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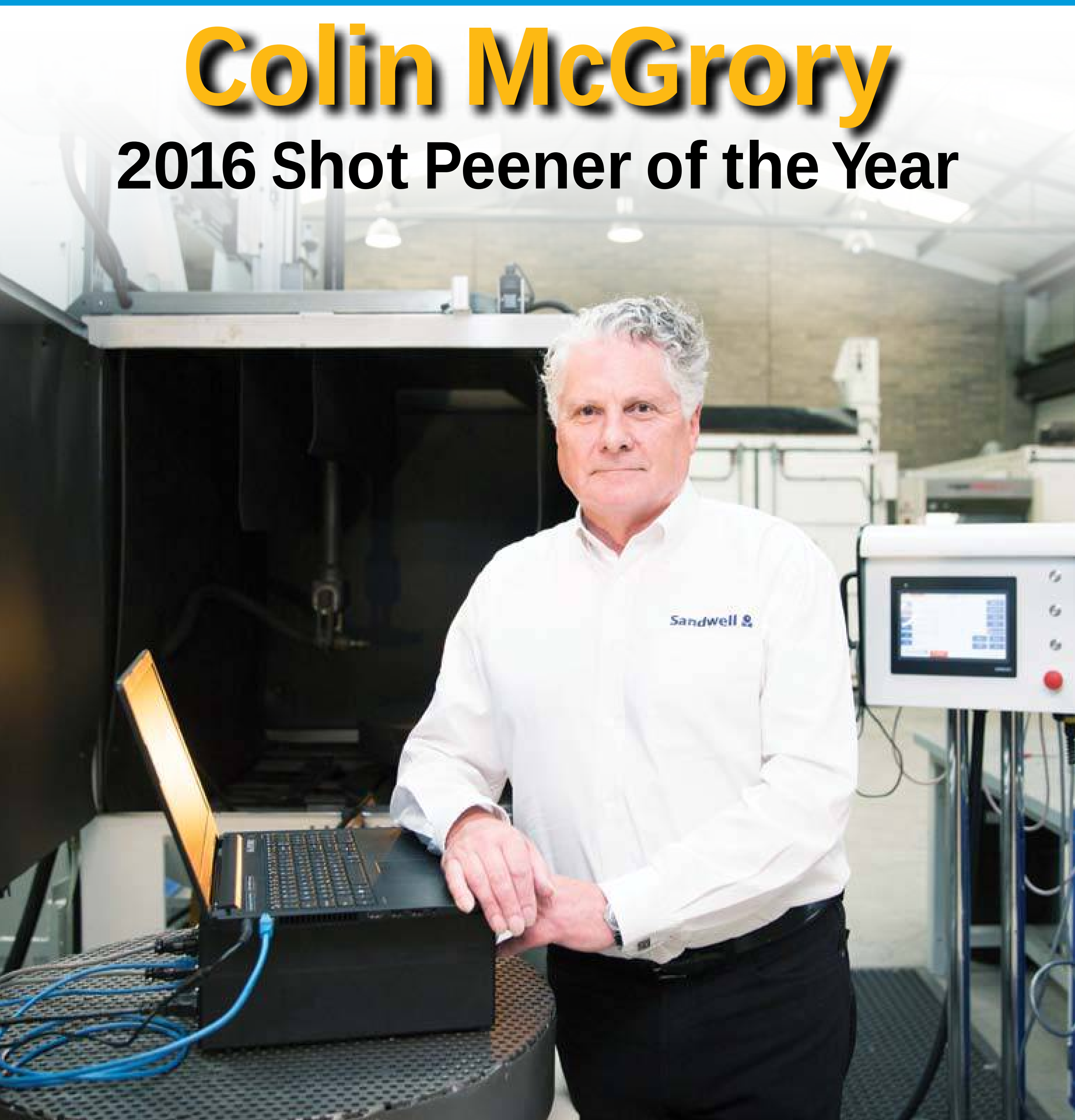
The Shot Peener

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

Colin McGrory

2016 Shot Peener of the Year



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Colin McGrory is our **2016 Shot Peener of the Year**. Read why it was an unanimous decision by the staff of *The Shot Peener* magazine to recognize Mr. McGrory for his achievements and contributions to our industry.

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

In This Issue

IT WAS CELEBRATION TIME. I was pleased to see so many of our long-time friends at the 25th Annual Shot Peening Workshop. We also had a very large number of first-time attendees, which is a great sign of growth in the shot peening world. This means that the practice of shot peening is expanding into new market areas. I hope you enjoy the photo review of the workshop—I think you'll agree it was an productive and rewarding event for all.

JACK CHAMPAIGNE

The winter issue of *The Shot Peener* honors the **Shot Peener of the Year**. Voting for Colin as the 2016 recipient of the award was an easy decision. I visited his facility, Sandwell UK, while in the United Kingdom for an EI shot peening training workshop this summer. I quickly saw that he has the equipment and the knowledge to perform very precise shot peening. Our conversation confirmed what I was seeing—Colin is a big-time contributor to the shot peening process. University students frequently apply for internships at Sandwell, primarily because of his stellar reputation in the auto sports industry. Congratulations, Colin.

