

Volume 24, Issue 1 Winter 2010
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The **Shot Peener**

Fine Particle **SHOT PEENING**

Its applications and advantages

Plus:

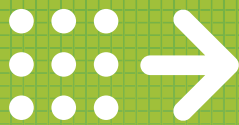
A Cautionary Tale

The 2009 Shot Peener of the Year

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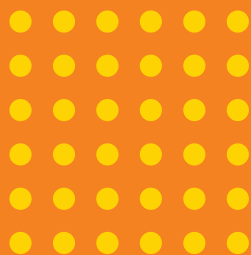
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The Shot Peener

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

4

Fine Particle Shot Peening

Fine particle shot peening (FPSP) is widely used in Japan but doesn't receive as much attention elsewhere. Our introduction to FPSP points out the unique characteristics and benefits of this peening process.



8

The Shot Peening Forum

What do you do when you have a question or problem related to shot peening? Online help is available in the Forum at www.shotpeener.com. The Shot Peening Forum is a tremendous resource and a good way to share your expertise with others.



The Shot Peener

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Articles

Cautionary Tale: Shot Peening Compression Springs P.14

Shot peening has left laps and a white layer. Should a springmaker be concerned?

Shot Peening Comes Along for the Ride P.18

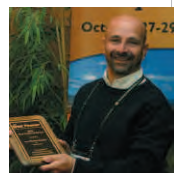
David Thomas, Technical Instructor/Engineering Training with Air New Zealand, brings his work home.

ICSP-11 Call for Papers P.20

The ICSP-11 Organizing Committee is seeking papers that further the understanding and knowledge of shot peening. Abstracts are due June 1, 2010 and an abstract submission form is included in this magazine.

The 2009 Shot Peener of the Year is Announced P.24

Michele Bandini received the award at the U.S. Workshop.



Meaning, Measurement Philosophy and Verification of "Peening Intensity" P.26

An academic study from Dr. David Kirk.

Industry News P.38

News from KLM, Nadcap, and Electronics Inc.

The Parting Shot P.42

Moving Ahead: Nadcap Training, SAE Specs



An Introduction Fine Particle Shot Peening

Fine particle shot peening (FPSP) is fine, powder-like spherical media (20-200 μm in diameter) thrown against metal surfaces at speeds of more than 100 m/sec. The typical hardness of FPSP media, which can be metallic, ceramic or glass, is 750-1000 HV. The machine used in the process is a modified pneumatic shot peening system. Like conventional shot peening, fine particle shot peening improves fatigue strength and stress corrosion fracture resistance. Its greatest additional benefit is that it produces a very smooth surface finish. However, the idea to use fine particles was likely motivated by economy, not efficiency—a creative thinker looked at the fines from cast steel shot production and wondered if they could be put to good use.

Component designers should understand the advantages and disadvantages of both processes. The following is a comparison between conventional shot peening and fine particle shot peening.

Shot Peening Advantages

- Greatly improves strength and fatigue resistance
- Well-known process that is relatively inexpensive to implement
- Has substantial research and quality controls to enhance its value
- Media and equipment are readily available
- Creates a pebbly surface that is advantageous in certain applications

Fine Particle Shot Peening Advantages

- Improves surface hardness and wear resistance
- Ultra-smooth surface is ideal for bearings, seals, or close-tolerance areas
- Will not distort close-tolerance parts
- Will not damage soft or fragile parts

Shot Peening Disadvantages

- Pebbly surface finish isn't suitable for all applications
- Can distort close-tolerance parts

Fine Particle Shot Peening Disadvantages

- Limited availability in U.S. and Europe
- Media can be difficult to use and few equipment and media manufacturers are experienced with it
- Limited depth of compression might make it unsuitable for some applications

Entrepreneurs will see that the first two "Fine Particle Shot Peening **Disadvantages**" could easily be changed to "Fine Particle Shot Peening **Opportunities**." The technology is already being

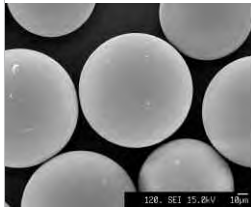
exploited in Japan. Fuji Kihan Company and Fuji Seisakusyo Company have patented a fine particle peening process that they market to the Japanese automotive and worldwide motor sports industries. According to an article posted at the JETRO (Japan External Trade Organization) web site, Fuji Kihan has licensed this technology to over 130 companies. Eighty percent of these are Japanese auto and auto part manufacturers. Japan also has a Fine Particle Shot Peening Society.

The scope of the process is evident in several papers presented at the 2008 Tenth International Conference on Shot Peening (ICSP-10) in Tokyo.* An excellent example of Japanese FPSP research was presented by M. Yoshizaki of Hino Motors. Mr. Yoshizaki presented "Improvement in Tooth Surface Strength of Carburized Transmission Gears by Fine Particle Bombarding Carburized Process." The abstract reads:

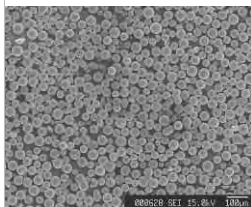
Gear surface fatigue endurance tests were carried out using gears treated with the fine particle bombarding (FPB) process under three different peening conditions. Shot peened gears by a conventional impeller-type machine were used as comparison. The results showed that FPB increased the tooth surface strength (pitting resistance) by 1.21 to 1.28 times in Hertzian stress compared to the conventional impeller-type shot peening. Next, the influence of FPB on the tooth surface properties such as residual stress, hardness, roughness, surface texture, etc., were examined. After obtaining the results, the following factors of FPB that influenced tooth surface strength increase were discussed: (a) high residual compressive stress produced below the surface, (b) greatly increased hardness below the surface, (c) excellent conformability of the tooth surface, (d) micro hollows on the tooth surface generated after running. The author pointed out that the latter two were unique factors caused by FPB and contributed much to the improvement of tooth surface strength.

Additional ICSP-10 paper topics were "Fine Particle Bombarding Technology and Functional Development of Metal Surface," "Improvement of Corrosion Resistance of High-Strength Aluminum Alloy by Fine-Particle Bombarding Treatment," "Influence of Fine Particle Bombarding on Surface Strength of Carburized Steel Under Rolling Contact Condition,"

*ICSP-10 Proceedings are available for purchase at www.shotpeener.com



Low sodium glass bead shot peening particle



Low sodium glass bead fine shot peening particle

Mitsubishi Heavy Industries, Nagoya Aerospace Systems is using fine particles made from low-sodium glass which differs from glass beads specified in AMS 2431/6. Low sodium glass beads have a lower consumption rate than that of glass bead.

Images are courtesy of Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems



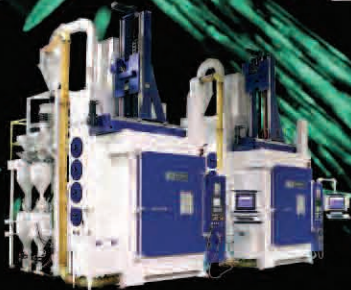
Kathy Levy is the owner of InfoProse and works as a technical writer and marketing consultant

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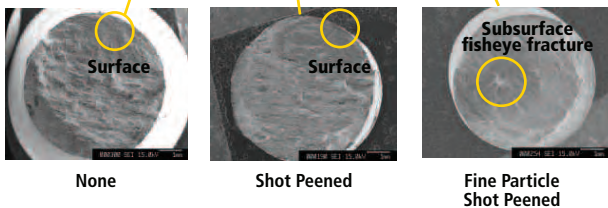
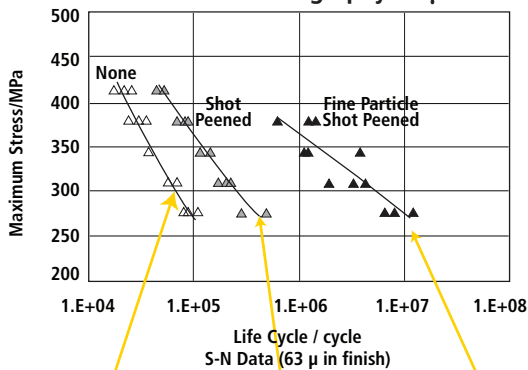
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“Formation of Homogeneous Lamellar Structure with Nano-Scale Grains Under Material Surfaces by Fine Particle Bombarding,” “Effect of Fine Particle Bombarding on Thermal Fatigue Property of Tool Steel for Die Casting” and “Applicability of Fine Particle Peening on Surface Modification of Aluminum Alloy.”

Fine particle shot peening has been so successful for the Japanese automotive industry that a suitable FPSP process is in development in Japan for aluminum aircraft parts. A. Inoue, T. Sekigawa and K. Oguri with Mitsubishi Heavy Industries presented “Fatigue Property Enhancement by Fine Particle Shot Peening for Aircraft Aluminum Parts” at ICSP-10. According to the abstract:

Fatigue life of conventional shot peened 7050-T7451 aluminum parts was increased by several times, while that of fine-particle shot-peened aluminum was increased by more than 10 times compared with that of as-machined. The compressive residual stress on fine-particle shot-peened surface covered adequately with uniform dimples is higher than that on shot-peened surface. Fracture surface observation revealed that the fatigue crack of fine-particle shot-peened samples originate at the subsurface layer, which shows the high compressive residual stress at very near the surface and the less-roughened surface prevents crack initiation from the surface. Fine particle shot peening can improve fatigue life more than shot peening, which shows fatigue crack initiates from small flaws and laps on the surface created by shot peening.

S-N Data and Fractography 63 μ in.



