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The Shot Peener

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

Precision Shot Peening Offers New Solutions

Glass Bead Polishes Apple

2012 Shot Peener of the Year

New Remanufacturing Technology

Principles of Almen Strip Selection

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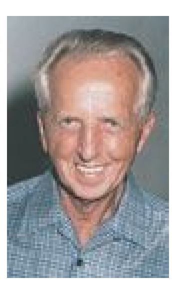

THE SHOT PEENER

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

Change Is Inevitable, Growth Is an Option

We all like change—when someone else does the changing. We get the latest and greatest version of whatever product (read Toys for Boys). We don't want last year's car model or previous software release. But how are we at updating or redesigning our own products and services to adapt to changes that are coming at us faster and faster?

JACK CHAMPAIGNE

Consider how robotics evolved in the automotive industry and eventually worked their way into shot peening cabinets. PLC became so inexpensive that relay logic joined the dinosaurs of technology. Those changes happened slowly compared to the way that the internet and digital communication tools are swiftly changing the way we work. For example, the http-based MTConnect protocol will deliver real-time information on every machine on your shop floor through an iPad or smartphone. Your electronic technicians are more likely to carry an iPad or smartphone than a Volt-Ohmmeter. Calibrations via USB connections have pushed aside small mechanical tools (we used to call them trim-pots because they would trim or adjust a parameter).

Speaking of smartphones, this small, ubiquitous device is changing manufacturing at every level. Electronics Inc.'s customer service staff now asks a customer to snap a photo of the machine with his phone, or maybe even make a short video clip, so we can quickly identify the product and the problem.

Where technology has simplified tracking and analysis issues for customer service, it's presenting challenges—and opportunities—in product design. Products are now expected to store calibration information, record operating time and temperature, and even alert us to when it's time for preventative maintenance or re-calibration.

The industrial world is suffering from chronic high unemployment rates and slow economic growth. But, at the same time, manufacturers desperately need qualified employees. Our local technical college offers two-year programs like the Manufacturing Production and Operations (MPRO) curriculum. The MPRO prepares students to be skilled equipment operators in today's high-tech manufacturing environments. This is a very good thing.

It's challenging, but we're also embracing change and growth at Electronics Inc. because we know that the opportunities are immense. We hope the new year holds positive changes and growth for you and that *The Shot Peener* magazine plays a role in keeping you informed.

Best wishes for a happy, healthy and prosperous new year.

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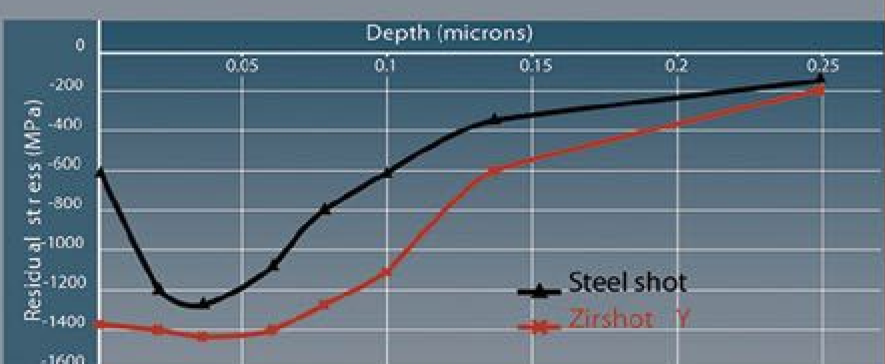

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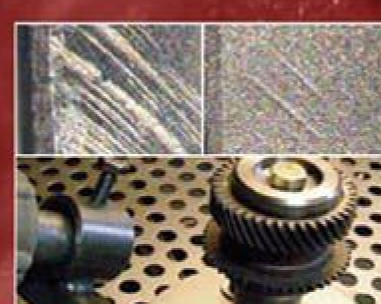

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Ruthann Browning | Automation Specialist | Comco Inc.

An Alternative Solution to Shot Peening Challenges

THE COMCO JOURNEY INTO SHOT PEENING

Comco Inc., a California-based company, has 40 years of experience providing micro-abrasive blasting technology to medical, microelectronics, precision machining and aerospace industries. Micro-abrasive blasting projects a blast of clean, dry air mixed with pure micron-size abrasive media, delivered through a nozzle selected to suit the application: cleaning, cutting, surface texturing, abrading and yes, even peening — but at a highly detailed and micron-size level. All micro-abrasive blasting is performed in a vacuum-activated chamber to remove the dust created by the process. For most applications, micro blasting is a manual process performed by an operator within a clean workstation. To eliminate operator variance, automated systems were designed, which ultimately led to the development of Comco's automated lathe system.

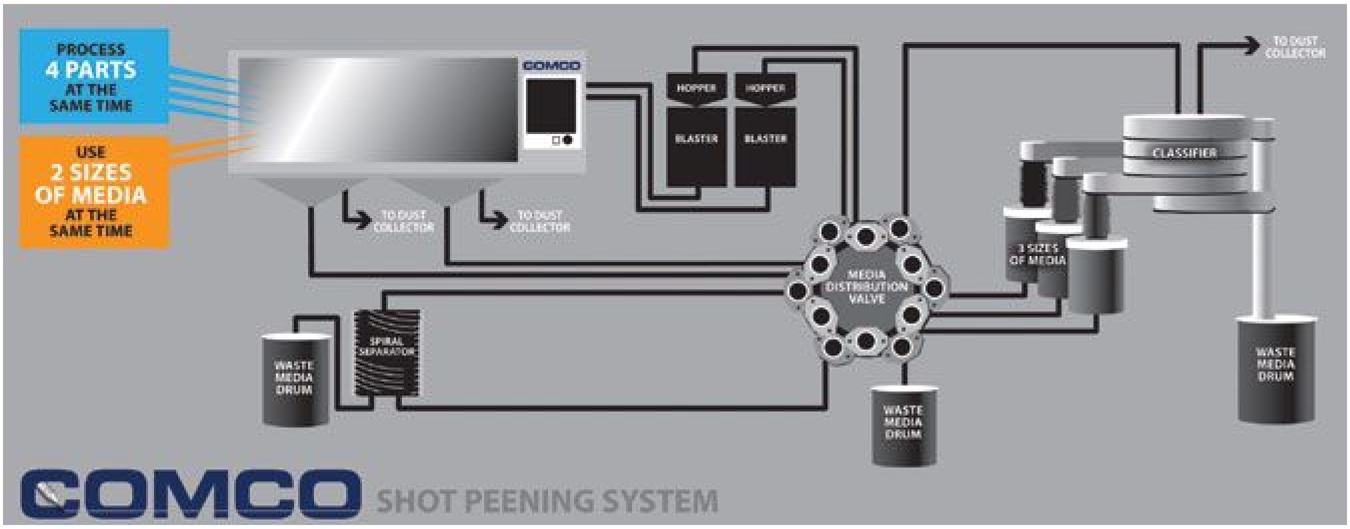
The Comco Advanced Lathe provides precision micro-abrasive blasting for demanding high-production environments. It is highly automated and much larger than the largest Comco manual or semi-automated micro-abrasive blasting system, but the actual blasting is at the micron level (the abrasive is usually 10 -150 microns). It also performs a type of shot peening using glass bead media, but the size of the media is typically 150 micron or finer.

The shot peening media is reclaimed for reuse, rather than disposed of after a single use like the micro-abrasive blasting media. However, the theory behind both micro blasting and shot peening is basically the same: accurately mixing air and media and then shooting it at a target part.

Comco was approached by a customer who used the Advanced Lathe for micro-abrasive blasting and was interested in applying the same system motion and automation platform to an existing piece of peening equipment.

Technically, and economically, it was far better to develop a new system to meet the customer's needs and thus began the concept of "precision shot peening." Aside from basic automation, there were quite a few areas that would benefit from improvement in the overall process as well. The customer's peening requirements for the various parts were very similar—they included a number of "tubes," power shafts of small turbine engines and linear actuators for large turbine engine thrust reversers that required S-110 peening on the OD and S-70 peening on the ID. Both the ID and OD were regional blasts. The IDs of these parts are around 40" long and as small as 0.75".

Although the project initially grew from this specific customer application, a larger scale format for precision shot peening would address a need in the industry for a new process that was optimized for selective peening of high-value and intricate parts, or to peen areas that are hard to reach and/or would normally require substantial masking.



Peening four shafts ID/OD simultaneously for aerospace

The Comco Advanced Lathe system was the "skeleton" for the body and brain of the new system, because of its well-accepted existing automation platform. But the end system had to reach far beyond the scope of micro blasting. It had to not only create a focused peening method for any surface or part, but it now had to use larger media and not only peen with it, but reclaim it and properly sort and size the shot peening media for reuse. The reclamation system also needed to eliminate any particles that were not spherical.