When I was asked to consider the WA Clean product for inclusion in the magazine, it took me back to my college days working for an electrical panel builder who serviced the abrasive blast cleaning industry. They had developed a device called "Scale-O-Meter" to determine the cleanliness of shot-blasted steel sheet. The operation was quite simple. The operator placed "Scotch" tape onto the surface to be analyzed and removed it and then placed it onto a microscope slide. This was then inserted into a small slot where a light source and photo cell determined the opacity of the slide. A kit with various degrees of dirty/clean slides was used as a comparison. I don't recall that it ever went to market since it could not relate to SPC standards. So when I read about the WA Clean, my reaction was: Well, it's about time! I'm all for products that advance quality control in the blast cleaning industry.

Best wishes to all for a happy, healthy and prosperous New Year!

It has become a workshop tradition: The attendees wear their workshop t-shirts for the group photo.

THE SHOT PEENER

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The 2016 Shot Peener of the Year
Colin McGrory

COLIN MCGRORY is an entrepreneur, an innovator and a shot peening explorer. Colin appreciates being part of a successful business, but he especially thrives on continually learning something new about the shot peening process.

Colin is the Technical Director of Sandwell UK. He and Liz Slater, Managing Director, founded the company in 1997. Sandwell UK provides shot peening, decorative finishing, specialist coatings, advanced technologies, failure analysis and performance engineering consulting to high-end clients in motorsports, oil and gas, renewables, aerospace, medical and consumer products.

Colin's interest in shot peening started long before he and Liz founded Sandwell UK. He began his career as a Metallurgical Engineer for military and civil aircraft systems. He transferred those skills to what many of us would consider to be a dream career in the world of Formula One. For over 20 years, he was fortunate enough to work alongside many of the greatest motorsport designers and engineers.

The following interview with Colin will showcase the reasons he was chosen as our 2016 **Shot Peener of the Year**.

The Shot Peener: When and where were you first introduced to shot peening?

Colin: I became aware of shot peening during my metallurgy studies but I didn't really appreciate or fully understand the process. During my time in aerospace, I became more aware as it was an accepted process although I was never directly involved at that time. I think it was really in the early 80s when we were seeing component failure on transmission parts of race cars that I started to read research papers and began to recognize the benefits of the process.

Engine performance was increasing and the level of electronic control of engine parameters was producing a much more sophisticated stress pattern within the transmission. I had introduced various NDT methods to analyze cracking and to understand root cause, but the main objective was to increase component life. I introduced the first shot peening cell in Formula One in 1984 to process gears and associated transmission components. This had a significant outcome in terms of reliability.

The Shot Peener: What was it about shot peening that earned your dedication to the process?

Colin McGrory inspects a part that was peened in the RoboPeen—an 8-axis robotic shot peening system designed by the Sandwell UK team.

Colin: When I first heard about shot peening it was almost like a secret magical process and I was intrigued by this. In fact, I still am!

Shot peening appears to be a relatively simple operation with control of the variables, media size and type, flow rate and velocity, but I soon realized the interaction between these controllable variables and the component is an extremely complex one. The transformation of the energy state in a material during shot peening, whether by recrystallization, dislocation or surface compliance, can produce unexpected results. It is this unpredictability that makes the process so interesting. Just when you think you fully understand the process, another little anomaly is uncovered that questions your whole understanding.

The Sandwell staff has increased the life and performance of many components over the years. It is so satisfying when a designer is confined by limits of packaging, size or material


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and has an unresolved fatigue issue. This is where shot peening comes into its own. Engineers and designers working together to develop a technique which significantly increases fatigue life is testament to the validity of the process.

Shot peening is an extremely subtle technique—it's so important to tune the process to the material and understand its ability to respond. I think people look at a residual stress graph as a measure of depth and magnitude and think they have optimized their technique, but there is so much more to learn. Every graph tells a story and it's important to read the graph and try to understand and quantify the technique.

The Shot Peener: We admire your entrepreneurial spirit. Why did you leave an illustrious career with Jaguar Racing to start Sandwell UK?

Colin: During my time in motorsport, I read about and researched surface enhancement processes, including DLC coatings, superfinishing, carbonitriding, shot peening and many others. We were always chasing performance and I always knew that working with the surface of materials is a great way to add value in terms of fatigue life or fatigue load. I wanted to put some of this knowledge into practice; hence, I bought a machine and started to shot peen on my own. Sandwell started out as a part-time project, initially as much to improve my own understanding of the process while I continued to work for Jaguar Racing. Soon, however, I felt I had something to offer in terms of my knowledge and my ability to understand the needs of customers. The mentality of top level motorsport is very much a "can-do attitude" and I adopted this approach for Sandwell.

I wanted to provide the best possible service in terms of quality of process and turnaround time which I knew was critical for race teams on short lead times. Because of this, I have always had high demand from motorsport companies for our services. This approach has opened many other doors for us and, 20 years later, we reach into almost every industry and still dedicate our time to satisfying our customers' needs.

Sandwell very much goes its own way. We need to be commercially viable, but our business is about developing machines, techniques, and furthering our understanding of the effects and benefits of shot peening on a wide range of components and materials. We interact and work closely with our customers.

It's important to understand that most engineers and designers do not have an in-depth understanding of the shot peening process and it is our responsibility to apply our knowledge to their parts to ensure improved reliability and performance.