Fatigue life is strongly affected by crack initiation position. Fatigue Life Cycle by Surface Crack initiation is one or more shorter than Subsurface initiation.
Resource: Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems

Engineered Abrasives (EA), a manufacturer of blast finishing and shot peening systems, is one of the few U.S. companies that provides fine particle shot peening services. EA developed their Fine Steel® peening in 1999 with General Motors in an effort to replace expensive ceramic bead peening and still effectively reduce gear tooth pitting. Engineered Abrasives’ Fine Steel® peening uses fine steel at 150 microns screened at 100%. The fine particle peening gives a highly compressive residual stress on the tooth surface and the resulting small dimples retain beneficial oil for the elimination of gear tooth pitting. Fine Steel® peening is more involved than other shot peening processes. For example, it requires a special media valve for flow rate control and pressure vessel to handle the fine

media. The tooling is made from tungsten carbide because of the higher wear than from conventional peening media. Media screen separator systems wear faster and hoses must be changed often. Operators need to empty media screen separator systems and dust collectors more than with conventional shot peening.

An upcoming application for fine particle shot peening in the U.S. is in the medical implant industry. Electronics Inc. (EI) has received Patent No. 7,131,303 for Shot Peening of Orthopaedic Implants for Tissue Adhesion. Proper adhesion of soft tissue to orthopaedic implants is important but has proven difficult to achieve. For example, if the implant surface to which tissue adherence is desired is too smooth, tissue cannot easily adhere to the implant and the body forms a tissue capsule around the implant, sealing it off from the rest of the body. This impairs the implant’s function. Since the implant constantly moves relative to the tissue, the resulting friction causes inflammation and creates a capsule of dead tissue. Accordingly, implant surfaces to which tissue adherence is desired have been textured, but too great a degree of surface roughness can permit connective tissue and bone to grow into the fissures. The implant essentially grows into the body and removal of the implant becomes almost impossible, and, if possible, results in major bone loss. The patent Summary of the Invention cites:

According to the invention, the portion of an orthopaedic implant to which tissue adherence is desired is treated by microbead, that is, shot that is much smaller than shot used to effect strengthening of the implant. Microbead has a diameter in the range of about 10 microns-300 microns and when used at normal intensity causes indentations on the surface of the implant of about 10 microns to about 50 microns. This does not cause compression of the layer just below the surface, but instead provides fine, shallow texturing of the implant that permits the fibroblasts of the connective tissue a surface to which to adhere. However, the implant is not rough enough that it will interlock with hard tissue, such as bone tissue. Furthermore, shot peening is a well-known and relatively simple, inexpensive and controllable process to effect the desired tissue adherence. Other methods of surface treatment are more difficult and expensive, and are less easily controlled to effect the degree of surface roughness that permits soft tissue to adhere, but that is not rough enough that hard tissue will also adhere.

The patented invention can also be a duplex peening process as noted in the patent’s Description of the Preferred Embodiment: Method of treating a surface of a medical implant by shot peening said surface using larger shot sufficient to cause compression of the layer immediately below said surface to increase hardness and thereafter shot peening said surface with smaller shot sufficiently small to effect texturing of said surface without substantial compression of the layer immediately below said surface to improve tissue adhesion.”

EI is sponsoring research of the process at a major U.S. university in preparation for commercial development.

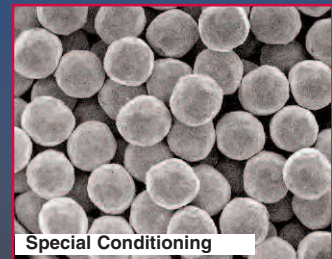
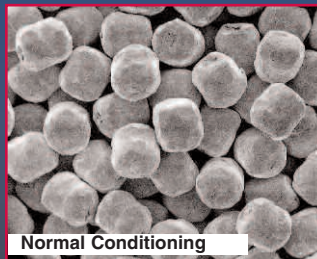
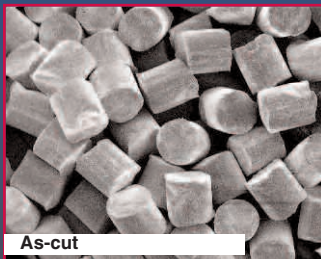
Fine Particle Shot Peening has tremendous growth potential. In an effort to explain its merits to SAE members, Takahiro Sekigawa with Mitsubishi Heavy Industries shared a PowerPoint presentation on FPSP usage in the Nagoya Aerospace Systems, Material Research Section of Mitsubishi Heavy Industries at a recent SAE shot peening subcommittee meeting. The International Scientific Committee for Shot Peening has again included FPSP in its list of desired topics for its 2011 conference. **The Shot Peener** magazine will continue its discussion of fine particle shot peening in upcoming issues. ●

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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.

Q&A

The Shot Peening Forum

Peened Holes Increase or Decrease in Diameter as a Result of Shot Peening?

Jack Champaigne
Mishawaka, Indiana, USA

I was recently asked if peened holes increase or decrease in diameter as a result of peening. My meager experience suggests that holes get larger but I'm wondering if there are materials or peening parameters that would actually cause the hole to get smaller. I realize that the material thickness is an important parameter, (i.e., thick material - deep hole) may not change very much at all. Can anyone else add experience to this question?

Mohammed
Montreal, Canada

Yes, it will decrease hole diameter and we used shot peening to decrease a diameter that was oversized so it will be smaller. Denting the surface causes material to be pumped out from the surface and that looks like peaks but if you use any polishing after, you will go back to your initial diameter. Also if your nozzle is not straight, you will have ovality problem and you will be confused if the diameter is smaller or bigger, actually it is oval.

Please note that always check your material kind and thickness and intensity goes with that.

michael.a.sorenson2
Renton, Washington, USA

Jack - in most cases, I have seen examples where hole sizes have grown after shotpeen. I believe this to be due to overall shotpeen growth factors. It can become more pronounced where depth of hole is thin, and intensity is high (more shotpeen growth). This becomes an issue for close tolerance holes (hole size range less than .0030), where if hole is not undersized prior to shotpeen and drilled/bored to full size, then after shotpeen, hole size can grow out of tolerance. However, I have seen cases where hole sizes have shrunk. It has been at lower intensities (.004a/.007a) -

I believe shotpeen growth is so small, and the apparent shrinkage could be attributed to peaks made by the shotpeen indentations only. If intensity was higher, growth would be more, and more than enough than the apparent shrinkage due to the peaks of peening indentations. I would be curious to see other examples of this from others.

Socrates

Michael's comments agree with shot peening theory. An internal 'ring' of compressed material is generated by shot peening. Some of the residual stress in this ring has to be relieved by increasing the diameter of the ring - generating a balancing tensile force in the underlying material. Hence the 'real' hole diameter increases. 'Apparent' diameter change depends on the induced change in surface roughness. This depends on the pre-peening roughness and the shot size.

Maximum Flow Rates of Steel Shot or Cut Wire Shot?

Marco Klijsen
Kaatsheuvel, the Netherlands

Hi, does anyone have information on max. flow rates of steel shot or cut wire shot at given pressure and given nozzle diameter? I am facing problems getting a stable media flow using 8 kg/min cut wire shot #23 (=0,8 mm) at 6 bar through a 6 mm nozzle. All machine settings are correct and media flow is stable until 4 kg/min. After increasing the flow, the flow starts to get unstable.

Any recommendations and/or info is welcome.

Jack Champaigne
Mishawaka, Indiana, USA

Marco,
Go to shotpeener.com and then "Learning." From there go to "Graphs/Charts/Tools." From there click on first entry under "Air Peening Applications." This document will give you

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Posts have been edited for clarity

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some guidance on flow rates and air pressure, etc. Your alternative is to continue to experiment and note the maximum flow rate achievable for a given air pressure. The nozzle and hose size are also important factors to keep in mind.

Joe McGreal
Monticello, Iowa

Steel media is difficult to suspend evenly in blast hose over long distances. Steel media needs relatively high velocities to remain evenly suspended in blast hose. Sharp bends in blast hose causes coagulation of media and resulting flow problems. Smaller diameter hose will increase the velocity of the air and media reducing the uneven flow rates. It's best to use the shortest hose length with the shallowest bends possible.

Use a Smaller Almen Strip?

Alfredo
Madrid, Spain

We have to shotpeen a gear with teeth length smaller than the Almen strip. We have always worked with bigger gears, and we usually locate the Almen strip along the gear root (middle of the teeth length). If I use a standard Almen strip, the shot will not impact along the whole strip, so I assume the Almen intensity measured will be wrong.

- 1) Should I use a smaller strip? In this case, can I correlate the results?
- 2) Should I locate it in other position (not following the gear root)?

Jack Champaigne
Mishawaka, Indiana, USA

Can you modify your gear root to be large enough for the Almen strip? Another possibility is to simulate the gear root, mount Almen strip onto a fixture that represents the angle of impact and distance to nozzle.

Jack Champaigne
Mishawaka, Indiana, USA

Also see this link for use of shaded strip:
<http://www.shotpeener.com/learning/hole.pdf>

Alfredo
Madrid, Spain

Thank you for your quick answer. Based on both information you have attached, I think the shaded strip option is more consistent from the quality standpoint. Am I wrong? There is one issue I don't really understand. In the step 1, when I am developing the process with the standard Almen strip, I assume the scanning of the nozzle has to cover the whole length of the strip, am I wrong? Thanks again.

Jack Champaigne
Mishawaka, Indiana, USA

You must scan the entire strip to establish your peening intensity. Let's put some numbers into an example. Let's suppose you need a 10A intensity and the standard size A strip will not fit the tooth root, however you are able to fit strip into the tooth root that becomes only partially covered.

Obviously this strip won't accumulate enough dents to curve properly so you need to continue with an experiment. Expose a standard size A strip to the blast stream until you can verify that you have the parameters adjusted to achieve the 10A intensity. Next, you place an A strip in the blast stream that receives only partial coverage by using hard masking to shield the ends of the strip. This strip won't curve as much as the fully covered strip but it does curve enough to give you a "relative" reading. You must now perform your peening whilst achieving this new value or relative reading. In the event that the masked A strip does not curve very much you might decide to substitute a N strip with hard masking on ends. It will exhibit more curving because it is thinner. Whatever its curvature measures will become your target value for process control. In essence you have correlated the curvature of two different strips when exposed to the same blast stream thus allowing you to fit a strip into your limited root space.

