Summer 2018
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The Shot Peener

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

Emerging Technologies and Blast Machines

PLUS: SURPRISING BENEFITS OF A SHOT PEENING WORKSHOP | SHOT PEENING AND ADDITIVE MANUFACTURING | WOOD AS STRONG AS METAL

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

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 : 430(H) X 400(W) X 400(D) mm
Positron source : Na-22 (under 1MBq)
Measurement time : 5 min minimum

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

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

Making a Contribution to the Future

I CAME ACROSS some notes from earlier SAE meetings that included projects on coverage and intensity determination. Numerous meetings were dedicated to these projects. Here we are nearly 35 years later and we're still talking about the same subjects at our meetings.

JACK CHAMPAIGNE

Does this mean we just cannot get it right or is the technology evolving? I think it is the latter. Technology is evolving rapidly. Now, in addition to quality improvements in the Almen strip performance, we are seeing progress with non-destructive testing during high-volume production. Our SAE committee recently established a task group to explore the use of image analysis for media size and shape inspection which could go a long way in removing subjective inspection results and reduce the inspection time. It seems like the only thing that remains constant is that everything is changing.

If you haven't attended a shot peening workshop lately you might want to think about the workshop this October (9th-11th) in Lombard, Illinois. The workshop includes three days of extensive training in all aspects of the peening and blast cleaning processes with the added benefit of exhibitors showing their latest technology. The SAE meeting is planned for Friday the 11th so those interested can stay and attend a day-long discussion of the Surface Enhancement Committee and the Aerospace Surface Enhancement Committee. I know these meetings are important just by judging from the attendance roster with attendees from the US, Canada, Mexico, Germany, England, France, Japan, Italy and others. Maybe you have something to contribute. Think about joining us. There is no registration fee for SAE meetings.

The photograph was taken at the April SAE meeting at the SAE headquarters in Troy, Michigan. Many of these participants traveled great distances to make a contribution to the future of shot peening.

THE SHOT PEENER

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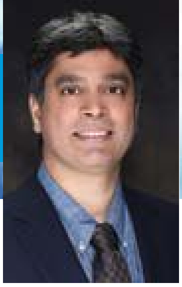


Kumar Balan | Blast Cleaning and Shot Peening Specialist

Emerging Technologies and Blast Machines

INTRODUCTION

Nicholas Negroponte, the founder of the Massachusetts Institute of Technology (MIT) Media Lab, predicted the "unwiring" of wired technology during a speech in 1984. Over two decades later, the way you use your addictive handheld devices is clear testimony to his predictions. Similarly, albeit at a slower pace, our industry has also seen its share of innovations over the years. A PLC to control the programmable features of a cleaning or peening machine is no longer an optional feature. Most machines now have a touchscreen operator interface instead of a decoration of pushbuttons and illuminating lights on the panel.

A recent news item on ThomasNet described a new design protocol at GM—they are now partnering with Autodesk. (Autodesk is a leader in 3D design, engineering and entertainment software.) GM uses the software to review hundreds of component designs, utilizing both new and legacy parts, resulting in lighter, yet stronger, components. Most of us are familiar with part/design redundancy and can relate to the advantages derived by GM with this development. Although our industry is often referred to as "low-tech and high-touch"—implying the reliance on human interaction in our processes—it most certainly has progressed along the right path. Is this path parallel to the industrial environment that's familiar with emerging technologies?

Artificial Intelligence (AI) is one of these emerging technologies. AI is the ability of a machine or any other entity to make human-like decisions given the same information. With vast amounts of available data gathered at various process points in a machine, for example, AI-enabled systems can make decisions that are structured and fact based. Our unique world of blast cleaning and shot peening is now also presented with products of additive manufacturing and related techniques, and customers are placing stringent demands of product quality, traceability and machine intelligence when their products are processed in our machines.

Robert E. Joyce, Jr, President and CEO of Norican Group (parent to Wheelabrator, Disa, Italpresse Gauss and StrikoWestofen) feels that their customers' industries are "well ahead of this curve" and cites the example of GE Aviation's investment in 3-D printing of jet turbine blades. Mr. Joyce reinforces his company's commitment to new technology when he said, "We created a Norican Digital organization last November to begin building out our strategy and approach to participate in the growing requirements our customers have in this area."

Bernhard Kerschbaum, the CEO of Rosler in Battle Creek, Michigan, a large, global manufacturer of surface finishing equipment, added, "Our equipment has already started incorporating special sensors and monitoring options including possibilities of remote access. This is Rosler's way of investing in Industry 4.0 projects and in active collaboration with our customers' process control needs."

WHAT DOES AI MEAN TO OUR INDUSTRY?

During a recent smartphone purchase, I remarked that the device cost as much as a laptop. I was consoled by the vendor with the reasoning that the phone also had as much computing power! I under-utilize the phone's capabilities by employing it only for emails, phone calls and the occasional application, but the device can't be blamed for that. Similarly, almost all well-designed blast cleaning machines and all shot peening machines are built with a PLC and process monitoring/control components. They have the potential to share a significant volume of information. We are certainly not using them to their full potential either.

Mr. Joyce agrees with this when he said, "Norican's metal-part manufacturing customers are keen to unlock the hidden potential of their operations through a much richer and deeper understanding of the information that each machine is (or could be) generating. We categorize this into Machine-based and System-based data sets. Machine-based data sets include real-time energy consumption, energy transfer, sound levels, and wear part degradation. System-based data sets use the results of the machine-based data to transmit important information through the production flow to alter downstream operations in the event of a machine/process disruption."

To illustrate this, let's take the example of a high-production environment where blast media flow from nozzles or wheels is designed to be continuous to eliminate blast stabilization delays. A classic example could be an inline connecting rod peening machine with two sets of identical blast wheel arrangements in series to peen both sides of the

rod after flipping each part, or two distinct machines in series in the case of coil spring peening where the second machine is employed for dual peening. Any irregularity arising in the first machine, such as that caused by reduced media flow, will require increased exposure time, translated into reduced conveyor speed. Temporarily ignoring the need for new saturation curves, etc., in both cases, the second machine could alter its process parameters to correspondingly slow down the cycle or, in certain cases, shut down the blast wheels so that machine component wear is reduced with corresponding control of operating costs. Downstream processes such as inspection or super-finishing would also benefit from this communication. Blast machines are maintenance-intense and such data transfer allows predictability of wear and the required planning for it.

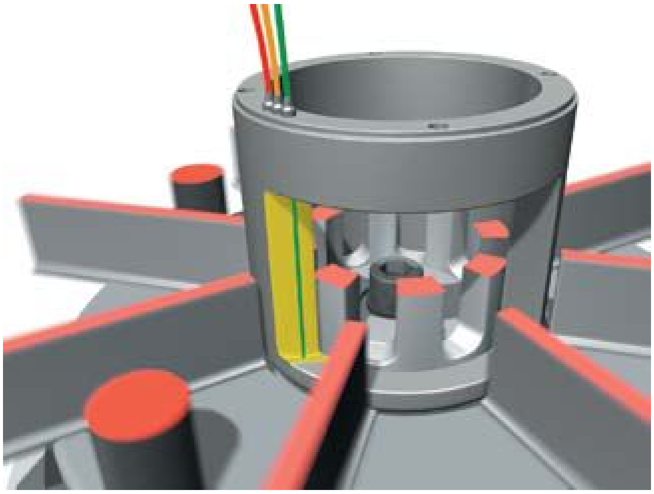
"Specially formulated controls in Rosler machines notify the user of required maintenance tasks based on machine run-times," said Bernhard Kerschbaum. "The next level of sophistication uses sensors that monitor parameters such as vibration to improve the accuracy of predicting component wear and eventual failure." Mr. Kerschbaum is drawing our attention to the limitation of AI-compatible controls when he added, "Continuous measurements of surface finish or effectiveness of shot peening results are not always practical, and self-learning systems have to rely on post-process inspections involving an offline surface measurement or a trained eye."

IS AI LIKELY TO ALTER THE INDUSTRY STRUCTURE?

Automated blast cleaning and shot peening operations have already embraced advanced technology. For example, industrial robots, used for machine tending and mainstream blast and handling operations, have increased exponentially. Robots with better sealing and build quality are used now even in dusty environments. As for controls, aerospace customers have already placed enough demands on us that we're experts in designing controls with process checks and traceability. In response, quality equipment manufacturers have supplied machines with hardware capable of generating "big data" such as pressure/speed/velocity monitoring, closed feedback loops for media flow, real-time display and correction of process parameters.

These developments have prompted the machine operator to acquire new skills. The operator is now capable of robot path programming in addition to simply calling up a recipe/technique to peen a part. Complex parts such as blisks require advanced programming techniques since they present the risk of distortion if peened unevenly. The AI architecture now adds a purpose and effective use for this generated data.

There's another advantage to the machine's decision-making abilities. Mr. Kerschbaum said, "With such monitoring and diagnostics, fewer experts can monitor more equipment. Introduction of Industry 4.0 and IoT (Internet of Things) to equipment will help compensate for the growing skill shortage in manufacturing." He makes a great point because automated process compensation and control achievable through AI have the capacity to direct the customer's team to an impending issue (control cage wear, recorded by a sensor, that has started altering the blast pattern for example), or alert the OEM's service staff to place a service call in the immediate future.