Like micro-abrasive blasting, precision shot peening equipment required metering exact quantities of media and air, ensuring the tightest process control. A proprietary "blaster" was developed that could positively introduce the shot peening media into the air stream. A side benefit of more accurate media delivery was the ability to hold tighter intensity tolerances than standard shot peening systems. Once the design was set and tested for all the basic changes needed, the process was optimized for highly selective peening and for parts requiring repeated peening with different media or using the same media, but requiring different blast pressures — or both simultaneously.

Peening five bone screws simultaneously with small lathe

COMPARING STANDARD SHOT PEENING TO PRECISION SHOT PEENING

Precision shot peening brings an entirely new concept to this field and is related to its larger cousin, traditional shot peening. There is a very substantial difference between traditional shot peening, however, and precision shot peening. Traditional peening takes a "shotgun" or blanket blast approach to peening parts. It blasts spherical media (glass bead, ceramic bead, stainless steel, cast steel, or cut wire) at the surfaces to be peened using nozzles that range in internal diameter (ID) from 0.250" to 0.625". This nozzle is fixed and the part is held up to 18" away from it. Media hits the part in a wide spray.

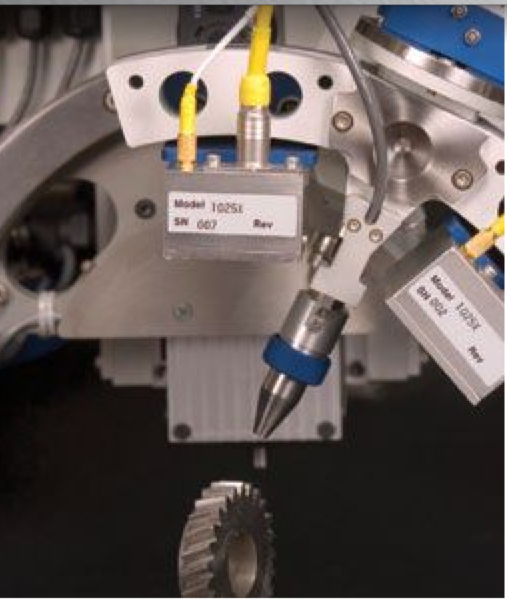
Precision shot peening takes a "machine gun approach" to peening. Typical nozzle sizes are 0.060" to 0.185" ID. This smaller nozzle size creates a very collimated media stream and ensures that 100% of the media hits the part. The nozzles move above the part and focus the peening blast directly to the area to be strengthened.

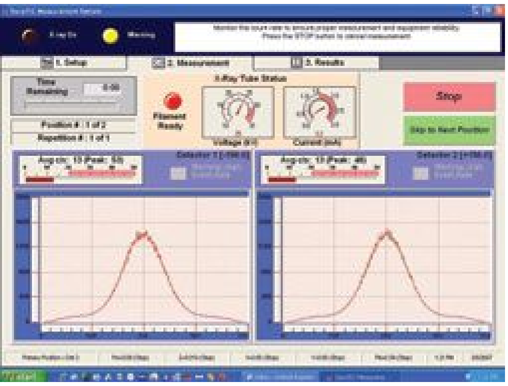
Traditional shot peening machines are very large and require huge air compressors. The machines are also typically armored inside with half-inch metal plates because the media that isn't hitting the part is constantly bombarding the interior machine walls, wearing them away. Coupled with automation, a precision shot peening system needs no protective steel plating, requires very little or no masking of parts, and needs a far less costly air compressor.

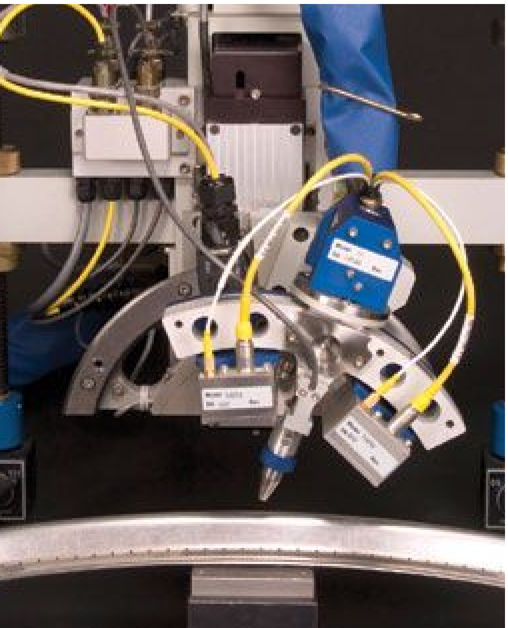
Most traditional shot peening machines process one part at a time or use a semi-automated indexing turntable or other fixture that will index the parts sequentially. But these all still peen each part individually, with an operator loading and unloading as needed. The smaller nozzle size and tighter control allow a precision shot peening system to process multiple parts at the same time, such as peening both ID and OD of four tubular components simultaneously.

Small ID/OD are peened simultaneously

Materials Testing Services







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Precision shot peening equipment requires metering exact quantities of media and air, ensuring the tightest process control. It does this by positively introducing media into the air stream, as opposed to methods used by traditional shot peening equipment: gravity, syphon or magnetic-feed systems. A side benefit of more accurate abrasive delivery is the ability to hold tighter intensity tolerances.

Also, standard shot-peening machines can peen with either ferrous or non-ferrous material, but they can't handle both. Precision shot peening machines can deliver all media.

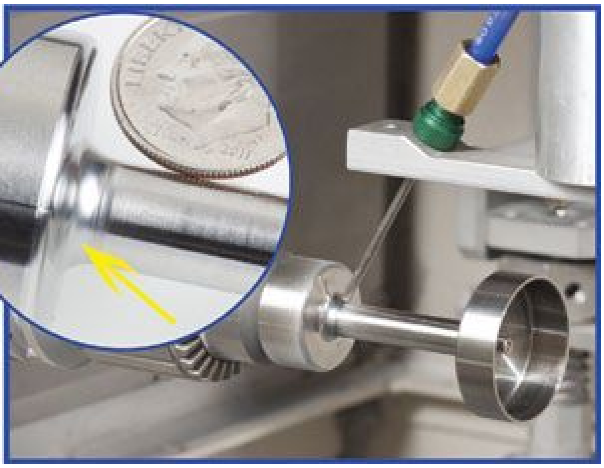
MARKETS THAT BENEFIT FROM PRECISION SHOT PEENING

Precision Shot Peening offers a wide variety of options to accommodate a large variety of parts. Quick change tooling allows for fast changeover for large or small parts or production runs.

The first customer's system was equipped with two blasters for the delivery of two different medias simultaneously. Both the ID and OD of their parts could be peened in one step. Further, the machine had four spindles to process four parts at the same time by splitting the media stream. One blaster was loaded with S-110 shot and the other with S-70 shot. A slightly tilted OD blast nozzle peened the outside surfaces while catching the reflected shot in a rubber damper flap. This arrangement allowed for delineation between peened and unpeened of around 0.030" without masking the part. The IDs were simultaneously being peened with S-70 by the second blaster. A very long "lance" ID blasting nozzle directed the media radially within the part. The nozzle had a guide so that it was partially supported by the opposite wall of the part being blasted.

For shot peening job shops, who do all types of peening, precision shot peening systems are a great addition because

Comco's automated precision shot peening equipment



Radius peening without masking

they offer flexibility, a fast changeover in many applications and save time, labor and energy. High volume OEMs, like gear manufacturers, can benefit by the flexibility, elimination of masking and the ability to do multiple parts processing. The flexible and modular design allows the system to be placed in smaller, tighter spaces. The dust collector, spiral separator and classifier can be placed up to 50' away from the lathe chamber for flexibility in tight spaces.

In general, like all shot peening machines, precision shot peening is used on gear parts, cams and cam shafts, coil springs, connecting rods, crankshafts, gearwheels, leaf and suspension springs, rock drills, and turbine blades. However, some applications truly benefit from the focused peening delivered by these new systems more than others, particularly when the designs are intricate, when more than one peening process is needed or whenever substantial masking is normally required.

CONCLUSION

The Comco Shot Peening System is not meant to replace the traditional shot peening process. In many cases, traditional peening is still the preferred approach. However, this system can be a welcome addition for shot peening job shops, OEMs and even in-house peening departments. Precise delivery and highly accurate nozzles that move and focus on the part, rather than being fixed, help meet untapped potential in the peening industry. What precision shot peening brings to the market is an alternative that may in some applications be a replacement, but in many operations, will be a welcome complement to standard peening.