Alfredo
Madrid, Spain

Thank you again. Your explanation is clear. We will do that.

Relationship Between Arc Height and Level of Compressive Stress?

Name and Company Withheld
India

Jack,
Does arc height always accurately indicate compressive residual stress levels at a specific depth in the Almen strip? If yes, then can we correlate that to residual compressive stress in our parts consistently? What are the variables that would make that a poor measure for process control?

Jack Champaigne
Mishawaka, Indiana, USA

The answer is a "qualified" yes. The Almen strip is curving as a result of the compressive stresses induced and if the key process parameters are unchanged then yes, the stress in your part will be consistent. However, media size and hardness may influence the (compressive) residual stress at a given intensity. It is therefore very important that you maintain the media quality and shot projection (velocity and flow rate).

Name and Company Withheld
India

But, what is the correlation between the Almen arc height and the level of residual stress. Is there a simple formula or algorithm for the relation between the two? Also, can we have a similar relationship between increase of hardness due to 'cold work' by peening and the residual stress level?

Jack Champaigne
Mishawaka, Indiana, USA

A simple chart is shown at our web site "Learning on Line":

<http://www.shotpeener.com/learning/multi%20depth%20vs%20intensity.pdf>

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Specifications: J443 Changes for Intensity Verification

Jack Champaigne Mishawaka, Indiana, USA

Saturation curves for new set-ups are (usually) understood and practiced appropriately. Intensity verification has often been performed without regard for requirement that the strip be presented to blast stream for the T1 saturation curve time (often using machine settings for full coverage or cycle time). This is especially troublesome when multiple holders are on a fixture. Many times (almost all?) the strips are presented at the latest saturation time and then hope to get all holder arc heights to fall within the tolerance band. This is often futile, and doesn't comply with the J443 directive to expose each strip at its own T1 time.

Revisions being discussed for J443 would allow a target arc height approach whereby the arc heights of each holder at the latest T1 time are then recorded for verification runs. These verification arc heights must then be within ± 0.015 inch of the target arc height and may (or may not) still fall within the tolerance band.

A modification of this approach would involve translating the tolerance band for each new target arc height thus preserving the intention of the original tolerance. This would be helpful for instance when the intensity is determined to be .0118 and is accepted for a tolerance band of .009-.012. If the target arc height then becomes, for example, $.0130 \pm 0.015$, then this holder position may be allowed to receive to high of an intensity if it was later verified to be .0145.

Pete Bailey Hamilton, Ohio

Intensity verification requires proof that the T1 arc height established at process setup is still within the required intensity range for subsequent parts. It requires running a new Almen strip at T1 time. For Almen fixtures with multiple Almen locations with different T1 times it should be allowed to select one of the T1 times to run all strips provided that for the different T1 time strips the positions of their T1 arc heights in the range are translated to the common T1 time on the saturation curve of each. Thus there will be a new "range" for each strip.

AircraftProps Ohio

We like the proposal for changing J443. Our studies in the past have concluded that it is practical to run to target arc heights for verification. Can I suggest that you meant to write ± 0.0015 (instead of ± 0.015) in your example?

On a side note we suggest dropping the word "Saturation" and moving forward with the term "Intensity Determination Curve." This is something we think helps clear any confusion with all the rookies who are tempted to think that intensity calculations tell you something about coverage. This new term also brings a very convenient easy to say and write acronym "IDC."

michael.a.sorenson2 Renton, Washington, USA

From Pete Bailey's reply, it is unclear to me on how a new "range" would be developed for each strip location of a

multiple strip intensity verification. I agree with the proposed change of running intensity verification to a selected target arc height, with an allowed variation of ± 0.0015 . The target arc height is selected from each strips' saturation curve, at the time for the strip that took the longest time (longest T1 time) to saturate.

Socrates

I see two basic problems with J443 verification. The first is that the derived peening intensity time, T1, rarely corresponds to an integral number of passes/strokes/rotations. Target verification arc height at an integral number can easily be calculated using the equation derived for the saturation curve (assuming computer-based analysis of data sets is being used). A convenient integral number of passes is substituted into the equation and out pops the corresponding point on the saturation curve. This technique is available as a simple add-on to any of the Solver programs. The second problem relates to multiple holders. Again, target verification arc heights can be generated by substituting into the corresponding equations for each holder. It seems logical to adopt a precise 'rule' governing choice of peening 'time'. Why not take the average of the several T1 times and round that up to the nearest integral number of passes? Conversely, it seems illogical to insist on a blanket ± 0.0015 " variation. Some users may be happy with a larger variation and some may require a smaller variation - especially for critical components. The significance of ± 0.0015 " also depends on the required intensity limits. ●

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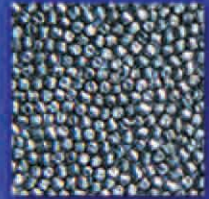
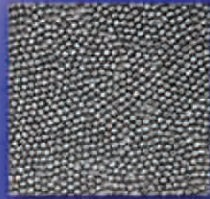
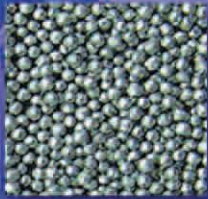
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Cautionary Tale: Shot Peening Compression Springs

Shot peening is a process used by the spring industry that brings significant benefits to spring performance. It is a process that is not always fully understood. Springmakers usually know that the process improves the fatigue resistance of the springs they make, but do not always fully understand the mechanism behind this improvement. The purpose of this cautionary tale is to explain some of the theory behind shot peening of compression springs, which will help springmakers and their customers understand the process and the benefits it brings.

Shot peening of compression springs is a process that involves bombarding the whole surface of the spring with very many particles of rounded shot. The impact from the shot is so numerous that at least 80 percent of the spring surface is covered with small dents. Often 90 or 100 percent coverage is specified, but IST (Institute of Spring Technology) recommends an absolute minimum of 80 percent to be effective. Each impact produces a small dent and around that dent there will be a layer of material that has been work hardened by the impact and a deeper layer that has a residual compressive stress. After shot peening, the benefits accrued are:

- a) The spring surface is harder (stronger).
- b) The original wire surface is smoother with the original wire drawing marks being largely obliterated.
- c) There will be a residual compressive stress on the inside surface of the compression spring where the applied stress in service will be a maximum.

All three of these benefits will contribute to the improvement in fatigue performance. But it is the last, the generation of a residual compressive stress that is the most important by far. It should be the strategy of spring manufacturers to maximize the residual stress. It should be noted that the residual compressive stress from shot peening offsets the resolved tensile component of the applied or operational stress.

Maximizing residual stress presents a problem to most springmakers because they have no machine for measuring this parameter in the springs theypeen. Manufacturers of engine

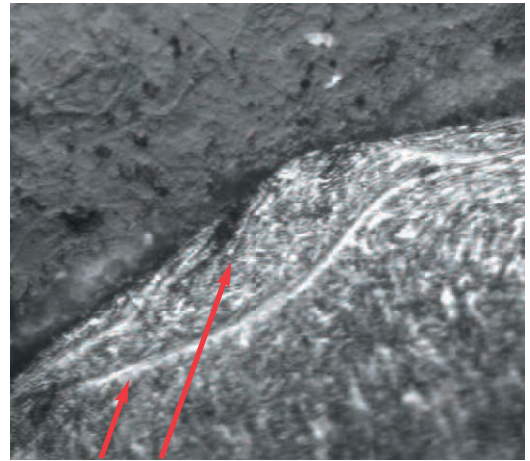


Figure 1: White lines and lap due to shot peening

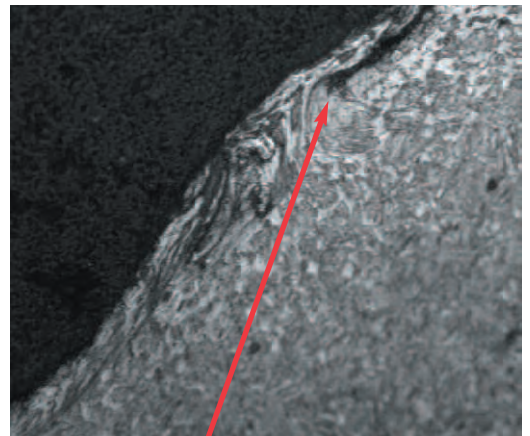


Figure 2: Cold working of the spring surface due to shot peening and lap

valve springs probably have the X-ray equipment necessary for measuring residual stress.

If you don't make these very high performance springs, you probably have the means to measure the intensity of your shot peening using Almen strips. If the shot you use is between 2 and 20 percent of the spring wire diameter, then the higher the Almen arc rise the better the peening will be. However, there is a possibility of over-peening using this clumsy approach to optimize your process. Over-peening is not a disaster, because spring performance will always be better with over-peening than

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with no peening at all. However some buyers of springs are concerned about over-peening. This is particularly true when a company's metallurgist finds laps and a white layer at the surface of shot peened spring, as shown in the two photographs. Figure 1 shows the white layer and a shallow lap, and figure 2 shows a lap.

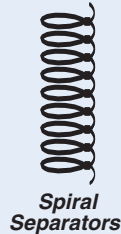
Would your customer be worried by the shot peening shown in the photographs? A recent inquiry to IST asked whether the white layer was friction martensite (adiabatic martensite)? Another asked if the damage shown in figure 2 was excessive.

The answer to these very reasonable questions was that the performance of the springs photographed above was satisfactory. So you should not be particularly worried by this appearance. The white layer is due to work hardening and is not friction martensite (which would be a disaster if present). Laps are inevitable with good shot peening and if the depth is less than 5 microns for cold-formed and 10 microns for hot-formed springs, they probably don't matter. Reassured? I hope so, but there are several other cautionary tales that the author could write on this subject if there is sufficient interest. ●



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, by phone at (011) 44 114 252 7984, fax (011) 44 114 2527997 or e-mail m.hayes@ist.org.uk.

