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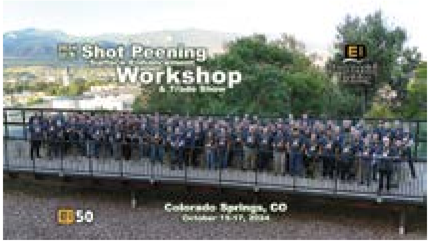
The Shot Peener

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

Jack Champaigne

2024 Shot Peener of the Year



The manual blast set-up for the testing program at Ervin's test lab. (See the article on page 12.)

A Progressive Surface robotic Shot Peen System will be installed in Purdue University's Materials and Manufacturing Research Laboratory.

THE SHOT PEENER
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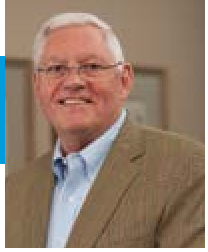

OPENING SHOT

Jack Champaigne | Editor | The Shot Peener

Shot Peening Research Thrives at Purdue University

The Purdue Center for Surface Engineering and Enhancement (CSEE) meeting in September validated the growth of materials engineering research in the USA.

The conference was a multiple industry consortia with participants from several Materials Engineering schools in attendance, including Heat Treating and Casting.

Representatives from over a dozen industries shared information on how to make surfaces of structural materials better.

The CSEE's industry sponsors link Purdue's research to real-life applications and this keeps manufacturing growing and current with today's fast moving technology processes.

Presentations relating to shot peening included:

- "Wear and Fatigue Behavior of Surface Modified Additively Manufactured Components" by Professors Michael Titus, Michael Sealy, and Paul Mort.
- Professors Paul Mort and David Johnson covered "Stress Mapping of Almen Strips, Correlating to Peened Parts."

An event at a local pub with the Purdue Heat Treating Consortium staff, Purdue faculty, and students was a great opportunity to network. Thank you to the Purdue team that made this event possible.

Langdon Feltner and Kumar Balan discuss the capabilities of the test stand supplied by senstenso. The pressure pot was donated by Clemco. Kumar represented Ervin Industries at the event—Ervin is an industry sponsor for CSEE.

Langdon Feltner, a Purdue Graduate Research Assistant, reviews the capabilities of the sentenso shot peening test stand at a demonstration in Purdue's Manufacturing and Materials Research Laboratories.

THE SHOT PEENER

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2024 Shot Peener of the Year
Jack Champaigne

THE TIMING was ideal this year to celebrate Jack Champaigne's standing in the shot peening community. Jack launched Electronics Inc. in 1974 and for the next 50 years, he has worked tirelessly to validate and support the shot peening industry. The following are a few of his pioneering contributions.

PRODUCTS

The MagnaValve. Jack's first major product was the MagnaValve®. EI now produces five MagnaValves for air-blast machines and 15 for wheel-blast machines. The MagnaValve is used in at least 74 countries for shot peening and wheel blast applications. Additional valves are in development.

One of the earliest MagnaValves and controllers

Almen Strips and Gages. Thanks to Jack's relentless pursuit of the best Almen strip on the market, EI's Almen strips are the "industry standard" worldwide.

Jack also extended the EI Almen gage family to include an Aero Almen gage and the mini-strip gage.

Rotary Flapper Peening Products. Jack recognized the aerospace industry's dependence on shot peening and began carrying the 3M rotary flap peening products because they are ideal for peening small areas on new or repaired parts. The success of these products were key in launching EI's flapper peening training. More on that in the next section.

WORKSHOPS, SEMINARS, TRADE SHOWS, AND ON-SITE TRAINING

"A rising tide lifts all the boats" could well be Jack's philosophy toward the shot peening community. (The quote is often contributed to John F. Kennedy.) Jack believed that educating product design managers, machine operators, foremen, supervisors, and maintenance and quality control engineers on how to do shot peening properly would elevate its position in manufacturing.

EI sponsored the first-ever annual Shot Peening and Blast Cleaning Workshop in 1991 in Atlanta, Georgia. From that time on, the shot peening industry became a more open, well-respected, and productive community.

EI continues to pick interesting and easily accessible locations in the USA for the workshops. Industry leaders are chosen as the instructors so participants gain practical knowledge they can take back to their facilities. Topics cover every aspect of shot peening, blast cleaning, and rotary flap peening.

EI Shot Peening Training now provides workshops, seminars and on-site instruction for military bases and companies worldwide.

Part of Jack's marketing genius was that he knew elevating shot peening would sell more EI products, too. Trade shows featuring EI products and other industry leaders are held in every EI USA workshop.

CERTIFICATE OF ACHIEVEMENT PROGRAM

Students are encouraged to take an exam after the workshop to show their company that they have acquired competency in the course curriculum. This inspired Jack to develop an Achievement Exam program. The Level I, II and III exams identify a higher level of shot peening performance for career advancement, spotlight the commitment of an organization to educational development, elevate professional standards, and promote the growth of qualified personnel throughout the industry. Almost 10,000 individuals have

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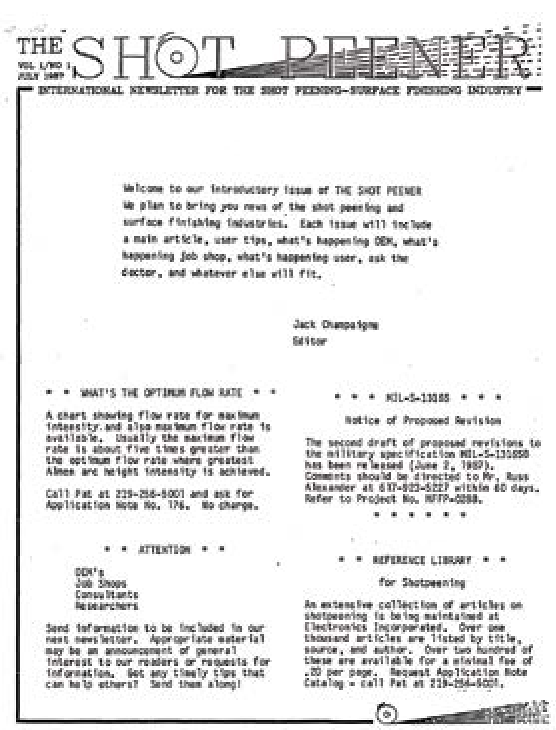
received a certification via these programs and the certificates are now displayed in facilities across the world.

In 2001, Jack Champaigne and Pete Bailey launched their unique on-site training program for the FAA—it was the first program of its kind and it was developed specifically for the FAA. The program was so well received that EI applied for and received designation as the only FAA-accepted source for shot peening inspector training. Aviation personnel enrolled in the FAA/AMT (Aviation Maintenance Technician) awards program and FAA auditors and inspectors could now receive credit toward their yearly FAA training requirement by taking EI's FAA-Accepted Courses and passing their Achievement Exam Program exams either through EI's workshops or on-site training programs.

Speaking of on-site training, EI also created on-site training for companies that want instruction on their own processes for a larger number of employees.