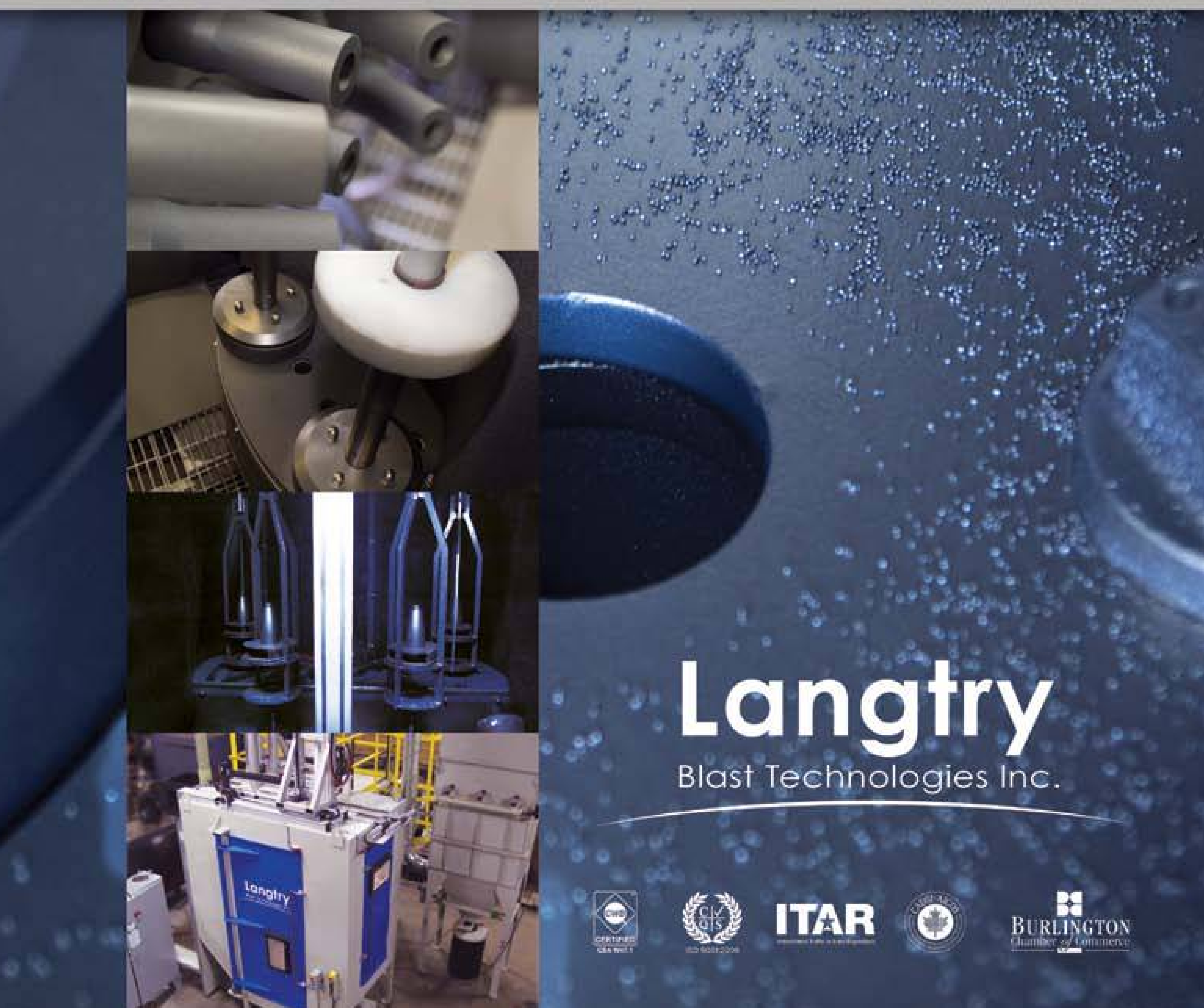


Sensors inside a Wheelabrator blast wheel identify wear and automatically shift the control cage.

In a blast machine, it's common to hear the operator comment that "the machine doesn't sound right during operation." Let's take the example of a wheelblast machine where the parts that commonly wear are within the wheel/turbine assembly. The machine/blast wheel generates a characteristic sound when operating at optimum performance and sounds distorted when not doing so. Rotating at 3000 RPM and generating media velocity about 300 feet per second, this dynamically balanced assembly can demonstrate greater maintenance predictability when its individual parts such as control cages, impellers and blades are closely monitored with regular reports of its normal wear patterns. In other words, the reliance on a human and the variance in interpretation among different operators no longer need to be the predictor of maintenance.

"The new industry shift is perhaps not so positive for suppliers that do not respond by designing their equipment to be Industry 4.0 compatible. In the future, the value of equipment will be gaged based on its ability to improve shop floor data flow in addition to its obvious task of shot peening a part to required specifications. If a blast machine supplier is unable to improve shop floor data flow, that gap might be filled by technology companies with the possibility of them emerging as major players in our industry by displacing blast machine companies," predicted Mr. Joyce. He explained it further by providing an example of UPS partnering with SAP to set-up 3D printing capabilities throughout the United States. Mr. Joyce added, "One will have to go back to the


POWER ON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industrial revolution to look for a similar shift given the exponential amount of change unleashed in our customers' industries in the next decade."

How plausible is this in our industry? What will happen to your customer's constant demand for consignment spare parts when they can 3-D print them in their own plant? How about patents, duplication, and ultimately the liability? Additive manufacturing is gaining prominence in the manufacture of production parts and will this lead to an end-user that prints blast nozzles or blast wheel parts? These are relevant points that will get addressed as we adopt this shift into our daily schedules. Like most, our industry is also driven by the demands of our customers, predominantly automotive and aerospace. As we know, AI is not just a buzzword in both industries. Our industry will have to find a way to work through procedural hurdles and think in terms of the benefits it can provide.

IS MY JOB AT RISK?

This is probably the most commonly pondered question in our industry! Gary Kasparov was the world chess champion who had won over 180 championships when in 1997 IBM's Deep Blue beat him at his own game. In a recent TED talk, Kasparov eloquently explained that the triumph of machines is indirectly a human victory. Rather than fearing AI and the effect it might have on your career, he suggests challenging it. His conviction in a successful partnership with machines is summarized in the following three resulting value sets: (Human Intuition + Machine Calculation), (Human Strategy + Machine Tactic) and finally (Human Experience + Machine Memory). These value sets emphasize the complement that machines will offer humans and point out the attributes in both parties that are distinct and can't be duplicated.

To address the question of job security, let's first explore the impact of automation on our workforce. Automation, the precursor to AI, has met the following goals: repeatability, reduction in labor costs, quality assurance and general productivity increase. Production lines were re-invented with automation and robotics replacing manual labor either by attrition or direct elimination. As production volumes and the demand for consistent surface finish increased, our industry started automating some of those manual processes with robots, both custom and standard. Along with this development arrived process control and conformance to specifications. Machine operators sought training in the process and transformed themselves into banks of theoretical know-how coupled with practical insights.

Although a shot peening machine operator may not understand Bragg's law and X-ray diffraction, the effect of increased pressure on the measurable results of arc height and over-exposure to media are known to him. AI is an extension of this knowledge, except transmitted with purpose in a digital format directly by the machine controls. In our industry, the goal of AI thus far has been in predictive maintenance. The opportunity to extend this reach to other fields is promising. The human element can't be eliminated by AI, at least not in blast equipment. However, complacency is a threat. An AI-centric approach, whether in the front or back end of the process, requires a skill-set that's heavily reliant on process knowledge. The only way to avoid redundancy is re-training, taking advantage of the generated data and improving the process.

SOME PRACTICAL THOUGHTS

It's myopic to draw conclusions on topics as fresh and evolving as these emerging technologies. Instead, listed below are some insights into the possible outcomes in our industry.

- Creation of a robust database of tribal knowledge is essential for an AI-centric system to be successful. This database can be utilized not only for predictive maintenance, but also in the front end to seek suitable solutions to a challenging shot peening or blast cleaning application.
- Additive manufacturing is growing and traditional inventory levels of spare parts could see relief. Economies of scale needs to be re-defined.
- If technology is going to take center-stage, will existing manufacturers embrace technology, or will the likes of a Siemens or Allen-Bradley dominate the shot peening process/industry?
- The shot peening world continues to develop and evolve. However, the process is still being understood only at a fundamental level by some of its users. The correlation of arc height to intensity (saturation curves), coverage and residual compressive stress are still being digested by some. Will they concern themselves with perfecting their peening process or dive into the information gathering and disseminating trend demanded by AI?
- Power, whether used to generate compressed air or operate multiple blast wheels, is expensive. By monitoring transmitted energy, blast patterns (abrasive concentration and proper targeting on the part), and speeding up and slowing down a blast cycle to compensate for upstream issues, the user can not only get a better control of operating costs, but also shut down the process rather than produce defective parts due to upstream shifts from normal. This could be justification enough to embrace this change in most wheelblast machines.

AI mimics human cognitive functions; however, AI can do it at a higher level due to the speed and power available in computing platforms. In Gary Kasparov's words, humans have understanding, machines rely on calculations. Machines work on objectivity whereas humans have dreams and a passion to achieve them. AI and other emerging technologies are now well-rooted in our customers' industries. It is incumbent upon us to use that passion to stretch the smartness of our machines to achieve tangible goals of smart productivity.

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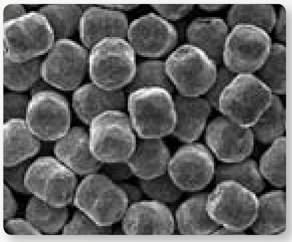
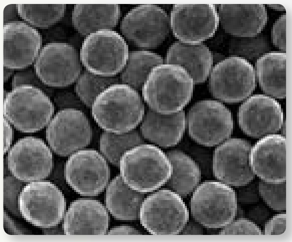
- **Highest Resistance to Fracture** Premier Cut Wire Shot media tends to wear down and become smaller in size rather than fracturing into sharp-edged broken particles, which may cause surface damage to the part.
- **Lower Dust Generation** Highest durability equals lowest dust levels.
- **Lower Surface 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



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Kathy Levy | Associate Editor | The Shot Peener

The Surprising Benefits of a Shot Peening Workshop

SURPRISE! This article has nothing to do with shot peening training. It won't promote classes in intensity, coverage or machine maintenance. It will, however, address three specific groups of people—Decision Makers, Exhibitors, and Employers—but please read ahead to see if you can take advantage of the same benefits they receive from participating in an Electronics Inc. (EI) Shot Peening Workshop.

#1: BENEFITS TO DECISION MAKERS

The "decision makers" in the context of this article are the people challenged with the task of bringing shot peening in house. I can't stress this strongly enough: The decision makers should attend a shot peening workshop **BEFORE** making big decisions, especially equipment purchases. The following are three scenarios that highlight the reasons decision makers should attend a workshop.

This is more complicated than we thought

A process engineer who was given the responsibility of developing an in-house shot peening program attended an EI shot peening workshop. Afterwards, he expressed his astonishment over the complexity of the shot peening process to Dave Barkley, the EI Shot Peening Training Director. The engineer went back to his company with a much different impression of shot peening. Regardless whether the company decided to bring shot peening in house, the investment in the workshop was worthwhile. If the company decided to move ahead with an in-house shot peening program, they had valuable information for mapping out a successful strategy. If they decided to continue to send their components to a shot peening job shop, they now have the knowledge to better evaluate the work.

We bought the wrong equipment

A company purchased a shot peening machine from a leading manufacturer but after attending a workshop they confided to Dave that a rotary flapper peening program could handle their needs. Don't let this happen to you. Research is crucial when developing a shot peening program and this leads nicely to my next point.

The exhibitors and instructors were so knowledgeable and helpful

The environment is friendly and relaxed at an EI Shot Peening Workshop and the exhibitors look forward to answering your questions. Under no other circumstances can decision makers meet with so many leading OEMs at one time. In addition, workshop instructors are experts in their fields and they are generous with their time. A typical EI workshop has several social events where students, instructors and exhibitors can talk. A workshop is also a rare opportunity to meet attendees that already have an in-house shot peening facility. They have a wealth of experience to share.

#2: BENEFITS TO EXHIBITORS

This sharing of knowledge isn't a one-way street. Two exhibitors with industry-leading companies recount how they benefit from talking with students.

> Jim Whalen, Progressive Surface
>
> Every year at the workshop we learn something from attendees on how we can make improvements in our products. We have incorporated these ideas into our PRIMS user interface, Saturation Curve Solver and, most recently, more and more customers are asking about the tools and technology that would minimize the chance for operator error when loading a part, nozzle or program. These requests for error proofing have helped us justify the investments we have made into developing "intelligent" peening machines that incorporate vision and measurement technologies.
>
> Sometimes as equipment builders we assume that everyone who buys a shot peening system knows the process and applications as well as we do. Year after year, however, we see how many new faces are coming to learn the process. They don't learn about the shot peening process in school so we have taken a much more active approach to assure that customers have basic process

understanding as part of our machine training, that they understand how to complete a saturation curve, and what the difference is between coverage and intensity. If they have not been to a workshop to really understand these process basics, we make sure we cover that with them.

