Volume 25, Issue 4 Fall 2011
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The Shot Peener

The Boeing 787 Dreamliner is 50% composite by weight, 80% composite by volume

Composites Are Flying High

Will Shot Peening Stay Aloft?

An Expert's Opinion on Composites Versus Metals
New Landing Gear Materials
Is Shot Peening Keeping Pace?

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Celebrating 25th Year

The Shot Peener

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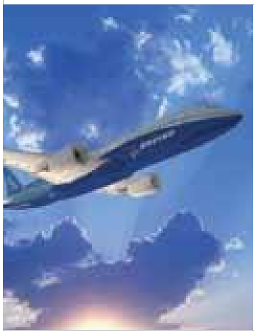


An expert in aerospace composites and metals answers the question:

Will Shot Peening Stay Aloft?

The Boeing 787

The Boeing 787 materials listed by weight:

- 50% composite
- 20% aluminum
- 15% titanium
- 10% steel
- 5% other

The aircraft will be 80% composite by volume. Aluminum is used on wing and tail leading edges, titanium used mainly on engines and fasteners, with steel used in various places.
Resource: www.wikipedia.com

Composite materials have been used in aircraft interiors for years and now they are making their way into aerospace structural components. To keep tabs on composites, we kept in touch with Derick Baisa while he was the Director of Marketing for C&D Zodiac Inc. /Northwest Composites. The overhead luggage bins in planes with which you have a love/hate relationship? C&D Zodiac has been producing them, and many other composite components, since 1987. Mr. Baisa recently left C&D Zodiac to be the Business Development Manager at AMT, a precision machining and assembly aerospace facility in Arlington, Washington.

AMT manufactures structural parts for the world's leading original equipment manufacturers and tier one suppliers such as Boeing, Airbus, Bombardier, Gulfstream, Hawker Beechcraft, Cessna, Sikorsky, Spirit AeroSystems, Triumph and Goodrich. AMT's experience and capabilities span multiple segments of an aircraft, including the engine pylon, struts, wing box, wings, vertical stabilizer, horizontal stabilizer, floor beams, wheel well and interior components. AMT has 3, 4 and 5-axis high-speed machining capabilities up to 33,000 RPMs and hard metal machining capabilities.

AMT outsources shot peening to several companies. To meet their high volume and quality control requirements, AMT placed a shot peening machine in a shot peening vendor's facility for their exclusive use.

Now Mr. Baisa is able to give us his viewpoint from both sides of the playing field and we are pleased to share our most recent conversation with you.

Shot Peener magazine (SP): Are metals and composites truly competitors?

Derick Baisa (DB): I would say yes. Composites and metallics are competitors in the structural aerospace market. We've seen the trend shift towards more and more composite components on aerospace structures; however, there will always be a good portion of metallics in structures. Of course, we're also noticing a rise in titanium components that interface with the composite details due to the compatibility of these materials.

SP: Are composites a threat to the aerospace shot peening industry?

DB: Yes. Composites have always had a strong hold on aircraft interiors but have now made their have way into structural components. Some of our metallic components have been re-designed to composite, mainly for weight savings, although we have recently witnessed some new designs that are bucking the trend and are being redesigned from composite details to metallic for better weight savings and fatigue life. But as engineering designs evolve and include more composite materials, it will have an effect on shot peening requirements.

SP: Will shot peening still have a role in aerospace manufacturing?

DB: This is a good question. The trend in recent designs has been toward composites or other lighter weight materials such as aluminum lithium. Composites are now used in components which were traditionally metallic such as floor beams, fuselage frames, wing ribs and longerons. I think we will see good competition between these new breeds of materials in future designs.

Shot peening will continue its role in the production of metallic aerospace parts, despite the trend toward composites, because commercial aerospace is in a growth market. But even though it's growing, the commercial aerospace industry is challenged at the moment with rate increase announcements on almost every platform. These rate increases, along with Boeing's recent decision to re-engine the 737, mean that we should see the existing 737 metallic structure around for a much longer time. This work is now sustainable through the foreseeable future.

This is good news for machine shops like ours as well as shot peeners that will service this part of the market. In fact, the rate escalations for the 737 mean much more work content in the future. 737 rates are confirmed at 31.5 shipsets (ss)* per month through the end of 2011 and 35 ss/Mo. in 2012, 38 ss/Mo. in 2013 and 42 ss/Mo. in 2014. There's also talk that Boeing is looking into even higher rates of 50-60 ss/Mo. This is on top of 777 rates from 7 ss/Mo. to 8.3ss/Mo. and 747 rate increases from 1ss/Mo. to 2 ss/Mo.

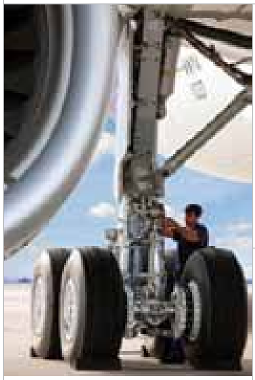
787 Rates will start to escalate upward towards 10 ss/Mo., also with their first delivery scheduled for September of this year. On the other side of the Atlantic, Airbus is doing the same and their new A320neo is selling like hotcakes. They posted 600+ orders and agreements during the Paris Air Show.

AMT is in "rate readiness mode." We're querying ourselves and our vendors to prepare for the high volume of work. Wow! Aerospace is a booming market in an otherwise slow economic recovery.

SP: Thank you for your unique perspective, Derick.

**A shipsest is the full complement of a part assembly required to equip and complete one specified aerospace vehicle for full operation.*

Derick Baisa is the Business Development Manager at AMT, a precision machining and assembly facility for aerospace.



New Landing Gear Materials

The development of new materials for the aerospace industry is moving at a rapid pace. And what herculean tasks these new materials must accomplish: Durability, robustness, weight reduction, cost economies, and environmental responsibility. Even so, steel components in landing gear are being challenged on every level and it's important to recognize the changes and opportunities for the shot peening industry.

Polymer Matrix Composites

In 2010, Fokker Landing Gear, located in the Netherlands, signed a three-year agreement with Goodrich Corporation to introduce thick-walled polymer matrix composite (PMC) landing gear drag braces for the Lockheed Martin F-35 Lightning II joint strike fighter aircraft. PMC is a plastic matrix reinforced by high-performance carbon or organic fibers. The fiber reinforcement is stronger than the matrix and provide stiffness and strength. Reinforcement is laid in a particular direction within the matrix and the resulting PMC will have different properties in different directions (anisotropic properties).

Fokker Gear has brought the development of PMC technology to a position where it can be certified and qualified against FAA/EASA requirements with these benefits:

- Increased aircraft performance due to weight reductions of up to 30%
- Increased durability and robustness of landing gear
- Elimination of metal corrosion and cracking

Messier-Bugatti-Dowty is using fiber-reinforced composite braces, too. A U.S. company, Albany Engineered Composites, is preforming the carbon fiber braces for Messier-Bugatti-Dowty's 787 landing gear structure. The preforms will be infused with epoxy resin via resin transfer molding and will provide weight savings to the 787. Messier-Bugatti-Dowty has also used ultra high-strength steels (300M steel) and aluminium alloys in landing gears.

Titanium and Titanium Matrix Composites

A number of the Boeing 787 landing gear components, including the main gear inner cylinder, have been made from titanium by Messier-Bugatti-Dowty—a first in the industry. According to Messier-Bugatti-Dowty, titanium provides weight savings and the strength of existing steels.

In an article titled, "The Science of the Safe Landing Gear" from www.aerospace-technology.com, Messier-Bugatti-Dowty is evaluating components in titanium matrix composites, which are claimed to far exceed the performance of 300M steels and titanium. "The use of metal matrix composites is currently uneconomical, but they clearly offer great future potential," the article states.

High-Strength Stainless Steels

New high-strength stainless steels offer a high corrosion resistance, high fracture toughness and excellent corrosion resistance. Aubert & Duval, a member of the global company Eramet, claims that the strength of its MLX17 high strength stainless steel is such that "a 1mm diameter wire would be strong enough to lift a car." MLX17 (X1CrNiMoAlTi12-11-2) is capable of 1700 MPa; aluminum and titanium are used for hardening. Applications for MLX17 include landing gears, actuators, and flaps.

In addition to stainless steel's strength and anti-corrosion properties, it has environmentally-responsible attributes—it doesn't require toxic cadmium surface treatments like other steels and stainless steel is recyclable.

Economy and Weight Will Be the Final Arbitrators

If these new materials are equally robust and reliable compared to their predecessors, their success in the marketplace will depend upon their ability to reduce weight and lower fabrication costs since these are two crucial factors in aerospace manufacturing today.

Fokker Landing Gear's Polymer Matrix Composite drag brace

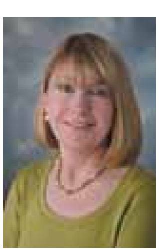
Shot Peening and its related processes are keeping pace with advancements in materials as evidenced by the quality of work presented at the Eleventh International Conference on Shot Peening

Shot Peening Research Keeps Pace with New Materials

I admit that most of the material presented at ICSP-11 was over my head. I enjoy reading a paper's Abstract, Introduction and Conclusion, but the actual research..not so much. I went to paper presentations, not because I hoped to understanding the data, but to meet the people that were capable of doing the work.

I didn't appreciate the real-life applications of the research until I started the article on new landing gear materials. In a stroke of luck, I picked up the ICSP-11 Proceedings and started thumbing through the Index. Titanium 6-4, Titanium Matrix Composites. High Strength Stainless Steels. They were all there—the materials that contribute to advancements in technology.

Now I see the International Conferences on Shot Peening in a new light. It's a gathering of the best minds in shot peening *and* the future of the shot peening industry. I've compiled a few of the new materials and related ICSP-11 papers but there were many more gifted academic and industrial researchers at ICSP-11 who are pushing the boundaries of shot peening. I provided the author's work affiliations—note the collaboration between universities and commercial facilities in many of the projects.



Kathy Levy is a Technical Marketing Writer at InfoProse.