THE SHOT PEENER MAGAZINE

No one but Jack could foresee the need for a magazine for a niche market in the manufacturing world. *The Shot Peener* magazine started as four typewritten pages in 1987. EI used the magazine to sell its Almen strips and MagnaValves, and Jack invited other companies to promote their products. *The Shot Peener* covers topics of importance to a wide range of readers — from OEMs to engineers to academics to machine operators—and is distributed to over 76 countries.



THE SHOT PEENER

VOL 1/NO 1
JULY 1987

INTERNATIONAL NEWSLETTER FOR THE SHOT PEENING-SURFACE FINISHING INDUSTRY

Welcome to our introductory issue of THE SHOT PEENER. We plan to bring you news of the shot peening and surface finishing industries. Each issue will include a main article, user tips, what's happening OEM, what's happening job shop, what's happening user, ask the doctor, and whatever else will fit.

Jack Champaigne
Editor

* * WHAT'S THE OPTIMUM FLOW RATE * *

A chart showing flow rate for maximum intensity and also maximum flow rate is available. Usually the maximum flow rate is about five times greater than the optimum flow rate where greatest Almen arc height intensity is achieved.

Call Pat at 219-256-5001 and ask for Application Note No. 176. No charge.

* * ATTENTION * *

OEM's
Job Shops
Consultants
Researchers

Send information to be included in our next newsletter. Appropriate material may be an announcement of general interest to our readers or requests for information. Got any timely tips that can help others? Send them along!

* * * MIL-S-13165 * * *

Notice of Proposed Revision

The second draft of proposed revisions to the military specification MIL-S-13165B has been released (June 2, 1987). Comments should be directed to Mr. Russ Alexander at 617-923-5227 within 60 days. Refer to Project No. AFFP-0288.

* * * * * *

* * REFERENCE LIBRARY * *

for Shotpeening

An extensive collection of articles on shotpeening is being maintained at Electronics Incorporated. Over one thousand articles are listed by title, source, and author. Over two hundred of these are available for a minimal fee of .20 per page. Request Application Note Catalog - call Pat at 219-256-5001.

The first Shot Peener magazine was published in July, 1987

SHOT PEENER OF THE YEAR AWARD

In an another novel effort to elevate shot peening, as Editor of *The Shot Peener* magazine, Jack created the "Shot Peener of the Year" award in 1992. Every year since then, the magazine has given the award to individuals in the industry that have made significant contributions to the advancement of shot peening. (Visit www.theshotpeenermagazine.com for a complete list of recipients.)

PATENTS

The MagnaValve hasn't been Jack's only innovation—he along with other EI engineers have contributed to over 30 patents. He is developing patented processes and products to this day.

ONLINE LIBRARY (www.shotpeener.com)

Jack is a seeker of information and to hold his vast number of papers and articles, he introduced the first online library devoted to metal surface enhancement in 1995. In addition to the online library, the website includes current news, a Q & A Forum, Tools, and a Buyer's Guide.

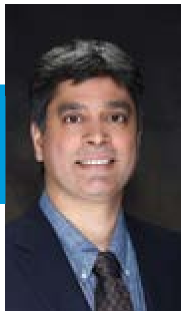
INDUSTRY ORGANIZATIONS

Jack has also contributed to the advancement of shot peening by volunteering his time to the International Committee on Shot Peening, the Surface Enhancement Division of Society of Automotive Engineers (SAE), and the Aerospace Metals Engineering Committee (AMEC) of the Aerospace Materials Division of the Society of Automotive Engineers. Mr. Champaigne was appointed Chairman of the International Scientific Committee on Shot Peening (ISCSP) in 1996 and was the host of the Sixth International Conference on Shot Peening held in San Francisco, California. He was also the ISCSP Chairman and host of the Eleventh International Conference on Shot Peening in 2011 when the conference was held in South Bend, Indiana.

"My career is full of serendipities. It's hard to believe that my first 50 years at Electronics Inc. is here. The next 50 years should be just as exciting. My work with Wheelabrator in 1979 led to controls and valves for Boeing peen forming. After we satisfied the need for air pollution controls, I dedicated my efforts to valves and controls for shot peening applications. The first workshop in Atlanta in 1991 then led to on-site training opportunities in the US and foreign countries. Step by step the story unfolded—*The Shot Peener* magazine, the web site www.shotpeener.com, participation in the International Scientific Committee, and the SAE committees. It all blurs; it past too fast. As the market started to expand we added distributors in foreign countries (now over 20). The future wasn't clear but I sensed that surface integrity was a large opportunity for growth. I am so grateful for all of the wonderful people I have had the privilege to work with, especially Prof. Dr. David Kirk who has now retired. We will dedicate a future issue of *The Shot Peener* magazine to his legacy." —Jack Champaigne

The 2024 USA Workshop

Colorado Springs, Colorado • October 15-17



AN INSIDER'S PERSPECTIVE

Kumar Balan | Blast Cleaning and Shot Peening Specialist

The Logic Behind Selecting Hard Media

INTRODUCTION

The great Leonardo da Vinci, in current times, would have been considered an individual with unsure prospects due to his variable interests. He was an active painter, draughtsman, engineer, scientist, theorist, sculptor, and architect (and you thought your life was difficult because you had to re-plot a saturation curve due to media contamination). Nevertheless, one of his quotes reads, "Nature is the source of all true knowledge. She has her own logic, her own laws, she has no effect without cause nor invention without necessity." Incapable of such profound thoughts, I am going to plagiarize his revelation into a relevant article for our discussions here!

Recently, I was trying to analyze the actions of a customer that attempted to optimize their cleaning process. This customer had determined that changing shot size from S-230 to S-330 would give them better quality cleaning, reduced re-blast and other related benefits—all positively impacting productivity. This exercise did result in some process improvements but there was a price to pay with the use of a larger size media. Tight geometries on their structural steel fabrication remained uncleaned. I attributed this to the fact that due to its relatively larger size, S-330 had less particles per pound of shot than S-230. Further, the reduced percentage of small particles in their work mix might have contributed to lack of "scouring" action that was previously carried out by smaller particles of abrasive. Cause and effect were clear and obvious.

Yet another example I present is with a customer that peens parts for the oil and gas industry. Since they were peening an experimental part to prove-out the benefits of shot peening, they were at liberty to select media size without being constrained by a drawing or specification that limited the peening media size they could use. They were pleased with the intensity and coverage provided by S-460 until their design team demanded a marginal but higher intensity than before. Upon deliberation, and the desire to keep the rate of coverage unchanged, they stayed with the same shot size but switched to a higher hardness to achieve their increased intensity target retaining their original cycle time for 100% coverage. Cause and effect resulted in a positive outcome this time! I often remind myself to bring this up with product and process designers for consideration before switching shot sizes.

When this topic comes up for discussion at peening workshops, I explain that switching to a higher hardness grade will result in a 0.0015" to 0.002" increase in intensity. Further, I have also informed my class, purely from anecdotal reports, that this increment in intensity is exponentially higher with larger shot sizes such as S-460 and above. It was time to test out these hypotheses, and I managed to do so recently at Ervin's test lab in Tecumseh, Michigan.

