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The Shot Peener

The South Bend Century Center

Venue for the Eleventh International Conference on Shot Peening (ICSP-11)

South Bend, Indiana USA • September 12-15, 2011

Inside:

WELCOME TO SOUTH BEND | ICSP-11 ACTIVITIES AND TOURS • MEET AMS 2590: ROTARY FLAP PEENING

DEVELOPING A PEENING PROCESS SPECIFICATION • HOW ACCURATE IS STEEL MEDIA HARDNESS TESTING?

and much more

Volume 25, Issue 3 **Summer 2011**

Celebrating 25th Year

The Shot Peener

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

Celebrating 25 years in publication • Over 6,000 readers in 80 countries

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Articles

The atrium of the South Bend Mariott

There are many reasons to like this Indiana city, centrally located in the United States. We picked out a few that will be of interest to the shot peening conference attendees.

Seven Great Things About South Bend

The Venue for ICSP-11

Eleventh International Conference on Shot Peening (ICSP-11)

September 12-15 2011

Century Center

South Bend Indiana USA

#1 Accessibility

It's easy to get to South Bend. The South Bend Regional Airport—the only transportation center in the U.S. that houses air, rail and bus service in one location*—is easily accessible from the Atlanta, Chicago, Cincinnati, Detroit and Indianapolis international airports. Once you're in South Bend, cabs, rental cars, buses, trollies and shuttles are readily available.

#2 The Century Center Convention Complex

Located in downtown South Bend, the Century Center is only minutes from the South Bend Regional Airport and Interstate 80/90 (Interstate 80/90 connects Chicago and South Bend).

The facility is famous for its 30-foot glass wall, facing the St. Joseph river. We'll also enjoy its multiple presentation theaters, exhibit space and dining rooms with outstanding catering services. We'll have lunches on the "island," a spacious patio on the St. Joseph river.

The Century Center Convention Complex was designed by noted architects Philip Johnson and John Burgee. Some of their other designs include the Avery Fisher Hall at Lincoln Center in New York city, the Crystal Cathedral at Garden Grove, California, the Boston Public Library in Boston, Massachusetts, and the Studio Theatre at Kennedy Center in Washington, D.C.*

#3 The Mariott Hotel

The Mariott has all of the amenities of a fine hotel including a large fitness center and good eateries, plus it's within walking distance to the College Football Hall of Fame and a restaurant district that includes the upscale LaSalle Grill, the South Bend Chocolate Café, and Tippecanoe Place in the Studebaker family mansion.

#4 The Skyway

The Century Center and Mariott are connected by a skyway. ICSP-11 attendees can walk the short distance from their hotel to the conference without parking or transportation hassles, much less an umbrella if the weather turns rainy.

#5 It's Economical

One of the ICSP-11 organizing committee's concerns was to keep costs reasonable during the recession. South Bend has outstanding transportation, accommodations, restaurant and entertainment choices in every price range.

#6 Proximity to Chicago

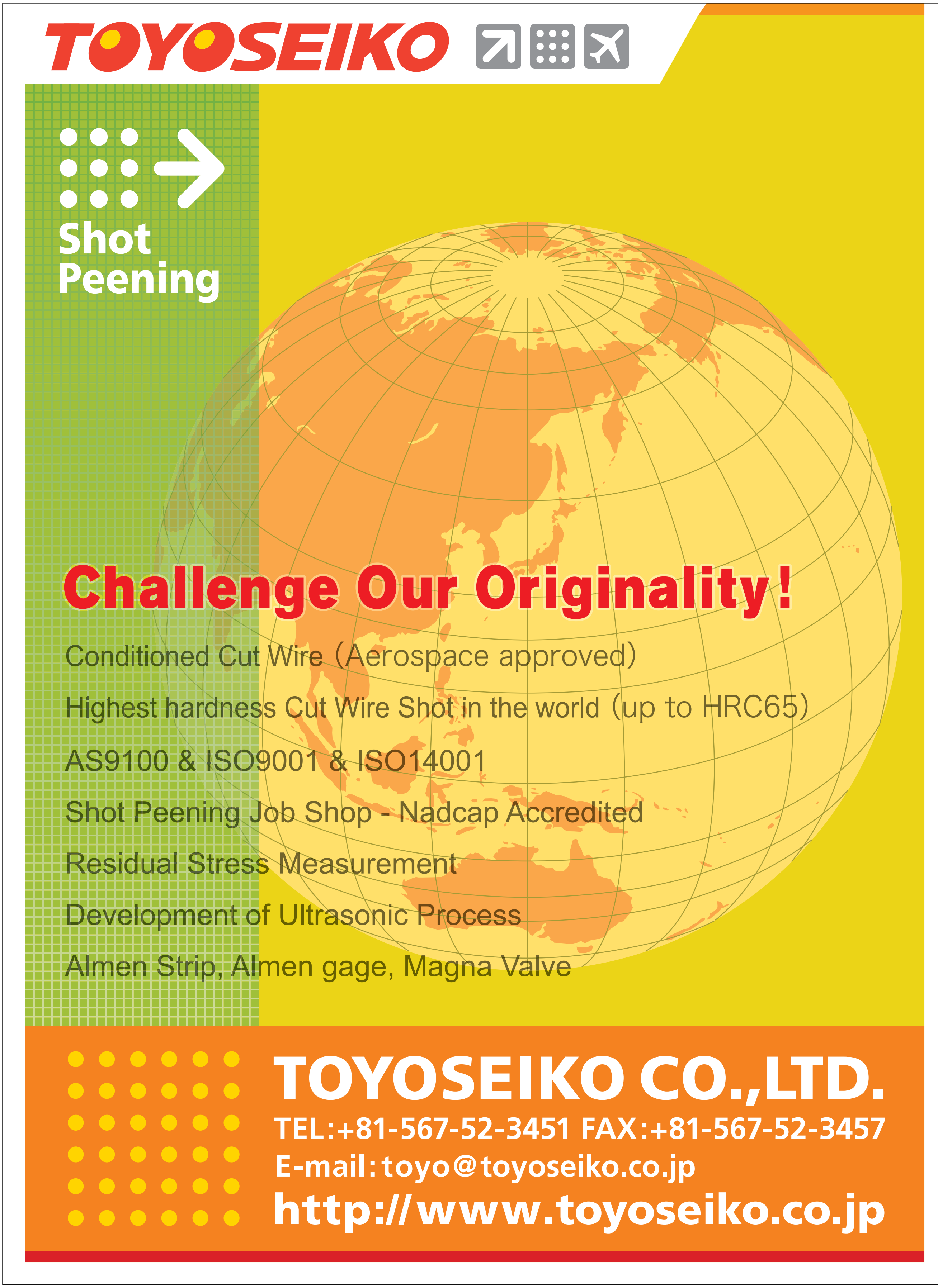
South Bend is 94 miles/151 km from Chicago. Train and bus services are available and a shopping excursion is planned for guests of ICSP-11 attendees and presenters. Chicago is one of the most exciting cities in the world and this is a great opportunity to experience it.

#7 There's Plenty to See and Do

The following is a partial list of all there is to see and do while in South Bend. Maps, restaurant lists and coupons, and an entertainment guide will be part of your registration packet.

- University of Notre Dame (an ICSP-11 tour)
- College Football Hall of Fame
- Studebaker Museum (an ICSP-11 tour)
- South Bend Chocolate Company
- Northern Indiana Center for History
- South Bend Regional Museum of Art (located in the Century Center)
- Amish Acres Historic Farm (an ICSP-11 tour)
- Electronics Inc. facility (an ICSP-11 tour and lunch)

* Resource: Fun Facts at www.visitsouthbend.com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Manufacturing in South Bend

- In 1868, the Oliver Chilled Plow Works in was established by James Oliver. To commemorate the company's contribution to South Bend, a 36-acre Oliver Industrial Park has been built where the former manufacturing plant stood. It features the original restored Oliver boiler house.

- Studebaker was a wagon and automobile manufacturer based in South Bend. Founded in 1852 and incorporated in 1868, the company was originally a producer of wagons for farmers, miners, and the military. Studebaker entered the automotive business in 1902 with electric vehicles and in 1904 with gasoline vehicles.

- Bendix was founded in 1924 in South Bend, by the inventor Vincent Bendix. Bendix manufactured brake systems for cars and trucks, supplying General Motors and other automobile manufacturers.

- AM General, the manufacturer of the military Humvee, HUMMERs, and general engine products, has their corporate offices in South Bend. The production facilities are located eight miles away in Mishawaka, Indiana.

- Manufacturing in South Bend is going nano - the city and the University of Notre Dame are developing industrial parks to house regional and Fortune 500 businesses, including nanoelectronic firms.

Things to See and Do While at ICSP-11

The Golden Dome of the University of Notre Dame is one of the world's most recognized college landmarks. We'll be touring this beautiful campus.

Travel just a few miles out of South Bend and you're in Amish country. ICSP-11 attendees will be able to travel the Amish countryside and visit the Amish Acres Historic Farm. (Photo courtesy of the Elkhart County Convention & Visitors Bureau.)

