Winter 2019
Volume 33, Issue 1 | ISSN 1069-2010

The Shot Peener

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

Dr. Yuji Kobayashi

THE 2018 SHOT PEENER OF THE YEAR

PLUS: ▮ INTELLIGENT MACHINES 2.0 ▮ MAGNAVALVES: FEEL THE POWER! ▮ TESTING MEDIA DURABILITY USING AIRBLAST ▮ METALS ARE ALIVE!

Peening Innovation

COVERAGE CHECKER

COVERAGE CHECKER

COVERAGE CHECKER the device for easy and precise coverage measurement

Coverge Measurement Device

Easy USB connection to your PC

※PC is not included ※Device image

- Automated coverage inspection eliminates human error
- Multiple operators will get consistent results
- Beginners can measure coverage as skillfully as experienced operators
- COVERAGE CHECKER measures in coil spring bores and other narrow areas
- A nozzle is available to measure coverage in the interior walls of holes
- With the addition of the focus adjustment attachment, COVERAGE CHECKER easily measures curved surfaces
- USB connection to your PC (USB cable is included)
- Compatible with Windows XP,7,8 and 10

※Specifications of this device may be changed without notification.

Positron Surface Analyzer

PSA Type L-Ⅱ

PSA Type L-P

Non-Destructive Inspection

by Anti-coincidence System

US Patent : US 8,785,875 B2

Application

- Shot peening inspection (Inspection Depth : Down to 100 micron)
- Evaluation of Fatigue behavior
- Evaluation of sub-nano size defect
- Free volume on Polymer and Glass

Specification

Device size : Type L-Ⅱ W400 X L400 X H358 [mm]
Type L-P W125 X L210 X H115 [mm]
Positron source : Na-22(under 1MBq)
Option : Autosampler function (4 - 8 stage)

Distributor

Country	Company	TEL	E-MAIL
USA	Electronics Inc.	+1 574-256-5001	sales@electronics-inc.com
CANADA	Shockform Inc.	+1 450-430-8000	sales@shockform.com
EUROPE	SONATS	+33 251-700-494	sonats@sonats-et.com

TOYO SEIKO CO.,LTD.
World Leading Company for Shot Peening
TEL:+81-567-52-3451 FAX:+81-567-52-3457
toyo@toyoseiko.co.jp
www.toyoseiko.co.jp

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

OPENING SHOT

Jack Champaigne | Editor | The Shot Peener

The Power of Patents

Why Patents are Important

Companies can spend a lot of time and money to bring a new product to market and this investment may be protected with a patent. Patents are granted by governments to encourage inventors to share their intellectual knowledge. In exchange, the inventor is granted exclusive use of the technology for a limited time—usually 20 years.

Patent attorneys are often used to file for a patent due to the complex nature of the rules and regulations. There are three main sections of a patent: The abstract, the description, and the claims. Full disclosure of the idea is required in the description to support the claims of the patent and the drawings must completely and clearly illustrate the nature of the device or method being patented.

The claims are the most important part of the patent. Someone practicing any aspect of one or more of your claims is in violation of infringement and you may bring a lawsuit to prevent his/her continued infringement.

My First Attempt to Obtain a Patent—Learning the Hard Way

I appreciate the effort and determination it takes to receive a patent. Electronics Inc. and I have received 14 patents in shot peening control technology, but this was after a very rocky start for me personally. My first submission to the United States Patent and Trademark Office failed to achieve "allowance." To make matters worse, I barely salvaged a nearly disastrous demonstration of my prototype to a shot peening OEM. I modified my claims in the patent application and finally received US Patent 4,523,146 titled "Mass Flow Indicator for Metal Particles" in June, 1985. It essentially stayed dormant since trying to commercialize this concept proved too difficult. But I do have a nice walnut plaque on my office wall.

Dr. Yuji Kobayashi's Patents and His Contribution to Shot Peening

I was impressed with not only the number of patents granted to Yuji Kobayashi, our Shot Peener of the Year, but also the diversity of the projects. (Dr. Kobayashi authored and co-authored 12 patents in the United States and 24 patents in Japan.) I especially like his US Patent 10,022,839 B2 where eddy currents are used to detect if a nitride layer exists. If there is no nitride layer, then the part is exposed to the shot peening process.

And here's what I know after my own experiences with patents: The patents awarded to Dr. Kobayashi represent hard work, perseverance, and an in-depth understanding of the shot peening process.

That's why we were so pleased to recognize Dr. Yuji Kobayashi as the 2018 *Shot Peener of the Year*.

At the US Shot Peening workshop, the Electronics Inc. staff surprised Dr. Kobayashi with 12 commemorative plaques—one for each of his US patents.

THE SHOT PEENER

Editor
Jack Champaigne

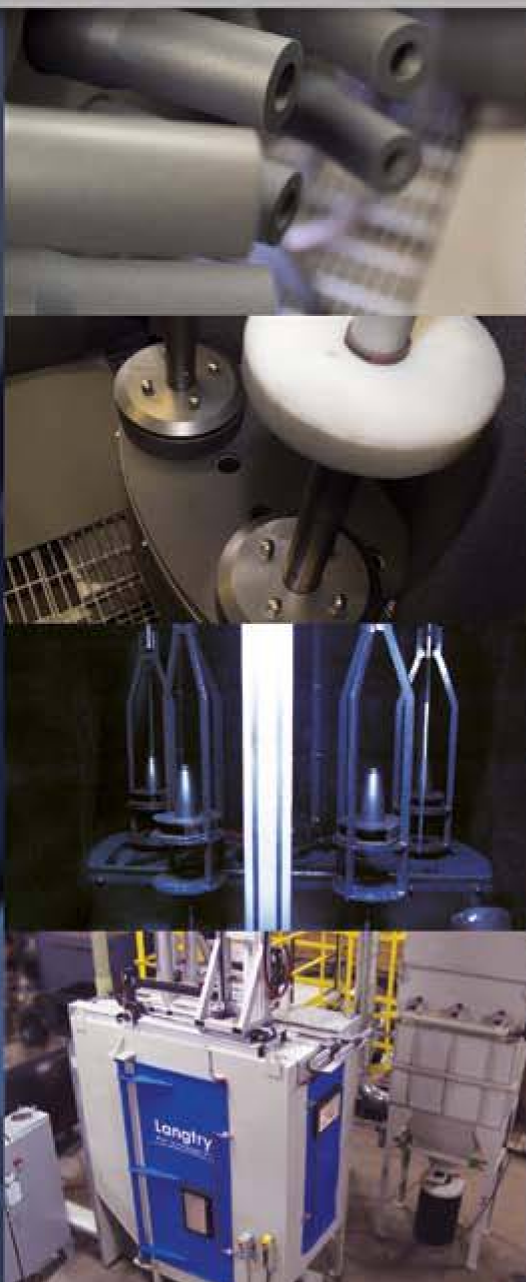
Associate Editor
Kathy Levy

Publisher
Electronics Inc.

For a free subscription of the *The Shot Peener*, go to www.theshotpeenermagazine.com

The Shot Peener
56790 Magnetic Drive
Mishawaka, Indiana, 46545 USA
Telephone: 1-574-256-5001
www.theshotpeenermagazine.com


POWER ON


Langtry

2018 Shot Peener of the Year
Dr. Yuji Kobayashi

SINCE 1992, *The Shot Peener* magazine has given "The Shot Peener of the Year" award to individuals in our industry that have made significant contributions to the advancement of shot peening. *The Shot Peener* staff was pleased to give the 2018 award to Dr. Yuji Kobayashi.

"Dr. Kobayashi was selected because of his extensive efforts to improve the shot peening process as evidenced by his receipt of 36 patents for shot peening methodology and equipment design. In addition to his job responsibilities at Sintokogio, Dr. Kobayashi contributes to the industry through his volunteer work. He is an active member of the SAE Surface Enhancement Committee and the Aerospace Surface Enhancement Committee. He was elected to membership into the International Scientific Committee on Shot Peening in 2008," said Jack Champaigne, Editor of *The Shot Peener* magazine.

We are very pleased that Dr. Kobayashi answered the following questions for us. His answers provide more insight into his contributions to our industry.

The Shot Peener: What are your job responsibilities at Sintokogio?

Dr. Kobayashi: I work in Research and Development in shot peening and shot blasting.

The Shot Peener: What is your work history?

Dr. Kobayashi: I have worked at Sintokogio for 22 years. Before that, I worked at Toyota for three years.

The Shot Peener: In addition to your contribution to the SAE Surface Enhancement Committee, the SAE Aerospace Surface Enhancement Committee and the International Scientific Committee on Shot Peening, do you belong to shot peening societies in Japan?

Dr. Kobayashi: Yes, I am a board member of the Japan Society of Shot Peening.

The Shot Peener: Receiving 12 US patents and 24 patents in Japan is quite an accomplishment. Was there a patent-related project that was especially interesting or rewarding to you?

Dr. Kobayashi: The patent on shot peening for water cooling holes of die casting die is interesting as an original process. In addition, I believe that patents related to X-ray residual stress measuring instruments that can be used in-line are types of patents that were not found at Sintokogio until now. I applied for 38 domestic applications in Japan in 22 years of experience and 24 patents were established. I think that this is perhaps the most among Sintokogio.

The Shot Peener: Have you published research papers on shot peening?

Dr. Kobayashi: Yes. The following were my first published papers:

- *Effect of Shot Peening on Mechanical Properties of Magnesium Alloys:* Journal of Material Testing Research Association, vol. 55, No. 4 (2010), pp. 165-172.
- *Influences of Mechanical Properties and Retained Austenite Content on Shot-Peening Characteristics:* Transactions of Japan Society for Spring Research, vol. 57 (2012), pp. 9-15.

I have co-authored 11 papers. The most interesting thing in the most recent paper is about fatigue strength of 3D printed material.

- *Influence of Shot Peening Treatment on Rotating Bending High-Cycle Fatigue Properties of Additive Manufactured Maraging Steels Material:* Kiyotaka Masaki, Yuji Kobayashi, Yuta Mizuno, Journal of the Society of Materials Science, Japan, vol. 67, No. 10, pp. 891-897, Oct. 2018.

The Shot Peener: What are your thoughts regarding receiving the 2018 Shot Peener of the Year award?

Dr. Kobayashi: I think that it is a very honorable thing. In Sintokogio, equipment designers and sales personnel for equipment are subject to respect, but research and development are not so. For young researchers, this award also has a big impact.

Sintokogio employees helped Dr. Kobayashi celebrate his receipt of the 2018 Shot Peener of the Year award.

PREMIER

PREMIER SHOT COMPANY

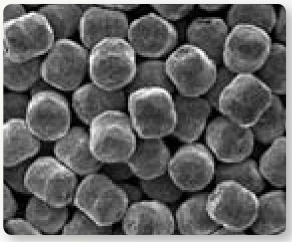
1666 Enterprise Parkway Twinsburg, OH 44087

A Cut Above

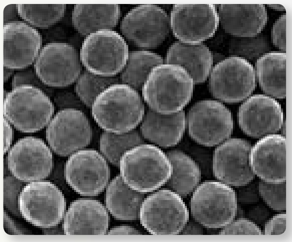
The advantage of Premier Cut Wire Shot

- **Highest Durability** Due to its wrought internal structure with almost no internal defects (cracks, porosity, shrinkage, etc.) the durability of Premier Cut Wire Shot can be many times that of other commonly used peening media
- **Improved Consistency** Highest consistency from particle to particle in size, shape, hardness and density compared to commonly used metallic media.
- **Highest Resistance to Fracture** Premier Cut Wire Shot media tends to wear down and become smaller in size rather than fracturing into sharp-edged broken particles, which may cause surface damage to the part.
- **Lower Dust Generation** Highest durability equals lowest dust levels.
- **Lower Surface Contamination** Cut Wire Shot doesn't have an Iron Oxide coating or leave Iron Oxide residue — parts are cleaner and brighter.
- **Improved Part Life** Parts exhibit higher and more consistent life than those peened with equivalent size and hardness cast steel shot.
- **Substantial Cost Savings** The increase in useful life of Premier Cut Wire Shot results in savings in media consumption and reclamation, dust removal and containment, surface contamination and equipment maintenance.

