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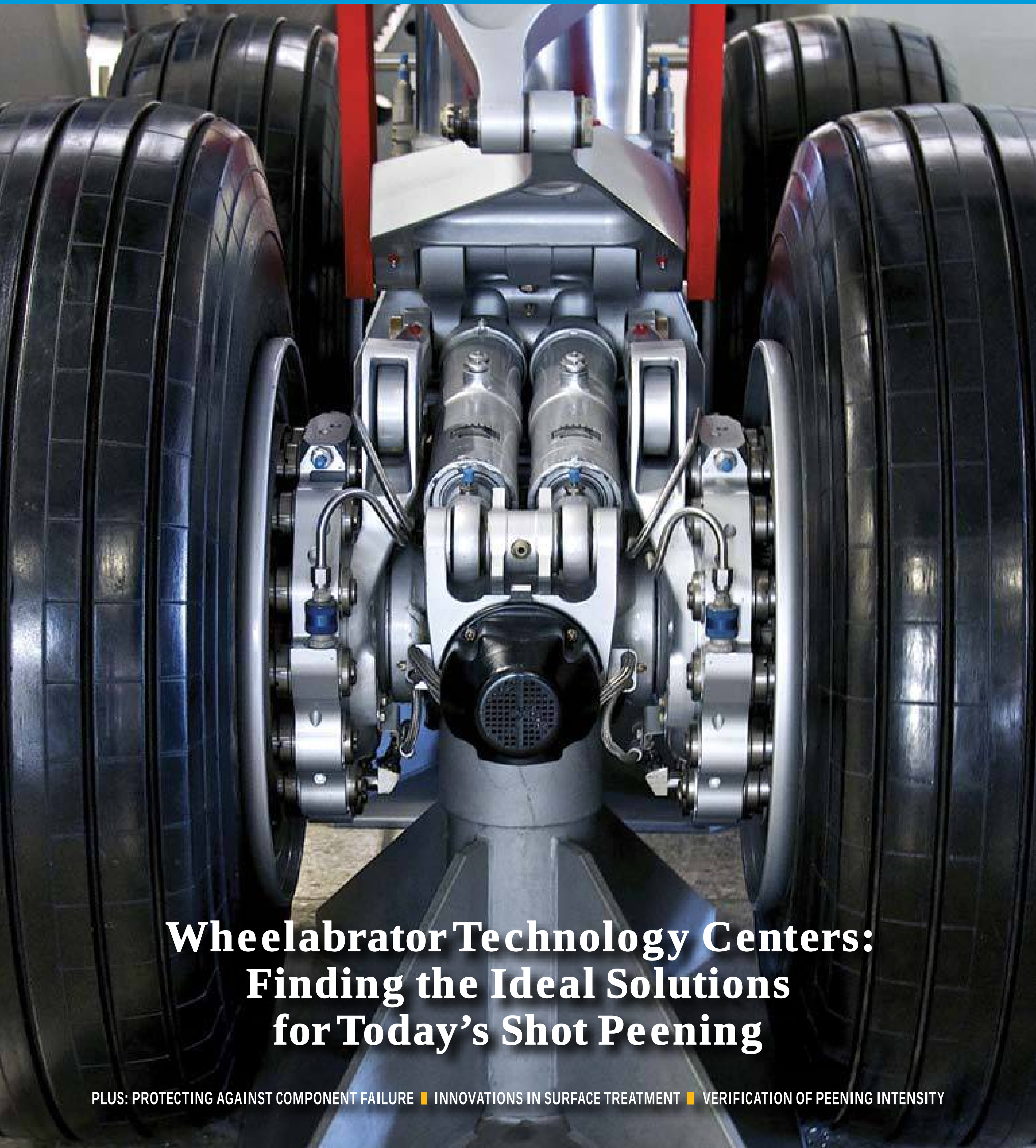
The Shot Peener

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



Wheelabrator Technology Centers: Finding the Ideal Solutions for Today's Shot Peening

PLUS: PROTECTING AGAINST COMPONENT FAILURE | INNOVATIONS IN SURFACE TREATMENT | VERIFICATION OF PEENING INTENSITY

THE SHOT PEENER

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

Articles of Particular Interest

Dr. Kirk's "Verification of Peening Intensity"

JACK CHAMPAIGNE

Peening machine parameters are established by experimental settings of machine variables and submitting Almen test strips to the blast stream for increasingly longer exposure times and graphical analysis of the arc heights. Using the 10% rule (developed by SAE in 1984), the machine peening intensity could be declared. Once the machine is placed into production, a procedure is needed to verify its consistency.

J443 Revision in 2003 described (for the first time) the procedure for intensity verification. It states:

"Confirmation readings shall be taken at a frequency determined to be appropriate to assure consistent peening intensity. Confirmation of peening intensity is accomplished by shot peening a test strip at the time T, as determined in the previously established saturation curve. The arc height shall fall within the intensity tolerance specified for the part."

The problem with this procedure is the time "T" might not be available. For example, if the machine is run on the basis of the number of revolutions, the value of "T" is 4.3 revolutions. The strip arc heights for 4 revolutions most likely would be different than exposure of the strip to 5 revolutions. Whichever exposure time was used, either 4 or 5, the acceptance criteria was held to "...arc height shall fall within the intensity tolerance." This generally worked (it was close enough) until you had a large number of test strips on a fixture with a large number of "T" times. How were you supposed to pick the exposure time for the test fixture and what are the accept/reject requirements for the arc height readings? This was finally addressed in J443, revised in 2010, with the concept of Target Arc Heights. This concept is eloquently explained by Dr. Kirk on page 28.

The Center for Surface Engineering and Enhancement at Purdue

I was pleased to learn that Purdue University is establishing a Center for Surface Engineering and Enhancement (C-SEE) on their campus. Their extensive laboratory facilities and faculty are eminently qualified to offer leading-edge research into the basics and advanced facets of surface treatments from shot peening to laser peening. See the article on page 16 for more information on this exciting announcement.

And So Much More...

I'm not allotted enough space to review every article in our Fall magazine except to write that I'm continually impressed by the quality of work being done in our industry. I hope you have the same sense of pride as I do—it's great to be a part of this vibrant community. A big thank you to all of you that take time from your busy schedules to share information with our readers.

THE SHOT PEENER

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A Match Made in Testing: Equipment Solutions for Shot Peening Tasks

Ron Wright, Automated Airblast & Peening Manager at Wheelabrator, explains how to find the right process and equipment for any given shot peening task—and the methods that help in making the best choice.

AUTOMOTIVE AND AEROSPACE components are getting lighter and lighter. And wherever engineers decide next to take away a bit more material to reduce weight, there is likely to be a peening process required to strengthen the now slimmed-down part. That's why shot peening is becoming a key process across ever more part categories. Finding the right tool for this process is critical – to achieve the precise patterns of stresses needed, as well as repeatable results.

It is not uncommon for process owners to approach a shot peening project with a pre-conceived idea of the equipment they need. This choice, however, can really only be made through careful analysis and thorough testing. With a broad array of potential solutions and machine concepts available, this preliminary work is crucial when deciding the best way forward.

Conversely, if the process is being designed for a component that historically never required peening, this very application challenge may have been solved elsewhere in the world. The Wheelabrator Technology Center in Metelen, Germany, for example, has just developed a new design of flexible lances for internal peening, ideal for emerging applications such as intricate internal areas of engine blocks or the internal lengths of a hollow torsion bar.

High-accuracy robotic air peening system for landing gear.

Advanced Testing for Advanced Processes

Testing methods and the accuracy and depth to which shot peened parts are now commonly examined have advanced hugely, not least driven by the proliferation of peening in Automotive, with its pressures of time, cost and scale.

The role of testing in finding the right process cannot be overstated. Even though a component may look as if it has been completely treated by a shot peening operation, only advanced testing will fully reveal the pattern of residual compressive and tensile stresses worked into the surface.

The use of X-ray diffraction, for example, will show if the area just below the surface has not been treated sufficiently and if the compressive layer is compromised. In applications where a precisely peened surface virtually is a structural element of the part design, not getting it right means risking part failure or under-performance, with potentially catastrophic consequences.

Assessing Needs to Narrow Down Choices

While getting the process right to meet exacting specifications is at the heart of any equipment choice, workflow and quality needs also have to be taken into account when narrowing down machine concept options. Careful assessment of the specification requirements, part complexity, throughput and media choices are key identifiers in the preliminary evaluation. In most instances, based on experience, a wheelblast or airblast solution can be selected at this initial evaluation stage.

At Wheelabrator, we always aim to remain technology-agnostic, meaning that we don't rush into a decision between air and wheel technology until we have done some tests. This approach allows us to work across disciplines on finding the best blast process for a given application, be it a combined

Multi-axis air system for peening landing gear.

wheelblast/airblast machine or equipment that requires sector expertise from elsewhere in the Wheelabrator network. For example, I work closely with my colleague Alain Portebois in Charleville, France, and can draw on his application experience in advanced shot peening solutions for Aerospace and Automotive customers in Europe and around the world.

Refining the Concept – More Testing

For a shot peening project that, for example, looks to process large quantities of relatively simple parts, such as springs, connecting rods or (solid) torsion bars, our team at the Wheelabrator Peening Technology Center will use knowledge and experience of previous, similar processes. This would streamline efforts and allow us to move very quickly to the Application Validation phase using wheelblast technology from our Technology Centers in Burlington, Ontario, or Metelen, Germany. This next phase then involves the development of saturation curves to determine intensity, as well as coverage mapping. Empirical throughput calculations are also carried out, using data garnered from these testing efforts.

If, however, the application is to process relatively complex parts, such as transmission components, landing gear, aircraft structural components, or if the demand is to achieve higher intensities or use multiple media sizes, the team will use the same evaluation methods and techniques, and again move efficiently to the Application Validation phase. But in this case, a high-accuracy air peening system would be selected, with CNC or robotic control from the Wheelabrator Technology Center in Charleville, France, complete with specification-compliant supervision software to ensure absolute precision and process reliability.

Avoiding Costly Surprises

Two recent examples may suffice to show how this holistic, needs-based approach to equipment selection pays off. The task was to find the right shot peening solutions for connecting rods and clutch springs respectively. Both of these components could—on the face of it—be treated with either blast technology. But in both cases, testing and analysis showed a clear winner, backing up the choice of technology with empirical evidence.

