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The Shot Peener

Gearing Up for the Next Generation

Plus:

The Value of the Shot Peening Operator
Flapper Peening Process Review
Accuracy of Declared Peening Intensity Values Study


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Volume 24, Issue 2 **Spring 2010**

The Shot Peener

Dedicated to sharing information and expanding markets for shot peening and blast cleaning industries

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Gearing Up for the Next Generation

Special process suppliers need trained and experienced technologists. At the same time, special process skills are being lost worldwide due to an aging engineering workforce. Performance Review Institute (PRI) is taking steps to improve the quality of the workforce and ensure that skills are transferred to the next generation of workers.

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Shot Peening Operator is Key to Success

A shot peening operator that oversees a controlled shot peening process ensures that each and every component is properly peened. Fortunately, training and certification for shot peening operators are more accessible than ever.

The Shot Peener
23 years in publication
Over 5,900 readers
in 81 countries

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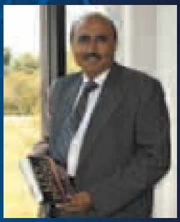
Gearing Up for the Next Generation



Mr. Hafeez is the Executive Director of Global Business Development and Corporate Strategies, Research & Development, at the Performance Review Institute (PRI). PRI is used by over 50 prime contractor and government agencies worldwide to manage over 2,000 accredited suppliers in the aerospace industry.

Understanding specifications and standards, such as AC7117 or AS9100, is not enough—organizations also need to have people with know-how and experience. A supplier legacy is defined by the quality of their products and the workers "trained" in making the product.

The most basic way of describing training is "an activity that changes people's behavior." Increased productivity is usually given as the most important reason for training, but there are many other benefits, such as staff motivation and inspiration. If product quality is not the motivation, it should be asked, "why not?"

The lack of emphasis on product quality becomes all the more important for highly-skilled technologists, where the business need for retention is higher because such qualified, experienced individuals are hard to replace. Today, mistakes are costly and "product quality escapes" cause millions of dollars in repairs or recalls, and are sometimes fatal.

This is timely because, according to the Aerospace Industries Association, the average aerospace engineer in the USA is nearly 60 years old, with approximately 27% already eligible for retirement. Meanwhile, the number of aerospace engineering degrees awarded in the USA fell 47% between 1991 and 2000, according to a report by the Commission on the Future of the United States Aerospace Industry. The trend is not limited to the aerospace industry; the entire field of engineering is in decline and continues to be on the top 10 list of most in-demand positions globally—for every industry, as shown by the results of a survey of 43,000 employers from 32 countries.

For all these reasons, Performance Review Institute (PRI) has worked with many quality-focused organizations such as Alcoa, SAE International, Goodrich Corporation and Honeywell Aerospace, to develop quality-related professional development courses and certification programs designed to consolidate and grow the knowledge base among engineers to ensure that a high level of quality is not lost because of an inexperienced work force.

Kevin Ward, Enterprise Quality Director for Special Processes at Goodrich Corporation explains, "Special process skills are being lost around the world due to an aging workforce. It doesn't seem glamorous to young people compared to something like software engineering. At the same time, the work is spreading around the world. We determined that there was a need to capture special process knowledge and share it for the benefit of the industry. Inadequate training in special manufacturing processes—or the lack of any training at all—is a common finding during Nadcap accreditation audits conducted around the globe to ensure the competency, capability and consistency of companies performing special processes. In recognition of this shortcoming, aerospace prime contractors and suppliers, including Goodrich, have pooled their resources to help PRI develop special manufacturing processes training. By gathering input from these sources, PRI has put together a cohesive, global training package."

There are two key focus areas of PRI's training: quality and technical ability. Through eQuaLearn, PRI offers courses in a range of quality-related topics, including *Introduction to Aerospace Quality*, *Root Cause Corrective Action* and *Internal Auditing*. The objective of these courses, which were developed and validated by industry experts, is to improve the quality of personnel in the industry and ensure that valuable foundation skills are transferred to the next generation and throughout the world.

On the technical side, eQuaLified provides an industry-recognized special process personnel qualification system developed and validated by subject matter experts. Via special processes exams and training courses, eQuaLified ensures consistency and excellence amongst special processors and provides competency validation for both Primes and Suppliers. This has been welcomed by aerospace industry representatives, like Chet Date, Director of

An eQuaLearn's "Introduction to Pyrometry" course was held in Rome, Italy in February.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An eQuaLified pilot program hosted by Goodrich Corporation

Quality Systems & Regulatory Compliance at Honeywell Aerospace. He explains, "Through eQuaLified, we can reliably judge the suitability of a candidate to perform special process tasks because it indicates a certain level of individual proficiency, all over the world."

eQuaLified objectively characterizes the special processes skills and knowledge of aerospace personnel levels:

- Process Operator – Process Operators understand and perform the basic hands-on operations of the special process.
- Process Planner – Process Planners are capable of designing manufacturing processes and interpreting process procedures to conform to customer specifications and requirements. Process Planners are capable of problem solving and resolving day-to-day issues.
- Process Owner – Process Owners are capable of writing, reviewing and approving processes, procedures and qualifications of lower levels. Process Owners design new processes and resolve issues among all the other levels.

This means that employers the world over will be able to have staff hold a globally recognized, industry-designated status. It also gives organizations a way to recognize and employ technologists who have been acknowledged by the industry in a formalized global program.

The quality of personnel is as important as understanding the specifications and standards. All companies need to make sure they have the right people to do the job right. Otherwise, the risk of escapes, rework and simple human error goes up, which is bad for morale and finances. In the current climate, no one can afford that.

Perhaps Ward sums it up best: "The focus now must be to capture today's knowledge and pass it on to the next generation. Or we will find ourselves looking at a product in the future and not knowing what to do with it. Sharing our knowledge and harmonizing it throughout the industry is the best thing we can do now for the future."

For more information about the programs detailed in this article, visit www.pri-network.org.

Shot Peening Operator is Key to Success

by Kathy Levy

Shot peening isn't to be taken lightly. Its distant cousin, blast cleaning, can easily flaunt its success—if it looks good, it is good. But shot peening's value is more than skin deep and, at this time, there isn't an economical non-destructive test to verify its merit.

To ensure that peening specifications are met, process controls in media, intensity, coverage and equipment must be followed. The customer specifies the intensity range and it's the operator's expertise with tools like media separation, saturation curves, coverage and machine maintenance that determines if the component meets the customer's specifications. And if the shot peening operator works for an aerospace supplier, the operator's work will be reviewed in an audit.

These responsibilities offer tremendous opportunties for a trained, certified shot peening operator. A trained, certified shot peening operator brings confidence and clarity to the shot peening process. With an operator's help, design requirements are met for each and every component that goes through the shop. When a process is accurate and repeatable, an auditor can quickly and easily verify the work. The cost savings from the elimination of reworks is notable and the freedom from liability is immeasurable.

Thanks to the advent of third-party training programs in the early 1990s, training and certification are easily achieved. Training companies, like Electronics Inc. Education Division, work with Nadcap and the FAA to design programs that benefit the aerospace industry. (Training programs address the needs of automotive, energy and medical implant suppliers, too.) A company is encouraged to train everyone associated with shot peening since teamwork is important to a well-run program.

Shot peening may have tougher validation requirements than other metal treatments, but meeting these requirements give shot peening operators and their employers the edge in a competitive economy where quality is becoming increasingly valuable.

Photo courtesy of Electronics Inc. Education Division

Shot peening training is available through workshops and on-site programs. A good program covers all aspects of shot peening, from theory, to real-life applications, to audit prep. On-site programs can be customized to match the specific needs of the facility.

Do you have a question or problem related to shot peening? Online help is available in the Forum at www.shotpeener.com. The following are recent posts at the Forum—note that solutions came from the Forum Administrator, Jack Champaigne, and other forum members from around the world. The Shot Peening Forum is a tremendous resource and a good way to share your expertise with others.

The Shot Peening Forum

Editor's Note: Posts have been edited for clarity

Peening Resistant Materials

CHS
Bogota, Colombia
As some of you might know by now, I'm currently designing a stress peening machine for leaf springs. The machine has some jigs where the leaves are placed in a stressed position. This means that these jigs will be shot peened many times and therefore they have to be able to withstand this kind of punishment. The jigs I've designed are basically made of rectangular plates and cylindrical rods with standardized diameters. And everything is welded together. However I wish to know if someone here could recommend a specific type of material for this purpose. Someone told me about high chrome-vandanium alloys and someone recommended www.hardsteel.net. Does anyone here have any recommendations? They would be greatly appreciated.

Werner Müllerschön
D -72555 Metzingen, Germany
Best material we found is a special kind of hard alloy. Life times of > 10.000 hours you can reach. If you send me your e-mail address, I'll send you some pictures of liners showing condition after thousand of running hours without any wear and tear.

Almen Strip Yield Stress

Miao
Montreal, Canada
I am going to simulate the Almen test process with finite element method. Is there anybody that has more material properties of Almen strip, such as yield stress, tangent modulus, or the stress-stain relationship of Almen strip at high speed strain, etc. Thanks!

Dennis
The Netherlands
As per SAE J442 the strips are made of SAE 1070 coiled rolled spring steel. Some properties are given at the following website: http://www.substech.com/dokuwiki/doku.php?id=carbon_steel_sae_1070&DokuWiki=fc14ceb703f4bb45b4368a3950673cc5

Perhaps the values given there are sufficient for a FE model.

Welding Almen Blocks

DavidP
Montreal, Canada
Hi, I'd like to know if SAEJ442 permits to weld almen blocks to form an Almen fixture. If not, can I manufacture Almen blocks with additional holes and/or tabs that could be used to fasten them to the fixture?

Walter
East Hartford, Connecticut, USA
SAE J442 does not limit the method of attaching test blocks. Welding is frequently used method.

J442 is the revision process now to add a statement allowing one or two extra threaded holes for mounting as long as the holes to not protrude into the strip mounting area.

Don't go crazy with the welding otherwise you may compromise the hardness of the test block. The best method would be to heat treat your entire fixture once complete.

Jack Champaigne
Mishawaka, Indiana USA
David, You should also be careful that the Almen holder does not warp due to the welding. Also, you might be required to prove the flatness of the working surface during an audit so you might want to plan ahead how to verify the flatness while it is welded into place.

Split Shot Recover

TEMPEREDSPRING
England
Anybody aware of a suction lance type system to recover 0.8mm shot particles from a pit into a storage hopper (possibly with built in dust removal)?

