

The Shot Peener

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



Dr. Langdon Feltner
2025 Shot Peener of the Year

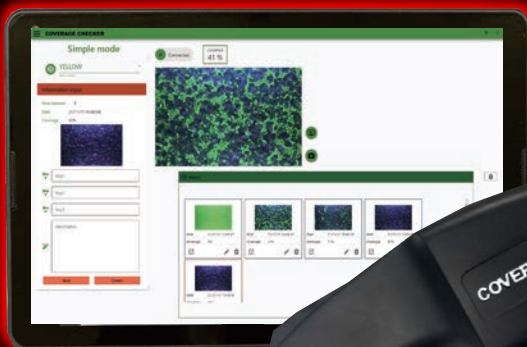
Peening Innovation

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CHECKER



COVERAGE CHECKER

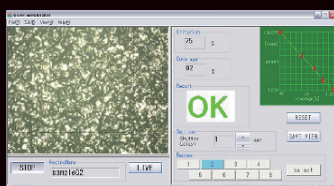
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- UV light version Coverage Checker can measure the coverage even on oxidized surfaces and uneven peened surfaces, which was difficult to measure with normal version.

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Specification

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6

Shot Peener of the Year 2025 Dr. Langdon Feltner

Congratulations to our 2025 Shot Peener of the Year, Dr. Langdon Feltner. Since 1992, The Shot Peener magazine has recognized individuals for their contributions to the shot peening industry and scientific community.



10

ICSP15 Recap

The 15th International Conference on Shot Peening took place at Purdue University in September.

16

Walter Beach Appointed to SAE Chair

18

A Photo Review of the 2025 USA Workshop

20

Kirk Retrospectives: Alternative Scaling of Almen Strip Saturation Curves

Donovan Stumpf expands upon Dr. David Kirk's bending model of the Almen strip, by observing intensity in terms of energy rather than arc height. This technique can permit multiple peening arrangements to be compared, giving operators more informed control of machine settings.

30

Viking Wheelblast Systems Launches SD Max 1600 Press Release

Viking Wheelblast Systems Launches SD-MAX 1600- a new wheelblast system designed to maximize uptime, simplify maintenance, and extend service life

32

An Insider's Perspective: Are We Partial to Airblast Peening

Kumar Balan explores the differences between airblast and wheelblast peening, and how each may be better suited to a peening arrangement. He further discusses the challenges and benefits of switching your peening process accordingly.

36

X-Ray Residual Stress Measurements of Shot Peened Components

Dr. David Kirk presents the basic engineering principles that are relevant for understanding how residual stresses can be measured in shot peened components.



Tecnar exhibits at ICSP15



Collaboration at USA Workshop



Viking's SD Max 1600

THE SHOT PEENER

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



OPENING SHOT

Jack Champaigne | Editor | The Shot Peener

Passing the Torch

Passing the torch to the next generation is the theme of this opening shot. I remember attending the SAE Fatigue Design & Evaluation (FD&E) meeting in 1985. There were six divisions of this committee, and I wandered into the Surface Enhancement Division. Charlie Barrett, from Metal Improvement Co. was the chairman. After Barrett's passing in 2006, I was elected chairman of the division. The FD&E committee was sponsoring a collaborative on FEA study on welds and I suggested that a sample be shot peened. Progressive Surface did the treatment. During the meeting, the results of the fatigue testing were shown along with the estimate of lifetime. There was a long pause when the photo of the shotpeened weld was shown: it had not failed, but rather, the fatigue tester had failed. I was delighted. Now the other five divisions would have an interest in shot peening. Not so fast. They still had no interest in shot peening. I requested a divorce; it was granted. The Surface Enhancement Division became the Surface Enhancement Committee with me as chair- this included a seat on the Materials, Processes and Parts Council.

I was aware of another SAE activity called the Aerospace Metals and Engineering Committee (AMEC), which was founded in 1972. I requested permission to join and was eventually granted admission in 2004. The meetings were held at Asilomar in California, an old YMCA campground. I arranged to get one room on campus that had a small kitchen and a living room with a fireplace. Each year, I would stop at the local liquor store and buy some "good" wine, and then next door at the hardware store, I could purchase the lye needed to make hot soft pretzels. Then chairman Jay Pengra brought the 12" cast iron skillet so I didn't have to bring that through security.

After attending several meetings where 90% of the conversation focused on heat treating, I suggested we establish a sub-committee devoted to Surface Enhancement- permission granted. In 2008, we met separately from the leading group and then, once again, I suggested we revise our status and become the Aerospace Surface Enhancement Committee (ASEC). Then, for expediency, as chair of both committees, I suggested that we meet only twice a year, rather than four times, in a combined meeting space. Eventually, the Spring meeting was held at SAE headquarters in Troy, and the Autumn meeting was held at the annual EI Workshop, to attract attendees to both meetings.

So, as Paul Harvey would say, "Now you know the rest of the story". ●



THE SHOT PEENER

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For a free subscription of *The Shot Peener*, go to www.theshotpeenermagazine.com

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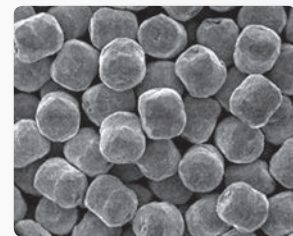


The advantage of Premier Cut Wire Shot

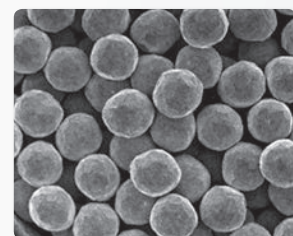
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2025 Shot Peener of the Year Dr. Langdon Feltner



THE 2025 SHOT PEENER OF THE YEAR award goes to Dr. Langdon Feltner, a rising voice within the shot peening community whose work is reshaping how the industry approaches variability, sensing, and digital integration.

A recent doctoral graduate of Purdue University, Feltner has co-authored over 10 publications across both academic and industry-facing venues and has presented research at major conferences, most recently the International Conference on Shot Peening in September 2025. Through his work with Purdue's Center for Surface Engineering and Enhancement (CSEE), he has helped to strengthen the connection between academic theory and industrial application. His contributions demonstrate a rare balance of theoretical insight and practical applicability — hallmarks of a future leader within the surface enhancement industry.

JOINING THE SHOT PEENING INDUSTRY

Feltner's foray into shot peening began during his year-long senior design project with American Axle and Manufacturing in 2021–2022. What started as a scoped academic project quickly evolved into a career-defining pursuit.

“For most people, a senior project ends when you turn in the final report,” Feltner reflected. “I want to express my gratitude to Dr. Mark Gruninger for allowing me the opportunity to continue to work in this industry.”

That early work introduced Feltner to the complexities of shot peening, while his continued research with advisor Dr. Paul Mort—and in collaboration with CSEE's network of industrial partners—shaped his technical and intellectual development. Those experiences revealed not just the scientific and process-level challenges of shot peening but its potential as a field still ripe for innovation.

A THESIS ON STOCHASTICITY AND VARIABILITY

Feltner completed his doctoral defense on November 19th, 2025. His dissertation investigates stochastic behavior in shot peening processes — or, in simpler terms, variability that lies beyond direct process control.

“The goal of my dissertation,” he explains, “is to understand the role of stochasticity in shot peening processes— everything from cycle-to-cycle variability in component performance to micro-scale fluctuations in residual stress and surface finish.”

His work provides vital insight into quantifying and modeling these unpredictable elements to better predict performance outcomes. Building upon his expertise in computational modeling, he developed a reduced-order process flowsheet that couples media degradation and recharge dynamics with real-time residual stress prediction. The model offers a new path toward data-driven process optimization and improved reliability in industrial applications.

HOPES FOR THE FUTURE OF THE INDUSTRY

Looking ahead, Feltner hopes to see the shot peening community more closely integrated with the advanced manufacturing movement. He envisions a future where shot peening evolves in step with data-driven, intelligent production systems—an interdisciplinary effort linking materials science, automation, and process control.

“There's a broader national initiative—led by organizations like the DOE, NSF, and DOD—to modernize manufacturing through data-driven, intelligent systems,” he said. “When we

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align shot peening research with those strategic priorities—embracing tools like digital twins and autonomous process control—we help secure the future of the industry.”

REFLECTIONS ON THE AWARD

Receiving the Shot Peener of the Year award came as a surprise for Feltner.