Being an exhibitor at the workshop provides the perfect setting for conversations with equipment users outside of the typical procurement process. These discussions have really helped us understand customers' needs, the issues they have running peening equipment in production, and the things that if incorporated into machines would improve the quality of their shop output. They share good experiences as well as bad and it's all great information to help us to become better equipment providers. It is hard, if not impossible, to have these types of honest discussions under the restrictive procurement process.

Phil Waser, Ervin Industries
Ervin's philosophy is to "Never Stop Improving" and the shot peening conferences continue to be events from which to draw inspiration. At EI workshops, we present non-partisan facts about peening media and combine it with a description of Ervin's unique processes that allows conformance to SAE and AMS specifications. During these presentations, it's very common for participants to express their realization of the importance of using and maintaining good quality peening media in their process.

As an example, an engineer from an aerospace MRO came up to us during a workshop to discuss our recent test procedure for a new shot they were using. His company had sent us their media sample to test for durability and other attributes with the Ervin Test Machine at our lab in Adrian. He told me that the Ervin material was found to be more durable than the competition. Though this was an expected result, we learned from the engineer that increased durability meant more than just a reduction in operating costs. To them, media quality had a direct impact on repeatability and accuracy of their peening process. Ervin thrives on such validation of our product quality and acknowledgement from the end users.

On yet another occasion, we were able to help out an aerospace customer we met at the workshop develop a very specific grit blast media at Ervin Technologies in Tecumseh. Ervin Technologies is the R&D center for our North American operations and this interaction enhanced its profile within the aerospace industry.

#3: BENEFITS TO EMPLOYERS

Recent surveys of American manufacturers support a feeling common in our industry—many manufacturers are thriving and embracing innovation.* Unfortunately, a lack of skilled workers is the biggest impediment to growth at this time. Obviously, training creates skilled workers but it's also an effective way to keep good employees. Here are three positive messages an employee receives when she/he is sent to a shot peening workshop.

1. I'm valuable to this company. It's a good feeling to know you are worth the investment of training.

2. Shot peening is a great industry. An underlying message of shot peening training is this: Shot peening makes a valuable contribution to many industries. Participants leave the workshop with a sense of pride in what they do.

3. I am an achiever. When a student earns a Certificate of Achievement, he/she feels are a sense of accomplishment. It can also put them on a career path within your company.

Appreciated and motivated employees are much less likely to move to other companies or leave manufacturing for other fields. And finally, the most obvious benefit of training to employers is peace of mind—the peace of mind that comes from knowing your employees are implementing a controlled shot peening program.

*A recent survey on American manufacturing can be found at www.thomasnet.com/pressroom/Industry_Market_Barometer.html.

Photographs are from the 2016 USA EI Shot Peening Workshop in Indianapolis, Indiana.

Abrasive Blasting of Motorcycle Exhaust Parts

MARKET:
Automotive

APPLICATION:
Abrasive blasting cleaning of motorcycle exhaust parts prior to coating

THE CHALLENGE:
A major supplier of exhaust pipes, mufflers, and exhaust shields to the motorcycle industry wanted to improve the efficiency of their blast cleaning operation. The existing process, that utilized two in-line automated blast cleaning systems, was extremely labor intensive, offered incomplete parts coverage and also resulted in an excessive loss of media.

The first blast cleaning system was equipped with a rotary head with six fixed guns for blasting, while the second system employed a horizontal oscillator that also utilized six fixed guns. The parts, ranging in size from a few inches to approximately 2 feet long by 15 inches wide, were being manually loaded onto magnetic trays designed to hold them steady during blasting and then transported through the blast cabinet on a conveyor.

Each system required two operators—one to load parts and one to unload parts and return them to the front of the machine via a return conveyor for a second pass to blast the reverse side—thus making the process slow and unable to keep pace with the painting line. Also, parts coverage in both systems was incomplete due to the rotary head only having six guns and the horizontal oscillator only blasting each section of the part one time.

Additionally, the conveyor-based design of the two blast systems presented another challenge to the supplier. With both ends of the blast cabinet being open and the parts trays being returned via an open conveyor, there was an excessive loss of media during the production process. Not only was media being blown out of the openings at each end of the machine, it was also easily spilled as the trays were lifted from the conveyor. A large volume of media was ending up on the factory floor. At a price of $0.80 per pound for the aluminum media being used, it was a significant concern.

THE SOLUTION:
Empire technical sales personnel and application engineers met with the manufacturer to evaluate the current process and determine their requirements.

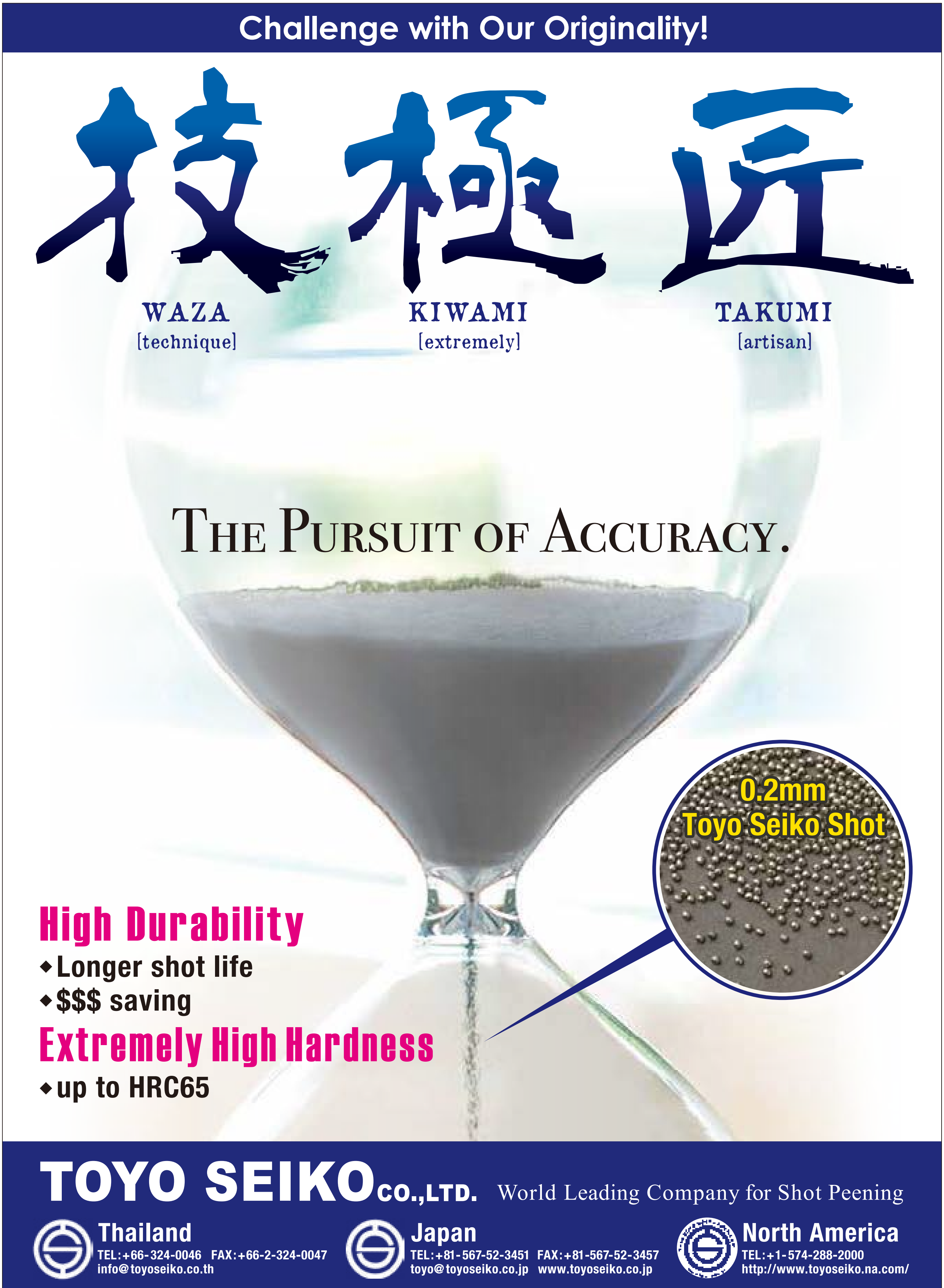
After careful analysis Empire recommended replacement of the two in-line blast systems with a single automated continuous turntable machine. The new machine featured a suction blast system that employed two rotary heads each outfitted with nine blasting guns. Empire recommended the proper size and orientation of the guns that would ensure complete coverage of the parts and meet the required quality standards.

To improve productivity and speed up the blasting process, the new unit was designed with both front and rear loading stations. This would enable the front operator to load new parts into the system, while the rear operator's duties would be to flip the parts at the rear station thus eliminating the return conveyor entirely.

The continuous turntable was sectioned off into four quadrants, or pies, each featuring magnets to hold the parts covered with Ultra-Wear™, Empire's proprietary surface that resists wear and abrasion. In addition, lighting was included above workstations for added visibility.

In order to prevent the loss of media, each rotary head was given an independent air supply and was sectioned off with curtains from the rest of the machine. In addition, two additional vestibules were created after each rotary head that housed blow-off stations and dual rows of brushes and rubber fingers to ensure removal of media prior to the parts being flipped or removed from the machine.

BENEFITS:
Empire was able to provide a unique solution that increased production in the blast cleaning operation to a level that exceeded the paint line, while at the same time reducing the number of operators required by 50% from four operators down to two operators and cutting floor space in half. Part finish quality was also greatly improved, reducing the number of rejects and returns. The motorcycle parts supplier was able to reduce costs, improve overall turnaround time on their products and improve the final product quality.



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Toyo Seiko Shot
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◆Longer shot life
◆$$$ saving
Extremely High Hardness
◆up to HRC65
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Assessment of As-Printed, Machined, and Post Processed Additive Layer Manufactured Ti-6Al-4V for Aerospace Applications

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S. McArthur, Curtiss-Wright Surface Technologies, United Kingdom, steve.mcarthur@cwst.com

THANK YOU to Curtiss-Wright Surface Technologies (CWST) for sharing a recent research project on Additive Layer Manufacturing (ALM) and shot peening. Additive manufacturing is an important topic in our industry, especially for aerospace applications.

The project was initiated by the helicopter division of the Leonardo company in the United Kingdom. Leonardo manages the design, development, testing, production, support and sales of the complete range of rotary aircraft available for commercial, public utility, security and defense use. Leonardo has used the services of the CWST facility in the U.K. for many years.