THE TEST PROCESS

Common applications are served by S-110, S-170 and S-230 sizes of cast steel shot. To address non-Aerospace and high intensity applications such as in Railway and Oil & Gas, I also included S-550 in my testing. As you know, AMS grade media is manufactured in two hardness ranges (ASR: 45 to 52 HRC and ASH: 55 to 62 HRC). However, SAE grade media, or media designated for land-based vehicles, is manufactured in four different grades of hardness: 40 to 51 HRC (categorized as standard hardness, 'S' by Ervin Industries), 47 to 56 HRC (M hardness), 54 to 61 HRC (L hardness) and min 60 HRC (H hardness). For the purposes of my tests, I used S, M and H hardness ranges of media in all sizes listed above.

Along with SAE grade media, I also tested with ASR170 and ASH170 to compare outcomes. In addition to the difference in hardness grades, AMS grade media (or MILSPEC as some continue to refer to it as) is screened to a tighter tolerance and conditioned to remove mis-shaped particles—generally held to a tighter manufacturing tolerance. Since my test would involve multiple media changes (11 to be exact), I elected to use a small pressure blast cabinet with vacuum recovery system and manual blast capability. A centrifugal wheelblast machine would have resulted in insufficient clean-out of the previous media size and potential cross-contamination. My previous experience with peening experiments in a test lab with wheelblast machines and multiple media sizes regularly resulted in cross-contamination between media sizes with the inevitable double-knee saturation curve (the first knee from the smaller media size, followed by the second representing the larger media). Therefore, a wheelblast machine was

not an option for my test. The media that I used for my tests was unused and based on experience I know that screening practices at Ervin will guarantee particle size distribution conforming to SAE J-444 and AMS 2431/1 or /2 as applicable. Media breakdown was not a significant criterion given the few cycles that my testing consisted of.

Majority of peening applications, particularly in Aerospace, tend to be with airblast machines. Therefore, I created a baseline by developing saturation curves at 40 PSI. In order to draw parallels with the velocity generated in a wheelblast machine, I developed another set of saturation curves under similar conditions except at 70 PSI. Field data gathered over the past has indicated that velocity in the range of 250 to 270 FPS is generated at 70 PSI. This is the range where most wheelblast peening applications operate.

Pros of this test

1. Manual operation allowed an 80–85 degree impact angle on the Almen strip
2. Small blast cabinet provided a highly controlled environment with minimal cross-contamination
3. Small cabinet limited the variability of stand-off distance
4. Rapid media changeover due to the size of the cabinet and reclaim system

Cons of this test

1. Holding the nozzle in a steady fashion in relation to the Almen strip was challenging at high pressures, particularly with large media sizes.
2. Though 70 PSI testing was to simulate a blast wheel, several other factors such as wheel condition and settings (control cage, impeller, and blades) will also influence the outcome. This was difficult to simulate in my test.

Other constant parameters in my testing included a stand-off distance between 4" to 6", media flow rate of 6 lb per minute using a ¼" nozzle for smaller sizes and a 3/8" for S-550. My goal as stated earlier was to study the effect of media hardness on intensity values so that I could guide my blast clean and shot peen users on their media choice. In spite of some of the constraints (cons) listed above, I am hopeful that this exercise will achieve the desired outcome.

Figure 1. Manual blast test set-up

THE OUTCOME

Let us start with some fundamental information on the peening media that was chosen for the tests. Table 1 lists nominal diameters of different shot sizes along with their volumes. Volumetric increase is quite significant from one size to the other in our choice of sizes; notwithstanding the fact that a few SAE sizes have not been listed and tested between S-230 and S-550. This data might partly explain the results depicted in Chart 1 on page 16.

1. The spike in intensity values is consistent between standard and M hardness shot, i.e., from 40-51 to 47-56 HRC, between 30-40%.
2. The percentage increase in calculated intensity is higher going from M to H hardness (47-56 to min. 60 HRC), with increase in shot size. As to be expected, increase in intensity from standard to high hardness is significant. Is that justification enough to use a harder shot simply to take advantage of the high-particle count? It is important to remember that hard particles are also more brittle and susceptible to fracture faster than their softer counterparts. In shot peening applications, one of the goals in media maintenance is to keep sharp edges generated from broken particles out of the media stream.
3. Increase in particle volume and mass (mass = density x volume) could be an obvious reason contributing to this spike.

	Nominal diameter	Volume	Increase	Range	Particles/lb
	Inches	Cubic Inches			
S-110	0.011	0.0000007			2,100,000
S-170	0.017	0.0000026	269%	S-110 to S-170	745,000
S-230	0.023	0.0000064	148%	S-170 to S-230	324,000
S-550	0.055	0.0000871	1267%	S-230 to S-550	240,000

Table 1: Volume of different shot sizes

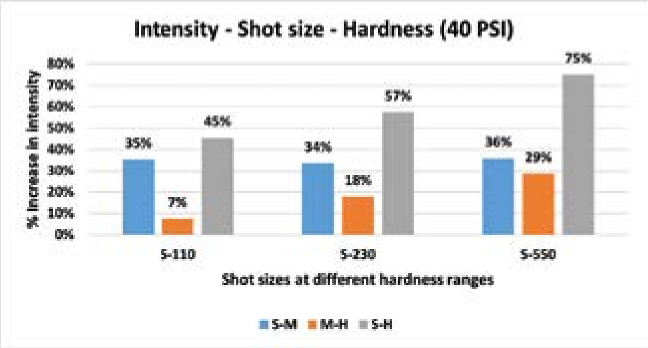


Chart 1: Characterization of three common media sizes at different hardness ranges

70 PSI			
	S-M	M-H	S-H
S-110	31%	3%	35%
S-230	39%	10%	53%

Table 2: Increase in intensity between different hardness ranges at 70 PSI

	40 PSI	70 PSI
ASR-ASH170	31%	34%

Table 3: AMS grade media performance

4. Chart 1 depicts results when peened at 40 PSI. The results were comparable when peened at 70 PSI to mimic wheelblast velocities. Similar results were noticed with AMS (formerly MILSPEC) grade media.
5. Though the tests were carried out with only cast steel shot, a similar outcome can be logically expected with regular and high hardness conditioned cut wire.

CHALLENGES AND ANOMALIES

- One of the challenges of peening anything manually, including an Almen strip, is that it achieves coverage quite rapidly. Therefore, at low air pressures and small media sizes, the possibility of achieving saturation before the first data point is quite high. My first data point was at 15 seconds—peening for shorter duration than was impractical.
- Among a total of 19 saturation curves, I finished with three, type 2 saturation curves. Though a type 2 curve doesn't necessarily imply an error in the process, it is important to be able to identify a potential incorrect data point falsifying type 2 curve conditions. In such cases, it is best to repeat the data point or the entire exercise if necessary.
- I noticed an anomaly during the AMS media portion of the test. Whereas all tests were conducted with a media flow rate of 6 lb/min, an incorrect valve adjustment resulted in a 12 lb per minute flow rate with ASR170 at 40 PSI. When the error was detected (the nozzle appeared to be choking), the valve was closed a few rounds to reduce the flow to 6 lb/min and testing continued. The recorded arc heights and resulting intensity surprisingly showed very little variation from the high flow rate condition, leading to anomalous conclusions. *I would have expected the intensity to increase with reduced media flow.*

HOW IS THIS DATA USEFUL?