“It’s an elite club,” he said. “When you look back at the list of recipients dating back to 1992, you see the most influential people in this industry. You never expect to be honored with an award like that. I’m just very grateful for the opportunity to have received it.”

He extends his thanks to his advisory team at Purdue, The Shot Peener Magazine, as well as the entire EI team for encouraging his research endeavors. He also acknowledges the support of CSEE and the member companies that provide the collaborative environment essential to continued progress—their perspective and feedback have shaped his research.

“This dissertation turned into something more illuminating than I could have imagined ... we’ve put together a very creative perspective on the shot peening process, while staying grounded in industrial practice and focused on applicability,” he said.

For Feltner, this recognition isn’t just a milestone — it’s a reminder of the collective effort driving the shot peening industry forward.

“I hope people see this award as forward-looking — a symbol of where we’re going as a community, not just where we’ve been.” ●



Dr. Langdon Feltner with previous Shot Peener of the Year award recipients.

View His Dissertation

To read Dr. Feltner’s dissertation, visit <https://feltner515.github.io/homepage/>

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ICSP15 Recap



On September 22, 2025, Purdue University welcomed 150 attendees from 10 nations to the 15th International Conference on Shot Peening. Held in West Lafayette, Indiana, the ICSP spanned four days marked by interdisciplinary connections and a shared commitment to expanding shot peening research.

The week began with touching tributes to some of the pioneers in the shot peening industry. First, Jack Champaigne of Electronics Incorporated prepared a tribute to Prof. David Kirk's contributions to the industry. Dr. Kirk was named a lifetime member of the ICSP in 2002, after a career in metallurgy that spanned many decades. Then, Volker Schulze paid homage to the late Lothar Wagner. Wagner left behind a legacy of pioneering fatigue-life research in shot peening, including serving as Chair of Physical Metallurgy and Materials Technology at the Technical University of Brandenburg at Cottbus. Both were influential to the international shot peening community and will be missed greatly.

The first technical talk, given by Mario Guagliano, Chair of ICSP, explored the use of finite element analysis to reverse-engineer the impact patterns observed on the walls of Pompeii, revealing attributes of the weapons used. "A highlight of the week was having Mario, the last International Scientific Committee president, do such an interesting talk. He did it in Milan and kind of started Purdue with this thing; it was like a proper handoff to have him start the week," noted Mark Gruninger, of Purdue. This presentation provided a fascinating parallel to how multiple industries, just like multiple disciplines of research, can benefit from intersectional collaboration.

The conference featured a robust schedule of 52 technical talks, covering a wide spectrum of topics: explorations of industrial applications and additive manufacturing; in-depth analyses of stress and surface dynamics; studies on surface engineering and alternative peening techniques. These presentations underscored the theme of expanding research across traditional and emerging domains — emphasizing not just how shot peening strengthens materials, but how it is evolving into new applications, materials and processes.

This atmosphere of shared purpose was also evident throughout the exhibition hall. Twenty-four exhibitors, including five interactive tables, demonstrated new technologies and offerings from various industry representatives. Purdue's Materials and Manufacturing Research Laboratory (MMRL) served as the focal point of this atmosphere, allowing attendees to observe results from CSEE's industry-paired research projects and introducing them to some of the newest technological capabilities and innovation opportunities. "The demonstrations that we ran, coupled with the image analysis that we can do, offer the industry significant opportunity to very quantitatively describe what's going on in situ. That really gives practitioners an opportunity to feel much more informed about the peening that's taking place," said Gruninger.

The week wasn't all lectures, though. Between talks, Purdue's dining and catering department provided delicious, flavorful meals featuring staples of Midwestern cuisine. Each meal was accompanied by a short program, including a talk on the history of ICSP from Dr. Abbas Niku-Lari, ICSP Founder, sponsor presentations, and an inspiring video message from Indiana Governor Mike Braun. More notable, though, was the

A Tribute to Prof David Kirk

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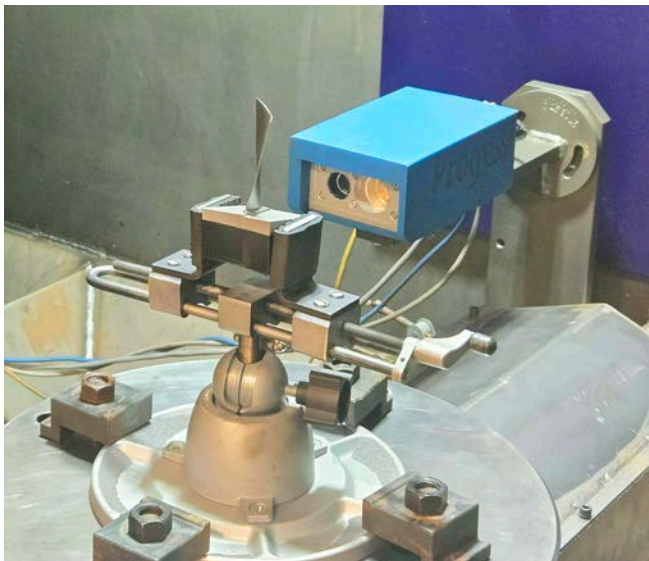
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Dr. Yuji Kobayashi demonstrates Sinto's Intensity Sensor



Progressive and Tecnar demonstrate the Shotmeter particle velocity measurement system



Shota Watanabe of Toyo Seiko celebrates a win at the Indianapolis Motor Speedway Museum

exchange of ideas between researchers and industry professionals that filled the room. Heads were bent over notebooks littered with sketches and formulas; business cards were passed between hands; peals of laughter rang out between old colleagues.

The cultural event, a trip to the Indianapolis Motor Speedway Museum, introduced attendees to a staple of Indiana—the Indy 500. The visit started with the immersive 3-D theatre, welcoming guests to the Brickyard with flair. As the sound of roaring engines and cheering fans echoed throughout the room, it was hard not to feel engulfed in that moment of Indiana tradition. From there, attendees explored the museum, with many taking turns competing in the virtual proving grounds. They were also treated to a private tour of the winner's circle, complete with the chance to climb up to their rightful place on the podium.

ICSP-16 will be hosted by Dr. Yoshihiro Watanabe of Toyo Seiko. The conference will take place at the Nagarakawa Convention Center in Gifu Prefecture. Proposed activities include a tea ceremony, cormorant fishing, and a tour of the Seki Hamono Museum for a demonstration of traditional Japanese sword forging.

"I've been in business for almost 40 years. In the end, that's the common denominator of any of them, whether it's selling chocolate or shot peening equipment- it's people. People are the common denominator. You can see awesome people in so many of the companies that attended ICSP-15, from companies and universities. People who know a lot and people who are younger and contributing from a far different educational experience, it's pretty clear to see that is going to usher in a whole new level of understanding. ●

View Papers & Proceedings

To view the conference proceedings and all published papers, visit <https://www.icsp15.org/>.



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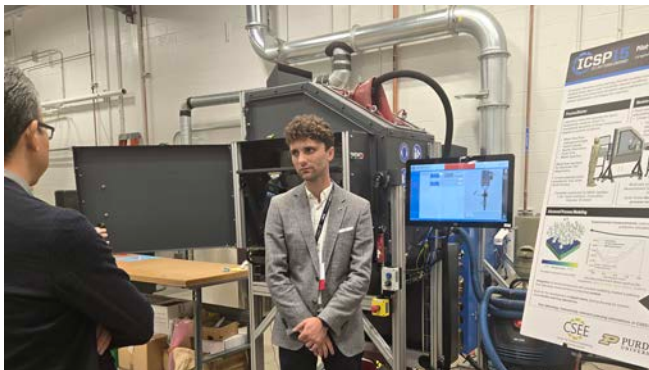
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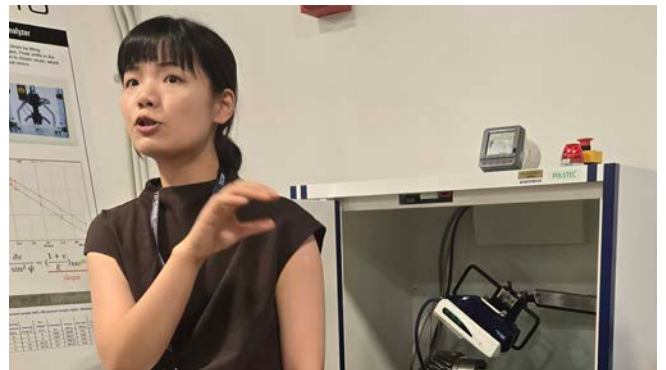
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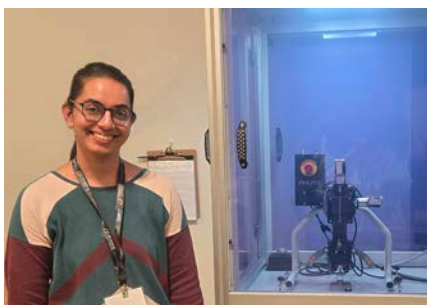
ICSP Exhibitors and Sponsors