TITANIUM ALLOYS

Titanium 6-4 (Ti-6Al-4V) is still the workhorse of the titanium industry and accounts for over 50% of total titanium alloy production but new titanium alloys are moving in. Researchers are exploring the benefits of shot peening and other surface enhancements on titanium alloys including a study on shot peening and fatigue life of Ti-6Al-4V, a comparison of conventional shot peening to ultrasonic shot peening on aero-engine bladed disks, and shot peening and ball-burnishing on Timet's new titanium alloy: TIMETAL - 54M (Ti-5Al-4V-0.5M0-0.4Fe).

Paper Title:
Numerical Analysis of Shot Peening Effects on the Fatigue Life of a Titanium Alloy

Authors:
Bae, H.[1], Ramulu, M.[1], Flinn, B.[2], Diep, H.[3]

1 Department of Mechanical Engineering, University of Washington, Seattle, Washington
2 Department of Materials Science and Engineering, University of Washington, Seattle, Washington
3 The Boeing Company, Seattle, Washington

Paper Title:
Ultrasonic Shot Peening (USP) on Ti-6Al-4V and Ti-6Al-2Sn-4Zr-6Mo Aero Engine Components

Authors:
Stoll, I.[1], Helm, D.[1], Polanetzki, H.[1], Wagner, L.[2]

1 MTU Aero Engines GmbH, Munich, Germany
2 Department of Materials Science and Engineering, Technical University of Clausthal Clausthal, Germany

Paper Title:
Shot Peening and Ball-Burnishing to Improve HCF Strength of the New Titanium Alloy TIMETAL-54M

Authors:
Zay, K.[1], Shan, Y.[1], Kosaka, Y.[2], Wagner, L.[1]

1 Institute of Materials Science and Engineering Clausthal University of Technology, Germany
2 Timet Henderson Technical Laboratory Henderson, Nevada

TITANIUM MATRIX COMPOSITE

Titanium Matrix Composites (TMCs) are too expensive for current use but have great implications for automotive and aerospace components. The following papers explore the unique aspects of TMCs as related to shot peening: Their reinforced particles make the microstructure and residual stress distribution more complicated than in traditional metals, and the thermostability of composites after shot peening hasn't been widely studied. Substantiation of shot peening's benefits to TMC and the acceptance of TMC in the marketplace will greatly increase shot peening's scope of application.

Paper Title:
Application of the FEM for the Prediction of the Micro-Region Stress of TiB2/Al Composite

Authors:
Huang, J.[1], Bian, K.[1], Jiang, C.[1], Wang, Q.[2]

1 School of Material Science and Engineering, Shanghai Jiao Tong University Shanghai, P.R. China
2 Dafeng Daqi Metal Grinding Material Dafeng, P.R. China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Paper Title:
XRD Investigation of Thermal Relaxation Behavior of Microstructure in TiB2/Al Deformation Layer Introduced by Shot Peening

Authors:
Luan, W.[1], Jiang, C.[1], Chen, X.[2]

1 School of Material Science and Engineering, Shanghai Jiao Tong University, Shanghai, P. R. China
2 Shanghai Carthing Machinery, Shanghai, P. R. China

HIGH-STRENGTH STAINLESS STEELS

"High strength stainless steels and age-hardenable super-alloys are rapidly gaining favor with designers in the aerospace, military and other industries who are challenged to meet higher performance expectations and stringent regulatory requirements at lowest life cycle cost," writes Anthony Guitterez, member of ASM International, in his article on high strength stainless steels for Carpenter Technology. Faculty members from the Academy of Armored Forces Engineering presented their work on 30CrMnSiNi2A, a low-alloyed steel widely used in Chinese aviation.

Paper Title:
The Effects of Ultrasonic-Aided Deep Rolling Process on Fatigue Performance of 30CrMnSiNi2A Steel

Authors:
Xie, J., Zhu, Y., Huang, Y.

Faculty of Remanufacturing Engineering
Academy of Armored Forces Engineering, Beijing, China

ALUMINUM LITHIUM ALLOYS

Aluminum-producer Alcoa intends to get back into the aerospace market with their Aluminum Lithium Alloy. Alcoa claims an airplane made with the new metal would be up to 10% lighter than composite-intensive planes, giving airlines additional fuel savings, and cost up to 30% less to make, operate and repair. Aluminum is also much more recyclable than other materials. "Once the airliner is sent to the desert for retirement, the aluminum airplane will be much easier to recycle into a new airplane than its composite cousins," wrote Jason Paur with www.wired.com

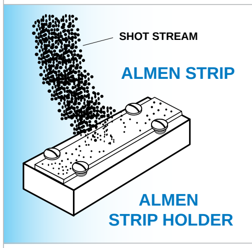
Aluminium lithium alloys were missing in the ICSP-11 Proceedings, probably because they aren't a commonly-used material. Curiously enough, researchers from the United Kingdom presented a paper on Aluminum Lithium Alloy at ICSP-3 in 1987. "A1-Zn-Mg alloys have been in use for many years, but recently alloys based on A1-Li have been developed with improved strength-weight ratios and it is thought that they may become widely used aircraft alloys in the 1990s,"[1] state the authors.

Paper Title:
The Effect Of Shot-Peening On Fatigue And Fretting Fatigue Behaviour Of 8090 And 7010 Aluminum Alloys

Authors:
Fair, G., Noble, B., Waterhouse, R.

Department of Metallurgy and Materials Science
University of Nottingham, United Kingdom

[1]C.J. Peel, B. Evans and D.S. McDarmaid: "Aluminium-Lithium Alloys III," Inst. Met. London (1986), 26.



Key Terms in Intensity Control

for the New Shot Peening Technician

Intensity control is essential for process reproducibility and repeatability and it's an area where many new shot peening technicians could use a helping hand.

In an effort to help, we've supplied definitions for the key terms in the intensity control process.

almen strip. Almen strips are test coupons made of SAE spring steel that measure the energy of the shot stream, or the "intensity." The strip is fixed to a holder and is exposed to the shot stream. The residual compressive stress imparted into the strip from peening will cause the strip to arc toward the peened side when released from the holder. The amount of "arc height" is a function of the intensity and is quantifiable and repeatable. The strip's arc height is measured on an Almen gage.

Almen strips are categorized by thickness into three groups: "N", "A", and "C". The strips can be further classified by flatness (prebow) and hardness.

Thickness
"N" strip thickness = 0.031" (0.79 mm)
"A" strip thickness = 0.051" (1.29 mm)
"C" strip thickness = 0.094" (2.39 mm)

The thickness determines a strip's ability to arc during peening so each strip has an appropriate intensity range, as expressed by the arc height measurement from an Almen gage.

The "A" strip is considered the standard strip and is used when the required intensity range is .004'' - .024''. When an intensity lower than .004'' is required, the thinner "N" strip should be used. The "C" strip is used to achieve an intensity above .024''.

The length and width are the same for all three strips: 3" x .75" (76.2 mm x 19.05 mm).

Flatness. See **prebow**.

Hardness
Hardness affects the strip's performance: As hardness increases, the arc height decreases. "A" and "C" strips have a hardness range of HRc 44-50. "N" strips have a hardness range of HRa 72.5-76.0. In more critical applications like aerospace, the part's designer will specify an Almen strip with a smaller hardness range.

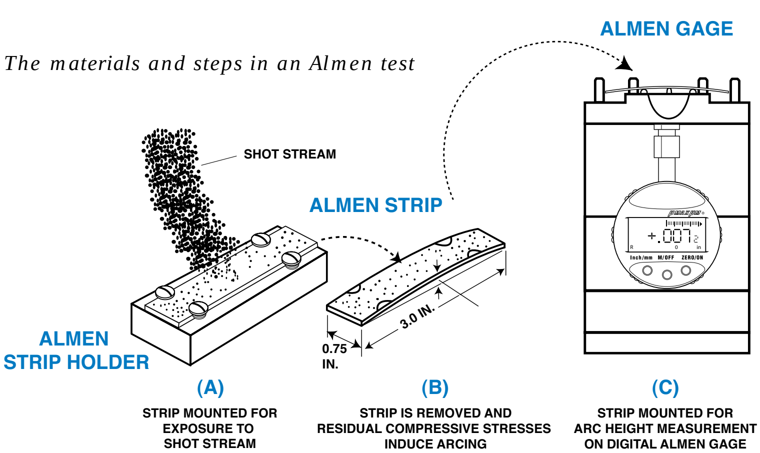
almen gage. An Almen gage measures the height of the arc of a peened Almen strip. The "arc height" is the quantitative representation of the applied force of the shot stream or the "intensity" of the shot stream. The energy of the shot stream directly influences the amount of compressive stress imparted into the surface of a component.

Almen gages have a digital readout with a .0001'' (.001 mm) display and .00005" (0.00127 mm) resolution. The high degree of resolution improves accuracy and ensures repeatability and reproducibility in the shot peening process. See Figure 1.

almen strip holder. Almen strips are mounted on an Almen strip holder for exposure to the shot stream. Almen holders are mounted on a test part or custom fixture and placed in locations where verification of the energy of the shot stream (intensity) is crucial. See Figure 1.

almen test. An Almen test is a crucial part of a controlled shot peening process because it

Figure 1. The materials and steps in an Almen test



verifies intensity. Intensity is the energy of the shot stream and it directly influences the amount of compressive stress imparted into the surface of a component.

Almen strips, gages and holders are the industry-standard tools for an Almen test—a procedure to measure the arc height of a shot-peened Almen strip. The arc heights from Almen tests are used to plot a Saturation Curve. Data from a saturation curve verifies the appropriate intensity reading for the process. **See saturation curve**.

An Almen test ensures that the shot peening machine is set up and running according to the approved parameters so that damage to valuable parts is prevented. Almen tests are repeated during long production runs to verify that the processing parameters haven't changed.

arc height. Arc height is the degree of curvature of a peened Almen strip as measured on an Almen gage and is expressed in inches or millimeters. It is the quantitative representation of the applied force of the shot stream.

almen intensity. The Almen intensity is a designation that specifies the arc height (as measured on an Almen gage) and the Almen strip type. For example, the proper designation for a 0.012'' (0.30 mm) arc height using the A strip is 0.012A (0.30A). This designation is often simplified to "12A."

coverage. *Coverage (noun): The extent to which something is covered.*

Coverage is the measure of the original surface area that has been covered by shot peening dents. It's one of the key parameters of the shot peening process and is controlled by equipment cycle time.