As Cut



Normal Conditioning



Special Conditioning

Premier Shot Cut Wire Products for

Automotive • Medical

Aerospace Applications Worldwide

(330) 405-0583

1666 Enterprise Parkway,
Twinsburg, Ohio 44087

premiershot.com

Ken I'Anson | Sales Engineer | Progressive Surface

Intelligent Machines 2.0

INTRODUCTION

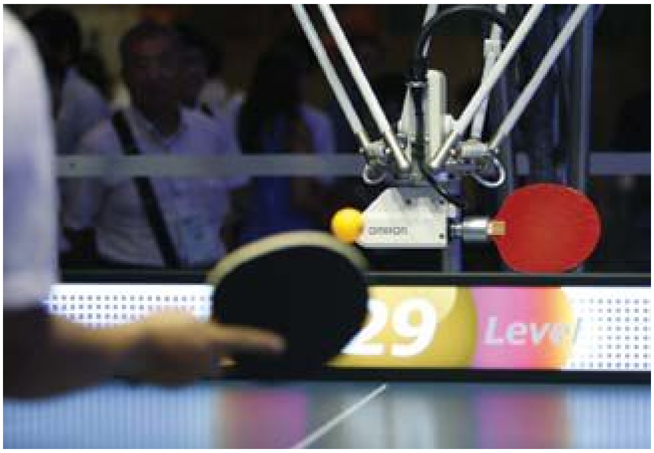
I was pleased to see Kumar Balan introducing the subject of Artificial Intelligence (known as AI) to the Shot Peener subscribers recently in the Summer 2018 edition ("Emerging Technologies and Blast Machines"). Kumar didn't quite ask if the Shot Peening industry was ready for AI or not, but I'll attempt to crack the door open, exposing some light on current examples that show tremendous possibilities, then try concluding if it is AI.

Wikipedia describes AI as, "Intelligence demonstrated by machines, in contrast to the natural intelligence displayed by animals and humans." The description goes on to say, "The term artificial intelligence is applied when a machine mimics cognitive functions that humans associate with other humans such as learning and problem solving."

For a device or system to operate in the AI world, sensors must interface with the surroundings or environment with human-like senses including sight/light, touch/force, sound, temperature and smell. All these sensors are already used in common commercial applications and they are just waiting to be adopted by our industry, Shot Peening!

AI Demonstrations and Applications

Here are some fun examples of AI that are out in the human world right now. The Japanese automation/parts maker Omron has demonstrated AI at several trade shows and conferences, much to the amusement of humans. Omron's "Forpheus" is a table-tennis playing robot that has done well with all levels of challengers to the point that now it can return the table-tennis ball within 50 mm of the destination and can rank its human opponents as beginner all the way to expert.



Omron has developed a table-tennis playing robot named "Forpheus."

Budweiser and OTTO have driven a transport truck, filled with cases of beer, on a 120-mile (200 km) delivery with the driver in the cab but not driving the truck. The driver guides the transport to the highway and then engages the AI. The truck drives the route without any further driver intervention until the truck exits the highway near the delivery location. YouTube has a great video of this demonstration. As another example, early in 2018, Starsky Robotics demonstrated their AI abilities with a completely driverless vehicle over a 7-mile (11 km) route. Wow.

I'm sure we've all seen television car commercials where a car parallel parks itself perfectly with the driver in the car but not touching the steering wheel. This feature was designed by Toyota in 1999 and it is called the Intelligent Parking Assist System (IPAS). Now you can find this convenience on several cars around the world. The system works by the driver finding a parking spot they like and driving just past it. The IPAS is activated, and the car begins to back into the chosen parking spot. Perfect!

Author's note: I recently rented a car with this feature, but I wasn't brave enough to give it a try by wedging between two unsuspecting parked cars that I didn't own. I'm sure everything would have worked out fine, but I didn't want to leave windshield notes for new friends that I'd met by accident.

Shot Peening Example

Recently, Progressive Surface had the privilege to design and commission a shot peening version of IPAS. I describe this system like an IPAS feature simply because we still require the operator to select the feature to be peened, and once the shot peener controller is engaged, the part feature is located, checked, confirmed and processed. Just like parallel parking!

The shot peening industry has struggled to peen small diameter oil holes in Low Pressure Turbine shafts (LPT shafts) for decades. The LPT shaft oil holes were once considered too small to peen by entering the bore. The shot peening industry answered this problem with the development of very small rotating deflector nozzles or lance nozzles. Accurate and repeatable shot flow control has been available for over 30 years; however, accurate control of very low media flows were developed to meet the need. At this point, shot peen operators could now access the oil hole bores by inserting very small diameter lance nozzles and the media control was reliable enough that small lances didn't become plugged with media. Great!

The next problem to overcome was getting the small lance into the oil hole bore on a production basis without damaging the LPT shaft or the carbide lance. This process required the shot peen operator to enter the peening cabinet, get their face and eyes very close to the target and line-up the lance and bore with very little margin for error. The operator/visual alignment process was hampered since the operator was forced to view these two components—the hole and lance—from the side and not directly overhead.

Two planes of view would be helpful, three planes of view would be perfect, and neither is possible with the operator alignment method. This is due to the physical size of the lance nozzle rotating device and the length of the LPT shaft. Perfect alignment proved to be difficult and misalignment would cause contact.

The following are application-specific parameters for the LPT shaft.

- Hole Size – 4 mm dia x 12 mm depth (0.156" dia x 0.50" thick)
- Shaft Diameter – ranges between 80 mm to 155 mm
- Number of Holes – depending on the part, holes range from 4 to 16 on a single shaft.
- Lance Size – 3.0 mm OD (0.122" OD)

Our customer no longer wanted the operators to be responsible for the lance-to-hole alignment and the consequences if the alignment wasn't perfect. Our customer also stated they wanted us to apply the "maximum automation" required to solve this problem.

Our first step was to fabricate metal tubes that represented the LPT shaft with oil holes. We then fabricated a set of precision rollers, added motion control, and then placed a test robot adjacent to the test stand. Bravely we purchased a precision industrial camera, mounted it over the shaft and proceeded to fail miserably locating the oil holes!

We learned a hard lesson on locating a small diameter hole on the surface of a cylindrical part. Perpendicularity was paramount. Basically, if the hole wasn't 100% perpendicular to the lance, the hole opening appeared reduced in area for the approach of the lance. A tight clearance situation now became tighter!

We quickly realized how difficult this application was. The following few weeks saw a flurry of e-mails back and forth with vision companies and specialists, only to find that we had exhausted the current state of technology. If the hole was located on a very thin metal cross-section, the angular error wouldn't be too bad, but in this application the hole diameter to length ratio was 3:1. If the shaft was misaligned by 5 degrees, the lance would collide with the part.

The camera technology could easily find a dot on a shaft with no problem. If the hole was tapered—smaller at the far end—the camera could align the two circles concentrically within each other and provide perfect alignment. We asked the customer if the operator could apply a mask over the hole with a larger cut-out that the camera could identify as

Loading a low-pressure turbine shaft for peening.

two circles. An aiming device if you will. "No, maximum automation" was the reply.

OK, stay calm and march on. We concentrated on camera imaging, trying to find a way to enhance the observed image to the point that we found the machined shaft surface caused the built-in camera lighting to create nasty reflections, distorting the feature image we're trying to locate. Our project success was starting to look pretty bleak, or maybe even dark.

Then a breakthrough and as Bob Dylan once sang, "the darkest hour is right before the dawn." Our engineering team realized the light reflections could be used to locate the hole. With some advanced programing, we could rotate the shaft clockwise or counter-clockwise to align the hole image with the reflections.

The original intent was to have the camera mounted in the peening cabinet, but once we realized how important the lighting, reflections and stand-off were, we decided to mount the camera to the robot.

We added additional sensors to the shot peen cabinet and they act as digital micrometers to ensure the lance and clearance probe are not damaged. The gauging system also checks the geometry of the robot tools to ensure they are correctly located within very tight tolerances.

The final feature was a wall-mounted Almen strip holder with a shaded-strip mask, representing the exact hole dimensions being peened. Once the Almen strip test is confirmed, the hole peening program is commenced and the shot peening system continues and operates in complete automation.

I don't think the above described system operates much different than the IPAS parking assist. Both systems depend on the driver, or as in the shot peening example, the operator, to get the unit near the intended location. Then with several drives, sensors, feedback and software all working in concert, they complete a human task with 100% accuracy without human intervention. Is this AI you ask? I think it's pretty darn close.

Conclusion

It's my opinion that our Shot Peening industry lives in a zone between two powerful forces—on one side we have a fairly traditional, show-me type industry that hangs on to Almen strips with all the misgivings and opportunity for errors. And on the other side, we have a sensor and control industry that shows so much promise with critical gauges, controllers, sensors, and even 3D scanners that create point cloud images of complex parts. This technology could possibly perform all the part programming for shot peening in the future.

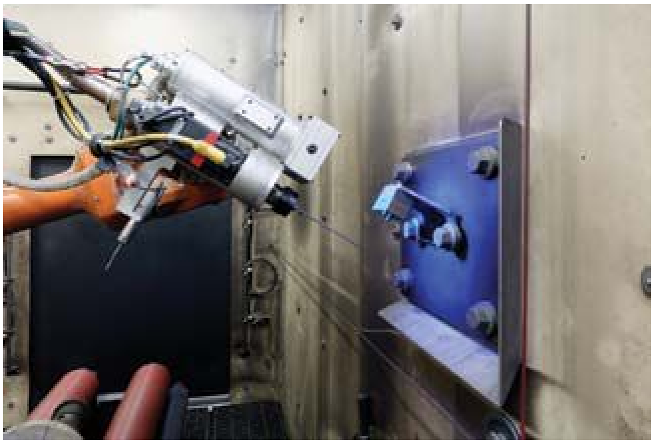
I don't believe it's too great of a stretch to think that powerful software packages could take a 3D model file and apply the correct peening intensity and coverage requirements to achieve the best shot peening benefits for that part. Who knows, maybe there's a University Ph.D. Student working on this solution right now.

As I look back on a 40-year career in shot peening, I remember working with crude analog gauges, cumbersome fixtures that were actual parts with many Almen strip holder blocks and making saturation curves on graph paper using a french curve template. I can see how far we've come. The practice of shot peening has never been so accurate, repeatable and well defined as it is in the current state using modern tools and intelligent equipment.

I'm encouraged as a participant in the latest series of sensor-based and flexible shot peening systems, that they will someday be the industry norm.

Does AI have a place in shot peening? I believe it's just around the corner and frankly, I can't wait!

Author's note: The end user and part owner wished to remain anonymous; therefore, we have not shown the actual LPT shaft and shot peening machine.



Camera locating the simulative hole in an Almen strip holder.

Rotary lance entering the hole of a shaded Almen strip.

Stainless Steel Components for the Energy Industry

MARKET: Energy

APPLICATION: Abrasive blast cleaning of stainless steel components for cosmetic reasons and to eliminate the need for additional finishing.

THE CHALLENGE:

A major manufacturer of stainless steel components for the power generation industry needed the ability to improve the appearance of the stainless steel surface to make it more homogeneous and in turn eliminate the need for painting or additional finishing.

Specifically, they wanted to remove discoloration due to welding, machining and tooling marks, and scratches from the manufacturing process. The housings were produced in various sizes and weighed up to 3,500 pounds each which made it challenging to handle and manipulate. Due to the extreme weight, the shipping costs to and from subcontractor were a major factor. Quality was also a major concern as a single unit could sell for as much as $100,000. As a result, they were looking both to bring this process in-house and to find an automated minimum labor solution that would guarantee a consistently high quality finish every time.

THE SOLUTION:

Empire technical sales personnel and application engineers met with the manufacturer to evaluate the current process and determine their requirements. As a result, Empire developed and installed a custom engineered and automated abrasive blast cleaning system that was able to accommodate large, heavy parts.

The overall system measured 20' wide x 26' long x 20' high. Designed to fully process components of various sizes, the system employed a fully automatic 11-axis robotic system with turntable and a special lift enclosed in a two-story blast room with an extension for loading. Due to the large size and shape of each component, special fixturing was designed to secure them on the turntable for processing. A crane located outside of the blast room was utilized to manually load a component on to the fixture. Once loaded, a servo motor would automatically move the component into the blast chamber and close the door to seal the enclosure.

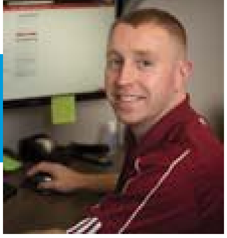
A key feature of the system was the ability to automatically blast all of the components' surfaces, including those covered by the fixturing. Once inside the enclosure, a six-axis robotic arm will automatically blast one side of the upper section of the component. The turntable will then rotate 180˚ to allow blasting of the opposite side of the part. Due to the fixturing required to hold this heavy part, the robot was not able reach the lower areas. Since the components were shaped like an upside down "U", Empire's engineers designed a special hydraulic manipulator that grabbed them under the upside down "U" and lifted them out of the fixturing. This allowed the robot to blast one half of the bottom and, after a servomotor rotated the hook, the other half can be processed.

To enable precise coverage of all surfaces on the component, the robot controller utilized Robot Master software to govern the operation of the robotic arm. A key feature of the software is the ability to simulate and view all motions in advance during the design stage to ensure there would be no collisions or out-of-path areas prior to actually building the system. This was also a big advantage as the amount of workspace required for the system was a concern. Being able to precisely simulate the robot's path allowed Empire to design a system that efficiently utilized the space required for blasting and resulted in an optimal size room that ultimately saved valuable workspace.