The College Football Hall of Fame is across the street from the Mariott.

ICSP-11 attendees are invited to Electronics Inc., home of the MagnaValve and numbered Almen strip, for a tour and hospitality.

Copshaholm, built in 1895 and now a museum, was originally the home of J.D. Oliver, president of the Oliver Chilled Plow Works. The furnishings on all three floors are original, giving visitors a remarkable glimpse of how the Oliver family lived during their 72 years in the home. Copshaholm is within walking distance of the Mariott and the Century Center.

The Studebaker National Museum has 120 vehicles in the collection including a 1835 Conestogo Wagon and a 1966 Cruiser—the last vehicle produced by the company. The Museum displays approximately 70 vehicles at any time, with an additional 40 vehicles kept in "visible storage" in the Museum's lower level. The collection features several one-of-a-kind vehicles like the 1956 Packard Predictor and the 1934 Bendix SWC.

Meet AMS 2590: Rotary Flap Peening of Metal Parts

AMS 2590 is a new specification that was released in December 2010. It was written by a team led by Peter Bailey, formerly a Staff Engineer with General Electric Aircraft Engines, to provide technical improvements to MIL-R-81841. MIL-R-81841 was released in 1972 and it has had an interesting history. It became an AMS document in 2001 and went back to being a MIL spec in 2004, with several revisions along the way. During all of these reversions; however, weaknesses in the spec were never addressed. Mr. Bailey has made AMS 2590 current with the advancements in equipment and procedures of this popular shot peening process.

AMS 2590 has significant technical improvements over MIL-R-81841 in four areas:

1) The inclusion of two methods for the determination of intensity that are independent of peening time
2) Simplified calculation of required tool speeds for peening inside holes
3) Methods for determination of peening time based on material hardness
4) Improved operator qualification requirements

1) Intensity Determination Methods

SAE 2590 requires either the SAE J443 10% rule or the Almen strip coverage method, with the 10% rule as the preferred method. (The Almen strip coverage method is helpful when the 10% method doesn't seem to level off or "saturate.")

2) Simplified Calculation of Required Tool Speeds for Parts with Holes

AMS 2590 has an easier method of calculating tool speeds for parts with holes of ½ – 1¼-inch diameter. The required tool speed is established by determining the speed necessary to achieve the required intensity on a flat surface and then multiplying the speed by the hole size factors provided in easy-to-use charts.

3) Part Peening Time

AMS 2590 states, "The area to be peened shall be peened in increments of time and visually inspected for coverage until full coverage is achieved. Coverage time is a function of part material hardness. Soft parts will receive larger peening dimples and will cover faster than harder parts. For coverage requirements greater than 100%, the time to reach 100% shall be determined first prior to further coverage peening. Higher coverages require time multiples of the 100% coverage time for the peened area." The new spec clarifies that the **part's** hardness determines the appropriate level of coverage, not an Almen strip.

4) Improved Operator Qualification Requirements

Flapper peening is a manual process with a handheld tool. The skill of the operator is therefore crucial to a controlled flapper peening process. AMS 2590 acknowledges the importance of the operator with requirements for:

- Qualification testing based on individual techniques rather than reproducing predetermined intensities vs. RPMs
- Intensity development skills including proper Almen strip and Almen gage handling
- Intensity determination and verification through the use of saturation curves
- Part peening qualification to demonstrate coverage
- Operator qualification records
- Operator status maintenance

AMS 2590 is available for purchase at www.standards.sae.org/ams2590 for $65.00. Discounts are available for SAE members.

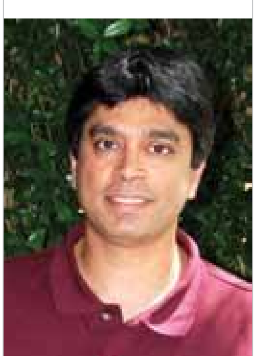
About Peter Bailey

Prior to retirement. Mr. Bailey was Staff Engineer, Advanced Manufacturing Process Development Manufacturing and Quality Technology Department for General Electric Aircraft Engines. During his last 12 years at GE, he concentrated on shot peening and flapper peening, including the flapper peening of GE parts and training of GE operators. Since his retirement from GE, he has worked as a flapper peening trainer and material developer for Electronics Inc. workshops and on-site programs.

Developing a Peening Process Specification

Railway wheel with Almen blocks at areas of intensity verification.

Rail transportation is a good example of an industry outside of shot peening's typical aerospace/automotive client base.



Kumar Balan is a Product Engineer with Wheelabrator Group and a presenter at the Electronics Inc. Education Division workshops.

Specifications can be broadly classified into two categories – (a) process and (b) monitoring. Process specifications are determined after thorough testing of the component and conducting tests for failure and residual compressive stress. This is directly related to the component and its expected life term. Monitoring specifications are more involved and are created after years of equipment use, a thorough knowledge of the process, and an understanding of its evolution. The shot peening industry relies on a few select specifications such as AMS and MIL for monitoring information.

Most of us working with or within the aerospace and automotive sectors are familiar with specifications. The requirement to conform to specifications, and design the peening process around them, is critical to these industries.

While the typical shot peening operation would never be involved in developing a monitoring specification, there are situations where a new peening process specification is necessary. For example, a new process in a mature industry, like automotive, that hasn't been clearly defined would benefit from a process specification. In addition, several new industry sectors have realized the benefits of peening and are eagerly seeking its adoption in their production processes.

This discussion will show how to develop process specifications by starting with the basics of a controlled shot peening process.

Before we begin, you might be wondering why anyone would want to bind themselves down with a specification, when one doesn't exist. The justifications are as follows.

Why Do You Need a Specification?

You Sub-Contract Your Shot Peening Services

Many manufacturers depend on sub-contractors to handle commodity-type work that isn't part of the company's core, value-added tasks. Some companies outsource the entire shot peening process because they don't have the knowledge and/or production volumes to justify the purchase of peening machines. In order to conform to their own quality systems, they must specify how this operation will be conducted by their sub-contractor.

You Have Multiple Facilities

Consider another situation where a large company is bringing shot peening in-house in several of their facilities. They have the volumes to justify purchasing multiple peening machines. Without a specification in hand, commonality of the peening results in all the plants will be almost impossible to achieve.

You Want a Competitive Advantage

Specifications provide a benchmark to differentiate a company's product in today's competitive environment that requires higher quality standards.

The Basics

Let's discuss the basic elements of the shot peening process.

- The purpose of peening is to induce a residual surface compressive stress.
- The depth of the compressive stress is determined by the shot stream velocity which is controlled by the blast wheel speed or air pressure.
- Intensity is determined by using Almen strips.
- Coverage is a function of exposure time and media flow rate.

A controlled shot peening process will be sequenced as follows:

1) The operator sets the proper velocity by adjusting the blast wheel or air pressure for the required target intensity.
2) Once this velocity is established, the operator determines the optimum shot flow for conditions in Step 1.
3) Saturation curve is plotted and intensity is determined.
4) The part is exposed to the blast for the required time to achieve 100% coverage.

Now that we've covered the basics, let's review the work that goes into developing a process specification.

Intensity, Shot Specification and Coverage

The designer of a new process is likely starting with a clean slate and some idea of the life-cycle expectation after peening. Commonly, a fair amount of reverse engineering has gone into determining the intensity. Peening tests are conducted on the component and it's peened to several ranges of known intensities. The component is then tested by the designer for residual compressive stress and life cycle/failure, where possible. With the establishment of an acceptable stress value and life cycle, the corresponding range of intensity is determined. These tests can be carried out with the help of an equipment vendor or through a job shop specializing in shot peening services.

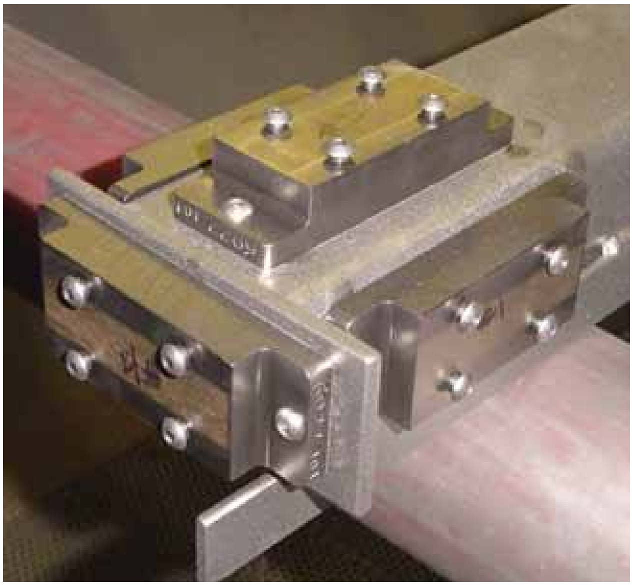
The tests also provide information on the type and size of peening media used during the test for inclusion in the specification.