Ruthann Browning
Comco Inc.
2151 N. Lincoln Blvd.
Burbank, California 91504
818-941-5500 • info@comcoinc.com • www.comcoinc.com

Hali Diep Named 2012 Shot Peener of the Year

THE SHOT PEENER magazine has named Hali Diep as the 2012 Shot Peener of the Year. Mr. Diep is an Associate Technical Fellow in Surface Enhancement/Shot Peening at Boeing Research and Technology. He has been with Boeing over 28 years and his fields of expertise include Surface Enhancement, Shot Peening, Laser Peening, Failure Analysis, Metal Processing, and Aluminum Heat Treating. He is the custodian of BAC specifications and Boeing's design manual.

In addition to his work at Boeing, Mr. Diep generously shares his expertise with other organizations. He serves as Vice-Chairman of the Aerospace Material Engineering Committee - Surface Enhancement (AMEC-SE) and is a member of the International Scientific Committee for Shot Peening. Mr. Diep worked on the local organizing committee for the Eleventh International Conference on Shot Peening in 2011 and contributed two research papers to the conference.

"The Shot Peener magazine gave Mr. Diep the 2012 Shot Peener of the Year award because of his outstanding work on surface enhancement and shot peening for The Boeing Company and his contribution to AMEC-SE. He has a thorough understanding of shot peening processes and can translate his knowledge into specifications and procedures. He helped the AMEC committee write a new specification for manual peening that involved operator training and certification, and his contribution was invaluable to us," said Jack Champaigne, Editor of *The Shot Peener* magazine and AMEC-SE Chairman.

Since 1992, *The Shot Peener* magazine has given The Shot Peener of the Year award to individuals in the shot peening industry that have made significant contributions to the advancement of shot peening. For a list of previous award recipients, visit www.theshotpeenermagazine.com/shot-peener-of-the-year.

About the Boeing Technical Fellowship Program

The Boeing Technical Fellowship, founded in 1989, allows select engineers and scientists to continue their professional growth by applying their expertise to the many technical challenges in the aerospace industry, thereby adding value to the company. Boeing employees become Associate Technical Fellows, Technical Fellows and Senior Technical Fellows via a selection process based on their technical knowledge and expertise and their impact across the company.

Hali Diep received The Shot Peener of the Year award at the 2012 Shot Peening and Blast Cleaning Workshop

"Thank you for the award, it is a great honor for me. I am looking forward to continuing our work with the members of SAE, AMEC-SE and International Scientific Committee for Shot Peening to fine tune and further improve this great technology."

—Hali Diep
Associate Technical Fellow in Surface Enhancement/
Shot Peening at Boeing Research and Technology

Three Dreamliners in the Boeing's final assembly plant at Everett, Washington. Mr. Diep works for Boeing Puget Sound and provides technical support to the Everett facility.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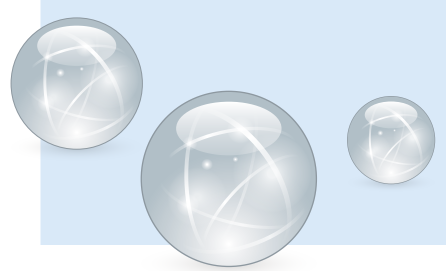


Glass Bead Polishes Apple

and other informational bites on this popular media

Many Apple store fronts are covered in stainless steel. The satin finish on the metal panels was achieved with glass bead blasting.

APPLE'S FIRST FLAGSHIP store in New York's SOHO district brings to mind an Apple notebook: a spare, elegant metal housing for its ground-breaking technology. It was one of several Apple storefronts covered in the GB-60™ stainless steel surface. "GB" stands for glass bead and "60" is the bead size used to finish the metal panels. The process was developed by Zahner, a manufacturer of high quality metal and glass products used in art and architecture.

If glass bead adds polish to the world's most expensive apples, what else should we know about it?

Start with the Finish

Zahner also calls their GB-60™ panels, "satin stainless steel" panels. Glass bead is well-known for its ability to give a soft sheen to a metal surface without etching surfaces, changing tolerances or imparting ferrous pollutants.

The satin finish has another architectural benefit: it is glare free. The Apple storefronts have a beautiful metallic finish, but they don't blind pedestrians when the sun hits the panels.

Glare can be problematic indoors, too. A manufacturer of stainless steel laparoscopic surgical tools asked Clemco Industries to improve their finishing operation. Part of Clemco's solution was a blasting cabinet that used glass bead. Glass bead blasting quickly and easily removed the burrs and oxidation with an unexpected bonus. "To the manufacturer's delight, their customers raved about the matte-finish—it served to eliminate the reflective glare on the instrument from the operating room's high-intensity lighting, an obstacle they had lived with for years. Removing the shine from the surface of the instruments increased surgical productivity," said Herb Tobben, Clemco's Sample Processing Manager.

Glass Bead is Clean

Glass beads are inert, meaning that they are chemically inactive and will not leave

ferrous or other undesirable residue on the work piece surface. Glass bead's "cleanliness" makes it popular in medical applications where a contaminate-free surface is crucial.

Glass Bead is Green

Potter's Industries, a leading producer of glass beads for metal finishing, produces their beads from clean recycled glass cullet. Cullet is crushed and decontaminated glass that is ready to be remelted. Glass recycling uses less energy and releases less carbon dioxide than the manufacturing of new glass, it produces local jobs, and it keeps tons of glass waste out of landfills. Potters Industries says that they recycle over one billion pounds of glass each year.

Safe Glass Bead Manufacturing is Clearly Better

"Not all glass beads are created equal," said Chris Davies with Potters Industries. "Unlike the clean recycled cullet used to make glass bead in North America, some manufacturers in other countries may still use the soda and lime glass manufacturing process that contains hazardous materials like arsenic and lead." That's why in August 2007 and January 2008, the SAE (AMS 2431/6C) and the Air Force (MIL PRF 9954C), added heavy metal limits to their Glass Bead for Cleaning and Peening Specifications—100 ppm for Lead and 75 ppm for Arsenic. These specs also reduce the health risks associated with landfill disposals and breathing in spent glass bead dust.

In addition to using cullet, Potters takes additional steps to exceed spec requirements. "Every truckload of cullet that enters our property is tested for arsenic and lead. If the test results are even marginal, the entire truckload is sent back," said Robert Mulhall, Vice President and General Manager at Potters Industries.

Glass Bead is Aggressive and Gentle

Glass bead has the ability to clean without damaging the surface. "When used properly, glass bead can remove paint from a light bulb without breaking it," said Mr. Mulhall. These attributes make glass bead one of the most versatile cleaning and deburring air blasting media on the market—glass bead removes burrs from delicate medical needles and cleans swimming pools without harming the glaze on the pools' tiles.

Glass Bead Is Not a Peening Lightweight

Shot peening layman assume that steel shot peens better than glass bead because shot is more dense. In real practice, however, conventional shot peening machines are capable of delivering glass bead at much higher velocities than steel shot, so there is a trade-off. The fact is, up to the higher velocity levels where glass beads begin to fracture, glass and steel peen with equal results.

Any Questions?

Would you like to know what size glass bead to use for your peening process? Need to know what size bead to use in a cleaning process? Do you want to achieve a particular finish? Chris Davies, the "Answerman" at Potters Industries, can answer your questions and help resolve metal finishing problems. Call him at Potter's Research and Development Center in Conshohocken, Pennsylvania at (610)651-4660. The following is a typical question for Mr. Davies.

Question

My experience is that a few MROs in China use glass beads that are the required size range, but not necessarily from a approved vendor list, for their peening jobs. The problem is that some of these glass beads are very brittle and break down easily. Their machines have built-in classifiers, but I was wondering if there are detrimental effects from using these beads.

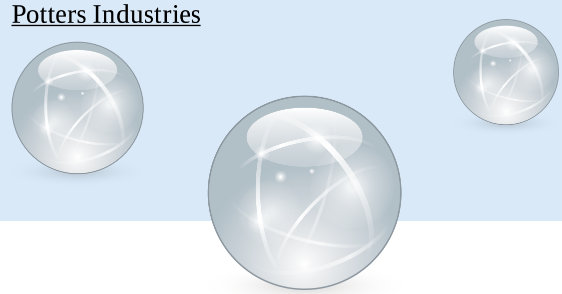
Adam Chai
Director of Corporate Affairs
Pakpal Surface Technology

Answer

You are right to be concerned. When quality round glass beads bombard the metal's surface to create a layer of compressive strength, the part isn't damaged or chipped as it could be if angular particles were used. Inferior glass beads may look round, but air bubbles or inclusions compromise their compressive strength and ability to maintain a spherical shape. When these beads are used in peening, they break down quickly and the roundness of the particle is compromised. Then the metal surface can be damaged and stress risers created—creating the opposite effect of what you can obtain with proper glass bead peening.