Jack Champaigne
Mishawaka, Indiana USA
I got a flyer from Fox Venturi Eductors that may be of interest. They have a web site at http://www.foxvalve.com

khi@ptihome.com
Grand Rapids, Michigan
For good industrial portable vacuums for recovering media contact Thorne Pneumatic, 1 800 461-6180, Larry Wood.

MJWilson
In the last 2 years, my company has purchased two excellent systems from Industrial Metal Fabricators in Chatham, Ontario. We actually use the systems to load our Peening machine and Cleaner. It pulls shot out of a 45 gallon drum with a wand and propels the media (S280) 35 feet up into our hopper, no mess no bags, no handling, no waste. We are also able to recycle all of our sieved shot in our Shot Cleaner for a substantial $$$$ savings in shot purchasing. Give them a call at 519-354-4270 for more info ask for Allan or Frank.

michelle
Have two shot peen machines with Torit dust collectors and shot separators to separate out trash and damaged shot.

MJWilson
For shot recovery visit www.ciaccess.com/~indmetal.
The best systems I have seen. They are so good we bought two.

R&O and Over-Peening

Dennis
The Netherlands
We do repairing and overhauling of load compressors at our facility. The impellers of these machines (which are made of Ti-6Al-4V) sometimes require repairs or rework. Afterwards they are shot peened. I have two questions regarding this:

1) I know there has been research regarding coverage and intensity vs. fatigue life of Ti-6Al-4V parts. But this seems to be applicable only to new parts. What criteria should we use for R&O parts? How many times can one repair a part, shot peen it, place it back into the field, get it back after a number of operating hours and repeat this procedure? Or to put it more concretely: how many times can we shot peen a part before the shot peening itself becomes detrimental to the part, taking into account that the part experience operating conditions between each session? Is there any literature available on this topic?

2) As said these parts have a number of operating hours between each R&O shop visit. During operating conditions these parts experience centrifugal and thermal loads. Is there any literature available regarding the influence of operating loads on the shot peen layer? Will the compressive stress slowly decrease? If so, what is the effect of this on the number of times such part can be shot peened?

Holger
Germany

1) Impellers are rotating parts. They are lifetime limited. Normally, shot peening during the repair is limited up to 4x. I heard from cases that more than 5 x shot peening over the lifetime destroyed the part during service. The coverage should not exceed no more than 1000% in total except special areas like holes which are peened under impingement angle of 45°.
2) The operating temperature up to 500°C.During service the compressive stress will be reduced, but not to zero. The rest of it and the other effect of shot peening will be good enough.

Pete Bailey
Hamilton, Ohio
I don't think there is one answer that fits all parts and all alloys and all service conditions. Holger's answer sounds like a good practical limit, though. I have seen examples of a high strength alloy that has coverage limits when peened at high intensity and an other alloy peened to 5000% coverage without life damage.

Dennis
The Netherlands
Holger: 4x indeed sounds like a good practical limit. Do you know any literature which we can refer to for this? An specification that limits shot peening to 4 times without any basis is a bit tricky. Rejection of part solely based on the fact that it already has been peened 4 times is probably not acceptable, unless there is research that backs up such limit.

Regarding the operating temperature, we know this will affect the compressive stress somewhat, but we like to quantify this. Any literature available? Anything known about the impact of this stress reduction on the number of the times a part can be peened?

Yu-kui GAO
Beijing
This is a interesting question, and the answer cannot be clear. The titanium alloys are sensitive to surface integrity and the key or important factor is the surface roughness and thickness of parts. Ti-6Al-4V can be employed to manufacture compressor blades of engine and link joints in aircraft. For compressor blades, the thickness and surface roughness are factors which should be reviewed when choosing coverage. And in Specification of shot peening for aeronautical parts which I proposed, the coverage of parts of Ti-6Al-4V should not exceed 400% when shot peening new parts, and the times of repairing and overhauling is less than 4 and the coverage of each repairing and overhauling is not larger than 200%.

I hope it can be useful because our investigation of shot peening of Ti-6Al-4V illustrates sensitiveness of surface integrity to fatigue and the strength of Ti-6Al-4V is not high compared to high strength steels, so my advice is less coverage will be beneficial to fatigue.

When Quality Matters

Got a question about shot peening, abrasive blasting, or sample processing? Herb can help.

Call Herb Tobben at 636-239-8172 or submit your request online at www.clemcoindustries.com Herb Tobben is Sample Processing Manager for the ZERO and AEROLYTE brands of Clemco Industries Corp., Washington, Missouri. He is a speaker at the EI Shot Peening Workshops.

Every day, there are more and more 'knock off' products that look similar on the outside but are cheaper in price. In our business, quality is sometimes a tough sell. The reasons for resistance range from "I want to spend as little as possible up front" to "I don't understand why I need to spend more." That's when the discussion turns to value. Deciding what to buy must include a product life cycle cost analysis that goes beyond the initial product price. Other things to consider include labor costs associated with production, and the time and money the customer must spend to get the job done. It boils down to learning how to recognize the benefits of using an efficient, quality product. But quality goes beyond what's apparent on the outside; it's reflected in design, engineering, and tech support—the whole product package.

Fortunately, within the shot peening community, the trend is one of increasing concern with quality. Customers seek great design and engineering, tech support, and an equipment system that consistently gets their job done right as quickly and efficiently as possible. We've noticed that customers are taking a much more serious look at the companies they do business with because they seek expertise, reliability, and trustworthy partners. The reasons more and more customers are taking such a hard look are numerous, but very high on the list is safety and liability. Is it worth the risk of producing a product that may jeopardize safety or the company's reputation?

When it comes to shot peening, expertise is critical. The process of shot peening is exacting. It is used on metal parts that are subjected to frequent cycle stress, stress reversal, twisting, and torsional stresses. To prolong life and avoid early failure caused by a fracture that begins at the surface, controlled shot peening is applied. The shot peening process alters the metal surface through repeated striking with a high-velocity stream of spherical particles. These particles are peening media, most often steel shot, ceramics or glass beads. The media produce round indentations on the surface, causing a stretching of the surface and a rising of the edges of the indentations above the original surface.

Complete peening produces a compressive stress layer, the depth of which will vary from application to application. Beneath this depth, a tensile stress layer develops and achieves equilibrium and provides for longer fatigue life of the shot-peened part.

How does shot peening improve quality?

Shot peening increases fatigue life. It does so in parts subjected to dynamic loading, which is a repetitive, cyclical loading that causes bending and twisting. Parts like fuel injector components, aircraft landing gear, helicopter blades, leaf and coil springs, gear teeth, drive shafts, torsion bars, axles, rotor, compressor, turbine blades, and many others, see better fatigue life after shot peening.

Shot peening reduces stress corrosion cracking. Residual stress leaves metals more susceptible to corrosion, particularly in high-strength materials, from a complex interaction of corrosives on sustained tensile stress in the metal surface. Components such as landing gear and hydraulic tubing benefit from shot peening.

Shot peening prepares parts for plating. Plating often develops fine cracks and preparing a surface with shot peening prior to plating can prevent the cracks in the plating from affecting the substrate in items such as landing gear cylinders, among others.

Shot peening straightens parts deformed during manufacturing. Selective peening can to a certain degree straighten critical areas. Some applications include bulkheads, large machined structural shapes, and deformed heat-treated parts.

Shot peening reduces tensile stresses after grinding. The process can convert residual stresses from tensile stress to compressive stress, producing a uniform compressive layer, which increases fatigue life and lengthens the service life of high-strength steel parts.

Shot peening reveals poor bonding in electroplated parts. When incorporated into a rigorous quality-control program, shot peening can be used to detect adhesion problems and expose imperfections.

Shot peening reduces casting porosity. Castings are often porous, and shot peening with the right media size can close the pores, compress the surface, and reduce hydraulic leakage in die-cast parts, transmission housings, and gear boxes.

Shot peening can alter part dimensions. Useful either when first designing and manufacturing a product or when rebuilding one,

shot peening can increase or reduce part size. Shot peening can be used to increase the diameter of a shaft or decrease the diameter of a hole.

Shot peening improves lubricity and oil retention. Because of its effect on the surface, shot peening reduces friction and can improve oil retention, thereby improving lubricity in parts such as engine pistons and cylinder walls.

Shot peening reduces notch sensitivity in high-strength steel. High-strength steel is susceptible to fatigue cracking, also called notching. The stronger the steel, the more likely it is to crack. With shot peening, the steel surface is improved, giving it a longer life cycle. Shot peening is often used to treat steel with a strength rating of more than 200,000 psi. It is commonly used on landing gear and springs.

Safety- and quality –conscious manufacturers understand the benefits of shot peening and carefully follow specifications. They accurately document the process to ensure consistency and repeatability. Proper controls over peening intensity, arc height, and coverage produce consistent results. And sophisticated equipment for monitoring, measuring, and documenting such variables enhance the value of shot peening.

Bottom line: shot peening is complex. Learning everything you can about it, so that you can properly apply it to your particular application, takes time and dedication. Take it from someone who has spent years learning, just follow a few simple steps—make sure your shot peening system is of high quality and engineered to incorporate the features dictated by your application, consult with an experienced practitioner, like me, and attend the Electronics Inc. Shot Peening Workshop. ●

Cautionary Tale: Marketing of Extension Springs

The best way to market extension springs is to claim that your company's springs outperform your competitors'. If this marketing is based upon research results, it should be sound. However, very little research has been done to quantify the performance of extension springs until now. A systematic study of extension spring loops has been conducted within Techspring, a European research project of which I was the project manager.

In this cautionary tale, readers will be exposed to Techspring research results in order to answer some of the marketing claims made to me by springmakers, like:

- "I changed from English (crossover) loops to German, and the customer reported that life was now satisfactory."
- "I changed from German loops to English, and this sorted the breakage problem."
- "By increasing the hook diameter slightly, the life of the extension springs was improved."
- "By reducing the hook diameter, it stopped the hook failing in service."
- "Shot peening the end loops delayed the service failures by over a year."

One or two of the above reports may be exaggerations, delusions or marketing hype of the worst kind.

As the croupier* to the spring industry might say "Messieurs, faites vos jeux." Translated: "Gentlemen, place your bets." Is your money on English or German hooks, enlarged or reduced loops compared to the body coils? Or do you put all your faith in shot peening?

One thing is certain from the Techspring project— the reliability of the extension spring was never transformed to complete satisfaction. The life improvement from each of these measures was always disappointingly small.