1. The tests validate the possibility of using higher hardness peening media to achieve higher intensity values. The quantitative data validates that this increase can be made in stages with the first stage (S-M) leading to a significant jump in intensity. It is useful to point out here that hardening transforms the metal, in our case, media particle to a stronger structure and a different metallurgical state. The downside to this transformation is that it becomes brittle and easier to break.
2. A direct result of using hardened material is that the increase in intensity will not be at the cost of reduced coverage. On the contrary, coverage will be impacted (slower) had you opted for a larger size shot to achieve the same goal.
3. It is useful to know that the trend is the same at different air pressures (especially in the range of velocity generated by a centrifugal blast wheel).
4. Applications that have the flexibility to peen with SAE grade media can test four different hardness grades (instead of two with AMS grade) to determine the optimum balance between intensity, coverage, shot size and hardness (taking media breakdown into consideration).
5. All the above apply to cleaning applications as well where tenacious scale or rust might require the use of harder media without affecting cycle time or re-clean potential.

FUTURE STEPS

I have often commented on the slow pace of development in our industry, but there are still a lot of nuances that when explored could make peening (and cleaning) much more effective. Some future possibilities include:

- Filling the blanks and creating a matrix with other media sizes that were not tested.
- Non-metallic peening media such as glass bead and ceramic. Possibly conduct similar tests with aluminum oxide, commonly used in grit blasting Aerospace parts prior to thermal spray. Our goal is to study the change in impact energy with hardness, and this energy is vital in cleaning as well as grit blasting in terms of creating uniform surface topography.
- Media degradation (metallic and non-metallic) and its effect on intensity.
- Creating a similar set of data with suction guns (with non-metallic peening media and small size shot).

I look forward to reporting on the above as we continue on our path!

Acknowledgment: I would like to thank the Ervin team consisting of Cory Smith, Mark Hash, Michael Konecny, and Sarah Robertson for their efforts to help with this test.

Progressive Surface to Install Shot Peening Equipment in Purdue Manufacturing Lab

Progressive Surface, Inc., of Grand Rapids, Michigan, and Purdue University's School of Materials Engineering (MSE) have entered into an agreement for Progressive Surface to install pilot-scale robotic shot peening equipment into Purdue University's Materials and Manufacturing Research Laboratory (MMRL). The equipment is slated to be operational by mid-2025 and it will be demonstrated during the International Conference on Shot Peening (ICSP15). ICSP15 will be hosted by MSE in September 2025 in conjunction with MSE's Center for Surface Engineering and Enhancement (CSEE).

A Progressive Surface robotic Shot Peen System will be installed in Purdue University's Materials and Manufacturing Research Laboratory.

Professor Dave Bahr, Head of MSE and Chairman of ICSP15 and Executive Director of CSEE, said, "There are a number of outstanding companies in the greater than $5 billion per year global shot peening industry. While we're excited to partner with many of them in CSEE and ICSP15, we're particularly grateful to be engaged with Progressive Surface to supply this equipment. This peener, when coupled with our existing peening test stand, will enable our continued graduate and undergraduate research into shot peening as well as provide our industrial collaborators the unique setting in MMRL to gain insights into a broad array of world-class manufacturing processes."

Jim Whalen, President of Progressive Surface, commented, "We're pleased to be expanding our partnership with MSE by providing this equipment. Our relationship has significantly grown during the last several years as made evident by our participation in CSEE and multiple shot peening focused projects that have effectively blended relevant industrial surface engineering topics with first-class academic principals."

ICSP15 Update

Conference Topics

- Corrosion Performance
- Fatigue Performance
- Forming
- General Surface Engineering
- Industrial Applications
- Laser Peening
- Process Parameters
- Residual Stress Measurements
- Shot Peening Modeling
- Surface and Surface Layer Properties

Topics are subject to change as the conference date of September 22, 2025 approaches.

Exhibition Opportunities

Starting in early October 2024, booth spaces were assigned to companies that committed to exhibit space. Please contact Mark Gruninger at mgruninger@purdue.edu to see if booth spaces are still available.

WE HAVE THE WORLD COVERED

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

HIGH DURABILITY CUT WIRE SHOT (REDUCTION OF WASTE)
NON-DISTRUCTIVE INSPECTION DEVICE (POSITRON SURFACE ANALYSIS)

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

PEENING PROCESS USING NEEDLE PEENING EQUIPMENT FOR WELDED INFRASTRUCTURE (BRIDGE AND VESSEL)
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PRESS RELEASE
Malyn Industrial Ceramics, Inc. | *https://malyn.com*

Malyn, the Last U.S. Manufacturer of Boron Carbide Nozzles, is on the Market

Malyn Industrial Ceramics, Inc.
https://malyn.com

Michael Malyn, owner and President of Malyn Industrial Ceramics, Inc. (MICI), has announced his retirement and his plans to sell the company. "My wife, Patricia, and I started this business 38 years ago. While it had its ups and downs, it has been a pleasure to work together all these years. Having our daughter, Christina, join us about 20 years ago made it even more special. This past year I turned 80 years old and we decided that we are not getting younger and there a few things we would like to do before our time is up. With that in mind, I contacted my dearest customers to let them know that Malyn Industrial Ceramics, Inc. will be going up for sale," said Mr. Malyn.

If a Malyn customer doesn't purchase the company, Mr. Malyn plans to offer the company on the global market. "I am sure your readers know this is a very niche market, but some of you may not know that we are the last manufacturer of boron carbide nozzles in the U.S. Boron carbide is ideal for nozzles for shot peening because it's very durable and dependable. It's third in hardness only to diamond and cubic boron nitride."

Malyn Industrial Ceramics, Inc. was founded by Mr. Malyn in 1986 in the small town of Akron, New York. Establishing the unknown company was difficult, but Mr. Malyn did test parts for clients and the company quickly gained a reputation for on-time delivery of affordable, high-quality products. Today, MICI ships custom-made boron carbide nozzles and other boron carbide components around the world.

Until the company is sold, it is under the management of the family team that prides themselves on immediate response and personal contact. "Our business is strong, which is a blessing, and we look forward to a successful transition to new ownership," said Mr. Malyn.

For more information on Malyn Industrial Ceramics, Inc., contact Michael Malyn at 716-741-1510.

Editor's Note

Mayln has been a loyal advertiser in *The Shot Peener* magazine and the company participated in many EI Shot Peening training workshops.

Michael and Patricia will be missed by the shot peening community but we wish them a very happy retirement.