Additional features of the unit included lower and upper glove ports and conveniently located manual nozzles inside the blast enclosure for touch-ups. A man lift was also employed so workers could easily reach the upper glove ports in order to blast areas at the top of the seven-foot component.

BENEFITS:

Empire was able to supply an abrasive blast cleaning system with precise robotic control of blast areas and material-handling features that not only increased productivity, but also assured repeatability—a major concern in this quality-intensive application that affected the manufacture of critical components. The housing manufacturer was able to reduce costs, improve the overall turnaround time on their products, and maintain greater control over final product quality.



ENGINEERING NOTES

Bryan Chevrie | Product Engineer | Electronics Inc.

MagnaValves: "Feel the Power!"

YOU MIGHT REMEMBER from my last article that my wife and I set out on a journey to become Spartans. Well on the 20th of October in the year 2018 we stormed the Toyota Stadium and walked away VICTORIOUS! It was so much fun and yet challenging. I was able to overcome all obstacles presented before me, but one. The Spear Throw. If I was living in Sparta in 435 B.C. and I threw a spear the way I did that day, I would have been dragged behind a horse until dead.

Figure 1: Becky and I are Spartan!

Next year, I plan on going for the Trifecta and I will nail the spear throw. For those that don't know what a trifecta is, it is three races (a 5+ km, a 13+ km, and a 20+ km) all in the same calendar year.

In the continuing pursuit of successful MagnaValve® installations, I am going to discuss power supply connections and requirements. I know for some, this sounds like simple stuff. It is only three little connections. How in the world could someone screw that up? But we see MagnaValves and controllers in less than ideal installations all the time.

On the surface, it seems so easy: Connect the positive supply, the common, and ground, and you're done. Well you must start by selecting a proper supply. Most people get that correct; however, everything that is connected to that supply draws current from that supply and these currents MUST be managed. This is where everything falls apart.

Many people understand that current leaves the supply and travels down a wire to some device, such as a MagnaValve. However, some people fail to consider that this current must return to the power supply from which it came. The layout, path, and all the connections within this loop are very important.

To add complexity to this problem, there is the return current path back to the supply and there is ground. These are NOT the same thing. But they often get treated like they are the same thing. Bruce Archambeault stated it perfectly in his book titled "PCB Design for Real-World EMI Control." He wrote, "If inductance is one of the most commonly misunderstood concepts, 'ground' is the MOST misunderstood."

Earth Ground

Let's talk a little about Earth Ground to start with. Earth Ground is just that—the big round thing that you stand on, or that thing you hit when you slip on ice. The earth has an electrical potential; we call this potential 0V and often we use that as a reference. Everything else that sits on or floats above it has an electrical potential that is greater than, less than, or equal to the electrical potential of the earth.

Humans can become a path for current to travel between two objects that has an electrical potential greater than or less than 0V. If this current is great enough, it will make for a very bad day for that human. Sometimes this is done intentionally—it's called the electric chair.

To prevent humans from touching things they shouldn't touch and to protect the stupid ones, we put metal boxes around everything that has an electrical potential greater than or less than the earth. Then we take a wire and bond those metal boxes to the earth. That way we can ensure that both the metal boxes and the earth are at the same electrical potential. As a result, when a human is standing on the earth and touches one of those metal boxes, they don't "feel the power." That is called Earth Ground, not to be confused with Chassis Ground, which is different.

Chassis Ground

Chassis Ground, in the simplest form, is using the body or chassis of the equipment as the ground connection point for all electrical devices that are bolted to the equipment.

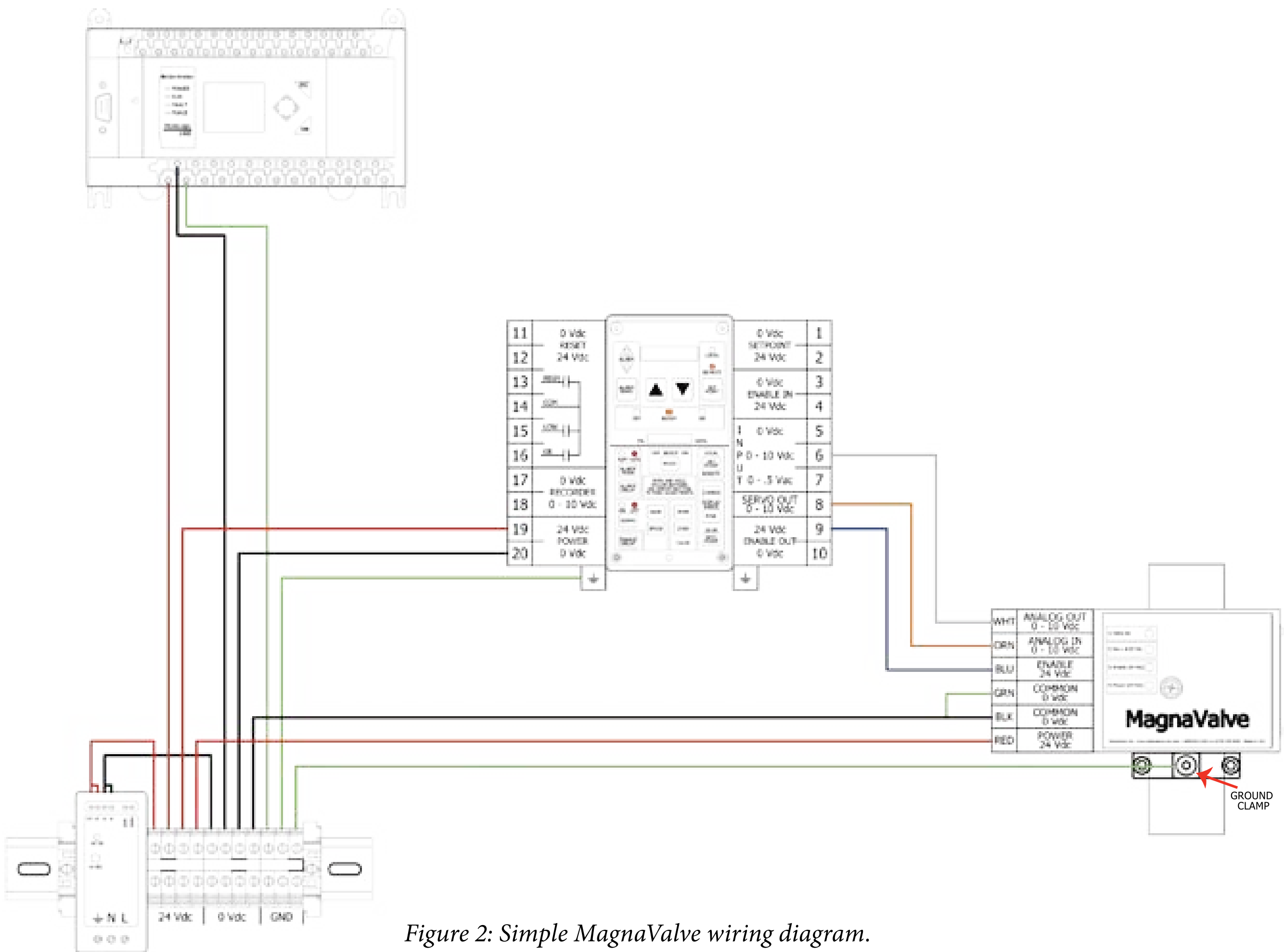


Figure 2: Simple MagnaValve wiring diagram.

It's a giant terminal block, if you will. The equipment is then connected to Earth Ground. An example of this might be all the electrical conduit and plumbing on a peening machine. To have a wire connect to each pipe fitting or conduit fitting would not be feasible. Therefore, all the piping, conduit, and fittings are manufactured from metal and attached to the machine using metal fasteners. Now if the machine is properly attached to Earth Ground, any human that touches the conduit, plumbing, or the machine itself will not have a shocking experience.

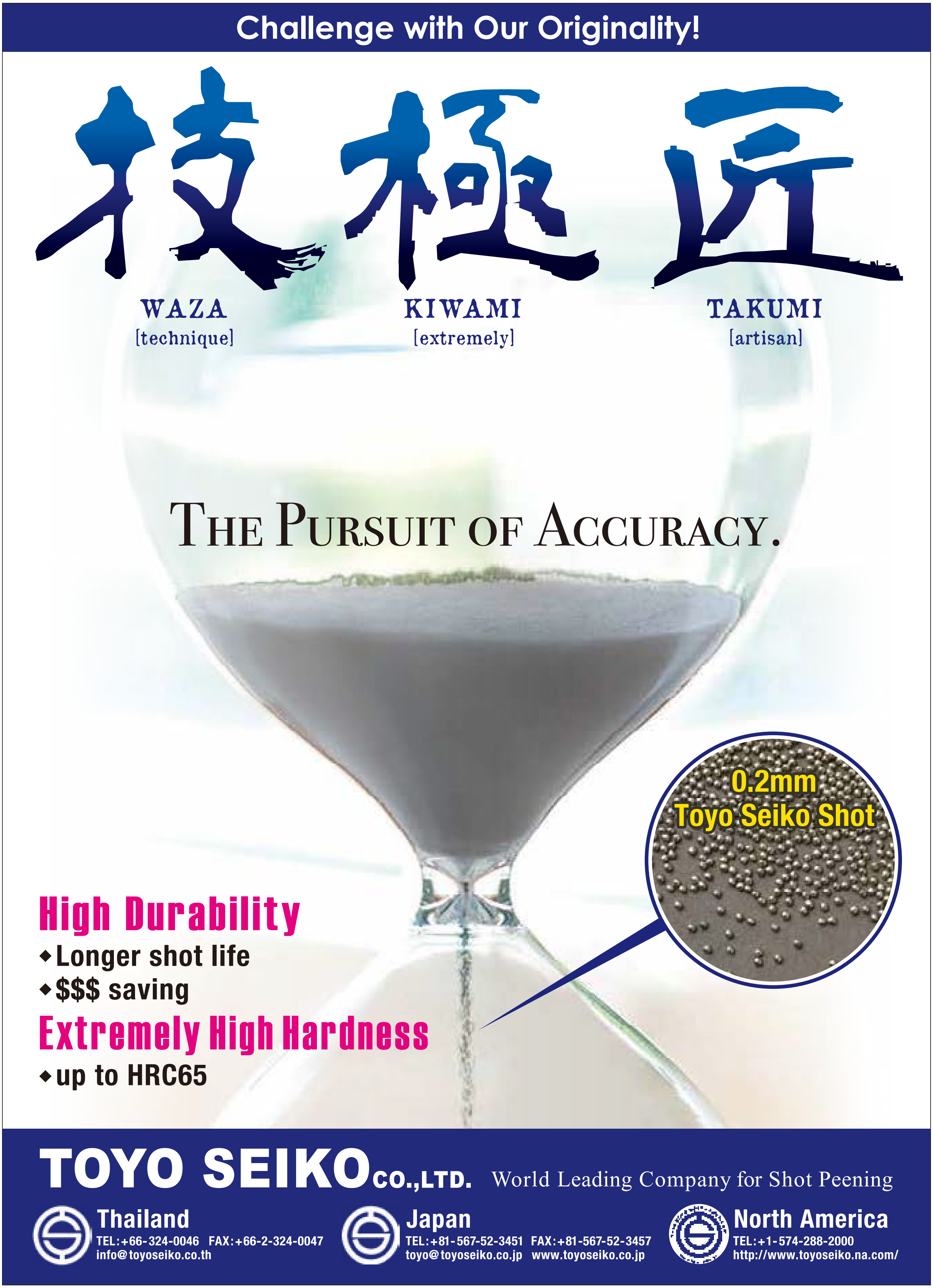
Another example of Chassis Ground is the transient and over-voltage protection in the MagnaValve. Any time there is voltage surge on the supply lines or an ESD (Electrostatic Discharge) to the enclosure of the MagnaValve, all the excess energy is redirected to the pipe of the MagnaValve. (Variable Frequency Drives for motors use this same technique; more on that in a later article.) The pipe is typically grounded through the plumbing of the machine. If the plumbing is not a sufficient grounding connection, then a ground clamp (see Figure 2) could be purchased to connect the MagnaValve directly to the ground bar in the panel.

Shielding

Shielding, which has a very specific function, is unrelated to human safety. Shielding could be required for a device or wiring to a device. This shielding maybe necessary for the safety of the device or to prevent electrical magnetic interference to the device itself or other devices close by.