When peening the part at the specified intensity, the designer will decide if 100% coverage is sufficient. The complexity of the part geometry may dictate a higher percentage of coverage. As an example: The intensity needs to be between 0.010 – 0.012 A, achieved with S 230 (specify hardness if required) and the coverage at 150%.

Component testing and the part geometry will determine the type of media propulsion system — compressed air or centrifugal wheel. Production volumes and type of peening media will also play a role in this selection. Most specifications will not dictate the type of equipment, but will list the variables to be monitored in each of the systems. The machine variables, such as speed of the wheel and air pressure in a compressed air system, will be governed by the process itself and are not bound by any specification. Measuring and monitoring these variables will be required.

After the process parameters are defined, it's then relatively simple to list the machine components. These include the following:

- Closed loop feedback for air pressure or wheel speed
- Closed loop feedback for media flow control



Machine Verification Tool (MVT) with intensity verification in multiple planes.

- Vibratory classifier for shot size control
- Spiral separator for shot shape control

Other process-related checks could include:

- Drop tests to verify shot flow through each blast wheel/nozzle
- Shot size sampling during the process with a sieve shaker

Intensity Verification and Location

The intensity tests would have been conducted with one of three commonly used Almen strips – N, A, or C. In the earlier example, we used an 'A' strip as a reference. The designer of this process and the component's designer will be aware of the critical areas on the part such as those with high tensile stress concentration. These are the areas that will need attention for peening coverage, and these are the locations where intensity will need to be measured.

Therefore, for a particular component, in addition to the above process details, the designer can also clearly specify the areas where intensity will be measured in order to qualify the process. There could be multiple areas for a given component.

This becomes a bit challenging when the user is faced with several parts to peen, as in a job shop. Special Machine Verification Tools (MVT) are employed to verify the intensity in multiple planes and geometries.

In certain cases, it may be critical to protect the areas around the critical peening surfaces. In this situation, the specification will have to specify masking and prevention of overspray. Such areas may include, but are not limited to, threaded portions and machined areas.

Reference Specifications

Specifications such as AMS 2432 have evolved over the years. They're very comprehensive and include critical process monitoring requirements:

- Air pressure/wheel speed measurement
- Nozzle position verification
- Criteria for shot (or other peening media) screening
- Shot shape control
- Part exposure control (such as monitoring table or conveyor speed)
- Nozzle holding fixtures (equivalent control cage setting in case of a wheel type machine)

This list is an example of the depth of information in these specifications that can be used for reference when developing your process. After determining the process details, intensity, coverage, etc., your spec may refer to AMS or similar specifications for conformance.

If your process specifications have been determined with the proper parameters, monitoring specifications will provide a healthy background to develop and conduct your peening operation.

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Herb Tobben is Sample Processing Manager for Clemco Industries Corp., Washington, Missouri. He is a regular speaker at the Shot Peening Workshop and was honored with the 2010 Shot Peener of the Year Award from Electronics Inc.

The problem:

My job has changed a lot over the years. It once was that our customer sent me a manually finished part and told me how many more he was trying to finish in the same amount of time through automation. He typically needed a machine to process a single part in very large quantities. Through testing, I figured out the blast media, pressure, and parts handling, and we were done – a machine to handle the process was thus conceived.

Today, my job involves a lot more communication. Both the customer and I learn a lot through discussion and a thorough delving into both their manufacturing process as well as the blasting or peening process as we work through the project together. The problems are more complex because, more and more often, customers have multiple parts to process in smaller batches. Their challenge is to work out their process so that they can adapt one machine to handle all of their parts. More frequently these days, they are operating in a lean environment where cellular manufacturing is becoming more common. They are concerned about part movement, set-up time, and wait time between operations. Their goal is to eliminate overproduction and only produce items when they are needed. If successful, they will produce cost savings and have better control of their operations. It's all a matter of process design.

One particular customer presented a range of parts that were flat and about four-feet square. The parts varied in thickness from sheet metal to six inches thick. Some had Ra requirements, others did not. It was important to avoid part distortion. This project involved sample processing hundreds of parts. We learned that their manufacturing process produced more residual stress on one side than the other. Over the course of many months and more than a half-dozen processing runs, we eventually determined that they needed four distinct gun setups, special parts handling for the thin materials, and several sizes of aluminum oxide media.

The solution:

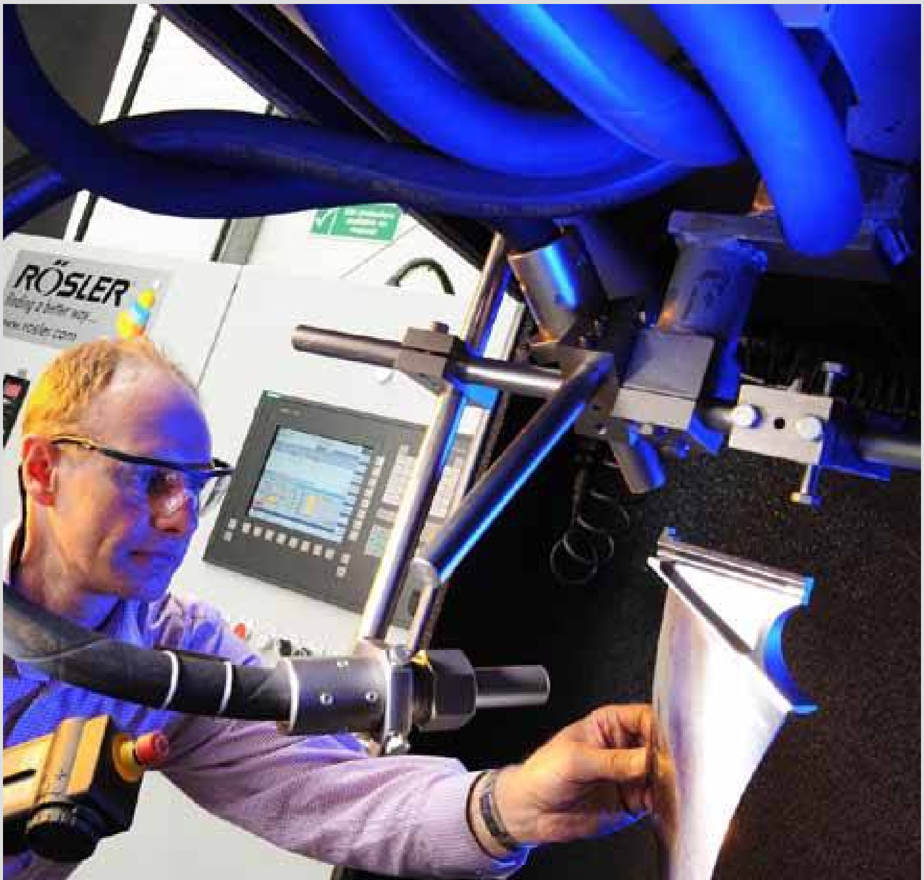
During this project, the customer and I became very well acquainted. Our goal was to design a process and machine that would be flexible enough for their various parts. On their side, they were willing to adapt their work flow to reconfigure the machine for the four setups needed to accommodate processing all the different parts.

The automated machine they purchased had 20 suction nozzles, a split-belt conveyor, a media reclaimer, reverse-pulse cartridge-style dust collector, and an elaborate media separation system. The electrical controls were mounted in a free-standing NEMA-12 enclosure. The split-belt allowed simultaneous blasting from above and below, while hold-down fixtures and slightly elevated blast pressure from above kept the parts in place. To prevent marring any of the parts, a unique urethane conveyor belt minimized contact with the part.

A 3600-cfm reclaimer was used to separate good alox from dust and fines. And for the three sizes of media, the alox travelled through a multi-deck vibratory separator into three separate storage hoppers according to size. Each hopper had 20 metering valves allowing operation as needed for whichever setup was employed. A media-add system replenished the supply of properly-sized media on demand.

Separate pressure regulators were provided to control the upper and lower banks of automatic guns, which were adjustable. Individual valves controlled the 'on' and 'off' of each blast gun, and variable belt speed controlled the blast duration. To keep the work area clean and minimize waste of compressed air and blast media, the machine had an exit vestibule with fixed brushes, pull-through air flow, and blow-off nozzles to clean the parts. Sensors triggered the blast cycle upon entry, and the blow-off nozzles prior to exit.

With every specially engineered machine, a critical component we deliver is training. With their involvement from the beginning, the engineers were pleased with the versatility of the machine. They were confident that following operational and maintenance training, their process operators would be sufficiently multi-skilled for the range of tasks involved in their work cell. And that they would be comfortable adapting to future process changes their production line required.



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0.15
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0.25
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We also manufacture industrial blast conveyor systems, abrasive blast table machines, CNC abrasive blast machines, dust collectors, air deburring machines, pressure vessel systems and sand blasting equipment.

We design and fabricate all equipment at our plants in Illinois and ship around the world. We are experts at transporting and installing machines in our customers' facilities and our training and support ensures a fast start-up on the new equipment.