Coverage is specified by a percentage. If the goal is "100% coverage," the length of machine cycle time to achieve 100% coverage will depend on the hardness of the material to be peened.

The machine cycle time to achieve 100% coverage is determined through visual inspection and can be corroborated with coverage check tools. Once established, the shot peening technician uses this time as a base to achieve levels of over-coverage (for example: 150%, 200%, 300%).

The concepts of coverage and saturation, and the timing necessary to achieve both, are confusing to new and experienced shot peening technicians. It takes longer to achieve 100% coverage than it takes to achieve "saturation," the required intensity reading of a shot peening procedure derived from a saturation curve. The "peening time" in the saturation curve graph is NOT the machine cycle time needed to achieve 100% coverage on the Almen strip. Also, the amount of machine cycle time necessary to achieve 100% coverage on the component will be different than for an Almen strip due to differences in material hardness. See **saturation curve**.

exposure time. Exposure time (also called "peening time") is the time variable when developing a saturation curve. Exposure time is not the appropriate length of time for the machine cycle; however, since it will take longer in most cases to achieve the desired amount of coverage on an Almen strip and the component. See Figure 2 and **saturation curve**.

intensity. Intensity is the measure of the energy of the shot stream. The energy of the shot stream directly influences the amount of compressive stress imparted into the surface of a component. Surface residual compressive stresses provide resistance to metal fatigue and some forms of stress corrosion. Intensity can be controlled by media size, media type, media impingement angle and shot stream velocity.

Intensity is expressed as the arc height measurement of a peened Almen strip on an Almen gage. For example, a specification requests a .010 ±.002 A. An intensity of 0.010" is called for with an approved variance of 0.002" on a type "A" Almen strip. The acceptable range is from 0.008" to 0.012".

intensity verification. See **saturation curve**.

metal fatigue. Metal fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loadings—loads that are applied over and over again. If the loads are above a certain threshold, microscopic cracks will begin to form at the surface. Eventually a crack will reach a critical size and the structure will fracture.

Shot peening creates residual compressive stresses that confer resistance to metal fatigue. See Figure 3 on page 16.

plasticity. Plasticity is the deformation of a material undergoing non-reversible changes of shape in response to applied forces. In shot peening, shot impacts the metal and makes dents. The peened metal then displays plasticity because permanent changes have occurred within the material's surface.

prebow. Pre-bow, or the variation from "perfect" flatness, in the unpeened Almen strip acts like a latent bias in the arc height measuring system. A strip that has a pre-bow of .001 inch will have a .001 inch higher arc height than a strip with zero pre-bow. If the initial pre-bow value is negative, than the resulting arc height will be diminished by the same amount. A compensation scheme may be used to negate some of these effects by taking a net reading of the strip arc height.

Almen strips are classified in grades of varying prebow tolerances to meet a wide range of applications, from automotive to aerospace.

residual compressive stress. Residual stresses are stresses that remain after the original cause of the stress has been removed. Shot peening creates residual compressive stress, a beneficial stress that provides resistance to metal fatigue and some forms of stress corrosion. See **stress**.

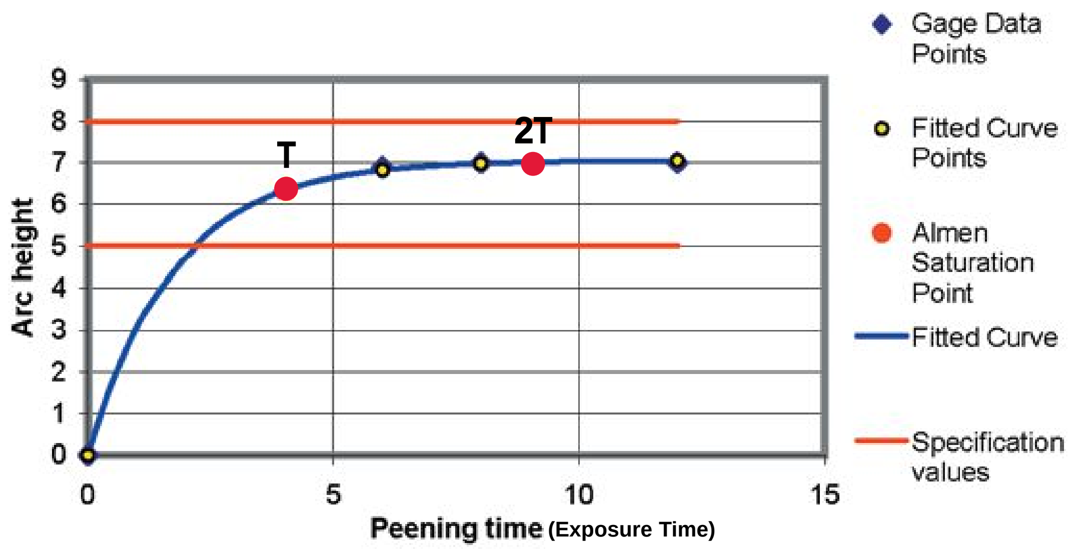


Figure 2. Saturation occurs when doubling of the peening time (2T) from T results in less than a 10% increase in arc height. The saturation curve was plotted with a computerized curve solver program.

saturation curve. *Saturation (noun): The state or process that occurs when no more of something can be absorbed, combined with, or added.*

A saturation curve is the graphical plotting of arc height versus exposure time to determine "intensity" (the velocity of the shot stream). It's the accepted method for verifying or establishing the requested intensity reading. The saturation curve is plotted with a minimum of four arc height readings that were taken during a peening session with fixed machine parameters. Saturation is defined as the earliest point (T) on the curve where doubling the peening time (2T) produces a 10% increase in arc height. This is called the 10% Rule. The arc height at "T" is then used as the intensity reading of the shot stream at a given time for a particular machine setup. If the arc height reading at "T" is not within the requested tolerance band, then machine adjustments must be made and a new saturation curve generated. See Figure 2.

saturation curve solver program. Plotting arc heights for a saturation curve is time-consuming and often inaccurate. Computerized curve solver programs are available that simplify the procedure.

specification. A specification is an explicit set of requirements to be satisfied by a material, product, or service.

The products and procedures of the shot peening process are regulated by public specifications like those issued by the Society of Automotive Engineers (SAE), a customer-supplied specification or an in-house spec. The shot peening requirements in a specification will typically have these components: References to an applicable industry specification (for example: SAE J442), the area to be peened, the media and the intensity.

stress. When a force is applied to an object, the object is said to be experiencing stress. Stress is effectively a measure of an object's response to a force. Stress can either be positive or negative depending upon the nature of the force. If a region of a component is stretched, then the stress is generally positive, or tensile. If the region is squeezed then the stress is negative, or compressive.

Tensile stress is usually considered bad, a compressive stress is usually considered beneficial. Imagine a small crack that has formed in a surface (Figure 3). If the stress around the crack is tensile, the crack is pulled apart by the stress and becomes deeper.

On the other hand, if the stress is compressive, then the crack is pushed together and grows no farther. Shot peening puts residual compressive stress into the surface of a metal to inhibit or slow the growth of cracks and thus improve the fatigue life and wear resistance of critical components.

tensile stress. Tensile stress (or tension) is the stress state leading to expansion; that is, the length of a material tends to increase in the tensile direction. Tensile stress is the opposite of compressive stress as compressive stress is the stress on materials that leads to a smaller volume. See Figure 3.

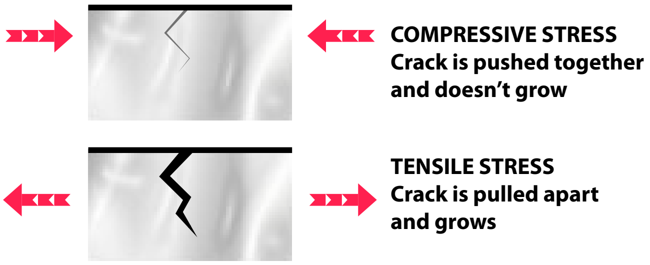


Figure 3. Compressive and Tensile Stress Comparison

Based on a drawing by Darren Huges, Institut Laue-Langevin in Grenoble, France

Dave Barkley, trainer with Electronics Inc. Education Division, demonstrates flapper peening at the 2009 China workshop.

China:
An Emerging Peening Market

To establish its role as a major subcontractor for the building and repair of aircraft, China collaborates with foreign firms like Boeing, Airbus, Rolls Royce, and General Electric to achieve technological transfers. In the past 10 years, China's manufacturing capabilities and labor intensive MRO facilities have been enhanced to meet future international and domestic needs of aircraft demand. This trend is set to continue as China improves its transport infrastructure in the next decade.

For special processes like shot peening, which are so critical for aerospace, there are limited FAA-certified training courses in the country. So the first problem for the aerospace industry here is the lack of qualified personnel to execute this process effectively. The second is the language medium for these training courses. Chinese is still by far the main language in China so it's not surprising when AMS and engineering specifications are interpreted differently from what they should be.

I started participating in Electronics Inc. Education Division's shot peening workshops in Singapore in 2004. In 2008, Electronics Inc. Education Division (EIED) and Pakpal agreed to host a shot peening workshop in Chinese and provide proper training in China. We had no idea where it would lead us. First, we had to ensure that lecture materials were translated correctly and the terminology was consistent. Then we had to make sure that all questions would be translated on the spot. Getting proper FAA certificates for their training is a priority for many, so we wanted students to understand and answer their examination questions in Chinese.

The logic behind shot peening is pretty simple to explain: It's a method of inducing compressive stresses to relieve metal fatigue. Everything gets complex once students start asking relevant questions: What is the difference between intensity and arc height? How does media affect your coverage? How do you control machine parameters to ensure repeatability in your process? How do part geometries and specifications affect your decision on the kind of equipment needed?

Adam Chai coordinates the Electronics Inc. Education Division workshop in China. He is Director of Corporate Affairs for Pakpal Surface Technology, a manufacturer of Dry/Wet Blasting and Peening Equipment that specializes in CNC peening equipment for the Chinese aerospace industry.

The 2009 workshop attendees at the Pakpal Surface Technology facility in Shenzhen, China

How do you interpret your specifications like AMS2430 or AMS2431? I can't get the intensity, can't I just use the arc height with full coverage on the strips and forget about the saturation curves? (The answer to the last one is obviously no, and we'll explain why in Chinese during the workshop.)