The project first looked at English vs. German loops. It was observed that springs which rolled smoothly on a bench performed better than those that did not. In other words, when the end hooks protruded outside the space envelope made by the body coils, the hooks failed prematurely on test. When the loops protruded, the springs "rocked and rolled" on the bench. While rock 'n' roll has its place, it is not best for extension spring life. The research results were very similar for English or German loops for extension springs of index 8 and larger, when these hooks were accurately made. So claims A and B cannot be justified. Many think that the sharp bend required to form the English loop is a stress raiser, and indeed it is (especially when the index is small), but this is not the position of maximum stress. The loops all failed at the position shown in figure 1, whether they were German or English loops.

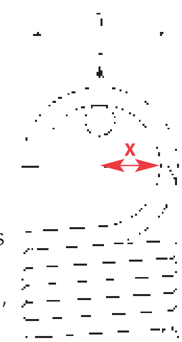


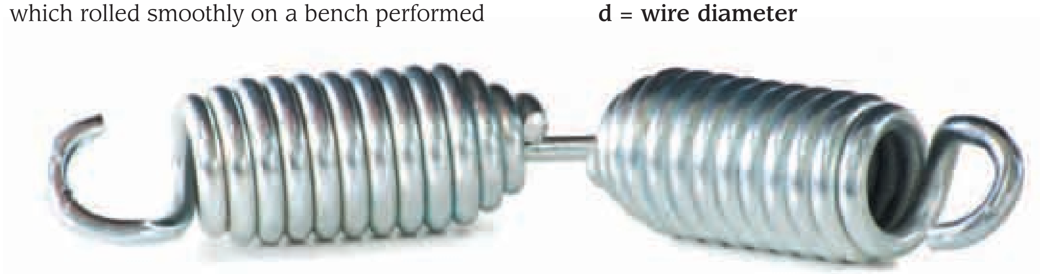
Figure 1 Fatigue fracture always occurs in this region

The bending stress at the failure position should be calculated. The Techspring project studied the formula used by IST, which is as follows:

$$q_b = \frac{16\,F D_L K_L}{\pi d^3} + \frac{4F}{\pi d^2}$$

$$k_L = \frac{4w_L - 1}{4w_l - 4} \quad \text{where} \quad w_L = \frac{D_L}{d}$$

qb = bending stress in the loop or hook
F = spring load
DL = Mean diameter of loop
d = wire diameter



Article was originally published in *Springs* magazine and is reprinted here with permission by the Spring Manufacturers Institute (www.smihq.org)

This formula proved to be accurate and is recommended. It is one that is absent from spring design standards such as EN13906-2.

Looking at this formula it is clear that the stress in the end loop will be minimized if the loop diameter is reduced. I guess the claimants (and there have been a few), who said enlarged loops improved the life were deluding themselves. How much should the loop diameter be reduced so that the springs no longer fail in the loops? For the answer to this question, you will have to wait for the next installment of this thrilling tale of extension spring loop research in the next issue of *Springs*.

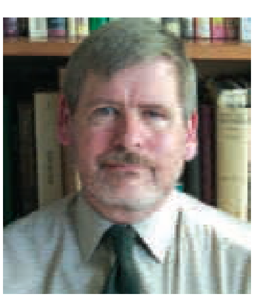
The claim made for shot peening of end loops should be examined first, because this might be the simplest way to stop the end loop being the weakest point in an extension spring. 302 stainless steel extension springs with accurately made English loops were supplied to the Techspring project. They were tested without glass bead peening and all the springs failed at the position shown in Figure 1. After glass bead peening, some springs failed in the loop, but others failed at the sharp bend at a position shadowed from the streamed shot. The fatigue lives were as shown below.

The moral of this cautionary tale is "Base your marketing on research and not on guesses." That will improve the standing of your company and the industry in general. Claims A to E may all have had an element of truth, but to solve end loop problems you will have to wait for the next installment of this tale. ●

**A croupier or dealer is a casino employee who takes and pays out bets or otherwise assists at a gambling table. (Source: Wikipedia)*

Body stress range/MPa Load Positions/N	Life without shot peening / cycles	Life with peening / cycles
200 - 750 (14 - 52N)	21.8k H, 23.3k H	53.4k H, 64.1k B
200 - 700 (14 - 48.5N)	27.6k H, 29.9k H	81.4k H, 114.6k B
200 - 650 (14 - 45N)	26.7k H, 46.0k H	189k B, 196k B
200 - 600 (14 - 41.5N)	44.1k H, 44.2k H	4 @ 1000k
200 - 550 (14 - 38N)	2 @ 1000k	

H = Failure in the hook   B = Failure at the sharp bend at the base of the hook



Mark Hayes is the senior metallurgist at the Institute of Spring Technology (IST) in Sheffield, England. He manages IST's spring failure analysis service, and all metallurgical aspects of advice given by the Institute. He also gives the spring training courses that the Institute offers globally. Contact Hayes at (011) 44 114 252 7984, fax (011) 44 114 2527997 or e-mail at m.hayes@ist.org.uk.

The Eleventh International Conference on Shot Peening

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Triennial Conference and Exhibition of the International Scientific Committee for Shot Peening

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YOU ARE INVITED TO SUBMIT A PAPER TO THE ELEVENTH INTERNATIONAL CONFERENCE ON SHOT PEENING (ICSP-11)

SCOPE

The ICSP-11 Organizing Committee is seeking papers that further the understanding and knowledge of shot peening. Related mechanical surface treatments, such as deep rolling, laser peening, ultrasonic peening, combined processes, and other cold work processes inducing compressive surface residual stresses, are within the scope of the conference, especially when compared to shot peening. Shot peening and related mechanical surface treatments have proved to be powerful instruments in enhancing the resistance of components to various kinds of stress-induced damage, largely with respect to fatigue and corrosion damage. The service lives of a wide variety of structural components, irrespective of shape and dimensions, can be improved dramatically by shot peening. The commercial benefits of applying mechanical surface treatments are increasingly recognized, particularly in the automotive and aerospace industries.

ICSP-11 will be an important international meeting for discussing the science, technology and applications of mechanical surface treatments. It will offer a unique forum, enabling scientists and engineers to deepen and update their knowledge of all aspects of mechanical surface treatments. The conference will cover a range of surface treatment topics based on technological aspects, process procedures, changes in the surface state, process simulation, service properties, and fields of application.

The study of shot peening's benefits and uses are crucial as the need grows for stronger and lighter metal components in transportation, medical and many other applications.

TOPICS

- **Applications**
  Automotive, Aerospace, Welds, Mining, Gears, Springs, Medical
- **Modeling and Simulation**
  Lifetime Prediction, Load Capability Prediction, Stress Profile, Incorporating Shot Peening Into Design
- **Alternative Processes**
  Laser, Deep Rolling, Ultrasonic-Activated, Needle Peening, Burnishing
- **Fatigue and Fracture**
  Steel, Aluminum, Titanium, Carburized Steel, Stress Relaxation by Time / Temperature
- **Surface Characteristics**
  Measurement of Residual Stress, Stability of Residual Stress, Surface Finish
- **Technological Developments**
  Machine Architecture, Alternative Media, Process Monitoring and Control, Specifications, Auxiliary Equipment, Non-Destructive Testing
- **Special Applications**
  Fine Particle Shot Peening, Stress Corrosion Cracking and Fretting Remediation, Reduction of Sliding Friction, Medical Implant Tissue Adhesion Improvement, Medical Implant Peening Special Considerations, Cavitation Peening
- **Miscellaneous Topics**
  Non-Classical Equipment and Technologies of Peening, Peen Forming, Theory / Mechanics, Applications and Benefits, Improvement of the Fatigue Behavior of Structural Components, Fundamental Aspects of Modeling

IMPORTANT DATES

Abstracts Due
June 1, 2010

Notification to Authors
August 1, 2010

Manuscript Drafts Due
January 1, 2011

Final Manuscripts Due
June 1, 2011

LOCATION

ICSP-11 will be held at the Century Center in South Bend, Indiana. The Century Center will be an ideal venue for the event. The facility has well-appointed auditoriums, exhibition space and dining rooms. South Bend, Indiana is accessible by several international airports.

GENERAL INFORMATION

SUBMISSION OF ABSTRACTS

The deadline for the submission of paper abstracts and posters is June 1, 2010. Submissions will be judged by the Local Organizing Committee on originality, significance, interest, clarity, relevance and correctness. Authors will be notified after August 1, 2010 regarding the acceptance of their submission.

Papers: The abstract should not exceed one page. Please use standard symbols and abbreviations. Length and format requirements for final papers are as follows: Word 2003 - 2007, 8.5 x 11-inches page size. Template is available for download at www.shotpeening.org/ICSP-11.

Posters: The poster forum allows researchers to present recent and ongoing projects. The poster session is an excellent forum to discuss new ideas and get useful feedback from the community. The poster submission should include a brief description of the research idea(s) and the submission must not exceed two pages. Accepted posters will be displayed at the conference.

Final Submissions: Submissions of the final manuscripts are due electronically. Detailed instructions for the submission process will available at www.shotpeening.org/ICSP-11 after June 2010.

PROCEEDINGS*

Papers accepted and presented in person at ICSP-11 will be published in the ICSP-11 Final Proceedings. Preliminary Papers and Final Proceedings will be distributed to attendees at no charge. Copies of the Proceedings book will be available to the general public for a nominal fee. Accepted submissions will be treated as confidential prior to publication in the ICSP-11 Proceedings. Manuscripts submitted to the International Scientific Committee for Shot Peening (ISCSP) for publication at the conference become the property of ISCSP.

*All accepted papers will be distributed in preliminary copy form at the conference. The final ICSP-11 Proceedings book will include only papers presented by the author(s).

CONFERENCE LANGUAGE

English

REGISTRATION FEE

The registration fee is $800.00. The fee includes administrative costs, Preliminary Papers, Final Proceedings, lunches, break refreshments and a banquet.

EXHIBITION

There will be an exhibition of products and services related to the topics of the conference. Interested companies and organizations should contact the Conference Chairman for costs and more information.

CONTACT INFORMATION

Conference Chairman
Jack Champaigne
Electronics Inc., 56790 Magnetic Drive, Mishawaka, Indiana 46545 USA
Telephone: 1-574-256-5001 Email: icsp11@shotpeening.org

For more information, visit www.shotpeening.org/ICSP-11

The event will attract approximately 250 attendees from academic institutions and industrial organizations worldwide.