ALM is being successfully used to build metallic components under *static* loads; CWST and Leonardo explored the fatigue strength of ALM components under *cyclic* loads. The Ti-6Al-4V fatigue test specimens were either additive layer manufactured to the defined dimensions or were machined down to the dimensions from additive layer manufactured cylinders. The components were divided into five batches: As Machined; As Printed; As Printed and Shot Peened; As Printed, Shot Peened and/or Superfinished; and As Printed and Superfinished.

After fatigue testing, the As Printed fatigue samples exhibited substantial loss of fatigue life. Jochen Fuhr, one of the authors of the paper and General Manager for CWST North American Shot Peening, offered his thoughts on the results of the research program.

> *The problem with AM/3D printed parts is mainly the surface roughness, possible defects, inclusions or thermal effects in the close surface area which can lead to early cracking under cyclic load. One way to overcome this weakness is to remove this surface by milling or turning after printing—which might be easy on a simple geometry like a fatigue probe, but impossible on the complex structures for which this printing technology is ideally suited. Our machined samples were 3D-printed cylinders that were turned/machined down to the required fatigue sample shape. After this machining process, all surface-related failures from the printing process were completely removed.*
>
> *Another way to improve the fatigue strength is to put the surface area in compressive stresses by shot peening which, on those samples, also reduced the overall roughness after printing. This shot peening process can also be used on more complex parts but there are limitations even here. As there are still subsurface defects from the printing process, the fatigue strength is not as high as the machined ones, but much higher than printed-only specimens. When it comes to cyclic loading, the aerospace industry will have to find a solution for the uncontrollable loss in fatigue strength and here shot peening and super finishing might be an ideal solution—technically and economically.*

CWST is currently working on R&D projects in additive manufacturing with INCONEL or stainless steel for other customers in order to find a solution.

The following excerpts from the paper provide much greater detail on the project and the complete paper is available for download from the online library at www.shotpeener.com.

ABSTRACT

Especially within the aerospace field there is a large interest in manufacturing increasingly complex components in the most economical way based on the relatively small volumes required by this industry. A very promising technology that may fulfil these requirements is the Additive Layer

Background image courtesy of Progressive Surface

Manufacturing (ALM) process which is already used for an increasing number of metallic and non-metallic components usually under static loads only.

Within this paper the focus is on the fatigue performance and cyclic loading of ALM components made of Ti-6Al-4V material widely used in the aerospace industry. Fatigue samples were treated by different processes including machining, shot peening and superfinishing after the "printing process". In addition, the post ALM treatments have been applied in variations and combinations to determine their individual effect on the fatigue strength of the ALM components.

Keywords: Additive Layer Manufacturing (ALM), Ti-6Al-4V, Fatigue Testing, Shot Peening, Superfinishing, Residual Stress, Roughness; Topographical Features

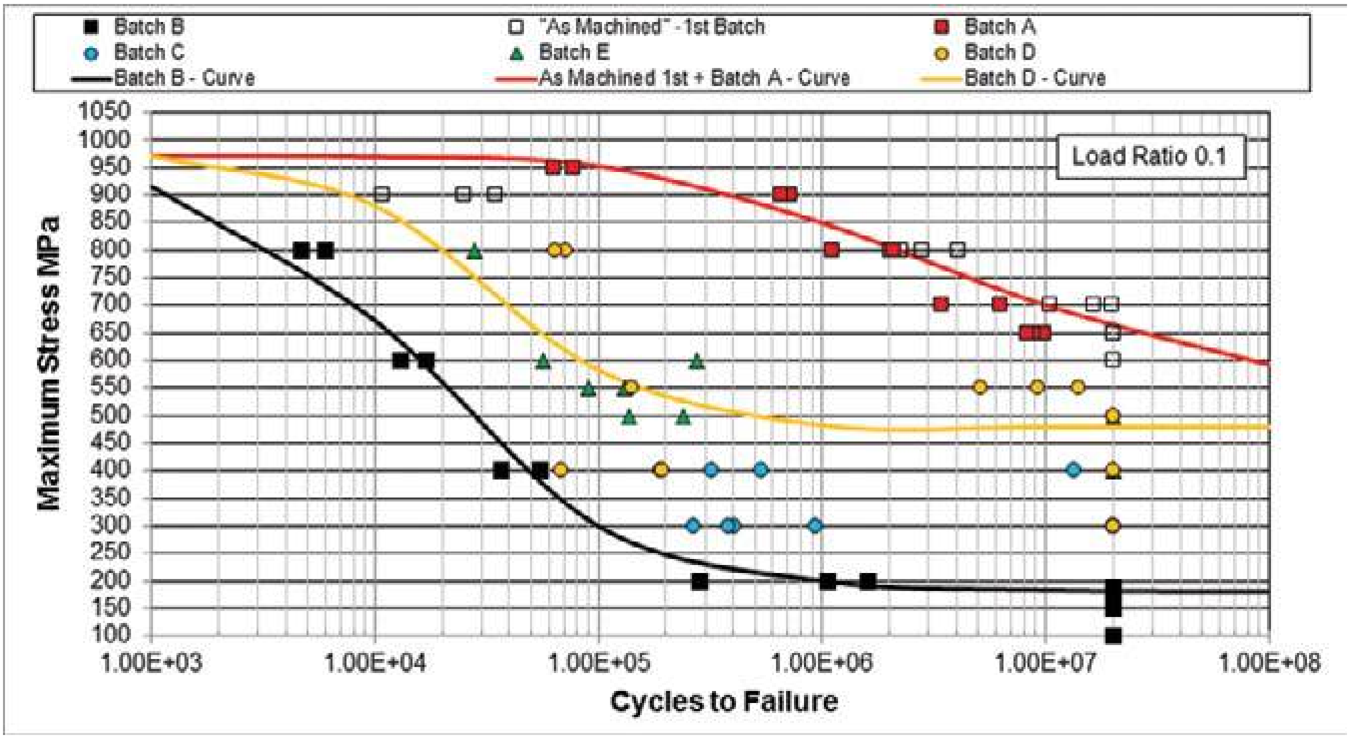
INTRODUCTION

Based on the initial characterisation trials carried out by the Leonardo Materials Laboratory, on the static and fatigue property data for ALM produced Ti-6Al-4V, Design Engineers have used this data to model and stress two ALM parts. As one of these parts was a flight critical part, Design and Stress Engineers required additional fatigue test data on both "As Printed" ALM and the effect post-processing techniques, e.g., shot peening and/or superfinishing, had on the fatigue properties of "As Printed" ALM. Consequently, this paper summarises the main topics results of the evaluation carried out by the Leonardo Materials Laboratory on "As Printed", machined and post processed ALM produced Ti-6Al-4V especially in terms of fatigue performance.

CONCLUSIONS

When compared to the "As Machined" ALM produced fatigue samples the "As Printed" ALM fatigue samples exhibited a substantial loss in fatigue life. The reason for this substantial loss in fatigue was due to four main factors, i.e., a rough surface, presence of surface contamination, evidence of tensile residual stresses in the surface and the creation of surface flaws/notches caused by partially remelted powder particles resulting in cold shuts/oxide films.

The fatigue life of the "As Printed" ALM can be increased by using shot peening, super-finishing or a combination of both post-processing techniques, in which the greatest improvement in fatigue was achieved by the use of shot peening combined with super-finishing. However, although substantial improvements in fatigue endurance are possible, fatigue endurance cannot be restored to the "As Machined" condition largely due to the fact that surface flaws/notches caused by partially remelted powder particles resulting in cold shuts/oxide films are still present.



S/N Curve of "As Printed" [Batch B], "As Machined" [Batch A], Shot Peened [Batch C], Shot Peened/Superfinished/Shot Peened and Superfinished [Batch D] or Superfinished alone [Batch E]. Note: Samples tested to 20 million cycles are defined as "run outs" (i.e., un-failed samples)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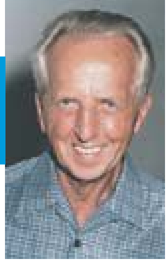

ACADEMIC STUDY

Dr. David Kirk | Coventry University

Almen Strip Quality

INTRODUCTION

Shot peeners are required to declare values of peening intensity derived at prescribed intervals. These values depend, to a significant extent, on the quality of the Almen strips that are being used. The primary factor defining "quality" of Almen strips is that they should be accurate. Accuracy is defined as a combination of bias and precision. Fig.1 illustrates the concept of bias. Imagine that there was some way in which we could know the "true value" of the arc height that should result from a fixed time of exposure to a fixed shot stream. If we then expose a batch of strips for the same time to the same shot stream, we may find that the mean value of the measured arc heights was different from the "true value". This difference is called "bias".

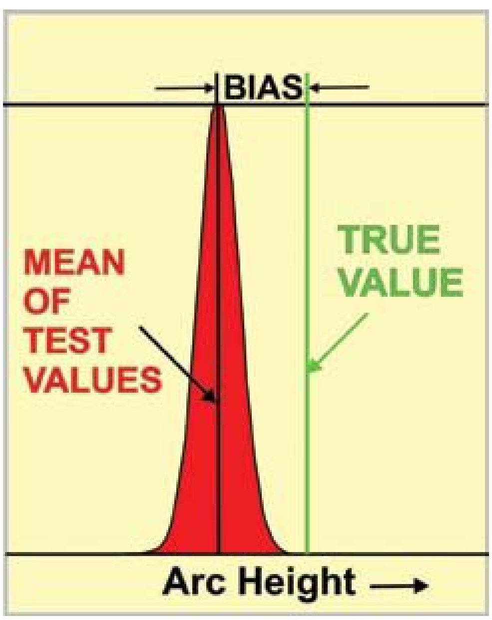

Fig.1. Bias exhibited by a set of Almen strips.

Fig.2 illustrates the complementary property of precision. The mean values of arc height for the two sets are spread over small and large ranges for high and low precision respectively.

A high accuracy for Almen strips therefore requires that they exhibit both high precision and a minimum of bias. Strip manufacturers have to cope, however, with a number of factors that can affect accuracy. This article presents the theoretical background to these factors. It is complementary to a comprehensive and fact-based study presented by Bailey

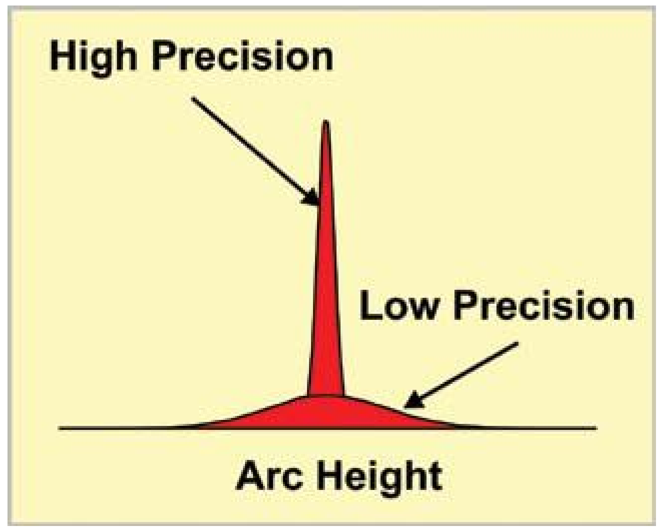

Fig.2. High and low precision exhibited by two different sets of Almen strips.

and Champaigne ("Factors that influence Almen strip arc height", ICSP9, 2005, pp392-399). Because of the large number of factors involved, some are dealt with here in much greater depth than are others.