It never fails to amaze me that each year we present the same topics, but each year there is something new to learn. This is the result of the dynamic interaction between speakers and students in the lecture room for the first two days. On the third day, optional on-site training is provided at Pakpal's equipment facility where we perform a controlled shot peening process. This is especially helpful for new service personnel. For more experienced operators, the third day gives them an opportunity to explore other issues. For example, there is only one desired intensity range but there are so many different permutations of parameters (flow rates, pressure, impingement angles, etc.) that allows you to fulfill your task. What is the most efficient way? The answers can vary widely and this stimulates a more in-depth analysis.

I feel that this collaboration effort has been unique and the entire experience has been a rewarding one. I thank EIED trainers for travelling across the world to a foreign land to provide training four years in a row. The fact that speakers, experts in the field, and students can share information in their native language has benefits unlike any other workshop or seminar. This year we had a student returning for the third time and he passed the Level III examination. I guess we must be doing something right.

Many in the aerospace and automotive industries are beginning to understand the benefits of shot peening. Unfortunately, concepts like intensity and coverage still cloud many minds, and we have only scratched the surface. I look forward to future workshops with EIED and hope to contribute more to the development of shot peening in China. There is a long way to go before we can attain complete coverage on this topic.

Hong Xian Da is First Student to Receive Level Three Shot Peening Achievement Certificate in China

Hong Xian Da, Peening Technical Engineer at Taikoo Landing Gear Services Co., Ltd., (TALSCO) has received the Level One, Level Two and Level Three Shot Peening Achievement Certifications. "Much of the content in the Level Three exam is based on knowledge and expertise gained from working in the shot peening industry. By passing all three exams, Mr. Hong has demonstrated a strong understanding of every aspect of a controlled shot peening process," said Dave Barkley, Director of Electronics Inc. Education Division.

"Thanks for everything, it really helps that the lessons are conducted in Mandarin as my command of English is not that strong. I also appreciate the fact that there is a lot of interaction between students from different facilities and with speakers from different backgrounds. To me this is a very important part of the workshop. It's an honor to be the first student to pass the level 3, I hope my colleague who have just passed level 2 will be next. The flapper peening exam is next on my list."

—Hong Xian Da

Instructors and students at the 2010 China workshop

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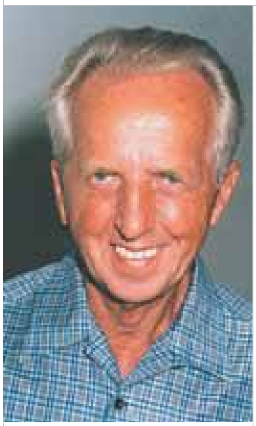


Dr. David Kirk is a regular contributor to The Shot Peener. Since his retirement, Dr. Kirk has been an Honorary Research Fellow at Coventry University, U.K. and is now Visiting Professor in Materials, Faculty of Engineering and Computing at Coventry University.

Continuous Measurement Versus Intermittent Indication of Peening Intensity Curves

INTRODUCTION

Peening intensity curves are of vital importance for effective shot peening. They can be either continuously measured or intermittently indicated. The difference in approach can be illustrated by an everyday example. Imagine that a daily outdoor temperature curve is needed. We could connect a thermocouple to a chart recorder and set that to run for twenty-four hours. That would correspond to continuous measurement of temperature changes and give us a continuous curve. Alternatively we could record temperatures intermittently using, for example, the radio signals from a digital thermometer. These recordings could be plotted on a graph but they would only be an indication of a curve. We would have to invoke a curve-fitting procedure to deduce a possible continuous curve. Fig.1 illustrates the essential difference between the two procedures.

Fig.1b can only be an indication of the actual shape of the curve shown as fig.1a. The four points of fig.1b actually lie on the continuous curve, fig.1a. An estimate of the shape of the curve indicated by just the four points might well be "Your guess is as good as mine".

Current standard shot peening practice is for a set of intermittent indications to be made involving the deflections of a set of Almen strips peened for different total times. These are then used to indicate a continuous curve which can then be analyzed for parameters such as peening intensity. It is, however, also possible to produce a peening intensity curve directly using continuous measurements. The difference is indicated in fig.2 (page 26).

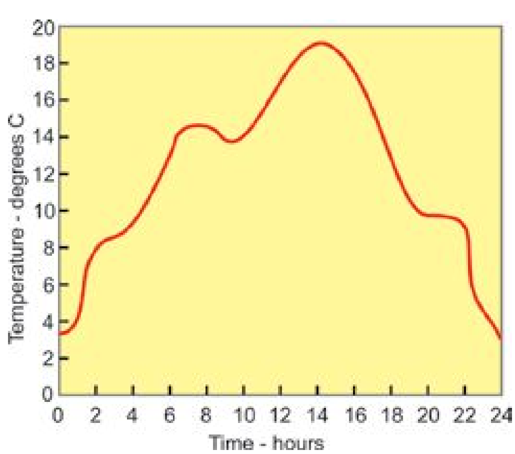


Fig.1a Continuous measurement of a temperature/time curve.

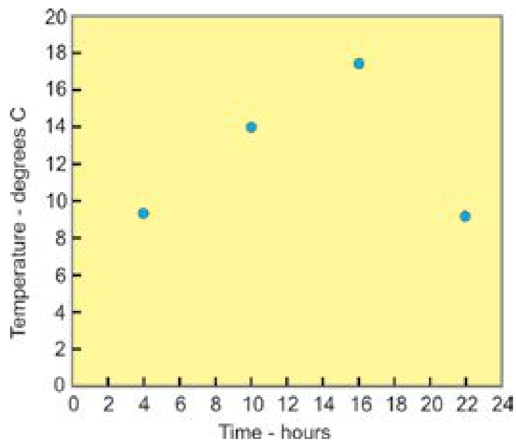


Fig.1b. Intermittent indication of a temperature/time curve.

This article aims to compare and contrast these two approaches. It is concluded that continuous measurement can be a useful supplement to established intermittent indication of peening intensity curves.

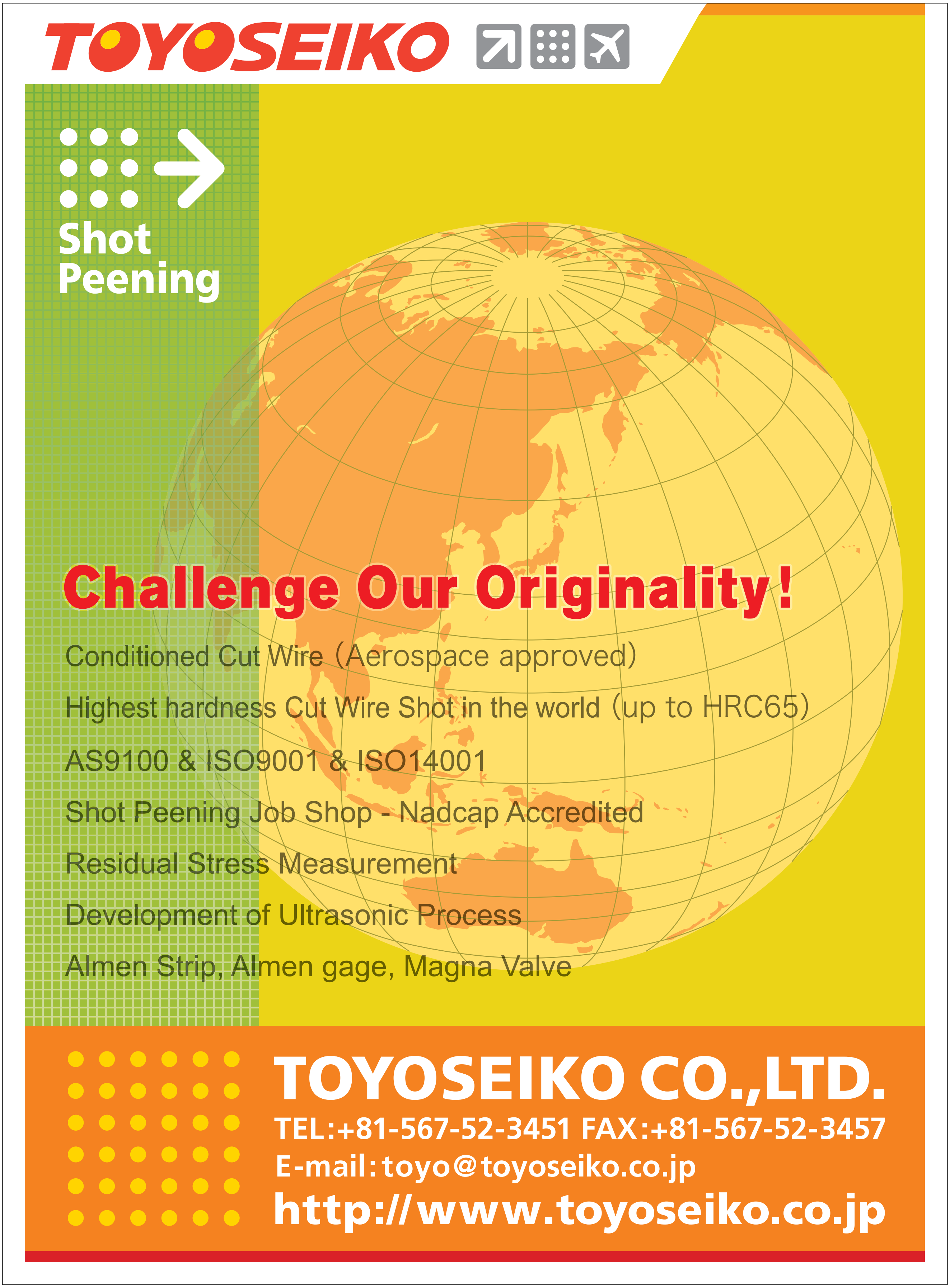
CONTINUOUS MEASUREMENT OF PEENING INTENSITY CURVES

Techniques

A continuous peening intensity curve can be produced if the shot stream is static relative to an Almen strip. This concept was introduced by the author at ICSP5. The strip deflection is monitored while the strip is still clamped to its retaining block. During peening, a clamped Almen strip adopts the complex shape shown in fig.3 (page 26).