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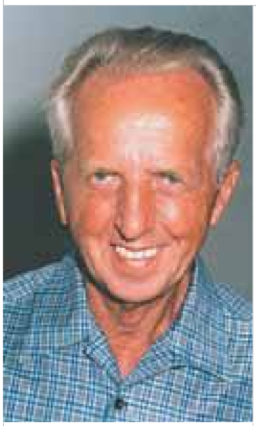

Variability of a Shot Stream's Measured Peening Intensity

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

INTRODUCTION

A particular shot stream should always be regarded as a combination of shot particles carried along in a stream of fluid. The fluid is normally air but is sometimes water and could, conceivably, be any one of many other fluids.

Shot streams differ from one another in terms of their average peening intensity. The principal causes of this difference are generally well-understood being: shot size, velocity and density. An independent increase in any one of those parameters will increase the average peening intensity. The measured peening intensity for one particular shot stream is not, however, constant – it is a variable quantity whose variability is less well-understood. This variability of peening intensity – as derived from a saturation curve – depends on three factors: position, angle and time. A useful acronym to bear in mind is "**PAT**", with the **P** standing for **Position**, **A** for **Angle** and **T** for **Time**.

Shot peening requires strict control of each shot stream's peening intensity. This article therefore attempts to explain how and why the peening intensity of a particular shot stream varies.

SHOT STREAM CONSTITUENTS

A shot stream has two basic constituents – a fast-flowing fluid and entrained shot particles. The combination of the two can be expressed as a pictorial equation, see fig.1.

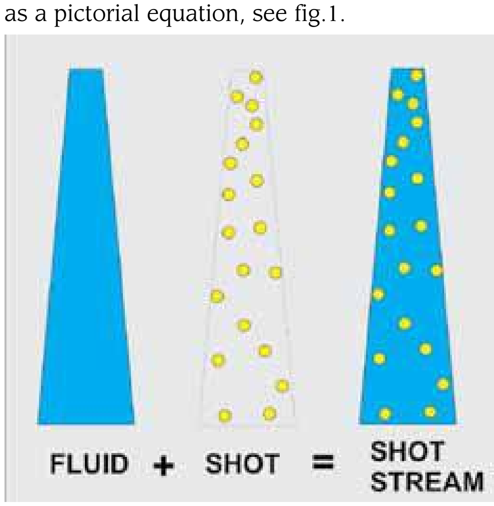

Fig.1 Fluid and shot constituents of a shot stream.

The portrayal of a fluid shown in fig.1 is idealized. The shape of real fluid streams depends on factors such as the type of propulsion – wheel or air-blast – and the particular variant of propulsion unit being employed. With wheel-blast equipment the air is not compressed so that the shape of the air stream is largely a function of blade design. With air-blast equipment the primary factor influencing the air-stream pattern is the shape of the nozzle.

A very important question is: "Which is moving faster – the fluid or the shot particles?" The answer is not immediately obvious. As the particles leave either the nozzle or the blade tip there are alternative answers. For suction-fed air-blast machines the fluid (air) is moving much faster than the shot particles as it emerges from the nozzle. For direct-feed air-blast machines the air is, on emergence, moving faster than the shot particles and for wheel-blast machines the particles are moving faster than the air (which in this case is simply incidental rather than the propulsive agent). Using a venturi-type air-blast nozzle to induce supersonic air speeds will mean that the emerging air is moving very much faster than the shot particles.

VARIATION WITH POSITION

Peening intensity varies with position in a given shot stream. This variation corresponds to the unavoidable variation of shot particle velocity with its position in the shot stream. The governing factor is the "Law of shot stream particle acceleration". This law, stated in words, is that "Any given shot particle will be accelerated if the surrounding fluid is moving faster than the particle, and vice versa". Stated as an equation we have that the accelerating force, **F**, of the fluid acting on a shot particle is given by:

$$\mathbf{F} = \mathbf{k}(\mathbf{v_F} - \mathbf{v_P}) \qquad (1)$$

where **k** is a positive constant, $\mathbf{v_F}$ is the velocity of the fluid and $\mathbf{v_P}$ is the velocity of the particle. If $\mathbf{v_F}$ is greater than $\mathbf{v_P}$ then $(\mathbf{v_F} - \mathbf{v_P})$ is positive so that **F** is positive – therefore pushing on the particle to accelerate it. If, however, $\mathbf{v_F}$ is less than vP then $(\mathbf{v_F} - \mathbf{v_P})$ is negative so that **F** is now negative – meaning that the particle is now pushing on the fluid and is therefore being decelerated. The difference between $\mathbf{v_F}$ and $\mathbf{v_P}$, $(\mathbf{v_F} - \mathbf{v_P})$, is the 'relative velocity'.

A mental picture of equation (1) can be obtained by using an analogy. Imagine walking along a long straight road at a steady 5 kph with a wind of strength 10 kph on one's back. There is now a force proportional to (10 – 5)

trying to accelerate one's forward movement. If the wind dropped to 5 kph there would be no accelerating force at all. If, further along the road the wind dropped to 2 kph there would be a force proportional to (2 – 5), a negative quantity, resisting forward movement and trying to slow one down - deceleration.

The shot peening equivalent of this analogy is illustrated in fig.2. Air velocity and shot velocity are represented as vectors so that velocity magnitude is indicated by the length of each arrow. Bear in mind that the air velocity decreases rapidly with distance from the nozzle.

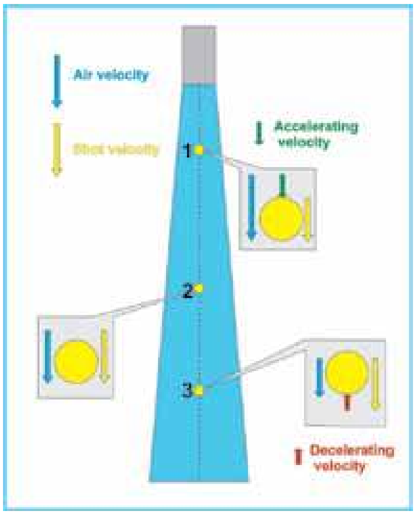

Fig. 2 Vector diagram showing change of relative air/shot velocities with position.

Imagine a shot particle at position 1 where the air velocity is greater than the shot velocity. There is, therefore, a net accelerating velocity causing the particle to increase its velocity. When the particle reaches position 2 the air and shot velocities are the same so there is now neither acceleration nor deceleration. At position 3 the air velocity has slowed down so that the shot particle is now travelling faster than the air. This gives rise to a net decelerating velocity causing the particle to slow down.

A shot stream contains a vast number of individual particles. Each particle will have a different relative velocity - depending on its position in the shot stream and its own size and shape. It should also be borne in mind that the air flow at the outside of the stream is being slowed dramatically by the static air surrounding the stream. Getting a mental picture of the overall effect for all of the particles in a given stream is very difficult. One analogy (conjured up by the Annual Boxing Day Duck Race held in the author's home town) is of thousands of plastic ducks being dropped into a fast-flowing stream of water. The water flow is fastest at the center of the stream and very slow at the banks of the stream. As the stream widens the average water flow rate decreases. An overall picture emerges of ducks moving in a pattern that can be visualized. This pattern is the same as the iso-intensity diagram shown for suction-fed shot particles, fig.3.

The maximum shot velocity/peening intensity for suction-fed particles occurs in the center of the stream at a particular distance, D, from the nozzle.

Measuring the variation of peening intensity with stand-off distance, D, for a particular shot stream, is fairly straightforward. An Almen strip holder can be placed at different measured distances from the nozzle/blade-tip. Care should be taken to ensure that the axis of the shot stream always passes along the major axis of the Almen strips. Full saturation curves can be produced for each of several distances. Fig.4 shows an example of intensity variation established for S170 shot, straight 5mm diameter nozzle, 2kg/minute feed rate and suction-fed air acceleration pressure-adjusted to give approximately a 10-12A intensity. The most important feature is that a maximum peening intensity, h_{max}, occurs at a definable stand-off distance – 245 mm for this particular shot stream.

At each distance from the nozzle the shot velocity/peening intensity will also vary across the shot stream, as indicated in fig.5 (page 28).

The measured peening intensity will also vary with position of the Almen strips. A 'High' value will therefore be obtained if the major axis of the strip coincides with the

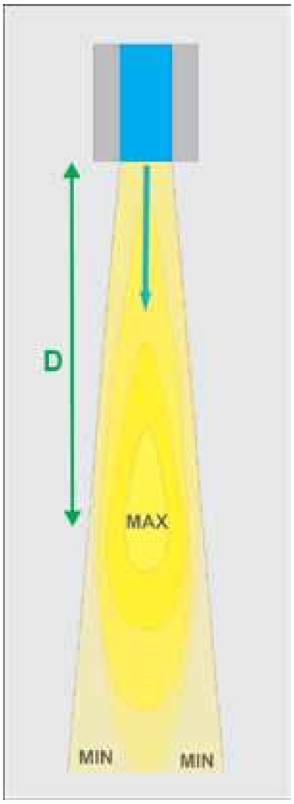

Fig.3 Schematic iso-intensity diagram for suction-fed shot particles.