For the connecting rods, testing was done with both air and wheelblast. The analysis showed very similar compressive stress distributions for both processes, but the production requirements demanded a faster solution for the task, so a wheelblast machine was chosen.

The circumstances were slightly different for the clutch springs. The current, generally accepted method of shot peening these components was with wheel blast technology. Yet the customer was observing a high failure rate of the peened parts and subsequently consulted Wheelabrator on the shot peening process.

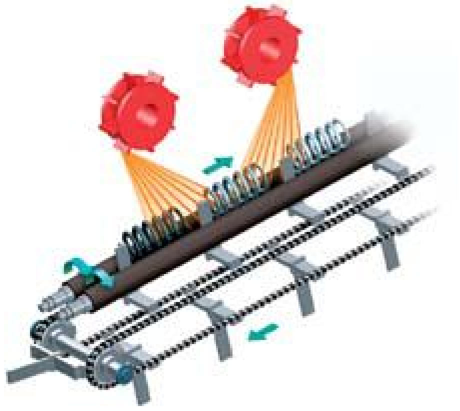
Our team identified the high stress areas, treated them strategically with robotic airblast technology and thus solved the failure problem. If this analysis had been performed at the beginning of the shot peening exercise, the failure problem would have been solved before it was allowed to occur in a live production setting.

Conclusion

Shot peening has gone mainstream. It takes place in a broad range of component categories and is often carried it out in extremely pressured production environments. This means it is crucial to get the process right first time and make use of the most suitable technology available.

Regardless of the equipment solution, the optimum delivery of spherical media to the appropriate high tensile areas of the part is the ultimate goal. If this is not applied properly, highly stressed parts will be subject to fatigue failure, crack propagation or stress corrosion.

Advanced testing and an open-minded, structured and application-driven approach to equipment selection are key to finding the perfect machine match for any given shot peening task.



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Protecting Against Component Failure

Metal Surface Treatments • Engineered Coatings • Fatigue Testing

MANY OF OUR READERS are familiar with the shot peening, laser peening and peen forming services of the Metal Improvement Company (MIC). The company has been in business since 1945 and has 40 job shops around the world.

A lesser known fact is that MIC is a business unit of Curtiss-Wright (CW), falling under their Surface Technologies division. This business unit has several offerings related to enhancing performance and preventing/analyzing failures. In addition to shot peening, CW also provides different types of coatings and analytical testing in 30 well-established facilities throughout the world.

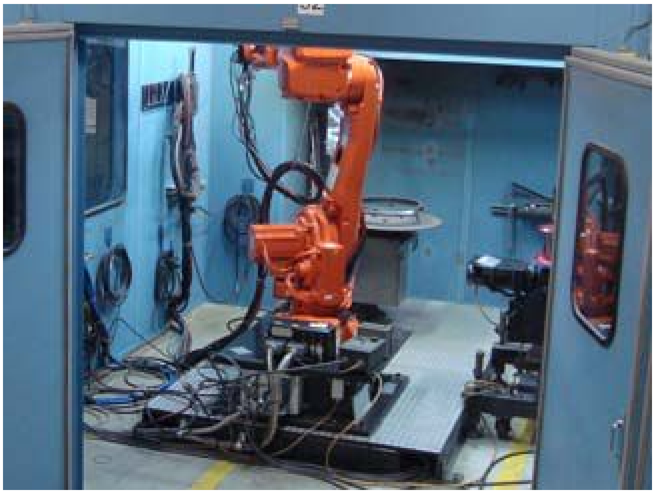
Engineered Coatings

CW provides two general types of coatings. They are solid film lubricants (SFL) and thermal spray (TS) and both have subcategories. SFLs (also called dry film lubricants) can be described as "lubricating paints" or "soft coatings". There are many applications in almost all industries where lubrication is required and oils and greases are not practical. Lubrication is a broad category and can consist of reducing "rattles and squeaks" in automobiles to proving proper torque-tension feedback when installing specialized fasteners. SFLs operate over broad temperature ranges (-200°F to over 1400 °F) and can withstand very high surface contact pressures.

When corrosion is a concern, zinc-flake based coatings can be utilized. They have a sacrificial-based nature—the zinc 'sacrifices' itself in order to protect the underlying metal—that makes them effective for outdoor conditions. They are commonly used on automotive and off-highway vehicles on exposed surfaces like brake rotors. SFLs can also have corrosion inhibitors added so they provide multiple solutions. An example of the widespread use of SFLs is aircraft fasteners. A large commercial aircraft can utilize six-million fasteners and about half require a SFL for either lubricating or corrosion inhibiting properties.

CW has business units in the USA and UK that apply thermal spray coatings. Their proven surface treatments meet industry demands for lighter materials, improved performance and life extension. The three most common industries are Aerospace, Power Generation and Oil and Gas. The Aerospace and Power Generation industry frequently utilizes thermal spray coatings to provide thermal barrier and corrosion protection of components in the hot section of the Jet and Industrial Gas Turbine (IGT) engines.

Lubricity treatments are just one of the many engineered coatings available at the Lombard, Illinois plant.



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The Oil and Gas industry uses thermal spray coatings for hard, erosion/abrasion resistant surfaces in harsh environments. Other industries serviced are automotive, medical mining, steel mill and other demanding industrial markets. We can prevent premature failures due to fatigue, corrosion, wear, galling and fretting. Across the various divisions, these thermal spray processes are available:

- HP/HVOF and HVOF
- ID HVOF (down to 4" ID)
- Plasma OD and ID
- Combustion and Arc Wire
- Solution Plasma Spray
- Spray and Fuse
- Kinetic/Cold Spray
- HVAF (M3) OD and ID down to 7"
- Rokide, all in fully automated booths

The FW Gartner Division also provides laser cladding services—essentially a welding process utilizing an infinitely controllable laser beam as its heat source—and PTA Cladding/Hardfacing.

Materials Testing Services: Fatigue Testing

IMR Test Labs, a CW subsidiary, is an international firm offering a complete scope of materials testing services, including chemical analysis, cleanliness testing, corrosion testing, mechanical testing, metallurgical analysis, failure analysis, fatigue testing and much more.

Fatigue testing in a lab environment is especially valuable to the shot peening industry. Testing an optimized shot peening process in this way is the closest simulation to real-world conditions. Since these components will be assembled into critical applications, most engineers want to know whether destructive testing in a laboratory correlates with their calculations on part life.

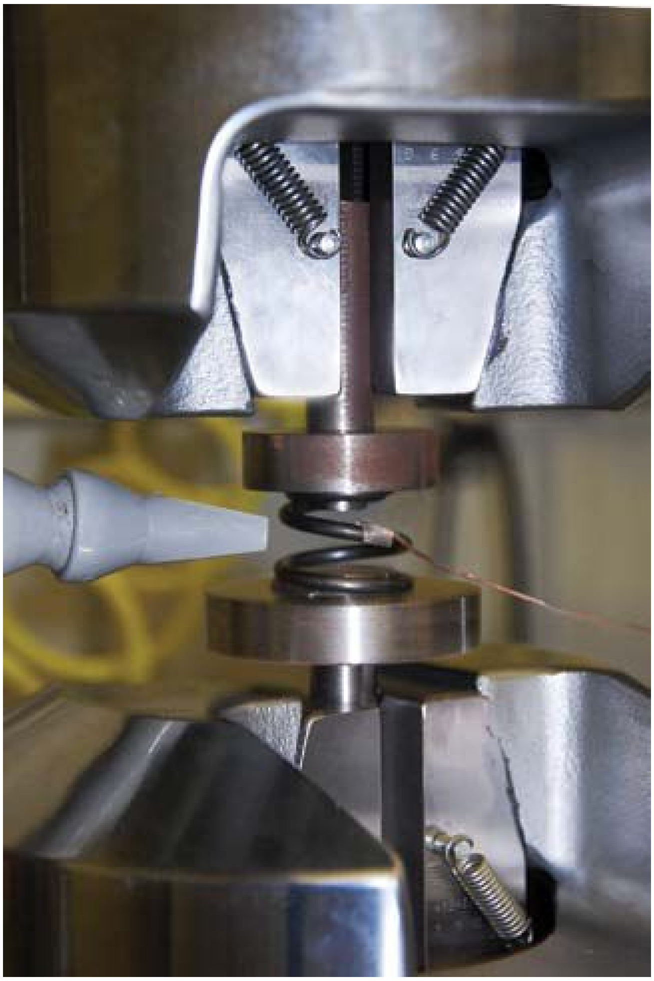
Most commonly, the laboratory performs fatigue testing at slightly elevated stress levels. This allows test engineers to complete the testing in a reasonable amount of time yet preserve the high-cycle fatigue nature of the application. Examples of industries that use laboratory fatigue testing are Automotive, Aerospace, Medical, Oil and Gas, and Offroad industries.

IMR Test Labs offers a variety of services for the evaluation of materials. They have various frames designed to handle a wide range of loads and samples. They can perform testing on:

- Metals
- Coatings (coating shear)
- Polymers
- Composites (fiber-reinforced, ceramic-matrix)
- Nonmetallic/Metallic hybrid materials
- Finished products

Not only does IMR Test Labs offer accredited fatigue testing, but their staff can also provide insightful, informative analysis and reporting after testing. The metallurgical engineering group is well-versed in fractography and failure modes. They have a full microscopy lab (light, optical, SEM) and the support of chemistry, mechanical and other groups.

For more information on any of these services, please email **Dave Breuer** at dave.breuer@cwst.com or call him at (262) 893-3875.



Fatigue testing a spring in the IMR Test Labs, a subsidiary of Curtiss-Wright.

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Modern Technology Reproduces Ancient Japanese Art Technique

NASHIJI is a form of Japanese lacquer work used to create the background of a pattern. The technique is very old—it flourished in the Muromachi period (1338–1573) in Japan. To create nashiji, gold or silver flakes called nashiji-ko are sprinkled onto the surface of the object (excluding the design) on which lacquer has been applied. Nashiji lacquer is then applied and burnished with charcoal, so that the gold or silver can be seen through the lacquer. The name nashiji is thought to have originated because the lacquer finish resembles the skin of a Japanese pear called "nashi."[1]

Today, the PNEUMA BLAST® machine from Fuji Manufacturing utilizes modern technology to reproduce this slightly textured, semi-glossy pattern on numerous items. Fuji Manufacturing calls this surface the "Pear Skin Finish." Because this surface finish hides scratches and is aesthetically pleasing, the PNEUMA BLAST machine is used on camera bodies, watch cases, cell phone cases, aluminum wheels, containers for cosmetics, eyeglass frames and more.