We often take on a small job that is not in itself financially beneficial, but if we can learn from it, if we have to develop a new technique or produce a nozzle to access certain areas, then the value of the work is in the knowledge we gain. I guess I'm fortunate in that as it is my company, we tend to choose the more interesting work even if it is not always the most financially rewarding.

The Shot Peener: We mentioned earlier that Sandwell UK provides several surface finishing services. Would you like to elaborate on that?

Colin: Whilst shot peening is our core business, it is very much part of a suite of engineering processes that complement each other. We try to offer a one-stop shop where parts can be shot peened, superfinished and, in some instances, coated or given a final decorative finish. We like to think that within our range of processes we can offer a customer a number of solutions to their component performance needs. Having the range of processes on site means we have a much wider understanding of what works and what doesn't. This depth of knowledge is invaluable when working with customers to develop engineered solutions.

The Shot Peener: Your contribution to the advancement of shot peening is especially evident in your research projects. Please tell us what Sandwell is working on.

Colin: Like for most companies, most of our work and client list must be kept confidential, but I can share that we're working on a joint project to develop techniques to manage stress in additive manufactured parts. Another joint project is the development of a cell to improve the surface finishing of additive manufactured parts by integrating laser polishing and shot peening. We are also exploring a shot peening method to generate nanocrystalline structures in high-strength materials.

The Shot Peener: What are your thoughts on receiving **The Shot Peener of the Year** award?

Colin: I am delighted to join the list of highly regarded individuals in my profession. To me there is no greater accolade than to have the recognition of your peers. I was certainly not expecting this and as such it makes this award even more rewarding.

About **The Shot Peener of the Year** Award

Since 1992, *The Shot Peener* magazine has given **The Shot Peener of the Year** award to individuals in our industry that have made significant contributions to the advancement of shot peening.

Visit www.theshotpeenermagazine.com for a complete list of past **Shot Peener of the Year** award recipients.

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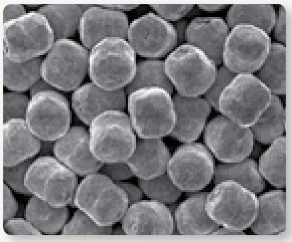

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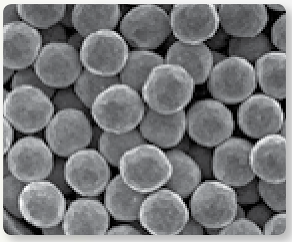

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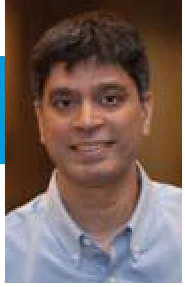

Kumar Balan | Engineer | Empire Abrasive Equipment

Shot Peening Achievement Exams: A Review

Every expert was once a beginner and every expert had to pass many tests to achieve such a high level of competency. That said, a casual google search on "fear of exams" came back with 21,100,000 results in 0.52 seconds! For most of us, a formal examination is thankfully a distant memory. As the 25th US Shot Peening and Blast Cleaning Workshop was coming to an end, certain emotions were perceptible among the students. They ranged from anxiety, curiosity, nervousness, and of course, a reasonable sense of accomplishment since more than two days of information had been thrust upon them, earning them a Certificate of Attendance. Many of the students would be taking the EI Achievement Exams. This review will help attendees of future shot peening training programs prepare for the exams. The exams are meant not only to add to existing memorabilia in your work space, but also to inform your peers that you are a trusted knowledge base for the peening process.

The History of the Shot Peening Achievement Exams

At the 2016 workshop, Jack Champaigne, President and Founder of Electronics Inc. (EI), explained the history, need and significance of the three levels of exams.

"The exams were designed to recognize a student's level of competence in shot peening," Jack explained. "To some extent, they were also a barometer of the quality of shot peening education from our speakers at the workshop. As the workshop gained popularity within the industry, vendors supplying critical components to the shot peening industry expanded their participation by speaking about their individual expertise, leading to the growth of the course curriculum. As a natural progression, these vendors brought with them process control expertise that resulted in repeatability, reliability, accuracy and fine tuning of the peening process. The three levels of testing were created to establish the student's expertise, understanding and ability to handle peening projects of increasing complexity."

Dave Barkley, Director of EI Shot Peening Training, said, "FAA recognition of our training programs came in 2000 with their acknowledgment of the importance of process control, knowledge and competence in shot peening. This led to EI's development of three levels of testing —Level 1: Beginner, Level 2: Advanced and Level 3: Professional."

Active participation in the shot peening workshop is necessary when preparing for an exam. The workshops cover the core material and FAA-accepted material found in Level 1 and 2 exams. Students with industry background will find the first two exam levels very manageable, which is also why they are permitted to take them at the same workshop. The workshops also offer advanced classes conducted by industry experts. These classes focus on real-world, practical applications with interactive discussions to help students taking the Level 3 exam.

Level 1: Beginner

The Level 1: Beginner exam is split into three parts. Part A is a series of true/false questions, Part B has multiple choice questions and Part C tests the student's knowledge of saturation curves. The mechanics of peening, and the fundamentals of stresses, peening media, intensity, coverage and saturation curves are also covered. A student must have a basic understanding of graphs—how to plot, read and ultimately draw direct inferences from the data.