One example of shielding is in switching power supplies. If you have ever looked at a switching power supply and thought to yourself, "Boy they sure put a lot of effort into the enclosure. They had to punch all those holes in that cool pattern and bend all those flanges so neatly." That wasn't done to look nice—that metal enclosure must be connected to Chassis Ground or Earth Ground and it picks up and redirects all the magnetic radiation that the electronics are creating to the Chassis or Earth Ground. This prevents that magnetic radiation from interfering with electronics close by that may be sensitive to magnetic radiation.

Another example of shielding is a shielded cable. Many controls engineers and panel electricians never give much thought to what happens when current travels through a wire. As current travels through a wire (specifically an AC power


Challenge with Our Originality!
技極匠
WAZA
[technique]
KIWAMI
[extremely]
TAKUMI
[artisan]
THE PURSUIT OF ACCURACY.
0.2mm
Toyo Seiko Shot
High Durability
◆Longer shot life
◆$$$ saving
Extremely High Hardness
◆up to HRC65
TOYO SEIKO CO.,LTD. World Leading Company for Shot Peening
Thailand
TEL:+66-324-0046 FAX:+66-2-324-0047
info@toyoseiko.co.th
Japan
TEL:+81-567-52-3451 FAX:+81-567-52-3457
toyo@toyoseiko.co.jp www.toyoseiko.co.jp
North America
TEL:+1-574-288-2000
http://www.toyoseiko.na.com/

signal, a pulse, or a PWM), a magnetic field is generated surrounding that wire. As current travels in one direction, the magnetic field expands and if it stops or changes direction, the field collapses. And the opposite will happen when a wire is located in an expanding or collapsing magnetic field—a current is generated in the wire.

If there are two wires in a conduit and there is a changing current traveling through one of the wires, the magnetic field surrounding that wire will be expanding and collapsing. The other wire located in the same conduit will be experiencing the expanding and collapsing magnetic field and therefore will have a forced current travel through it. This poor routing could induce noise in a sensor signal or cause a PID loop to become unstable along with various other problems. Proper panel layout and proper wire routing will prevent these types of problems from occurring; however, when there is no forethought in planning the panel layout and how the wires should be routed, shielded cable often become the band-aid to fix a problem that should have never existed.

Supply Selection

One of the questions that is often asked is, "How big of a supply is needed to operate a MagnaValve?" We recommend 2A per MagnaValve / controller combo. Some MagnaValves use less current than others, but 2A per valve and controller is a good rule-of-thumb and will work for all MagnaValves.

Figure 2 shows the start of a typical installation. Here we have a 5xx-24 MagnaValve, a FC-24 controller, a PLC, and a 24 Vdc power supply. The 24 Vdc supply will supply power to the controller, MagnaValve and PLC.

In this example, the 5xx-24 MagnaValve is the device that will pull the most current from the power supply. And more importantly, the MagnaValve uses a PWM signal to control the flow rate of shot. Figure 3 shows the current and voltage waveforms for a MagnaValve set to 50% duty cycle and powered by a 24 Vdc @ 2A supply. Notice there

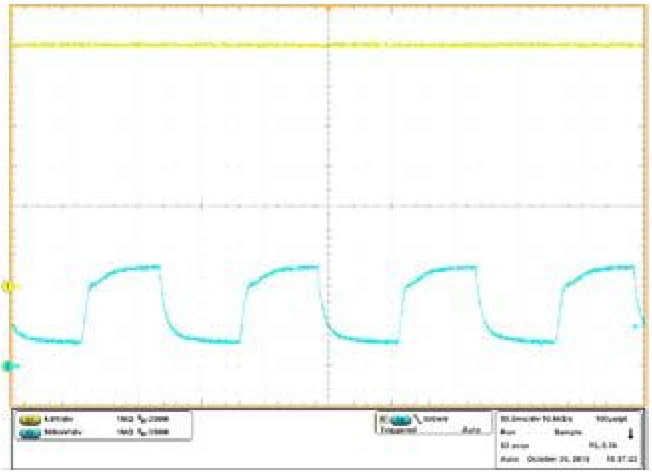


Figure 3: Normal MagnaValve operation at 50% duty cycle with 2A supply.

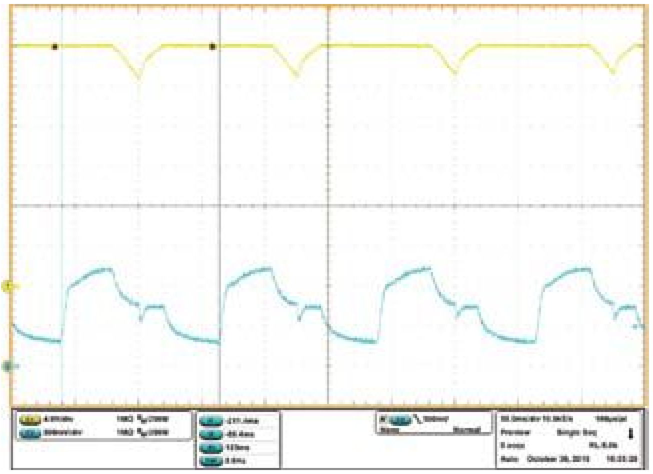


Figure 4: MagnaValve operation at 50% duty cycle with 0.75A supply.

is approximately 1.25A for current draw and no clipping or voltage droop.

You might be wondering, "What would happen if the supply was too small?" Very good question. Figure 4 shows the same setup but using a 24 Vdc supply with a 0.75A limit. Notice the current and voltage waveforms. There is approximately 3.5 Vdc of droop on the voltage supply and an excessive amount of distortion in the current. Not only does this affect the performance of the MagnaValve, but it also creates high-frequency harmonics that could disrupt nearby sensitive electronics.

A few additional considerations: In Figure 3 notice that this is a changing current (pulsing) and it has the potential to cause interference in sensitive electronics. The power supply wires for this device MUST be routed with care. It is highly recommended that the power supply wires to the MagnaValve be connected to the power supply terminal block in a STAR connection (see Figure 2). This means a direct connection to the terminal block without daisy chaining to other devices. If more than one MagnaValve is installed on a machine, each MagnaValve must have its own connection directly from the terminal block.

I hope these articles are taking some of the mystery out of that Black Box known as the MagnaValve. I will keep revealing the hidden secrets. For next time, there is plenty more on grounding, panel layout, and routing.

About Bryan Chevrie

Bryan Chevrie is a Product Engineer with Electronics Inc. In addition to the research and development of new products, Bryan provides product support and conducts classes in shot analysis and media masking at the EI Shot Peening Training seminars and workshops. Before his employment at EI, Bryan worked at K & R Electric as a Commercial/Industrial Electrician. He earned the rank of Sergeant in the United States Marine Corps Reserve during his six years of service.

Control

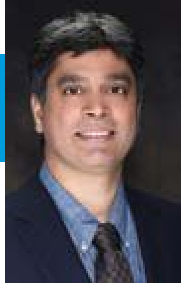
Empire Abrasive Equipment continues to lead industry with best in class peening and grit-blast solutions. Our highly controlled air-blast and recovery technology enables quicker production times. Our multi-discipline team of experienced engineers, along with state-of-the art manufacturing and testing facilities, deliver solution driven designs for a diverse range of industries; from aerospace and automotive to energy and medical.

For over 70 years, we've been perfecting air-blast technology. Today, Empire has the most extensive range of advanced solution-driven equipment to exact any of your air-blast needs.

Let Empire engineer your competitive edge.

EMPIRE
ABRASIVE EQUIPMENT

Empire Abrasive Equipment | 2101 W. Cabot Blvd. | Langhorne, PA 19047
215-752-8800 | Airblast@Empire-Airblast.com | www.Empire-Airblast.com



AN INSIDER'S PERSPECTIVE

Kumar Balan | Blast Cleaning and Shot Peening Specialist

Testing Media Durability Using Airblast

INTRODUCTION

In the Fall 2017 issue of *The Shot Peener*, we discussed a similar topic, "The Critical Role of Metallic Shot in Achieving Consistent Shot Peening Results." Our focus then was to determine the durability and transmitted energy of blast media using the Ervin Test Machine. I used J445 as the guideline, specifically the procedure as described under 5.3: "100% Replacement Method." The topic involved using a centrifugal blast wheel type system to test durability and characterize critical media properties. Although a valid and time-tested procedure, it is limited to metallic media only.

Airblast nozzles are commonly used when cleaning or peening with non-metallic media. This type of propulsion generates greater momentum and is most effective for this media type. Additionally, velocity generated by using air-type media propulsion systems could be significantly higher than that with centrifugal blast wheels. For example, an 18" blast wheel running at 3600 RPM generates media velocity of about 360 feet per second, which is still a fairly high velocity for most cleaning and peening applications. In contrast, a long, wide-throat venturi nozzle at 90 PSI can develop a velocity of 535 feet per second (source: Abrasive Blast Cleaning Handbook, A.B. Williams). At this velocity, blast (and peen) media impact and failure characteristics are much different than when propelled from a blast wheel. Such high air pressures and velocities are quite common in manual airblast cleaning applications as well as when shot peening truck transmission components, mining bits, and railroad accessories.

Here, we will focus on developing a technique for testing media characteristics in an air-type propulsion system.

PURPOSE AND TEST CRITERIA

Media breakdown has several ramifications; the obvious one being the "nick" on the component caused by a sharp, fractured particle of metallic media. Incorrect size (i.e., broken media) of media can lead to improper transfer of impact energy. The breakdown of media may not be immediately visible and it can be disastrous. In general, media degradation, if gone unnoticed, can lead to catastrophic results. Shot peening machines are typically equipped with classifiers and spiral separators to keep media quality in check, but it's still critical to know the media's operating limits.

Media selection is generally not a luxury available in shot peening, but it is possible in blast cleaning and critical to the economics of the cleaning operation. Except for a few manual peening processes, the majority of shot peening applications using nozzles are automated. In contrast, in the world of contract blasting, the majority of cleaning projects are manual, with air pressures in the range of 90 to 120 PSI, or as high as can be generated by their compressed air system. Therefore, testing media durability under these circumstances becomes imperative.

Versatility in such a test machine is important and should ideally address key variables in an airblast process. Listed below are the common ones.

Enclosure. Despite that it is not easy to control the proliferation of a blast stream discharged from a nozzle, it is critical that almost all the media is re-captured within a controlled enclosure (commonly called the Blast Cabinet). For the purposes of our test, this cabinet could be a standard manual blast cabinet with enough distance between the two end walls to allow for alteration of the stand-off distance (distance between the nozzle and the target plate). A suggested cabinet size is between 48" (1219 mm) and 60" (1524 mm). Typical cross-sectional area (depth x width x height) of such cabinets will be around 48" x 48" x 36" or 60" x 60" x 74". Large cabinets pose challenges in media collection, but they will also provide the maximum flexibility when physically adjusting machine components during test parameter changes.

Target Plate. When shot peening a component, it is established practice that the peening media be harder than the component. On the other hand, hardness of the component determines the absorption of energy and also the media breakdown rate. Therefore, our test machine needs to have the flexibility to accept target plates of different materials and hardness. In order to establish a baseline, the media could be calibrated with commonly used metals such as Mild Steel (up to 50 HRc), Spring Steel (45 HRc), Aluminum and Titanium.

The target plate should be fitted on a mount that is also capable of being positioned at different angles since it is never recommended to blast (or peen) a component at right angles to it. The tilt will also allow us to study the effects of energy loss at angles shallower than 90 degrees.

Media propulsion: Suction and Pressure. While manual cleaning operations generally tend to be pressure blast systems, suction systems are common in automated peening machines, particularly those using non-metallic media such as glass bead and ceramic. It is generally known that suction systems are not capable of generating as much energy through media propulsion as pressure-type systems. However, this fact needs to be tested and validated. The test machine needs to be equipped with a mount that can accept a pressure blast nozzle as well as a suction gun. Like the target plate described earlier, this mount should also have a tilt feature to allow positioning it at different angles and stay fixed at that desired angle during blasting.

It might be obvious to the reader, but still important to mention, that different nozzle sizes and types will be used as part of the test procedure.

Media Reclaim. As in the 100% replacement method described in J445, the airblast test procedure will also start with a defined amount of media. This quantity will be dependent on the media type in order to accommodate their varying breakdown rates, and the need to conduct tests for the required length of time. For example, media with greater breakdown rates such as aluminum oxide and glass bead will be tested with a larger quantity than more durable media such as steel shot, cut wire and ceramic. Regardless of the quantity, the test machine should be designed with a reclaim system that closely simulates (or duplicates) an actual machine.

Given that we're discussing a test machine, the focus should be on providing every particle of media the opportunity to hit the target and be recycled at the quickest possible turnaround time. Therefore, the test machine should be equipped with a small capacity blast tank (1 CFT or smaller) depending on availability of associated valves and fittings without major customization due to being scaled down. Thus, the discharged media falls by gravity into a screener located below the hopper with separation of fines and unusable media through the different classifier screens. This arrangement eliminates the need for modifications to the reclaim system to operate with larger media sizes and limits it to simply changing screens. This arrangement allows efficient collection, separation and review of the generated dust without the need for a dust collector which could potentially retain dust within the cartridge and lead to incorrect measurement of broken media.