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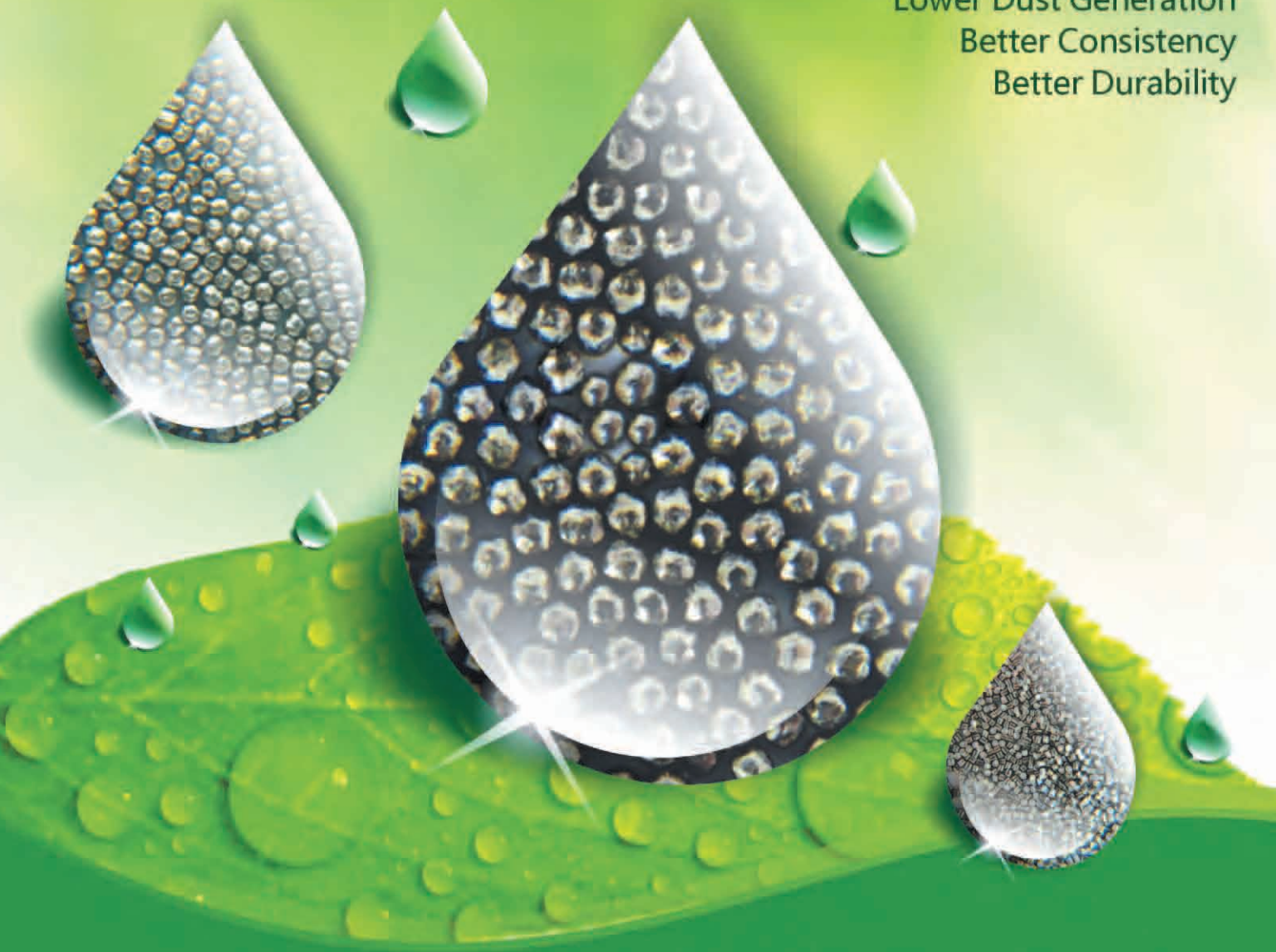
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Shot Peening Comes Along for the Ride



David Thomas has been the Technical Instructor/Engineering Training for Air New Zealand based in Christchurch, New Zealand for over 28 years. David teaches Basic Aircraft Engineering, Roto Peening, Shot Peening, Hardness Testing, Heat Treatment of Metals, Aircraft Structural Repairs, Metallic Materials, and Composite Construction and Materials.

In addition to his enthusiasm for sharing information, David enjoys keeping fit (he's the president of the Air New Zealand Gym Fitness Club). He has biked to work for 35+ years. "Biking to work is fun," says David. What wasn't fun was the intermittent problem of broken spokes. He would have to remove the wheel, tire and tube to gain access to the broken spoke. The spokes always failed at the same place—the radius of the bend close to the hub.

"I teach roto peening and shot peening so I knew that the failure was primarily due to the tension stresses in the bend area, leading to fatigue failure," said

David. He decided to get the spokes peened with glass bead. "I can report that since peening the spokes, no further failures have occurred. I take the same route every day so conditions have remained the same. Glass bead peening of the spokes provided a 100% improvement in reliability. I am on the lookout for further uses for the mechanical pre-stressing to add durability to other components," he added.

After we heard David's story, we researched the internet to see if anyone else has had his experience with broken spokes and his success with shot peening them. We found lots of marketing for "shot-peened rims" but no shot-peened spokes even though broken spokes are a common annoyance. Maybe David can start a new industry?

Not everyone can apply their work skills at home — a brain surgeon, for example — but David was able to "practice what he preaches" and engineered a solution that he appreciates every day. ●



Above: David Thomas enjoys riding his bike to his job as the Technical Instructor/Engineering Training for Air New Zealand. Left: One of Dave's bike spokes that was peened with glass beads.

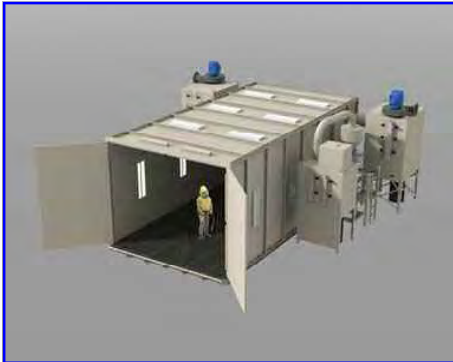
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SCOPE

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.

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IMPORTANT DATES

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Notification to Authors
August 1, 2010

Manuscript Drafts Due
January 1, 2011

Final Manuscripts Due
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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

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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 be 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.

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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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Shot Peener of the Year

Ing. Michele Bandini

Since 1992, The Shot Peener magazine has awarded The Shot Peener of the Year to individuals in our industry that have made significant contributions to the advancement of shot peening

The staff of *The Shot Peener* magazine is proud to award Michele Bandini, General Manager of Peen Service, the 2009 Shot Peener of the Year award. Michele was chosen because of his extra efforts to understand the technical aspects of peening and, in particular, how hard carburized gears can be most effectively treated. He has continued to work with universities and other organizations to establish fundamental relationships between peening practices and peening benefits. Michele has been an official trainer for Electronics Inc. for several years and always receives outstanding reviews for his presentation materials and delivery methods.

Michele is very accomplished at combining research with industry. After receiving his PhD on "Application Criteria of Shot Peening Process," he didn't end his relationship with the academic environment. In the first years of Michele's professional career, he created a network of research that involved the University of Bologna and industrial companies that were interested in exploring the application of the shot peening process.

In 1995, one of Michele's professors at the university asked him to share his experience with students. "I thought it a great idea and

was very honored. Students were interested right from the first lessons. The world of racing, in particular Formula 1, and the aerospace industry, are two very fascinating fields. This experience was so interesting and involving so as to urge me to undertake other collaborations," said Michele.

After a few years, Michele started similar projects with Prof. Guagliano of the Department of Mechanics of the "Politecnico di Milano", and Prof. Scardi and Prof. Fontanari of Trento University. "Today, after all these years, teaching has become an integral part of my job," he added. "The connection generated from this collaboration between University and Industry creates the fundamentals for the necessary competence for research and the results create a synergy that speeds the development of industrial applications. It is my personal opinion that sharing knowledge enriches everyone."

Michele has completed research in the following shot peening fields:

- Bending fatigue of carburised toothed gears
- Pitting fatigue of carburised gears
- Alternate bending fatigue of Al 6082 light alloy
- Alternate bending fatigue of Al 7075 light alloy
- Alternate bending fatigue of nitrided crankshafts
- Stress analysis and fatigue on springs

In addition, Michele is a member of the scientific committee of EUROPEAN TECHSPRING PROJECT. In his spare time, Michele enjoys his passion—playing golf. ●

Jack Champaigne, Editor of *The Shot Peener*, presented Michele Bandini with the 2009 Shot Peener of the Year award at the U.S. Shot Peening and Blast Cleaning workshop in Albuquerque, New Mexico.



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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.

Meaning, Measurement Philosophy and Verification of "Peening Intensity"

INTRODUCTION

"Peening intensity" is the depth-inducing capability of a shot stream. Shot peening causes plastic deformation of component surfaces - inducing compressive residual stress in the deformed surface layer. The depth of the plastically-deformed layer needs to be controlled. Shot streams have several properties that allow us to control the depth. Consider, by way of analogy, a stream of bullets fired by a machine gun. That stream has the ability to surface damage a target. This ability depends on the size, velocity and hardness of the bullets. Large, hard-nosed, bullets fired at high velocity will generate much deeper surface damage than will small, soft-nosed bullets fired at low velocity. A clear parallel can be drawn with the depth-inducing capability (peening intensity) of a shot stream.