The glass bead you mentioned can't be meeting AMS 2431/6 because the spec covers all quality control parameters for glass bead including chemical stability, hardness, and angular composition, not just size and roundness.

Chris Davies
Research and Technical Service Specialist (the Answerman)
Potters Industries



New Manufacturing Project to Save Millions in Reclaimed Parts

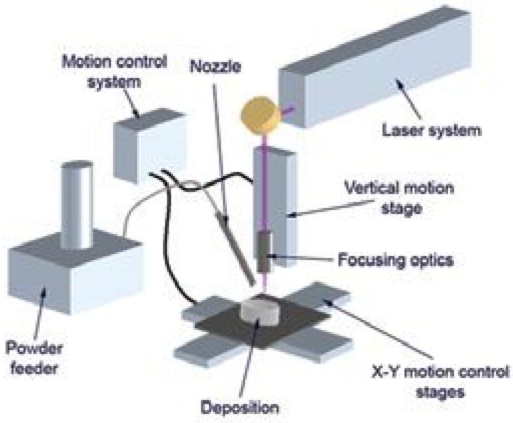
RECLAIM, a cutting-edge project at the £40 million Manufacturing Technology Centre (MTC) in Coventry, United Kingdom, has the potential to save UK industry millions of pounds by re-manufacturing high-value components, such as turbine blades, that would otherwise have gone for scrap.

The RECLAIM project uses laser cladding, automated inspection and high-speed machining in a single, fully integrated re-manufacturing cell. The technology enables manufacturers to repair and recycle worn high-value components to a consistently high quality. The innovation is expected to make a major contribution to the efficiency of the aerospace, defence and power industries in particular.

As well as repairing damaged and worn parts, the system can be used to manufacture complex new metal parts, upgrade obsolete parts and reconfigure standard parts for low-volume applications.

The work is being carried out under the auspices of the Technology Strategy Board, a body established by the UK government to drive innovation. The Board has contributed more than half of the million pound-plus research and development costs. As well as the Manufacturing Technology Centre, the industrial partners in the RECLAIM project include software developer Delcam plc, metrology equipment developer Renishaw plc, laser processing equipment manufacturer Electrox, CNC integration experts Precision Engineering Technologies Ltd., and turbocharger manufacturer Cummins Turbo Technologies. In addition, Leicester DeMontfort University played a key role in the development of the laser cladding system.

MTC operations director Leigh Carnes said every industrial sector has a requirement for re-manufacturing and it contributes around £5 billion to the UK economy, not to mention its impact on environmental sustainability and the avoidance of waste. However, conventional re-manufacturing processes are slow and labour intensive. “The new process enables cost-effective, rapid and reliable re-manufacturing of high-value engineering parts. It can be fitted onto existing machine tools, and allows seamless transition between cladding, machining and inspection operations. There is no doubt that this technology— a world first for the MTC and its partners—will transform the whole process of re-manufacturing,” said Mr. Carnes.



WHAT IS LASER CLADDING?

Laser cladding is a method of depositing material by which a powdered or wire feedstock material is melted and consolidated by use of a laser in order to coat part of a substrate or fabricate a near-net shape part (additive manufacturing technology).

It is used to improve mechanical properties or increase corrosion resistance, repair worn-out parts, and fabricate metal matrix composites.

Image and information courtesy of Wikipedia

Remanufacturing occurs to some extent in every industrial sector. It is most prevalent in sectors with high-value goods or high technological content, for example aerospace, defence and power turbines. It is one of the most efficient ways of recycling worn parts as remanufacturing consumes only a fraction of the energy required to manufacture of new parts. Remanufacturing contributes around £5 billion to UK economy and makes a substantial impact on quality-of-life and environmental sustainability by employing over 50,000 people and recovering around 270,000 tonnes of high value materials with an equivalent carbon saving of 800,000 tonnes of CO_2.

Unfortunately, remanufacturing of engineering components entails a series of operations requiring parts to be transferred around manufacturing facilities and often to subcontractors. Each process is labour intensive and dependant upon the skill of the operator. The new RECLAIM cell enables cost-effective, rapid and reliable remanufacturing of high-value engineering parts. Current commercial competition in this field is limited to specialised laser cladding cells which can cost in excess of £1m to buy. These cells are not only expensive, but they are only able to undertake cladding operations and inspection and machining has to be processed on other equipment.

The beauty of the RECLAIM system is that it can be fitted onto an existing machine tool. When not in use, the laser cladding and inspection heads are housed in the tool changer and are ready to be brought into action, this enabling seamless transition from between cladding, machining and inspection operations.

The RECLAIM cell was assembled in the Manufacturing Technology Centre and tested on a range of industrial components including automotive turbochargers produced by the Cummins Turbo Technologies Ltd., who are the key end-user partner in the project.

In addition to filing patents to protect innovative features of the cell, a company is being established to commercialise the RECLAIM system. To support the commercialisation of the results of the RECLAIM project, the Manufacturing Technology Centre is undertaking further work to refine the design of the system.

ABOUT THE MTC

The Manufacturing Technology Centre (MTC) opened in 2011 following a £40 million cash injection from the West and East Midlands development agencies. It is a partnership between some of the UK's major global manufacturers and three forward-thinking universities: Birmingham, Nottingham and Loughborough as well as TWI Ltd, the operating division of The Welding Institute.

The MTC aims to provide a competitive environment to bridge the gap between university-based research and the development of innovative manufacturing solutions, in line with the UK government's manufacturing strategy. The MTC has been established to prove innovative manufacturing processes and technologies in an agile environment in partnership with industry, academia and other institutions. The MTC provides a high quality environment for the development and demonstration of new technologies on an industrial scale, providing a unique opportunity for manufacturers to develop new and innovative processes and technologies in a low-risk environment.

The areas of MTC's technology focus are appropriate to both large and small companies and are applicable across industry sectors. Founder industrial members of the MTC are Rolls-Royce, Aero Engine Controls and Airbus UK and members now include manufacturing companies from multiple sectors.

Further information, visit the MTC website at www.the-mtc.org or telephone Eleanor Thomas at 02476 701683.

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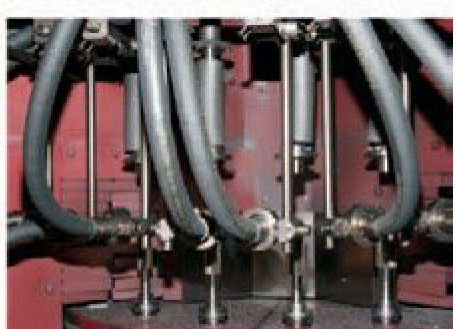

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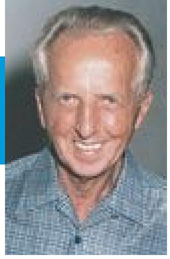


ACADEMIC STUDY

Prof. Dr. David Kirk | Coventry University, U.K.

Principles of Almen Strip Selection

INTRODUCTION

The guiding principles for Almen strip selection are thickness, variability and shape. Thickness selection, **N**, **A** or **C** is a normally matter for users rather than shot peeners.

Thickness is the most important factor, because it is directly connected to the users' peening intensity requirement. As a general rule, the greater the required peening intensity the thicker will be the most appropriate Almen strip.

Every Almen strip has some variability – in spite of having to meet specification requirements. The tighter the specification the greater will be the cost incurred in satisfying those requirements. It follows that critical components (for which shot peening generates a large added value) will justify the use of higher quality Almen strips than non-critical components.

Almen strips are normally rectangular and are available in both standard size and as 'mini-strips'. Circular 'strips' are also available for the continuous generation of peening intensity curves.

This article aims to show why proper selection of thickness, variability and shape of Almen strips are important factors in satisfactory shot peening. There are a very large number of 'in-house' specifications for Almen strips as well as the familiar SAE specifications J442 and J443. To avoid unnecessary complexity, the article is based on the SAE specifications.

THICKNESS

SAE J442 specifies three standard thicknesses of Almen strips – designated as **N**, **A** and **C**. The corresponding allowed thickness ranges are 0.76/0.81, 1.27/1.32 and 2.36/2.41 mm respectively. All three have the same major dimensional ranges of 75.6/76.6 mm length and 18.85/19.05 mm width. The approximate relationships between peening intensity arc heights are that:

C strip reading x 3.5 = **A** strip reading and

A strip reading x 3.0 = **N** strip reading.