The deflection of the central portion of the strip (between the hold-down screws) can be continuously monitored using a Linear Variable Differential Transformer, LVDT. An LVDT with an appropriate range has extraordinary sensitivity and accuracy. Hence it can easily cope with the fact that the as-clamped deflection is only about one-third of that of the entire strip after its release from the hold-down screws.

There is no fundamental reason why peening intensity must be determined using rectangular strips. That shape is purely historical, probably reflecting the ready availability of rolled strip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that could easily be guillotined into standard lengths. Continuous measurement devices employing circular disks were described in detail by the author at ICSP6. Fig.4 illustrates the basic principles that are involved. Test disks are used having the same thicknesses and of the same steel as Almen strips. When the disk peening diameter is about 40mm the disk deflection is close to that of a conventional Almen strip deflection. Washers of different

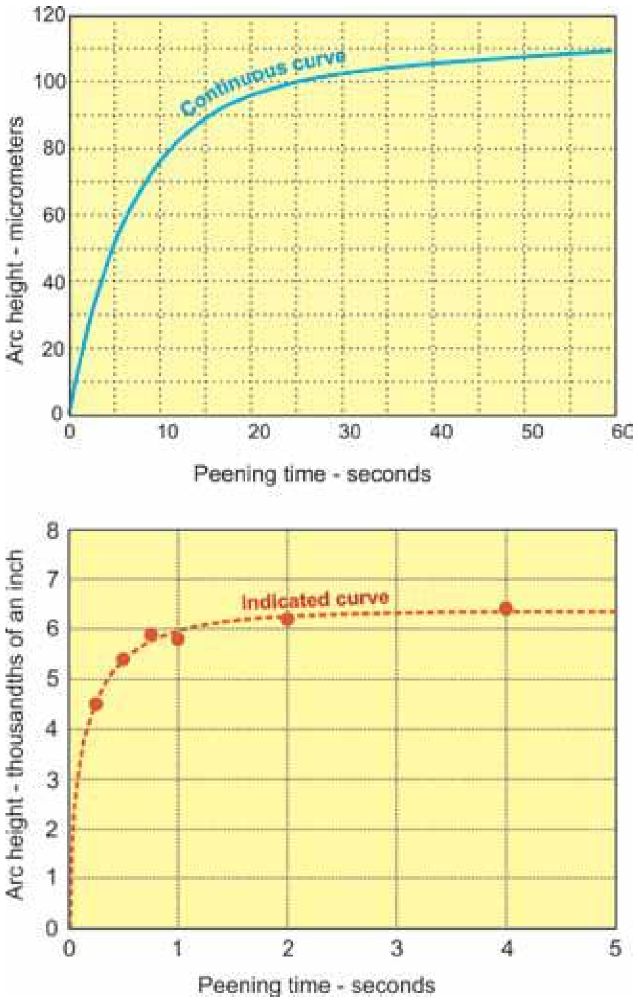

Fig.2 Comparison of Continuously measured and Indicated peening intensity curves.

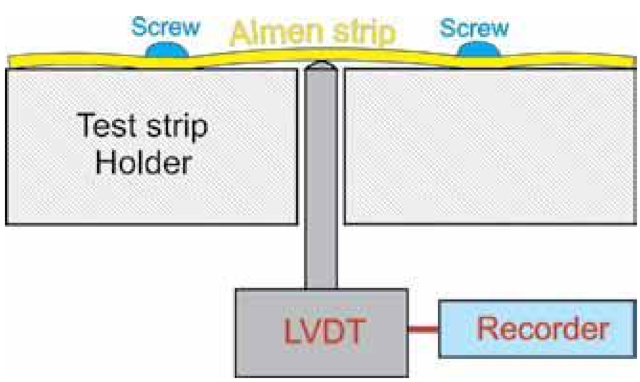

Fig.3 Schematic representation of Almen strip holder modified for continuous measurement of as-clamped strip deflection.

diameters are employed that allow the peened disk area to be fine tuned.

For both types of continuous monitoring device, calibration against standard intermittent measurements will reveal the appropriate relationship:

$$H_S = k.H_C \quad (1)$$

where H_S is the peening intensity determined using the standard Almen strip technique, k is the derived calibration constant and H_C is the peening intensity determined using continuous measurement.

For continuously-monitored Almen strips, **k** is approximately equal to 3 but for continuously-monitored disks it can be arranged so as to be approximately equal to 1.

Advances in data transfer technology would now permit the use of more compact devices than those described, with deflection signals being transmitted wirelessly to a computer for automatic translation into peening intensity and critical time values. Even with basic technology, continuous monitoring will allow peening intensity to be determined in less than a tenth of the time required using the standard Almen strip method.

Applications

The following are just some of the several applications that can be envisaged for continuous monitoring of peening intensity.

1) OEM & Setting-up: The enormous saving in time afforded by continuous monitoring could be very useful for OEM's and large peening organizations. They require a very large number of peening intensity measurements when verifying new facilities and when setting-up for a new scale of component. Occasional cross-checking with conventional intensity measurement would, however, be necessary.

2) Single-pass peening: Many organizations achieve specified levels of coverage in a single pass for which a

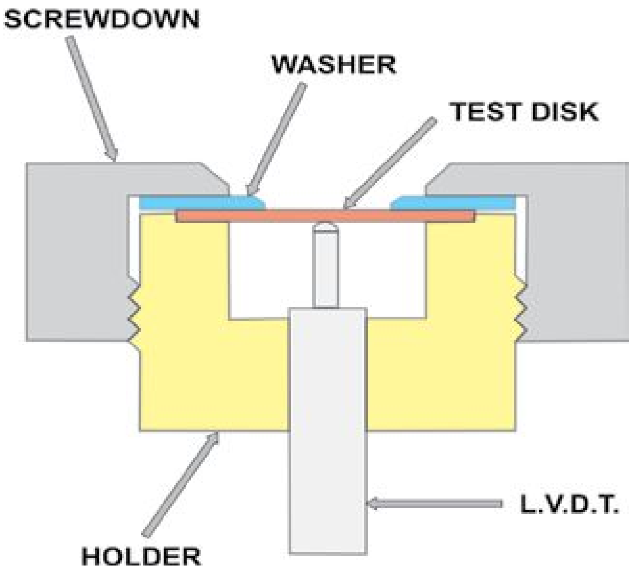

Fig.4 Schematic representation of disk device for continuous intensity monitoring.

single peened Almen strip will have reached so-called "saturation". Specifications covering this type of situation allow for a "Type 2" saturation curve to be produced (where the arc height does not increase significantly after a single pass). With continuous monitoring the approach to "saturation" for a single strip can be evidenced in one pass—without the need for more strips to be peened using multiple passes. Fig.5 illustrates the single-pass situation when a shot stream passing from Position 1 to Position 2 along a path LM aims to give "saturation" of an Almen strip.

There are three factors that affect arc height evolution as a shot stream passes over an Almen strip. Firstly, there is the proportion of the shot stream that is impacting the strip. This will initially be zero, building up to a maximum and then falling to zero as the stream's 'shadow' finally leaves the strip. Secondly, the arc height contribution falls as the coverage increases. Thirdly, the maximum contribution, other things being equal, would occur when the center of the shot stream coincides with the center of the strip. The net effect of the three factors would be reflected in the output of the L.V.D.T. shown in fig.5. Hypothetical output/time curves are shown in fig.6. The arc height is shown as having been calibrated to be the same as that which would occur after unclamping of the strip. It is assumed, just for illustration, that the shot stream takes 4 seconds to travel from Position 1 to Position 2.

If a specified arc height range of 8-10 was being targeted then Curve A would indicate that the intensity was too close to the maximum allowed value. The early leveling-out of the curve does, however, indicate that "saturation" has certainly been achieved. For Curve D the deflection achieved only just meets the minimum requirement. Additionally, the very late leveling-out indicates that

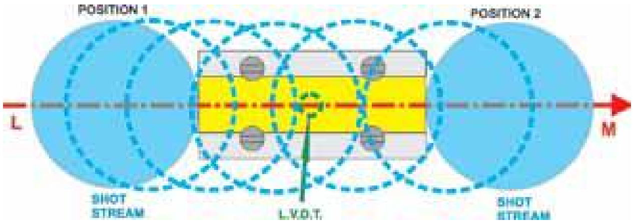

Fig.5 Schematic representation of shot stream passing across an Almen strip.

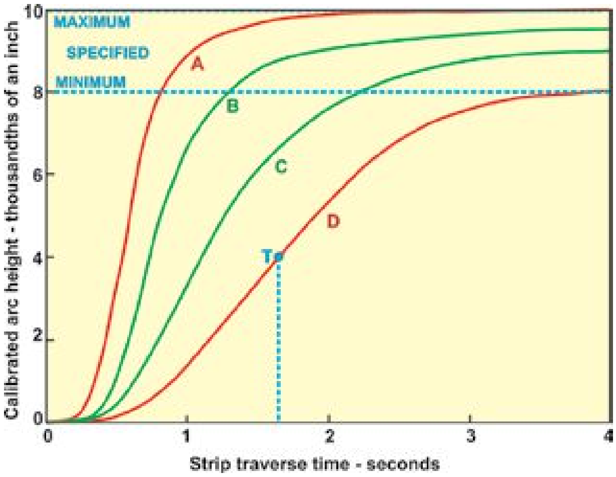

Fig.6 Examples of continuous single-pass arc height curves.

"saturation" has not been achieved. Curves B and C would be typical of peening that did achieve the stipulated single-pass requirements. The point "T" shown on Curve D is a possible defining parameter being the time required to achieve half of the exiting arc height.

3) Shot Stream Intensity Stability: Intermittent measurements of Almen strip deflection give a very unreliable indication of a given shot stream's intensity stability. Each intermittent measurement involves either multiple passes at a fixed traversing rate or single passes at different traversing rates. For each single pass the intensity may vary as the shot stream is traversing the Almen strip but such variation would not be shown up by the single deflection measurement. For multiple passes each pass contributes a fraction of the subsequently-measured deflection. The intensity may vary between passes, as well as within each pass, but again that would not be revealed by the single deflection measurement. Further discussion is included in the next section. Continuous measurement of arc height does, however, show the degree of intensity stability.