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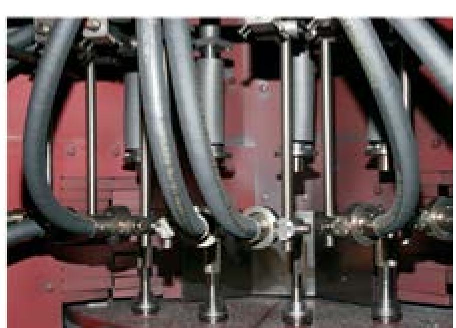

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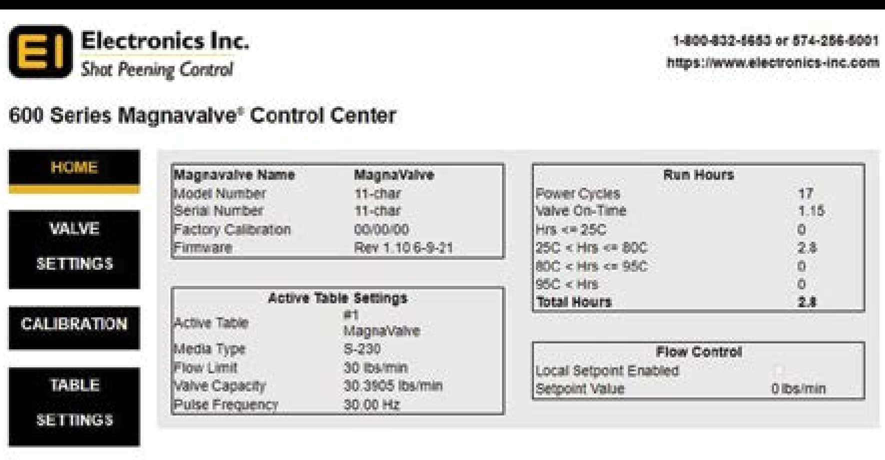

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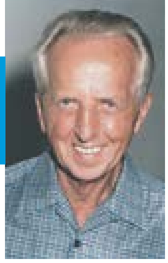

ACADEMIC STUDY

Dr. David Kirk | Coventry University

Two Strip Setting-Up and Verification Program for Peening Intensity

INTRODUCTION

The most accurate method of estimating peening intensity is to produce and analyze a saturation curve constructed from the arc heights of four (or preferably more) peened Almen strips. There are, however, situations where it is expedient to employ a quicker, albeit less accurate, method. These include when a new set-up is being developed and when an established set-up has to be periodically verified. This article presents a simple computer program that optimizes two-strip setting-up and verification testing.

Fig.1 shows the basic features of peening intensity estimation based on the arc heights of four Almen strips peened for different time periods. These time periods can be actual times but are commonly integral numbers of passes or strokes of the shot stream over the Almen strip. The peening intensity is preferably estimated as the unique 'time' for which doubling that time produces a precise 10% increase in arc height. That unique time, **T**, will rarely coincide with an integral number of passes. Moreover, each strip's arc height falls somewhere within an error band. Computer programs, such as the Solver suite, easily and objectively derive the unique peening intensity, **H**, that occurs at the defined time, **T**. The required objective is that **H** shall lie between user-defined upper and lower values.

A feature of saturation curves is that, for a steady shot stream, they all have a characteristic shape. This shape corresponds to a mathematical equation. The set of data points (arc height versus peening time) can be computer fitted to a known mathematical equation.

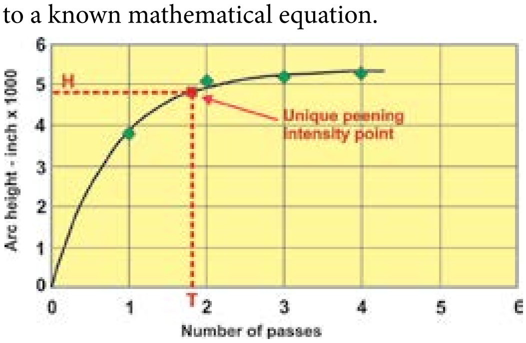

*Fig.1 Unique peening intensity, **H**, occurring at the defined time, **T**.*

PRINCIPLE OF THE TWO-STRIP PROGRAM

The simplest mathematical equations that reasonably represent saturation curve shape contain only two parameters, **a** and **b**. Two such equations are the rational and exponential functions:

h = a*t/(b + t) and

h = a(1 – exp(-b*t))

where **h** is arc height and **t** is peening time.

Two data points are produced having coordinates $\mathbf{h_1.t}$ and $\mathbf{h_2.2t}$. Note that the second peening time, **2t**, has to be double that of the first peening time, **t**. These two data points are assumed to lie exactly on a two-parameter equation's curve, as illustrated in fig.2. The co-ordinates of the two data points are then used to 'solve' the equation for its parameters **a** and **b** and hence determine the equation's unique peening intensity value, **H**, at a corresponding peening time, **T**.

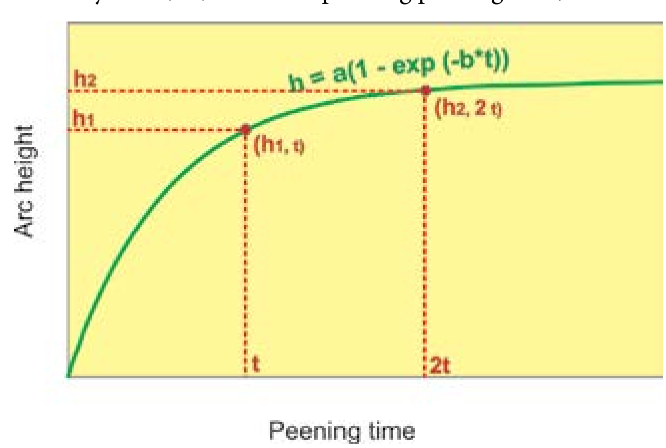

Fig.2 Two data points, (h1, t) and (h2, 2t), lying exactly on a two-parameter curve.

Solving of Equation for its Parameters, a and b.

The following description is only of the methodology required to solve equations. Details of the solution process are contained in the Appendix to this article.

Solving of any type of two-parameter equation is based on manipulating a pair of simultaneous equations'. The pair is obtained by substituting the two measured values of both **h** and **t** ($\mathbf{h_1.t}$ and $\mathbf{h_2.2t}$) into the curve's equation. Manipulation

of this pair of simultaneous equations allows one parameter to be eliminated—hence yielding the value of the remaining parameter. Having determined that parameter its value is substituted into the equation to yield the value of the second parameter.

The manipulation and substitution routines required for the two quoted equations yield the following general expressions for **a** and **b**:

Equation	a	b
$h = a*t/(b + t)$	$h_1*h_2/(2h_1 - h_2)$	$2t(h_2 - h_1)/((2h_1 - h_2)$
$h = a(1 - exp(-b*t))$	$h1\^{}2/(2h_1 - h_2)$	$-ln(h_2/h_1 - 1)/t$

Peening intensity, H, at Time, T, obtained by using Parameters a and b.

For the rational function equation the unique peening intensity, **H**, is **9*a/11** at a time, **T**, of **9*b/2**. For the exponential function, **H** is **0.9*a** at a time, **T**, of **2.303/b**. Hence we have the following general expressions for **H** and **T**:

Equation	H	T
$h = a*t/(b + t)$	$9*h_1*h_2/(11(2h_1 - h_2))$	$9*t(h_2 - h_1)/(2h_1 - h_2)$
$h = a(1 - exp(-b*t))$	$0.9*(h_1\^{}2)/(2h_1 - h_2)$	$-2.303*t/ln(h_2/h_1 - 1)$

TWO-STRIP PROGRAM

The expressions described in the previous section have been used to compile an Excel-based program. Fig.3 is a sample of the program's worksheet. For this sample, 'perfect' data point values have been used (h2 being exactly 10% greater than h1).