Abstract Submission Form is included in this magazine

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Engineered Abrasives manufactures custom and turnkey equipment for high-volume applications. Our machines are used around the world in the most demanding shot peening and blast finishing operations. We specialize in patented rotary index machines for the automotive and aerospace industries. Our index machines aren't just rugged—they are smart, too. Every action is controlled and monitored and our closed-loop systems ensure foolproof and safe operation. No media or energy is wasted at any point in the operation.

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CONTROL by MagnaValve

Industry News

Compass Wire Cloth Corporation: Years of Value, Quality and Service

Vineland, New Jersey For almost 30 years, Compass Wire Cloth has been the premier fabricator of screens for any industry which sifts, sorts, scalps or separates material. Whether standard or custom, their screens fit virtually ALL OEM equipment. Their new 65,000 sq. ft. fabrication facility is ISO 9001:2000 certified, and they are proud of their reputation for service, quality and value. Their warehouse contains one of the most comprehensive inventories of wire cloth in the inventory, in a wide variety of meshes, diameters and alloys. Here's what a few of their customers have to say:

"(Compass Wire Cloth) provides good quality products. You don't have to worry about receiving an inferior product, they are very reliable."
— McLanahan Corp.

"Good quality, price and lead time, and top-notch service."
— Twin City Wire

"Service is great; if you need something they will quickly make it, put it on a truck and ship it out. They stand behind everything they sell – reliability is key."
— Fanwood Crushed Stone

"Service is first class, can't beat it. They give me the best prices and nobody can beat them."
— Mayslanding Sand and Gravel

They fabricate screens to fit all round vibratory separators and Compass Wire Cloth's focus is maximum screen life through efficient product performance. The company's product line includes vibratory screens, pre-tension screens, ultrasonic screens and their own Compassonic Ultrasonic system. Their pre-tension screens are produced in a temperature controlled environment, using their exclusive line of 16-gauge stainless steel thin lip frames.

By the way – don't dispose of those used frames. Compass Wire Cloth offers discounts to refurbish them!

Give Compass Wire Cloth a call to discuss your needs. Sales professionals are ready to quote your requirements and provide you with a quality screen at a competitive price. Visit them on the web at www.compasswire.com or call 800-257-5241.

Rolls-Royce Building U.S. Machining Plant

Washington, D.C. Rolls-Royce recently started construction on a new component finishing plant in suburban Washington, D.C., a $500-million project that will be its largest North American manufacturing facility when fully completed. The 1,000-acre site in Prince Georges County, Virginia, represents an initial investment of about $170 million, according to Rolls, and it will feature space to accommodate suppliers' and partners' co-location in the future.

The company manufactures engine systems for civil and military aerospace, marine and energy markets. The Crosspointe plant in Virginia will finish-machine aerospace components and products, including turbofan discs for some of Rolls' civil aerospace engines. Examples of these are the Trent 1000, Trent 900 and Trent XWB engines for the Boeing 787, Airbus A380 and A350 XWB, respectively.

Discs are the part of a turbofan engine that contains the blades. Disc production at Crosspointe could begin as early as 2011.

Rolls also projects a second building on the site for machining blisks, i.e., bladed discs. These are gas-turbine engine components that incorporate fan blades and discs into a single piece. Blisks manufactured at Crosspointe would be used in the F136 engine for the Joint Strike Fighter.

A Rolls spokeswoman explained that the forged blisks would be manufactured elsewhere and delivered to the site for finish machining.

"Rolls-Royce is investing in America," stated James M. Guyette, President & CEO, Rolls-Royce North America. "This is a historic day for us as we begin construction on our first manufacturing facility built from-the-ground-up in the U.S. Crosspointe will be a flagship operation for Rolls-Royce, and the significant investment we are making here will enhance our competitiveness in global markets and position us for future growth."

The Crosspointe campus also will be home will to the Commonwealth Center of Advanced Manufacturing (CCAM) and the Commonwealth Center for Aerospace Propulsion Systems (CCAPS). CCAM is a higher-education partnership founded by the Commonwealth of Virginia, the University of Virginia, Virginia Tech, Rolls-Royce and other partners. CCAM is intended to be a world-class research facility for design and manufacturing technologies. CCAPS is a virtual research and technology center.

In Memory of Einar Borch

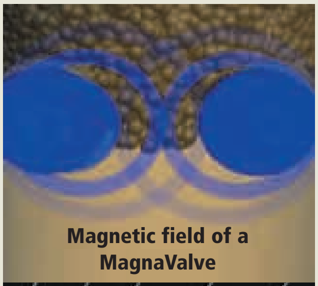
Einar Borch, a legend in the blast cleaning and shot peening industry, passed away on January 8, 2010 at the age of 96. Mr. Borch started working in the metal shot and grit industry in 1936—about the time of the first commercial application of the centrifugal wheel. He joined Ervin Industries in 1981 as a Product Development Manager and worked full time until 2000, when he retired at the age of 87.

In addition to his contributions to Ervin, he served as chairman of the Foundry Equipment Manufacturers Association Statistical Committee and the Statistical Committee for the Casting Industry Suppliers Association.

Mr. Borch published numerous technical articles on the use of cast steel abrasives. He was also a contributing author for manuals and specification advisories for the blast cleaning and peening industry. Many of his articles are available in the library at www.shotpeener.com.

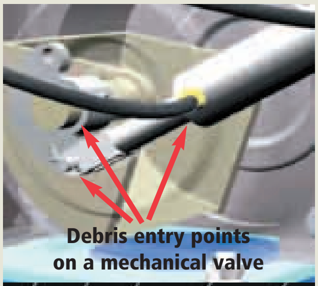
MagnaValve

THE MAINTENANCE-FREE MAGNETIC MEDIA VALVE



Magnetic field of a MagnaValve

When no power is applied to the MagnaValve, the permanent magnet stops all media flow. This is an important feature of the MagnaValve. If the power to the valve is interrupted for any reason, the permanent magnet in the valve securely holds the shot without the need for a secondary mechanical shut-off valve. MagnaValve owners never need worry that shot will flood a machine in event of power failure.



Debris entry points on a mechanical valve

A mechanical valve is prone to seizing since debris can enter the valve through its moving parts. Valve seizures put a blast machine out of service. Also, mechanical shut-off valves can leak and flood the wheel assembly with shot. Because of its unique design, the MagnaValve isn't damaged by flowing media and it is completely sealed against debris. The MagnaValve's permanent magnet eliminates leaks.

Benefits of a MagnaValve

- Maintenance-free
- Cost savings from the efficient use of media and lower media disposal fees
- Optimizes the load of large horsepower motors thereby reducing energy consumption
- Many control options available to suit your application
- No risk of machine malfunction due to running out of shot during procedure
- Confidence that your product was blast cleaned properly
- Compliance to specifications is readily attainable
- Requires less operator time
- Available in 24 Vdc and 110 Vac models
- Works with most steel media sizes
- Environmentally responsible—conserves energy and media (less media in landfills)
- Over 27 years of proven performance in the field and trusted worldwide
- Available for wheel and air blast machines

Additional Information:
Request our case study on an Australian automotive foundry that replaced grit valves with MagnaValves on their blast machines. The MagnaValves ended the maintenance problems and downtime associated with the grit valves and provided many other benefits. Call 800-832-5653 / 574-256-5001 or send email to sales@electronics-inc.com.

Electronics Inc.
Blast Cleaning Control

Accuracy of Declared Peening Intensity Values

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.

INTRODUCTION

Peening intensity is the arc height of one particular point on a simulated saturation curve that is declared as meeting specification requirements. Three stages are involved:
(i) **Generation of a Data Set** – Several Almen strips are given different amounts of shot peening and the induced arc height is measured for each peened strip.
(ii) **Simulation of a Saturation Curve** – the data set values are used to simulate a saturation curve that represents the continuous change of arc height with amount of peening.
(iii) **Declaration of Peening Intensity** – a particular point on the saturation curve is selected and declared to be the peening intensity value.

The definition of the term "accuracy" depends on its context. For peening intensity it may be defined as having three components:
(i) **Closeness to the true value**,
(ii) **Exactness of measurement** and
(iii) **Repeatability of measurement**.

Any consideration of peening intensity accuracy has to be related to the 'target intensity range' and its required accuracy.

Shot peeners, inspectors, users and equipment manufacturers have a shared interest in the accuracy of declared peening intensity values. This article attempts to present a detached analysis of the several factors that influence the accuracy of these values. It is shown that by far the greatest source of inaccuracy lies with the different interpretations of saturation curves allowed using current specifications. Declared peening intensity values vary by more than 10% for a given saturation curve - depending on the interpretation that is employed.

TARGET INTENSITY RANGE

Users specify a range of peening intensity values as a requirement that has to be met. Rather surprisingly this range does not have a specified accuracy. Fig.1 is a representation of a typical target intensity range – in this case 10-14 (using imperial units). As a target range, the values of 10 and 14 are exact quantities. Any declared peening intensity value less than 10 or greater than 14 fails to hit the target.

Fig.1 Representation of a Target Peening Intensity Range of 10-14.

Whether or not a particular declared peening intensity value hits a required target depends on the exactness of measurement. Assume, for example, that a shot stream's peening intensity is precisely 9.8758 (noting that we cannot actually measure to that degree of precision). If our measurement technique allowed two decimal places of exactness then that value would be rounded to 9.88 – failing to hit the target. With one decimal place of exactness the value would be rounded to 9.9 – again failing to hit the target. For no decimal places of exactness (using a crude measurement technique) rounding gives a value of 10 – now hitting the target!

Current measurement procedures normally declare peening intensity values to one decimal place of exactness. It would, therefore, appear reasonable that 'hitting the target' should be specified as a range with a minimum declared value of 10.0 and a maximum of 14.0. That implies, allowing for rounding, that the actual peening intensity was between 9.95 and 14.04. Allowing simple integral declared values would only prevent the actual peening intensity being acceptable if it was lower than 9.5 (rounding to 9) or higher than 14.4 (rounding to 15).

GENERATION OF A DATA SET

A typical data set of six strips, using imperial units for arc heights, is given in Table 1 on page 28.

Table 1 SAE Data Set No.8.