Dr. Langdon Feltner demonstrates MMRL's Pilot-Scale Shot Peening Test Stand



Jia-Huei Tien demonstrates MMRL's Pulstech XRD setup



Rajeshree Varma demonstrates MMRL's Proto XRD setup



Tecnar exhibits their velocity measurement technology



Attendees tour the facility at MMRL

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PRESS RELEASE

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Walter Beach Named Chair of SAE Committees



Walter Beach, SEC and ASEC Chairperson

Peening Technologies of Connecticut's Vice President, Walter A. Beach, has been named Chairperson of the SAE Surface Enhancement Committee and the Aerospace Surface Enhancement Committee. He succeeds Jack Champaigne of Electronics, Inc., in both roles.

This committee has long played a vital part in advancing the science and practice of surface enhancement through technical collaboration and innovation. "I am honored to work with this group of talented professionals who have come together to pursue one goal – the continual improvement of the shot peening process," said Beach.

His involvement with both SAE International and Nadcap goes back to the early 2000s — first by helping to develop the original Nadcap checklists for AC7117, /1, /2, and /5, and later by joining the SAE Surface Enhancement Committee and the subsequently formed Aerospace Surface Enhancement Committee (ASEC). Over the years, he has sponsored several important document revisions, including AMS2430, AMS2432, and ARP7488.

"I would also like to offer a heartfelt thank you to Jack Champaigne of Electronics, Inc., for his decades of dedicated leadership," Beach added. "Jack's stewardship has brought together people and companies from all over the world with a shared purpose — to continually improve the shot peening process. His tireless work has set the foundation for the collaborative, technically rigorous community we're all proud to be part of." ●



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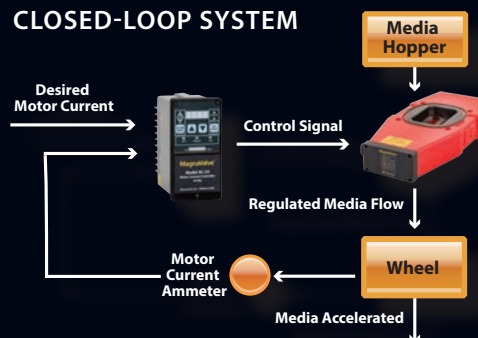
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ACADEMIC STUDY

Donovan Stumpf, R. Varma, L. Feltner, P. Mort | Purdue University

Dr. Kirk Retrospective: Alternative Scaling of Almen Strip Saturation Curves

INTRODUCING THE DR. KIRK RETROSPECTIVES

Dr. David Kirk's articles in *The Shot Peener* have long been among the most valuable resources for both new members of the peening community and its seasoned practitioners. Known for translating complex ideas into clear, practical explanations, Dr. Kirk bridged the gap between theory and application — a connection that remains as vital today as when his first papers were published. Whether addressing the fundamentals of peening or the finer details of Almen strip composition, his writing continues to make the science more accessible.

Now, a new generation of researchers is carrying that legacy forward. Under the direction of **Dr. Paul Mort of Purdue University's School of Materials Engineering, Donovan Stumpf, Rajeshree Varma, and Langdon Feltner** will reflect on Dr. Kirk's conclusions and explore how his ideas continue to evolve in the era of advanced materials and digital manufacturing.

Each article in the *Dr. Kirk Retrospectives* series will revisit a cornerstone of his work, pairing his vital insights with new research — honoring the past while charting the future of peening innovation.

This article explores how an energy-based approach can extend Dr. Kirk's bending model of the Almen strip. The main idea is that when Almen saturation data are scaled by peening energy rather than time, the results from different peening conditions and strip thicknesses can align on a single, unified curve.

ENERGY OF PEENING:

Energy in shot peening can be defined in several ways, depending on the chosen reference. Using basic peening parameters—media velocity, mass flow rate, and exposure time—the total kinetic energy of the peening media can be estimated as:

$$KE = \frac{1}{2} \dot{m} t v^2 \quad (1)$$

where $\dot{m}$ is the mass flow rate (kg/s) through the control valves, v (m/s) is the measured media velocity, and t (s) is the exposure time.

This total kinetic energy represents the energy carried by the media, though not all of which is transferred to the surface. Energy losses occur due to rebound, impact angle, and stream divergence, meaning only a portion of the energy contributes

to plastic deformation and residual stress. Nevertheless, kinetic energy serves as a strong comparative basis for different peening setups, as it captures the primary process variables of flow rate and velocity.

Additional ways to define energy or work imparted due to peening involve measuring the response of the part itself. Some studies have estimated the work done during peening using residual stress depth profiles. Model-based approaches can also be implemented to calculate how much of the media's energy is actually absorbed by the surface. Experimentally, the work required to flatten a peened Almen strip can serve as a measure of the energy change caused by peening. Each of these methods provides useful comparisons between peening conditions and coverage levels, though they require additional testing and data collection.

Kinetic energy, by contrast, is much easier to calculate. Modern velocity measurement methods are becoming readily available, using sensors such as high-speed cameras, optical systems, or acoustic devices mounted on the nozzle or at fixed positions within the chamber. Once the media velocity is known, the energy can be estimated directly from



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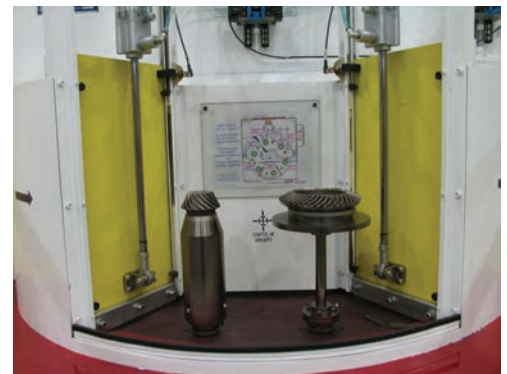


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72" Flex Peener three (3) Spindles at each Station for High Volume Gears. Can do Eight (8) Different Type Gears with our Patent Pending one pc. Tooling Holders. Shown with Robot Load.

velocity, flow rate, and exposure time. This provides all the information needed to scale Almen Strip saturation curves across different peening setups.

ALMEN STRIP ARC HEIGHT MODEL SCALING:

Dr. Kirk proposed a simple bending model to provide a framework to describe how a peened Almen strip bends in response to surface compression. In his formulation, the measured arc height is determined by the ratio between the bending moment and the strip's elastic stiffness [1]:

$$h = \frac{631M}{EI} \quad (2)$$

where M is the bending moment, E is the Young's modulus, and I is the second moment of area of the strip cross-section. By substituting in the known strip geometry and expressing the bending moment in terms of the average compressive stress, σ , acting over a depth, d , the equation becomes:

$$h = \frac{3\sigma d}{Et^3}[t - d] = \frac{3\sigma d}{Et^2} \left[1 - \frac{d}{t}\right] \quad (3)$$

To better separate the geometric effects, the effective depth of the compression zone can be defined as d' in equation 4 and the corresponding normalized arc height defined in equation 5.

$$d' = d \left(1 - \frac{d}{t}\right) \quad (4)$$

$$h' = \frac{ht^2}{d'} = \frac{3\sigma}{E} \quad (5)$$

These quantities help separate geometric effects from those driven by energy input or material response. When the induced compressive stress is proportional to the applied peening energy, the normalized height, h' , provides a consistent basis for comparing different strip types. This formulation establishes the foundation for evaluating Almen strip behavior across varying thicknesses and peening conditions.

ALMEN STRIP SATURATION CURVE FITTING:

Almen strips have been the standard for measuring peening intensity since the first issue of SAE J443 in 1952 [4]. Their response over time follows a characteristic saturation curve, which has been modeled extensively. The most commonly used equations are summarized in Table 1.