The Pear Skin Finish is also used to improve the function of many items. The finish improves oil retention and prevents glare and slippage. Objects that benefit from this surface treatment include paving stones, heating pipes, golf clubs, and paper forwarding rolls.

The titanium tiles for the Sensoji temple were spray blasted with the PNEUMA BLASTER® to achieve a "Pear Skin Finish."

A detail from the roof that highlights the intricate design of the roof tiles.

The Sensoji Temple and the PNEUMA BLASTER®

Sensoji (also known as Asakusa Kannon Temple) is a Buddhist temple located in Asakusa. It is one of Tokyo's most colorful and popular temples. According to legend, in the year 628 a statue of an enlightened being named Kannon was found in the Sumida River by two fishermen. The chief of their village recognized the sanctity of the statue and enshrined it by remodeling his own house into a small temple in Asakusa so that the villagers could worship Kannon.[2]

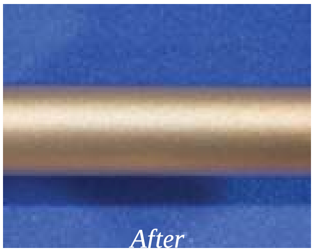
Recently, when the Sensoji temple wanted to replace the clay roof tiles of the temple with titanium tiles, they choose the Pear Skin Finish of the PNEUMA BLASTER® to give the tiles the historical and refined appearance necessary of such an important landmark. The project was completed at the Fuji Manufacturing facility and it required the treatment of 90,000 titanium tiles. As an additional point of interest, after the new roof was installed, its gross weight was decreased from 900 tons to 180 tons and the temple is now better able to withstand earthquakes.

[1]Britannica.com [2]Wikipedia.com

The PNEUMA BLASTER®

The PNEUMA BLASTER® equipment utilizes a digitally controlled spraying process for the stable and continuous spraying of steel shot and non-ferrous media. It is used in shot peening and the thermal spray pretreatment of non-magnetic media such as ceramic shot, alumina, glass beads and more. Stable and constant blasting is possible even with shot smaller than 200 µm.

The PNEUMA BLASTER® by Fuji Manufacturing uses a digitally controlled spray for the stable and constant application of steel shot and non-steel media.



Copper tubing before and after receiving the Pear Skin Finish by the PNEUMA BLASTER®.

Purdue University Announces the Launch of the Center for Surface Engineering and Enhancement

PURDUE UNIVERSITY has announced their vision to be the leading industry-university research alliance for the metal surface finishing industry. The embodiment of their vision is the Center for Surface Engineering and Enhancement (C-SEE) on the Purdue campus. The goals of the center are to serve consortium members' needs, establish a knowledge base, and educate the future leaders of the industry.

The research capabilities of C-SEE will be available to industries and government agencies. Pre-competitive research is available to member groups as well as specific and proprietary research for individual organizations. The program offers access to test equipment, research staff and disciplines that most companies do not have.

Research will be defined by the participating groups or organizations. The research will be conducted by undergraduate and graduate students seeking industry positions and the research programs will be under the leadership of these Purdue faculty members:

David Bahr, PhD, Professor and Head of Materials Engineering. Mr. Bahr's research spans a range of materials-reliability issues, from hydrogen embrittlement to high-strain MEMS, to dislocation nucleation in metals.

Gary Cheng, PhD, Associate Professor, School of Industrial Engineering. Mr. Cheng's research is in laser materials processing and materials processing, microsystems technology and nanostructured materials in manufacturing.

Michael Sangid, PhD, Associate Professor, School of Aeronautics and Astronautics. Mr. Sangid's expertise lies at the confluence of materials science, solid mechanics, and manufacturing.

Electronics Inc. has collaborated with Purdue on the development of C-SEE and will be funding research on three projects related to shot peening. "As a Purdue alumnus, I am pleased and honored to be a part of the C-SEE program. As a manufacturer, I'm eager to have access to research on topics that have interested me for years. Finally, theory will become practice and we will be able to commercialize these ideas," said Jack Champaigne, President of Electronics Inc.

If you are interested in learning more about C-SEE, please contact David Bahr at (765) 494-4100 or dfbahr@purdue.edu.

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by Kumar Balan | Engineer | Empire Abrasive Equipment

Shot Peening's Contribution to Blast Cleaning Equipment

WHILE THIS ARTICLE'S HEADLINE suggests that blast cleaning is somehow dependent on shot peening, the truth is shot peening might not exist if it weren't for blast cleaning. For those who are familiar with the history of shot peening, and with apologies to village blacksmith whose original utilization of peening is often ignored, beneficial residual compressive stresses were discovered in automotive engine valve springs that had been shot blasted to remove paint. John Almen, an engineer at General Motors in the 1930s, made this discovery and developed the tools that became crucial to today's commercial shot peening process.

The automotive industry began peening components, such as high-volume springs and transmissions, and the process quickly gained recognition. The Almen gage, Almen strips and SAE specifications gave shot peening credibility as a repeatable and measurable process and soon aerospace came on board. Aerospace added shot peening to their list of techniques for the manufacturing and refurbishing of landing gear, engine components and aircraft structures.

Blast cleaning doesn't have such a well-documented history or dramatic evolution, but its purpose was not an accidental discovery. The vast number of parts and surfaces that have been cleaned in the last hundred years attest to its popularity. In addition, the life of a downstream coating is only as efficient as the pretreatment process and blast cleaning is the most popular pretreatment process. Blast cleaning takes the largest share of investment funds in the surface finishing market.

So how does our industry view these closely related processes? The following are common perceptions from users of blast cleaning and shot peening equipment:

Blast Cleaning	Shot Peening
Commoditized	Critical
Low-Tech	Controlled and Regulated
Volume-Based	Specification-Based
Dirty and Noisy	Training is Essential
A Necessary Evil	Beneficial

Clearly, blast cleaning deserves more respect because blast cleaning equipment has evolved over the last 20-25 years to incorporate:

- PLC for programmable features
- Affordable and sophisticated automation (Example: robotics)
- Better dust collection techniques
- Adoption by demanding industries (Example: medical)

These improvements were adapted from shot peening equipment. Let's look at the features of shot peening that have migrated to blast cleaning and how these features are changing the blast cleaning machine industry.

Measurement, Quantification and Repeatability

Shot peening results are objective and blast cleaning results are subjective. The goal in peening is a numerical value of intensity (i.e., the transfer of impact energy), leading to a residual compressive stress value and expected improvement in the fatigue life of the component. The quantification of results leads to validating the process independent of the machine operator, equipment, location and any other non-process related variable. For example, the peening intensity of 0.011 A (or 11A), determined by using Almen strips and plotting a saturation curve, can only mean the transference of a finite amount of impact energy.

In contrast, a component is determined to be "clean" by visual inspection only. What if we recognize that measuring the part's cleanliness via Almen strips could be a more valuable tool than visual inspection? The benefits would be:

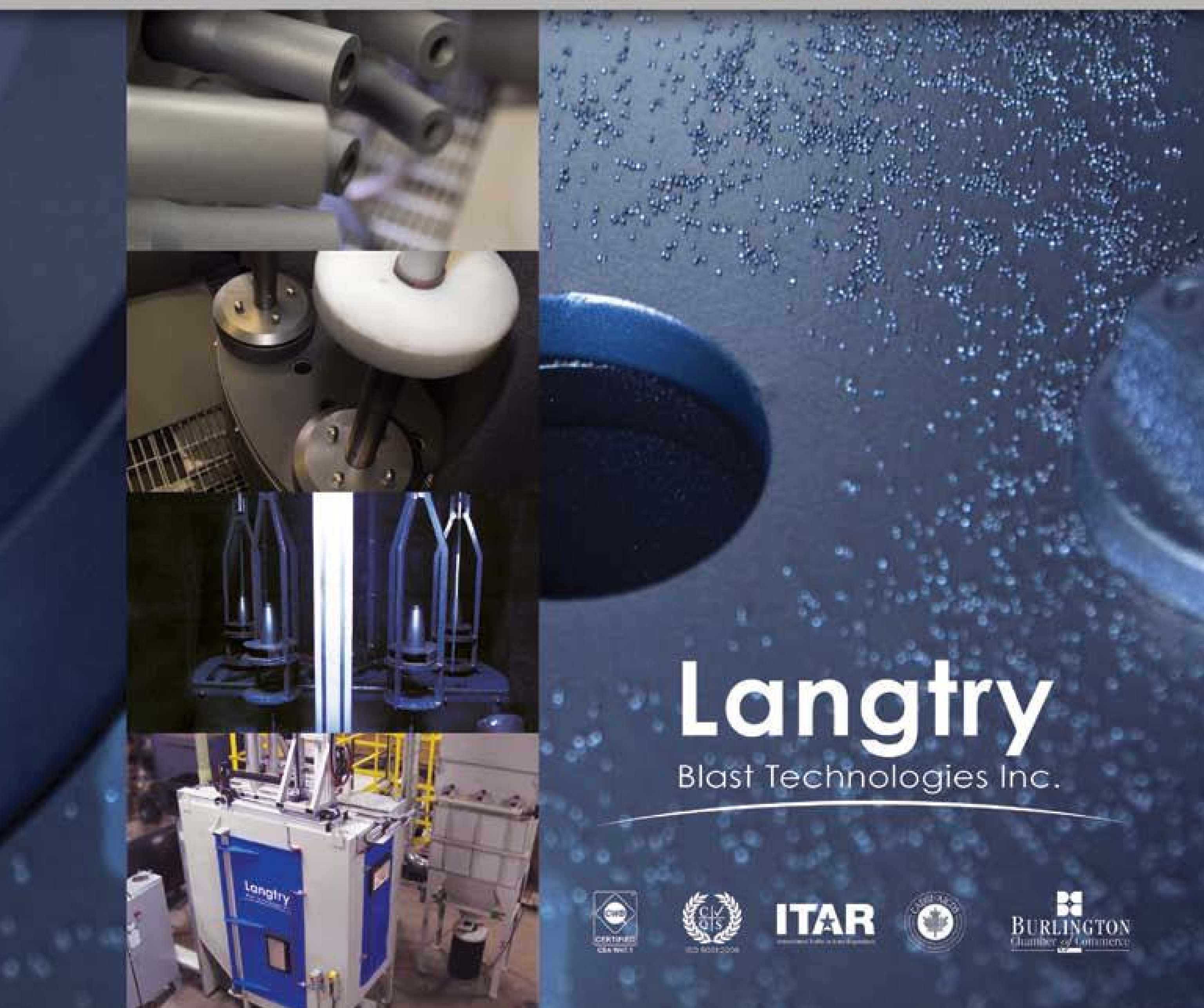
a) the establishment of a quality standard for cleaning

b) proactive identification of the deterioration of the process that addresses the classic conundrum: "Nothing has changed with the machine but the parts aren't getting as clean"

c) a simple check of the machine's health and wear of machine components

d) opportunities to introduce cleaning to industry sectors with established processes


POWER ON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Blast cleaning facilities with niche applications have implemented Almen strip practices to quantify and validate their cleaning operations. It's reasonable to expect that demanding industries, like medical, will adopt this practice, too.