Time equivalent	Arc height inch x 1000
0.25	8.1
0.5	9.6
0.75	10.0
1	10.3
2	10.8
4	11.3

It is generally assumed that the 'time equivalent' values for every point in a data set are absolutely accurate. These values may be either integral numbers of passes/strokes or a reciprocal of the relative speed of the shot stream to the Almen strip fixture. The arc heights, on the other hand, cannot be absolutely accurate. "Closeness to true value" is largely a function of gage calibration. "Exactness of measurement" refers to the last significant digit of the measurement. This involves 'rounding' (which is carried out visually for analogue dial gages and automatically for digital dial gages). Hence, for example, the arc height for the first data point in Table 1 will actually lie somewhere between 8.050 and 8.149. 8.050 would be rounded-up to 8.1 and 8.149 would be rounded-down to 8.1. "Repeatability of measurement" is a function of both gage design and operator training/diligence. Even if the same peened strip is only being removed and replaced several times on a gage then the last significant digit will not always be the precisely the same.

'Rounding' is so commonplace that its significance is easy to overlook. **Rounded numbers carry with them the implication of exactness**. The third data point in Table 1 is shown, correctly, as having an arc height of 10.0. If, however, 10 had been entered that would have implied that the measured arc height was somewhere between 9.5 and 10.4 – rather than lying between 9.95 and 10.04. This is a small but important aspect of data presentation. Other important aspects of rounding are the avoidance of spurious exactness and spurious inaccuracy. For example, the average of three arc heights 10.1, 10.4 and 10.2 is 10.23333333, etc. To quote such exactness would be spurious (the arc heights themselves only being exact to one decimal point) so that the average should be declared as being 10.23. Spurious inaccuracy can occur when interpreting peening intensity times. For example, a peening intensity time, T, of 10.44 might well have been rounded down to 10.4. A 10% increase of this rounded-down time is 11.44 which, in turn, rounds down to 11.4. Increasing 10.44 by 10%, on the other hand, gives 11.484 which then rounds-up to 11.5. It is the 'double rounding' that has created the spurious inaccuracy of 11.4 - when the more accurate value is 11.5.

SIMULATION OF SATURATION CURVES

A continuous curve has to be simulated, using a small number of data points, as the second stage of peening intensity value declaration. This simulated curve can only be an approximation to the 'true shape'. This could only have been drawn if a large number of accurate data points had been available.

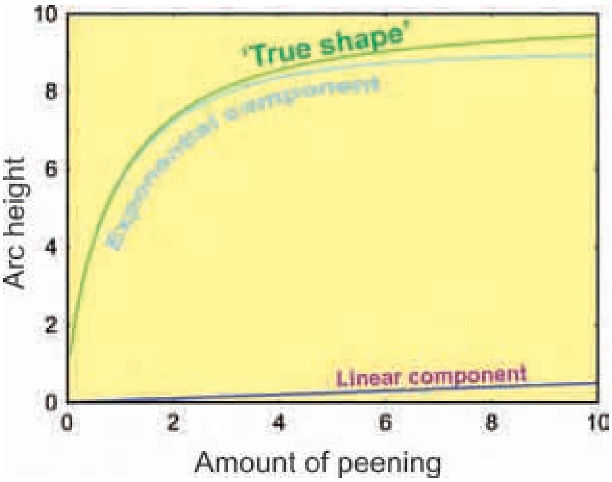


Fig.2 'True shape' of continuous saturation curve.

Fig.2 shows the 'true shape' for a shot stream that is constant in terms of peening intensity potential. It has been shown that this 'true shape' can be accurately represented by a combination of two components: three-parameter exponential and linear.

Hence:

'True shape' = Three-parameter Exponential component + Linear component

The mathematical equation representing the 'true shape' is:

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

where h = arc height, t = peening time and **a**, **b**, **c** and **d** are constants.

Reliable simulation of the 'true shape' using equation (1) would require a large number of accurate data points. As a compromise, curve equations are selected that are simpler than that of the 'true shape'. Typical simpler shapes have the equations shown below:

$$\mathbf{h = a*t/(b + t)}$$
$$\mathbf{h = a(1 - exp(- b*t))} \textbf{ and} \qquad (2)$$
$$\mathbf{h = a(1 - exp(-b*t^c))}$$

A common feature of these simpler equations is that they all exponential – not having the linear component of a 'true shape' saturation curve.

The accuracy of simplified saturation curves depends upon three properties of the data set used in its production. These are:

(i) **Number of data points in the set**,
(ii) **Spread of the data points (in terms of amount of peening)** and
(iii) **Individual and collective accuracy of the data points in the set**.

Fig.3 shows an example of a data set that does allow accurate simulation of the 'true shape' of a saturation curve. The set has six, well-spread, accurate, data points. The data is an excellent fit to the 'true shape'equation (1) – indicated by the r^2 value of 0.99853 (r^2 is a commonly-used measure where a value of 1.00000 represents a perfect fit). An even better fit is obtained to the three-parameter

equation **h = a(1 – exp(-b*t^c)) r²** = 0.99866. A very good fit is also obtained for the two-parameter equation **h = a*t/(b + t)** - with an r^2 value of 0.98680.

The data set shown in fig.3 can be assumed to be accurate because it is a good fit to a 'true shape' curve. There is an obvious linear component to the 'true shape' curve. The other two curves shown are still very good fits – even though neither curve has a linear component.

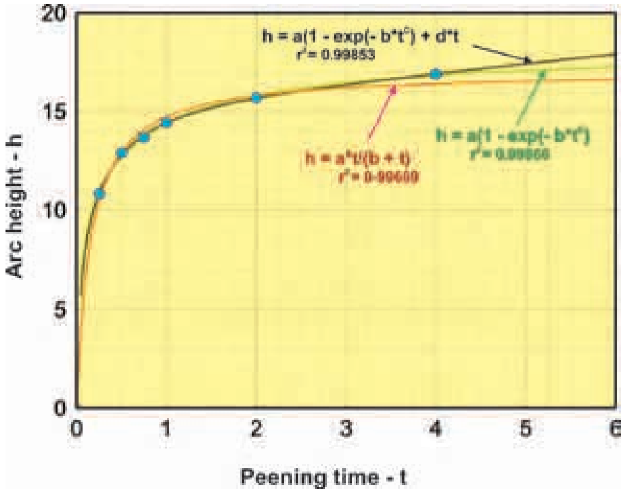


Fig.3. Data Set fitted to 'true shape' and rational function equations.

Fig.4 is for a data set that <u>could</u> have been obtained for the same shot stream that gave the data set used for fig.3. This four-point set has been deliberately chosen in order to illustrate the importance of number of points, data spread and point accuracy.

The data set has been fitted to each of the three exponential equations listed previously as equations (2). Different fits are obtained because (i) there are only four data points, (ii) the spread of points is poor – involving too high a proportion of long peening times and (iii) the individual point accuracy is poor because three successive points have almost the same arc height – rather than having a progressive increase in arc height.

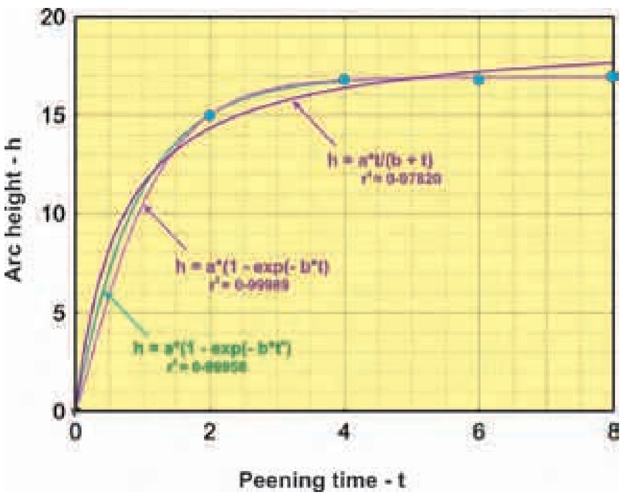


Fig.4. 4-point data set fitted to different equations.

It is important to appreciate that:

It is incorrect to assume that 'goodness of fit' implies accuracy.

Accuracy requires 'closeness to the true value'. Just because a set of data is a good fit to a particular shape of curve does not mean that that the data set is accurate. That aspect is illustrated in fig.4. The rational function **h = a*t/(b + t)** has the worst 'goodness of fit' but is probably the most accurate! The lesson to be learned is that data points should be fitted to a known shape of curve – not the other way round.

Manual simulation of a saturation curve is less accurate than computer-based curve-fitting, for several reasons: (i) the 'closeness to true value' is dubious because there is a natural tendency to draw a curve that is a good fit to the data points - rather than one having the known 'true shape' of a saturation curve, (ii) 'exactness' cannot be assured and (iii) 'repeatability' depends on who is drawing the curve.

DECLARATION OF PEENING INTENSITY

This third stage involves selecting one point on the simulated saturation curve to be the declared peening intensity. Selection can be achieved either by analyzing the simulated saturation curve or by simply choosing one of the data points. There are, however, three different definitions of "peening intensity" that can be invoked. These three definitions may be termed "10%", "Up to 10%" and "Not more than 10%, for Special Cases." Each of these will indicate a different peening intensity for the same shot stream!

1"10%" Peening Intensity Definition

The "10%" definition is **"the arc height <u>of</u> the point of a continuous saturation curve that increases by 10% when the peening 'time' is doubled."** "**of**" means a unique point of the simulated saturation curve – not a data point from the set used to produce the curve. The difference is illustrated in fig.5 where the peening intensity is declared to be "8.7". With this definition "increases by 10%" is meant to be exactly that – not a rounded value.

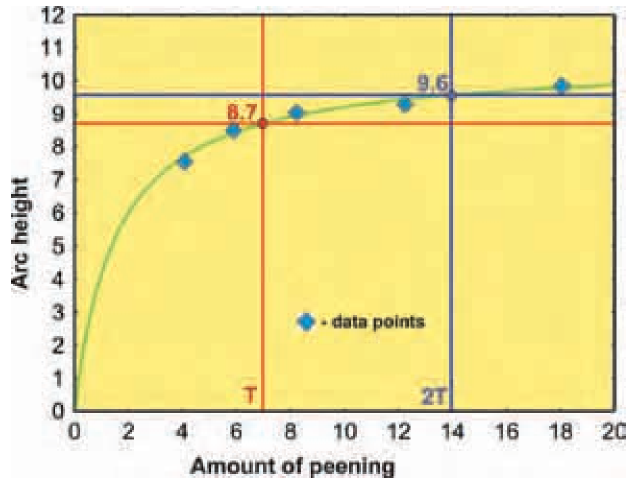


Fig.5 Unique peening intensity point of 8.7 at T.