TWO-STRIP PEENING INTENSITY ESTIMATOR for SET-UP and VERIFICATION

A	h = a[1-exp(-b*t)]
t	2
h1 @ t	11.00
h2 @ 2t	12.1
H =	11.00
T =	2.00

B	h = a*t/(b + t)
t	2
h1 @ t	11.00
h2 @ 2t	12.1
H =	11.00
T =	2.00

Fig.3 Example of Excel worksheet for Two-strip Estimator program

With 'perfect' values the first data point coincides exactly with the unique peening intensity, **H**, and is at the unique time, **T**. The second 'perfect' data point, at **2T** has an arc height exactly 10% greater than **H**. For such a perfect pair of data points every equation representing a saturation curve must yield exactly the same values for **H** and **T**. Normally, however, the first of the pair of data points will be different from **H,T**. The derived **H** and **T** values will then depend, slightly, upon the particular equation that is being used. The difference will only be substantial if the first data point is a long way away from **H,T**.

SETTING-UP PROCEDURE

Setting-up of a new peening project has two prime objectives. These are to ensure that the control factors (air pressure/ wheel speed, shot size, feed rate, nozzle diameter, stand-off distance etc.) produce:

1) A peening intensity that is within the customer-specified range and
2) the required level of coverage in an economical time.

The level of expertise, prior knowledge and experience that is applied during setting-up will determine how closely an operator can forecast the shot stream's intensity and the time needed to reach the intensity point.

There is no direct connection between peening intensity and coverage. There is, however, a direct connection between coverage and the time, **T**, at which the unique intensity, **H**, occurs. For example, it may be known from previous experience, that a particular component/ material reaches a nominal "100% coverage" in a time 50% greater than that to reach **T** (on Almen strips). If a customer requires "300% coverage" and **T** is found on setting-up to be, say, 2.4 passes then we will need 1.5 x 2.4 x 3 passes = 10.8 (or 11 as an integral number of passes).

Real test data is used in the following Case Study – everything else is hypothetical.

Case Study: Two-point Setting-Up Tests based on SAE Data Set No.3

An example of what could have been several two-point setting-up tests is shown in fig.4. This is, in fact, SAE Data Set No.3. This data set is tested using, for simplicity, only Curve A of the program.

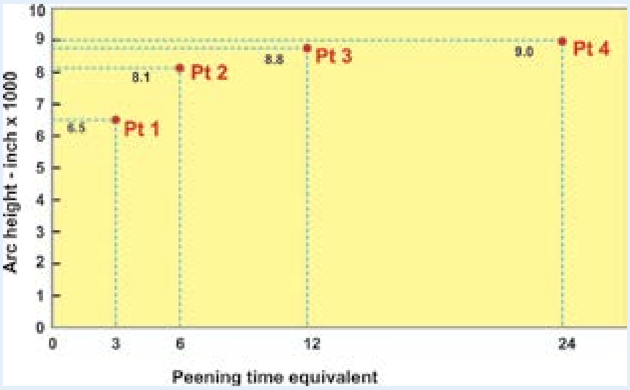

Fig.4 Four data points produced for a given shot stream.

For this study it has to be imagined that three pairs of points were produced independently by three different operators.

1 Imagine that the first operator's best guess for a two point setting-up gave points 1 and 2. Feeding the values t = 3, h1=6.5 and h2=8.1 into the computer program predicts that the peening intensity point will be **H = 7.8 @ T = 4.9**.

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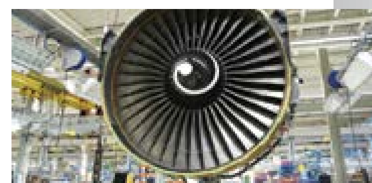

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2 Imagine next that a second operator's best guess gave points 2 and 3. The computer program now predicts that the peening intensity point will be **H = 8.0 @ T = 5.6**.

3 A third operator's best guess gave the points 3 and 4. The computer program now predicts that the peening intensity point will be **H = 8.1 @ T = 7.3**.

The three predictions can now be tested against the customer's intensity requirement and against each other. All three predictions of peening intensity, **H**, are reasonably close to one another. If the customer's intensity requirement range had been, say, 6 to 10, then it could have been assumed 12 that the machine settings were good—whichever of the three point pairings had actually been produced. It would then have been worth producing a full saturation curve. If, on the other hand, the customer's intensity requirement range was 10 to 14, then machine settings would have to be modified. For a required range of 8 to 10, the predictions would indicate that a slight 'tweaking' of one or more settings to increase the peening intensity would be advantageous.

The three predictions can be tested against each other by comparing them with the saturation curve peening intensity derived using all four points. Fig.5 shows the effect of saturation curve analysis using the Solver 2EXP program.

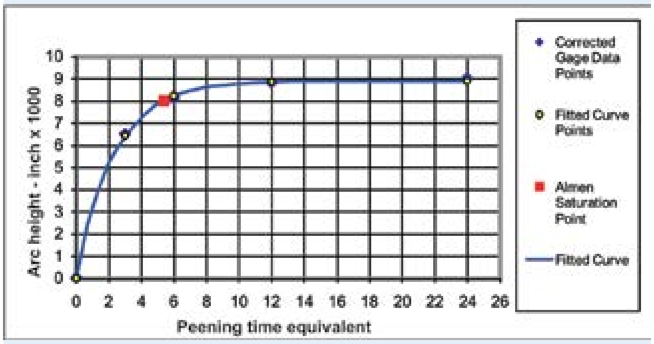

Fig.5 Solver 2EXP analysis of the four data points given in fig.4

Analysis using the Solver 2EXP program on all four data points indicates that the best estimate of peening intensity is **H = 8.0 @ T = 5.4**. The three imagined two point predictions were **H = 7.8 @ T = 4.9**, **H = 8.0 @ T = 5.6** and **H = 8.1 @ T = 7.3**. It can be seen that the intermediate pair of points (with times of 6 and 12) gives the closest match to that from all four points. That is because the time, 6, of the first point of that pair is closest to the unique peening intensity time of **T = 5.4**.

VERIFICATION PROCEDURES

Shot peeners are required to verify, at regular intervals, that the shot stream's intensity continues to be within the specified range. A balance has to be struck between excessive and inadequate testing. The simplest verification tests require only one strip to be peened. Earlier specifications required that this strip be peened at the peening intensity time, **T**. This is clearly impossible if **T** is not an integral number of passes/strokes/table rotations. The latest version of SAE J443 addresses this problem and allows the single strip to be peened at the nearest practicable time to **T**. The arc height reading from the single strip "must repeat the value from the saturation curve plus or minus 0.038 mm (± 0.0015 in)."

A central problem with single-strip procedures is that they cannot possibly verify that the shot stream's intensity is being maintained! That is because an infinite number of saturation curves can pass through any one point (and the origin 0,0). Fig.6 illustrates this phenomenon and includes the fitted curve shown in fig.5. That fitted curve has a derived peening intensity of 8.0 occurring at a time, **T**, of 5.4 passes. Two additional saturation curves are shown in fig.6 having peening intensities of 9.0 and 13.5 respectively. Both curves pass through the point (5.4, 8.0).