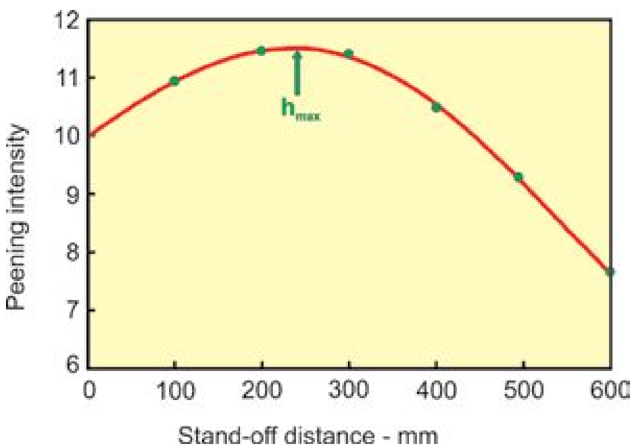

Fig.4 Measurements of peening intensity variation with stand-off distance.

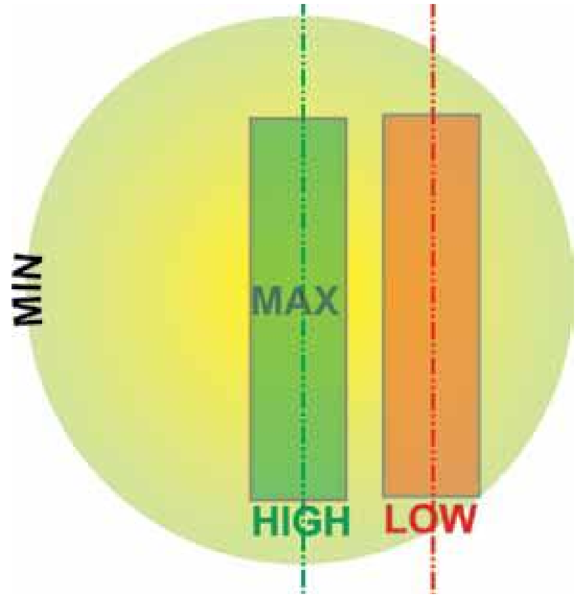

Fig.5 Cross-section of shot stream showing maximum intensity at center.

central maximum of the shot stream. A 'Low' value will occur at other relative positions.

Iso-intensity distributions vary with the type of shot acceleration. With direct-feed air blast the air/shot velocity difference at the nozzle is much smaller than it is for suction-feed air blast. A different situation exists with wheel-blast machines. Particles leaving the blade tips are travelling faster than the blade-driven air (centrifugal speed being added to the blade tip's tangential speed). This means that deceleration takes place continuously after leaving the blade tip.

Measuring the variation of peening intensity <u>across</u> a shot stream is experimentally difficult. An indirect estimate can easily be obtained by measuring the variation of indent diameter (indent diameter being directly related to peening intensity). Measurements have been carried out that involved using a 'sliding shutter' between stationary Almen strips and a fixed air-blast nozzle. These indicated that the indent diameter – and hence peening intensity – fell by some 30% between the center of the impact zone and its outside edge. This translates to a corresponding variability to the peening intensity.

VARIATION WITH ANGLE

Shot particles striking a component other than perpendicularly induce shallower indents. This means that the depth of deformation is reduced with a consequent reduction in peening intensity. Fig.6 shows an example of how measured intensity varies with impact angle. This phenomenon has been described in detail in a previous article (The Shot Peener, No.3, vol.19, 2005).

VARIATION WITH TIME

The measured peening intensity of a shot stream depends on three time-dependent factors, each of which can have long-term, short term or immediate influences. These can be categorized as:

1 **Shot characteristics**,
2 **Velocity control** and
3 **Intensity measurement regime**.

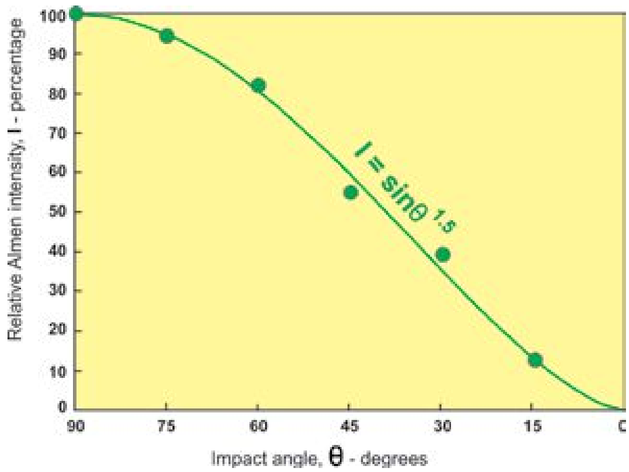

Fig.6 Effect of impact angle on Almen saturation intensity, N strips, S110 shot.

1 Shot Characteristics.

Shot characteristics - average size, size distribution and shape - vary continuously with time. Fig.7 is a schematic representation of several factors that conspire to ensure that every characteristic varies with time. These can induce either long-term (slow), short-term (rapid) or instant changes in a given shot stream's intensity.

One example of long-term intensity change is that due to shot wear. Gradual wear of the shot charge particles is the simplest to understand. Every shot particle circulating in the system will suffer wear. Over a long period of usage the shot charge would eventually fail to meet specification size requirements. Fig.8 (page 30) is an example of the effect of long-term wear of S110 shot on average shot stream intensity – assuming that all other parameters remain constant. A new charge of S110 shot set to give a shot stream with a peening intensity of, say, 11A might eventually wear down to a size of S70. If no other peening parameters were changed the intensity would then be approximately 7A (imperial units). In practice, however, peening parameters would be adjusted to take account of this size reduction.

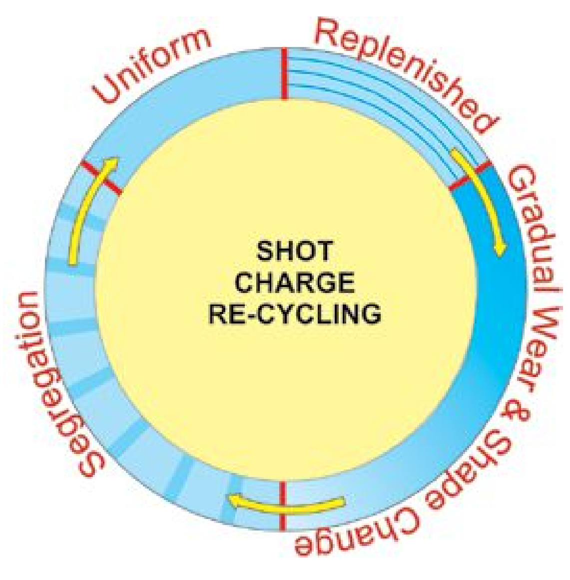

Fig.7 Time-dependent factors affecting shot stream characteristics.

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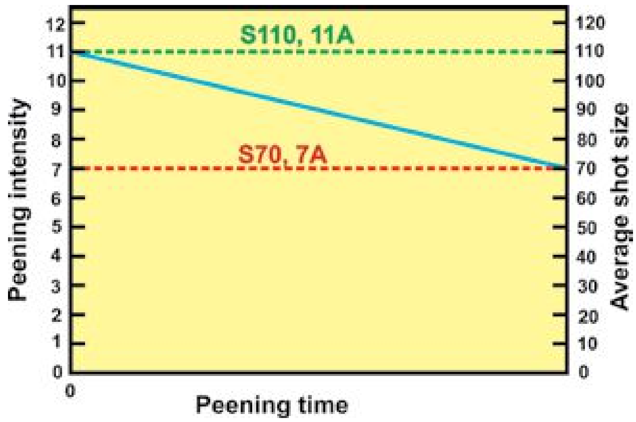

Fig.8 Effect of long-time wear on shot size and induced peening intensity.

Shape change over long time periods is particularly significant for cut wire shot streams. Cut wire particles gradually become more spherical. This type of shape change will be greatest for conditioned cut wire and least for spherical-conditioned cut wire. Theoretical considerations would predict that the measured peening intensity of a given cut wire shot stream would therefore decrease slightly with time – due to shape change.

Segregation induces short-term changes in peening intensity. Shot particles seize every opportunity to segregate – obeying the laws of physics. Several segregation opportunities arise during each complete re-cycling of shot. Natural segregation is represented in fig.7 as 'banding' of the average shot size delivered to a shot stream's nozzle. Forced segregation occurs by the act of replenishment with new shot.

Fig.9 illustrates how short-term shot size changes can affect saturation curve measurements. One particular example of change, based on actual industrial experience, has a 'finer' band of shot always being accumulated at the feed entry region of the hopper. Thereafter 'coarser-than-average' shot was fed into the nozzle. For that particular situation the path of arc height change with peening time would follow 0ABC. A whole range of peening intensities could then be deduced – depending on the selected peening times. If, on the other hand the 'coarser-than-average' band of shot had arrived first then the path would be 0DBE – with different peening intensities being indicated.