The saturation curve shown in fig.5 was derived using a Solver 2PF program for a set of five data points. Determination of the peening intensity, shown as 8.7 occurring at a 'time' T, was carried out automatically. The point at which the intensity increases by exactly 10% is shown as 9.6 (to the nearest decimal point) occurring at the doubled time of 2T. Computer programs calculate the peening intensity point's position with enormous precision. It would, however, be bad practice to claim a higher precision than can be justified by that of the actual data points. Maximum accuracy is achieved by having a data set with points on either side of the declared peening intensity point.

Manual interpretation of manually-drawn saturation curves cannot, of course, involve the required 10% increase with the same exactness as can be achieved using a computer program. Having drawn a smooth curve on large graph paper it is, however, still possible to determine the "10%" peening intensity point with acceptable precision. The standard procedure is iterative – first guesses are made for T and the values of the curve at T and 2T are compared for nearness to a 10% increase. Using the curve shown in fig.5 for example, first guesses for T/2T might well be 6/12 and 8/16. 6/12 corresponds to an 11.4% increase whereas 8/16 corresponds to an 8.8% increase – one increase is too high and the other is too low. A second guess is therefore that 7/14 would be closer to a 10% increase than either 6/12 or 8/16. By coincidence the increase for 7/14 is precisely 10.0%. At the time, T, of 7 the curve's arc height is 8.7 with 9.6 at 2T – correct to the required precision. It should be noted that there is no question of an 'error band' being needed for the 10 in the 10% increase. Exactly 10% is used for the calculations. All that is needed is to arrive at a T/2T pairing that identifies the peening intensity value to the required exactness – normally to the nearest 0.1. A useful aid, that removes the need for calculating 10% increases, is a two-column chart. Arc height values appear in one column and 10% greater values in the adjacent column. Such charts are easily produced using Excel.

The process of selecting the required T/2T pairing can also be facilitated by the use of pre-printed transparent "10% graph paper" - an example of its application being shown as fig.6. A transparency is placed over chart paper containing the manually-drawn saturation curve. This curve is intersected by several of the "10% lines". The most appropriate line is the one that intersects at two 'amount of peening' points where one is twice the other. In fig.6 AB, the most appropriate line, has been highlighted. This intersects the manually-drawn curve at T and 2T. At T, the arc height is 8.66 which rounds to 8.7. Interpolation allows further refinement of the intersections so that 2T becomes very close to being twice T although it still yields the peening intensity to be 8.7 when rounding to one decimal place. The use of this aid may appear cumbersome but, with a little practice, identifying T and 2T becomes very quick. A 'workshop' version involves plotting the data and drawing the saturation curve using a graphed whiteboard. The "10% graph paper" transparency is then projected onto the whiteboard using an overhead projector.

The mathematical basis for "10% graph paper" is given as an appendix to this article. This allows anyone to produce their own copies.

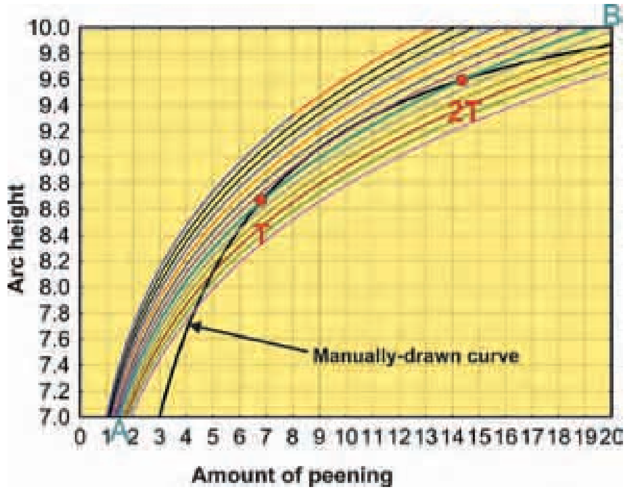


Fig.6 "10% graph paper" on top of a manually-drawn saturation curve.

The most important feature of the "10%" definition is that it leads to a single, unique, value of peening intensity.

2 "10% or less" Peening Intensity Definition

The "10% or less" definition is "**the arc height of the point on a saturation curve that increases by 10% or less when the peening 'time' is doubled**". This requirement is illustrated in fig.7. The same saturation curve as was used for fig.5 has been plotted but with an extended 'amount of peening' scale. Data points have been omitted – for clarity. Any pair of points, such as those shown as 14 and 28, can be used when applying the "10% or less" intensity definition – provided that the lower point is either at or to the right of A. This leads to the "10% or less" intensity curve as shown in fig.7. For the simulated saturation curve of fig.7 the peening intensity values that could be declared are anywhere between 8.7 and 10.6.

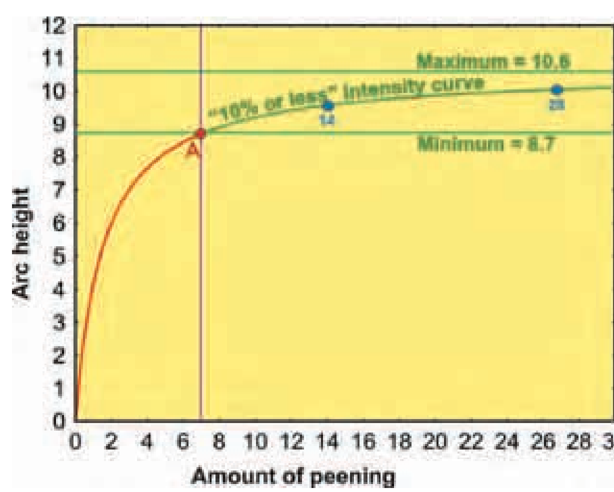


Fig.7 "10% or less" intensity curve.

It can be argued that, in practice, most users of the "10% or less" intensity definition would declare an intensity closer to the minimum available value than to the maximum available value – thus narrowing the "error band" of 8.7 to 10.6. Against that there is a probability that a saturation curve having large "amount of peening" times would not show an exponential flattening-out. The arc height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tends to increase continuously, albeit slowly, with long peening times. It is probable that users of the "10% or less" intensity definition also construct saturation curves manually. The subjectivity of that procedure then increases the error band even further.

An important feature of the "10% or less" peening intensity definition is that the declared value is not unique, it can vary substantially for a given shot stream - introducing a substantial error band.

3 "Not more than 10%, For Special Cases" Peening Intensity Definition

There are some peening shop procedures where the minimum peening 'time' (one pass/stroke/rotation) that can be applied is longer than the time, T, of the unique point determined using the "10%" intensity definition. A third intensity definition is therefore sanctioned that is based on a schematic "Type II saturation curve". This type of saturation curve (similar to fig.2 in SAE Specification J443) is presented as fig.8. The corresponding J443 definition of intensity is quoted as follows:

" For type II saturation curves the intensity is defined as the arc height value of the first data point (i.e. at the minimum possible exposure time, t) provided that the arc height rises by no more than 10% when the exposure time is doubled – time 2t. The intensity shall be interpreted as the arc height value of the first strip reading."

A "type II" saturation curve is based on two assumptions. The first is that all of the measured data points have similar arc heights – so that a horizontal line is a reasonable representation. The second assumption concerns the variation in arc height prior to the first data point. This is shown as increasing linearly from zero until it intersects with the first data point (since it is not possible to establish a more accurate intersection point). For the quoted intensity definition the declared intensity is that achieved after one pass.

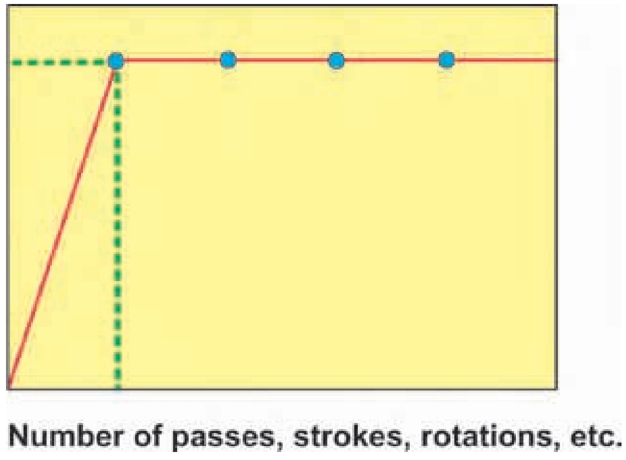


Fig.8 Type II saturation curve for "Special Cases."

The SAE presentation of a "type II" saturation curve is only 'schematic'. An actual set of arc heights for 1, 2, 3 and 4 passes would not normally be identical. Fig.9 illustrates the relationship between "Type I" and "Type II" saturation curves for a more realistic set of data points. "Type I" is the normal shape of saturation curve - that allows the derivation of the unique peening intensity point, S.

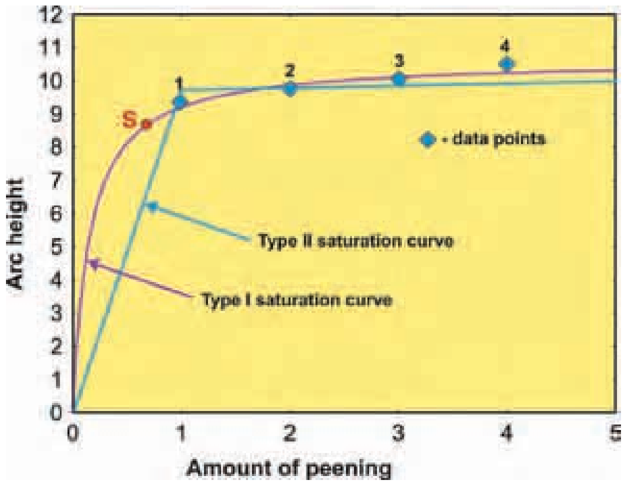


Fig.9 Comparison of normal saturation curve, type I, and "special case" curve, type II.

The first data point on a type II saturation curve can be anywhere to the right of S. It follows that the range of declared peening intensity points would be the same as when applying the "10% or less" definition described previously. In most real situations the first data point, 1, would not be anywhere near as close to S as in the example used for fig.9. Unlike the two previous definitions, the declared intensity value is that of a single data point. Any value based on a single measurement is less accurate than one that is based on averaging several measurements.