"Peening intensity" is the parameter used to define and regulate the depth-inducing capability of a shot stream. When shot peening was in its infancy, J. O. Almen recognized the need for quantification of this capability. He conceived the brilliant idea of measuring the depth-inducing capability indirectly - by measuring the deflection induced in a set of steel strips peened for increasing periods. The term "Saturation Curve" was coined to describe the increase in peened strip deflection that occurs with increased peening time. A particular point on that curve, "Peening Intensity," is used to quantify a shot stream's depth-inducing capability. The greater the strip deflection at that point the greater is the shot stream's capability. The equipment and procedures needed to estimate peening intensity are detailed in standard specifications J442 and J443.

This article addresses three major problems associated with "peening intensity" - attempting to provide at least partial solutions. These problems concern the actual meaning, measurement philosophy and verification of peening intensity.

MEANING OF PEENING INTENSITY

"Peening intensity," part of the specialized vocabulary that is employed by the shot peen-

ing industry, is used to regulate the depth of the compressively-stressed layer that is induced when a shot stream bombards a component. As peening intensity is increased so does the depth of the compressively-stressed layer - other things being equal. This is illustrated schematically by fig.1. We know then that the depth of the compressed layer is directly related to the peening intensity of the shot stream. The units of peening intensity are the same as those for depth of induced compressed layer - micrometers (or thousandths of an inch).

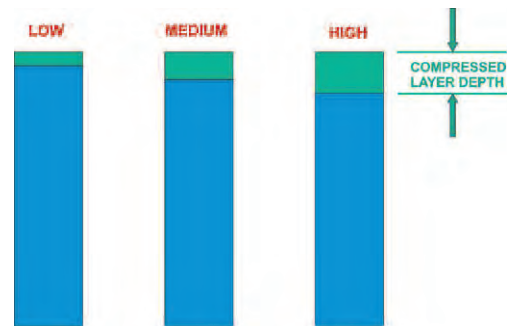


Fig.1 Influence of Peening Intensity on depth of compressed surface layer - as induced at "full coverage."

Of itself, a shot stream has only a potential peening intensity (depth inducing capability). This potential is realized, to a greater or lesser extent, when the shot stream impacts a targeted component. Consider again, by way of analogy, the stream of bullets fired by a machine gun. That stream has the potential to surface damage a target. A parallel can again be drawn with the potential depth-inducing capability (peening intensity) of a shot stream.

It is very important to appreciate that:

peening intensity varies with distance

This variation is illustrated schematically, for an air-blast stream, by fig.2. In essence, shot continues to be accelerated by the faster-moving air stream as it exits from the nozzle. Deceleration is, however, provided by the surrounding static air. The combined acceleration/deceleration produces a maximum shot

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velocity at some distance, M , (usually some 200-300mm for commercial peening equipment). With wheel-blast machines deceleration starts as soon as the shot leaves a blade.

If we compare peening at a distance M with that at some greater distance from the nozzle, x , two features of practical importance are apparent. The first is the obvious difference in peening intensity at the two positions. The second is that there is almost no variation of intensity with distance fairly close to M whereas there is an obvious range of intensity fairly close to x .

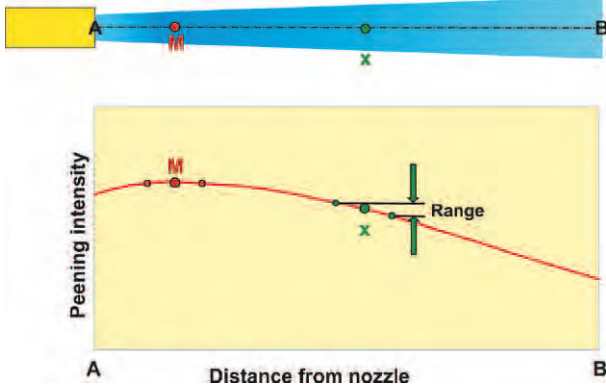


Fig.2 Variation of potential peening intensity with distance from nozzle.

There is a small variation in potential peening intensity across the section of a shot stream. This variation is, fortunately, not important - because the shot stream is moved tangential to the targeted component.

The impact effect of either bullets or a shot stream will depend on the target's properties – thickness, hardness, inclination to the stream, etc. We can extend the machine gun analogy to include measurement of impact effect. Sheets of body armor placed in the “line of fire” will be indented to an extent that depends on the surface damage potential of the bullet stream. In order to quantify this potential we would need a test with standardized sheets (in terms of material, hardness and thickness) placed at 90° to the stream and at a known distance from the gun's nozzle.

MEASUREMENT OF PEENING INTENSITY

There is currently no method available that can directly measure the potential peening intensity of a shot stream. We have to rely on measuring the impact effect of the shot stream on Almen strips placed at 90° to the shot stream. The distance from the nozzle to the strip has to match the distance from nozzle to workpiece. This equivalence of distance is important because of the distance variation of peening intensity – as illustrated in fig.2.

The procedures for peening intensity measurement are described in specification J443. This requires the measurement of the deflections induced in a set of Almen strips peened for different time periods. Deflection, as arc height, is plotted as a function of peening time (or the equivalent of time). If the set comprised an infinite number of strips then we would have a continuous “saturation curve” of data points. This is, of course, impracticable and real sets are limited in number, normally to between four and eight

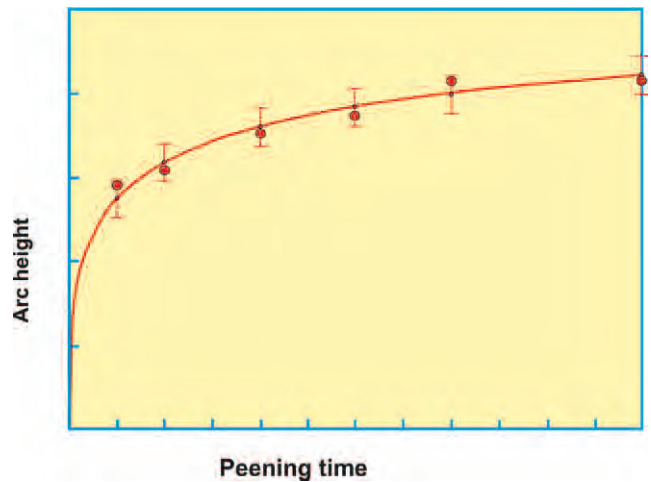


Fig.3 Continuous curve versus a six-point data set.

strips. Fig.3 shows the difference between a continuous curve and a six-point data set. It is important to bear in mind that:

Individual data points, of necessity, have variability

The variability of data points can be represented by error bars – as shown in fig.3. Each error bar indicates the upper and lower limits of “expected values.” If the bar limits correspond to one standard deviation on either side of the mean value then two-thirds of values would, on average, lie between the error bars. If on the other hand, they are set at two standard deviations, nineteen out of twenty would, on average, lie between the error bars. In fig.3 the bar limits have been set at two standard deviations. All six values lie between the error bar limits. Hawk-eyed readers may perceive that if the limits had been halved (to one standard deviation) then two of the six points (one in three), would then lie outside the bar limits.

Having obtained a set of data points the next problem is to derive a value for the peening intensity. There are two different methods detailed in J443. We can either (i) use a computer program to analyze the data or (ii) manually select the lowest data point that meets a specification requirement. Both methods are affected by the quality of the data in a given data set. Data that varies from a smooth curve by only small amounts can be categorized as “good” whereas large variations would constitute “bad” data. An important observation is that:

The variation of data from a smooth curve is a measure of the effectiveness of production control.

(1) Computer Analysis

The use of computer analysis to estimate peening intensity has several advantages. These include: **objectivity, uniqueness of intensity value and utilization of every data point.**

Computer analysis is based on (a) fitting the data set to a pre-selected equation and (b) determining the unique point on the corresponding curve that satisfies the criterion that:

Peening intensity is the arc height for which doubling the peening time gives a 10% increase.

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For a given fitted curve there is only one point that satisfies this criterion.

Four factors influence the accuracy of computer-analyzed data sets. These are: (i) the data range relative to the unique peening intensity point (ii) the "quality" of the data set (iii) choice of fitting equation and (iv) the number of points in the data set.

(i) Data Range

One important feature of data range is that: "The set must include at least one point having a shorter peening time than that derived for the peening intensity point." The importance of this feature can best be illustrated by an actual example. Consider Data Set No.1 from the eight examples provided by the SAE Sub-committee on Surface Enhancement. Imagine that, instead of the first point, another point had in fact been obtained – 7.1 at a time of 16. The two data sets are shown as Table 1.

Table 1

SAE Test Set No.1 together with Modified set.

SAE TEST SET No.1		MODIFIED SET	
Peening Time	Arc Height	Peening Time	Arc Height
4	6.0		
6	6.9	6	6.9
8	7.0	8	7.0
12	7.0	12	7.0
		16	7.1

Computer analysis, using the French-specified fitting equation, gives the curves shown in fig.4. The SAE Test Set points, 1 to 4, yield a peening intensity of 6.4 at a time of 4.75. For points 2 to 5, on the other hand, the indicated peening intensity is 5.9 at a time of 1.08.

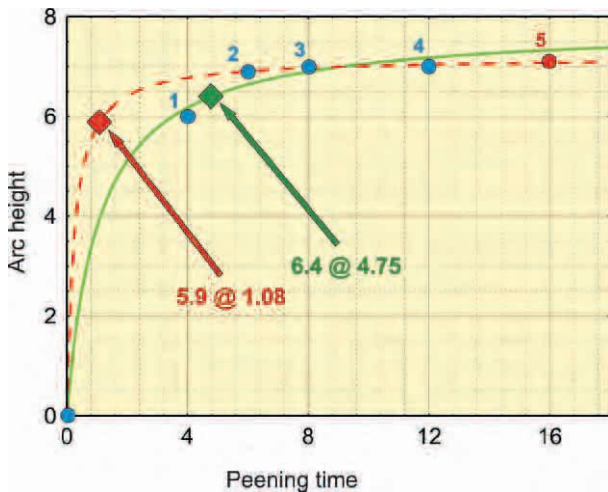


Fig.4 Effect of data set range on derived peening intensity point.