The 2-parameter model represents a simple exponential rise, while the 3-parameter version introduces a curvature adjustment through the exponent, b . The 4-parameter model further adds a small linear term to improve fitting accuracy at higher coverage levels, though it typically requires many data points for reliable convergence.

Table 1: Common models to fit Almen strip saturation curve data.

Model	Time-Scaled Equation
2-parameter	$h(t) = a(1 - e^{-bt})$
3-parameter	$h(t) = a(1 - e^{-bt^c})$
4-parameter	$h(t) = a(1 - e^{-bt^c} + dt)$

To enable direct comparison of peening conditions across different setups, media kinetic energy can be used in place of time in these models. Since time is proportional to total kinetic energy under constant flow conditions, the corresponding energy-scaled equations are summarized in Table 2.

Table 2: Alternate form of Almen strip saturation curve models using energy.

Model	Energy-Scaled Equation
2-parameter	$h(E) = a(1 - e^{-bE})$
3-parameter	$h(E) = a(1 - e^{-bE^c})$
4-parameter	$h(E) = a(1 - e^{-bE^c} + dE)$

Replacing time with energy effectively rescales the x-axis, aligning curves obtained under different peening pressures or flow rates. This enables direct comparison of data from multiple experiments, provided that impact angle and

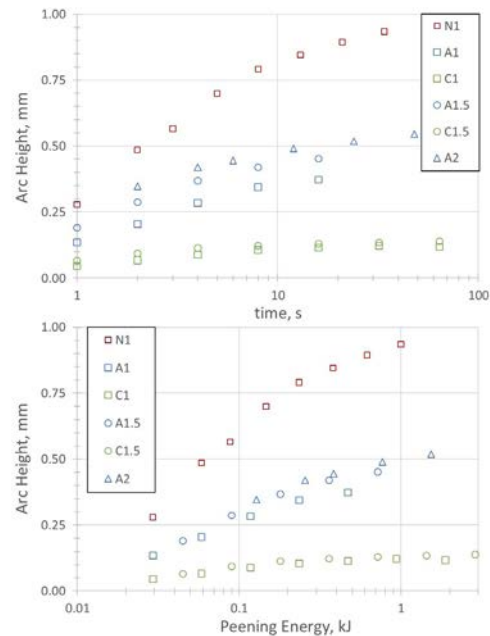


Figure 1: Almen strip saturation curves for N, A, and C strips at varying blast pressure (1, 1.5, 2 bar). Logarithmic scaling is used for increased fit visibility.

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standoff distance remain comparable, as both influence the actual energy absorbed by the surface.

Figure 1 shows Almen saturation curves for N, A, and C strips at various blast pressures (1, 1.5, and 2 bar). The upper plot uses time as the independent variable, while the lower plot applies energy scaling. When plotted against energy, the curves converge more closely, although differences in strip stiffness still require additional normalization.

To further collapse the data across different strip thicknesses, the measured arc height can be normalized by the square of the thickness, h' , and adjusted for the effective depth of the compressive zone, d' . This gives the normalized relation:

$$h' = \frac{ht^2}{d'} = \frac{ht^2}{\left(1 - \frac{d}{t}\right)} \quad (6)$$

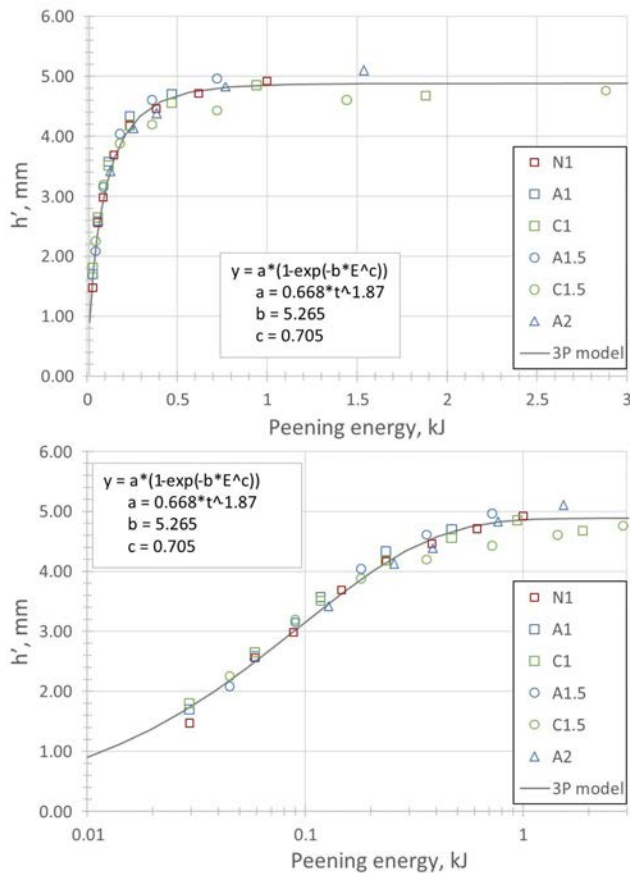


Figure 2: Energy-scaled Almen strip saturation curves for N, A, and C strips at multiple peening pressures. The upper plot shows the fitted 3-parameter model, while the lower semi-log plot highlights the early-energy regime and the effectiveness of the applied scaling in collapsing data across strip types.

Figure 2 illustrates the resulting data collapse when both x-axis (energy) and y-axis (geometric) scaling are applied.

The parameter c can be determined empirically by identifying the best fit to the experimental data under a given set of conditions.

When the data are scaled to account for the applied kinetic energy and the strip geometry, the responses from different pressures and strip types align closely along a single collapsed curve. This doesn't imply a universal law, but it demonstrates that combining energy and geometric factors can reveal consistent trends in strip behavior across multiple setups.

In practice, if new data begins to deviate from this curve, it can signal a change in the peening process, such as variations in media velocity, flow rate, coverage, or geometry. In this way, the collapsed curve serves not only as a comparison tool but also as an indicator of process stability and strip response.

CONCLUSIONS:

Shot peening parameters are often difficult to compare across different equipment. Blast pressure can vary with tubing length and orientation, and nozzle size affects air velocity—both lead to changes in media velocity even when using the same media type. Since the energy absorbed by the part is what ultimately drives residual stress, energy provides a more direct link between process conditions and material response. Although measuring the exact absorbed energy remains challenging, the total kinetic energy of the media stream offers a practical and physically meaningful approximation. With modern velocity sensors and flow control systems, energy-based scaling can be applied to collapse Almen strip saturation curves into a unified framework that incorporates both process energy and strip geometry.

Dr. Kirk's original bending model demonstrated how material and geometric factors influence measured arc height. Extending that model through an energy-based perspective helps bridge the gap between machine settings, material response, and measurable outcomes.

Dr. Kirk's work made the fundamentals of peening clear, accessible, and directly applicable. The approach presented here builds on that same foundation—continuing his effort to connect theory with practice and deepen our understanding of the shot peening process. ●

Citations:

- [1] Kirk, D. (2009). Strip Factors Influencing Almen Arc Height. The Shot Peener.
- [2] Kirk, D. (2007). Peening Intensity Curves. The Shot Peener.
- [3] Kirk, D. (2018). Almen Strip Quality. The Shot Peener
- [4] SAE International. (1952). SAE J443: Procedures for Using Standard Shot Peening Almen Strip.

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Viking Wheel Blast Systems Launches the SD-MAX 1600

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Rose Hill, KS – September 2025 — Viking Wheel Blast Systems proudly announces the launch of its latest innovation: the SD-MAX 1600 Blast Wheel. Designed for exceptional durability, reduced maintenance time, and consistent blasting performance, the SD-MAX 1600 marks a major advancement in wheel blast technology.

This next-generation blast wheel delivers a powerful combination of precision engineering and operator-focused design, making it ideal for high-production environments in foundry, manufacturing, oilfield, and fabrication industries.

“The SD-MAX 1600 is the result of years of customer feedback and real-world field testing,” said Deron Lock, President at Viking Wheel Blast Systems. “We designed every component to maximize uptime, simplify maintenance without adding expensive gimmicks, and extend service life.”

Key Features of the SD-MAX 1600 Include:

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- ✓ Low-Vibration, Balanced Assembly – Extends the life of internal components
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- ✓ No gimmicks or features that add replacement parts and cost.
- ✓ Bolts have been eliminated where possible to reduce shot locking of threads.
- ✓ Improved Maintenance Access – Simplifies service with safety-first features
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- ✓ Precision cast special alloy liners – Longer-lasting protection with precise alignment
- ✓ A truly “toolless” design for securing liners. A spring-loaded lever holds the liners in place without the need to hammer in a wedge or tighten a bolt.