DISCUSSION

The accuracy of declared peening intensity values depends on the accuracy achieved at each of three succeeding stages: generation of data set, simulation of saturation curve and declaration of peening intensity. These are interdependent stages. If the data set is inaccurate then the two succeeding stages cannot rectify that inaccuracy. Poor simulation of a saturation curve (even when based on an accurate data set) will mean that an accurate declaration of peening intensity becomes impossible. Finally, even if an accurate simulation of a saturation curve has been achieved (based on an accurate data set) then there remains the problem of deciding which arc height on the curve is to be declared as the peening intensity value. For the same shot stream, the declared peening intensity value will vary by more than 10% - depending on which of three different definitions of "peening intensity" is invoked. This is obviously not a satisfactory situation.

Error bands are additive so that a definition-induced error band only makes life more difficult for shot peeners. The 'definition-induced error band' can easily be eliminated for Type I saturation curves by deleting the "10% or less" definition completely. Unique saturation intensity values can easily be derived by applying just the "10%" definition. Type II saturation curves, on the other hand, necessitate a different intensity definition. Overall, the use of just two intensity definitions would be a welcome clarification of a presently ambiguous situation.

Declared peening intensity values should be rounded to an agreed level of exactness - one decimal point when

working in thousandths of an inch arc height. It should not be possible for a measured peening intensity value to be rounded to an integral value in order to satisfy a customer's stated range. For example, a measured value of 9.5 should not be allowed to satisfy a stated range of 10 -14.

Appendix

DERIVATION OF MATHEMATICAL EQUATION FOR "10%" GRAPH PAPER

The required feature of "10%" lines is that the y-value should increase by precisely 10% when the x-value is doubled. A starting position is to assume that the variation of y with x is of the type shown in equation (1) in which **c** is a constant:

$$\mathbf{y = x^c} \tag{1}$$

Doubling of **x** to yield a 10% increase in **y** can be expressed as equation (2):

$$\mathbf{1.1y = (2x)^c} \tag{2}$$

Equation (2) can be written as:

$$\mathbf{1.1y = 2^c.x^c} \tag{3}$$

Dividing equation (3) by equation (1) gives that:

$$\mathbf{1.1 = 2^c} \tag{4}$$

Applying logarithms to equation (4) gives that:

$$\mathbf{c = \log_2(1.1)} \tag{5}$$

Equation (5) is the required solution for the constant, **c**. It is that "**c** is the log to the base 2 of 1.1". The required mathematical equation for a series of "10%" lines becomes:

$$\mathbf{y = a.x^c} \tag{6}$$

where **a** is a variable and the constant **c** is equal to $\mathbf{\log_2(1.1)}$.

The numerical value of the constant, **c**, is given (to five significant figures) by:

$$\mathbf{c = 0.13750} \tag{7}$$

Substituting **c = 0.1375** into equation (6) gives the final working relationship that:

$$\mathbf{y = a.x^{0.1375}} \tag{8}$$

The example of derived "10% graph paper" shown as fig.6 was obtained by substituting a limited number of values for **a** into equation (8) and superimposing the resulting curves onto a conventional orthogonal gridline background. Working examples of "10% graph paper" use a much larger number of values for **a** – say 40 to 60. The paper can either be converted into a transparency or used directly for plotting data points and simulated saturation curve.

Variability Study of the Flapper Peening Process

Sylvain Forgues is the president of Shockform Inc. Sylvain has over 20 years of experience in shot peening, robotics, stress analysis and fatigue life improvement techniques for the aerospace industry. Sylvain is an active member of the SAE Aerospace Metals and Engineering Committee. He is an authorized flapper peening trainer for Electronics Inc. Education Division and has authored papers on shot peening and allied processes.

Introduction

Flapper peening is an important process to quickly re-peen small areas that have seen surface damage. It was developed more than 50 years ago and is extensively used on aerospace components such as landing gears, wing skins, helicopter hubs, etc.

In this article, statistical tools will be used to evaluate the impact of certain parameters on the flapper peening process variability. Once the important parameters are determined, the control of these parameters will be discussed.

Taguchi Method for Quality Engineering

Genichi Taguchi, a Japanese engineer and statistician, developed a very efficient statistical approach to determine the influence of parameters in a process (Ref. 1). Using his technique, only a limited number of trials are needed to determine which parameters are responsible for the process variability. With this information, it is possible to better control these important parameters thereby making the process more stable and robust.

The Taguchi method was used to study the parameters of the flapper peening process. Four main parameters were considered in the experiment. They are the rotation speed, the operator technique, the flap age and the magnet height. These parameters were selected because of their perceived influence on the process after discussions with several organizations using flapper peening on a daily basis. For each parameter, a high and a low value representative of a normal process was selected, as illustrated in Table 1.

Table 1

Parameter	Low=1	High=2
1) Rotation Speed	3900	4100
2) Operator Technique	Operator 1	Operator 2
3) Flap Age	New	Old
4) Magnet Height	Flush	0.125" High

An average rotational speed of 4000 rpm was selected for the experiment. This rpm usually gives an Almen intensity in the order of 0.010A. The low and the high values of ±100 rpm represent the acceptable rotational speed variability in the current military specification MIL-R-81841.

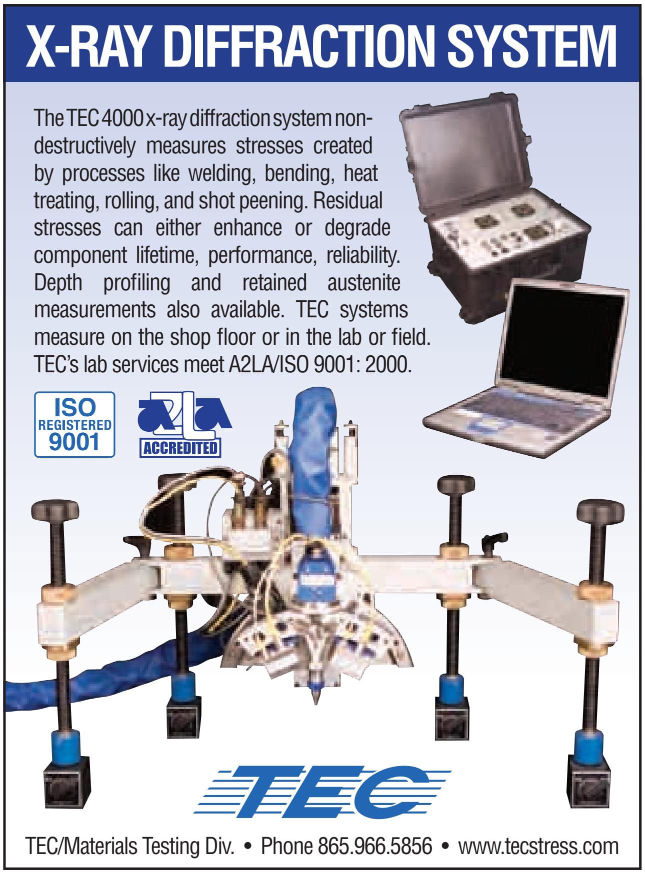
For the operator technique, two operators were selected for the experiment. They were both trained under a FAA certified course and were selected at random because of their availability at the time of the experiment. It is important to note that this parameter includes possible variability in the process for the height of the flap with respect to the part, for the coverage pattern and for the parallelism of the flap with respect to the part.

For the experiment, the flaps were either brand new, or with at least 30 minutes of previous peening. In both cases the flaps were not missing any tungsten carbine balls. These values were selected to represent some OEM specifications that require a flap to be changed after 30 minutes. The purpose was also to investigate the perception that flap preparation (removal of resin on tungsten carbide balls) can influence intensity and that flap effectiveness changes with usage time.

The last parameter selected is the height of the magnets inside the magnetic Almen block. This parameter was selected because of the perceived notion by some operators that changing the height of the magnet has an impact on

Table 2

Experiment	RPM A	Operator B	AxB	Flap C	AxC	AxD	Magnet D	Results Intensity
1	1	1	1	1	1	1	1	
2	1	1	1	2	2	2	2	
3	1	2	2	1	1	2	2	
4	1	2	2	2	2	1	1	
5	2	1	2	1	2	1	2	
6	2	1	2	2	1	2	1	
7	2	2	1	1	2	2	1	
8	2	2	1	2	1	1	2	



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the Almen intensity. The height of the magnets can be easily changed by tightening of loosening the screws holding the magnets. For the experiment, the magnet height was selected as flush to the top of the magnetic block or allowed to move up to height of 0.125" above the surface of the block.

An L8 orthogonal array (Table 2 on page 38) was used to study the four main parameters and their interactions. The strength of the Taguchi method is that only eight trials need to be performed to determine the influence of all four parameters. These trials can be performed more than once to increase the confidence in the results. For each trial, the parameters can either have a low value equal to one (1) or a high value equal to two (2) as defined in Table 1.

For each trial, a complete five-point saturation curve was generated. From this saturation curve, the intensity is obtained using Dr. David Kirk's saturation curve solver (Ref. 2). The intensity is the result for each trial. Using these values, calculations are performed to determine the influence of each parameter.

Flapper Peening Analysis of Variance

The influence of the four parameters is presented in Figure 1. In increasing order of influence, we find the magnet height, the rotation speed, the flap age and the operator technique.

Magnet Height

The magnet height on the magnetic block has a negligible influence on the flapper peening process. As long as the magnets are flush with the surface or above, the location of the magnet shows negligible impact on the resulting intensity.

Flap Rotational Speed

The flap rotational speed is the third most important parameter in terms of influence on the process. This might be surprising since the intensity has a direct relationship with the rotational speed. The results actually show that the requirement to maintain the rotational speed at ±100 rpm is justified and ensures a low variability in the process.

It is often difficult to maintain constant air pressure in the shop and therefore maintaining ±100RPM capability can be a challenge. However, by using a closed-loop controller for the mandrel rotation speed we were able to maintain the required speeds automatically. Had this not been the case, then rotation speed would have been the dominant variance characteristic. It's easy to see that the next challenge is to have the operators properly trained and certified in the use of the equipment.

Flap Age

The results show that the condition of the flap can have a significant impact on the flapper peening process variability. New flaps, having a thin residue of resin on their surface, influence the effectiveness of the ball impact. This seemed to be a bigger influence than age of the flaps, whether they were new (resin removed) or had been in use for over 30 minutes.

The new flap variability can be further reduced by using the same flap for the complete duration of the job. Since flapper peening is mostly used on smaller surfaces, the complete job should require less than 30 minutes of peening.

Operator Technique

Operator technique has the most influence on the flapper peening process. Each operator holds and moves the tool differently which results in slight variations in flap height, parallelism to the surface and coverage patterns. Because of this, each operator has to generate his own saturation curve for each job. This ensures that the proper rotational speed is selected by each operator to obtain the required intensity.