Theoretical analysis of a quantitative topic necessitates the employment of mathematical techniques. Extensive use is made, however, of explanatory graphs. As the old saying goes: "Use a picture. It's worth a thousand words".

Most Almen strips are manufactured from SAE 1070 cold-rolled spring steel. Their allowed property ranges are described in J442. The strips themselves are key components in maintaining peening consistency. Primary defined variables include dimensions, chemical composition, hardness and elastic modulus.

It is concluded that a high level of accuracy can be, and is, achievable.

EFFECT OF ALMEN STRIP THICKNESS VARIATION

Almen strips, of necessity, vary in thickness to some extent. The effect of thickness variation can be estimated using the reasonable assumption that intensity, h, is inversely proportional to the square of strip thickness, t. That is because the rigidity (resistance to bending) of any rectangular strip is

proportional to the square of the strip's thickness. Expressed mathematically:

$$h = K/t^2 \quad (1)$$

where **h = peening intensity, K = a constant** and **t = strip thickness**

N Strip Estimations

(1) Assume that the "ideal" strip thickness for N strips is 0.79mm. As an example, further assume that the peening intensity is 0.100mm when employing this ideal strip thickness. Using equation (1) we have, ignoring units:

$$\mathbf{0.100 = K/0.79^2} \text{ so that}$$
$$\mathbf{K = 0.100 \times 0.79^2}$$

(2) Let us now assume that N strips are being used that are all 0.02mm thicker than the ideal, i.e., t = 0.81mm (the maximum allowed by J442). Using equation (1), together with the established value for K, we have that:

$$\mathbf{h^+ = 0.100 \times 0.79^2/0.81^2} \text{ or}$$
$$\mathbf{h^+ = 0.095}$$

This calculation tells us that measured peening intensity values will be reduced by 5% relative to the "ideal" if the strip thickness is at the top of the allowed range.

(3) Let now assume that the N strips being used are all 0.02mm thinner than the ideal, i.e., t = 0.77mm (the minimum allowed by J442). Using equation (1) together with the established value for K we have that:

$$\mathbf{h^- = 0.100 \times 0.79^2 /0.77^2} \text{ or}$$
$$\mathbf{h^- = 0.105mm}$$

This calculation tells us that measured peening intensity values will be increased by 5% relative to the "ideal" if the strip thickness is at the top of the allowed range. Taken together, we have the possibility of a 10% variation in measured peening intensity due simply to allowed variation in actual thickness of the strips. Note that this 10% variability is independent of the 0.100mm used in the specimen calculations.

Fig.3 is a graphical representation of the effect on declared peening intensity of strip thickness variation within the allowed range. This uses a precise relationship that applies irrespective of nominal peening intensity:

$$\mathbf{Devh^* \text{ - } \% = -100(1 - 0.79^2/t^2)} \quad (2)$$

Where Devh* is the deviation, as a percentage, from the intensity value that would have been derived if the Almen strips all had the "ideal" thickness of 0.79mm. The total possible range is 10%.

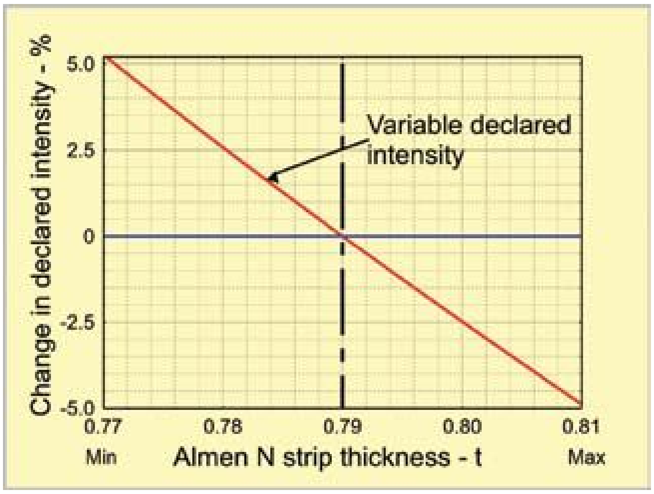

Fig.3. Effect of Almen N strip thickness variation on declared peening intensity.

A Strip Estimations

A strips are, of course, thicker than N strips. The thickness variation allowed by J442 is still ±0.02mm from an "ideal" thickness of 1.29mm. Estimates can be made by simply substituting 1.29 for 0.79 in equation (2) to yield:

$$\mathbf{Devh^* \text{ - } \% = -100(1 - 1.29^2/t^2)} \quad (3)$$

Where Devh* is the deviation, as a percentage, from the intensity value that would have been derived if the Almen strips all had the "ideal" thickness of 1.29mm.

The resulting effect is shown in fig.4 where the total possible range is now approximately 6%. This is predictably lower than that for the N strips because ±0.02mm is a smaller proportion of the greater strip thickness.

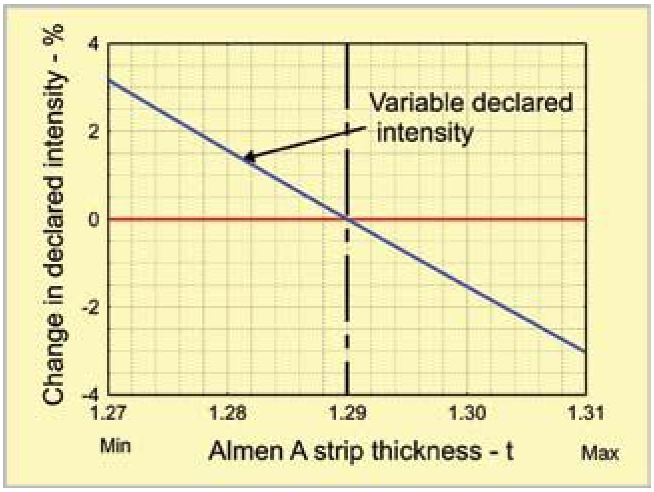

Fig.4. Effect of Almen A strip thickness variation on declared peening intensity.

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C Strip Estimations

C strips are even thicker than A strips. The thickness variation allowed by J442 is now ±0.03mm from an "ideal" thickness of 2.39mm. Estimates can again be made by simply substituting 2.39 for 0.79 in equation (2) to yield:

$$\mathbf{Devh^* - \% = -100(1 - 2.39^2/t^2)} \quad (4)$$

Where Devh* is the deviation, as a percentage, from the intensity value that would have been derived if the Almen strips all had the "ideal" thickness of 2.39.

The resulting effect is shown in fig.5 where the total possible range is now approximately 5%. This in effect balances the larger allowed range of thickness and the greater value for the "ideal" thickness.

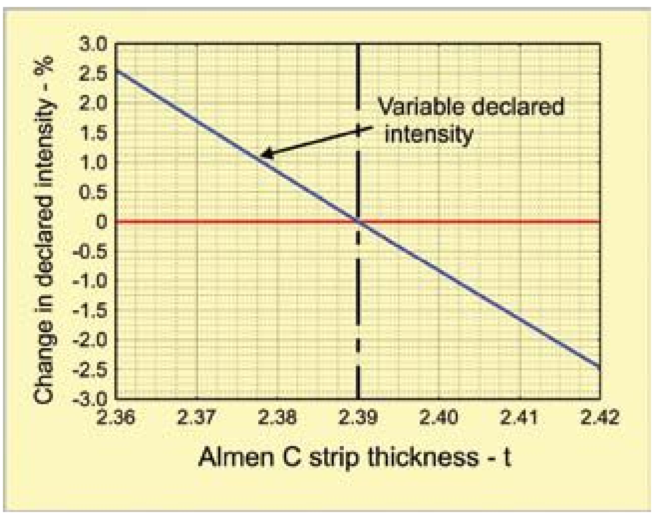


Fig.5. Effect of Almen C strip thickness variation on declared peening intensity.

Strip thickness is unlikely to vary for a given batch of strip material. It therefore follows that a significant amount of bias is possible and is more likely than a significant variation of precision.

EFFECT OF ALMEN STRIP LENGTH AND WIDTH VARIATION

SAE J442 allows a maximum variation of ±0.4mm for length and ±0.1mm for width from the "ideal" values of 76.0mm and 18.9mm respectively. Both length and width affect the rigidity of an Almen strip and therefore any arc height that will be induced by shot peening. The arc height, h, of any peened Almen strip has a simple relationship to the induced curvature, 1/R, of the strip (described in detail in the previous article in this series). This relationship follows from applying the "Intersecting Chord Theorem." Fig.6 illustrates the relationship.

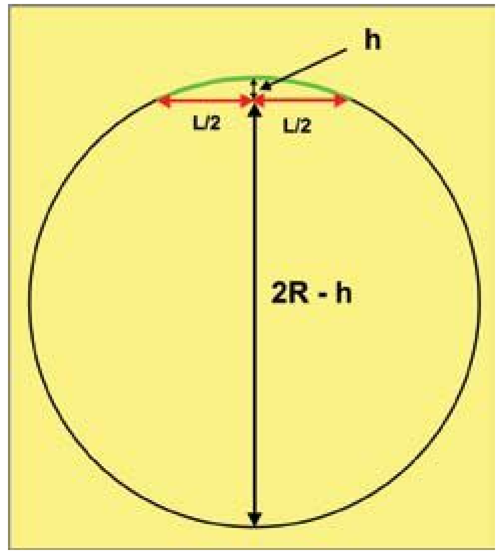


Fig.6. Intersecting chord theorem applied to an Almen strip.

Applying the intersecting chord theorem we have that:

$$\mathbf{h \times (2R - h) = (L/2)^2}$$

where L can refer to either strip length or strip width.

h is very small compared with 2R so that to a good approximation:

$$\mathbf{h \times 2R = L^2/4} \text{ or}$$
$$\mathbf{h = L^2/8 \times 1/R} \quad (5)$$

As explained in the previous article in this series, 1/R = M/(E x I), where M is the bending moment induced by peening, E is the strip's elastic modulus and I is the strip's rigidity factor. Substituting this relationship into equation (5) gives that:

$$\mathbf{h = L^2 \times M/(8 \times E \times I)} \quad (6)$$

Equation (6) applies to any peened strip. For the particular case when h is the peening intensity value, h*, we can say that:

$$\mathbf{h^* = L^2 \times M/(8 \times E \times I)} \quad (7)$$

Equation (7) can be used to estimate the effects of allowed variations in strip length or width (as well as other factors as discussed later in this article). Using the same method as that used for estimating the effect of strip thickness, we get the variation shown in fig.7 (page 32).

The estimated effect of permitted Almen strip length variation is indicated to be some ±1.0% of the declared intensity value. As this effect is expressed as a percentage, it accommodates the fact that arc height is actually measured between gauge balls' contact.