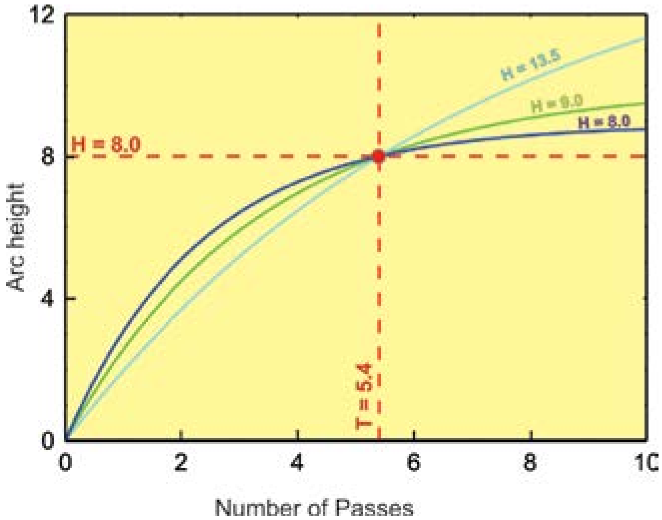

Fig.6 Different peening intensity saturation curves passing through the same point (8.0, 5.4).

If the original setting-up corresponds, for example, to a peening intensity of 8.0 then a single-strip verification arc height of 8.0 only means that the peening intensity is probably somewhere between 7.3 and a very much higher value!

An alternative to single-strip verification is two-strip verification. This is more expensive than single-strip verification. It does, however, afford some confidence that a given peening intensity is being maintained. Two-strip verification is currently employed in a number of organizations. The requirements for arc heights vary between organizations. It is suggested that the two-strip program shown in fig.2 could be employed for verification testing. The strips should be peened for times of **t** and **2t** where **t** is the nearest integral number of passes to the derived saturation peening intensity time, **T**.


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For example, if the full saturation curve was as shown in fig.5 then verification testing could be carried out at times of 5 and 10. If, for example, peening at those times gave arc heights of 7.9 and 8.6 respectively then those values could be substituted into the program. This, in fact, gives an estimated peening intensity of 7.8, 0.2 less than the 8.0 from the full curve but well within the J443 suggested range of ±1.5 (in thousandths of an inch). As a second example, if peening at times of 5 and 10 gave arc heights of 6.4 and 9.3 then the program would predict that the shot stream's intensity was 10.5 – 2.5 different from an 8.0 from the full saturation curve value of 8.0 and outside of the J443 suggested range of ±1.5.

DISCUSSION

The engineering industry progresses by embracing new ideas. Advances in computer-based technology and software have given rise to a huge range of new ideas and procedures. Reluctance to embrace these impedes progress and reduces competitiveness. The arc heights of peened Almen strips are an invaluable source of information when collected and stored effectively. That leads to an argument that the most effective utilization of arc height data should be computer-based. Techniques are already available for transferring arc height data directly from an Almen gage to an Excel spreadsheet. This data can then be used for a variety of purposes e.g. producing and analyzing saturation curves, setting-up and verification.

Optimum setting-up procedures require an efficient combination of operator experience and prediction technique. The two-strip program described in this article optimizes the prediction technique aspect but requires an initial 'best guess' as to the machine settings that will deliver the required peening intensity in an acceptable time. This 'best guess' can be based either entirely on an operator's prior knowledge or can invoke computer-stored data from previous setting-ups. Provided that the 'best guess' is reasonably good then peening of just two strips will be an effective guide to the adjustments necessary to complete setting-up.

Verification based on peening two strips and using the program described in this article is objective and efficient. Attempts to verify peening intensity by using only one strip are fundamentally flawed. That is because, as shown, any number of saturation curve—with different peening intensities—can pass through a single specified combination of verification time and arc height. The different peening intensity curves shown in fig.6 would arise, for example, through a combination of changes of both shot flow rate and shot velocity.

The two-strip setting-up and verification program is available, at no charge, from www.shotpeener.com.

Appendix

MATHEMATICAL SOLUTION OF TWO-EXPONENT RATIONAL AND EXPONENTIAL FUNCTIONS USING TWO DATA POINTS

Rational function: h = a*t/(b + t)

Substituting the two data points (h2,2t) and (h1,t) into the rational function equation gives the following pair of simultaneous equations:

h2 = a*2t/(b + 2t) and (1)

h1 = a*t/(b + t) (2)

Dividing equation (1) by equation (2) immediately eliminates **a**, giving that:

h2(b + 2t) = 2*h1(b + t) (3)

Applying some algebraic manipulation to equation (3) yields that:

b = 2*t(h2 – h1)/(2h1 – h2) (4)

Equation (4) is the required solution for **b** as all of the terms on the right-hand side are known.

Equation (2) can be re-arranged as **a = h1(b + t)/t**. Substituting the now known expression for **b** gives that:

a = h1{2*t(h1 – h2)/(h2 – 2h1) + t} (5)

Again applying algebraic manipulation to equation (5) gives:

a = h1*h2/(2*h1 – h2) (6)

Equation (6) is the required solution for **a** as all of the terms on the right-hand side are known.

The unique value **H** (for which doubling the peening time increases **H** by 10.0%) is given by **H = 9*a/11** so that the required equation is:

H = 9*h1*h2/(11(2*h1 – h2)) (7)

The unique time, **T**, that corresponds to **H** on the rational function curve is given by **T = 9*b/2**. Substituting the value for **b** given by equation (4) yields the required equation for **T**:

T = 9*t(h1 – h2)/(h2 – 2h1) (8)

Exponential function: h = a(1 – exp(-b*t))

Substituting the two data points (h2,2t) and (h1,t) into the exponential function equation gives the following pair of simultaneous equations:

h2 = a[1 - exp(-b*2t)]and (9)

h1 = a[1 – exp(-b*t)] (10)

Equation (9) can be written as:

h2 = a[(1 – exp(-b*t)*(1 + exp(-b*t)] (11)

Dividing equation (11) by equation (10) eliminates **a** to give that **h2/h1 = 1 + exp(-b*t)**. Taking natural logarithms on both sides and re-arranging yields:

b = -ln(h2/h1 – 1)/t (12)

which is the required solution for **b**.

Substituting the value for **b** given by equation (12) into equation (10) and doing some re-arrangement gives that

a = h1/[1 – exp(ln(h2/h1 – 1)]. This simplifies to:

$$a = h1/[1 - (h2/h1 - 1)] \qquad (13)$$

Equation (13) further simplifies to give the required equation that:

$$a = h1^2/(2*h1 - h2) \qquad (14)$$

For the exponential function the unique peening intensity is given by **H = 0.9*a** occurring at a correspondingly unique time given by **T = 2.303/b**. Substituting the derived values for **a** and **b** (equations (13 and (12)) yields:

$$H = 0.9*h1^2/(2*h1 - h2) \text{ and} \qquad (15)$$

$$T = 2.303*t/(-\ln(h2/h1 - 1)) \qquad (16)$$

Equation (16) can be further simplified, by introducing Common logarithmic form in place of Natural logarithmic form to give:

$$T = t/(-\log(h2/h1 - 1)) \qquad (17)$$

Editor's Note. This article was reprinted from the Fall 2010 Shot Peener magazine.