Media Size and Type Interchangeability. The test machine should be capable of (a) rapid change from one media type to another, and (b) complete evacuation of the previous media type to prevent cross-contamination. To address this requirement, the storage hopper and the blast tank should be provided with drains to empty out the media during changeover. The media in transit in the blast hose and nozzle should be flushed out as part of the changeover procedure. In the case of a pressure system, the tank inlet (pop-up valve) seals to prevent new media from entering the tank.

Consider the commonly used blast media listed in the following table. Media-holding capacities have been calculated using 80% utilization of tank volume. Flow rates vary quite widely depending on air pressure, media and nozzle size, whether suction or pressure, etc. However, for the purpose of our discussion, the flow rates below represent average values per nozzle.

Media	Specific weight (lb/cft)	Quantity in a 3 CFT Tank (lb)	Average flow (lb/min)	Blast capacity (mins) 3 CFT Tank	Blast capacity (mins) 1 CFT Tank
Aluminum Oxide	125	300	8	37	12
Glass Bead	100	240	6	40	13
Plastic	45 to 60	126	5	25	8
Ceramic	150	360	10	36	12
Steel Shot	280	672	15	45	15

The breakdown rate of the media listed above will vary with aluminum oxide disintegrating faster than the rest. In order to standardize on a test machine, it is suggested that a 1 CFT pressure vessel (tank), or smaller be used with the test quantity based on media type. This will allow the tank to blast itself empty within a reasonable amount of time.

Closed-Loop Feedback Systems. With air pressure being the primary determinant of impact energy, it is critical that constant pressure be maintained in the system during the test. Therefore, both suction and pressure systems should be equipped with the means to maintain the air pressure at a constant level and regulate it to that level during times of possible fluctuation. This feature is common in properly designed shot peening and grit blast systems.

WHAT ARE WE GOING TO TEST FOR?

Several hypotheses, beliefs, facts, "rules of thumb" and opinions exist in our industry. The proposed test machine can verify some of the common ones listed below.

Air pressure influencing durability. This is likely the most obvious aspect of media breakdown, and the test machine should have enough flexibility to test at different pressures at constantly maintained values.

Media size influencing durability. Larger-sized media tends to breakdown rapidly, or in the case of steel grit, round-off to the extent that their loss of sharpness renders them unusable for the intended purpose. This takes place at a much faster rate with non-metallic grit as compared to steel grit. A spiral separator, in addition to a size classifier, incorporated in the test machine can separate out the rounds from the non-round particles.

Media flow influencing durability. When gradually increasing the media flow at the same air pressure, the capacity of each media particle to transfer energy reduces, which in turn could reduce breakdown, or show increased durability. This aspect is more important in shot peening applications since it adversely affects intensity. A calibrated flow control valve, in the case of a pressure system, or a calibrated (by catch test) orifice plate at the outlet of the hopper could help achieving a defined, constant media flow rate.

Nozzle stand-off influencing durability. A few years ago, when conducting a test to study the effect of stand-off distance using a blast wheel, we found that the impact energy started degrading at distance beyond 6' (1.8 M). The proposed airblast test machine should allow varying the stand-off and characterize the effect based on different media and nozzle types as well.

Nozzle angle (of impact) influencing durability. You have likely heard from several sources that the minimum accepted angle for shot peening is 45 degrees and the ideal tilt is closer to 90 degrees. The adjustable nozzle mount in the test machine will allow us to study the differences in blast patterns and resulting impact energy at different settings.

WHO IS THIS MACHINE GOING TO BENEFIT?

The simple answer to this question is: Anyone who blast cleans or shot peens! Specifically, the following users are expected to derive great benefits from the information gained in the process.

Process/design engineers that want to determine the optimum media for their peening or cleaning operations. They can learn the parameter limits of a media for their peening, grit blasting or cleaning process and possibly alter such parameters to increase or extend its effectiveness during use.

Media manufacturers could characterize their media quality in terms of general use parameters, since "it depends" is not an answer that is widely popular among users of peening and cleaning equipment when they question media durability! Such an arrangement will also help compare similar media types from different manufacturers, thereby establishing the basis for a competitive edge.

General users of airblast. The Ervin Test Machine is very popular among users of steel shot, grit and cut wire shot to test the quality of media. The proposed machine could gain the same popularity among users of non-metallic media, especially those that monitor their operating costs closely.

POTENTIAL LIMITATIONS

The above information presents certain limitations and possibilities for further thought and improvements.

Media capture: Industry colleagues that have conducted catch tests in their airblast machines will appreciate the challenges involved in conducting a true "capture" of discharged media. The blast cabinet must be designed to minimize flat spots to prevent media accumulation and facilitate close to 100% capture of media discharged from the nozzle within the cabinet.

Physical size: Though it is tempting to make this unit portable, a true test can be performed only with a proper recovery system that includes a classifier. In the process, this test machine will have a large footprint and likely be a skid-mounted design with reduced manual portability unlike the Ervin Test Machine. The miniaturization of certain components to achieve portability requires further thought.

SUMMARY

This discussion is an attempt to get us thinking about a test procedure for blast and peening media when used in an airblast machine. Blast media is the perishable tool of any cleaning, grit blasting or peening process and it will also be one of your largest operating expenses, especially with non-metallic abrasives. With new materials being introduced for machine components more frequently, your customers will want you to enforce checks in the finish quality and your primary source of quality assurance is the media. Knowing the characteristics of the media will not only help assure finish quality, but also potentially reduce operating costs associated with the process and disposal of fines and dust.

About Kumar Balan

Kumar Balan is a shot peening and blast cleaning technical specialist. He assists industry leaders achieve business growth in North American and overseas markets. His expertise is in centrifugal wheel- and air-blast cleaning and shot peening equipment. Kumar has published many technical papers on blast cleaning and shot peening and is a regular contributor to *The Shot Peener* magazine.

Kumar is a speaker at industry conferences and training seminars worldwide. He is also a Lead Instructor for EI Shot Peening Training at their international seminars and workshops. Please email him at kbalan13@gmail.com.

Engineered Abrasives®

Manufacturers of the Finest Blast Finishing and Shot Peening Systems

(708) 389-9700 or (773) 468-0440

Email: mwern@engineeredabrasives.com Web: www.engineeredabrasives.com

ISO/TS16949
ISO 14001
FORD Q1
Certified
Job Services

All Engineered Abrasives® systems are available with the EA® Knowledge System®. The EA® Knowledge System® features computer animation on machine operation and maintenance, including how to do Almen Strips.

Engineered Abrasives® High-Volume Index Unit with complete Material Handling and Robotic System

**60" Index Unit
Ring and Pinion Gears
for High Volume**

**8 Pressure Nozzles
with MagnaValves®,
Buck Elevator, Sweco
and Dust Collector**

CONTROL by MagnaValve®

**All Tooling and Fixtures
Tool Steel hardened to 62 RC**

Engineered Abrasives® index units are the most durable machines on the market today with all our special features

Patented 72" Index Unit with Shot Flow Controls, Sweco, Bucket Elevator, 8 Nozzles and 16 Spindles. Designed for high-volume shot peening.

Look for RED components and surfaces to be sure you get Engineered Abrasives® quality equipment and OEM parts.

High-volume automotive systems for ring and pinion axle gears

Designed and built by EA®

Two (2) Index Units with complete load and unload Fanuc Robots and Conveyor System

Both machines built and tested on EA® floor

High-volume automotive systems for transmission gears

Designed and built by EA®

Three (3) Index Units with complete load and unload automation

All three machines built and tested on EA® floor

Single Cell Unit, 5 Pressure Nozzles

Bucket Elevator
Sweco System
MagnaValves®

6 Spindles each station for high volume

Dual Swing Doors for higher volume

Large 84" Index Unit, 12 Pressure Nozzles

ACADEMIC STUDY
Dr. David Kirk | Coventry University

Metals are Alive!

INTRODUCTION

Metallic objects abound in shot peening—steel shot, Almen strips, nozzles, wheels, etc. The metals used are alive! Essentially metals are made up of a regular framework of vibrating, charged, atoms (ions) surrounded by a cloud of high-speed electrons. The pulse rate of the vibrating atoms is about 10 trillion per second—more than that of the Earth's human population combined. The speed of the electrons is difficult to visualize—it is like comparing that of a supersonic bullet with that of a geriatric snail. Electron speeds are of the order of thousands of kilometers per second—enough to go round the Earth in less than a minute.

The aims of this article are twofold. One is to present a different perspective on the properties of metals. The other is to serve as primer in metallurgy for shot peeners. For this article the word "primer" means that it is intended to serve only as an introduction. Metallurgy is important because most of the objects used by shot peeners are metallic. Metallurgical principles underpin the usefulness of those articles.

METAL ION FRAMEWORKS

Almost all of the metals used by shotpeeners have one or other of three metal ion frameworks. These frameworks are called "crystal lattices" and are formed by the three-dimensional repetition of a basic unit cell. The three basic unit cells are body-centered cubic (b.c.c.), body-centered tetragonal (b.c.t.) and face-centered cubic (f.c.c.). Each metal atom is stripped of one or more electrons (which are negatively-charged) thereby becoming a positively-charged ion. The stripped electrons whizz around the lattice at an astronomical speed. There are so many of these moving electrons that they are commonly described as a "Cloud of free electrons". These free electrons are responsible for the metal's ability to conduct electricity and for the stability of the lattice.

The positively-charged metal ions tend to push each other apart. Conversely, the negatively-charged electrons push the ions together. A balance of forces is thereby achieved. Each metal ion is covered by an impregnable inelastic shield. This means that no external electrons can enter, whatever their velocity.

Fig.1 illustrates the body-centered cubic unit cell which has an ion centered at each of the eight corners of a cube together with one at the cube's center. The length of the cube's side, a, is called its "lattice parameter". Each of the ions pulsates at an enormous rate—a rate that increases with temperature.

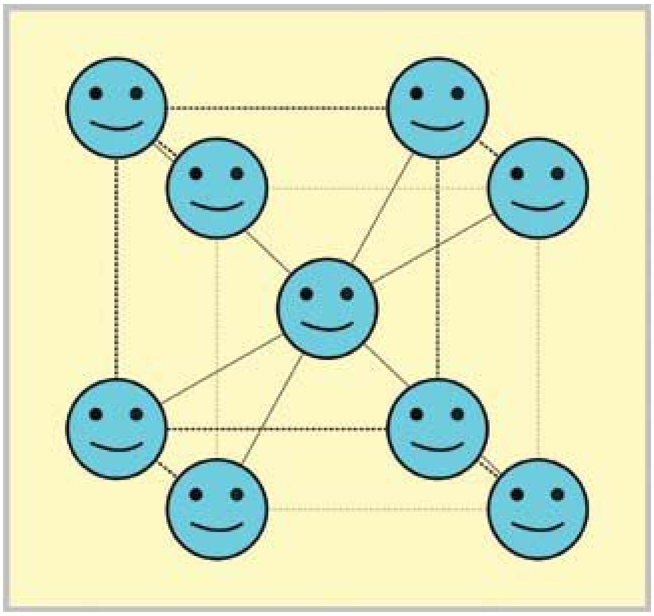


Fig.1. Body-centered-cubic unit cell.

Fig.2 (page 28) illustrates a body-centered-tetragonal unit cell which is similar to the b.c.c. unit cell but with one dimension, **c**, being larger than the other two **a**'s. This vertical axis stretching is caused by four carbon atoms acting in unison and exerting forces shown as red arrows. Again the metal ions pulsate at an enormous rate but the carbon atoms are in fixed positions. The metal ions are prepared to put up with the imposed stresses—temporarily.

Fig.3 (page 28) illustrates a face-centered cubic unit cell which has a metal ion centered at each of the eight corners of a cube together with a metal ion centered on each of the six faces of a cube. The center positions of the metal ions are generally shown as black dots. Only the five ions at the center of the front face have been illustrated for simplicity. Again all of the metal ions pulsate at an enormous rate.

For all three types of lattice, crystals are formed by repeating the basic unit cell in three dimensions.