Strip width and length are unlikely to vary for a given batch of manufactured strips. It therefore follows that a

significant amount of bias is possible and is more likely than a significant variation of precision.

EFFECTS OF INDUCED BENDING MOMENT VARIATION AND STRIP PLASTICITY

For any given type of Almen strip (N, A or C), the magnitude of the induced bending moment, M, will vary with the metallurgical properties of the strip material. The major property variations are of **initial hardness** and **rate of work-hardening**. Fig.8 is a reminder of what is meant by bending moment in the context of Almen strip bending. Two factors contribute to the strip being bent to a radius, R. One is the compressive residual stress in the plastically deformed surface layer. The other is the plastic deformation itself. As pointed out in previous articles in this series, these factors contribute equally to a strip's bending. For any given shot stream, both factors are affected by the initial hardness of the strip. Points to note are that: (1) the harder the strip the less is the depth, d, of the plastically-deformed surface layer and (2) the harder the strip the greater is the average value of the induced compressive residual stress in this plastically deformed surface layer.

The effect of these two key points on the bending force, F, and depth, d, is illustrated in the schematic figs.9 and 10 based on residual stress distributions. Bending force is proportional to the area under the residual stress versus depth curve. A simple way to estimate this area is to draw a rectangle that appears to have a similar area. For fig.9 such a rectangle would have an area equivalent to 100N (200MPa x 0.5mm x 1mm) which is similar to an estimate of 90N (450MPa x 0.2mm x 1mm) for the curve in fig.10. These force values correspond to curve area multiplied by each millimeter of strip width.

The residual stress profiles shown in figs.9 and 10 are purely hypothetical, i.e., not based on any factual evidence. They are intended merely to illustrate that both the average level of compressive residual stress and the depth of compression are important for estimating the bending force.

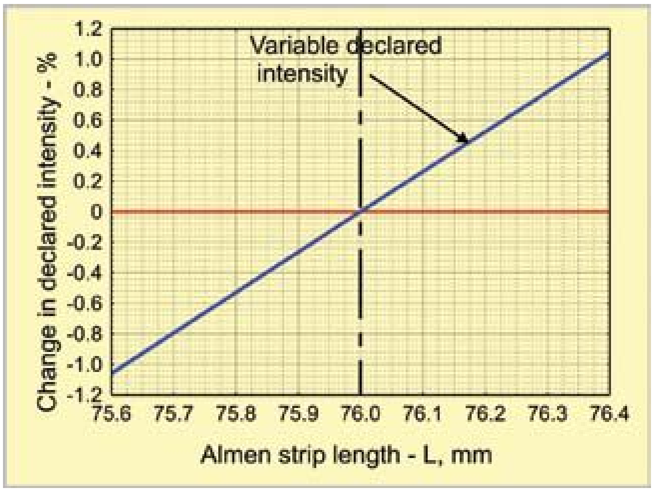


Fig.7. Effect of Almen strip length variation on declared peening intensity.

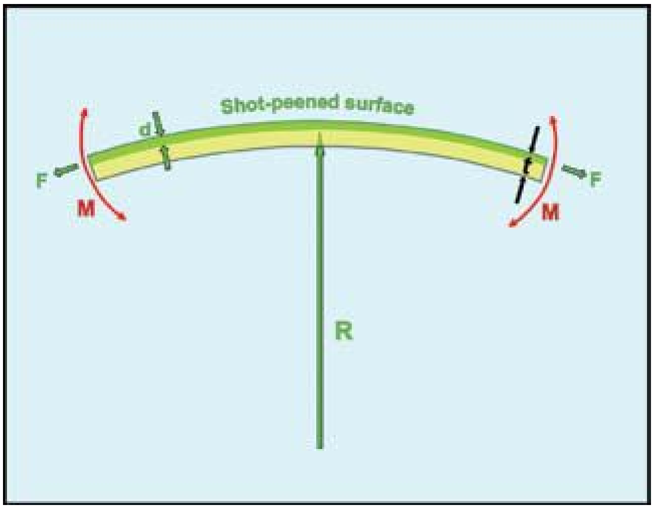


Fig.8. Bending moment, M, induced by force generated in shot-peened surface layer.

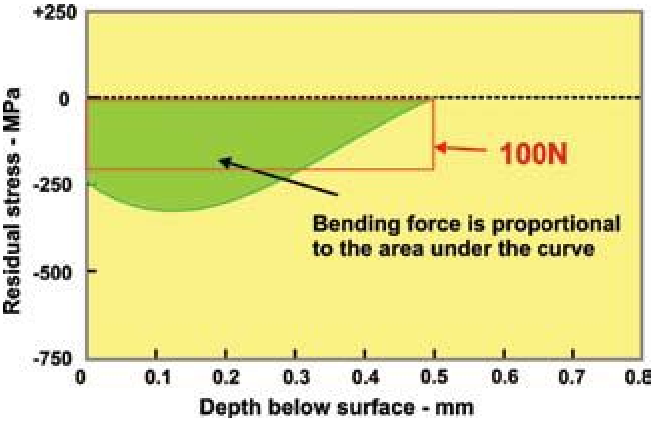


Fig.9. Bending force generation for relatively soft Almen strip.

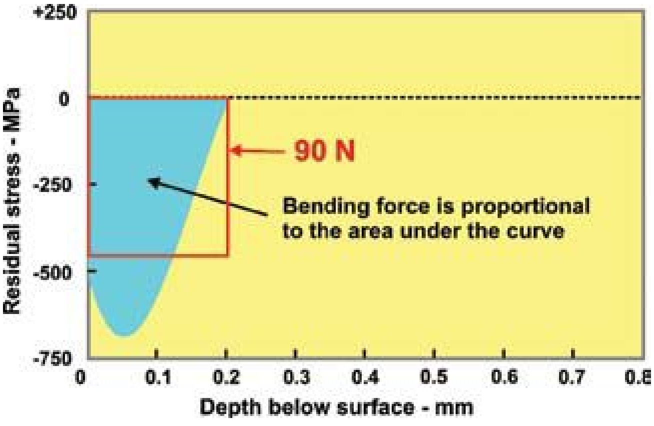


Fig.10. Bending force generation for relatively hard Almen strip.

We would expect that harder strip material would result in indents that have a smaller diameter. The Almen strip hardness range allowed by J442 is 44-50 HRC (72.5-76.0 HRA for N strips). 44-50 HRC is equivalent to Brinell hardness numbers of 409-481 (when using 3000kgf applied to a 10mm diameter ball). Using Brinell hardness is useful because it relates to the diameter of circular indents made by a ball rather than a shaped diamond.

The Brinell hardness relationship is given by the formula:

H_B = Applied force, P/(Surface area of the impression) (8)

Now the equation of the surface area of a circular indentation, also known as a "spherical cap", is quite complicated:

Surface area of the indentation $= \pi * D/2(D - (D^2 - d^2)^{0.5}$ (9)

where D is the diameter of the ball and d is the diameter of the indentation.

Substituting from (9) into (8) gives:

$$H_B = P/(\pi * D/2(D - (D^2 - d^2)^{0.5})) \qquad (10)$$

Fig.11 is a graphical solution of equation (10) for the maximum range of allowed equivalent hardness values (409-481 (when using 3000kgf applied to a 10mm diameter ball)). The curve is not quite linear. For a Brinell hardness of 409 (equivalent to 44HRC), the indent diameter is 3.02mm and for a Brinell hardness of 481 (equivalent to 50HRC), the indent diameter is 2.79mm. The difference in indent diameters is just over 8%. This is only relevant for the initial stages of shot peening. As peening progresses, we get multiple, overlapping indentations with corresponding work-hardening of the surface layer. The difference in hardness between the softer and harder Almen strips could then either decrease or increase!

It would be expected that higher levels of compressive residual stress would be induced in harder strip material than in softer strips. The corresponding bending force can be predicted using the "rectangle approach" used for figs.9 and 10.

The predicted bending force for the minimum allowed strip hardness is therefore proportional to 409 times 3.02 or 1235. For the maximum allowed strip hardness the predicted bending force is proportional to 481 times 2.79 or 1342. Arc height is proportional to bending force and 1342 is 8.0% greater than 1235. This leads to the theoretical prediction (in the absence of any other factors) that:

Almen strips with the maximum allowed hardness of 50HRC will give an 8% greater arc height than those with the minimum allowed hardness of 44 HRC.

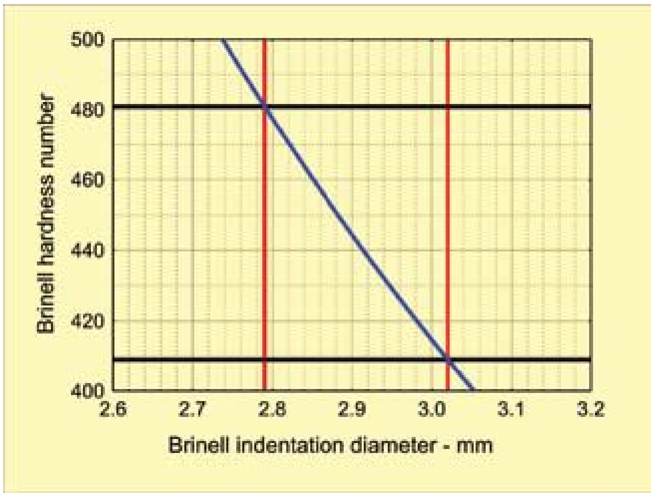


Fig.11. Variation of strip hardness affecting Brinell indentation diameter.

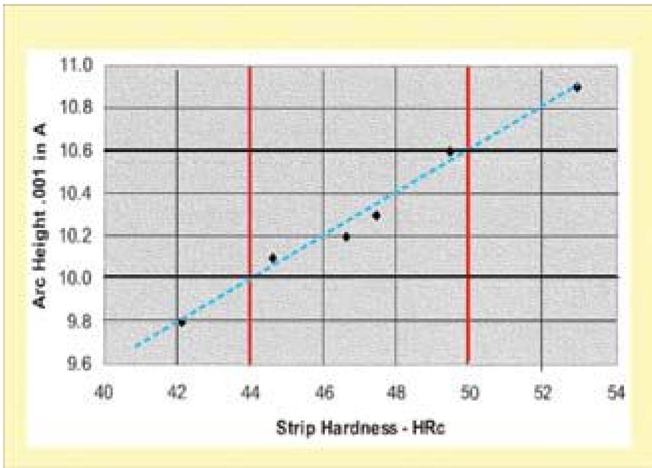


Fig.12. Effect of strip hardness on Almen arc height (Bailey and Champaigne).

Fig.12 is based on fig.1 of a paper presented at ICSP9 (P. Bailey and J. Champaigne, "Factors that influence Almen strip arc height", p392). Their results indicate a 6% increase (10.0 to 10.6) when strip hardness is raised from 44 to 50 HRC.