SAE J443 recommends that **A** strips be used for peening intensities from 0.10 mm to 0.60 mm. For intensities below 0.10 mm **N** strips are recommended and **C** strips for intensities above 0.60 mm. These recommendations are simplistic because (a) they do not allow for overlapping specified intensity ranges, (b) no lower or upper limits for **N** strips are recommended and (c) no upper limit for **C** strips is recommended. The overall situation is summarized in fig.1. This indicates (1) that the sensitivity of **N** strips is 3 times that of **A** strips, (2) that the sensitivity of **A** strips is 3.5 times that of **C** strips (3) recommended limits for the use of **A** strips and (4) a lower limit zone from 0.10mm downwards where there is an increasing lack of measurement precision.

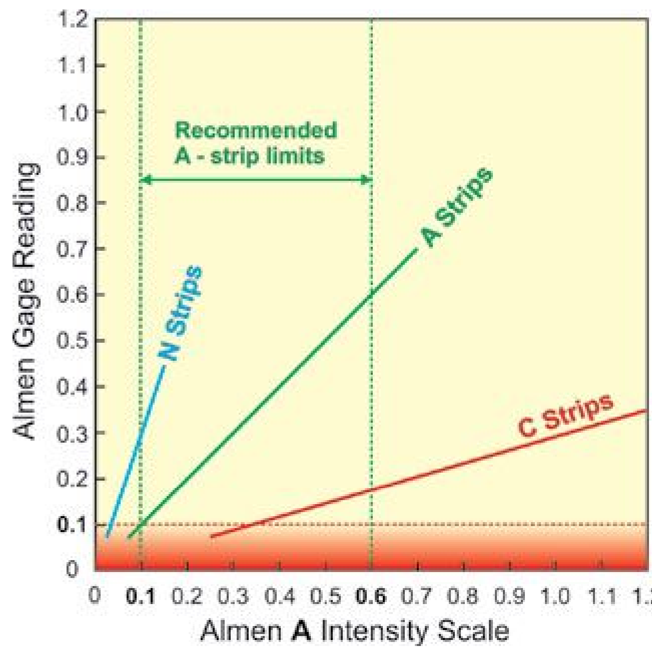


Fig.1 Almen strip sensitivities and recommended ranges of application.

The majority of shot peening is carried out with Almen **A** strips being involved. They are, however, the only ones that have specified upper and lower peening intensity limits. These recommended limits are illustrated in fig.1 and in fig.2.

An important question is:

Why are upper and lower limits recommended for Almen A strips?

Specified Lower Limit when using Almen A strips

A recommended lower limit of 0.10mm is specified because it has been judged

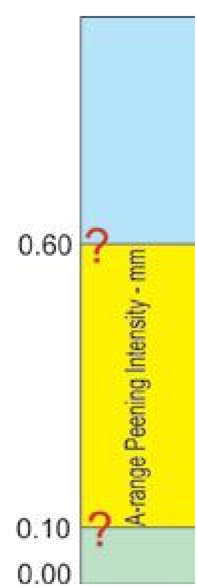
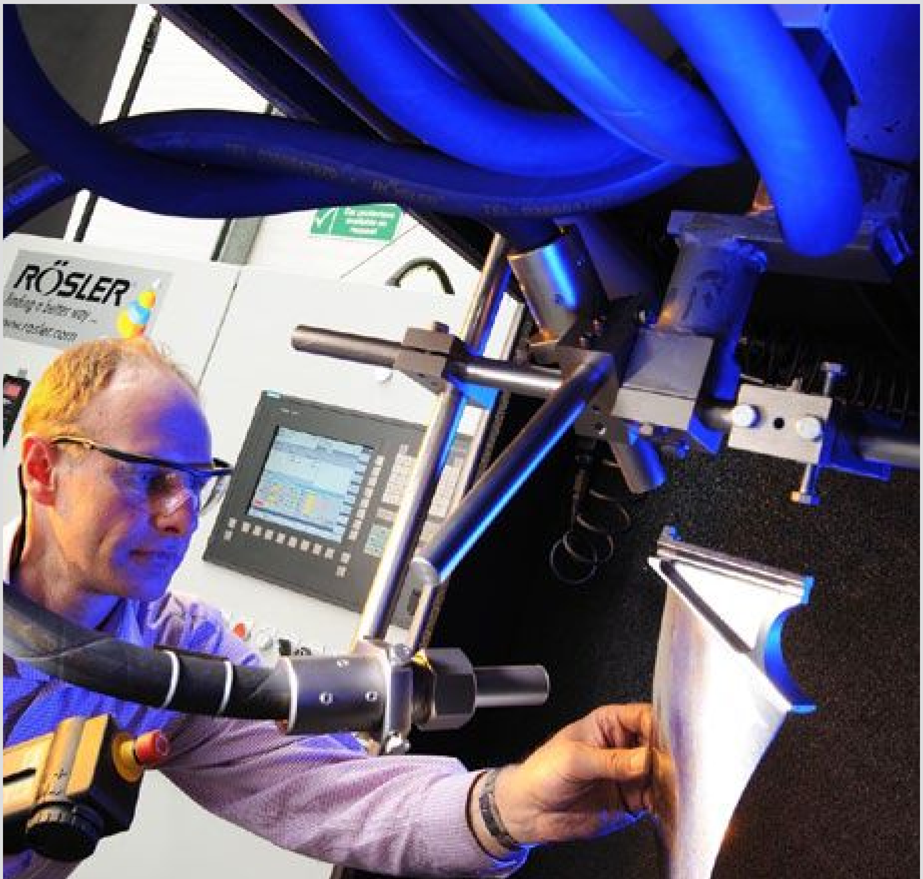


*Fig.2 Recommended Peening Intensity Limits for Almen **A** Strips.*



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that any value below 0.10mm cannot be measured with sufficient precision. This is logical if we compare measurements less than 0.10mm with the specified Almen gage precision of 0.001mm. For example, a reading measurement of 0.050mm reflects an actual strip deflection anywhere between 0.0495mm and 0.0505mm – for which the instrument would have to round to 0.050mm. With this example there is a ± 1% inaccuracy range. If, for the same shot stream, the thinner **N** strip was being used then the gage would now read 0.150mm rather than 0.050mm (deflections being some three times greater). Instead of a ± 1% inaccuracy range we now have ± ⅓% accuracy.

Specified Upper Limit when using Almen A strips

The specified recommended upper limit when using **A** strips is an intensity of 0.60mm. This compares with the strips' thickness of 1.295mm. Hence the ratio of allowed peening intensity to strip thickness is approximately 0.5. This limiting ratio can, and probably should, be applied to the other thicknesses of Almen strips.

Shot peening produces a surface layer of plastically-deformed, compressively-stressed, material. The depth of this layer increases with peening intensity. Increased peening intensity is generated by using a combination of increased shot diameter and shot velocity. If the depth of the deformed layer becomes too high a proportion of the strip thickness then strip deflection decreases. For the extreme example of using flat-ended needles it has been found that strip deflection becomes negative! The theoretical reasons for this behavior have been given in previous articles in this series.

Fig.3 is a schematic representation of observed findings for **A** strips. There is a linear response in terms of measured peening intensity against 'true' peening intensity from A to B. This is the 'working range' for **A** strips. Beyond point B there is an increasingly-rapid deviation from linearity.

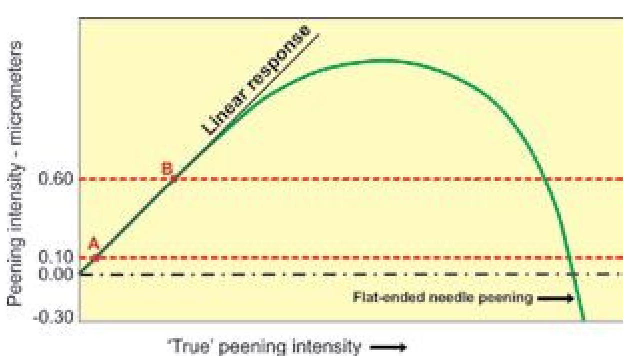

Fig.3 Schematic representation of measured peening intensity varying with 'true' peening intensity.

Upper and Lower Limits when using Almen N strips

It was pointed out previously that the recommended peening intensity upper limit for **A** strips was half of the strip thickness. Applying this ratio to **N** strips shows that the upper limit should be 0.39mm (0.785 x 0.5). The lower limit should be the same as for **A** strips – 0.10mm - applying the same argument about acceptable precision of measurement.

Upper and Lower Limits when using Almen C strips

Applying the 'half of strip thickness' concept to **C** strips would indicate that an upper limit of 1.20mm would be reasonable. The lower limit could be the same as for **N** and **A** strips – 0.10mm - applying the same argument about acceptable precision of measurement.