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The SD-MAX 1600 is available as an upgrade to existing Viking machines or as part of new equipment orders. For customers currently running competitive blast wheels, Viking offers retrofitting options to bring the power of the SD-MAX 1600 to your operation.

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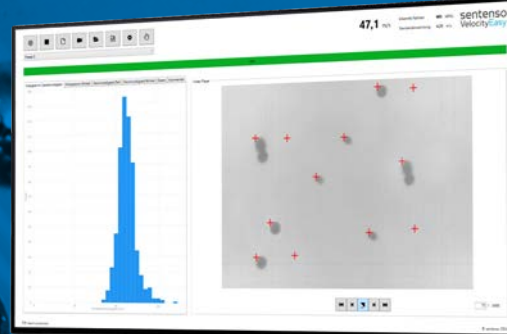
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Are We Partial to Airblast Peening?

THE OBVIOUSITY OF THIS QUESTION IS STRIKING. For those of you who wish to check the existence of this unique word, “obviousity,” do not bother, I admit that it is a non-standard word, much like the sources of most useful data in our industry! My introduction to this word was through my good friend, colleague, and guide to the nuances of wheelblast machines, Ron Barrier. Ron used to manage the demo facility at Wheelabrator in LaGrange, GA, where I first met him. ‘Interesting’ would be an understatement to describe every interaction I have had with him; he was a wealth of knowledge seldom found in published literature. Ron was once deputed to investigate a ‘browning’ issue faced by a large aerospace prime when peening their aluminum structural members. Ron called me from the site and said, “I inspected everything in the machine and could not find a ***n thing wrong with it. I then quizzed the operator on the time duration of this issue when the obviousity struck me like a lightning bolt”. The customer had mothballed the process for several months but failed to empty the shot from the machine. The shot had rusted and started discoloring the parts upon impact. The simple act of descaling the shot by running the machine without parts took care of the problem. What obviousity!

Among other things, Ron had practical demonstrations on double-knee saturation (a classic media contamination issue where the process ends up with two saturation points/intensities, one for each size of shot). Ron worked with demo machines all day and had to constantly switch between shot sizes. Ron’s demo lab had a large machine appropriately named ‘Big Bertha’ that could simulate about twenty different machines by varying process parameters and part handling. It was in this machine that Ron had conducted his famous ladder test to demonstrate the loss of velocity (and intensity) at increasing stand-off distances. Wheelabrator Engineering used this data when positioning blast wheels in complicated shot peening and blast cleaning machines.

As I was getting ready for another day of training at the recent shot peening workshop (Oct 27-29, 2025), I learnt that Ron had passed away on Oct 26th. Ron was one of those unsung

heroes in our industry, and I owe my blast machine education to this unconventional yet well-informed repository of knowledge. Ron’s informal contributions to this industry continue to be valuable. You will be missed by many, my friend!

AN INDUSTRY-DRIVEN COMPARISON
I was explaining to the students in one of my recent classes that the power ratio between wheel and airblast is 1:24. Consider a 3/8” nozzle flowing about 20 lbs per minute at 80 PSI. A single 20/25 HP blast wheel could easily flow 500 lbs per minute (x25 of the nozzle) of the same blast media. Therefore, there is a compelling argument to use a wheel unless your application requires peening with glass bead (referred to as ‘foo-foo dust’ by Ron B.) or similar media with low bulk density. Is the substitution that simple? Unfortunately, not. Several equipment manufacturers have attempted to design blast wheels that can efficiently propel non-metallic media but were met with limited practical success. Media breakdown, lodging between rotating members fitted with close clearance, and lack of sufficient mass to create an impact are some of the concerns. Others have attempted to assist propulsion with the infusion of compressed air, but the practice was not widely accepted. I took the opportunity to audit the progress in our industry in both machine types, with specific reference to shot peening applications within a time reference of the last three decades.

Wheelblast	Airblast
Direct drives (some with inverters)	Unlimited articulation (with robots)
Materials with increased wear-resistance	Active velocity measurement (closed loop)
Ease of maintenance	Integration with handling equipment such as tables, conveyors
Limited wheel articulation (wheel/mounting panel)	Visual monitoring of the process (cameras and sensors in the blast zone)

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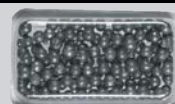
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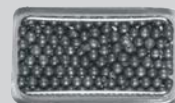
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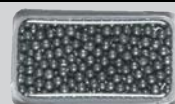
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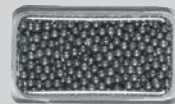
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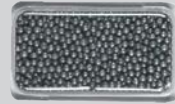
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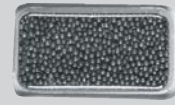
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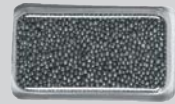
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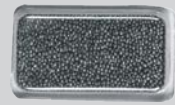
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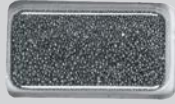
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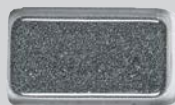
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Unlike airblast machines, wheelblast will rely on the cleaning market to direct it to the next stage in evolution. For our discussions, I will include those wheel peening machines used in the automotive industry for suspension, transmission, and power train components. Though I am certain that this industry sector is equally interested in repeatable and accurate peening results, their primary goal remains increased throughput. Therefore, unless any of the above attributes listed under 'airblast' leads to increased throughput, it is difficult for an equipment manufacturer to focus research efforts in that direction. To top that are the financial pressures that automotive OEMs and tiers constantly battle with. As a result, though opportunities exist to embrace some of the emerging technologies of airblast peening machines, wheelblast technology continues grow at a slower pace. Afterall, transmission failure in an automobile does not share the same criticality as fatigue fracture in an aircraft engine blade.

CONVERTING FROM WHEELBLAST

I recently learnt that a large landing gear OEM has made it mandatory to switch all its wheelblast peening equipment to airblast for this application. Supported by reasoning that I am not privy to, combined by the convincing ability of some of my industry colleagues, this switch could be influenced by several factors such as (a) perception of wasted blast pattern (most of these machines are fitted with 6-8 wheels, each powered by 20 HP motors), (b) the need for better control of the pattern in defined areas on the gear, (c) physical size of the machines (wheelblast machines of this kind are generally installed in a deep pit, combined with significant elevation above floor level – about 24'), and possibly (d) the relatively greater sophistication of airblast machines over wheelblast.

A non-aerospace application where I notice an increasing popularity of airblast is peening transmission components such as pinions and ring gears. This switch could be due to the need for higher velocity (and intensity) for newer styles of gears. Older wheelblast machines, peening with 14" diameter (assumption) wheels turning at 3600 RPM generated a velocity of 280 feet per second, whereas a 3/8" diameter nozzle at 90 PSI could generate a velocity that is much higher. If your temptation is to select a wheel size and speed to generate an equal velocity as the nozzle, you will also end up propelling x20 or greater quantity of shot, all of which will be at the high velocity. Needless to mention, this extra amount of shot might 'flood' the gear tooth or impact areas of the blast cabinet that hardly need peening! Flooding will create coverage issues in the critical root areas of the gear and impacting the cabinet will accelerate wear in an already high-velocity impact process.

Some non-aerospace applications that continue to be addressed by wheelblast machines are: shot peening of railway wheels to high intensity values, upwards of 0.010C, shot peening of leaf and coil springs in an inline arrangement with multiple, cabinet roof-mounted blast wheels, auto connecting rods, where the entire rod is to be peened instead of just the neck region, and OD areas of large mining bits (ID and small bits are peened in airblast machines).

THE CASE FOR HYBRID MACHINES

The advantages of high media flow, along with the surgical targeting of blast nozzles can be achieved with a hybrid machine. It is worth mentioning that the cost of those expensive electrical components is shared between the two systems. Though a bit more elaborate, such a machine shares other machine features such as the blast cabinet, reclaim system and dust collector. Finally, the need for certifying two machines is eliminated. A single audit and certification take care of that challenging activity. I can see hybrid machines offering a suitable peening solution for complex parts such as aircraft structures. Fixed blast wheels located in a symmetric pattern within a blast cabinet could provide uniform blast from both sides of the part while pre-determined areas with difficult features and geometry could be processed downstream using a robot or nozzle carriage mounted blast nozzle(s).