The intensity stability of a shot stream is shown by its deviation from the shape possessed by a perfectly-stable shot stream. This poses the question: "What is the shape of the intensity curve generated by a perfectly-stable shot stream?" Two approaches are available to provide an answer to this key question. The first is to analyze Wieland's data (ICSP5) where 388 Almen strips were subjected to nominally the same shot stream. Averaging out these values accommodates fluctuations in process variables. Analyzing by the author (ICSP9) indicated that an averaged-out shot stream would have a shape defined mathematically by a four-parameter equation:

$$\mathbf{h = a[1 - exp(- b*t^{c})] + d*t} \qquad (2)$$

where **h** is arc height, **t** is peening time and **a**, **b**, **c** and **d** are the four parameters.

Sixteen data points were used in the analysis which is far greater than would be commercially feasible (for regular use). A second approach, favored by the author, is to use continuous monitoring of a shot stream whose stability is maintained by applying rigorous laboratory conditions. Dozens of such curves were invariably best-fitted by equation (2).

Having established the shape for a perfectly-stable shot stream the next problem is to obtain an accurate curve for a specific, intensity-variable, shot stream. This can only be done economically by applying continuous monitoring. In the author's Coventry University shot peening laboratory, intensity variability could be effected artificially e.g. by changing the air pressure during a single intensity curve production. In commercial organizations unintentional variability would easily be indicated by deviations from the proper shape of intensity curve.

INTERMITTENT PEENING INTENSITY INDICATION

Standard techniques: Intermittent peening intensity indication is the industry standard. A number of Almen strips, usually four to six, are peened for different time periods. Each strip in a set can either be peened once but for different times or peened several times but for fixed individual times. The first alternative can be effected by varying the relative speed of travel of the shot stream and the strip. The second

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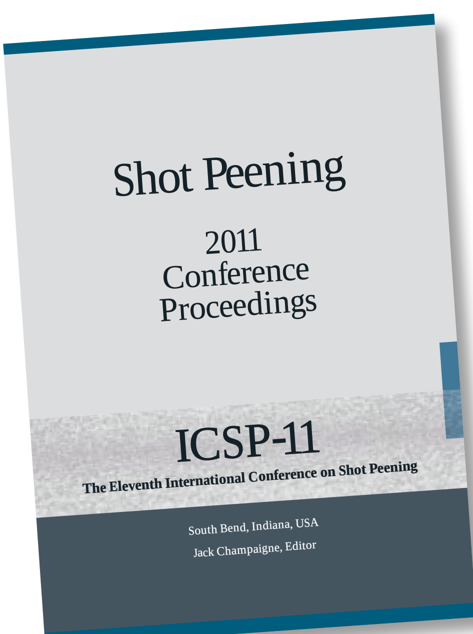

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alternative can be achieved by making different numbers of passes of the shot stream over the strip. Figs.7 and 8 illustrate the fundamental difference between the two alternative approaches. SAE Data Set No.4 has been selected as an independent example. Four strips were peened for 'time periods' of 1, 2, 3 and 4 units yielding arc heights of 3.8, 5.1, 5.2 and 5.3 respectively.

For fig.7, it has been assumed that the actual time periods were seconds. This means that a total of four passes were made involving strips being peened at progressively slower rates of travel relative to the shot stream. For each point it is not possible to ascertain the rate at which the total deflection was achieved.

For fig.8 it has been assumed that the actual time periods were multiples of a fixed time unit. Hence one pass involved a one second pass, two passes involved two one-second passes and so on. The generation of each deflection (other than the first) involves the sum of deflections induced in more than one pass. Possible contributions during each pass have been indicated. The actual contributions can only be guessed at – in the absence of continuous monitoring. There is an indication of a significant instability in either the shot stream or in the different arc height measurements.

The data set used for figs.7 and 8 would, of course, give the same peening intensity, H, using the same indicated curve.

Continuous monitoring can be employed to determine the generation of arc height during intermittent peening. Fig.9 is a schematic example of the type of reaction for four passes made over a clamped strip. During the first pass coverage is incomplete, whereas during the fourth pass coverage is almost complete. That is why the fourth pass has a relatively long period where the arc height change is very small.

Indicated Peening Intensity Curve: Intermittent measurements are used to indicate a corresponding peening intensity curve. Equation (2) shows that the 'true shape' of a peening intensity curve should be a four-parameter equation with a one-parameter linear component superimposed on a three-parameter exponential equation. This is illustrated in fig.10 where the four-parameter equation has been 'best-fitted' to the six-point SAE Data Set 10. It is worth noting that the 'extra' data point 0,0 should always be added to any data set.

Specifications require that a minimum of four data points are required in order to obtain a reasonably-reliable estimate of peening intensity. Users may require a greater number of points in order to improve on the reliability. The most effective use of a limited number of data points is to relate them to the method of interpreting the curve.

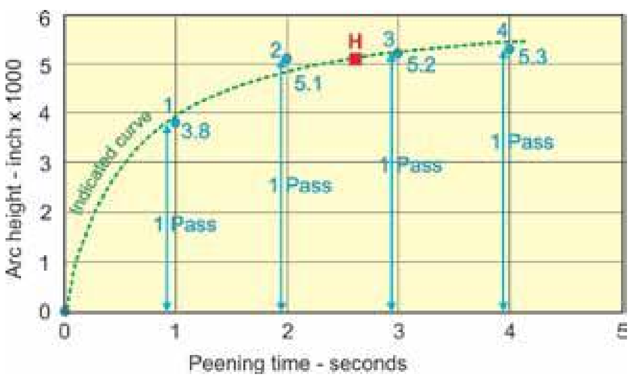

Fig.7 Intermittent indication of peening intensity using different time periods for each strip.

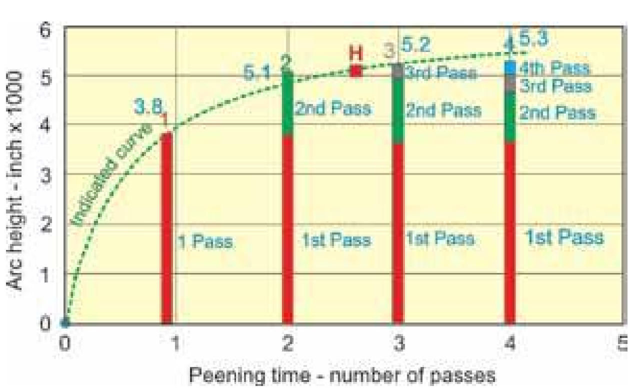

Fig.8 Intermittent indication of peening intensity using different numbers of fixed-time passes for each strip.

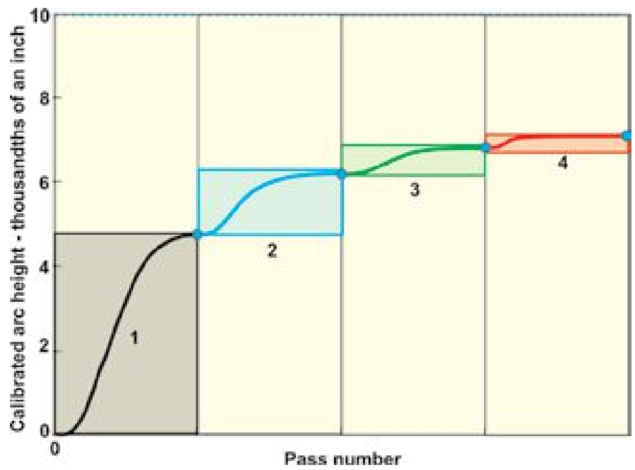

Fig.9 Individual contributions to arc height during four passes over a single Almen strip.

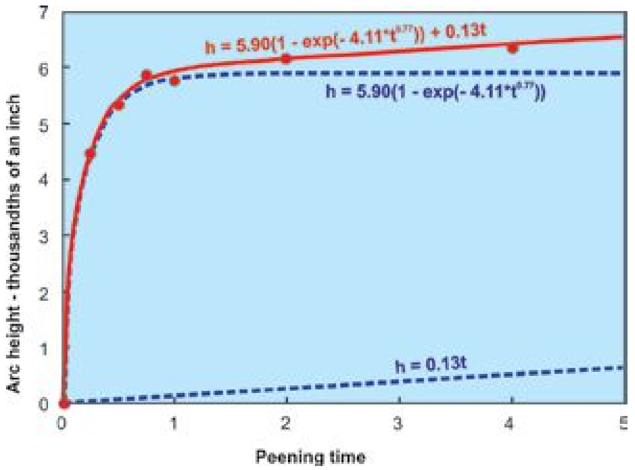

Fig.10 Four-parameter shape of curve indicated by SAE Data Set No.10.


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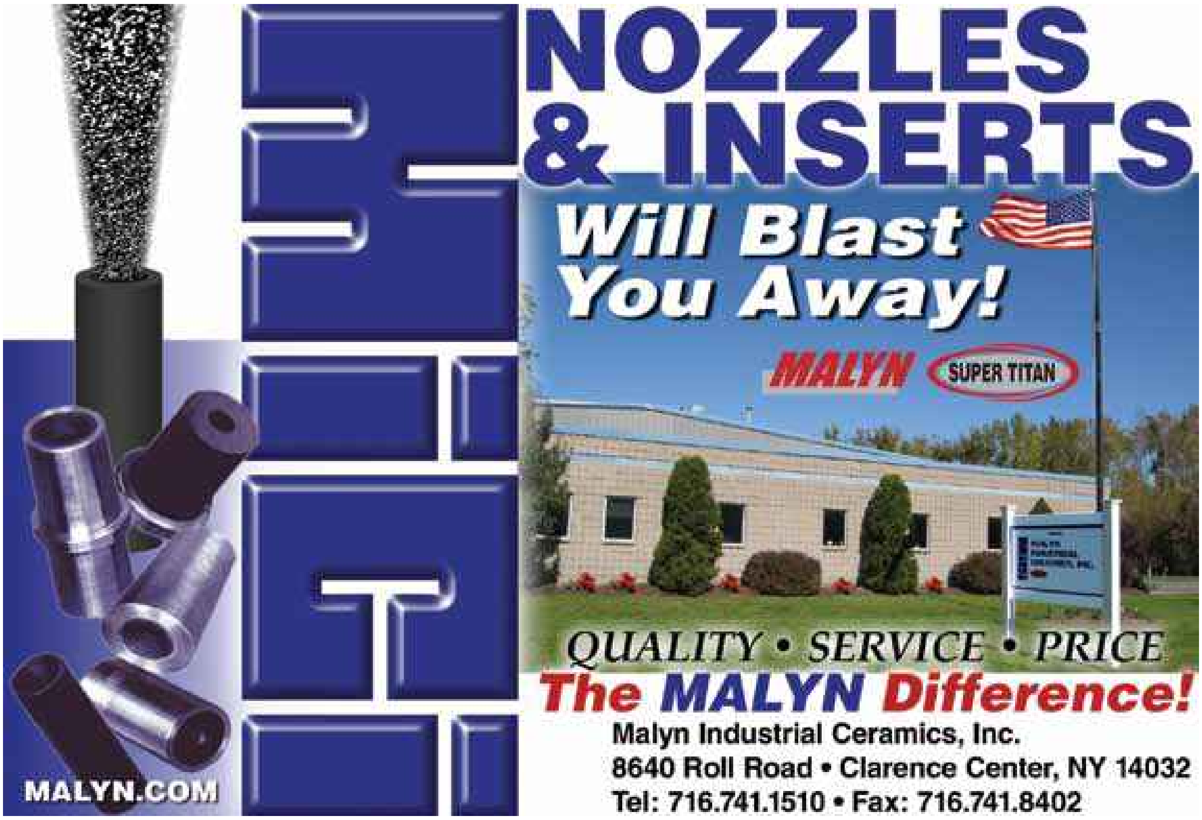
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INTERPRETATION OF PEENING INTENSITY CURVES