ALLOTROPY

Metal crystals can take collective decisions to change their crystal structure. This phenomenon is called "allotropy". The classic example of allotropy is that of carbon steels where, depending on prevailing conditions, the crystal structure can exist as face-centered cubic (on heating), body-centered-cubic

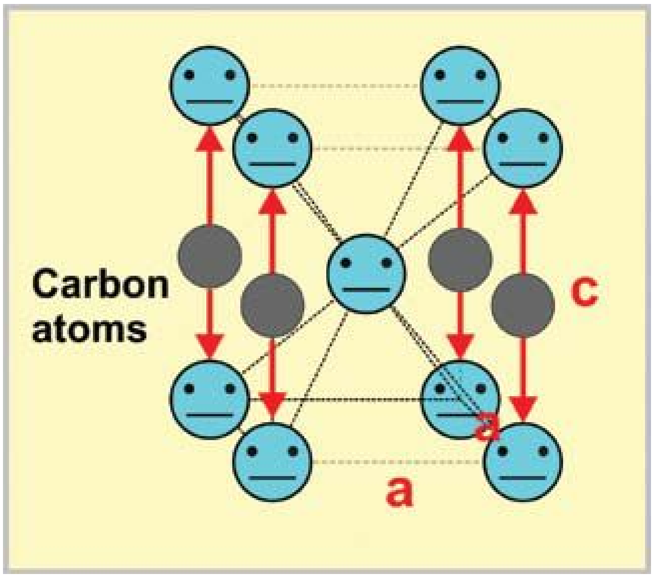


Fig.2. Body-centered-tetragonal unit cell.

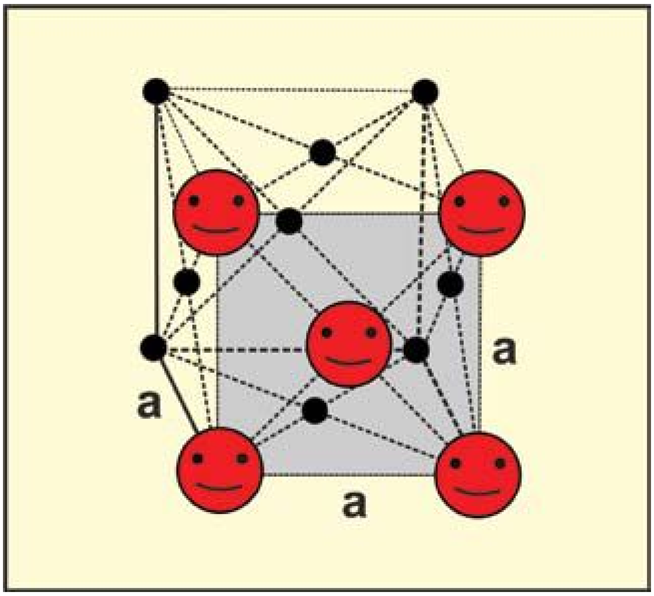


Fig.3. Face-centered-cubic unit cell.

(on slow cooling) or body-centered-tetragonal martensite (on fast cooling). This topic has previously been described in detail ("Properties of Carbon Steel Shot", TSP, Spring, 2011).

Fig.4 illustrates one important effect of cooling rate on carbon steel crystal structure. Above a certain critical temperature, C.T., iron ions exist happily in a face-centered-cubic arrangement called "Austenite" with much smaller carbon atoms moving around in the spaces between the ions. Below the critical temperature the iron ions cease to tolerate the interloping carbon atoms and collectively take decisive action. During both slow quenching and slow cooling there is time for three iron ions to be assigned to each carbon atom to form an iron carbide molecule Fe_3C. The iron carbide

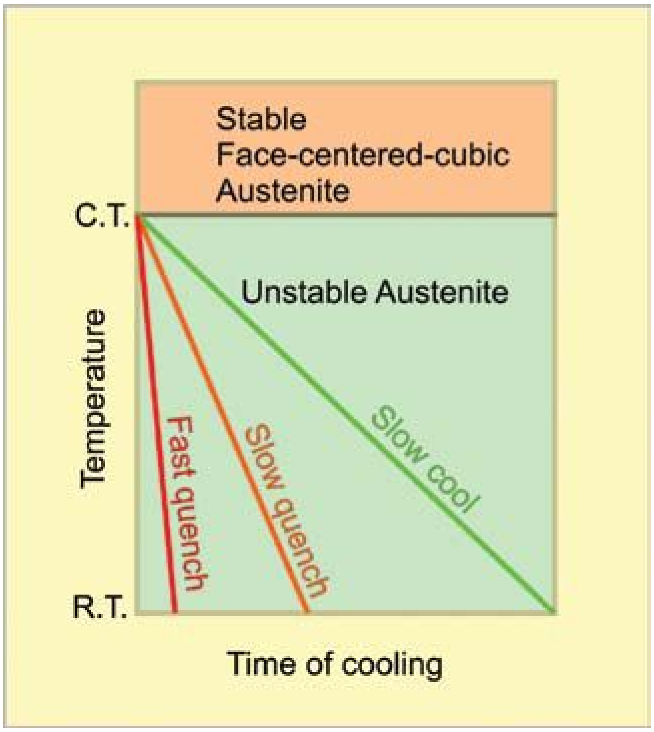


Fig.4. Range of cooling rates applied during heat-treatment of steels.

molecules are then assembled to form a very hard, brittle, material called "Cementite". The resulting structure at room temperature, R.T., becomes a mixture of relatively pure iron crystals with interspersed colonies of cementite. During fast quenching there is not enough time to form cementite. The face-centered-cubic lattice transforms itself into a body-centered-tetragonal arrangement where the carbon atoms have only to be moved tiny distances. If this cannot be fully achieved in the limited time available then numerous ghettoes remain of untransformed austenite—generally called "Retained austenite".

VACANCY MIGRATION OF METAL IONS

Metal ions are usually quite happy to remain centered on their own home lattice site. Every lattice does, however, contain a proportion of empty sites called "vacancies". Metal ions closest to a vacant lattice site feel the urge to migrate into that site, marked V in fig.5 (page 32).

The proportion of vacancies increases with temperature, as does the available energy for metal ion migration. It follows that the rate of vacancy migration also increases with increase of temperature. Interlopers, such as carbon atoms, being relatively small, can slow down migration by occupying some of the vacancies.

WORK-HARDENING

The more we deform metals the more they resist further deformation—a phenomenon called "work-hardening". A

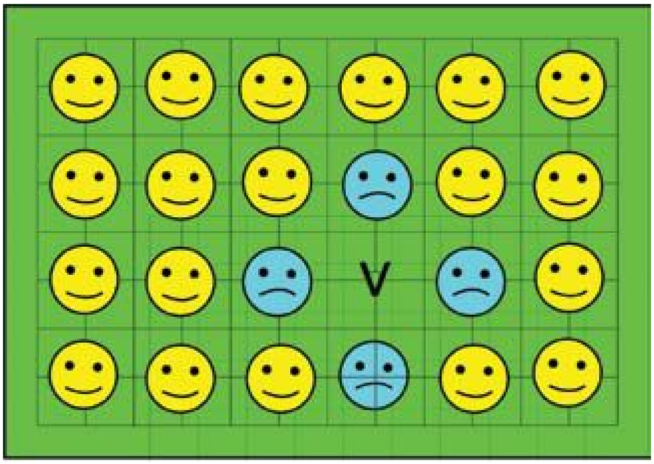


Fig.5. Schematic representation of vacancy condition.

simple demonstration of work-hardening is afforded by a stress-strain curve derived by tensile testing. The maximum stress that can be endured in a tensile stress is called the "U.T.S." (Ultimate Tensile Strength). It is important for shot peeners to appreciate that the U.T.S. derived from a tensile test is far lower than the maximum stress that can be endured on peening. Fig.6 is from a previous article ("Work-hardening During Peening", TSP, Summer, 2017). Denting is essentially deformation under conditions of high hydrostatic compression. Cold-rolling has a small hydrostatic compression component but which still allows at least ten times the maximum extension evidenced in a tensile test. Extrusion has a huge hydrostatic compression component that allows a thousand times the tensile test's maximum extension.

The author well-remembers a client objecting when informed of the magnitude of the maximum compressive residual stress in his shot-peened component. "That's impossible," he said. "It would be above the U.T.S." The reason had to be carefully explained!

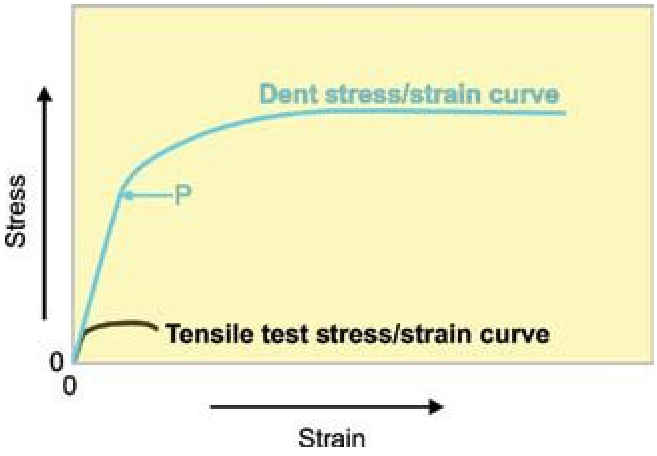


Fig.6. Stress-strain curves for tensile test versus denting.

When plastic deformation is imposed on a crystal of annealed pure metal, its behavior is analogous to it being a three-dimensional skating ring. Deformation is achieved by using crystal defects called "Dislocations". Fig.7 attempts to illustrate the main features of an edge dislocation. The term "edge dislocation" was originally coined because its structure, as shown, is analogous to the bottom edge of an extra sheet of ions appearing at X. If a shear stress is applied that just exceeds the shear strength the dislocation moves—analogous to the hump of a caterpillar moving towards its head. Note that for a caterpillar all of its remaining legs stay in position until the hump reaches its head. Similarly, for a metal crystal, it is only the position of the extra sheet that is moving, initially from X to X'.

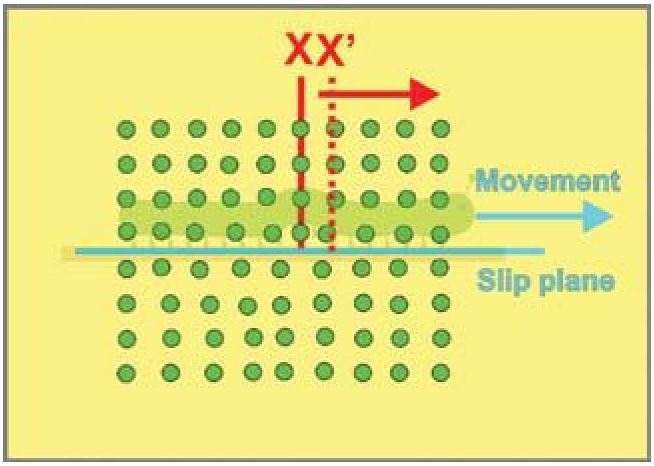


Fig.7. Structure and movement of an "edge dislocation".

Once a dislocation starts to move, it accelerates to the speed of sound! It then starts to replicate itself at a rate that is astronomical. An annealed crystal containing 10^6 dislocations per cubic centimeter may contain 10^{12} when deformed by an impacting shot particle. A million-fold increase in less than a thousandth of a second! This feature of annealed metal crystals being relatively-free of dislocations (when compared with cold-worked crystals) is the key to understanding work-hardening. A reasonable analogy is that of traffic on a city's streets. Imagine the streets being almost empty. Traffic can then move freely and fast. If, however, the number of moving vehicles suddenly multiplies a thousand-fold chaos would reign. Vehicles would crash into each other causing multiple pile-ups. Movement would then become very difficult. With deformation of metal crystals multiplying dislocations, travelling at the speed of sound, pile-up at crystal boundaries (and elsewhere), creating a back-pressure that slows down further deformation.

The distribution of the vast number of dislocations in a work-hardened metal can only be described loosely. Fig.8 (page 34) is a schematic representation of its most important feature—each crystal develops a substructure. Overall the


Ceramic Shots
Shot Peening / Blasting Media
Synco
Exclusive agent in India
Synco Industries Ltd.
trb@synco.co.in
www.ChemcoBeads.com
Chemco Advance Material (Suzhou) Co., Ltd
CHEMCO


World Leaders in Surface Engineering Technologies
METAL IMPROVEMENT COMPANY
• Large network of controlled shot peening facilities
• On-site shot peening, laser peening
• All major industry & OEM accreditations
• 50 job shop locations worldwide
FW GARTNER / CWST THERMAL SPRAY
• Thermal spray & laser PTA/cladding
• Precision machining & surface finishing
• Protect & reclaim functional surfaces
• 6 locations
IMR TEST LABS
• Metallurgical services
• Failure analysis
• Fatigue/corrosion/mechanical testing
• 5 locations in 3 countries
E/M COATING SERVICES
• Dry film lubricants
• Corrosion/chemical resistant coatings
• Phospate, Chem-Film, Ti anodize, Microseal®
• 12 locations in 5 countries
CURTISS-WRIGHT
Surface Technologies Division
Dave.Breuer@cwst.com
www.cwst.com
262-893-3875

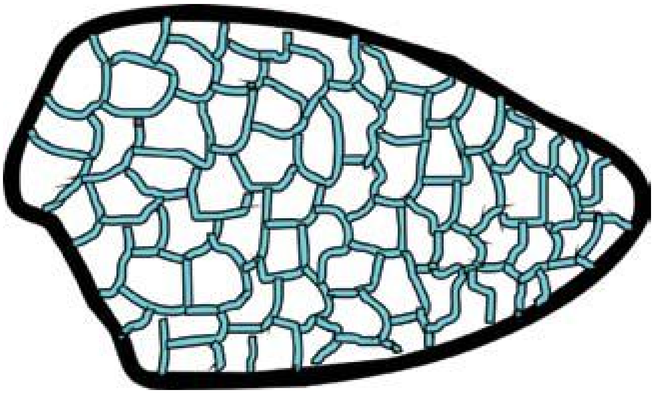


Fig.8. Schematic representation of sub-grains within a work-hardened crystal.

crystal has been divided up into millions of sub-grains. Each sub-grain is a region of relatively-low dislocation intensity whereas each sub-grain boundary is a region of very high dislocation intensity. Each metal crystal is not at all happy with this state of affairs and will take every opportunity to make life more comfortable.