A student that earns the Level 1 Achievement Exam certificate understands the basics of intensity, coverage, process control and saturation. Obtaining the knowledge required to pass the Level 1 exam is beneficial to many different members of a shot peening team. A manager will appreciate the effort and time invested in a sound peening process. The process engineer learns the variables that influence the outcome of his or her shot peening process. The operator receives a proper foundation for the task ahead—whether it be the next two levels of exams or setting up a peening process at work.

Shot Peening Level 2: Advanced

Most students take the Level 1 and 2 Achievement Exams on the same day. However, passing the Level 2 exam


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usually requires real-life industry experience in addition to understanding the information provided in the core workshop classes. Achieving Level 1 and 2 Achievement Exam certificates therefore establishes a student's technical proficiency in the shot peening process.

The Level 2 exam has questions in several different formats including true/false, multiple choice, fill in the blanks and the student's ability to visually inspect media. Requirements for the exam include:

- Real-life training (machine maintenance, design and selection) is a definite asset. It will help when answering questions related to media inspection and "what to do when" questions. For example: The media stream contains non-round contaminants or striping appears on the part while spinning in a nozzle stream.
- Knowledge of auxiliary equipment such as the Vibratory Classifier, MagnaValve, Spiralator and their influence on peening results.
- Knowledge of commonly used specifications; particularly where they pertain to media inspection, plotting the saturation curve, etc.
- Practical knowledge of how variation in process parameters effects the velocity in peening machines. For example, how the increase in air pressure affects intensity or how the size of shot affects coverage.

Bob Nirmaier, Automation Product Manager at Empire, has worked on shot peening projects for several years. "I finally decided to attend the workshop and take the Level 1 and 2 exams, which I passed. This qualification adds credibility when I help our customers design their peening process. I can now clearly articulate the metallurgical impact of process control in the machines we design and build. As an automation engineer, the merger of electronics, process and metallurgy is paramount to me in explaining the criticality of this process to our customers," said Bob.

Shot Peening Level 3: Professional

This exam requires a student's practical knowledge and real-life experience with a successful shot peening process, and less on memorizing slides and data. It's an essay-based exam and the questions are about many different aspects of shot peening—even topics that weren't discussed in any appreciable detail in the various classes.

The Level 3 exam should be approached with a healthy dose of caution because a question may require the ability to state the reasons for reaching a conclusion. For example, if a question is about the suitability of a wheelblast or airblast machine for an unknown application, the correct way to answer the question would be a listing of the pros and cons of each machine.

It is very common for students to allow a gap of one or two years between Levels 2 and 3, with the gap ideally spent gaining practical experience. When asked to comment about the Level 3 Achievement Exam, Dave Barkley didn't mince words. "The exam is purposely difficult and not based on workshop curriculum. Having an EI Shot Peening Training Level 3 Certificate tells the industry that you are a shot peening guru, so you have to earn it by truly knowing the process," he said.

A Testimony to the Benefits of Achievement Exams

Leo Krieger, the Advanced Manufacturing/Tooling Supervisor with Meggitt Aircraft Braking Systems, has been a regular attendee at the EI North American shot peening conferences. He is Level 3 Certified.

"The material covered in the core and break-out sessions pretty much covers all aspects of the Level 1 and Level 2 exams. The Level 3 exam involves "real-world" scenarios, and there may be one or two questions that could pose a challenge for some unless they have experienced these scenarios themselves. However, with a clear understanding of the shot peening process and by following the correct set-up procedures (saturation, intensity, coverage), you will be on your way to not only responding to the exam questions but also identifying and solving an existing problem in your current process at work," said Leo.

"My participation and success in the exams have definitely helped increase the quality of our peening operations here at Meggitt. It has helped me make our operators aware of the importance of plotting a saturation curve, and the appreciation that the slightest change in a setup (air pressure /wheel speed) can alter the intensity. In turn, our operators now appreciate the impact that making changes in the setup can have on the final products which in our case is very critical. Being able to help our operators when they run into a problem eliminates wasted time and improves overall operating efficiency. Information in the break-out sessions at the workshop has helped tremendously in this respect," added Leo.

Leo is confident the workshops and exams will encourage the future generation of shot peeners. He said, "I have witnessed many on their first day at the workshop tell me that they were attending the training and taking exams to better familiarize themselves with shot peening. By the end of the workshop, these individuals have a greater understanding of shot peening and feel encouraged to take their knowledge back to their workplace and attend future workshops."

As you can tell from Leo's comments, the benefits of taking the exams far outweigh the fear.

Examining the Future

The EI Shot Peening Training team regularly updates the Achievement Exams to keep pace with the expanding training curriculum, specification conformance, and advancing technology, thereby guaranteeing our success in a growing shot peening universe.