The main reason for producing a peening intensity curve is to be able to derive the "peening intensity" that can be associated with it. Unfortunately there is a dichotomy of opinion as to how that peening intensity should be derived. Consider the following imaginary conversation between an experienced shot peener, Joe, and a newcomer, Alec. This encapsulates the author's opinions on the subject.

Alec: "What do a set of arc heights tell me about the peening intensity?".

Joe: "If you plot them on a graph they will give you a shape something like that of a hill. The higher the hill the greater is the peening intensity."

Alec: "I've done that, but the hill doesn't have a top to it so I can't measure its height."

Joe: "The guy who invented it realized that, so he proposed that the 'knee' of the curve be used rather than the maximum height."

Alec: "That's fine but 'knee' is a bit vague isn't it?"

Joe: "I agree. What we need is to be more specific. I used to select the one point which obeyed a stated rule 'the point should be such that doubling the peening time gives less than a 10% increase in the arc height'."

Alec: "That still sounds a bit vague. The value then depends on where the points are on the peening intensity curve."

Joe: "Agreed. That is why I changed to using a computer to fit the data points to a curve of a known shape. The computer program then identifies the unique point on the knee of the curve that satisfies the more precise rule "a point on the fitted curve such that doubling the peening time gives a 10% increase in predicted arc height."

Alec: "That sounds a lot better. Why haven't you always done it that way?"

Joe: "When Almen invented the idea we didn't have computers – we had to use graph paper and pencils."

Alec: "Ugh! I suppose everybody now uses computers to find the peening intensity?"

Joe: "No. There are still people who prefer the old ways."

Alec: "Do the old ways offer any advantages?"

Joe: "There is an extra rule that requires the longest peening time point in a set to be at least double the time of the peening intensity point. With the old method that was easy to satisfy – just by always using very long peening times. With the more precise rule I have to make sure that the set of peening times satisfies this extra rule. That means being more aware of the factors that control peening time."

Alec: "You are starting to lose me. Can we have another chat tomorrow?"

Joe: "Of course. I will show you what I mean on some typical graphs."

The history and terminology used does not help to provide a clear guide as to how peening intensity curves should be interpreted. One problem is the current use of the term "Saturation curve". This implies that the curve flattens out as "saturation" is approached. In both theory and practice this does not happen for a truly-shaped curve. There is always a linear component which raises the arc height continuously with peening time. It would be better if the term "Peening intensity curve" was substituted for "Saturation curve". Another problem is that the definition of "Peening intensity" is ambiguous if both "not less than 10%" and "10%" are involved.

Determining the "Peening intensity" is straightforward for continuous monitoring – because there are hundreds of available data points. With intermittent indication of the curve we normally have only 4, 5 or 6 data points per curve (in addition to zero). The key question is "How should the data points be spread in order to determine the peening intensity curve and the peening intensity point most efficiently?" Setting vested interests aside, the answer should be based on how best to estimate the arc height at two 'peening time' points on the curve – the points at T and 2T where the arc height at 2T is 10% greater than that at T. With only four data points in a set one logical choice would be to employ peening times guessed to be at 0.5T, T, 2T and 4T. The two vital points, T and 2T, are then in the middle of the set. This maximizes the latitude (for process variation) that is available and the wide range of points helps when estimating the curve itself. On actual peening, success is then achieved if the resulting arc height data yields an acceptable peening intensity at a point anywhere between the guessed times of 0.5T and 2T. Fig.11 illustrates this approach applied to SAE Data Set No.3. The author of this data set has used four points in the peening time ratios 1:2:4:8 with the second and third points actually coinciding very closely with derived values for T and 2T. If the author had, in fact, been aiming at 0.5T, T, 2T and 4T then the aim was almost perfect.

A general rule for producing and interpreting peening intensity curves is to:

Concentrate on identifying the critical peening times T and 2T and their corresponding arc heights.

If only four data points are available then two should straddle the critical peening times. Curve-fitting should then

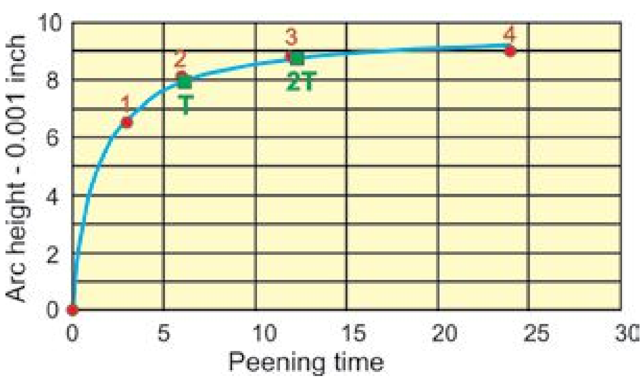

Fig.11 Interpretation of SAE Data Set No.3 with derived peening intensity time, T.


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involve only two fitting parameters. More data points per set give more flexibility, but at least two should still straddle the critical peening times. With six or more data points then a three-parameter curve will give more accurate peening intensity values.

DISCUSSION

Continuous monitoring of peening intensity curves has obvious attractions in terms of speed, accurate curve definition, correct intensity location and its ability to detect process changes during actual peening (rather than post-mortem). Its major disadvantages are the absence of corresponding specifications and the more complex technology that is involved.

Intermittent peening intensity curve indication, the current industry norm, is familiar and well-specified. Inertia should not, however, preclude the introduction of continuous monitoring when it is appropriate. Misconceptions about the shape of peening intensity curves abound and can only be reduced by determined efforts on the part of the peening industry itself.

It may be concluded that continuous monitoring and intermittent indication of peening intensity curves are complementary and not exclusive.

ICSP-11 Highlights

Open House at Electronics Inc.

ICSP·11

e Eleventh International Conference on Shot Peening

South Bend, Indiana, USA

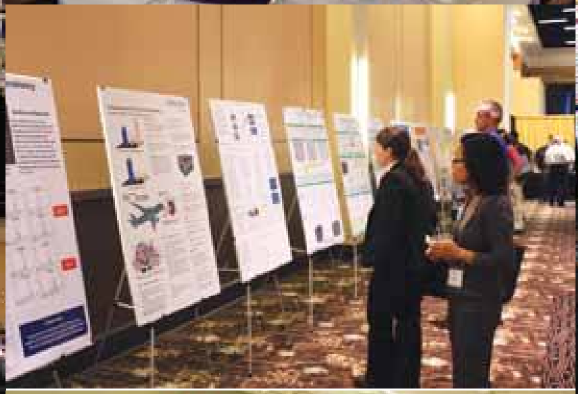
ICSP-11 Highlights

Paper Presentations

Welcome Receptions

Trade Show Exhibit

ICSP-11 Dinner



Industry News

No Pinch Points

Grand Rapids, Michigan. Rosler is pleased to introduce their RMT multi-tumbling batch blast machines. Using a special rotary barrel design, these durable units produce excellent blast coverage results and compared to conventional tumblast machines, they have no "pinch points" to damage even sensitive parts.

The RMT also features a simple design with few moving parts ensuring high up times and low maintenance costs. Easy automation with custom-made loading and unloading equipment make integration into existing systems a breeze. Plus, with the rotary barrel made of highly wear-resistant manganese steel, RMT machines provide years of reliable service.

Rosler's RMT machines suit every capacity requirement from 3-34 cu. ft. batch sizes and include a wide choice of blast turbines from 15-75 hp. For more information on Rosler's value-engineered RMT machines and how we offer special solutions for your challenges, please call 1-269-441-3000 or visit us on the web www.rosler.us.

Air-Operated Shot Blasting Machine for Surface Roughness of Locking Fasteners

Jodhpur, India. Locking fasteners, nut, volts and washers requires smoothness, free from burrs and required degree of surface roughness for zinc / chrome platting.

Flaws, cracks etc. more over the flatness and surface roughness is also important to be maintained for fasteners. This increases the critical requirement of abrasive blasting on job.

Earlier this was achieved by seven tank process which has been now against the pollution norms.

MEC SHOT has developed automatic air operated blasting machine for the De-burring & surface preparation of Locking Fasteners for consistency in repeatability. This abrasive blasting machine is featured with rotating Tumble Basket and fixed with gun oriented at different angles depending on the job profile.

The machine works on the suction principle of abrasive blasting. The lifted abrasive gets mixed with the compressed air in the blast gun to strike the job to be cleaned. The locking Fasteners are loaded / unloaded on revolving Tumble Basket. The Tumbling Fasteners get blast cleaned by fixed gun. The abrasive get recycled automatically in twin cyclones for fine media separation and transferred abrasive from storage hopper supply abrasive continuously and un-interrupted blasting operation. The dust generated during the blasting operation is trapped in Pleated Bags of dust collector & clean air is let out in atmosphere. Thus keeping the environment eco-friendly.