The modified data set has points that lie almost on a straight line. This renders accurate prediction of peening intensity virtually impossible.

A second feature of data range is that "The set must contain a point at a peening time at least twice that of the derived peening intensity time, **T**. This feature is necessary in order to be able to confirm that "Peening intensity is the arc height for which doubling the peening time gives a 10% increase" has been satisfied.

(ii) Quality of Data Set

Every data set will contain, to a greater or lesser extent, variation from a perfectly-smooth saturation curve. It is the amount of variation that defines the quality of the data set. Both random and systematic variations of measured arc heights are inevitable. The greater the number of points in a data set the easier it is to cope with these variations. If, however, the total variation is excessive then any form of data analysis becomes very difficult. The idiom "You cannot make a silk purse out of a sow's ear" becomes appropriate. A decision has to be made as to whether or not a data set is of acceptable quality. A subjective approach is to make a "commonsense" judgment - based on a visual inspection of plotted data points and the corresponding best-fitted curve. Objective approaches can be based on the closeness of fit of the data set i.e. the "sum of squares."

(iii) Choice of Fitting Equation

The choice of fitting equation (if choice is available) should be based on the number, range and quality of data points in any given set and whether or not a multi-fixture setup is involved. For the "Solver Suite" a rough guide would be (a) to use either EXP2P or 2PF programs for single-fixture situations with either four or five medium-to-good-quality points in each set (the wider the range of points the more likely it is that 2PF would be the better choice); (b) to use 2PF for multi-fixture situations with either four or five medium-to-good points in each set and (c) to use EXP3P for six or more points in each set.

(iv) Number of Points in the data set

It is not generally recognized that:

The precision of the derived peening intensity depends on the number of points in the data set

As an approximation, the error band for computer-derived peening intensity is equal to the error band for individual points divided by the number of points in the set. For example, if the individual data point error band width averages at 1.0 units for a set of five data points then the peening intensity error band width will be only 0.2 units (1.0/5). It follows that the larger the number points in a data set the more accurate will be the derived peening intensity.

(2) Lowest Data Point Selection

There are some situations that preclude the possibility of obtaining a complete saturation curve. These occur when a single pass (stroke or table rotation) gives an arc height close to the maximum given by repeated passes. Arc heights versus passes then appear as illustrated by fig.5. The peening intensity, **H**, is then defined as "the lowest data point for which arc height increases by no more than 10% when the peening exposure is doubled."

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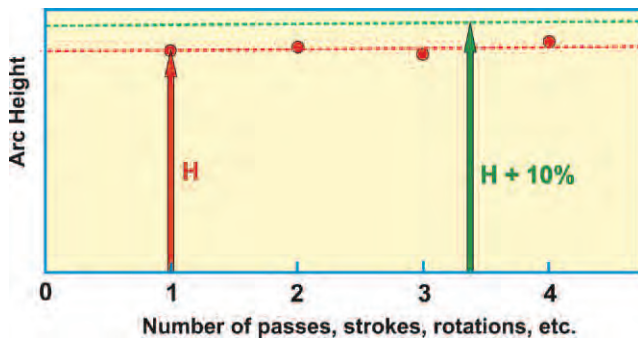


Fig. 5 Lowest data point for which arc height increases by no more than 10% when peening exposure is doubled.

The type of data point range in fig. 5 is similar to that of the “modified set” shown in fig. 4. It would therefore be inappropriate to attempt to apply a curve-fitting procedure. Peening intensities obtained using “lowest point selection” will be higher than those that would have been obtained if computer analysis of a saturation curve had been possible. The difference will be approximately 10%. Another significant factor is that the declared peening intensity value is now that of a single data point.

VERIFICATION

Peening is generally carried using an integral number of passes/strokes/table rotations. During setup one strip is peened for each of the several passes. The resulting data set is then used to produce a saturation curve. That curve is then analyzed to confirm that a satisfactory peening intensity has been achieved. This occurs at a derived time, **T**.

Considerable time and effort is expended in order to establish the machine settings that will yield peening intensities that fall within the specified tolerance band at the peening intensity time, **T**, – as is shown in fig. 6. Having established those settings it is necessary to verify, periodically, that those settings continue to provide consistent arc height responses. These responses are not, however, the same as peening intensities. Verification for situations involving a single Almen strip holder is relatively simple - when compared with that for setups that might involve several holders.

Single Holder Verification

Verification of intensity is described in the SAE Specification J443. Single strip exposure is allowed when a single holder is involved. This strip should, ideally, be exposed for the time, **T**, of the peening intensity point. It is pointed out that this is not feasible when integral numbers of passes/rotations are being used. Peening intensity times are, however, rarely integers, see fig. 6. J443 states that “the nearest practicable time to **T** should then be used. The arc heights obtained must repeat the value from the saturation curve +/-0.038mm...” The “value from the saturation curve” can be obtained automatically by employing a simple add-on to any Curve Solver program. This add-on substitutes the selected integral 'time' value into the fitted equation to yield the corresponding arc height. This arc height might properly be called the “target verification arc height.” It is not a peening intensity value. As with the derived peening intensity the precision of a saturation curve derived point is more precise than that of individual data points. A derived target verification arc height is shown in fig. 6. J443 requires that a single repeat exposure matches the target verification arc height to within

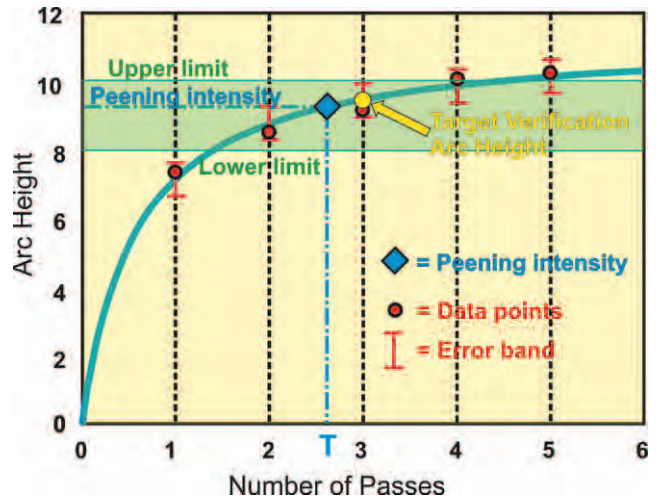


Fig. 6 Peening Intensity and Target Verification Arc Height derived from data points having integral “time” values.

+/- 0.0015” (+/-0.038mm). As an alternative, there is a simple procedure for adjusting the specification limits (upper and lower) to allow for the “time” difference between **T** and the selected integral verification “time.” This involves using the ratio of the target verification/peening intensity arc heights. Adjustment is achieved by simply multiplying the upper and lower limits by the calculated ratio. The following example serves to show how such adjustment could be applied in practice.

Example of Verification and Limit Adjustment for a Single-Holder Situation

The example, illustrated in fig. 7, is based on applying the Curve Solver 2PF program to SAE Data set No. 4. This yielded values of: a = 6.22 and b = 0.58 for the fitting equation $h = a \cdot t / (b + t)$ giving a peening intensity of 5.09 at a time of 2.62. Substituting 3 (for t) into the 2PF equation so that $h = 6.22 \cdot 3 / (3 + 0.58)$ gives the “target verification intensity” to be h = 5.21. Multiplying specified tolerance values (4 and 6) by 5.21/5.09 gives 4.1 and 6.1 as revised limits. Verification is achieved by peening for a “time” of 3 passes and requiring that the arc height lies between 4.1 and 6.1 (shown as green bars in fig. 7). For this particular example adjustment of the tolerance band is so small that it does not affect the verification outcome. Instances where the peening intensity point is much closer to a tolerance limit would, however, benefit from adjustment of that limit.

Multiple Holder Verification

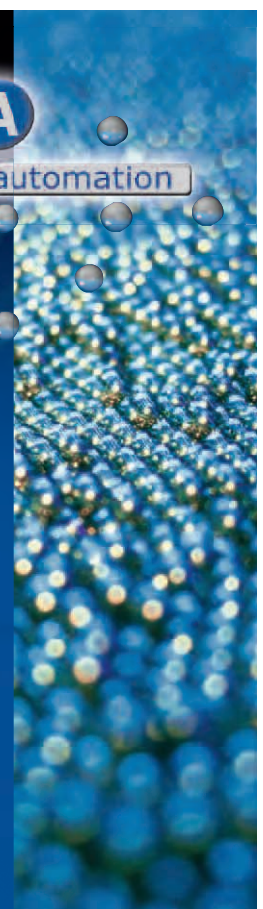
Using multiple holders on a fixture will produce multiple “saturation times,” **T**. J443 recommends that a single verification exposure time be used in these situations and that “The time selected should be not less than the shortest saturation time nor greater than the longest saturation time of the group of holders. The resulting arc height readings must then repeat the value achieved in the original saturation curve +/-0.038mm (+/- 0.0015”).”

An objective alternative (to the J443 recommendation) is to average the several peening intensity times and use the rounded-up integral value of that average. Verification can then be carried out by exposing one strip at each of the fixtures for that “rounded-up integral time.” The requirement for target verification arc height at each holder can be assessed in a similar way to that described previously for single-holder situations. A secondary problem is to be able to visualize the large amount of data that is involved.

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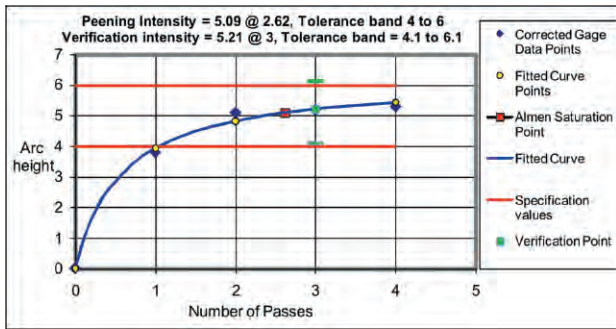


Fig.7 Verification procedure for SAE Data Set 4 using 2PF Solver program.