ALLOY HARDENING

There are two main types of alloy hardening: "Solid solution hardening" and "Precipitation hardening".

(1) Solid solution hardening

Alloying element atoms dissolved into a crystal's matrix will be either larger or smaller than those of the matrix. This is analogous to myriads of tiny bumps on a skating rink's surface. Fig.9 illustrates this bumping effect in cross-section. A moving dislocation line is analogous to a line of linked skaters moving across a rink. As individual skaters encounter a bump in the ice their progress is retarded.

(2) Precipitation hardening

Precipitation hardening is analogous to scattering grit on a skating rink. Dislocation lines can either slide over the precipitate particles or crash through them or even loop around them, multiplying as they do so. The effect is to increase the resistance to further deformation and hence increase hardness. Precipitation hardening is particularly effective when used for soft metals such as aluminum.

Precipitation occurs when unwelcome atoms are encouraged to leave the matrix of a crystal and form particles. Aluminum is commonly alloyed with a small percentage of copper to form hardenable alloys. At a high enough temperature, the copper atoms are dissolved in the matrix to form a solid solution. At a lower temperature, intolerance sets in and the copper atoms are made to combine with aluminum atoms to form particles of $CuAl_2$.

CRYSTAL BOUNDARIES

Crystal boundaries, also known as "grain boundaries," are important. The rules that are obeyed by metal ions within each crystal no longer apply at its boundaries. Just as a farmer might resent the loss of land caused by hedgerows, so the crystals resent the presence of boundaries. There is a natural tendency for the larger crystals to swallow up the smaller crystals leading to what is known as "grain growth". This process is accelerated by any rise in temperature. Steels austenitized at too high a temperature develop a very large crystal size. This has a deleterious effect on the properties of quenched steels.

Grain boundaries do not have the same regular structure that exists within each crystal. The metal ions at grain boundaries are not as closely packed as they are within the body of the crystal. Alloying element atoms can migrate at a relatively huge rate as compared with that allowed within crystals. This is exemplified by the process known as "decarburization". It was described in a recent article titled "Decarburization", TSP Winter, 2018. Pesky carbon atoms can be shunted rapidly along grain boundaries and made to join up with oxygen atoms at the metal's surface. This migration also allows for ferrite (b.c.c. iron) to form at the crystal boundaries as illustrated by fig.10.

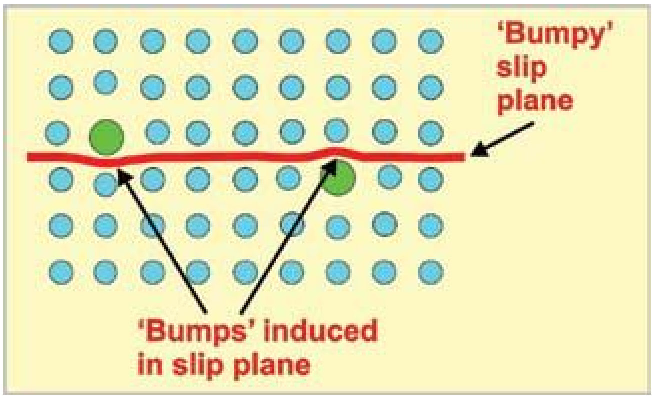


Fig.9. "Bumps" in a slip plane caused by solid solution atom.

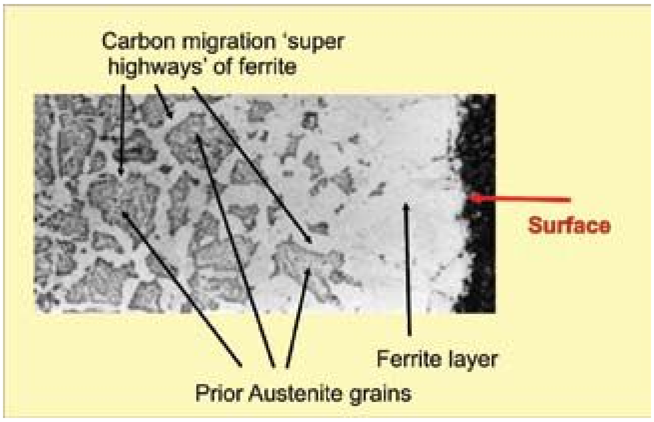


Fig.10. Carbon migration in carbon steels.

Another example of the importance of crystal boundaries is a phenomenon exhibited by stainless steels. Carbon atoms at high temperatures much prefer a close association with chromium atoms to being accommodated within a crystal's f.c.c. structure. Precipitation of chromium carbide therefore occurs at crystal boundaries as illustrated schematically in fig.11. The chromium carbide particles have the chemical composition $Cr_{23}C_6$. Chromium is the principal element that confers corrosion resistance to stainless steels. The gross lowering of chromium content therefore makes the steel much more sensitive to corrosion. Hence, the phenomenon is called "Sensitization". The crystal boundaries have become preferred corrosion attack zones.

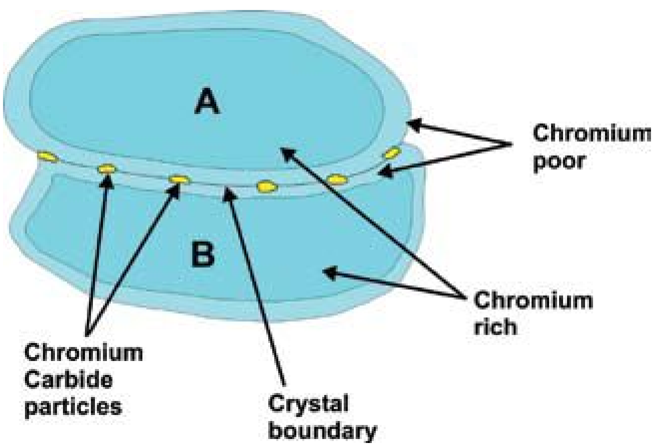


Fig.11. Chromium carbide precipitation at crystal boundaries.

If high tensile stresses are imposed on a metallic component at high temperatures, then a phenomenon called "Creep" occurs. The crystal boundaries behave as if they have been lubricated. Crystals slide over one another, keeping their integrity intact. Creep is so important for aircraft blades that many are fabricated as one huge crystal.

THERMAL EFFECTS

Deformed metals resent the carnage that deformation causes to their otherwise pristine, lightly-stressed, lattice arrangements. They will strive to restore order out of chaos. Restoration depends upon the crystal's metal ions having enough energy. Available energy depends upon the prevailing temperature. The higher the melting-point of a particular metal the greater is the temperature rise needed to supply the requisite energy.

Raising the metal's temperature and then keeping it there for different times is called "Isothermal annealing". Raising the temperature to a different temperature but keeping it there for a fixed length of time is called "Isochronal annealing". Both annealing processes are useful for analyzing property changes brought about by ion activity.

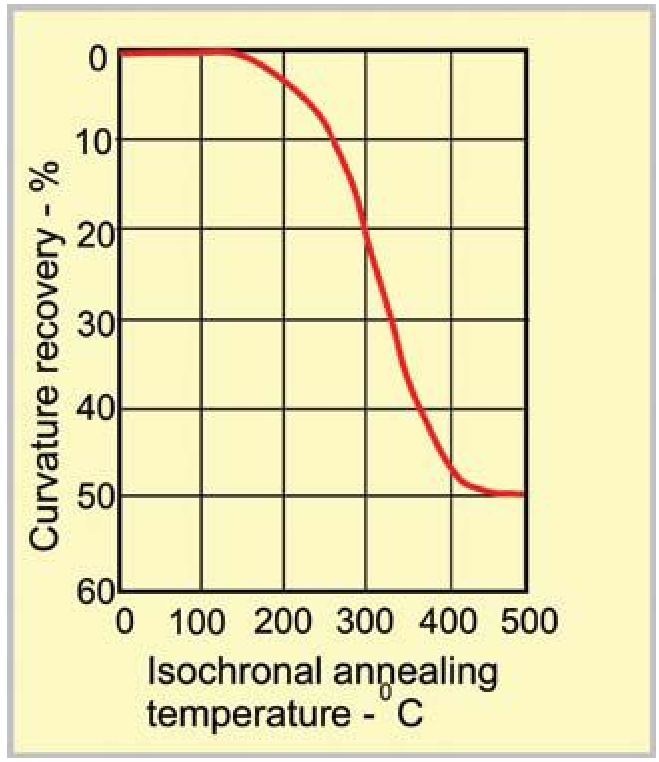


Fig.12. Effect of isochronal annealing on curvature of peened Almen strips.

Fig.12 illustrates how isochronal annealing reduces the curvature of peened Almen strips. Each strip was annealed for one hour. At temperatures above about 1500°C, the curvature of peened Almen strips began to be reduced. The rate of change of curvature subsequently increased to a maximum followed by a slowing down. Eventually no further change occurs. Mathematically speaking, the shape of this curve is dubbed "Sigmoidal". The inference from fig.12 is that the curvature induced by peening has two components. One is permanent, whereas the second is temporary. The temporary component of strip curvature is largely due to residual macro-stresses which are removed by annealing. Specifications rightly restrict the operating temperature for shot-peened components in order to combat stress-relief.

The increase of temperature during annealing gives the metal ions sufficient energy to carry out "disaster relief". Several processes can then be employed depending upon the magnitude of the annealing temperature. At low annealing temperatures so-called "Recovery processes" predominate. These are analogous to tidying-up a house and involve unwelcome dislocations being moved only short distances within the sub-grains—a process termed "Polygonization". At higher temperatures, large-scale rebuilding takes place with new grains being nucleated by polygonized sub-grains. This is "Recrystallization" with new grains absorbing pre-deformed material.

赛普优特
Superior Shot
专注 CONCENTRATE 专业 PROFESSIONAL
只为更好 ONLY FOR BEST CUT WIRE SHOT
• 喷（抛）丸磨料
Shot Peening (Blasting) Media
• 喷（抛）丸设备
Shot Peening (Blasting) Equipment
• 喷（抛）丸服务
Shot Peening (Blasting) Accessories & Service
ACCORDING TO:
SAE J441
VDFI8001
MIL-S-13265-C
AMS2431/3
AMS2431/4
AMS2431/8
YANCHENG SAIPU METAL PRODUCTS CO.,LTD
ADD: A-13 Minhao Industrial Park 224300 Yancheng Jiangsu China
E-Mail: rabrasive@vip.163.com
www.superiorcutwireshot.com
PARTNER
DOSHINE
DAFENG DOSHINE INTERNATIONAL CO.,LTD
ADD: No.1 Wuyi Ave 224100 Dafeng City Jiangsu China
Tel: 0086-139-0141-2688
E-Mail: keyneskhu@vip.163.com
www.doshineinternational.com

EQUIPOS DE ABRASIÓN, S.A. DE C.V.
Supplying spare parts for shot blast machines and shot peening accessories for the automotive and aerospace industries since 1991
SHOT BLAST PARTS
CHAIN LINKS
CUT WIRE SHOT
BLAST WHEELS
CAST NUTS
WHEEL LINERS
CONVEYOR FLIGHTS
MANGANESE PLATE 11-14%
ALMEN STRIPS
SHOT PEENING PRODUCTS
STRIP HOLDERS
MAGNAVALVES
ALMEN GAGES
ALMEN MINI STRIPS
3M FLAPPS
SHOT PEENING WORKSHOPS
FLAPPER PEENING KITS
Av. De las Granjas No. 61 - 3
Col. Jardín Azpeitia, Azcapotzalco
C.P. 02530 México, D.F.,
Tel. 011-52-55-5355-0947, Fax 011-52-55-5355-6391
E-mail: atencion@equiposdeabrasion.com.mx

Less recognized, but universally present, is the surface temperature rise induced by the energy transferred from the impacting shot particles. Some 90% of the work required to create each dent is transformed into heat energy. Surface temperature rises can vary between a few degrees to over a thousand degrees Centigrade. These temperature rises are, however, temporary as heat is made to diffuse away from the surface.