Specified Peening Intensity Ranges

Users specify an allowed range for their required peening intensity as well as specifying the thickness of strip that has to be used (**N**, **A** or **C**). Any specified range may, however, span over a 'recommended limit' e.g. 0.50 to 0.70mm using **A** strips. This is not a problem because it is recognized that measurements do not suddenly become invalid if they exceed a recommended limit. To allow a limited amount of overlapping is perfectly logical. Fig.1 includes a representation of reasonable amounts of overlapping - based on the previous arguments (gage precision and depth of deformed layer induced by peening). Users could use the mid-point of their required intensity range as a guide. For example the mid-point of a 0.50 to 0.70mm range when using **A** strips is 0.60. This does not exceed the recommended limit of 0.60mm, so that **A** strips should be specified. On the other hand a range of 0.08 to 1.10mm using **A** strips would have a mid-point of 0.95mm so that **N** strip usage should therefore be specified (with the three-fold correction) to become 0.24 to 0.33mm using **N** strips.

Effect of Strip Thickness on Gage Reading

Conventional Almen gage dials have a measuring tip that necessarily contacts the unpeened strip surface with some degree of force. This force is reported to vary between from about 50g up to 300g - depending on the manufacturer and the indicator mechanism involved. The force is a combination of an internal spring's force and the elastic resistance of any protective bellows surrounding the indicator's stem. Almen strips held on an Almen gage are therefore subjected to a tip force and must therefore bend – even if they have not been peened. Deflection of Almen strips under load has been the subject of detailed analysis in a previous article (TSP Fall 2009). The appropriate text-book, universally-recognized, bending of beams equation is that:

$$\mathbf{h = F*s^3/(48*E*I)} \qquad (1)$$

where **h** = maximum deflection at the center of the beam, **F** = force applied to the center of the beam, **s** = distance between support points, **E** = Elastic modulus of the beam and **I** = Second moment of area of the beam (equal to $\mathbf{w*t^3/12}$ for

rectangular beams when **w** is width and **t** is the thickness).

Equation (1) assumes that the beam is supported on rollers whereas an Almen gage uses four support balls. Some additional transverse deflection is therefore generated. This additional deflection is one-eighth of the longitudinal deflection (assuming no anisotropy of elastic modulus). Equation (2) incorporates the additional transverse deflection.

$$\mathbf{h = 1.125*F*s^3/(48*E*I)} \qquad (2)$$

The units for the force, **F**, are Newtons (N). A mass of 1kg will normally exert a force of 9.81 Newtons (the 9.81 being the numerical value of the standard acceleration due to gravity). Hence a mass of 1g will exert a force of 9.81 x 10^{-3}N. Substituting E = 200kNmm^{-2}, s = 31.75mm and w = 18.95mm into equation (2) gives the following relationship between strip deflection, **h** (in mm), tip force, **T** (in grams) and strip thickness, **t** (in mm):

$$\mathbf{h}\text{(in mm)} = \mathbf{T*9.81*10^{-3}*31.75^3*12/(48*200*10^3*18.95*t^3} \qquad (3)$$

which simplifies to:

$$\mathbf{h}\text{(in mm)} = \mathbf{T*2.071*10^{-5}/t^3} \qquad (4)$$

Equation (4) can be used to plot the variation of strip deflection caused by a range of gage tip forces. This has been done in fig.4 where the average thicknesses of Almen strips have been substituted.

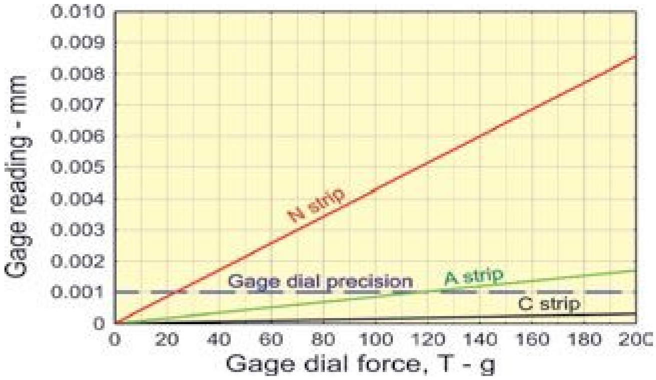

Fig.4 Effect of gage dial force on Almen strip deflection.

For a specified gage dial precision of 0.001mm (1 micrometer), strip deflection would not be detectable for **C** strips, barely detectable for **A** strips but would be expected for **N** strips. As an example consider a perfectly-flat unpeened Almen **N** strip being placed on an Almen gage whose dial exerted a tip force equivalent to 140g. Fig.4 predicts that the gage would read a positive deflection of 0.006mm. Turning the perfectly-flat strip over on the gage would again indicate a positive deflection of 0.006mm. This is equivalent to a "double phantom pre-bow"!

A simple experiment was carried out to examine the unsupported claim that "dial gages exert a force of up to 300g". Force meters are generally very sophisticated (and therefore expensive) but at least one simple but effective instrument is available for less than \$20. Fig.5 illustrates that instrument together with a typical analogue dial gage. 'UHU White Tack' was used to secure the push/pull spring balance to a heavy block whilst the dial gage was clamped.

Fig.5. Push/pull spring balance testing resistance force of an analogue dial gage tip.

Fig.6 shows the same push/pull spring balance being applied to a standard EI Almen gage – placed in a horizontal position for ease of measurement. The arrangement allows the 'force meter' to be 'inched' towards the dial gage (or should that read "micrometered"!).

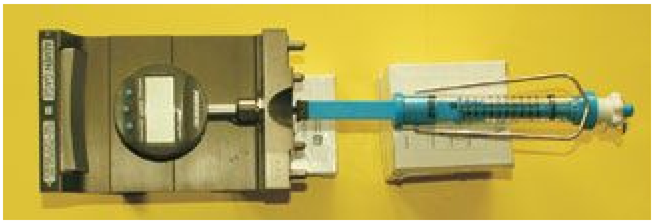

Fig.6. Push/pull spring balance testing resistance force of an EI TSP-3 Almen gage.

Table 1 shows some of the values obtained for dial gage tip resistance when testing the author's two analogue dials and two digital dial gages. General conclusions can be made – in spite of having tested only four dial gages. These are that (1) analogue gages impart a substantially larger tip resistance than do digital gages and (2) the tip resistance increases with

Table 1. Dial gage tip resistance forces

Gage	Initial Resistance - g	Resistance at 1.00 mm deflection - g
Analogue gage A	110	135
Analogue gage B (jeweled)	75	105
Digital gage - EI TSP-3	40	50
Digital gage - EI TSP-3 Aero	40	50

gage deflection. For the digital gages the tip force exerted on an Almen **N** strip would be predicted to induce a deflection of between 0.001 and 0.002mm (according to fig.4). For the analogue gages the corresponding deflection would be in the range 0.003 to 0.006mm.

VARIABILITY OF ALMEN STRIPS

Almen strip variability is only one of the several factors that shot peeners have to cope with. Others include shot size, shot shape, velocity, stand-off distance, impact angle, component shape and hardness. Collectively these variables mean that saturation curves must have a corresponding variability. This is illustrated by the 'reference example' shown in fig.7. For this example it is assumed that the mean peening intensity for a number of saturation curves, produced using a given quality of Almen strips and fixed peening conditions, was found to be 10 (imperial units).

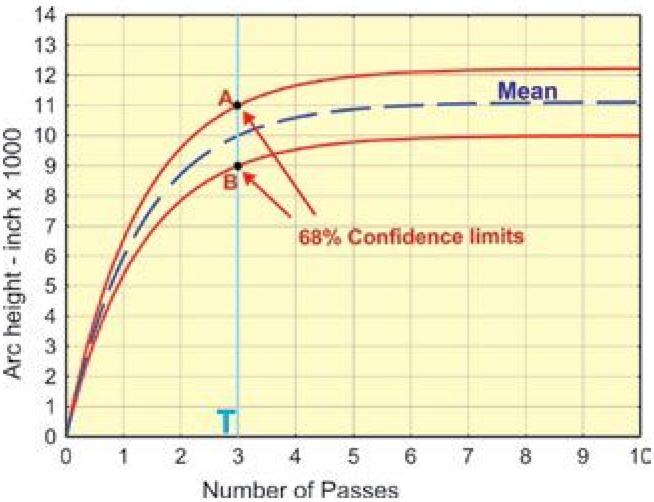

Fig.7. Example of saturation curve range with a peening intensity standard deviation of 1.

The curves in fig.7 have a scatter that has a standard deviation of 1 (imperial unit). This implies that more than two-thirds of the peening intensities would lie within ±1 (imperial unit) of a target figure of 10. If the customer requirement was 8 – 12 most shot peeners would (presumably) be quite happy with that sort of predictable range.

Almen strip variability has two quantifiable components: mean and standard deviation. Thickness, elastic modulus, pre-bow, steel composition and steel hardness are readily-identifiable factors that contribute to strip variability. A clear distinction must, however, be made between batch variability and inter-batch variability.