For more information, email Vivek Mehra, Vice-President of Marketing, at mail@mecshot.com or visit www.mecshot.com.

Electronics Inc. Education Division Announces 2012 Workshop Schedule

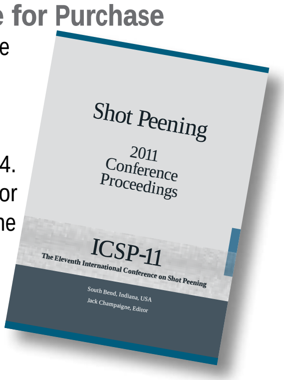
Mishawaka, Indiana. Electronics Inc. Education Division (EIED) will be holding 2-3 day training workshops in 2012 in these locations:

- Japan, Tokyo - February 28
- Mexico, Guanajuato - March 27-28
- Canada - April
- China, Shenzhen - July 11-13
- Singapore - July 24-25
- Germany - September
- USA - location to be announced at 2011 USA Workshop

Watch for more information in The Shot Peener magazine or visit www.electronics-inc.com/workshops.html for updates.

ICSP-11 Proceedings Available for Purchase

Mishawaka, Indiana. By directive of the International Scientific Committee for Shot Peening, the papers from the ICSP-11 Proceedings cannot be released for individual distribution until October, 2014. Until that time, the books are available for purchase at $250 (USD) plus shipping. The book has 77 papers on these topics:



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- **Fatigue, Failures and Remedies** - Ferrous Metals, Other Metals, Nano Metals
- **Corrosion** - Peening and General Corrosion Effects, Peening for Stress Corrosion Resistance
- **Stress Relaxation Effects** - Temperature
- **Special Applications** - Roller Burnishing, Fine Particle Peening, Laser Shock Peening, Ultrasonic Activated Peening, Peen Forming and Straightening, Peening of Medical Implants, Other Residual Stress Inducement/Improvement Methods
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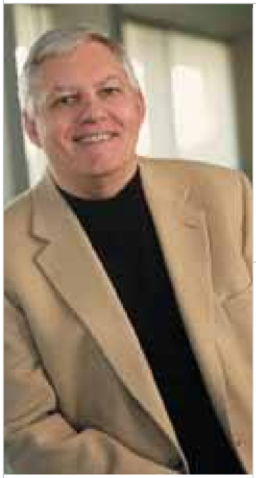


Reflecting Back on ICSP-11, Looking Forward to ICSP-12

I have been fortunate to be the Conference Chairman for the International Conferences on Shot Peening (ICSP) in 1996 and 2011. In 1996, we held ICSP-6 in San Francisco. A beautiful city like San Francisco is an exciting place but for ICSP-11 the committee selected South Bend, a small midwestern town, because it was a less expensive venue during the ongoing global recession and its easy access for international travelers.

There were additional advantages to holding the conference in my "hometown"—South Bend is connected to Mishawaka, Indiana, where I live and the location of Electronics Inc. I was able to host the members of the International Scientific Committee at a small reception in my home. Access to the Electronics Inc. staff was also a tremendous advantage during the two years the committee spent planning the event. ICSP-11 gave Electronics Inc. a unique opportunity to hold a welcome reception and a tour of EI. I think this broadened everyone's perspective of the shot peening industry and increased their pride in their jobs.

There were many innovative concepts presented at the ICSP-11 conference. We tend to think of peening in terms of rotating wheels or compressed air for media acceleration but newer concepts are finding application in this industry. There were several presentations on ultrasonic energy for peening. One application describe a device called a Sonotrod which vibrates at a high frequency (20KHz) to excite balls in a special chamber to effectively peen gears or other small components. This technology was also applied to a hand-held apparatus with needles which can be used for treatment of welds that may provide up to a ten-fold extension in the number of fatigue cycles before crack initiation. Another version of this tool can be used for peen forming.

Conventional peening for fatigue life improvement has been used for a long time in medical implants but a recent development in fine particle peening of implants revealed the capability of both increasing the tissue adhesion and, even more importantly, inhibiting bacterial growth due to the nanoscale changes in the surface.

The commercial exhibition area also contributed to the advancement of peening science. A new highly controlled rotary flap peening apparatus was demonstrated that offered high precision and repeatability. There was also a new device that can optically measure peening coverage. Another innovation was the use of sub-size strips for measuring peening intensity in small holes and slots as an alternative for shaded Almen strips. Flow control of ceramic or glass bead was demonstrated with a new device with automatic dosing and measuring of the media flow rate.

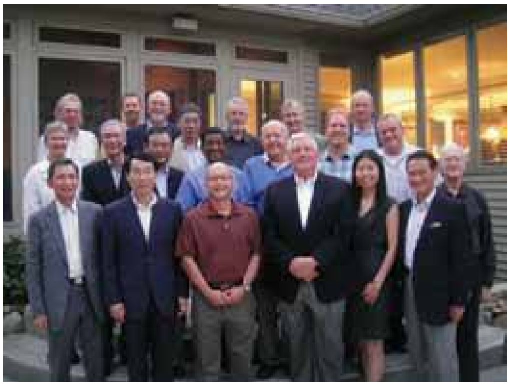
Looking Forward to ICSP-12

Where do we go from here? Goslar, Germany in 2014. Congratulations to Prof. Dr.-Ing. habil. Lothar Wagner (Clausthal University of Technology) for his selection as next chairman of the International Scientific Committee and conference host. He will be assisted by Prof. Dr.-Ing. habil. Volker Schulze (Universität Karlsruhe).

The former Imperial Town of Goslar has an 1000+ year history. Probably the discovery of silver and copper ore deposits induced the Saxon and Salic emperors to establish their largest and most secure palatinate here in the 11th century. For centuries it was the favored seat of government in northern Germany and at the same time a center of Christianity. Goslar was referred to as the "Rome of the North."

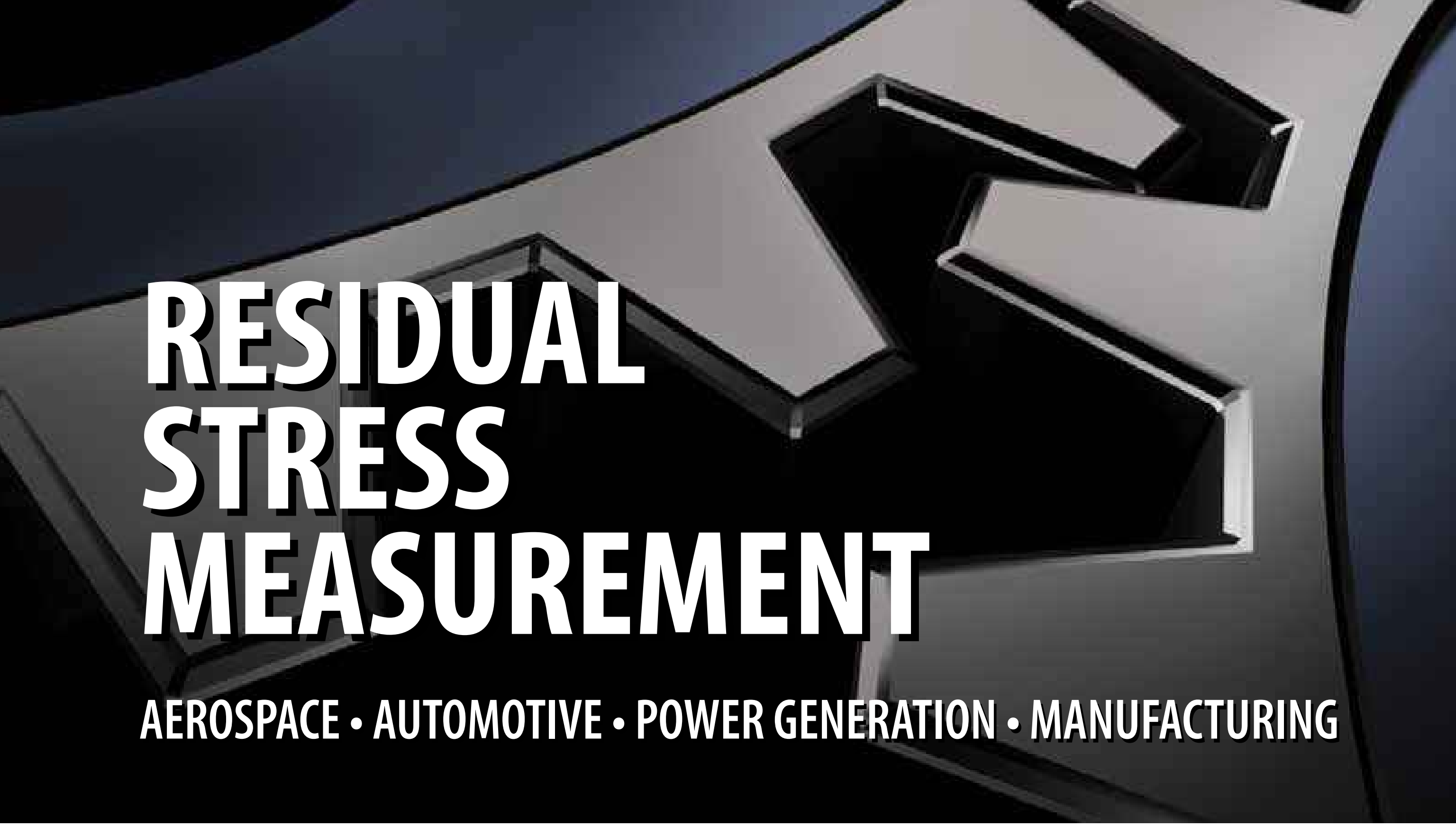
The Hanover international airport is only 60 miles from Goslar and the hotel "Der Achtermann" is well prepared to host the participants. Since Goslar is only about 20 minutes from Clausthal University, we know Dr. Wagner will enjoy the benefits of hosting the conference close to his hometown.

We all know that the rate of technologic innovations is ever increasing and we can only imagine what we will see in the next three years.



The Local Organzing Committee and the International Scientific Committee for Shot Peening at a party in my home.

South Bend's Mayor, Steve Luecke, gave a welcoming speech at the ICSP-11 dinner.



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