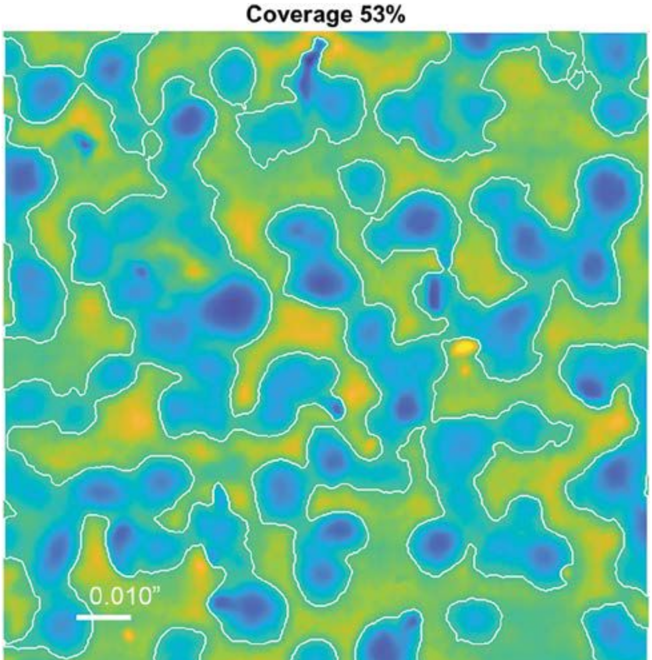
smaller sensors where the goal is to provide immediate tactile feedback to robots.

Where can readers go for more information? Resources?
Johnson: Readers can find more information about our company and technology on our website, www.gelsight.com, where they will also find a white paper on shot-peened surface characterization. There are also short demonstration videos about the technology on YouTube.



Rendering of 3D measurement of shot-peened Almen strip

Coverage 53%



Shot peening coverage analysis
Almen strip, peened with S390 shot at 60 psi, 7 revolutions
Dents in surface are automatically detected and measured

Lane Barnholtz | Senior Editor | Clemco Industries Corp. | www.clemcoindustries.com

K-9 Police Force's Favorite Toy Is Clemco 4-Ply Blast Hose

"WHAT NORAS LOVES just about more than anything," Police Officer Josh Jackson says of his partner, "is chewing on Clemco blast hose. I could throw down a T-bone steak and a section of blast hose—and Noras would take the hose every time."

Officers Noras and Jackson serve in Ohio's St. Clair Township Police Department. Noras is a four-year-old German shepherd that has been on the police force for three years. He is trained in narcotics detection, article searches, and suspect tracking and apprehension. Officer Jackson—who not only is Noras' partner and handler, but best friend—has been a police officer for six years in St. Clair Township. The rural township is located between Cleveland and Pittsburgh.

HIS BITE IS WORSE THAN HIS BARK

Noras (who is named after the actor Chuck Norris) began his relationship with Clemco blast hose as a pup. "During training, the dogs are given blast hose as a toy," Officer Jackson explains. "The hose is used as a reward. When the dogs are being trained to sniff out drugs, they don't realize they are searching for drugs—they think they are searching for blast hose. It's a game for them."

Noras and his favorite toy—a Clemco 4-Ply Hose

To put this in perspective, the 4-Ply Hose that Noras loves is Clemco's most durable blast hose. Its outer casing consists of four-layers of cloth and rubber-impregnated fiber winding. Because of its strength, 4-Ply Hose is widely used in shipyards, railyards, and other sites where hose receives particularly rough treatment. The hose can even withstand occasional light vehicle traffic without collapsing. However, even the Clemco 4-Ply Blast Hose cannot completely withstand Noras' bite.

"Almost nothing can stand up to the bite force Noras applies," Officer Jackson says, "except Clemco Blast Hose. That's why he loves it. Although I have to admit, I've seen him destroy a one-foot section of hose in less than three minutes."

CLEMCO DONATES HOSE TO NORAS AND FRIENDS

In February, Clemco donated its second 50-foot batch of 4-Ply Hose to the St. Clair Township Police Department for use by Noras and the department's other K-9 officer, Axel. But Noras and Axel are generous team members.

"We often train with the other K-9 departments in Columbiana County, which is where St. Clair Township is located," Officer Jackson says. "When I tell the other dog handlers that I have hose, they want some. The county has a total of nine dogs, and they all go crazy for the hose."

LEARN MORE

If you have questions about Clemco blast hose or other Clemco equipment, Clemco can connect you with one of its distribution partners who is located near you and who will answer your questions. Our distribution partners will help you determine which of Clemco's three types of blast hose is right for you: 4-Ply, 2-Braid or Supa.