Efficiency and Cost Controls

Blast cleaning machines run much larger production volumes than shot peening machines. Therefore, the opportunities for cost savings are greater in blast cleaning operations. Let's consider one such opportunity: **cleaning velocity**. In a centrifugal wheelblast machine, the media velocity is directly proportional to the wheel speed and diameter. Some wheels are capable of generating velocity in excess of 360 feet per second (110 meters per second). Similarly, airblast machines can generate velocity as high as 600 feet per second (183 meters per second) with the appropriate nozzle type and air pressure. Since there's a misplaced belief that high velocity will lead to faster cleaning, machines continue to blast at unnecessarily high impact energies, leading to greater media breakdown rates and increased operation costs.

In shot peening, we have a clear understanding of abrasive velocity and the need for its control. Higher or lower than optimum velocity will lead to incorrect peening results and potentially disastrous product failure. The closed feedback loop for air pressure, commonly seen in peening equipment, is now being employed to moderate air pressure in cleaning applications with the subsequent reduction in media and machine maintenance costs.

Choosing the correct **media hardness** can also reduce costs. Abrasive is typically manufactured in three hardness grades: Soft, medium and hard with brittleness increasing with the hardness level. In shot peening, there is a 0.001 to 0.002 increase in intensity from one hardness grade to the next. Because media hardness affects intensity, it is often part of a specification and the appropriate hardness levels have received a great deal of attention in shot peening applications. Using shot peening's knowledge base on media hardness, we can select the correct hardness for our cleaning applications and get a handle on operating costs. For example, your cleaning application may work to optimum levels with a softer grade of abrasive. But due to incorrect advice, your machine may be using a harder grade, leading to increased breakdown rates.

In general, increased **media flow rates** result in faster work cycles. This is also true for shot peening, with a slight twist. Increased abrasive flow could flood intricate areas of the part resulting in 'abrasive-on-abrasive' instead of 'abrasive-on-part' impact. This could also happen in cleaning applications, particularly when targeting small, confined areas (we are working with the assumption that the correct media size is being used). In shot peening, we have learned to monitor and control media flow rates. Some cleaning machines now employ automated flow control techniques, too. Commercially available flow control valves, such as the MagnaValve®, are designed with closed feedback loops to ensure constant media flow rate. Some foundries are adopting this valve because it doesn't have any moving parts and therefore requires little maintenance.

Controls

All shot peening processes are driven by specifications. In addition to the process specification, a part-centric specification is utilized to achieve desired the fatigue strength. Specifications have been defined to the point that they categorically state the requirement for Computer Monitored Peening (AMS 2432). The advantages of AMS 2432 are traceability, repeatability and accuracy. In addition to computer controls, peening applications have embraced robotics and advanced automation. Blast cleaning operations for the automotive industry are no longer content with relying solely on visual inspection—they are purchasing blast cleaning machines that have adopted the controls and technology of shot peening machines. Computer controls now allow critical process data from cleaning machines to be recorded and analyzed in a database to improve cleaning results and control operating costs. (An interesting note: The successful transfer of technology from shot peening to blast cleaning equipment is mostly due to OEMs that manufacture both.)

In Conclusion

As we have reviewed in this article, blast cleaning equipment design has greatly benefited from the shot peening process and equipment. However, there is the potential for even greater technology transfer. For example, shot peening operations, particularly in aerospace and medical, operate under very clean and relatively quiet conditions—two work conditions alien to many cleaning environments. To achieve these benefits, shot peening machines are built with sound-deadening materials and improved cabinet and work seals. Blast cleaning machines can certainly evolve in this area and quieter, cleaner blast cleaning operations would radically improve the perception of this vital industry. And as government and safety regulations increase, a cleaner and quieter factory floor might become mandatory.

More shot peening equipment will connect to the Industrial Internet in the next few years and real-time machine data will be captured and used to increase productivity and reduce downtime. Think of the implications for blast cleaning machines that tend to need more maintenance due to the wear and tear to their components from the abrasive and whose profitability is directly linked to productivity.

We hope this discussion has expanded your appreciation for blast cleaning and the close relationship between the improvements between shot peening and blast cleaning equipment. Shot peening equipment will continue to improve and the progression will continue to the benefit of us all.

by Taylor Hanes | Applied Ultrasonics | www.appliedultrasonics.com

Ultrasound to Improve Metals

ULTRASONIC IMPACT TECHNOLOGY (UIT) by Applied Ultrasonics uses ultrasonic energy and mechanical impact to improve metals. The ultrasonic device oscillates at a rate of 27,000 times a second, making it an effective and rapid way to reorient the grains in metal and impart beneficial compressive stresses into the material. Using a transducer to energize pins that impact the metal, UIT crafts a tight, pancake grain structure which is resistant to cracks and failure.

The UIT process was developed in the 1960s by Russian scientists to strengthen Cold War era submarines. Kept secret for decades, the technology arrived with its inventor in the U.S. in the 1990s. The technology has been refined by Applied Ultrasonics into an application that can be used for ships, aircraft, vehicles, bridges, dragline…any structure or component that uses metal.

One such application was for CF Industries' phosphate mining operation in Wauchula, Florida (acquired by Mosaic Co. in 2013). Their Bucyrus 1370 walking draglines routinely suffered typical cracking problems in the masthead. The cracks in the mastheads had to be repaired about every six months. These repairs typically required about five days of downtime, an expensive proposition with downtime averaging about $10,000 per hour.

The dragline manufacturer offered a suggested redesign to the masthead which involved doubling the plate thickness at the masthead and thermally stress relieving the field welds. While this redesign offers longer life than weld repairs to the cracked areas, it is much more involved. It requires lying the dragline boom down and takes thirty to 45 days to complete. The estimated cost of downtime for this repair is $7-10 million (that does not include the cost of the repair).

The personnel at CF Industries were interested in finding a way to extend the life of their weld repairs that would allow them to complete the repair in days instead of weeks and would not require them to detach the boom. Applied Ultrasonics had previously utilized its UIT technology at CF Industries on several applications over the years, and based on those successful repairs, CF Industries was convinced that Applied Ultrasonics' UIT was effective in extending the life of weld repairs.

Previous Dragline Experience with CF Industries

On a project that took place about two years before dealing with the masthead issue, CF Industries maintenance manager devised a field test to evaluate the effectiveness of the UIT process in his operation. In this situation, they were trying to address recurring cracks on the walking structure of the dragline (known as the propel structure). This structure sees enormous stress loads when the machine is walked from one location to the next, and repair of these cracks is a constant fact of life for dragline owners and operators.

The CF Industries maintenance manager realized that the recurring walking frame cracks repeatedly occurred on both sides of the walking structure, which gave him an excellent opportunity to compare the UIT process to the traditional weld repair process. He had Applied Ultrasonics personnel treat the weld repairs on one side of the walking structure of the dragline. The other side, which had cracks in almost identical locations, was repaired using the same welding procedures, but they were not treated with the UIT process.

The results were dramatic. One year after the repair, the side that was not treated with UIT required weld repairs at the typical six-month mark and again at the one-year mark. Meanwhile, the weld repairs that were treated with UIT had no cracks in spite of seeing identical stresses and workloads.

Based on this success story, CF Industries was convinced that UIT was an effective repair solution, and made the decision to employ UIT on the masthead repair.

Masthead Repair with CF Industries

Applied Ultrasonics deployed a team of UIT technicians to CF Industries' Wauchula phosphate mine site along with a state-of-the-art UIT 1000 System. CF Industries provided welders who worked to the CF Industries approved welding procedure. This procedure called for the cracks in the masthead to be completely gouged out until viable, sound material was reached. In the event of through cracks, the material was removed completely and prepped at a forty-five degree included angle.

The Esonix UIT handheld device from Applied Ultrasonics.

Continued on Page 26

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Once the material was properly prepped and welding began, Applied Ultrasonics' UIT technicians worked as a team with the welders, treating each weld layer as soon as the welder completed the final pass in the layer. Treating each layer allows the welder to continue working until the complete layer is laid down. Technicians treated the root pass, which is the first weld layer. Then, when the second layer was completed (typically consisting of the second and third pass), technicians treated the entirety of the second layer. The UIT process was applied to the toe of the weld, the weld body and the heat-affected zone (HAZ).

Applied Ultrasonics' UIT 1000 System is fast and easy to use. The UIT process is roughly 1.5 to three times faster than welding, and UIT can operate at typical inter-pass temperatures, so when the welders completed a weld layer, the UIT technician was ready to jump in and treat that weld layer. Based on the ability to treat quickly and at elevated temperatures, the UIT process did not add any appreciable amount of time to the total repair process. As with previous repairs which did not include UIT, the total time required for the masthead repair was about five days.

Results

The masthead repair was completed in May 2011, and as this publication goes to press, the masthead that was treated with UIT has experienced *no cracks in the 4+ years since the repair.*

Considering that cracks in the masthead used to require five days of downtime at $10,000 per hour, each of these downtime periods cost the mine about $1.2 million. By delaying the onset of cracks for over four years and allowing CF Industries to avoid eight of these repair cycles, Applied Ultrasonics' UIT helped CF Industries save $4.8 million.

Additionally, the walking structure cracks that were treated with UIT have now run for over six years, and like the masthead, CF Industries have experienced zero cracks in the areas treated with UIT.

The UIT Equipment and Process

Applied Ultrasonics' UIT is highly portable, easy to use and repeatable. The UIT 1000 System, which was utilized on the CF Industries applications, consists of three primary components: the generator that houses the electronics, software and PLC-based controller and operator interface; the water cooler which is a pump and heat exchanger system that circulates water through the hand tool; and the hand tool which is utilized to impact the treated surface.