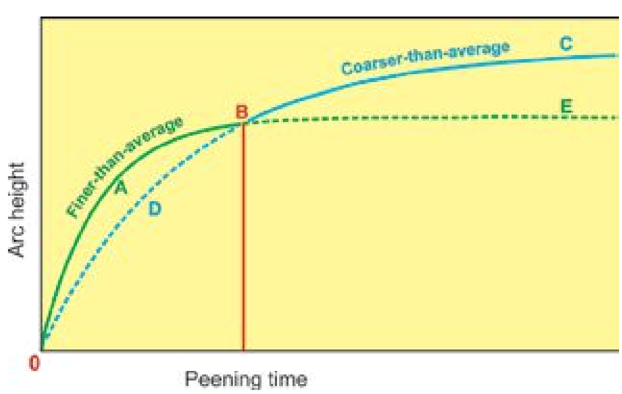

Fig.9 Schematic representation of shot characteristic effects on shot stream intensity.

Replenishment will give an almost instantaneous increase in the measured intensity of a given shot stream – equivalent to switching from the 'finer-than-average' to the 'coarser-than-average' curves of fig.9.

2 Velocity Control

The peening intensity of a shot stream is directly related to the average shot velocity, mass and diameter. Equations (2) and (3) are empirical equations that indicate the effect of shot velocity, v, on the peening intensity, I, that might be expected when using cast steel shot of a given nominal size, S:

$$I = S*0.0036659(1 - \exp(-0.010482*v)) \quad (2)$$

where **I** is in mm and **v** is in ms^{-1}.

and

$$I = S*0.00014432(1 - \exp(-0.0031949*v)) \quad (3)$$

where **I** is in inches and **v** is in feet per second.

As an example, using S170 shot **(S = 170)** having a velocity of 300 ft/sec **(v = 300)**, equation (3) predicts an intensity of 0.015". A 10% reduction in shot velocity **(v = 270)** predicts an intensity reduced to 0.014. Fig.10 is a graphical representation of the variation of predicted intensity versus shot velocity for a range of shot sizes, obtained using equation(2).

Shot velocity is, however, rarely controlled directly. Reliance is normally placed on maintaining either a given air pressure or a given wheel speed together with an assumption that the shot feed rate remains constant. Unfortunately all three factors (air pressure, wheel speed and shot feed rate) vary, to a greater or lesser degree, over short-, medium- and long-term time periods. Contributory factors include the fluctuating demands on air ballast tanks, ballast tank pressure cycling, voltage supply variations, deterioration of wheel blades and shot supply pipes, nozzle wear and shot feed control pulsation.

3 Intensity measurement regime.

There is a range of time-dependent intensity measurement

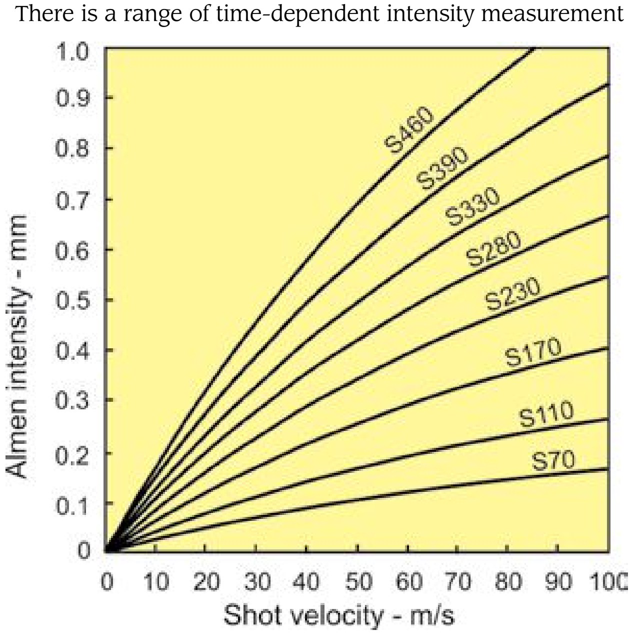

Fig.10 Almen intensity versus shot velocity.

factors. These have been extensively documented elsewhere so that they need not be described in detail here. Long-term factors include ball wear and indicator drift. Short-term factors include individual strip variation and strip placement. These time-dependent factors can, however, be monitored if the measurement regime incorporates appropriate calibration test pieces.

DISCUSSION

This article should not be regarded as being either comprehensive or authoritative. The intention was simply to highlight the fact that there are a large number of factors that cause variability of any particular shot stream. Evidence of that variability is experienced by every shot peener.

A recurring theme is that intensity control can be made more effective if every peening intensity measurement and set of machine parameters is stored in some form of data base. Changes in peening intensity for any given machine can then be assessed against the several possible causes of intensity change. ●

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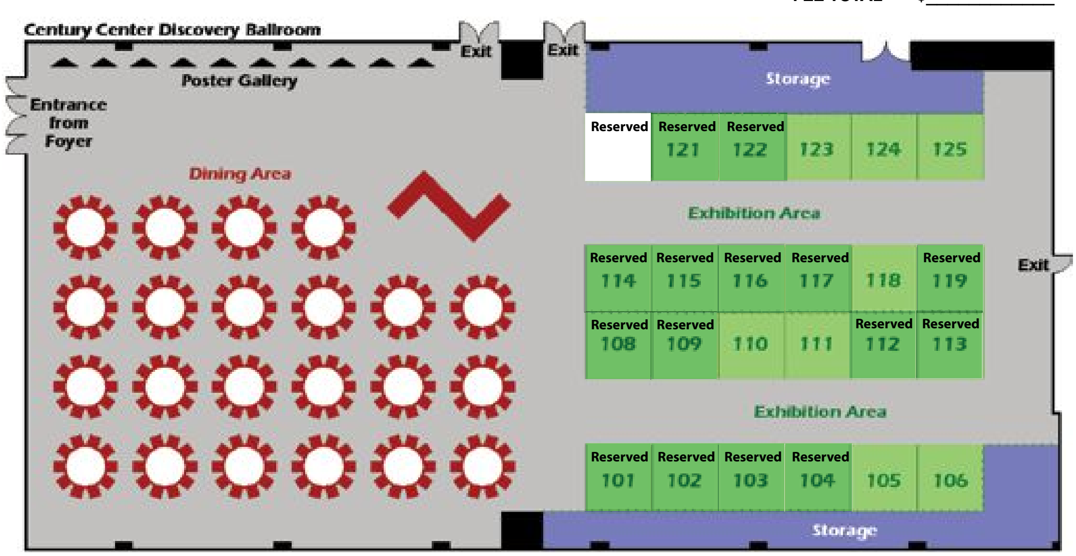

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(Online registration is available with secure PayPal, credit card, and bank wire fund transfer options at www.shotpeening.org/ICSP-11/registration.php)

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HOTEL RESERVATIONS

An enclosed, climate-controlled walkway connects the South Bend Century Center Convention Center to the full-service Marriott hotel. Rooms in the Marriott are available to ICSP-11 participants at a discounted rate of $109.00 (single and double rooms). Reservations must be received on or before 5 p.m., Sunday, July 29, 2011 to receive the discounted rate. To make hotel reservations, call 1-800-228-9290 or 1-574-234-2000 and mention "ICSP-11." For highlights and photos of the Marriott and a Visitor's Guide, please visit http://www.marriott.com/hotels/travel/sbnin-south-bend-marriott.

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- **Develop worldwide partnerships with industrial and education professionals**
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Industry News

Peening Technologies Receives Industry Approvals

East Hartford, Connecticut. Peening Technologies of Georgia (PTG) is pleased to announce the addition of General Electric Aviation to their list of customer approvals. PTG was audited in April of this year and approved by General Electric Aviation for the following processes:

- Shot and Glass Peening IAW P11TF3
- Shot Peening of Critical Components IAW P11TF8
- Shot Peening Legacy Peening IAW AMS-2430
- Shot Peening Legacy Peening IAW MIL-S-13161 /AMS-S-13165
- Shot Peening Legacy IAW Older GE Requirements: 99207HS2062,99207HS299,99207HS67,P11-TE3A,P11-TE3C and P11-TE4
- Manual Shot and Glass Peening IAW P11TF3.
- Tumbling, Fatigue Enhancement IAW P4TF6.

Peening Technologies of Connecticut (PTC) has added AMS 2432 to their existing Honeywell Phoenix approval. This now permits PTC to process Honeywell Flight Safety / Critical Safety items.

New LinkedIn Group for Shot Peening

Amsterdam, Netherlands. Marcel Van Wonderen, Master Engineer Process Equipment & Materials Development at KLM Engineering & Maintenance, has launched "The Shot Peening World" at LinkedIn.

"The Shot Peening process is, in my opinion, one of the most important MRO techniques in Aircraft Business (and often underrated). I thought it would be a good idea to start a discussion group," said Mr. Van Wonderen.