APPLICATION-BASED DECISIONS

Practically, all peening solutions are applications-based. The obvious ones are those that require the use of non-metallic media (airblast only), peening inside holes, slots and tight areas (airblast), low intensity values (airblast, possibly suction/syphon). The ones that could be processed with wheels or nozzles were listed and discussed earlier. Other aspects of a project that sometimes influence choice of media propulsion (when either will work) include commonality among existing machines in the plant, availability of power and/or compressed air, space, skilled workforce, end-user preference, and fixture design to list a few.

Though wheelblast machines are common for cleaning applications, apart from sophisticated users, many shot peeners are unfamiliar with the process. For such users, the list below should help with comparable process parameters:



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Parameter	Wheelblast	Airblast
Velocity	Wheel speed and diameter	Air pressure
Flow rate	Motor HP	Nozzle size
Coverage control	Masking	Masking and nozzle articulation
Size classification	Continuous sampling through classifier	100% Classifier
Removal of non-rounds	Spiral separator (sample)	Spiral separator (sample)
Calibration – velocity	VFDs or inverters for blast wheel	PID loop for air pressure
Calibration – exposure	Wheels are fixed	Nozzle movement can be calibrated for speed and position
Accuracy and repeatability	Requires regular monitoring of wear of wheel parts and replacement	Nozzle blast patterns are smaller with anomaly easily noticed on the part

CONCLUSION

Industries that manufacture mission-critical components are aware of the risks associated with not monitoring a process. Changing a well-established airblast technique with a wheelblast or other non-conventional peening tools needs to be accompanied by solid justification of the benefits. Except for a few aerospace applications, production rate is seldom discussed in terms of hundreds of parts per hour. This industry is obviously partial to airblast for their peening needs. Wheelblast machines are not as prolific in the medical implant industry either. They would certainly be well-advised to mimic aerospace practices and apply the technological breakthroughs achieved for their own unique applications.

So, where does this leave wheelblast machines? How would a company that focuses on wheelblast machines as their portfolio make their mark and dedicate their R&D investment dollars?

- Material technology – wheelblast machines are known to be louder (than airblast). Though mitigated by larger (and longer) cabinets, more work can be done in better materials to muffle the noise including the base metal and sound insulation techniques. Additionally, given the volume of media flow, better sealing techniques

will mitigate some of the stigma attached to using such machines.

- Maintenance – High rate of media flow = increased wear and maintenance needs. Focus on common maintenance aspects such as conveyor bearings, buckets in the elevator, access to upper reclaim parts such as rotary screens, airwash separators and simple implements such as media sample collecting stations at accessible elevations.
- Maintenance predictability (this seems to be the single largest attribute that AI could bring to our industry) – with the volume of parts in a wheelblast machine that require maintenance, controls could be geared to get us closer to the goal of a machine that defines its own maintenance protocols predicted well in advance.
- Active shot velocity measurement tools – such as the ones available with airblast machines (nozzle sensors and others)
- Less maintenance prone and cost-effective means of articulating blast wheels

The wish-list could be endless with the appreciation that not all of them could have commercial appeal or reasonable returns. I realize that this list needs to be qualified and validated through the lens of commercial viability. However, when you consider the volume of automotive parts that are processed in wheelblast peening machines, wheelblast machines could be made as appealing as their airblast counterparts! ●

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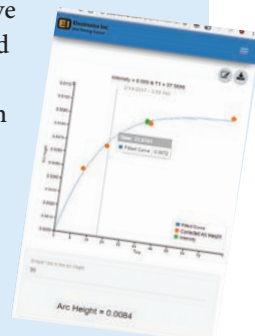
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ACADEMIC STUDY

Dr. David Kirk | Coventry University

X-Ray Residual Stress Measurements of Shot Peened Components

INTRODUCTION

It is a paradox that we cannot measure residual stresses directly. Measurements of strain can be made, which are then converted into stress using available elastic constant values. This procedure is familiar to anyone involved in strain-gage analysis. Tiny changes in some physical property (that is proportional to strain) are monitored - such as resistance changes in the fine wire of strain gages or of interplanar spacing for x-ray analysis.

There is a vast literature on x-ray stress analysis. The intention with this article is to present only the basic engineering principles that are relevant for understanding how residual stresses can be measured in shot peened components. An example is given to show how x-ray studies can reveal variations in residual stress with distance from a peened area.

INTERPLANAR SPACING CHANGES

X-ray stress analysis relies upon the fact that tiny changes in interplanar spacing of crystalline materials can be measured accurately. Fortunately virtually all shot peened components are crystalline. With a crystalline material we have a direct relationship between interplanar spacing and the angle of x-ray reflection. That relationship is embodied in the famous Bragg equation that can be expressed in the form:

$$n\lambda = 2d_{hkl} \sin\theta \quad (1)$$

where λ is the wavelength of the x-radiation used, d_{hkl} is the interplanar spacing of the crystal planes being monitored, n is an integer and θ is the angle of reflection.

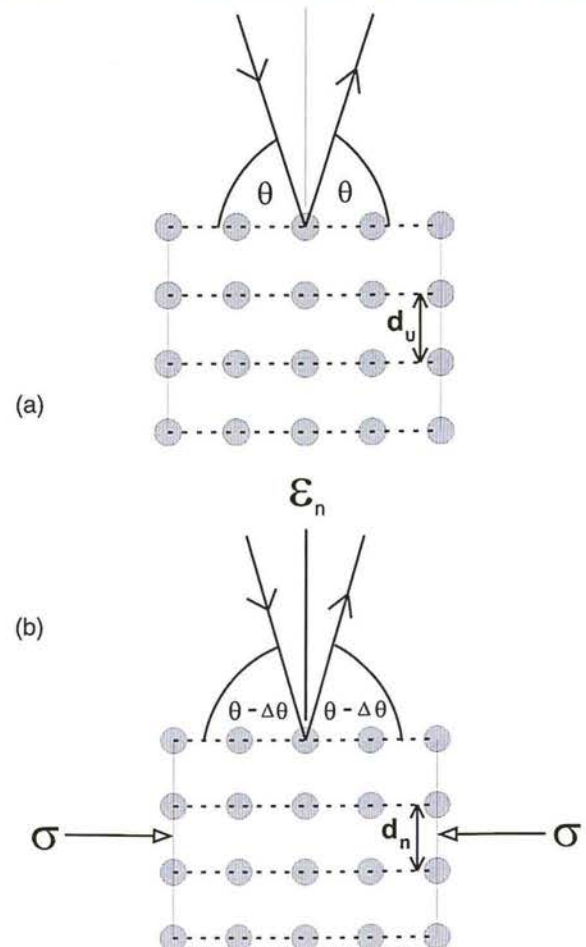
Differentiation of equation (1) yields:

$$\Delta\theta = -\Delta d_{hkl} / d_{hkl} \tan\theta \quad (2)$$

Equation (2) shows that for a residual stress causing a strain, $\Delta d_{hkl} / d_{hkl}$, there will be a movement, $\Delta\theta$, of the diffraction angle. The magnitude of $\Delta\theta$ depends directly upon $\tan\theta$, so that large diffraction angles are necessary. For peened high-strength steels there will be maximum compressive residual lattice strains of about -0.01. By substituting

in equation (2), we find that there will be a shift of x-ray diffraction angle equal to $+2 \cdot 138^\circ$ if the diffraction angle used is 75° . At a diffraction angle of 15° the same lattice strain would give a shift of only $+0.154^\circ$. Fig.1 shows a simplified representation of the x-ray diffraction situation.

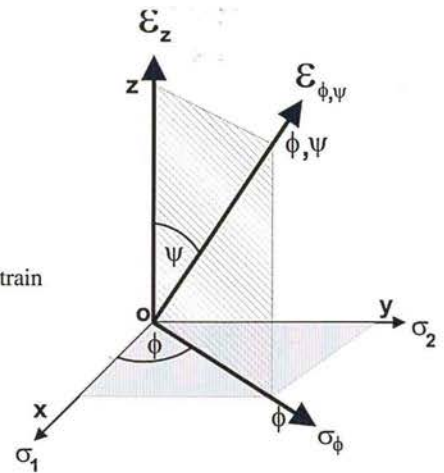
If we have no residual stress then the unstrained interplanar spacing, d_u , can be measured - as in (a). A compressive residual stress, σ_r , decreases the diffraction angle and the corresponding increased interplanar spacing, d_n , can be measured. The measured lattice strain is then $(d_n - d_u)/d_u$ which corresponds to the vector quantity, ϵ_n , shown in (b).