The UIT 1000 System is capable of packing into two hard-sided containers that are suitable for shipping anywhere in the world. The system runs on 110V or 220V and can be powered from a wall outlet or a suitable electrical generator. With its quick connect attachments, modular design and ease of use, the UIT 1000 System can be set up within about 5 minutes of arriving at the work site.

The hand tool is lightweight, ergonomically designed and spring loaded and does not rebound or recoil to any significant extent, creating a very comfortable operator experience. In the type of applications at CF Industries (i.e., treatment of weld repairs), the UIT process creates a dimpling of the treated surface and a groove at the weld toe. This plastic deformation makes visual QA/QC an easy and straightforward process, and it ensures the process is repeatable.

The UIT 1000 System is fast as well. Typical linear treatment speed is about three times faster than welding. As a result of this treatment speed, UIT is very cost-effective.

Broad Application Possibilities

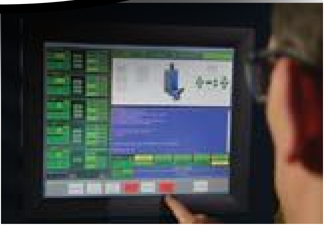
While the work at CF Industries was on weld repairs of cracked materials, UIT is in no way limited to that type of application. Applied Ultrasonics has effectively employed UIT on a wide variety of materials and applications. Materials successfully treated with UIT include: carbon steels, stainless steels, high strength steels, aluminum, titanium, bronze, Inconel and others.

While most of Applied Ultrasonics' UIT commercial experience to date is on repair welds, the process is also proven on machined surfaces and base metal. For example, Applied Ultrasonics has treated crankshafts and drive shafts with UIT in the manufacturing process. In most cases, the entire shaft does not need to be treated, just the high stress areas that are most prone to cracking and failure. Shafts can be treated immediately after machining or at any time in the life of the shaft. After treatment with UIT, shafts typically see triple their normal fatigue life or better.

Applied Ultrasonics' UIT is also well suited to automated applications. In many cases the most effective treatment methodology consists of controlling the UIT device by means of a robot, CNC machine or similar automated device. The level of control and repeatability afforded by such an automated solution obviously exceeds that possible through manual applications. In this type of setup, the body of the UIT tool is beefed up to withstand the rigors of higher run rates, and the automated process is capable of achieving better surface finishes than those typically found in manual applications.

Tool with Countless Possibilities

Applied Ultrasonics' UIT is a proven process with a strong track record in laboratories as well as a broad range of industrial applications. It has earned a reputation for saving millions of dollars in downtime avoidance and asset life extension. "But, is it right for me?" you ask. If you are experiencing cracks and failures in metal structures and components, it may be. If you have a critical weld subject to higher stress levels, it may be. If you are dealing with stress corrosion cracking, it may be. If you would like less downtime and more peace of mind, Applied Ultrasonics' UIT may be the right answer for you.















ACADEMIC STUDY

by Dr. David Kirk | Coventry University

Verification of Peening Intensity

INTRODUCTION

Verification of peening intensity is described in SAE J443 using just the three paragraphs of section 3.5. This article attempts to provide a much fuller explanation of the basic issues involved when attempting verification. These issues are summarized in fig.1. In tackling these issues we have first to consider just what (or which) defined peening intensity has to be verified. Different problems arise depending on if a single strip holder is being used or if multiple holders are involved. For the latter case, SAE J443 introduces the concept of a "Target Arc Height".

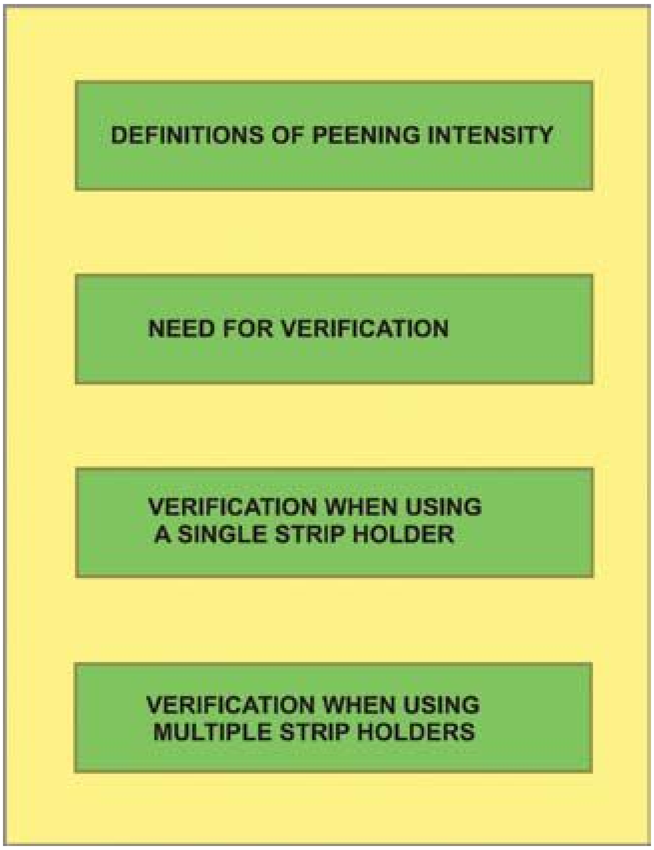


Fig.1. Basic issues involved in verification of peening intensity.

DEFINITIONS OF PEENING INTENSITY

Three different definitions of peening intensity are currently in use. These are not clearly named but are named here as: "10% rule", "10% or less" and "Type 2".

1. "10% Rule"

This is currently defined, in SAE J443, as the point on a saturation curve for which the corresponding arc height increases by precisely 10% when the peening time is doubled. SAE J2597 details appropriate computer techniques.

Fig.2 illustrates the use of computer curve-fitting and analysis when applied to SAE J2597 Data Set No.8. The derived peening intensity value, **H**, occurs at a peening time (or its equivalent) of **T**. This value increases by precisely 10% (to **1.1H**) when the peening time is doubled (to **2T**). **H** occurs at a point on the fitted curve (**H,T**) – not at a data point.

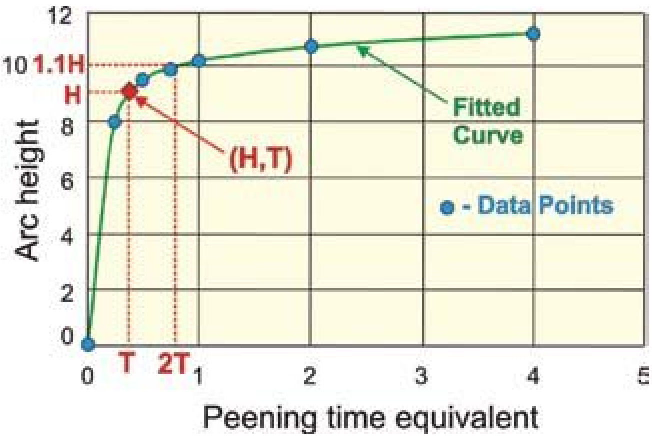


Fig.2. SAE Data Set No.8 plotted using "10% rule" to derive unique Peening Intensity, H.

The great advantage of this definition of intensity is that it is unambiguous. When allied to a computer curve fitting program the derived intensity, **H**, and the corresponding peening time, **T**, are unique, i.e., everyone will obtain the same values from a given set of data points.

2. "10% or less Rule"

This rule pre-dates the current 10% rule – being included for the first time in the 1984 version of SAE J443. It was an improvement on the previous "point on the knee of the saturation curve". It is, however, obsolescent - but "old habits die hard". It is not capable of providing a unique value for

either peening intensity or the corresponding peening time. That is because intensity is defined here as "that point on the curve beyond which the arc height does not increase more than 10% when the peening time is doubled".

Fig.3 illustrates the range of peening intensity and time values that could be reported for a particular shot stream. The reported values depend upon how an individual interprets data and also on how the data points are positioned relative to the minimum ($\mathbf{h_{MIN}}$). Both peening intensity, **h**, and corresponding time, **t**, are now variable quantities. Lower case is used here to follow accepted engineering/scientific practice for naming variables. The basic problem is that any point on the curve from the point $\mathbf{h_{MIN}}$ / $\mathbf{t_{MIN}}$ upwards satisfies the '10% or less Rule'.

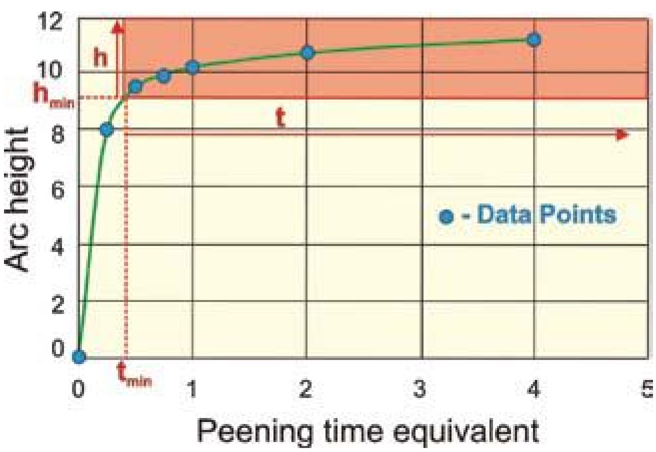


Fig.3. "10% or less Rule" applied to SAE Set No.8.

3. "Type 2 Rule"

This rule is not commonly used, but is included in SAE J443. It is allowed because: "In some cases, saturation curves can appear as exemplified in Figure 2 (Type II) and occurs only when process variables do not permit the attainment of earlier data points". The SAE's illustrative figure, reproduced as fig.4 with minor modifications, is somewhat misleading as it includes simply four data points of exactly equal arc height. That situation never occurs in practice (except as a fluke of measurement variability).

For 'Type 2 Rule' situations, SAE J443 states that: "the intensity is defined as the arc height value of the first data point (i.e., at the minimum possible exposure time, T) provided that the arc height increases by no more than 10% when the exposure time is doubled to time 2T." This statement is at variance with its own fig.4. A possible real situation is illustrated in fig. 5 which uses the last three data points of SAE J443 Data Set No.8.