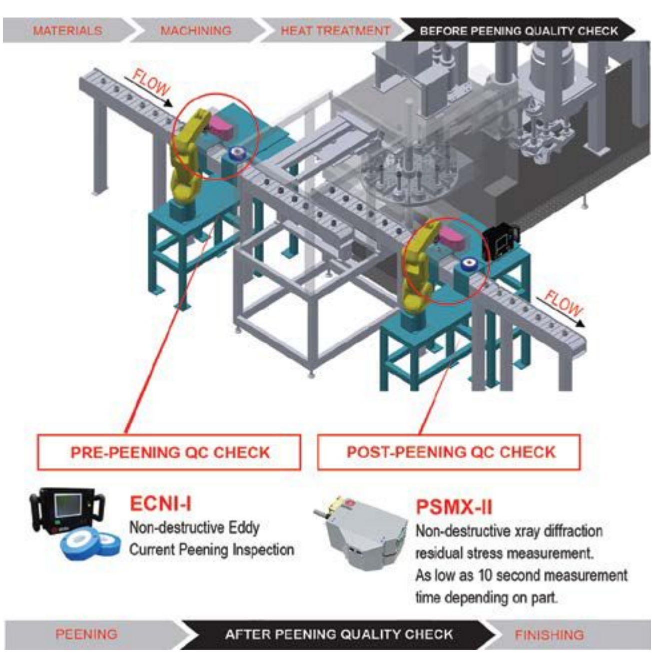
Clemco Industries is the world's largest manufacturer of air-powered abrasive blasting equipment used to clean, deburr, shot peen, remove coatings, finish or otherwise improve a surface being blasted. It manufactures contractor and industrial machines, as well as safety and blasting accessories, needed for just about any blasting operation, ranging from equipment for self-employed contractors to multimillion-dollar facilities for the U.S. military and its allies around the globe. If you need a machine or equipment for a specific application, we have it or can custom-engineer it for you.

Collect Residual Stress Data with Sightia in 10 Seconds

SINTO AMERICA, a global turnkey industrial solutions provider, launched Sightia™, a new surface evaluation technology that provides real time, non-destructive quality assurance checks for pre- and post-blasting or peening processes. Sightia™ is a class of technology encompassing a group of non-destructive testing equipment and services suitable for harsh industrial environment developed by Sinto America to evaluate surface properties of parts undergoing surface treatment processes and delivering accurate and repeatable results.

Sinto wants customers who are currently facing surface defects in their parts at different stages of manufacturing, including casting, machining, heat treatment and surface treatment processes, to overcome the challenges with the help of Sightia™ devices. Sightia is applicable for evaluating gears, springs, pins, fasteners and other cylindrical parts used within the automotive, aerospace, railway, infrastructure, construction and die-casting industries.

"This technology makes accurate, fast and consistent x-ray diffraction measurement possible. Sightia products are now proven in both the laboratory and in the field. Sightia allows for affordable 100% quality check on every part produced. Implementation is simple with Sinto's PSMX-I," said Charlie Gorman, VP Sinto Surface Treatment. Sightia's ECNI-I, a non-destructive peening inspection instrument, is used for detecting variation in machining, peening coverage and heat treatment. ECNI can detect defects on the surface of parts in just three seconds, ensuring 100% inspection without slowing down the production flow.



Sightia's PSMX-II, an x-ray residual stress measurement device, measures each product's surface residual stress without destroying it. With the PSMX-II, residual stress data can be collected in only ten seconds after parts have been peened. It is possible to inspect in-line by integration the technology into existing processes, making in-process quality control possible and minimizes distribution of defective products. Overall, Sightia provides a highly accurate, easy-to-use and reliable surface evaluation process.

Sightia's ECNI-I—a non-destructive peening inspection instrument

Sightia's PSMX-II—an x-ray residual stress measurement device

ABOUT Sinto America

Sinto America focuses on six primary markets- Foundry, Sand Processing, Bulk Material Handling, Automation, Surface Technologies and Surface Treatment. Sinto also provides contract blasting and precision shot peening services through our National Peening and Technical Metal Finishing divisions. Learn more at www.sintoamerica.com.

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Volker Schneidau and Wolfgang Hennig | www.sentenso.com

User-Specific Process Development Service for Shot Peening Applications

Process developments in shot peening applications are mostly an adaption from previous processes which have proven to fulfill requirements. What if companies are suffering from loss of experienced personnel, are facing new challenges in shot peening or are implementing shot peening for the first time? These challenges can be addressed by external experts with profound process know-how and vast experience.