The group has already attracted LinkedIn members from around the world in many different industries. If you're a LinkedIn member, request membership to the group. It will be a great resource for information and networking. If you don't belong to LinkedIn, the group is another great reason to join.

Capital Goods Industry Veteran Joins Pangborn Group as Director of Equipment Sales

Fairburn, Georgia, USA. Pangborn Group announced today that Dale Kroskey recently joined the company as Director of Equipment Sales for the company's Pangborn brand. In this role, Kroskey will be responsible for managing and developing Pangborn's outside sales team and distributors on equipment sales opportunities.

Kroskey joins Pangborn following a distinguished career in the capital goods industry. He was most recently Vice President, Roll Forming Technology and Business Development at Metalforming Inc. in Fairburn, Ga. Prior to that, he held progressively higher sales and product management positions during his 15 year tenure with Yoder Manufacturing, a division of Formtek. Kroskey holds a Bachelor of Science in Industrial Engineering and a Master of Business Administration, both from Kent State University.

Pangborn Group is an affiliate of Atlas Holdings LLC. For more information on Atlas, please visit www.atlasholdingsllc.com.

New 3,000 Pound-Per-Minute Media Valve for Wheel Blast Machines

Mishawaka, Indiana, USA. Electronics Inc. (EI) has introduced the newest media valve in their MagnaValve™ series: The WM 3000-24. The WM 3000-24 will throw 3,000 lbs of steel shot per minute in wheel blast machines with wheels up to 125 Hp. EI developed the valve in response to demand in Europe and China where the valves are used in wheel blast machines in foundries.

The MagnaValve is a magnetic valve that regulates the flow of steel shot. The MagnaValve's built-in sensor measures flow rate and, when used with EI's FC-24 Controller, the wheel motor amperage can be regulated to any value from no-load to full-motor load. The MagnaValve reduces media usage, energy costs, machine downtime, and wear and tear on equipment.

The MagnaValve's maintenance-free construction includes a rare earth permanent magnet for normally closed operation and an electromagnet for controlling shot flow rates. When no power is applied to the MagnaValve, the permanent magnet stops all flow. With power applied, the magnetic field is neutralized and shot is allowed to flow through the valve. If the power is interrupted for any reason, the permanent magnet in the valve securely holds the shot.

The valve is available in 24 Vdc but EI also manufactures 120 Vac MagnaValves. Valves are available with the capacity to throw 700 - 3000 lbs/min for 15 to 125 Hp motors.

Electronics Inc. manufactures products that improve the quality and control of blast cleaning and shot peening processes including the MagnaValve media valve, controllers, Almen gages and strips. For more information, visit www.electronics-inc.com or call 1-800-832-5653 (US and Canada) or (574) 256-5001.

ITAMCO Adds Large Gear Grinder to Wind Energy Capabilities

Plymouth, Indiana. Indiana Technology and Manufacturing Companies (ITAMCO) has integrated a Niles ZP 40 gear grinder into its gearing capabilities for wind turbine manufacturers. The ZP 40 grinder is capable of profile grinding external and internal gears with diameters up to 4,000 mm and face-width gears up to 1,750 mm, making it ideal for large planetary systems for wind turbine gearboxes.

"We purchased the ZP 40 gear grinder as an enhancement of our services, but its capabilities are another benefit for our wind turbine OEMs that want a turnkey solution," said David Neidig, Business Development for ITAMCO. "We're one of the few US facilities that can do it all, from cutting to finishing, even heat treating and shot peening."

The hardware and software features of the new grinder will enable ITAMCO to take hours out of the grinding process and ensure a quality level to meet DIN and AGMA standards. The ZP 40 machine features profile grinding with five-axis interpolation—an advantage when dealing with complicated tooth profile and lead modifications. Niles' stock dividing feature performs a multi-point touch probe analysis of every tooth and makes program adjustments prior to grinding, yielding substantial cycle time savings. The eccentricity compensation software assists in faster setups by reducing the time required to indicate large diameter heavy parts. The onboard inspection feature allows for gear inspection immediately after the gear is ground for quick analysis and verification of grinding results. ITAMCO also acquired another Zeiss Coordinate Measuring Machine (Zeiss MMZB CMM) for their Quality Control Lab. The Zeiss machine is ideally suited to verify critical wind energy system components.

The ZP 40 grinder is in a 33,000 sq. ft., climate-controlled grinding area in ITAMCO's Argos, Indiana plant. The area houses eight CNC grinding machines. The 385,000 sq. ft. facility has over 125,000 sq. ft. of 60-foot high bay areas with up to 80-ton lifting capability. ITAMCO has a second facility in Plymouth, Indiana; both have received ISO 9001-2008 certification.

Since 1955, ITAMCO has provided open gearing and precision machining services to most heavy-duty industries including energy, mining, marine, and aviation. ITAMCO is committed to the wind energy market: The company has initiated feasibility studies to determine the viability of powering their facilities with wind and solar energy. Learn more about ITAMCO at www.itamco.com or call (574) 936-2112.

August Discount Deadline for ICSP-11

Discounted Fees for Presenters/Attendees

To receive the discounted rate of $800.00, Presenters and Attendees must register and pay for the conference before August 12. The fee after August 13 will be $1,000.00 per person.

Discounted Fees for Accompanying Person

Guest registration fee before August 12 is $300.00. The fee will be $350.00 after this deadline.

Discounted Fees for Exhibitors

To receive the discounted rate of $2,500.00, exhibitors must register and pay for booth space before August 12. The fee after August 12 will be $3,000.00.

Secure registration is available at www.shotpeening.org. Payment can also be made by check but must be received by deadline to receive discounted rates.

PRI Launches the 2011 Nadcap Supplier Survey

The 2011 Nadcap Supplier Survey opened for responses on June 20, 2011. All accredited Suppliers are encouraged to complete the survey online to give their feedback on their experiences of Nadcap. The official launch coincides with the Nadcap Meeting, a forum for Primes and Suppliers which takes place three times yearly in locations worldwide.

This biennial survey is an initiative of the Nadcap Supplier Support Committee (SSC), which exists to represent and be the voice of the Supplier community. The Committee is made up of active Nadcap accredited Suppliers who are there to help new Suppliers through the process; as well as assisting experienced Suppliers in establishing, maintaining and improving their accredited processes.

This is the fifth issuance of a global aerospace Supplier survey by the Nadcap Supplier Support Committee; previous surveys have been conducted in 2003, 2005, 2007 and 2009. Valid trending data has already been identified and this year's survey will contribute to the overall picture. For example, in 2003, 25% of respondents indicated that in the areas related to Nadcap accreditation, they had seen an increase in Quality; by 2009, that had risen to 83% of respondents to the survey. Take the survey at www.surveymonkeycom/s/2011SupplierSurvey.

Rosler KS Series Wet Blast Machines

Battle Creek, Michigan, USA. Rosler reports that its KS series wet blast machines offer flexible, productive solutions while providing "uniform media flow and unequaled finish control." Standard machine cabinet sizes from 28-60" square and a wide range of sump and media capacities are available.

The KS high-volume wet blast process is a self-contained system which uses a slurry of abrasive media and water to clean, descale and degrease surfaces in a single operation. The slurry is directed through a special high-volume, internally-mounted pump to a blast gun where regulated air pressure adjusts the aggressiveness of the process. The process is free of dust and chemicals, and because it is closed-loop with the media and water re-circulated, there is no need for a drain. It also eliminates waste water pollution and costly disposal methods. Plus, by using water as a buffer between metal and media to cushion the shock and reduce the downward force, KS series wet blasting machines also eliminate the surface impregnation possible in traditional media to part processes. They are ideally suited for cleaning and deburring molds, circuit boards, parts and castings as well as preparing high performance surfaces for etching, matte finishing, peening and texturing.

For more information, please call 1-269-441-3000 or visit the website at www.rosler.us.

Profile Introduces Enclosed Spiral Separator

Rogers, Minnesota. Profile Industries has developed an enclosed spiral separator that reduces the noise level of the separation and prevents debris from mixing with recycled media during the process.

The enclosed cabinet design makes it possible for a worn spiral core to be replaced with a new one. The design also gives the unit more flexibility: The internal spiral core can be changed out with other core flight sizes and the cabinet's inlet and outlet are plumbed into the media recycle system. In less than three minutes, a shot peening operator can change the separator to classify S550 instead of S70, just by replacing the inner spiral core. In the past, to run more than one size media in a peening system, a facility would have needed two to four spiral separators and a diverter from the screen-sizing machine to send the appropriate media to each separator.

Additional benefits of the new design include:

- Dust collection can be added to remove airborn particles.
- Enclosure is powder coated in off-white but can be finished in customer-specified colors.
- Heavy-duty steel construction, also available in stainless steel.
- Maintenance-free: no moving parts and no electricity required
- Flow control options include fine-threaded cone assembly for manual media flow or MagnaValve and controller.
- Recycled media can be transferred into media stream through a transfer pump or manually with steel collection container.
- Cabinet's interior can be accessed by removing clear plastic observation panels.
- Optional interior rubber panels for added noise reduction and reduced cabinet wear.
- Standard configurations include short legs, tail legs, horizontal discharge, vertical discharge, inlet and outlet adapters.
- Custom configurations and designs to customers' specifications are available.
- Media process capacity available in 1000 to 8000 lbs per hours. Increased capacities are possible by adding to modular units.
- Easy to retrofit to wheel and air blast systems, with or without an existing spiral separator.
- Separates metal, shot, metal abrasives, ceramic beads, glass beads and more.