It follows that this rule permits a range of intensity values to be reported for a given shot stream (as does the '10% or less Rule'). The situations that it covers arise, presumably, when the components being peened are much harder than

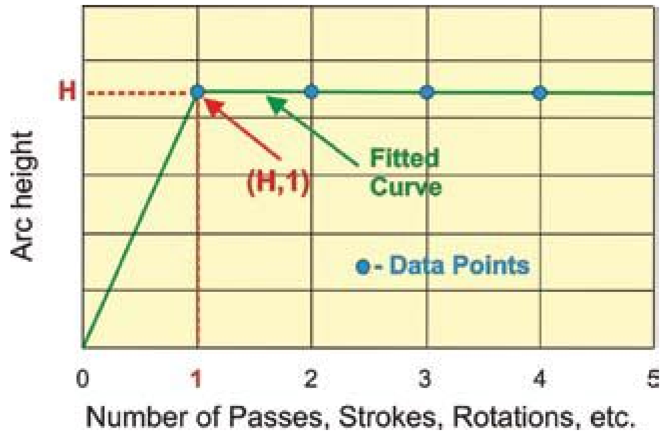


Fig.4. SAE J443 "Incremental based saturation curve (Type 2)".

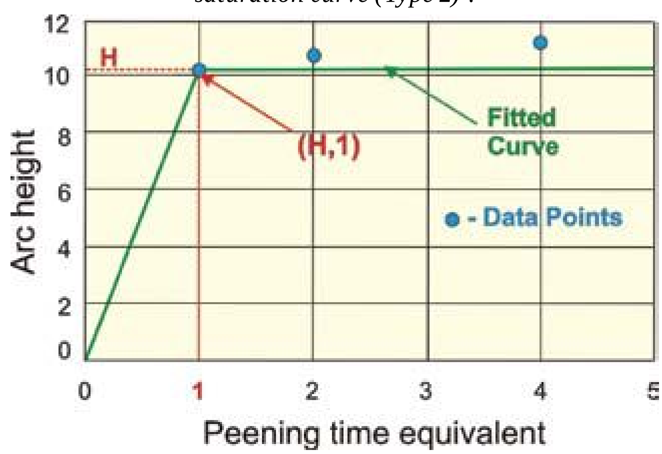


Fig.5. "Type 2" saturation curve for real data set.

Almen strips. Alternatives that would allow the '10% Rule' to be applied include the use of high-hardness Almen strips and masks. For the mask alternative, different fractions of a standard Almen strip could be exposed to the shot stream – simulating fractions of a single pass.

NEED FOR VERIFICATION

SAE J443 rightly requires that verification be carried out in order to ensure consistent peening intensity. "The frequency of intensity verifications shall be no longer than eight hours of operation". This requirement recognizes the fact that peening intensity, for fixed machine settings, can vary after a substantial time of plant operation.

Peening variables have two effects on a peening intensity curve. First is their effect on peening intensity arc height, H. Second is their effect on the peening intensity time, T. Within a specified eight-hour period the major variable affecting H will be the shot velocity whereas feed rate is the major factor affecting T. The two effects are not independent of one another. For example: A change in feed rate will normally induce a change in H as well as T.

This is illustrated in fig.6 where the overlap indicates interaction.

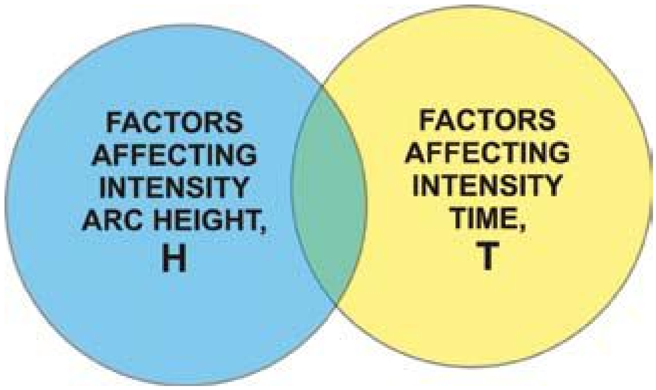


Fig.6. Interaction of factors affecting peening intensity point, H, T.

VERIFICATION WHEN USING A SINGLE STRIP HOLDER

The relevant section in SAE J443 is as follows:

> "When using a single holder on a fixture, a single strip may be used to verify intensity. This strip should, ideally, be exposed for the time T derived from the saturation curve and its arc height shall be within the stated tolerance. In practice, this is not always possible (for example, when integral values of strokes or rotations are used). When that condition occurs, the nearest practical time to T should be used. The arc heights obtained must repeat the value from the saturation curve ± 0.038 mm (0.0015 in) or other value acceptable to the responsible authority."

Fig.7 illustrates the SAE J443 requirements for verification. These involve 'either/or".

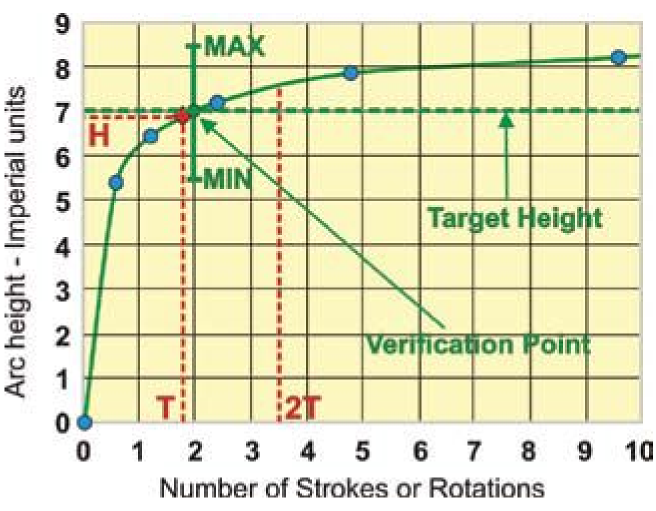


Fig.7. SAE J443 verification alternatives when using a single holder.

For the ideal situation, the single strip would be exposed to peening for the time,T, shown in fig.7. The arc height of this peened strip "shall be within the stated tolerance". Verification therefore only requires that the arc height of the single peened strip falls within the tolerance band e.g. 6 – 9 using imperial units. The tolerance is presumably that stated by the customer and is not specified within SAE J443.

When integral values of strokes or rotations are being employed SAE J443 is quite unambiguous. For example, if the established peening intensity curve was that shown in fig.7 then the single strip must be peened for 2 strokes/rotations. The resultant arc height must repeat <u>the value from the saturation curve</u> ± 1.5 (imperial units). This "value from the saturation curve" is shown in fig.7 as the verification point, (7, 2), which lies on the curve. Hence the requirement is that the arc height shall be 7 ± 1.5. Put another way we now have a "target height" of 7 when the strip is peened using 2 strokes/ rotations. That target must not be missed by more than 1.5.

The SAE J443 verification for single holders embodies an important principle. This is that the intensity of a shot stream is defined just as well by other points on the saturation curve as it is by just the one, critical, point on that curve (H, T). Hence any point on the saturation curve that is reasonably close to T can be employed as a verification point. This verification point has what is commonly called a "Target Height" – meaning that it is a target to be aimed at, see fig.7.

VERIFICATION WHEN USING MULTIPLE STRIP HOLDERS

The objective in this section is to expand on and clarify the SAE J443 multi-holder verification requirement. The SAE requirement is stated as follows:

> "Using multiple holders on a fixture will result in various exposure times for T. To simplify the verification procedure, a single verification exposure time or equivalent may be selected. The verification time selected shall not be less than the shortest exposure time no greater than the longest exposure time of the group of holders. New strips shall then be placed on the holders and exposed for this verification time. The resulting arc height readings of these strips shall be recorded as target arc heights and subsequent verification test results shall then repeat these arc height values within ±0.038 mm (0.0015 in). The resultant arc height readings do not have to be within the intensity tolerance band since the single verification time at a given location can be substantially less than or greater than verification time T. The purpose of the verification test is to confirm that the arc height at a particular location is consistent. The ability of the test strip to exhibit similar curvature for similar exposure time is sufficient evidence of consistency."

In trying to achieve the stated objectives, consider the following hypothetical conversation between Joe and Fred (a visiting peening expert and long-time friend of Joe's).

Joe's Big Problem

Joe: Hi Fred. Thank goodness you are here. I've got a big peening problem that is giving me headaches.

Fred: Hi Joe. What's the problem?

Joe: In a word, "verification".

Fred: Tell me more.

Joe: I am using up to 24 holders on a big component. I've managed to arrange the set-up so that every holder produces a saturation curve with a peening intensity within my customer's tolerance band. I am using a computer to help me produce curves and intensity values following the "10% Rule". My problem is that I have to verify all of these intensities at least every 8 hours of peening plant operation – according to SAE J443. I don't know if my method of verification is correct – it certainly takes me so long that I am losing orders.

Fred: It certainly shouldn't take so long but you are certainly obtaining intensity values properly. Let us take multi-holder verification one step at a time. As a first step have a drawing made of six typical saturation curves from six holders – 24 curves on one graph would look like a bowl of spaghetti! Just the curves and the peening intensity points – there's no need to include the data points. Ideally put the graph on a thumb drive so that I can edit it on my laptop

Joe: O.K. I must have read your mind. Here it is:

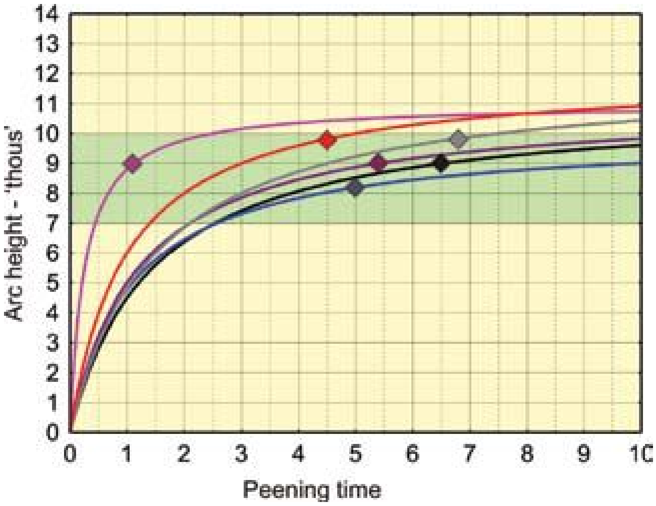


Fig.8. Saturation curves from six holders peened on the same component.