A simple computer program, based on Excel, has been devised that carries out all of the corresponding calculations automatically. The program also produces adjusted upper and lower tolerance limits. These could be used as an alternative to the “+/- 0.0015” requirement. The following example serves to show how the program could be applied in practice.

Example of Verification Procedure for a Multi-Holder Situation

For this example, it is assumed that the setup involves seven Almen strip fixtures. Saturation curves are produced for each fixture and analyzed using the Solver 2PF program. The corresponding derived peening intensities and times are shown in fig.8 and manipulated using the Excel-based “Verification Program.” The average of the seven peening intensity times, **T**, is **5.71** which rounds up to **6**. Lower and upper limits of **8** and **10** have also been assumed. Separate adjustments for **T = 6** are made to these limits (as described for the single-holder situation) for each fixture. The target verification arc height values (obtained by substituting **T = 6** into each saturation curve equation) are generated in the yellow column.

One strip at each of the seven fixtures is simultaneously peened for **T = 6**. The corresponding measured “verification arc heights” are entered in the blue column. Each value is required to lie between the adjusted lower and upper limits.

The differences between the verification and target arc heights are calculated and shown in the “Change” column. In order to simulate a “problem situation” the verification arc height values have been deliberately inflated - relative to the previous saturation curve arc height measurements at **T = 6**. The deliberate inflation shows up as a preponderance of “PLUS” values in the Change column. This preponderance would rarely occur randomly and is therefore indicative of a change in one or more of the control variables (such as air pressure or wheel speed). The final column shows, clearly, that all seven verification strips satisfy the adjusted tolerance band limits.

Two-strip Intensity Verification

One-strip verification cannot show that the shot stream’s intensity is being maintained. It simply confirms that the arc height response at a particular location is consistent. The situation is illustrated by fig.9 which contains the saturation curve of fig.7 together with two other curves. A target verification arc height at an integral peening time, **T_{INT}**, of 3 is indicated. Three saturation curves, having peening intensities shown at 1, 2 and 3, all pass through the same target verification arc height of 5.21. Two-strip testing will, obviously, differentiate between the three curves This is normally based on running the second strip

Fixture No.	Peening Intensity	T	Target Verification Height at Roundup	Verification Arc Height at Roundup	Change	Adj. Lower	Adj. Upper	Verification O.K.
1	8.2	6.00	8.2	8.8	0.6 PLUS	8.0	10.0	YES
2	8.7	6.80	8.5	8.6	0.11 PLUS	7.8	9.8	YES
3	9.0	6.80	8.8	8.9	0.11 PLUS	7.8	9.8	YES
4	9.2	5.00	9.5	8.7	-0.8 MINUS	8.3	10.3	YES
5	9.4	2.40	10.6	10.8	0.25 PLUS	9.0	11.2	YES
6	8.3	7.00	8.1	8.2	0.14 PLUS	7.8	9.7	YES
7	8.4	6.00	8.4	8.7	0.3 PLUS	8.0	10.0	YES

Average T = 5.71
Roundup = 6.00

Lower Specification Limit = 8
Upper Specification Limit = 10

Fig.8 Solver 2PF Verification Program applied to a seven-holder setup.

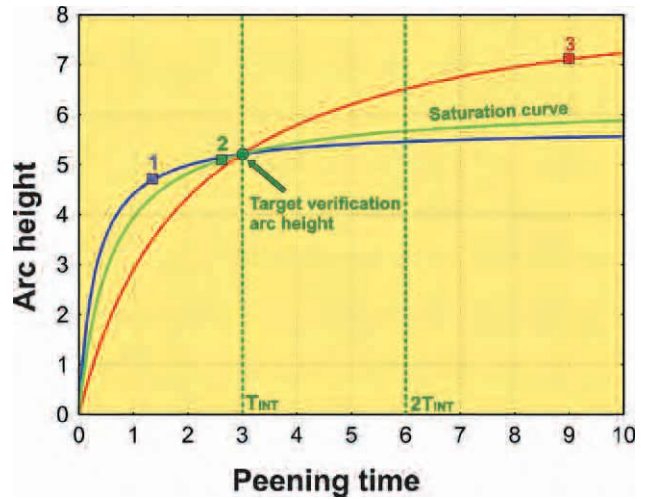


Fig.9 Alternatives to original saturation curve yielding identical target verification arc heights.

at **2T_{INT}** - twice **T_{INT}**. Two-strip tests therefore provide some degree of intensity verification.

It is worth noting that large changes of shot flow rate and shot velocity would be needed to change the peening intensities by the amounts shown in fig.9. Such large changes would not normally be encountered, but could arise if something drastic has happened to the control system.

SUMMARY

Peening intensity is the potential ability of a shot stream to induce a given depth of compressed, plastically-deformed, surface material. This potential ability is only realized when the component has been peened. It is important to appreciate that peening intensity varies with distance from the source of shot acceleration.

Quantification of peening intensity is achieved by measuring and analyzing the arc heights of a set of Almen strips - each peened for a different time. Plotted arc heights approximate to a continuous curve. Each data set can be objectively analyzed by using readily-available computer programs. The range (of peening times), quality of data points, number of data points and choice of fitting equation are important factors in achieving effective quantification.

Specification of the required peening intensity is normally based on a permitted range of arc heights at a derived, non-integral, peening time, **T**.

Verification with an integral number of passes involves target verification arc heights derived from the saturation curves. An objective Excel-based “Verification Program” is available that carries out all of the required calculations automatically. This is particularly useful if several holders are involved for a given fixture. Two-strip testing provides some degree of actual intensity verification. ●



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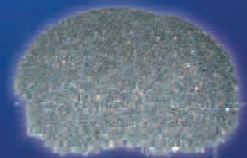
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Industry News

KLM Royal Dutch Airlines Celebrates 90th Anniversary Amstelveen, Netherlands. KLM was founded on 7 October 1919 for the Netherlands and its colonies, making it the oldest airline in the world still operating under its original name.

Celebration Events

The anniversary year, titled "KLM 90 Years of Inspiration," was launched on 1 January with a Celebration Flight. The passengers included KLM staff members, business relations, and 70 children from the Highflyers Foundation for chronically or terminally ill children. They boarded a Boeing 737-800 and a Boeing 777-200 for a flight over the Netherlands. Another memorable event was the official naming ceremony of the KLM tulip by CEO Peter Hartman and former model Frederique van der Wal. In July, 90 senior citizens who had never before flown in an aeroplane were treated to a flight by KLM.



Former Dutch model Frederique van der Wal and KLM CEO Peter Hartman presided at the official naming ceremony of the KLM tulip

Tour of Inspiration

This autumn, a special KLM lorry traveled to 30 cities throughout Europe. This 'Tour of Inspiration' will present all KLM's products and services. The lorry started its journey on 18 September in Billund, Denmark, and ended on 7 November in Munich, Germany. KLM has supported a good cause throughout this anniversary year, namely, Cycling Blue for Kenya. This is a joint project with the charity Cycling Out of Poverty. The aim is to train people in Kenya as cycle repairers, to set up cycle repair shops there and to finance bicycles for Kenyan children who live more than ten kilometres from their schools. KLM also held an Open House for KLM staff and their friends and family. Almost 40,000 people took the opportunity to visit parts of KLM they don't normally come into contact with during their work.

Demonstration Flight on Bio-Fuel during Anniversary Year

KLM Royal Dutch Airlines is the first airline in the world to make a demonstration flight on bio-kerosene with a select group of passengers. The first ever flight in Europe was on 23 November 2009, using Boeing 747 equipment. One of the aircraft engines ran on a fuel mixture made up of 50% sustainable bio-fuel and 50% traditional kerosene.

"This is an important step on the road to completely sustainable aviation," said KLM President and CEO Peter Hartman. "KLM has joined forces with its partners to vigorously stimulate the further development of alternative fuels. In so doing, we need to rely on the

input and support of all the relevant parties: the business community, government and society at large."

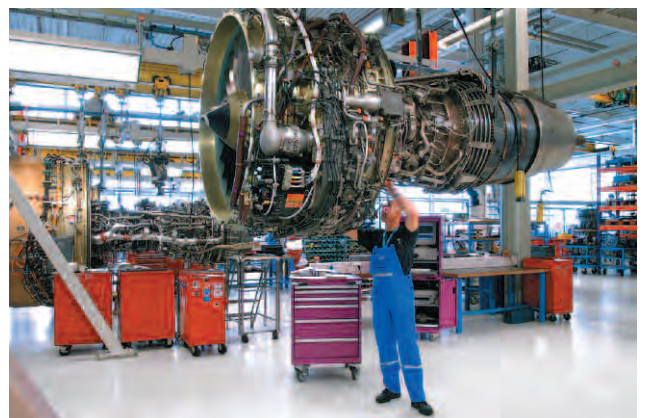
Along with Air France, KLM has for many years led the airline industry in the field of sustainable development. "In the decades ahead, the airline industry will be largely dependent on the availability of alternative fuels in its drive to lower CO2 emissions," said KLM Managing Director Jan Ernst de Groot.



KLM Royal Dutch Airlines operated its first passenger flight powered by sustainable biokerosene on 23 November 2009

The First Engineering and Maintenance Division

The founder of KLM, Albert Plesman, was a true visionary because he understood that an airline needed to own a technical staff to keep its aircraft "in the air." KLM's Engineering and Maintenance Division has been in operation for 88 years, making it the oldest aircraft maintenance, repair and overhaul department. "KLM Engineering and Maintenance division is the most experienced MRO shop in the industry and we are striving to be the most advanced shop in the world with the finest equipment, tools, materials and employees. Some of our technical achievements are the Ultra High Pressure Waterjet Stripping process, Electric Arc Spray process on GE engine parts and High Pressure High Velocity Oxygen Fuel process," said Marcel van Wonderen, Master Engineer on Process, Equipment and Materials Department at KLM.