Electrical conductivity of metals decreases with increase of temperature. This is because the metals ions then have greater vibration amplitude thereby interfering with the motion of the whizzing electrons (which are the ones enabling conduction). At very low temperatures the metal ions effectively go to sleep hence allowing, for some alloys, superconductivity.

RESIDUAL STRESS

Very important, for shot peeners, is the ability of metal lattices to store residual stresses. Metal lattices are elastic in the sense that planes of atoms can be either pushed closer together or pulled further apart, depending on the sign of the residual stress. Compressive residual stress will cause a decrease in spacing, as illustrated by fig.13. The consequent change in the lattice spacing, d, can be detected by x-ray diffraction.

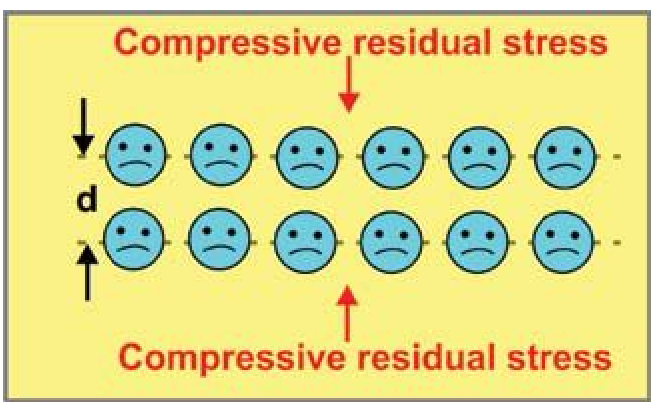


Fig.13. Compressive stress reducing interplanar spacing.

CONCLUSIONS

This article was written as a simple primer in metallurgy that would be palatable for the majority who has little interest in detailed aspects of the subject. Treating metals as if they were alive provides coherence. We can then imagine a metal ion lamenting, "Using thermal-imaging cameras, humans have started to film the misery imparted on a metal's surface." There are also numerous parallels that can be drawn between the reaction of metal ions and humans to outside influences.


ERVIN
AMASTEEL—CAST SHOT & GRIT
• AMS (2431) CAST SHOT
• SAE CAST SHOT & GRIT
• STAINLESS STEEL SHOT & GRIT
1-800-748-0055
www.ervinindustries.com
THE WORLD STANDARD FOR QUALITY


KSA
process automation
Automated Peen Forming Solutions
www.ksa.de.com
KSA Kugelstrahlzentrum Aachen GmbH · Weststraße 22-24 · 52074 Aachen · Germany

Complimentary eQuaLearn Training at USA Nadcap Meeting

Would you like to attend an eQuaLearn training free of charge? Registration is now open for training during the New Orleans Nadcap meeting! eQuaLearn will be providing seven complimentary courses February 18-21, 2019. The agenda includes the following programs.

Nadcap Audit Preparation. Designed to provide a complete overview of Nadcap requirements related to the audit.

eQuaLearn Chemical Processing Open Discussion Forum. A panel of several Nadcap Subscribing Voting Members of the Chemical Processing Task Group, PRI Chemical Processing Staff Engineers, and a Nadcap Chemical Processing Auditor will address the critical topics in an open discussion forum.

Process FMEA. This course presents the use of Process FMEA as part of Advanced Process Quality Planning in the Aerospace industry and describes the concepts of PFMEA, how it fits into Quality Planning, and the role PFMEA has in Risk Management.

Contract Review. Contract Review is a multi-disciplinary process which should ensure that all potential problems are identified and addressed before any commitment to supply is made. This course describes what must be done. The requirements are explained and illustrated by discussions around common problems and weaknesses.

Internal Audit Systems Overview. Designed to assist in the process of building an internal audit system and how to structure the key elements of this system for success while also explaining the vital relationship between Quality and Management.

Introduction to Aerospace Quality. Created to introduce the concept and key definitions of quality in the aerospace industry to professionals who are new to the quality field. It presents Aerospace Quality Management and the role of Nadcap, ISO 9001 and AS / EN / JISQ9100, and aerospace audits.

Root Cause Corrective Action Nadcap Style. Designed to provide an understanding of the basic concepts of Root Cause Corrective Action (RCCA) and application of how to apply those concepts to eliminate errors and defects.

Seats are based on a first-come, first-served basis. Registration fills up quickly so register today at www.eQuaLearn.com or contact PRI at eQuaLearn@p-r-i.org.

2018 US Shot Peening Workshop Recap

The 2018 US workshop looked more like an international workshop than an event held in the Midwest of the United States—its 138 students came from eleven countries. Other interesting numbers from the event include:

- 50 topics of importance to the shot peening industry were presented at the workshop
- 25 industry leaders shared their knowledge and expertise in the classrooms
- 68 companies were represented by students, instructors and exhibitors
- 200+ certificates were awarded to students that passed exams in shot peening and rotary flap peening

In addition, the EI Shot Peening Training staff was pleased that representatives from PRI/Nadcap and the FAA attended classes. It's fitting that these aerospace organizations are interested in shot peening training since shot peening is a critical process for that industry.

The 2019 US Shot Peening workshop will be in Orlando, Florida from September 30 to October 2. Visit www.shotpeeningtraining.com for updates and to register.

Workshops are a unique opportunity to meet with your peers and industry experts.

The group photo and t-shirts are workshop traditions.

Winoa Inaugurates New Steel Shot Plant in Blamaseda, Spain

THE WINOA GROUP is a world leader in metal abrasives with 11 industrial plants. It is a French company headquartered in the Isère region. Today, with an investment of more than 20 million euros, Winoa is inaugurating its new industrial plant in Spain on the outskirts of the Biscayan town of Balmaseda. This plant is now the most modern in its field.

The factory covers an area of 30,000 m². Four interconnected buildings have been erected to improve the distribution and communication in the production processes. It has induction furnaces, heat treatment furnaces, grinding stations and conveyor belts for storage and packaging. In addition, auxiliary installations use cutting-edge technology for water usage control and air treatment.

"The plant is completely automated and centrally controlled to ensure that only the very best quality metal abrasives are produced in an efficient and flexible manner. Thanks to these new installations, we are better able to adapt to the varying needs of our customers and to specialize in 'Premium' products," emphasizes Luis Resusta, MD of Winoa Iberica.

Sustainable Shot Production for a Global Market

The use of steel abrasives for surface treatment is essential in almost all industries: automotive, steel, renewable energies, rail and sea transport, aeronautical and construction, to mention only the main ones.

The plant in Balmaseda relies on the very latest production techniques in order to reduce its environmental footprint: a dual purification system to guarantee a clean environment inside and outside the plant, heat recovery equipment, smart sensors, and a water treatment plant meeting the highest standards of efficiency.

About the Winoa Group

The Winoa Group is a world leader in its field thanks to its 10,000 customers in 120 countries who trust the company. To maintain its position as market leader, it aims to constantly renew its products and its services that are provided by technical experts and its six Test and Research centers.

"This new factory is an excellent example of our four strategic pillars. By offering the highest standards in terms of safety and environment, it contributes to making us a company of choice. Thanks to our ultra-modern equipment, this factory will enable us to optimize our operational efficiency, which will guarantee our competitiveness, ensuring that we stay ahead of market trends. And finally, by focusing its operations on premium products and new industrial applications, it strengthens our position as a privileged partner in terms of customer services for surface preparation," highlights Pierre Escolier, CEO of the Winoa Group.

The Winoa group has 1,000 collaborators, 11 industrial plants, 80 sales offices and warehouses in 30 countries.

Toyo Seiko Signs Agreement with Winoa

TOYO SEIKO has signed an agreement with Winoa for the France-based company to become a distributor for Toyo Seiko's conditioned cut-wire shot. The distribution agreement was signed at Toyo Seiko's manufacturing facility in South Bend, Indiana, USA in September.

This alliance will create an unparalleled value proposition for manufacturers with demanding shot peening processes. Toyo Seiko is the only provider in the world offering cut wire of "HD" (High Durability) quality. This product has a unique and patented production process. Using the HD product, shot peening facilities can now optimize both the total cost of shot peening and their environmental footprint by improving their process efficiency by approximately 30%.

With this agreement, Winoa, an international leader in the manufacturing and distribution of steel abrasives, plans to increase its shot peening sales both in the automotive and in the aerospace industry by leveraging the certifications Toyo Seiko has already been granted by customers such as Boeing, GE, Pratt & Whitney.

Photographed from left to right: **Larry Catanzarite**, *consultant for Toyo Seiko's business development activities in North America;* **Darin Gleason**, *North America Zone Managing Director at Winoa;* **Joan Samual**, *Head of Global Product Management at Winoa;* **Dr. Yoshihiro Watanabe**, *Toyo Seiko's President and CEO;* **Shota Watanabe**, *Vice President of Toyo Seiko North America.*

Rotary Flap Peening Equipment

The following are helpful hints and critical information for the 3M rotary flap peening equipment from Electronics Inc (EI).

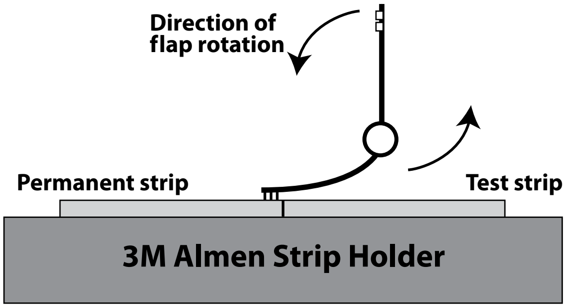
The 3M™ Roto Peen Almen Strip Holder

Do Not Tighten the Brass Screws

The height of the brass screws that hold the floating magnets in place has been pre-set by 3M. The position of the screws allows the magnets to move up and accommodate the arc of the peened Almen strip. If you tighten the screws so that the magnets can't rise, the Almen strip will slip off the holder.

Use the Correct Rotation Pattern

An Almen Strip is permanently attached to the holder surface. It acts as a sacrificial surface so the roto peen flap assembly does not encounter a sharp edge while the test Almen strip is peened. To take advantage of this feature, it is important that the flap is rotated from the permanent strip to the test strip (see illustration below). This rotation pattern will keep the shot from hitting the edge of the holder and dislodging from the flap.



The 3M Rotary Peen Flaps

Clean the Shot Before Peening

Given that these flaps are made by 3M—the global leader in the manufacturing of quality adhesives—it stands to reason that a quality product is used to adhere the shot to the flaps. To ensure a clean peened surface, rotate the flap against sandpaper for a brief amount of time to clean any adhesive off the balls.

Mark the Flap

A spot of paint on the backside of the flap, opposite the side with the shot, will help ensure that you are peening the surface with the shot and not the flap.

For more information, visit www.electronics-inc.com or call EI at 574-256-5001 or 800-832-5653 (USA and Canada).

Bye-Bye Counterfeits: PrinTracker Traces Origin of 3D Printed Goods

A STUDY by researchers at the University at Buffalo has proposed a new method for accurately tracking a 3D printed object back to the machine it came from.

Called "PrinTracker," the new process could help law enforcement and intelligence agencies track 3D printed guns, counterfeit products and other goods.

"3D printing has many wonderful uses, but it's also a counterfeiter's dream. Even more concerning, it has the potential to make firearms more readily available to people who are not allowed to possess them," said lead author, Associate Professor Wenyao Xu.

3D printers move back-and-forth while printing an object. Instead of ink, a nozzle discharges a filament, such as plastic, in layers until a 3D object forms.

Each layer of a 3D printed object contains tiny submillimeter wrinkles called in-fill patterns. These patterns are supposed to be uniform.

However, the printer's model type, filament, nozzle size and other factors cause slight imperfections in the patterns. The result is an object that does not match its design plan.

Like a fingerprint to a person, these patterns are unique and repeatable. As a result, they can be traced back to the 3D printer.

To test PrinTracker, the research team—which includes coauthors from Rutgers University and Northeastern University—created five door keys each from 14 common 3D printers.

With an inkjet scanner, the researchers created digital images of each key. From there, they enhanced and filtered each image, identifying elements of the in-fill pattern.

They then developed an algorithm to align and calculate the variations of each key to verify the authenticity of the fingerprint.

Having created a fingerprint database of the 14 3D printers, the researchers were able to match the key to its printer 99.8% of the time—even 10 months later!

The team also ran experiments involving keys damaged in various ways to obscure their identity. To their delight, the PrinTracker proved to be 92% accurate in these tests.