Thickness Variability

SAE J442 specifies allowed ranges of thicknesses for **N**, **A** and **C** strips. The process variables associated with strip manufacture are unlikely to vary substantially within the short time scale needed to produce one batch of strips. This is particularly true for strip thickness. Cold-rolling of steel strip is a well-established precision operation. Strip manufacturers can, therefore, obtain individual batches of strip material that have virtually constant thickness. There will, however, be differences between the mean thicknesses of any given batch. The difference is illustrated by fig.8. This assumes that the mean thickness of two acceptable N strip batches, A and B, is 0.77 and 0.80mm respectively and that both have the small thickness standard deviation of 0.001mm.

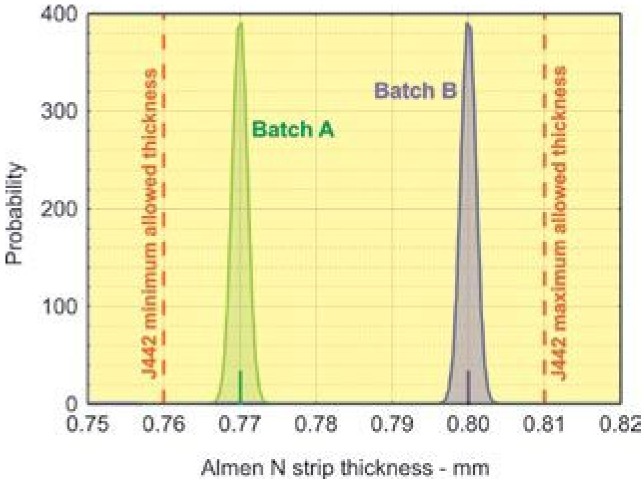

*Fig.8 Thickness distributions of two acceptable batches of **N** strips.*

A very important question is "Is the difference in mean thickness between batches A and B significant?" The answer is an emphatic "Yes".

For a given amount of shot peening the generated arc height reduces as the square of the strip thickness increases.

For the **N** strip example shown in fig.8 the measured peening intensity would vary by 7.5%, 6.0% for **A** strips and 2.5%. for **C** strips Referring back to fig.7 the mean peening intensity of 10 (imperial units) would be 7.5% different if Batch B strips were substituted for Batch A strips – and vice versa. A 7.5% difference corresponds to 0.75 in terms of mean arc height. That is significant.

Producing a saturation curve using a mixture of Batch A and Batch B strips would broaden the 'scatter band' of saturation curves. That is why manufacturers exhort users to "only use strips from a given batch when producing a saturation curve".

Elastic Modulus Variability

The arc height induced in any given strip is directly proportional to the elastic modulus of the strip. SAE J442 only

requires that the Almen strips be produced from SAE 1070 cold rolled spring steel. SAE 1070 has a range of allowed carbon contents and stated elastic moduli – 190 – 210 GPa. Of itself, that range of elastic moduli would be equivalent to ±0.5 (imperial units) for the reference example shown as fig.7. The quoted elastic modulus range does not allow for the variations of preferred orientation induced by mechanical working of the strip steel. Steel has an anisotropy factor of 2.5 meaning that the elastic modulus can vary by a factor of up to 2.5 as working changes the randomly-orientated steel crystals into the equivalent of a single crystal's orientation. Aero strips use an aluminum alloy for which the orientation relative to rolling direction is specified.

Hardness

SAE J442 allows the hardness of **A** and **C** strips to vary by ±6% and that of **N** strips to vary by ±2.4%. Assuming that induced arc height is proportional to strip hardness then there could be a corresponding effect on the mean of a set of derived peening intensities.

Pre-bow

This is a well-recognized effect with SAE J442 restricting pre-bow to 0.025mm for **N** and **A** strips and to 0.038mm for **C** strips. The extent of pre-bow for any given strip is easily allowed for when producing saturation curves.

DISCUSSION

The availability of three different thicknesses of Almen strips normally allows users to adequately regulate the peening intensity that they require. There are, however, 'overlap regions' between **N** and **A** and between **A** and **C** strip usage. The study presented here indicates that **A** strips would be the preferred option for both overlap regions.

Dial pointer force has been shown to be an important factor when using **N** strips. This is based on equation (4) which predicts that measurable dial pointer deflections of **N** strips are to be expected – equivalent to a "pseudo double pre-bow". This can be allowed for by assuming that it is a genuine pre-bow. An alternative solution, particularly appropriate for aluminum-based aero strips with their lower elastic modulus, is to use a non-contacting displacement meter. The validity of the important equation (4) has been confirmed by employing the same push/pull spring balance described earlier. The procedure is illustrated in fig.9 and the earlier prediction that 140g of force would induce a 0.006mm deflection was verified exactly. **N** Almen strip deflections predicted in fig.4 were also verified.

Variability of measured strip response to peening is an ever-present problem when sourcing Almen strips. Eventually this comes down to the quality of strips purchased. "Caveat emptor" is a famous Latin legal phrase meaning "Let the buyer beware" - very appropriate when purchasing Almen strips. The best strip manufacturers expend a great deal of care in the selection of strip material, in the various stages of strip manufacture and employ in-house shot-peen testing using laboratory-standard peening controls. In practice, Almen strip batches can have a remarkable consistency. That is the converse of the sum of the possible variabilities presented in this article.

Consistency depends primarily on purchasing good quality strips. This can be complemented by regular checking of force gage reaction to a given batch of strips. The reaction to a given applied force may vary during the lifetime of a given Almen gage. One effective test is to use a force meter to initially measure and periodically check the force being exerted by the dial gage. Different displacements can be applied with a force meter so that the variation of resisting force with point travel can be checked.

Two areas have been highlighted that are not properly covered by specifications such as J442. The first is the actual elastic modulus of the Almen strips. This should be specified for actual strip material - rather than by relying on the single-condition value quoted for SAE 1070. A second, very significant, area is the thickness variability allowed for the three thicknesses of Almen strips. The thickness ranges quoted in J442 are the same ±0.025mm for all three thicknesses. This roughly equates to ASTM A109 and A568 tolerances which do, however, increase with the strip thickness of cold-rolled steel strip. A thickness range of ±0.025mm is crude when compared to the much smaller tolerances offered by numerous rolled-strip producers – such as those using cluster mills. If specifications such as J442 allowed a tighter tolerance grade of strip thickness then inter-batch variability problems would be greatly reduced.

*Fig.9 **N** strip reaction to known applied force.*


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The following are a few of the current discussions in The Forum.

MIXED SHOT IN MACHINE

What would be the effect of accidental introduction of larger shot due to sieve failure during peening? Should you re-peen the part?

Pete
Bristol, UK

As with most problems of this type, "the devil is in the details." If the peening intensity is still being maintained within the user's required range and if the shot mixture still satisfies the specification for its size, then there should be no need to re-peen. If these requirements are not being met then re-peening will only serve to hide the larger indentations—which is not advisable.

Socrates

If there were about 20% larger shot in the machine by the end of processing, then I guess that the intensity would drop off. With the same air pressure the larger shot will be slower and possibly 'choke' the pipes.

I'll check start and finish arc height and see where we are then. Thanks.

Pete

Larger media with a given air pressure will increase intensity as the mass is larger while the velocity is the same.

If "choking" is significant enough to decrease CFM that would lead to lower velocities thus lower intensities. While possible, I wouldn't think a 20% increase in size would/should do that.

Dave
USA

Sorry my last message was unclear. We've had S170 contaminated with about 20% of S280. With increase of x2 in volume and almost x3 in cross sectional area with the larger shot, I thought choking would be likely.

Pete
Bristol, UK

Sorry, I did misunderstand. Choking aside, If you have 20% contamination of larger shot (determined via sieve testing), you're likely out of spec.

The discontinued AMS-S-13165 uses a single sieve for in-use media and would not disqualify the sample, however, it is a discontinued spec and you should follow AMS-2430.

AMS-2430 allows only 1/2% of the test sample on a #25 sieve, where you'll be clearly out of spec.

If the media does flow freely through the nozzle you still may achieve acceptable confirmation arc heights. You should generate new saturation curves. The larger media will increase the intensity but will take longer to saturate, thus resulting in a "double hump" saturation curve. If you chose to pursue this as a learning experience, make sure to have extra Almen strip data points at longer than normal exposure times.

Dave
USA

SHOT PEENING IN ROTATING BASKET

Where do I mount Almen strip holder? Do I test with springs in basket or do I run empty first?

Robb

How many parts are typically in basket and how big are they (size and weight)? What type of machine are you using? Is it wheelblast or airblast? Describe how the basket is placed in the machine.