Kumar Balan has described in his well-respected article series on tribal knowledge in shot peening that the loss of tribal knowledge is progressing. If substitutes do not grow in time, weakening of technical progress inside companies is the consequence. While universities and institutes perform a lot of peening research on very specific materials and thus create certain niche knowledge valid for only a small group of operators, we can find loss of practical knowledge in the industry. First and second generation shot peeners have left the process for reasons of internal redeployments, fluctuation or simply age. These effects have been reinforced by economic pressure and the pandemic.

CHALLENGING PROCESS DEVELOPMENTS

On the other hand, there is a strong need to control existing processes, improve surface enhancement effects, optimize utilization of the invested energy and to implement new peening processes to industrial parts which had not needed shot peening earlier. So what's the way out?

sentenso and its engineering partner, strahlportal, find an increasing market request for shot peening process development in the industry. While in the past most of these development requests came from the aerospace and automotive sector, new branches come into place now. As Wolfgang Hennig, process and training manager from sentenso reports, "Cutting and sawing tools or components with high pressure in small bores are typical examples for recent shot peening challenges. Moreover the sentenso team is facing extended peening targets on well-known parts like coil springs in sports cars or leaf springs in utility vehicles where new high-strength steels require more area specific and controlled shot peening."

Internal peening of a coil spring | Internal peening of blade slots in a rotor

WIDE AND DEEP PROCESS UNDERSTANDING REQUIRED

For such peening developments, wide and deep process understanding is essential. Most new peening processes require an experimental approach, iterative development steps and sometimes even modifications at the shot peening machine. For that kind of work vast process experience, specific engineering knowledge and strong affinity to practical work are the keys to success. In process development the achievements of digitalization and simulation will support but not at all replace the work of a collaborative team of experienced engineers and technicians.

sentenso founder and manager Volker Schneidau points out, "It should be fully recognized how machine settings like air pressure or wheel speed and media flow rate will lead to process parameters like media impact velocity and finally end up in quality parameters like intensity, coverage and, more importantly, residual stress distribution on the part. All these and several more parameters like media properties or nozzle and part movement interact with each others and require an appropriate combination of settings in order to keep the development time and costs affordable."

Flight direction and speed analysis at a blast lance for internal peening

And Wolfgang Hennig adds, "At this point it should be mentioned that the special quality characteristics, such as peening media properties, intensity and coverage, which are not common in other metal sectors, must be fully penetrated and understood. Due to the reason that knowledge in shot peening or in surface enhancement in general is mainly based on personal experiences and hardly integrated in practical mechanic training or academic engineering education, it

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is important to consider the time factor. Mostly it takes process engineers several years to gather enough background information, practical experience and, call it a feeling, for suitable process and quality parameters. This fact is very often underestimated in production and development departments, mainly on management levels."

But let's not just lament—it is better to see what we can do about it.

SOLUTIONS TO FUTURE DEVELOPMENT TASKS

1. Awareness

Our shot peening community should permanently insist on the importance and the benefits of surface enhancement in all related industry, research and development areas. We already see some promising trends in reputable engineering guidelines, in industrial research projects, and recent seminar programs of research associations and networks.

However, we cannot force companies to put more emphasis and implement serious control over shot peening based on know-how and machine technology. So we need to go further.

2. Training

Shot peening training is needed more than ever as tribal knowledge gets lost and requirements grow at the same time.

- The EI shot peening education program with standardized qualification levels is a very solid base for shot peening knowledge.
- We encourage more students with practical experience to take the Level 3 course and support the education with more high-level course material on the process and the quality parameters such as residual stresses.
- We should not forget that practical, hands-on shot peening training is crucial to the learning success. If this cannot be properly performed inside companies it should be integrated into the training curriculum.
- One other really helpful way to guide peening personnel is training on site where the trainer can easily address questions and tasks from every day work with the process and the machine.

Training will always form only part of the solution to challenging process development tasks. Even with reasonable qualification, process development inside companies is often limited by lack of suitable machines, machine controls, machine availability and time-to-market requirements.

3. External Process Development

Peening process development services can complement or even replace internal developments as a whole. There are several options to outsourcing this task. Advantages and disadvantages should be considered.

- In many cases it is the easiest way to start a cooperation with a machine manufacturer who provides an appropriate testing center. This can be a good solution if there is already a reliable relationship between the operating company and the machine manufacturer or if the manufacturer has very specific machinery available. The disadvantage could be a certain obligation towards the manufacturer and a limitation of technical solutions.
- It is also possible to bring processes to a shot peening service provider. There are several such providers in the market who have extended experience based on hundreds or thousands of earlier peening applications with similar requirements. In this case it is often not possible to gain control of all technical solutions of process parameters if the provider considers relevant parts of this information as confidential.
- A third way to external process development is the cooperation with a specialized engineering company for shot peening which provides consulting and testing capacities. Consequently companies need to pay for this service but will be fully supported with the engineers' expertise and the provisions of the testing facilities. The development work should be independent and transparent.