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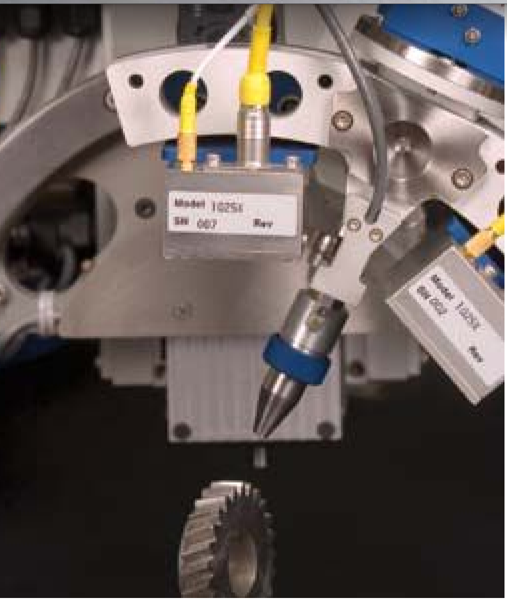

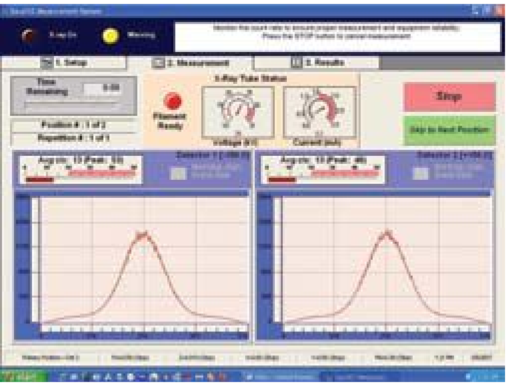

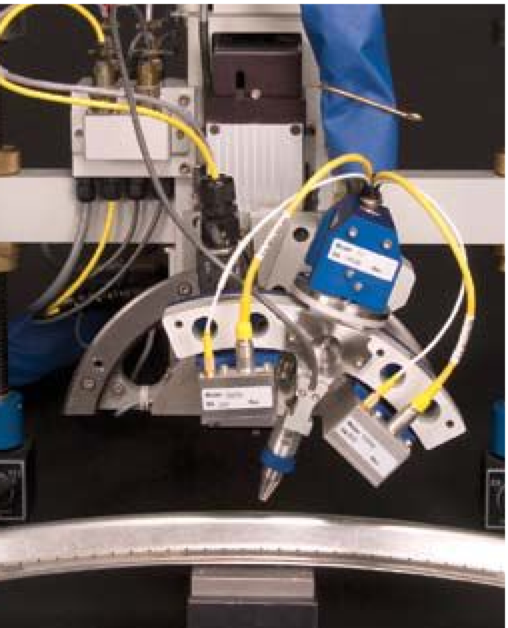

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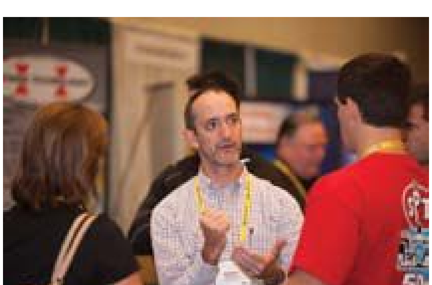
25th Annual US Shot Peening Workshop Highlights

The EI Shot Peening Training staff extends a big "Thank You" to the students, exhibitors and instructors that made the 25th Annual Shot Peening and Blast Cleaning Workshop a great success. The workshop was very well attended and as the photos show, the networking, class instruction and trade show combined to make it a rewarding event for all.

25th Annual US Shot Peening Workshop Highlights



High-Pressure Fuel Injection Systems: Shot Peening and Its Effect on Residual Stress

Student Researchers: Rachel Butler, Yuheng Du, Heather Macdonald, Kerui Sun
Faculty Advisor: John Blendell • Industrial Sponsor: Brian Wright and Andrew Armuth with Cummins Fuel Systems

CUMMINS FUEL SYSTEMS designs and manufactures high-pressure diesel fuel systems that must survive high-cyclic pressures during operation. Shot peening is employed as a surface strengthening technique on pressure-bearing surfaces of fuel system components where fatigue failure, due to alternating pressure, is most likely to occur.

Cummins Fuel Systems has been a long-standing supporter of Purdue Senior Design Projects and they sponsor a project almost every year. Precision shot peening and the measurement of the resulting properties are topics of special interest to the company.

The following is a reprint of the students' research poster.

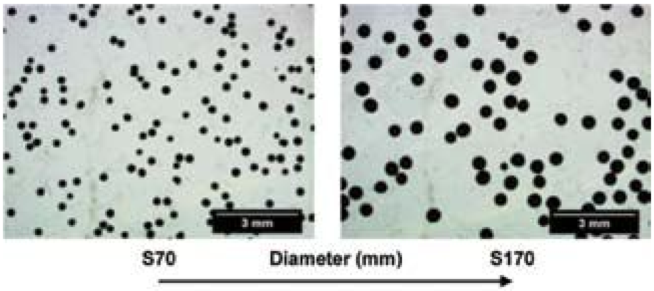
Project Background

Almen Intensity and residual stress were characterized by varying shot peening parameters and measured by X-ray diffraction (XRD). Hardness, surface roughness, and residual stress (RS) depth profiles were conducted on 4140 and 52100 steels as well as Almen strips to analyze the effects of variation in shot media size, shot pressure, and shot type. Hardness variation was seen to be the most influential variable in roughness and RS.

XRD techniques are capable of directly measuring crystallographic lattice strain which can be translated to stress by the $\sin^2\psi$ method. However, because XRD cannot be performed on small inner diameters such as that of fuel system components, Almen Intensity is instead used to monitor the shot peening process. The main objective of this study is to correlate the stresses measured with XRD to the Almen Intensity and determine the effects of altering shot peening parameters.