This concept is further illustrated by Figure 2 which shows the flapper peening intensity variability due to different operators. For this study, 25 trained operators were asked to generate a five-point saturation curve at 4000 rpm using the Flapspeed™ controller for flapper peening.

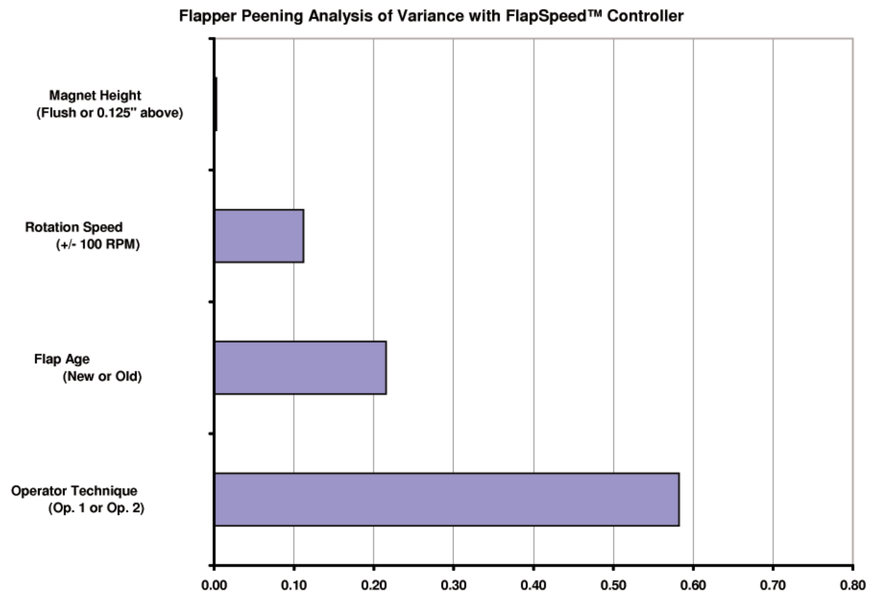

Figure 1 Influence of Parameters on the Flapper Peening Process

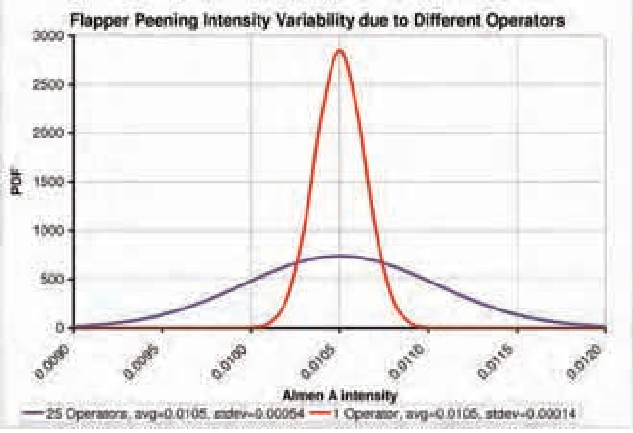

Figure 2

The FlapSpeed™ controller maintains the rotational speed at ±30 rpm thereby almost eliminating the variability due to rotational speed. The intensity was determined for each operator using Dr. David Kirk's saturation curve solver. The average intensity and standard deviation was determined for the 25 operators and plotted as the blue line in Figure 2. The red line illustrates the intensity variability when a single operator generates 10 saturation curves using the same settings.

The standard deviation for the single operator repeating his curves is almost one-third of the 25 different operators. This means that at ±3σ, the single operator would have experienced an intensity variability of less than ±0.0005A for a fixed setting while using different operators could bring that level to ±0.0015A.

Conclusion

The influence of four parameters on the flapper peening variability was studied. The analysis of variance revealed that the magnet height on the magnetic block had no significant influence on the process variability. The analysis showed that the flap rotational speed generated little variability as long as it was controlled within ±100 rpm.

The analysis also showed that the condition of the flap can introduce some variability in the process. This variability can be minimized by using a standardized procedure to clean the resin of the tungsten carbide balls, by using a single flap during the peening job and by keeping the duration of flapper peening jobs below 30 minutes.

The most influential parameter on the flapper peening variability is the operator. To minimize this variability, it is recommended that each operator generates his own saturation curve for each job. It was shown that a trained operator with proper control equipment can achieve a variability of less than +/-0.0005A when repeating the same job.

Overall, when carried out by trained operators with the proper control equipment, flapper peening is a very stable and repetitive process that is also fast, clean and easy.

References

1) Ross, J., Phillip, "Taguchi Techniques for Quality Engineering", McGraw-Hill Professional; 2nd edition, Aug 1 1995.
2) Kirk, Dr. D., "Almen Saturation Curve Solver", Microsoft Office 2003, Electronics Inc.,

Why Submit a Paper to ICSP-11?

Why should you submit a paper to the Eleventh International Conference on Shot Peening? The following excerpt from an article titled "The Benefits of Publishing Technical Papers," by Brenda Jameson with Micron Technology, Inc., makes the argument far better than I ever could.

> Few people recognize Nikola Tesla's name, but grade-school children can tell you that Thomas Edison invented the light bulb. It was Tesla, not Edison, who harnessed the alternating current that lights the bulbs of today. It was Tesla who invented radio, fluorescent lighting, and the bladeless turbines used in aircraft. He introduced the concepts of robots, computers, missile science, satellites, microwaves, beam weapons, and nuclear fusion.
>
> Tesla and Edison were world-famous scientists and colleagues who lived and worked in the same period. Both made important contributions to the industrial age. So why is one name well-known today while the other is obscure? Thomas Edison regularly engaged in public relations campaigns to communicate the usefulness of his inventions to his colleagues and the general public. He lectured throughout the world and authored over 3-million pages of information including 1,093 patents; the largest number of patents ever attributed to an individual.
>
> Nikola Tesla filed 99 patents in his 85-year lifetime. His lectures made him world-famous in his time, but he never once submitted an article to an academic journal. The inventions of Thomas Edison were published in technical detail, but many of Nikola Tesla's ideas and inventions were never documented or published and, consequently, were lost to humanity when he died.

I'm not suggesting that shot peening has changed the world like the invention of the light bulb, but its benefits and applications are increasing as the need grows for stronger and lighter metal components in transportation, medical and many other industries.

An ICSP-11 paper benefits the author(s) in four ways:

- establishes ownership of work
- enhances professional reputation
- provides networking opportunities with peers
- papers will be published in the Conference Proceedings book

Many of the contributors to the conference are from academic and research institutes, but papers are welcomed from industry, too. The only stipulation is that a paper addresses one of the approved ICSP-11 research topics—a paper won't be accepted if it's an advertisement for an organization. An example of an excellent paper from industry is "The Application of Mechanical Surface Treatment in the Passenger Car Industry." It was written by Peter Hutmann, BMW Group, Germany and presented at ICSP-8. (The paper was reprinted in the Summer 2004 *Shot Peener* due to its relevance to our readers.)

Student researchers and young engineers and scientists are encouraged to participate. If preparing an abstract, much less compiling your research into a paper, seems like a formidable task, the committee members and I stand ready to help you. If English isn't your first language, native-speaker editors will be pleased to review your abstract and/or article.

An alternative to a paper is a poster submission. The poster presentation allows academic and industrial researchers to present recent and ongoing projects. Accepted posters will be displayed at the conference and this forum is a good opportunity to discuss ideas and get useful feedback from the community.

ICSP-11 will also sponsor a trade show with exhibits from the leaders of the finest products and services in shot peening and related processes.

And the conference isn't all work. We are planning some terrific events where attendees will be able to relax, have fun and enjoy talking and sharing information.

The deadline for abstract submissions is June 1, 2010. More information on the conference is on page 20 and 21 of this magazine and a submission form is included. Please contact me at jack.champaigne@electronics-inc.com with any questions.

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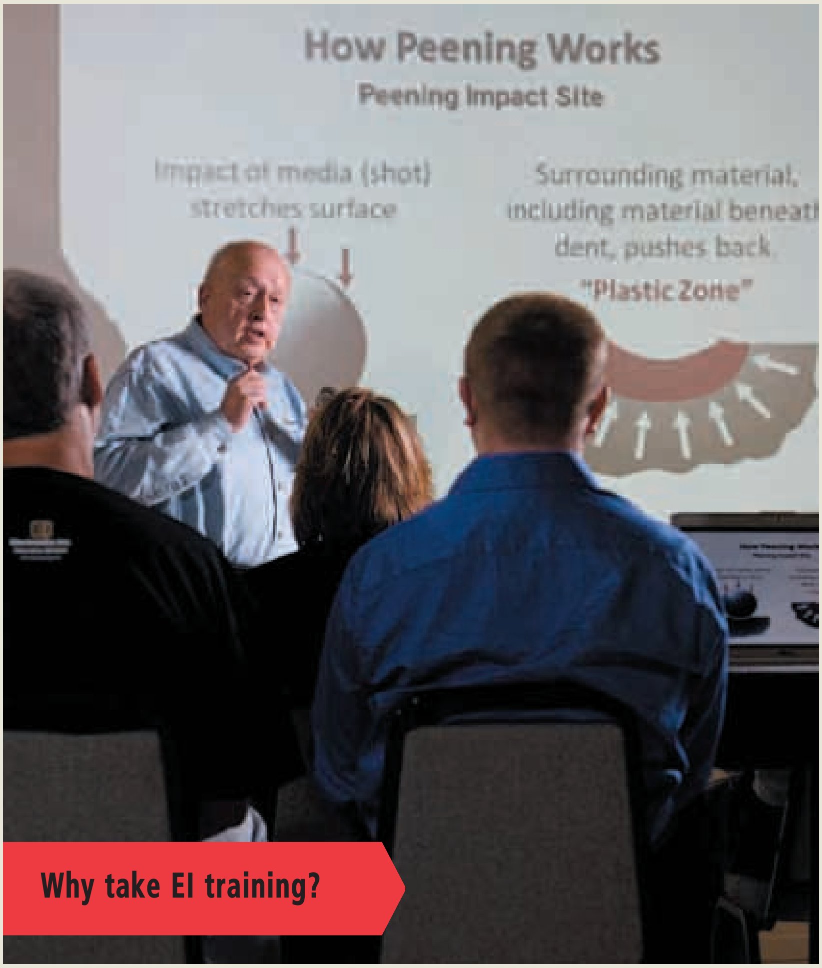

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