Fig.13 (page 36) represents the results of an internal EI study of the effects of strip hardness on arc height. This study involved a much wider range of strip hardnesses than that included in fig.12—the high hardness strips having been supplied by Toyo Seiko. The arc heights at the J442 limits could be calculated by inserting the range-limiting values into the fitted equations. Unfortunately, there appears to be an error in the stated polynomial equation. Using curve values obtained manually, the linear fit predicts a range of 17% for arc heights from 44 and 50HRC hardness strips. Substituting manually-obtained values for the best-fitting polynomial predicts a 9% range for arc heights from 44 and 50HRC hardness strips.

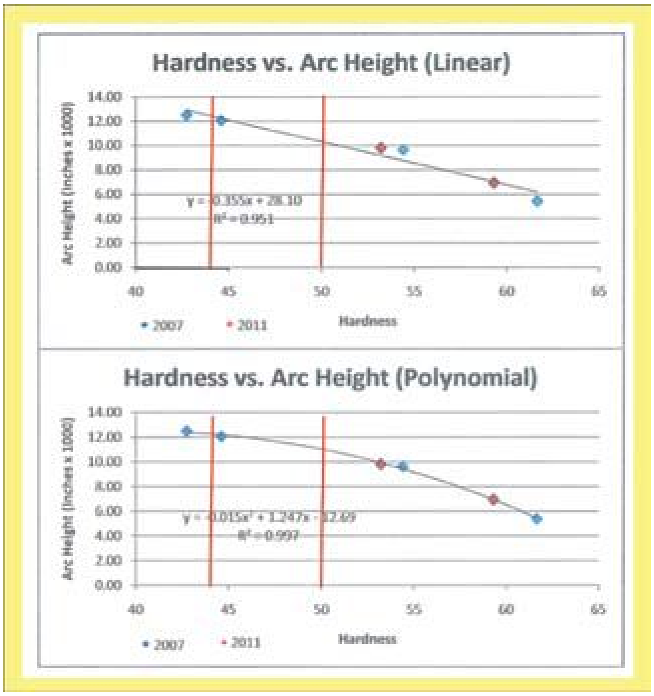


Fig.13. EI study of effect of strip hardness on curvature.

The fact that arc heights are consistent for a four-year interval indicates good precision. The predictions of either a 9 or 17% range of arc heights indicates that a significant bias can arise.

EFFECT OF ELASTIC MODULUS VARIATION

Arc height is inversely dependent on the magnitude of the elastic modulus, E. This is indicated in equation (6). The elastic modulus of 1070 steel can, reportedly, vary between 190 and 210GPa depending on the thermo-mechanical history of the strip. This would indicate the possibility of a significant bias —approximately 5%. Precision should, however, be good for a given batch of supplied strips.

EFFECT OF SURFACE FINISH

Polished Almen strips would be expected to lead to slightly higher arc heights for a given shot stream. That is because shot/surface contact angle is improved. Polishing is also relevant because it more closely represents the surface of most types of components. An EI study involving five different hardnesses of strip indicated a rise of from 12.0 to 12.3 (thousandths of an inch) as a consequence of using polished strips rather than unpolished strips.

DISCUSSION

The analyses that have been presented illustrate the significance of most of the variables that strip manufacturers have to cope with. Top-class manufacturers have strict control programs in place in order to ensure a minimum level of bias and a maximum of precision. Even without such programs there is a tendency for individual plus factors to cancel out minus factors. Premium-grade Almen strips are manufactured with rigid attention being paid to factors affecting quality.

Elasticity and plasticity properties govern material variability. Consistency can be checked by employing simple testing techniques. Fig.14 shows the force meter employed for the elasticity tests described in a previous TSP article (Fall, 2009). Fig.15 illustrates the principle of the ball-dropping plasticity test described in the TSP article of Summer, 2004.

Fig.14. Force meter gauging response of an Almen strip.

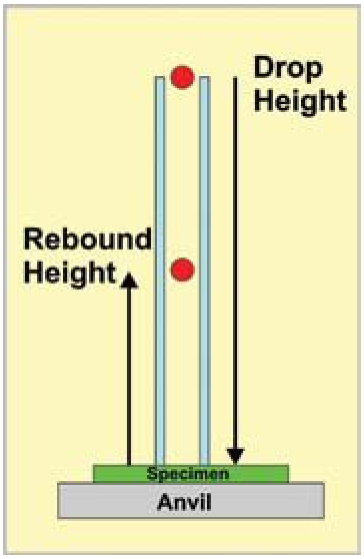


Fig.15. Ball-drop plasticity test principle.

In conclusion, it can be argued that the Almen Saturation Curve Test is still the most reliable method of gauging shot stream intensity. The strips themselves can be manufactured so as to display a minimum amount of bias and high consistency. A good case can be made for suggesting a halving of the current allowed thickness range for N strips. This would reduce the possible effect on deflection to the same as that currently possible for A and C strips.

UMD Researchers Create Super Wood Stronger Than Most Metals

ENGINEERS AT THE University of Maryland (UMD) have found a way to make wood more than ten times stronger and tougher than before, creating a natural substance that is stronger than many titanium alloys.

"This new way to treat wood makes it twelve times stronger than natural wood and ten times tougher," said Liangbing Hu, the leader of the UMD team that did the research, published in the journal *Nature*. "This could be a competitor to steel or even titanium alloys, it is so strong and durable. It's also comparable to carbon fiber, but much less expensive." Hu is an associate professor of materials science and engineering and a member of the Maryland Energy Innovation Institute.

"It is both strong and tough, which is a combination not usually found in nature," said Teng Li, the co-leader of the team and the Samuel P. Langley Professor of mechanical engineering at the University of Maryland. His team measured the dense wood's mechanical properties. "It is as strong as steel, but six times lighter. It takes 10 times more energy to fracture than natural wood. It can even be bent and molded at the beginning of the process."

The team's process begins by removing the wood's lignin, the part of the wood that makes it both rigid and brown in color. Then it is compressed under mild heat, at about 150˚ F. This causes the cellulose fibers to become very tightly packed. Any defects like holes or knots are crushed together. The treatment process was extended a little further with a coat of paint.

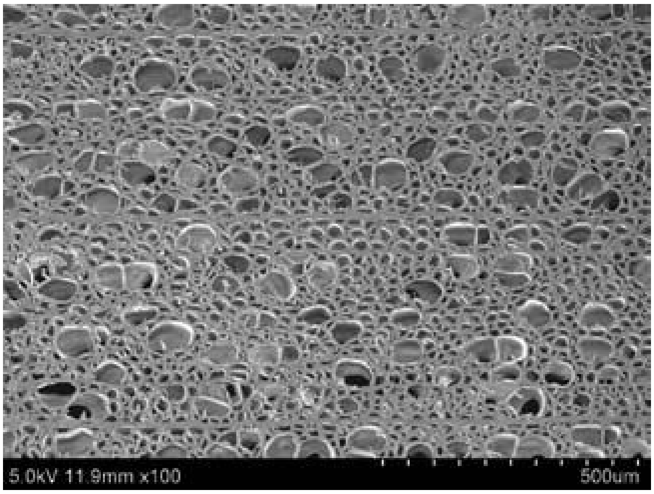
The scientists found that the wood's fibers are pressed together so tightly that they can form strong hydrogen bonds, like a crowd of people who can't budge—who are also holding hands. The compression makes the wood five times thinner than its original size.

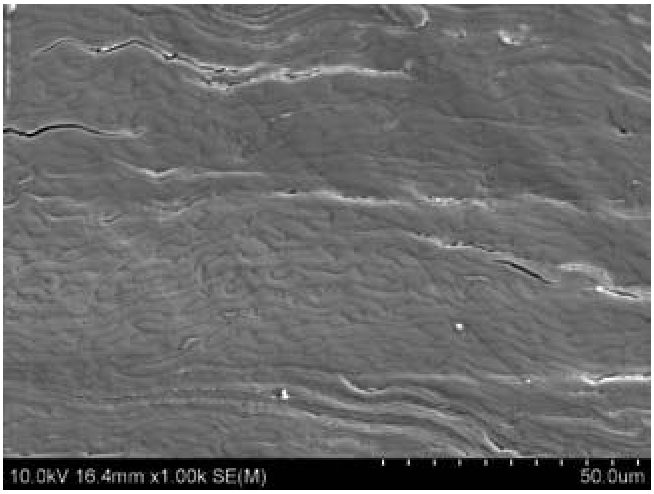
The team tested their new wood material and natural wood by shooting bullet-like projectiles at it. The projectile blew straight through the natural wood. The fully treated wood stopped the projectile partway through.

"Soft woods like pine or balsa, which grow fast and are more environmentally friendly, could replace slower-growing but denser woods like teak, in furniture or buildings," Hu said.

"The paper provides a highly promising route to the design of light weight high performance structural materials, with tremendous potential for a broad range of applications where high strength, large toughness and superior ballistic resistance are desired, " said Dr. Huajian Gao, a professor at Brown University, who was not involved in the study. "It is particularly exciting to note that the method is versatile for various species of wood and fairly easy to implement."

"This kind of wood could be used in cars, airplanes, buildings—any application where steel is used," Hu said. "The





Magnified images of (1) untreated wood and (2) the same wood treated by a new process invented by engineers at the University of Maryland that compresses the natural structures of wood into a new material five times thinner. Image Credit: University of Maryland.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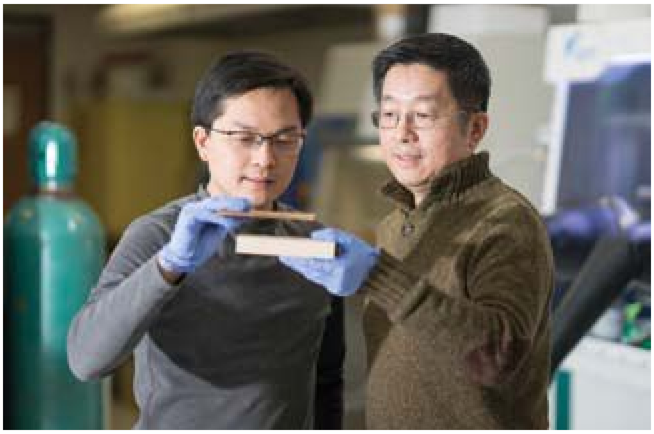
two-step process reported in this paper achieves exceptionally high strength, much beyond what [is] reported in the literature," said Dr. Zhigang Suo, a professor of mechanics and materials at Harvard University, also not involved with the study. "Given the abundance of wood, as well as other cellulose-rich plants, this paper inspires imagination."

"The most outstanding observation, in my view, is the existence of a limiting concentration of lignin, the glue between wood cells, to maximize the mechanical performance of the densified wood. Too little or too much removal lowers the strength compared to a maximum value achieved at intermediate or partial lignin removal. This reveals the subtle balance between hydrogen bonding and the adhesion imparted by such polyphenolic compound. Moreover, of outstanding interest, is the fact that wood densification leads to both, increased strength and toughness, two properties that usually offset each other," said Orlando J. Rojas, a professor at Aalto University in Finland.