Experimental Procedure

Steel coupons (76.1 mm x 18.95 mm x 6.35 mm) of 4140 (40-45 HRC and 50-55 HRC) and 52100 (58-62 HRC) were shot peened by Metal Improvement Company. Peening was performed using a ⅜" nozzle set perpendicular to the coupon and at 7" spacing. Nozzle oscillation speed across the coupon was 24 in/min for metallic shot and 12 in/min for ceramic shot until 100% coverage was achieved (3-8 passes). Single and dual shot media sequences were studied. S170-H and S70-H cast steel shot were utilized in single peening; dual peening experiments used S110-H and S70-H cast steel shots sequentially or S170-H cast steel shot and Z150 ceramic shot sequentially. S170-H and S70-H were chosen for comparison to the incumbent process; dual peening and ceramic shot were chosen for investigative data gathering.



The increased diameter size increased the potential to input more force into the surface of the sample, with residual stress.

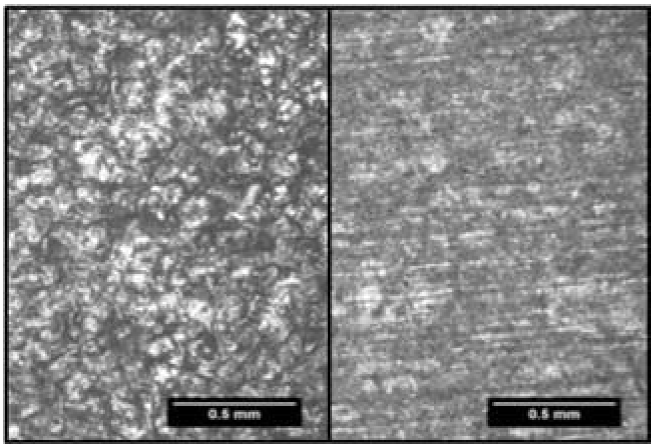
Samples were then examined via optical microscopy, profilometry, hardness, and XRD. XRD was performed using a chromium x-ray tube with vanadium filter, set to 25kV and 0.8mA. SaraTEC Analysis Manager v1.3.37 software calculated RS values using 4340 50 HRC for the material constant. This software also compiled RS depth profiles using XRD measurements obtained after incrementally electropolishing into the coupons. Three-dimensional optical profilometry (ZeScopeTM) gathered five surface roughness measurements across each sample.

Almen Intensity is the arc height measurement of thin, standardized, steel strips. If a sample is sufficiently thin, the compressive RS imparted by peening creates concave bending of the sample which is measured by regulated gauges (SAE J443).

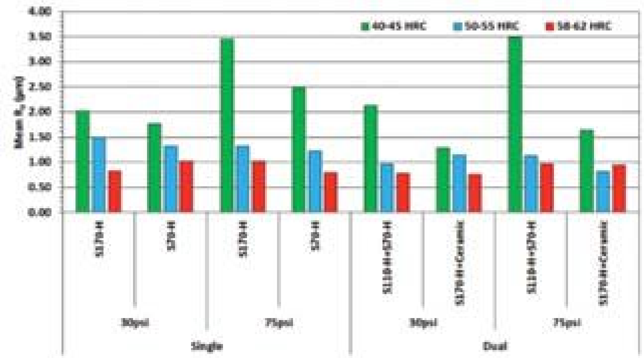
Results and Discussion

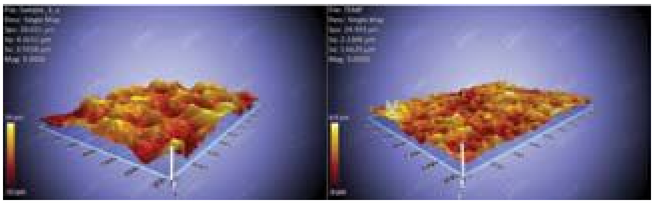
Roughness

Hardness was the most influential variable to surface roughness as shown by the 40-45 HRC sample. Changes in air pressure showed only slight differences in roughness. From only changing the hardness, softer coupons displayed rougher surfaces after peening. However, the 75 psi, S170+Ceramic dual-peened sample with 58-62 HRC displayed a higher



4140 40-45 HRC (left), 52100 58-62 HRC (right)



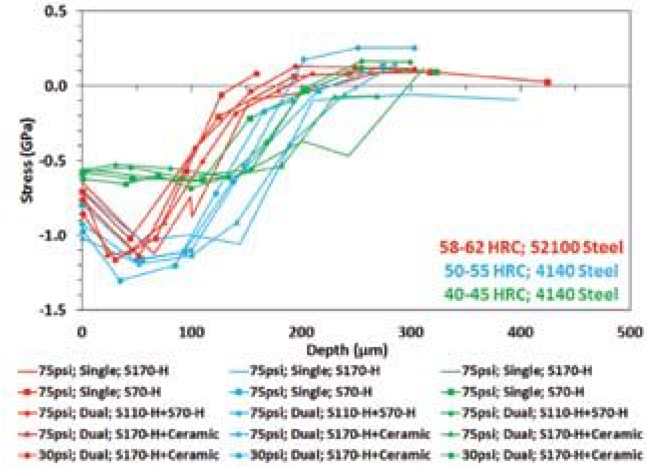


A S170-single peened (left) vs. a S170+Ceramic-dual peened (right) sample showed decreased roughness. The second, smaller ceramic deformed the surface more uniformly, resulting in a smoother surface.