As you can see, the six peening intensity times, T, vary from 1.1 to 6.8. The corresponding intensities are all within the customer's tolerance band – which I've marked as a green box. Where do I go from here?

Fred: As step 2 I'll load the graph onto my laptop, erase your green box, minimise the marking of the peening intensity points and insert minimum and maximum limits for any allowable verification peening time. Here we go:

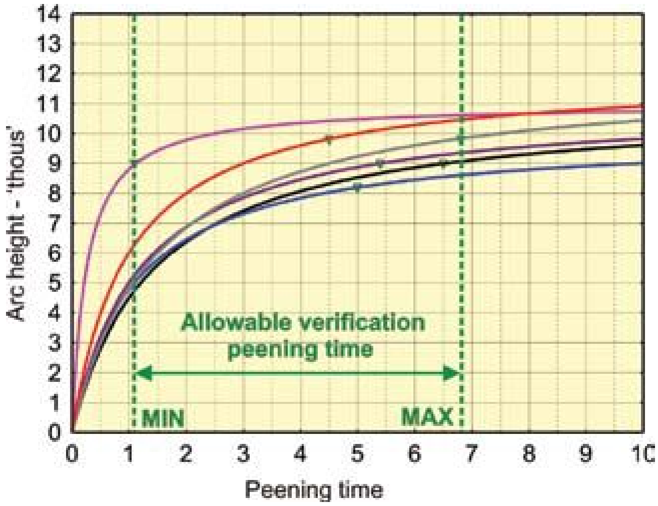


Fig.9. Range for allowable verification peening time using multi-holder setup.

Joe: Surely you've made a mistake by implying just one verification peening time?

Fred: No. SAE J443 clearly states: "To simplify the verification procedure, a single verification exposure time or equivalent may be selected." It also specifies that this single verification time must be between the shortest and longest from the full set of holders. That means that you are free to choose any time between the minimum and the maximum from your set of holders – to suit your convenience. Let us pick 6 as an allowable verification time. As step 3 I'll mark it on the graph. Here we go:

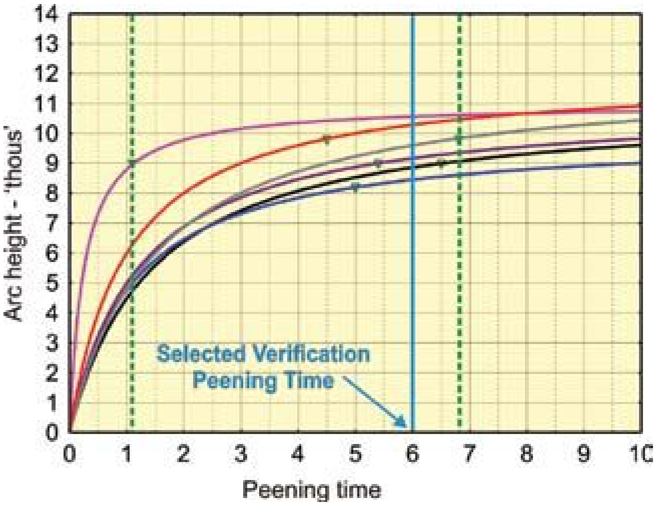


Fig.10. Selection of a single Verification Peening Time when using multi-holder setup.

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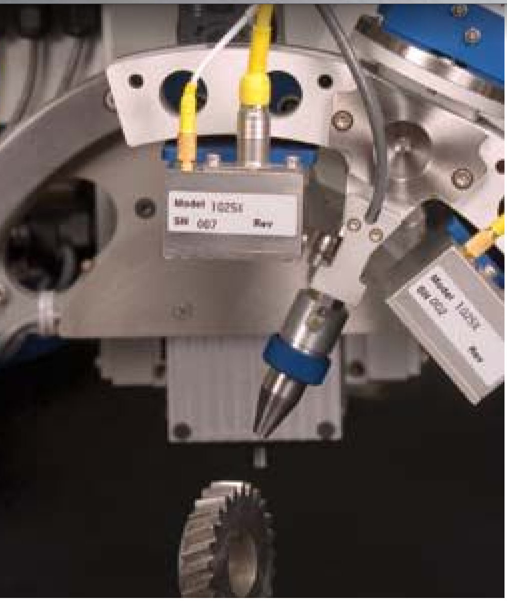

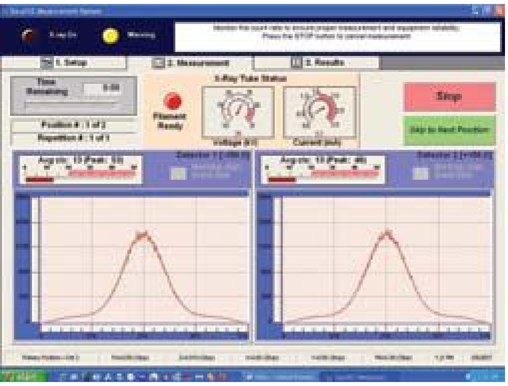

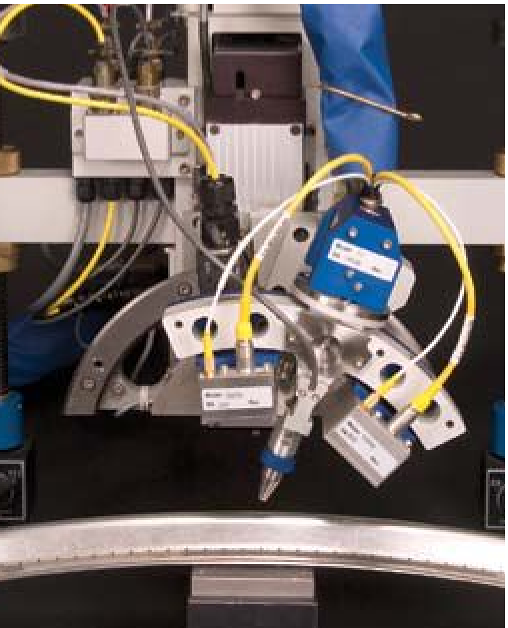

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Joe: What should I do next, Fred?

Fred: All you have to do is to find the six points where the selected verification peening time intersects the six saturation curves. We call these the "target heights". These are the arc heights that we have to aim at during verification. As step 4 I'll mark them on the graph, cut-and-paste, and then zoom in on my laptop so that you can see the target heights more clearly. I've just marked one target height of 9.6, but you can easily read off the other five from the graph. The smallest one is 8.5 and the largest one is 10.6.

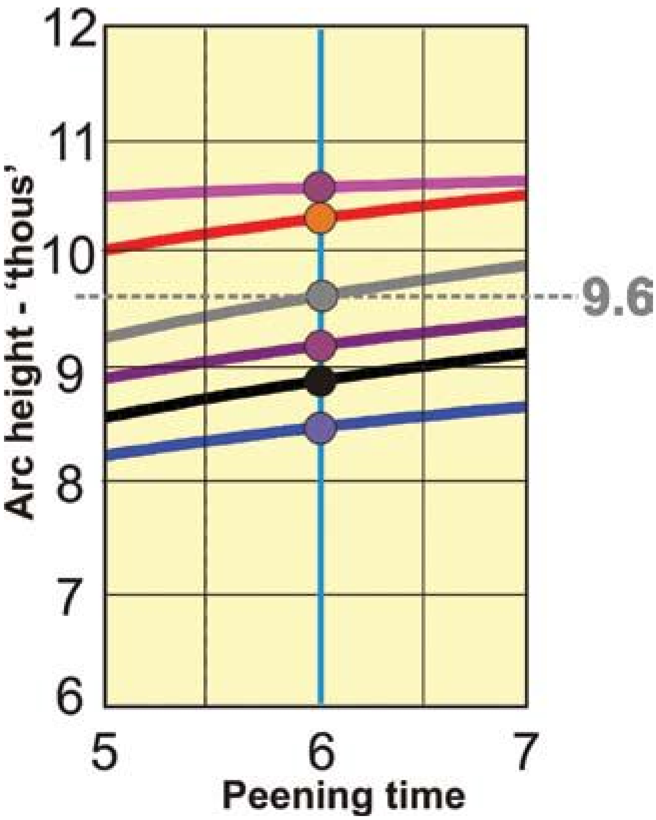

Fig.11. Target heights for a multi-holder set-up and a peening time of 6.

Joe: Yes, but the largest one is above my customer's tolerance band limit.

Fred: That doesn't matter. SAE J443 states that "The resultant arc height readings do not have to be within the intensity tolerance band."

Joe: That's O.K. but do I have to achieve all 6 target heights exactly?

Fred: No. You just have to put one strip in each holder and peen all of them for a time 6. If the measured arc heights after peening are within ± 0.0015" of the corresponding target height you are O.K. For example, at the target height of 9.6 that means that the verification requirement is satisfied if the deflection is anywhere between 11.1 and 8.1.

Joe: Wow that seems simple enough, why was I getting so confused?

Fred: Some of the wording in the current version of SAE J443 doesn't help. By the way what I have told you applies for any number of holders in your set-ups. Here is a checklist - before we go for that pint that you promised me.

Multi-Holder Peening Intensity Verification Checklist

STEP 1: Make a list of the peening intensity times, T, obtained for all of your holders and have all of the saturation curves to hand.

STEP 2: Tick the shortest and longest of list of peening intensity times. Pick just one convenient peening time anywhere between the shortest and longest of these times.

STEP 3: Mark where this selected verification peening time intersects each of the saturation curves. List each intersection as a "Target Height" corresponding to each of your holders.

STEP 4: Put one strip in each holder and peen all of them for your selected verification peening time. Measure the arc heights after peening and compare each of them with your target arc heights. Verification is achieved if each one is within ±0.038 mm (0.0015 in) of the corresponding target height.

SUMMARY

Periodic verification of shot stream peening intensity is a necessity. Variability of this intensity can never be completely removed, even with the use of every available control device.

Specified procedures for verification are not always completely clear and may require interpretation.

Verification when using a single holder can be specified in a relatively straightforward manner. The use of just a single strip is specified in SAE J443 and may be carried out at either the peening intensity point (H, T) on the saturation curve or at a nearby peening time that has a corresponding "Target Height" – which differs from H. The arc height obtained for the peened strip must lie within ±0.038 mm (0.0015 in) of the corresponding target height.