CUSTOMIZED PEENING PROCESSES

sentenso Smart Peening Solutions and its engineering partner strahlportal in Datteln, Germany are well-positioned for this type of work. Volker Schneidau says: "Even if sentenso is offering shot peening process and quality control equipment and the company also provides solutions to special requirements in machine engineering, our team is focused to follow the main principle in process development, always to find the best suitable solution to a customer peening task."

In order to achieve this goal sentenso has equipped its technology center with different air and wheel type shot peening machines, robotized nozzle and controlled part movement and tooling such as a big variety of peening nozzles. Part-holding fixtures and part verification tools (PVT) have to be customized. sentenso also provides all of its laboratory equipment including 3D microscope and fast and robotized stress measurement with single spot analysis of less than one minute on well accessible surface areas. These fast measurements allow for peening process optimization in extreme efficiency and a minimum of time. All information for the customer to implement

Discussions on an adequate process setup his own process is concentrated in a process report that documents the machine and part setup, the relevant process and consequential quality parameters.

Part verification tool with Almen strip holder

Due to the reason that residual stress distribution in the surface of a part can only be measured destructively, the in-process control tasks are essential for the peening machinery. The interpretation and repeatability of peening results needs detailed data acquisition and logging. Finally the way to success and especially the final process should be documented in order to create the basis for the main target—the process transfer into serial production.

Robotized residual stress measurement

CONCLUSIONS

Shot peening process developments can be challenging and time consuming. Limitations of human or technical resources, knowledge and experience may lead to the decision to use external service providers such as machine manufacturers, shot peening service providers or specialized engineering companies.

Process development is a journey which requires solutions to complex tasks as, for example, media type variation, intensity determination in difficult-to-reach areas, visual coverage development, edge inspections, topography analysis and often time consuming and costly, residual stress determination. For these tasks specialized skills are required which will mostly need a team of engineers, technicians and material experts who fully understand the development tasks. Moreover, it is very helpful if the team gathers knowledge and experience out of different branches such as aerospace, automotive or medical.

sentenso and strahlportal in Germany are well prepared to provide development services to international customers. In close cooperation with the process engineers, the peening task is realized with the required equipment. After its development, the process needs to be transferred from the test machine to the customer production machine. Such a process transfer is often less time consuming than a full process development on the production machine itself.


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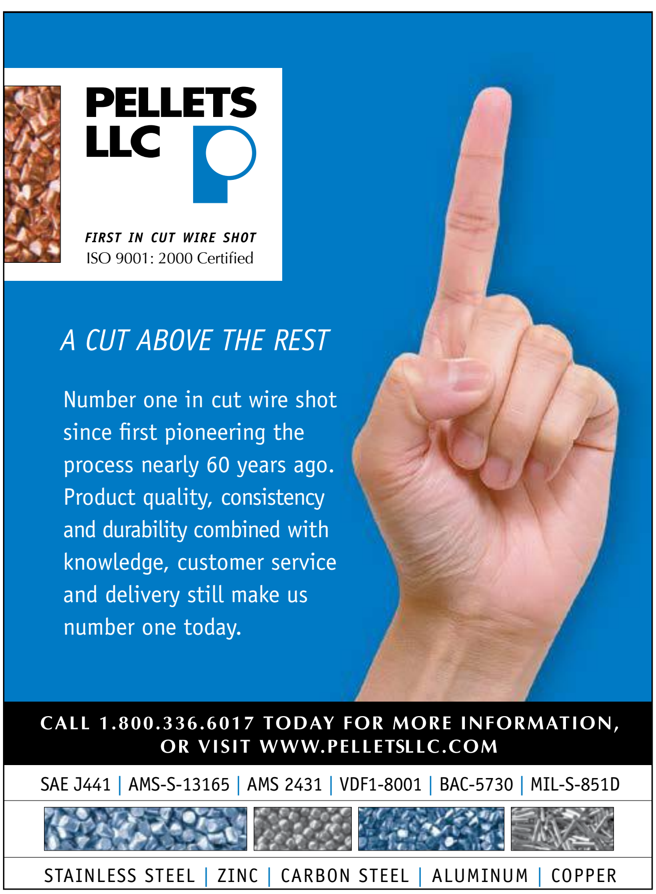
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