Hu's research has explored the capacities of wood's natural nanotechnology. They previously made a range of emerging technologies out of nanocellulose related materials: (1) super clear paper for replacing plastic; (2) photonic paper for improving solar cell efficiency by 30%; (3) a battery and a supercapacitor out of wood; (4) a battery from a leaf; (5) transparent wood for energy efficient buildings; (6) solar water desalination for drinking and specifically filtering out toxic dyes. These wood-based emerging technologies are being commercialized through a UMD spinoff company, Inventwood LLC.

About the University of Maryland

The University of Maryland, College Park, is the state's flagship university and one of the nation's preeminent public research universities. A global leader in research, entrepreneurship and innovation, the university is home to more than 40,000 students, 10,000 faculty and staff, and 280 academic programs. Its faculty includes two Nobel laureates, three Pulitzer Prize winners, 60 members of the national academies and scores of Fulbright scholars. The institution has a $1.9 billion operating budget and secures $514 million annually in external research funding. For more information about the University of Maryland, College Park, visit www.umd.edu.



Liangbing Hu (left) holds a block of wood transformed by a new process to become stronger than rivals titanium and tougher than steel. Teng Li (right) holds an untreated block of the same wood. Image Credit: University of Maryland.

INDUSTRY NEWS

Wheelabrator Group Consolidates North American Operations, Expands Georgia Hub

Wheelabrator Group Inc., a Norican Group company, announces it will be consolidating its North American operations, centralizing both sales and engineering by creating a NA Region Hub at its LaGrange GA facility. The company's Burlington, Ontario facility will close in a phased shutdown and services will transition to LaGrange by the end of 2018.

Wheelabrator NA Sales and Service Leader Marty Magill commented, "It's challenging to make such a significant change to our business when it impacts highly valued employees. We have not taken the decision lightly and we thank our loyal team for their contribution to our success. The centralization of our Wheelabrator NA business allows us to join our sales and technology teams under one roof. This has become necessary to ensure we can move swiftly to meet customer needs for equipment, parts and service technology in an increasingly 'just-in-time' manufacturing landscape."

The LaGrange facility will become the headquarters for all NA sales and service operations, engineering and technology development and the Customer Application Lab.

Wheelabrator will continue to leverage its flexible manufacturing footprint to strengthen the parts and equipment offering and improve both lead times and service levels. The company expects to expand its Monterrey, Mexico operations in 2018.

Pierre Tanguay, NA Supply Chain leader said, "Our mission is to exceed our customer's expectations and help them thrive in a fast-paced, highly competitive market. The flexibility of our sourcing, manufacturing and distribution model is critical to our commitment to provide competitively priced, best-in-class technology solutions."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An Energetic Approach to Predict the Effect of Shot Peening Based Surface Treatments

Ramin Ghelichi, Giorgio Crispiatico, Mario Guagliano and Sara Bagherifard
Politecnico di Milano, Department of Mechanical Engineering, Milan, Italy

This paper is a good example of the outstanding research being conducted in the Department of Mechanical Engineering at Politecnico di Milano. The university is the venue for the 14th International Conference on Shot Peening in 2020 and Dr. Mario Guagliano is the chairman.

To read the paper in its entirety, visit the online library at www.shotpeener.com.

ABSTRACT

Almen intensity and surface coverage are well-known to be the defining parameters of shot peening based surface treatments. These parameters are directly affected by material properties, the extension of the contact zone, the geometry of the impact pair as well as impact rate and velocity. These intricate relations have resulted in often dissimilar predictions of shot peening effects even while using identical combination of Almen intensity and surface coverage. With the introduction of new generation of impact based surface treatments, there is a need to find a more widespread parameter that would facilitate direct comparison of all different treatments and relate the main process parameters with the resultant mechanical characteristics.

Herein, we propose to use an energy based parameter to describe the peening process as a more universal approach, which incorporates collectively the effects of Almen intensity, surface coverage as well as diameter, material, and velocity of the impact media. A set of finite element analysis was developed to demonstrate the correlation of peening process effects with this energetic approach. Comparison with experimental data also confirmed that the proposed method could provide a quite good estimation of the effect of peening parameters on the treated material.

INTRODUCTION

Shot peening is a surface treatment mainly known for its favorable effects in enhancing fatigue strength of mechanical components. It has been widely used in machinery, aerospace, automotive industry and railway systems for decades. This process consists of impacting material surface with high velocity peening media (mainly steel shots or ceramic beads), to generate inhomogeneous plastic deformation and consequently induce compressive residual stresses on the surface layer of the treated material. With the advancement of technology and development of high tech equipment, the concept of shot peening, which is based on inducing plastic deformation with repetitive high frequency impacts, has been recently extended to a vast range of cutting-edge impact-based surface treatments. The new generation of surface treatments are developed to amplify the desirable effects of the conventional shot peening for a wider variety of applications ranging from classic industrial applications to biomedical ones. These processes can be listed as ultrasonic shot peening (USSP), high energy shot peening (HESP), surface mechanical attrition treatment (SMAT), surface nanocrystallization and hardening, severe shot peening (SSP), sandblasting and annealing, ultrasonic impact treatment (UIT) and ultrasonic impact peening, to name just the most noted ones. It is also to be underlined that some of these methods are basically using the same setup and mechanism and have been named differently due to the lack of consistency in the literature. Nevertheless, what all these methods have in common is the application of severe plastic deformation through high energy impacts to induce grain refinement, hardening, and compressive residual stresses through recurrent impacts of either shots, balls or pins using various loading schemes. Whatever the apparatus and loading arrangement, the obtained results are mainly influenced by a few parameters that all the aforementioned peening treatments share. The critical parameters are the indentation size produced by a single impact, which is in turn affected by impact velocity and impacting media's material and geometry, as well as the total exposure time; exposure time is the duration of the peening treatment when the target material is being impacted by the peening media. These factors are practically set through two pragmatic parameters used in conventional shot peening to control the consistency and facilitate replicating of the process, i.e., Almen intensity and surface coverage. Almen intensity is the industrial measure of the kinematic energy of the shot stream and is calculated by measuring the curvature of standard Almen strips exposed to shot stream at saturation point. Saturation point refers to the first point on the arc height vs. exposure time curve, where doubling the exposure time doses not change the arc height more than 10%. Although recognized as the universal parameter of shot

peening, estimation of Almen intensity is not straightforward and necessitates the use of apposite Almen strip and Almen gauge. Surface coverage, on the other hand, is the ratio of the plastically deformed area to the whole treated surface area. Considering the exponential behavior of surface coverage over time, coverages higher than 98% (highest surface coverage that can be measured visually also known as full coverage) are estimated by multiplying factors to the time required to reach full coverage.

For a long time, many researchers have tried to provide empirical graphs, formulations and numerical simulations to relate these main process parameters with mechanical behavior of the treated material. There are few successful efforts regarding distribution of residual stresses, work-hardening and the induced surface roughness. However, most available approaches are either limited to specific sets of process parameters and limited materials or are applicable to a range of process parameters and thus cannot be straightforwardly generalized. Besides, Almen intensity and surface coverage themselves are associated with multiple process parameters. For example, surface coverage is directly affected by the interaction between the impact pair, their material properties, and the contact zone, which are in line affected by shot and target material geometry as well as mass flow and peening velocity. Hence, there are reports of obtaining different distributions of residual stresses and extensions of plastically deformed areas, using the same combination of Almen intensity and surface coverage.

Herein, we propose that rather than using a combination of parameters like Almen intensity, shot diameter, shot material, shot velocity and surface coverage to provide an inclusive estimation of the effect of peening parameters on the functionality of the treated material, a single parameter that is directly related to the impact energy can be used for this purpose. A finite element model (FEM), previously developed by the authors [14] and updated incorporating varying impact angles and implementing both single impact and multiple impacts, has been used to prove the concept of the idea. The suggested energetic approach entails the effect of all factors associated with the media stream including its size, material properties and velocity into one single parameter and has the potential to be generalized for any impact based surface treatment. A set of experimental test data, for which we had access to all the process parameters and residual stress distribution, were simulated by FEM analysis to check the prediction of the energetic approach and assess its validity.

To read the paper in its entirety, visit the online library at www.shotpeener.com.

For more information on
this research project, please contact:
Sara Bagherifard at sara.bagherifard@polimi.it

Walther Trowal opens the North American Tech & Training Centre

TO COPE WITH THE INCREASING BUSINESS VOLUME in the Americas and to better serve the American customers in the field of surface finishing and preparation, Walther Trowal is expanding its sales branch in Grand Rapids, established in 2005, with additional manpower and a process development lab. Recently the Walther Trowal LLC has officially opened its North American Tech & Training Centre.

The company, initially established as a sales office, has become an operation with its own test center, after-sales service activities and a sizable warehouse for compounds, media and spare parts. Effective immediately, two recently hired application and sales engineers, stationed in Grand Rapids, are now supporting the already existing nine distributors in the US and Mexico, including our sales office in Querétaro, Mexico.

Moreover, the newly established process development lab, equipped with a range of different finishing machines, now offers American customers the possibility to test the Walther Trowal equipment with their work pieces directly in the United States and to optimize their finishing processes.

Ken Raby, Vice President and General Manager of the Walther Trowal LLC, is now in a position to serve his North American customers even better. "We consider close proximity to our customers as essential to our future success. With our expanding sales and technical base in Grand Rapids, we can adapt our processes and systems much better and much faster to the requirements of the American users. Especially in the field of mass finishing, it is essential to develop and optimize the various finishing processes for our customers through processing trials under manufacturing conditions in our test lab," he said.

The new Tech & Training Centre is also equipped with a lab for coating technology. This allows the customers to test various coating methods and develop the right process for their coating requirements.

Christoph Cruse, general sales manager at Walther Trowal in Haan, explains why the company is expanding its presence in North America, "The North-American market is somewhat different from Europe. Especially in the United States, the automobile industry is still a key player, but is subject to enormous cost pressures. That is why it is essential for us to offer our customers fast and competent service. Long reaction or downtimes are no longer acceptable! In addition, we also see a tremendous potential in the rapidly expanding aerospace industry and medical engineering."

In Latin America, Walther Trowal has also expanded its presence with the recently opened sales office in Queretaro, Mexico. The local staff is supported by the knowhow and service of the colleagues in Grand Rapids.

The capacity of the new, large warehouse ensures that the Walther Trowal LLC can offer short delivery times for equipment and consumables. The mass finishing, shot blasting and coating equipment as well as the plastic finishing media are still supplied from the Walther Trowal headquarters in Germany. Ceramic media continues to be manufactured at the plant in Stoke-on-Trent, Great Britain.

For more than 85 years Walther Trowal has offered modular and custom engineered solutions for a wide range of surface treatment problems.

Initially only making vibratory finishing equipment, over the years Walther Trowal has continuously broadened its product range and today offers a wide portfolio of equipment and services for improving all kinds of surfaces, e.g. mass finishing, part cleaning, shot blasting and drying of a wide spectrum of work pieces, last but not least, the coating of mass produced small parts.

The Test & Training Centre in Grand Rapids is equipped with a Rotamat coater for coating of mass produced small parts.

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