STRESS-STRAIN RELATIONSHIPS

The penetration of x-rays is so small that we can consider the situation for peened surfaces to be one of simple two-dimensional stressing. For any stressed component there will be two principal stresses, σ_1 and σ_2 , acting along x and y axes that are both perpendicular to each other and to a z axis (which is normal to the peened surface). With strain-gage analysis we can use a rosette of three gages to determine the directions, x and y, which the principal stresses make relative to some known direction, ϕ , see fig.2. Three strains are measured which are all parallel to the component's surface. With x-ray analysis we cannot measure strain parallel to the component's surface. Instead we rely upon strain measurements made at various angles, ψ , to the surface. Two such strain directions are illustrated in fig.2, being ϵ_z and $\epsilon_{\phi,\psi}$. As will be shown later, the residual stress, σ_ϕ , for the known direction ϕ is deduced from these measured strains.

Fig.2 Stress and strain symbols used in x-ray strain measurement.



$$\epsilon_{\phi,\psi} = \frac{\nu + 1}{E} \cdot \sigma_\phi \cdot \sin^2 \psi - \frac{\nu}{E} (\sigma_1 + \sigma_2) \quad (3)$$

where ν is Poisson's ratio and E is elastic modulus.

Equation (3) forms the basis of x-ray stress analysis. From a mathematical point of view, it is the simplest of all types of

RELATIONSHIP BETWEEN MEASURED LATTICE STRAINS AND RESIDUAL STRESS

The classical theory of isotropic elasticity, as enunciated by such legendary figures as Timoshenko, gives that:



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equation - a straight-line, $y = m.x + c$. As we vary the angle ψ the only parameter that changes is the lattice strain, $\epsilon_{\phi,\psi}$. We can therefore write equation (3) as:

$$\epsilon_{\phi,\psi} = m.\sin^2\psi + c \quad (4)$$

where m , the slope of the straight line, is equal to $\sigma_{\phi} (v + 1) / E$ and c , the intercept of the straight line with the lattice strain axis, is equal to $-(v / E) \cdot (\sigma_1 + \sigma_2)$.

The best way to understand any equation is to use it. Consider the hypothetical example illustrated in fig.3 .

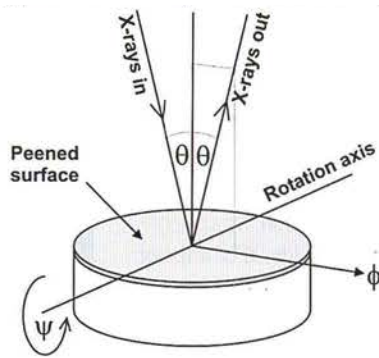


Fig.3 Peened disc showing orientation of significant directions.

A circular steel disc has been uniformly peened so that a surface residual stress of - 500MPa has been induced. In this particular situation the residual stress does not vary with angle ϕ , so that we have that $\sigma_1 = \sigma_2 = \sigma_{\phi} = -500\text{MPa}$. The elastic constants for this steel disc are known to be such that $E = 210\text{GPa}$ and $\nu = 0.30$. $\sigma_{\phi} (v + 1) / E$ then equals -0.0031 and $-(v / E) \cdot (\sigma_1 + \sigma_2)$ equals +0.00143. Putting these values into equation (4) gives that $\epsilon_{\phi,\psi} = -0.0031. \sin^2\psi + 0.00143$. This equation is plotted as fig.4.

Four points have been marked on the plot corresponding to ψ angles of 0, 30, 45 and 60°. The so-called “ $\sin^2\psi$ ” technique involves a set of such points and a least-squares straight line fitted to the points to establish the equation. The so-called “two-exposure” technique employs just two points and therefore does not require a least-squares fitting procedure to determine the straight-line relationship.

With x-ray stress analysis the parameter actually measured is the angular position, θ , of the diffraction peak. That is then converted into interplanar spacing, d_{ψ} , using the Bragg equation. A vital quantity is the interplanar spacing for unstressed material, d_u . We cannot, however, measure d_u directly for a stressed component. Instead we use an average

of measured ct -spacings. This procedure is illustrated by fig.5

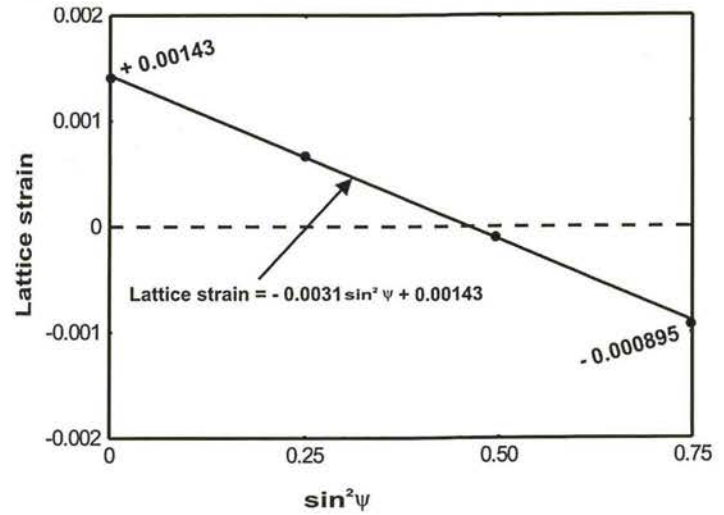


Fig.4 Linear relationship between lattice strain and $\sin^2\psi$.

for which the lattice strains of fig.4 have been converted into interplanar spacings. The known interplanar spacing for unstressed material, d_u , is given a value of 1.000000. Relative to that unit value the maximum and minimum measured spacings would be 1.001430 and 0.999105 respectively. The average of those two values is 1.0002675. Using 1.0002675 for d_u (instead of 1.000000) introduces an error of only one part in four thousand. That error is insignificant relative to the accuracy with which we know such factors as the elastic constants.

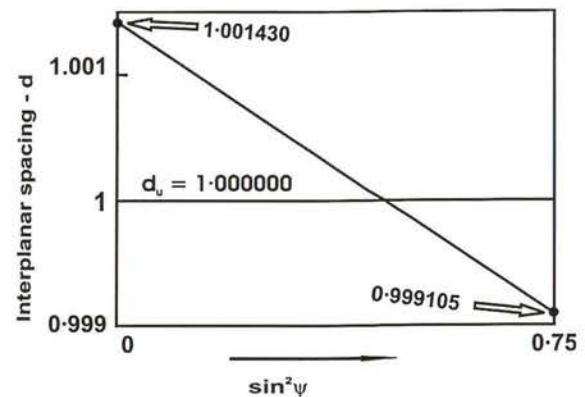


Fig.5 Data from fig.4 plotted in terms of interplaner spacings.

Within the phrase “classical theory of isotropic elasticity” the one beguiling word is “isotropic”. The bulk modulus, E , for a component manufactured from a given material can vary by more than 50%. That is because the elastic ‘constants’ of individual crystals vary with crystallographic direction. With x-ray stress analysis one specific crystallographic direction is involved - the perpendicular to the set of crystal planes

undergoing reflection. It is therefore necessary to use values for E and ν that have been measured using x-rays for the specific crystallographic direction and component material being studied.

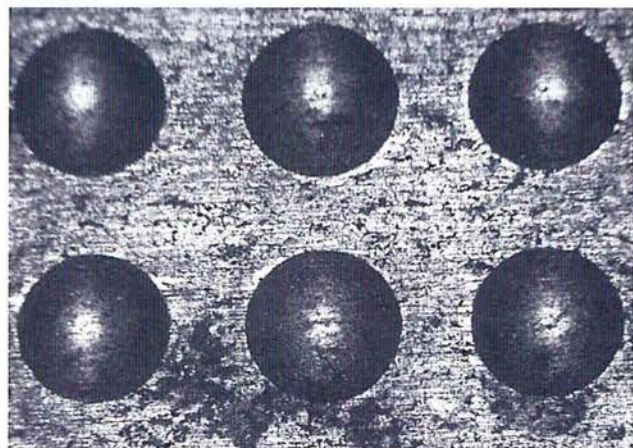


Fig.6 Part of ordered array of 0.67mm diameter indentations on mild steel plate.