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Verification Strips

Questioner #1: Can someone please clear up my confusion regarding acceptance test.

Intensity is determined by performing a saturation curve [J443], and coverage by [J2277], which are two completely independent processes.

The time required to obtain the coverage of our part is considerably shorter than the T1 time, therefore if we run a verification strip at the part process parameters the arc height will not be the same as what was obtained during the saturation curve. Or should the verification strips be run at the times used to determine the intensity?

If this is the latter, this will impinge on our available manufacturing hours which are already to capacity.

Answerer #1: Your statement: "...which are two completely independent processes" is key to this question. To validate intensity you must expose the Almen test strip at (or near) the T1 time derived from the saturation curve. Using shorter exposure times will not give consistent results or reliable information.

The verification strips should be run at the times used to determine the intensity.

Answerer #2: J443 3.5.2: When using a single holder on a fixture, a single strip may be used to verify intensity. This strip should, ideally, be exposed for the time T derived from the saturation curve and its arc height shall be within the stated tolerance. In practice, this is not always possible (for example, when integral values of strokes or rotations are used). When that condition occurs, the value used shall be rounded to the nearest practical time to T. An arc height is then obtained from the intersection of the saturation curve with that nearest practical time of T, see Figure 3. This intersection shall be called a Target Arc Height. A single strip subsequently peened for the selected nearest practical time must repeat the target arc height to within ±0.038 mm (0.0015 inch) or other value acceptable to the responsible authority.

If you have enough data collected to prove your process is stable and repeatable, perhaps you can supply that information to your customer and extend the intensity verification time?

Questioner #1: Thanks for the clarification.

Questioner #2: Does this mean that if you have enough data that you can test (verify your T1) your machine in the morning only or every eight hours of operation?

Does this also apply if I have different part geometries and intensities within that eight hour operation period?

If I have all saturation curves for all parts and all locations then how do I correlate doing a test in the morning only to verify (every eight hours)?

How do other folks go about not verifying your T1 for every part and every location within that part? I'd love to know your thoughts...

Answerer #2: What is the actual shot peening specification you are working to? If AMS2430 then J443 would apply.

Remember the actual peening specification that is imposed on your purchase order or engineering drawing is boss.

"Does this mean that if you have enough data that you can test (verify your T1) your machine in the morning only or every eight hours of operation?"

J443 Revision 2017-08
3.5 Verification of Intensity
3.5.1 When the machine settings are found that yield an intensity within the specified tolerance, a means of process verification and control shall be implemented. Intensity verification arc height readings shall be taken at a frequency determined to be appropriate for assuring consistent peening intensity. The frequency of intensity verifications shall not be longer than eight hours of operation.

Two schemes for intensity confirmation, one involving a single holder and strip, the other involving multiple holders and strips, are offered in 3.5.1.1 and 3.5.1.2. Note that the practice of intensity confirmation does not constitute an intensity determination since this would require development of a full saturation curve per SAE J443 using a minimum of four strips.

AMS2430 REV U
4.2.1 Acceptance Tests 4.2.1.1 Peening intensity verification (3.5.1 and 3.11.1) is an acceptance test shall be performed at

the beginning and, for lot sizes greater than one, at the end of each lot or every eight machine peening hours, whichever is less. Peening intensity verification shall also be performed whenever the in-process media requirements are violated or whenever the size, type, or all of media in the machine is changed. The intensity verification arc height shall be documented in accordance with 4.5. If approved by the cognizant engineering organization, intensity verification intervals may be changed.

"How do other folks go about not verifying your T1 for every part and every location within that part? I'd love to know your thoughts..."

If you have multiple parts that are processed using the exact same process and the same test fixture you should be able to use the data from the first verification across all parts processed for the next eight hours or end of lot.

If you change the process then a new verification test must be run.

Questioner #2: Thanks for your feedback on this...

How do you define a lot? Same part? Same geometry? Or could it be classed as eight hour working day?

"If you change the process then a new verification test must be run." Does part and part geometry come into play? Even if I were using the same intensity?

I'm trying to set up our machine so that we only verify that the machine is running at an intensity range of 6-12N on a standardized set up first thing in the morning at 45 degrees and 90 degrees. If both angles are ok then I'm ok to peen correct? I then know anything between these angles are also ok.

I have previously completed all my sat curves but just want to check that the machine is still running correct, once in the morning but not on every part and part location. A typical day would see different parts and geometries for that intensity range. I currently check all areas on all parts for verification and want to reduce some of our testing.

Would checking the intensity first thing (6-12N) be acceptable and ok to run many different part shapes and geometries? Is this also ok from an audit standpoint?

Answerer #2: From AS7766 Terms Used in Aerospace Metals Specifications: MATERIAL LOT: Material taken from a single heat of metal, processed at the same time into the same size and shape of product, and heat treated as a single heat treat lot. Note that many specifications contain definitions that take precedence.

"If you change the process then a new verification test must be run. Does part and part geometry come into play? even if I were using the same intensity?" If the machine is using the exact same parameters and the exact same intensity verification fixture, then yes you could use the verification data across different part numbers in my opinion. However, it's best to check with your customer and get it in writing.

I would suggest you list all the part numbers you are processing on the same Process Parameter sheet.

Again, in **AMS2430 REV U 4.5:** If approved by the cognizant engineering organization, intensity verification intervals may be changed. If you were to do this the customer would probably like to see a fairly significant amount of data, probably with less variation than the allowed ±0.0015.

Contamination of Cast Steel Shots

Questioner #1: Dear all, We are a aerospace components manufacturer in China. Recently we buy two tons cast steel shots from US, the shots meet to specification AMS-2431/1.

Opened the bag, we find that there have rust on the shots surface. Could anybody tell me how to remove this rust, and no effect to shots quality?

In the paragraph 3.6 of AMS-2431/1: Contamination shot shall be clean and free of dirt, grit, oil, or grease.

And the rust will effect lower peening intensity and deficient peening coverage, or not? Or other peening quality, such as part colouration?

Thank you very much.

Answerer #1: You should load the shot into your machine and blast a hardened steel plate for as many cycles as it takes to remove the "rust".

Answerer #2: This occurs quite commonly, especially when product is shipped overseas with freight sitting in containers over extended periods of time. A major manufacturer of engineered steel shot and grit poly lines all shipments, but rust is inevitable.

As mentioned above, it's best to cycle the media by blasting it against a target. Depending on the size of your machine and the quantity of shot it holds, you'll have to time it accordingly.

Rust is a surface phenomenon, and descaling it will not impact your arc height values. If the particle size gets reduced by impacts (which is the natural failure mode for any peening media), it will get eliminated by your airwash separator, cyclone or bottom screen in your classifier. "Descaled" shot will also help with avoiding part discoloration.

For your information, AMS grade material goes through a conditioning process prior to shipment. In other words, there is no surface rust on the shot particle during shipment. Transit rust is what you're noticing on the product.

We discussed this at a recent SAE meeting and none of us felt the need to make a statement about rust in the documents since it's subjective and a rather simple fix.

Hope this helps.

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