For more information, call Steve DeJong with Profile Industries at (763)428-5858 or visit www.profile-ind.com.

See the new enclosed spiral separator in Profile's booth at ICSP-11 and the Shot Peening workshop in Orlando this fall.

How Accurate is Steel Media Hardness Testing?

I was recently asked why there were variations among laboratory hardness reports for steel peening media. What I discovered in a brief investigation of the supplied reports was interesting and suggests that we need to pay attention to these findings. The hardness range of the sample is 45-52 HRc (Hardness Rockwell C scale). The accompanying illustrations indicate two areas of concern. First, there is a disparity among the laboratory results despite that all the labs were Nadcap accredited. Second, the sample had a higher hardness level than allowed in specifications.

An initial data analysis using only hardness averages indicated that there is, indeed, data scatter. A lab might accept the media if it looks only at the average values and claims that the results are within spec limits. I gained more insight into the data scatter with the histograms on page 41. The histograms made it easier to see that there is something drastically wrong. There should be a way for the labs to synchronize their readings since they are Nadcap accredited.

I'm not only concerned with the differences in the lab results as the sample had a much higher hardness than specifications allow. Figures 1-4 show the individual hardness readings in standard histogram display with the Lower Specification Limit (LSL) and the Upper Specification Limit (USL) set at 45 and 52 respectively. Each graph's readings are near the USL. Figure 5 combines all of the readings of the four graphs into one graphic and here we see that almost half of the data is above the USL. I used another graphical technique to further illustrate the data collection seen in Figure 6. This again shows the combination of all four tests but uses color bars to show how the four evaluations relate to each other.

It's interesting to note that Figure 1-Test 1 has two very high readings. If averaged, the media would meet the specification requirement. But this isn't an engineering college course where students get to "dismiss the data that doesn't fit." This is the real world and two high readings were reported and must be respected.

SAE document AMS 2431, Peening Media General Requirements, refers to ASTM E 18 "Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials." There is, however, a lot more that needs to be considered for a reliable hardness test of media. The following excerpts from SAE J 827 state:

Sample Mounting for Testing

Shot samples used for testing for hardness, microstructure, and objectionable defects shall be mounted one layer deep in Bakelite or other suitable strong metallurgical sample mounting media.

The mounted sample shall be ground to the center of the particles and polished by methods acceptable for microscopic examination. When grinding and polishing the sample, care must be taken not to overheat the sample and affect microstructure and/or hardness.

Hardness Testing

Hardness measurements shall be taken at the half radius on a minimum of 10 particles in the mounted samples.

The hardness shall be determined by using ASTM E 384 and using a 500 g load for sizes HCS S280 and finer, and 500 or 1000 g load for sizes HCS S330 and larger. Other microhardness test methods may be used as long as a reliable hardness conversion can be obtained by calibrating the test machine against known standards. Approximate conversion to Rockwell C Hardness Numbers can be obtained from ASTM 140 and from manufacturers of hardness testers.

If a laboratory doesn't adhere to these guidelines, then erroneous readings are likely to result. The requirement for "one layer deep" is predicated on the likelihood that a lower reading or an unstable reading will result if two shot particles are aligned vertically in the Bakelite. If severe grinding is used, then the shot particles might exhibit a lower hardness due to the tempering effect.

Another facet of this problem is the variables in hardness testing methods used around the world. Europe and Asia tend to use Vickers hardness while the U.S. uses Knoop hardness and converts the values to Rockwell C scale hardness equivalents. (Newbies can look this up on Wikipedia.)

This cursory review leads me to believe that more research is needed which might lead to a spec revision on data scatter. The issue with high-hardness media will have to be reviewed by the media producer.

Figures 1 - 4

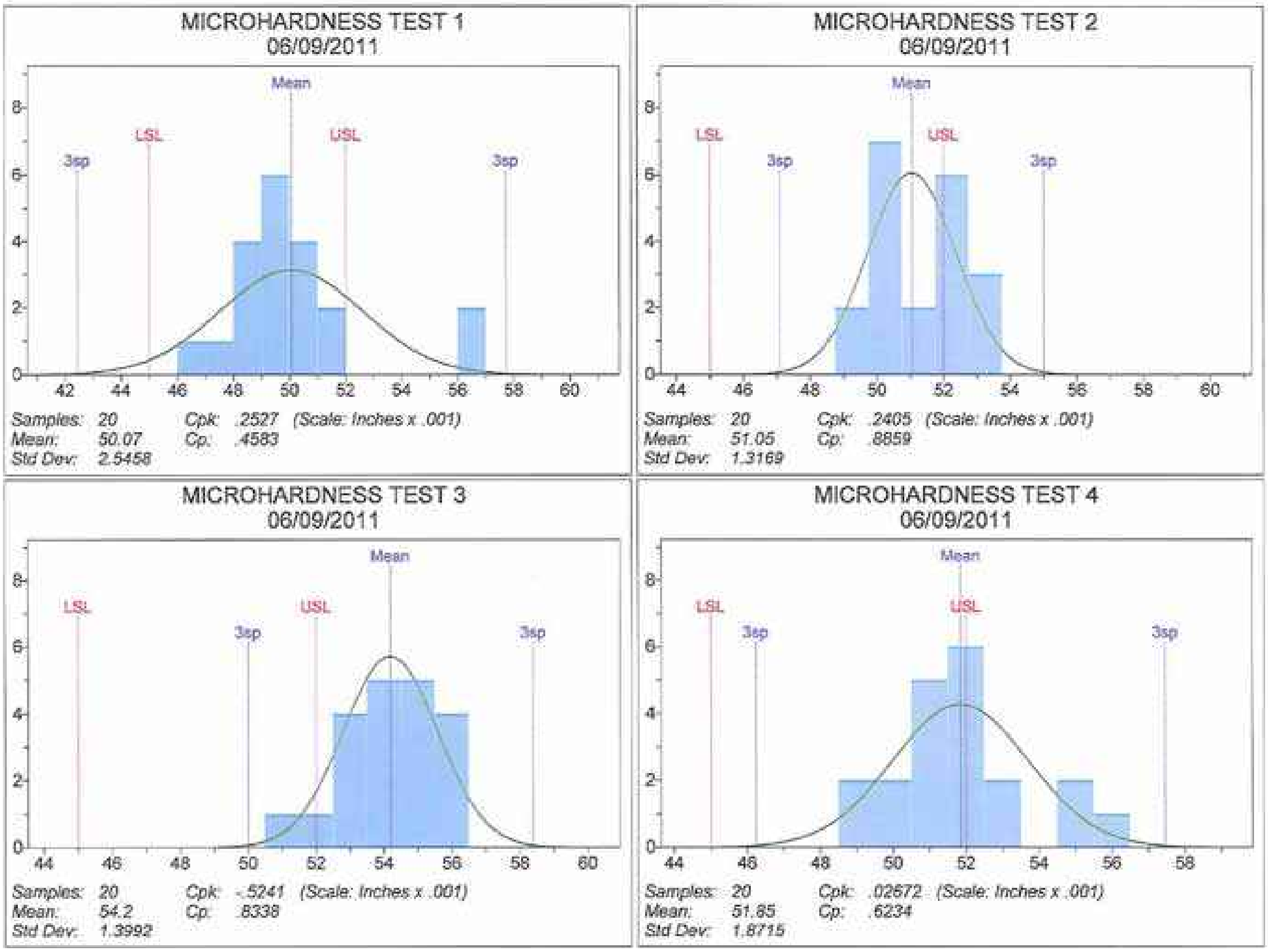

Figure 5

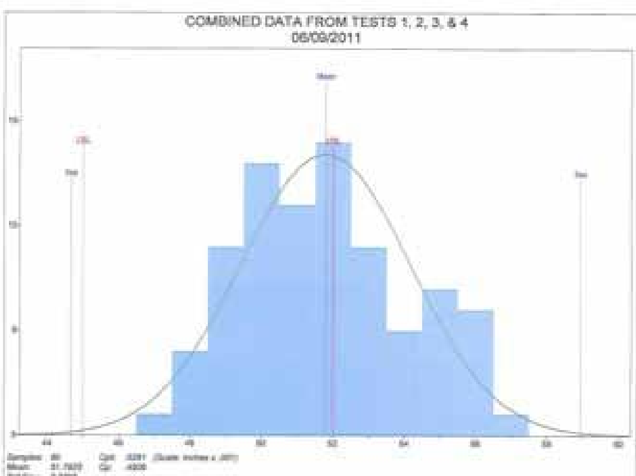

Figure 6