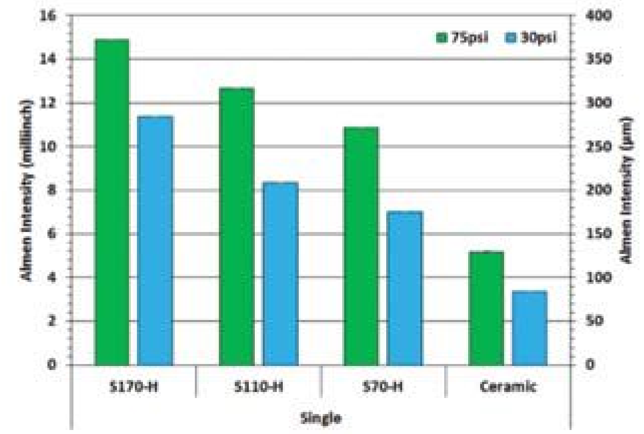
roughness value than expected. This was due to debris on the sample's surface increasing the distance between the highest and lowest measured points and thereby increasing the mean Ra value.

Residual Stress and Almen Intensity (AI)

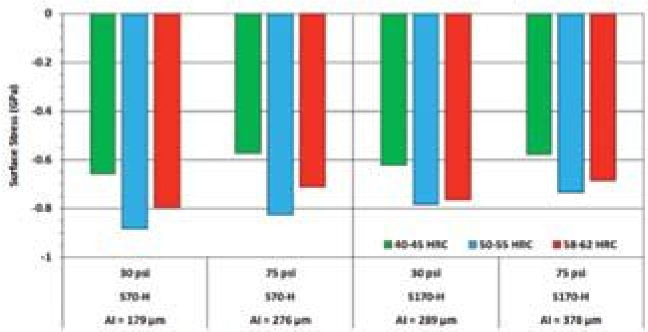
The initial hypothesis was that harder materials would exhibit larger RS due to deformation resistance. Results showed that the 50-55 HRC samples exhibited the largest compressive RS as seen in the depth profile.



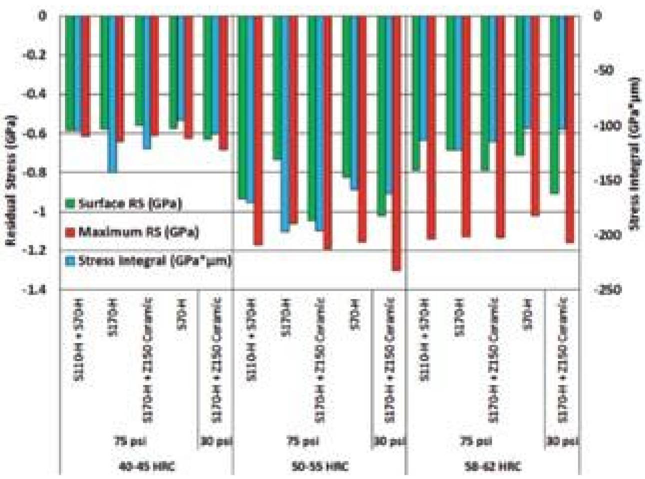
Almen Intensity values increased with pressure and media size. The ceramic shot was harder than the steel shot used, but due to mass decrease, the Almen Intensity was the lowest.



Surface RS decreased as air pressure increased.



Stress integral was defined by the definite integral of the depth profile for compressive stresses beneath the x-axis. This integral increased with shot size and corresponded to an increase in Almen Intensity implying that Almen Intensity can be correlated to RS.



Conclusions and Future Work

- Coupon hardness was the most influential parameter regarding material response. The 40-45 HRC material was unable to retain induced stresses.
- 52100 (58-62 HRC) contains carbides that may act to impede dislocation motion. When compared to 4140 (50-55 HRC), 52100 (58-62 HRC) may require a higher intensity shot peening process to induce the same RS magnitude.
- Future work should include measuring RS after peening of reduced-carbide 52100 as well as 4140 and 52100 samples of the same hardness.
- Immediate future work should include creating RS depth profiles of coupons peened at 30 psi to relate air pressure to maximum compressive RS and area under the depth profile curve.

"In the past, shot peening has served as a solution to improve a component's robustness when challenged by manufacturing in global markets. Moving forward we are interested in creating a bridge between design and manufacturing. On one hand, our designers focus on compressive residual stress for modeling and, on the other, manufacturers are concerned with Almen Intensity for process control," said Andrew Armuth, Current Product Leader – Materials Science Engineering at Cummins Fuel Systems."The work completed by Purdue has given us a foundation on which we can correlate compressive residual stress to Almen intensity. The thorough analysis will serve as a design tool and drive our shot peening process parameters," he concluded.

Acknowledgement

Metal Improvement Company, a division of Curtiss-Wright Corporation, was critical in the development and execution of this project.

For More Information

Companies interested in utilizing the research capabilities of Purdue Materials Engineering should contact Dr. David Bahr at dfbahr@purdue.edu or (765) 494-4100.