Jack
Mishawaka, Indiana, USA

About 100 pcs per basket, 1" od 1" long in Empire 3640SRC Airblast. Basket is mounted on the door at about a 30-degree angle.

Robb

It's more about the volume of parts and the weight of the individual part. You don't want the tumbling action of the parts to impart more compressive stress into the part then the peening action itself.

Walter
East Hartford, Connecticut, USA

Are there guidelines available? I am looking for a place to start; any help would be appreciated.

Robb

What specification are you working to? AMS 2430 forbids tumble/batch peening. What type of part are you planning on tumble peening? If it's a spring or a stamping, you are probably okay. If you're planning on tumble peening a machined part, I would advise that you don't.

Walter
East Hartford, Connecticut, USA

CLEANING AFTER SHOT PEENING

My problem is cleaning the surface after receiving it back from shot peening. We have aluminum shot peened with int.0.014A on many different sizes of parts that range from 2 feet to 15 feet. I have noticed that the dust from the peening process is very difficult to get out of the divots. We do have some parts that go back on the machine for boring and, of course, now we have coolant to deal with. Is there a cleaning solution available and rags that won't tear apart while scrubbing the peened surface? Any information on this would be appreciated. Thanks.

Ken
Montana, USA

There are a couple of ways to solve this problem. However, in order to do any of them you would have to check with the end user to be sure it is acceptable.

1) Nitric Acid Clean at in a solution 30-50% acid to water
2) Glass Bead blast clean .002-.006N intensity

Or you might want to look into this link: http://www.finishing.com/476/07.shtml. There is a reference to a citric-based cleaner that I have tested. It worked fairly well but not as good as the Nitric acid. We have not been able to use the citric-based cleaner as it is not yet approved by our aerospace customers.

Walter
East Hartford, Connecticut, USA

Thanks, Walter, for the advice and the link, I will check on specs and see if those solutions would be acceptable.

Ken
Montana, USA

WG Plus De Mexico Celebrates Open House

WHEELABRATOR GROUP recently celebrated the opening of a brand new 34,000 sq. ft. manufacturing and aftermarket parts and service facility in Mexico under the name WG Plus de Mexico. With a doubling of existing capacity, the Monterrey, Mexico facility supports regional (OEM) Original Equipment Manufacturing and aftermarket sales as well as equipment manufacturing operations for Wheelabrator's global customer base.

This facility is the culmination of investment in local operations since opening a small sales office in 2006. Following a rapid increase in sales, Wheelabrator Group made the decision to move to a larger facility in 2008 to provide expanded services to their customers. The requirement of additional space to meet local customer service, inventory requirements and the creation of a supply chain operation facility for the assembly of standard OEM equipment demanded the transition to a still larger facility in 2011. The 2012 expansion provides heavy duty manufacturing, secondary light assembly operations and aftermarket support to service the increased demand for all of the Americas.

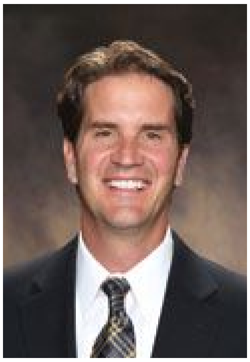
Unique After-Sales Capability

WG Plus de Mexico provides service and support through Wheelabrator Plus. Wheelabrator Plus is the after-market service, support and supply division of Wheelabrator Group. Wheelabrator Plus provides the necessary support to keep equipment running at optimum capacity. Replacement parts, services, maintenance, modernization of equipment, and training provide customers support to help them reduce operating costs, maximize customer productivity and leverage technology to support manufacturing improvements.

Wheelabrator currently employs 25 people in Monterrey, and this number is expected to increase.

WG Plus de Mexico facility in Monterrey, Mexico

Joel McGreal Promoted to General Sales Manager



JOEL MCGREAL of Ervin Industries, Inc. has been promoted to General Sales Manager. He will be responsible for the sales of AMASTEEL and AMACAST metal abrasives for North America.

Mr. McGreal has been with Ervin for the past 13 years as a salesman and district sales manager for the Iowa region. He will now be assigned to the Ervin Headquarters in Ann Arbor, Michigan.

Ervin Industries, established in 1920, is a privately held company based in Ann Arbor, Michigan.

Asbury Wilkinson Joins Ervin

ERVIN INDUSTRIES has announced that Asbury Wilkinson in Burlington, Ontario Canada has acquired Whytek Marketing and will represent Ervin Amasteel Shot and Grit and Amacast Cast Stainless Steel Shot. Their area of responsibility will be the Eastern Canada region.

Asbury Wilkinson is a leading supplier of materials to the Cast Metals Market as well as many other surface preparation market sectors. They have earned their reputation through quality products, knowledgeable sales engineers and excellent customer service. This will compliment the work Whytek Marketing has done and continue the growth in the Metallic Abrasives segment.

Embraer SA Subscribes to Nadcap

On 9th April 2012, **EMBRAER SA** became a Nadcap Subscriber. The company, located in Sao Paulo, Brazil, is now accepting Nadcap accreditation from its American, European and Asian suppliers in several disciplines including Non-Destructive Testing and Surface Enhancement.

iBlue: The First Industrial Bluetooth Transmitter

ITAMCO (Indiana Technology and Manufacturing Companies) has released the iBlue—the first handheld bluetooth transmitter that gathers crucial production data and sends it to bluetooth-enabled smartphones, tablets and computers. The iBlue replaces several tools including hardness testers, micrometers and temperature readers.

When the iBlue is paired with a bluetooth-enabled device, it gathers, records and sends data through its three ports: a K-type thermocouple port—the iBlue comes with a K-type thermocouple probe—, a 3-pin metal hardness probe port and a USB Human Interface Device (HID) enabled port that connects with a wide range of non-proprietary tools including keyboards, micrometers, calipers, and barcode scanners. No special software is required and data from the iBlue can be sent as a text email or placed into Microsoft Excel and Notepad. iBlue is compatible with the most common operating systems including Apple's iOS, Android, Blackberry, Windows and Linux.

"We've Got a Free App for That"

iBlue isn't ITAMCO's first foray into mobile technology; the company has launched several free smartphone apps for industrial applications. Two of their apps, **Hardness Tester** and **Convert Temperature**, extend the iBlue's capabilities. Hardness Tester calculates approximate hardness conversion numbers between popular Rockwell, Vickers and Knoop hardness scales for non-austenitic steels. The Hardness Tester smartphone app converts data acquired with the iBlue and a hardness probe. (The iBlue accepts D/DC, D+15, E, C, DL and G hardness probes.) The Hardness Tester will graph results and previous tests (Max, Min and Average) can be recalled with the touch of a button. The data can be sent to any compatible Air Print Printer from the app. The app is in conformance to ASTM A956-06 and ASTM E140-07.

iBlue is compatible with USB-compatible micrometers, hardness tester probes and K-type Thermocouples. A K-type thermocouple comes with the iBlue.

The Convert Temperature app converts different scales of temperature such as Fahrenheit, Celsius and Kelvin. Temperature readings can be emailed, printed, and graphed the same as the Hardness Tester data. The app works seamlessly with the iBlue and its K-type thermocouple probe (included with the iBlue).

The apps are available for Apple, Android and Blackberry smartphones.

iBlue and the Technology-Driven Shop Floor

The iBlue and smartphone apps are part of ITAMCO's overall initiative to bring technology to their own shop floor. Joel Neidig, an engineer at Indiana Gear (a division of ITAMCO) and one of iBlue's developers, said, "We're in the process of connecting our machine tools to a plant monitoring system so it just made sense to have an electronic method of gathering and distributing the temperature, dimensions and hardness data of our gear products." The iBlue is used by machine operators, engineers and quality control staff at Indiana Gear. "iBlue is saving me a lot of time on the shop floor because it's an all-in-one tool," said Michael Blum, one of Indiana Gear's Quality Control Specialists. "It's easy to carry around and it's accurate. We're already using data gathered from the iBlue to electronically track and analyze production processes." The iBlue has worked so successfully at Indiana Gear that the ITAMCO staff decided to market it worldwide.

iBlue Is Bundled and Priced for Economy

The iBlue comes with a USB charger cable, OtterBox belt clip and a K-type thermocouple probe. The iBlue package is priced at $499 and can be ordered online with Google Wallet at www.itamco.com/iBlue or by calling ITAMCO at (574) 936-2112. The Hardness Tester and Convert Temperature smartphone apps can be downloaded from the Apple App Store, Google Play, Windows Marketplace and the Blackberry App World. Search "ITAMCO" to locate the apps.

iBlue is easy to pair with bluetooth devices and simple to use. ITAMCO has provided how-to videos and a FAQ page at their website (www.itamco.com).