KLM Engineering & Maintenance Engine Services (Amsterdam Airport Schiphol)

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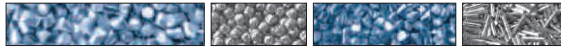
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2009 Aerospace Nadcap Supplier Survey Preliminary Results Revealed

Pittsburgh, Pennsylvania. The fourth biennial Global Aerospace Nadcap Supplier Survey was conducted by the Performance Review Institute (PRI) in 2009. The preliminary results were announced at the Nadcap meeting in Pittsburgh, Pennsylvania in October. Nadcap is part of PRI's Customer Solutions & Support (CS&S) which aims to identify and respond to customer need in all areas of business relating to quality. With over 500 responses, the data provided a clear view of the industry:

- Focus on Continual Improvement: 83% of respondents have seen a measured improvement in special process / product quality after Nadcap accreditation, compared to 25% in 2003.
- Globalization: Despite the challenges of global business, over 70% of respondents had no communication issues relating to language barriers in the Nadcap program.
- Communication: There were significantly less reported problems with the flowdown of requirements from Prime contractors - 33% of respondents said they never experienced a problem, compared with 9% in 2007.
- Economy: An increased percentage of respondents indicated that they would travel less to events such as Nadcap meetings due to the expense (17% up from 13% in 2007).

View the full preliminary report on the PRI website at www.pri-network.org. A complete analysis will be conducted by a team of industry representatives and presented at the Nadcap meeting in Rome, Italy in February 2010.

Coverage Predictor Program Available from Electronics Inc.

Mishawaka, Indiana. The Coverage Predictor Program will automatically calculate and graph the peening coverage for a set number of passes given an initial measured value. This program uses Microsoft Excel and is compatible with both Office 2003 and 2007 versions. Simply input your data (initial measured value of coverage) and the program will complete both the chart and the graph for predicted coverage. For example, suppose you achieve 40% coverage on the first pass. The Predictor Program indicates that with eight passes you should achieve 98.32% coverage. The program is available at no charge. To request Coverage_Calculation.xls, go to www.shotpeener.com/learning/program_request_form.php.

Dr. Kirk's article, titled "Shot Peening Coverage: Prediction and Control," is an excellent overview on coverage prediction and control. The article also reviews the computer-based coverage prediction programs developed by Dr. Kirk (single-measurement and multi-measurement coverage prediction programs). The paper is available for download at www.shotpeener.com/library/spc/2009014.htm.

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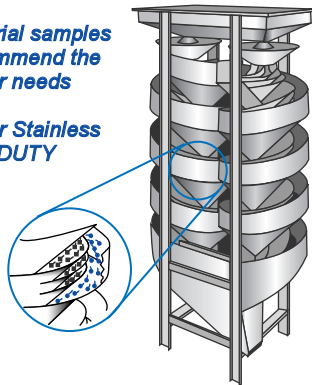
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Moving Ahead Nadcap Training, SAE Specs

I was pleased to be invited by Richard Sovich and Arshad Hafeez with Performance Review Institute (PRI) to the annual Nadcap Task Group meeting in Pittsburgh, Pennsylvania in October. A special meeting was held for Partners in Education to explore the expansion of training opportunities in non-traditional surface treatments as it relates to shot peening (Electronics Inc. Education Division is a Partner in Education with Nadcap). This should be a great help to aerospace primes and their contractors to facilitate consistent training requirements and curriculum materials. PRI presently has training programs in other interest areas and several aerospace primes were requesting assistance in specialized shot peening training.

I was also asked to give a presentation on shot peening that I called "Shot Peening State of the Union." It was well-attended and participants asked good questions. All in all, the Nadcap meeting suggests that the aerospace industry is continually placing more importance on quality shot peening processes.

Regarding SAE, the annual winter meeting of the Surface Enhancement Committee of AMEC will take place January 26-27 in Pacific Grove, California. The hot topics include AMS 2430 and AMS 2432 and, would you believe, the revised cancellation notice for AMS-S-13165, the old Mil spec? Several changes are proposed for AMS 2430 to help those transitioning from AMS-S-13165. The table of recommended peening intensities for various materials and thicknesses will be upgraded and included along with several other significant issues. For more information, or if you wish to join the sub-committee, contact me (574-256-5001) or Al Patterson at Lockheed Marietta (770-793-0239).

Another meeting topic will be for the aerospace primes that are deeply concerned that their parts might be peened in a job shop in a batch processing manner, such as barrel or tumble type equipment. We have some individuals that claim manual peening is

permitted in 13165 because it doesn't specifically say it's not allowed. AMS 2430 specifically states that manual peening shall not be used. A special notice for AMS 2430 was initiated that would require special permission to use such equipment. It's interesting to note that AMS-S-13165 specifically requires use of automatic equipment. As I read the paragraph from 13165, I conclude that manual peening is not allowed. I'll report. You decide.

Other issues on the table:

- Amount of material retained on the top sieve screen for glass bead
- Table of appropriate Intensity when not specified by customer
- Method of coverage determination for high-hardness parts
- Permission to substitute cut wire media for cast steel shot
- Permission to substitute shot size up or down one level
- Allow use of sub-size strips for intensity determination
- Procedure for in-machine media maintenance
- High hardness shot to be required for parts over 200 KSI
- Hardness requirement when using a scrap part for Almen fixture
- Media velocity measurements for process control
- Hardness testing of ceramic bead, methods and limits

You might be surprised at the length of the list of items under consideration, especially since AMS 2430 was first published in 1948, five years before MIL-S-13165 hit the streets. We'll keep trying. I won't retire until we get it right. ●

AMS 2430

3.2.1.2 The peening machine shall provide means of propelling, at a controlled rate, dry metallic shot by air pressure or centrifugal force, or propelling dry or wet glass beads or ceramic shot by air pressure, against the work, and means of uniformly moving the work through the shot or bead stream in either translation, rotation, or both as required. The nozzles and the work shall be held and moved mechanically.

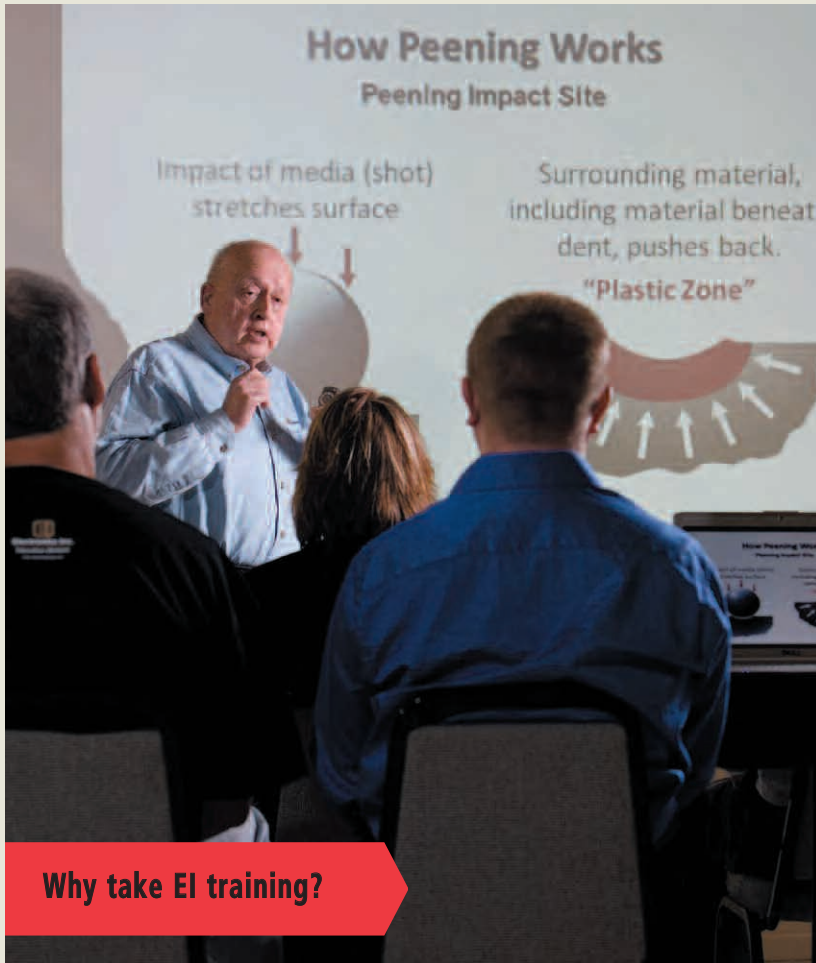
8.5 Manual peening is not directly addressed by this specification. Prior and future applications should be as agreed upon between processor and the cognizant engineering organization.

AMS-S-13165

3.2.1 Automatic shot peening: The machine used for shot peening shall provide means for propelling shot by air pressure or centrifugal force against the work, and mechanical means for moving the work through the shot stream or moving the shot stream through the work in either translation or rotation, or both, as required.

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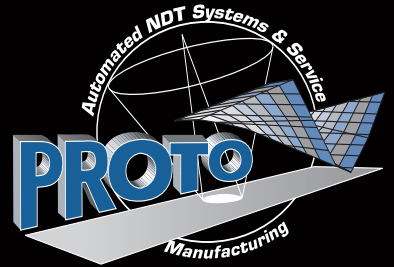
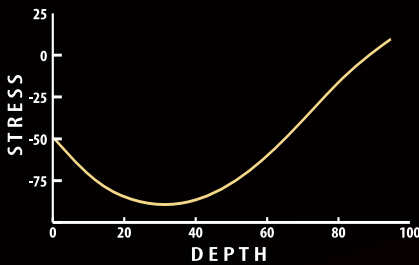


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