SURFACE RESIDUAL STRESS STUDY

A perfectly-ordered array of peening indentations was produced on an as-rolled plate of mild steel using a 2.00mm ball indenter and an X-Y table, see fig.6. The array involved 6 rows of 21 indentations in a square array. Each indentation was 0.67mm diameter and centred on a 1mm grid. Chromium $K\alpha$ radiation was used to determine the surface residual stress. The x-ray beam was constrained so as to irradiate a 12mm by 1.5mm rectangular area of the specimen. With the specimen mounted on a micrometer table, measurements of stress were made at intervals of 2.00mm along the measurement line shown in fig.7. Three of the ten measurement positions are shown.

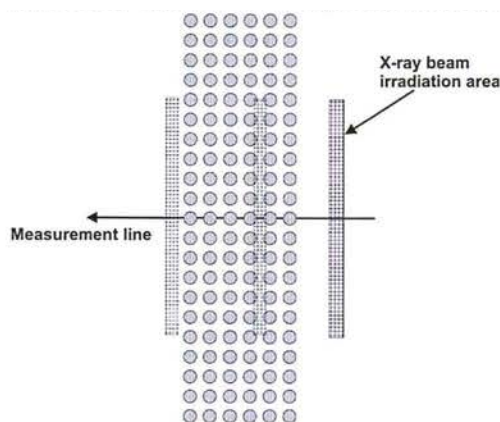


Fig.7 Schematic scale drawing of peened area and x-ray beam movement.

The primary objective was to determine the variation

of induced residual stress with distance. Measurement values are shown in fig.8 together with a superimposed representation of the peened area - to scale. The as-rolled plate had an initial tensile residual stress of 50MPa. It can be deduced from the measurements that peening has produced a maximum compressive residual stress of about 175MPa (some 40% of the U.T.S.) with a 'coverage' of only 34.7%. Compressive surface residual stress extends away from the peened region to a distance equivalent to about ten times the indentation diameters (far greater than previously supposed).

The array of indentations used for this experiment is atypical, but can be justified for research purposes. Further studies will be carried out using 'ordered peening' in the light of the useful results achieved. ●

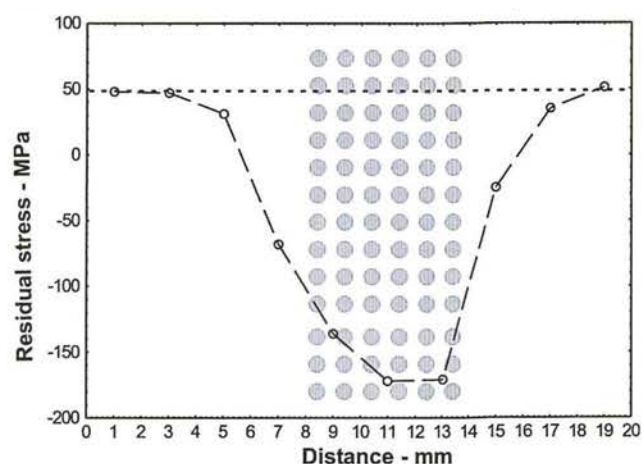


Fig.8 Variation of surface residual stress with distance across peened mild steel plate.

Editor's Note: This article is reprinted from the Winter 2005 Shot Peener magazine.

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Serial Number	11-char	Valve On-Time	1.15
Factory Calibration	00/00/00	Hrs <= 25C	0
Firmware	Rev 1.10 6-9-21	25C < Hrs <= 80C	2.8
		80C < Hrs <= 95C	0
		95C < Hrs	0
		Total Hours	2.8

Active Table Settings		Flow Control	
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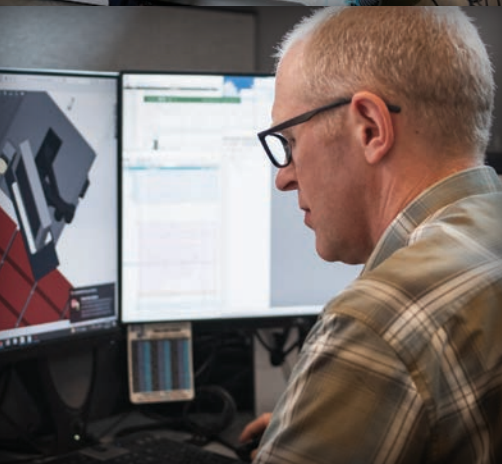
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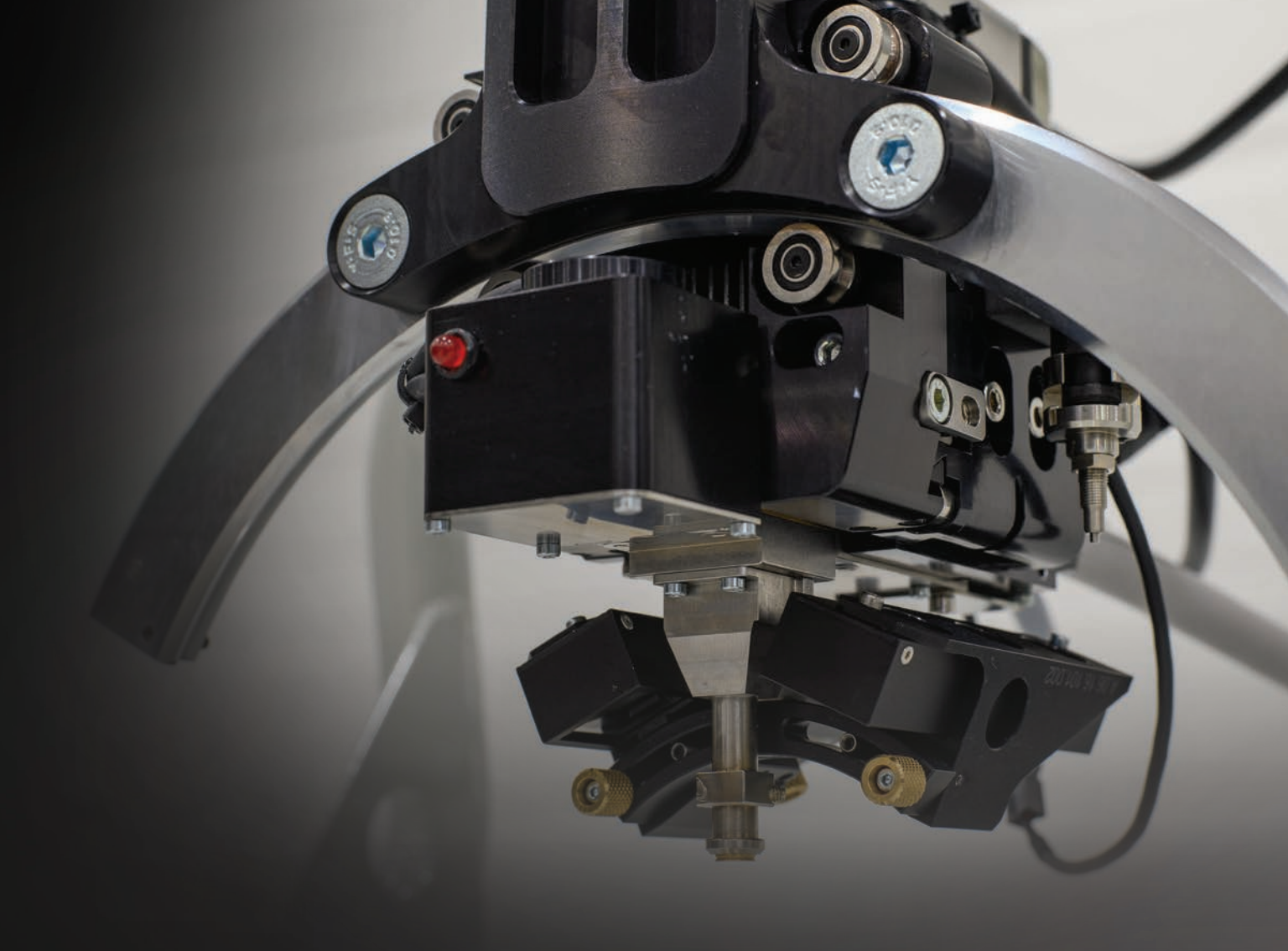
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