Verification when using multiple holders is specified in SAE J443 and requires one strip for each holder. To simplify verification, these strips can be peened using a single, common, verification peening time. This selected time can lie anywhere between the shortest and the longest peening intensity point times obtained for the set of holders. The arc heights obtained for the peened strips must lie within ± 0.0015" of a corresponding target height. This target arc height is the intersection of the common peening time with the saturation curve for that holder.

by Matej MIKLAVČIČ and Darko HOČEVAR | FerroECOBlast® | www.ferroecoblast.com

Robot-Controlled Shot Peening System for Landing Gear Overhaul

THE PROCESSING OF AIRCRAFT CHASSIS

The landing gear is the only aircraft system without built-in redundancy which means that 100% reliability of operation must be ensured for the pilot, crew and passengers. All the loads absorbed by the chassis during its life cycle should be taken into account, comprising tens of thousands of take-offs and landings, plus high mileage on the track.

Shot peening has always been one of the key processes in the production or overhaul of landing gear. The process is applied to the external and internal surfaces of the components. These are made of either high-strength steel (HSS) or modern aluminium and titanium alloys.

For the treatment of HSS components, steel-shot processing media is mainly used for achieving higher peening intensities. For the treatment of sensitive aluminium alloys, non-metallic media, such as glass or ceramic media, come into play at lower intensities.

Due to the complex geometry of the components and the technological requirements for various processing procedures, the integral solutions for the manipulation of nozzles and the regulation and control of the process prove highly complex.

The Ferročrtalič Company (FerroECOBlast®) has developed a robotic peening station featuring two connected chambers and two industrial robots. Thus, the full spectrum of shot peening treatment is covered. The peening station is designed in accordance with the requirements of SAE AMS 2432 concerning shot peening computerization as well as the strict instructions provided by the component manufacturers.

The process control is based on a complex technology, namely to achieve adequate productivity, efficiency and practical applicability of processed products, and all process parameters must be carefully regulated during the process itself.

The system is called ARSP+ARGB and is designed based on two robotic cells and intended for shot peening the outside and inside radii and surfaces of major aircraft landing gear components. As mentioned earlier, the constituent components made of different materials are of different sizes. The relevant shot peening requirements are beyond the capacity of any individual machining system. Consequently, the concept of two robotic cells associated with a conveyor line has been adopted. The intermediate conveyor line is intended for the manipulation of workpieces and connects the system as a whole.

The components are loaded onto the carrier rails by means of an integrated lift connecting the two cells. The workpieces are loaded onto one of the two trolleys featuring a synchronous servo rotary table, which enables the turning and precise positioning of the workpiece. Controlled by a robot controller, each synchronous drive of the rotary table acts as an additional (external) axis of the robot.

The ARGB cell is intended for shot peening at lower intensities within the Almen N range using a ceramic peening

Dual chamber shot peening system


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medium. The medium collection and recirculation system is based on pneumatic transportation. The ARSP cell is for shot peening at higher intensities within the Almen A range using a steel medium. The Almen A intensities range requires a system that integrates the use of two different granulates in order to cover the whole spectrum. As a standard solution for steel granulates with a high specific gravity, a mechanical collection and transportation system is used.

With two separate cells featuring different processing media, the problem of covering the entire spectrum of treatment intensity has been solved. On the other hand, the challenge of the workpiece's complex geometry has been solved by the use of different processing nozzles and the appropriate technology to manipulate these. Used for the normal shot peening of external surfaces are traditional blasting nozzles fixed on a 6-axis robot manipulator.

The 6-axis nozzle manipulation system works in conjunction with a synchronous rotary table for workpiece manipulation. It provides a variety of mutual combinations of rectilinear and rotational movements.

It was necessary to solve the processing of small radii of internal diameters of 10 to 50mm and depths of up to 500mm. A special rotary lance featuring a small rotating nozzle has been developed for this application. The drive of the rotary nozzles is done by means of a small servo motor enabling a constant rotational speed and repeatable procedures. The above-described system has already been proven to be effective in the shot peening of internal diameters and grooves on LPT disks of jet engines. The rotary nozzle-featuring system is also fixed on a 6-axis robot offering all the manipulation options of conventional nozzles. The rotating and the conventional nozzles are interchangeable and fed by the same blast pressure generators.

Additional technological requirements for processing internal radii with diameters greater than 50mm and depths up to 1500mm require a different approach. For this purpose, an ITP (Internal Tube Peening) system featuring a long rotating machining arm with a nozzle at its end has been developed.

Transport trolley with synchronous turntable

Two-axis linear movements are carried out in this case by a trolley moving along the conveyor line and the scissor type lifting mechanism.

Shot peening of aerospace components requires a continuous treatment without any interruptions. Any unplanned shutdown may result in a component not complying with the requirements and thus hazardous to operate. This is why the double pressure blast generator was adopted, enabling continuous processing by the simultaneous refilling with no noticeable air pressure fluctuations.

THE ROLE OF ROBOTIC MANIPULATOR

At FerroECOBlast, special attention is paid to industrial robots manufactured by ABB, whose features and functionality respond to all requirements such as SAE AMS 2432. Before the introduction of robots and CNC multi-axis manipulators, the process used to be solely based on “hard automation”, mostly based on a single-axis processing nozzle manipulation.

The robotic manipulation of processing nozzles enables manufacturers to deal with shot peening processes with absolutely predictable machining cycle times, results and costs per cycle. By positioning repeatability at ±0.04mm and the resolution of individual axles between 0.001° and 0.005°, a robot can easily follow the outer contours of any large and complex piece with only a single nozzle and one program, and it can position a small rotating nozzle in the required technological openings with a second program.

By using the ABB RobotStudio simulation package, the robotic shot peening manipulator can be programmed off-line with no direct connection to robot. Then the program can be uploaded into the robot controller. However, most operators and programmers prefer to supervise the actual position of the nozzle relative to the workpiece. This is why most of the software is developed by the way of storing the positions of the robot along the desired path of movement using the manual control panel. By using it, the programmer can adjust the distance between the nozzle and the workpiece, the angle of attack as well as its speed, and can also adjust both the position and the speed of the rotary table. The software code is stored in the robot controller located outside the cell. Subsequently, any processing programs can be recalled by manually entering the serial number of the workpiece in the control computer or by simply scanning a product bar code.

Due to the aggressiveness of the robot manipulator's working environment, all the moving parts, both inside and outside the processing cell, must be well-protected against abrasive impacts specific to shot peening. The ABB robots of the IRB-series feature an improved level of IP protection (version FoundryPlus 2) and additionally protected by


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Robotic manipulator featuring the rotary nozzle system

customized polypropylene protection they provide a perfect solution. Therefore, they comply with all the requirements for work in the abrasive environment characteristic of shot peening cells.

As well as being suitable for shot peening, durable and reliable, the robots must also be highly precise, repeatable and easy to program. A robot must offer a wide application range and provide sufficient freedom of movement to follow the contour of the entire workpiece. This especially applies for jet engines, where the requirements for processing large external and small inner radii are highly demanding. On the other hand, most of the work pieces rotate or move in front of the machining nozzles and therefore, their manipulation must occur at high speeds. Normally, linear speeds of 4 to 5m/min and rotations at approx. 720°/min are sufficient.

CLOSED-LOOP CONTROLS OF PROCESSING PARAMETERS

Not only have the robotic manipulators provided a superior method of manipulation processing nozzles, they have also proved crucial in improving the overall peening process. Using the incremental encoders on the servo drives of all the robot axis make a closed-loop feedback connection possible. Thus, the robot controller can be constantly supervised.

Closed-loop control of compressed air dosage and the mass flow rate of the peening medium have also contributed to the high reliability of the shot peening system. This is now able to operate from cycle to cycle without any supervision.

Currently, various technological solutions for the regulation of these process variables are available on the market. As an standard option ferrite media mass flow closed-loop control is commonly installed. This type of regulation is performed directly by means of the MagnaValve® magnetic valves.

The MagnaValve® is a normally closed valve regulating the flow of steel granulates for air shot peening systems. Its built-in sensor measures the mass flow through the magnetic valve. Together with a separate controller, it provides accurate and repeatable process mass flow.

Similar closed-loop systems, consisting of a proportional valve, i.e., a regulator and the control valve, are used for accurate and repeatable control of air pressure.

For technically complex aerospace components, shot peening procedures dictate specific requirements typical for a difficult-to-manage machining process. Given those requirements, the only logical and acceptable solution is following the procedure using robotic technology for manipulating the processing nozzles and cutting-edge systems for the closed-loop control of medium mass flow and working air pressure.

The entire processing cycle is supported by steel shot medium recovery and a management system comprising cleaning, volume-classifying and the automatic filling of cylinders. Modern systems are designed to allow operation with two or more different types of processing media.

Modern PLC-controllers with purpose-built software packages are used for control of the whole machining process. These are supported by the SCADA process visualization system on an industrial PC computer. The design of the modern SCADA systems allows for various functionalities, such as:

- process visualization
- real-time monitoring of parameters
- parametric programming and program recalling
- recording the history and printing messages
- flexibility of servicing manipulations and simulations of operation

Among these, we also find the SAE AMS 2432 standard requirements relating to the storage and archiving of process parameters, as well as their subsequent processing.

Conclusion

The shot peening systems described in this article provide exceptional quality from fully controlled and repeatable processes used for the treatment of complex components installed in military and commercial aircraft. Robotic shot peening systems contribute significantly to overall air traffic safety.

With the aerospace industries' increasing efforts to prolong the service life of their products, we are faced with more stringent and more precise requirements for shot peening. Our robotic shot peening system is a new tool used to optimize and extend the service life of components.

3rd CIRP Conference on Surface Integrity

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The 3rd CIRP Conference on Surface Integrity (CIRP CSI 2016) will take place on June 8 – 10, 2016 in Charlotte, North Carolina, USA. The goals of the conference are:

(1) Present recent trends in the study of surface integrity that are of strategic importance to manufacturing processes;

(2) Facilitate a sharing of scientific understanding of the effects of surface preparation techniques on the formation and consequences of surface integrity;

(3) Discuss case studies related to workpiece surface integrity;

(4) Identify the industrial needs/applications related to surface integrity.

The goals will be accomplished through keynote presentations from academia and industry, technical paper presentations, poster presentations, and industrial exhibits.

The conference is being organized by the University of North Carolina at Charlotte and is aimed at leading scientists and engineers in industry and research institutions. Presentations will range from fundamental research to industrial applications. Topic areas include:

1. Precision Machining
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$700 - Early Bird Registration

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