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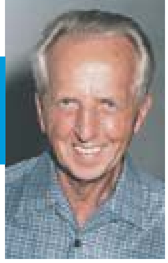

ACADEMIC STUDY

Dr. David Kirk | Coventry University

Coverage Variability

INTRODUCTION

Coverage is one of the most important parameters in shot peening. It is specified in J2277 to be the "Percentage of a surface that has been impacted at least once by the peening media." It is, however, impossible to avoid coverage variability. Measured coverage values vary because we cannot apply peening uniformly and also because the measurement technique itself is a variable. The topic is so important that it merits different approaches. Coverage variability was the subject of a previous article (TSP, Summer, 2009) using a largely mathematical approach. This article is much more descriptive, avoiding mathematical derivations.

Fig.1 is a schematic representation of the simplest type of peening. It assumes that a conical jet stream is moved steadily and linearly across a flat plate sample (colored green). As it passes across the sample, dents are created (colored gray). The result is that we have a pattern of dents with maximum coverage occurring along the centerline and zero coverage occurring at both edges. This represents the most extreme type of coverage variation. The maximum coverage level on the centerline will depend on several factors including shot flow, shot size, shot velocity, traverse rate and sample hardness.

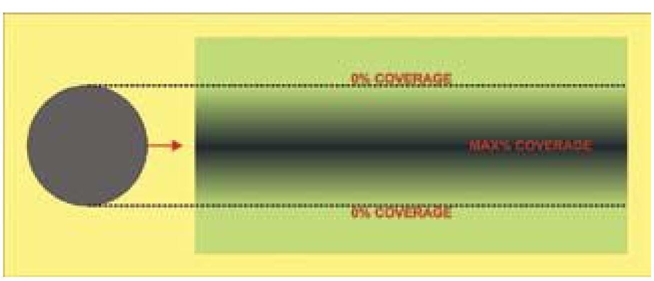

Fig.1. Extreme coverage variation induced by a single pass across a flat plate specimen.

This article concentrates on explaining the reasons for unavoidable coverage variation and suggesting methods for minimizing its effect. A substantial section has been included that compares the problems associated with paint spray and shot peening coverage.

LINEAR SINGLE-PASS COVERAGE GENERATION ON FLAT SURFACES

The transverse variation of coverage indicated in fig.1 is of considerable importance in shot peening operations. The following assessment starts by using an analogy. Imagine a five-soldier squad being ordered to march across three strips of soft ground, A, B and C. The three-soldier column marching across the central strip, B, would obviously leave three sets of boot prints as compared to the single sets for strips A and C. Boot-print coverage is three times as great for the central strip.

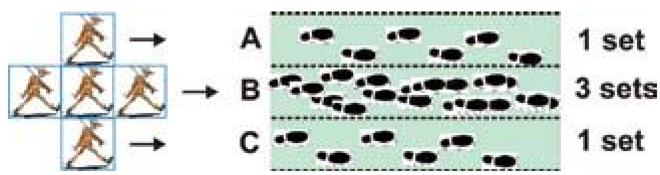

Fig.2. Five-soldier squad leaving boot prints on soft ground.

A five-soldier squad is not a good representation of a circular peening area. Fig.3 extends the analogy using 346 soldiers arranged in 20 columns. This arrangement is much nearer to that of a circle but makes mental picturing in terms of boot-print coverage more difficult. The implied coverage variation (top to bottom in fig.3) is also not very accurate. For the top and bottom columns there would be six sets of boot prints as compared with twenty for the six central columns.

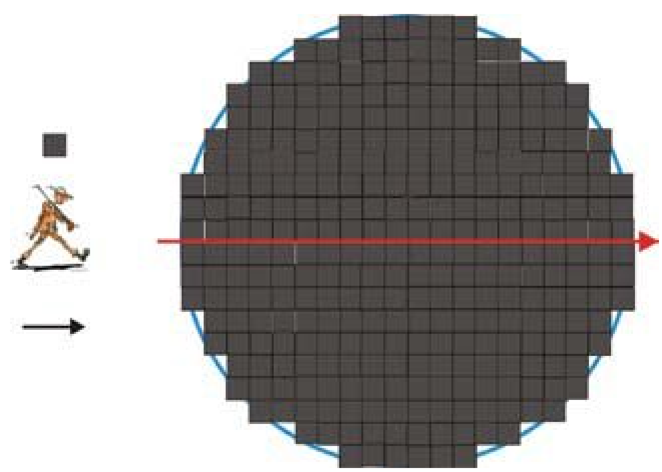

Fig.3. 346-soldier platoon representation of coverage generation.

An actual shot stream generates a vast number of indents as it passes over a component. Consider first a circular area within which peening indents are being uniformly generated. As such an area passes over a flat surface the relative coverage

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Presentation of Papers
The organizing committee aims at offering at least 75 paper presentations with a question and answer period.

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The conference papers will be compiled into a Conference Proceedings booklet.

Best Student Presentation Award
Students (undergraduate, graduate and post-doctoral fellows) are encouraged to present their works at the conference. A jury will evaluate oral presentations made by students and will distribute three "best presentation awards" during the banquet.

Exhibition
An exhibition of commercial products will be held during the conference.

Site Visits to Local Aerospace Companies
Montréal is an aerospace hub and local aerospace companies have agreed to offer site visits as part of the conference. At this time, Bell Helicopter Textron, Bombardier Aerospace, Pratt and Whitney Canada and L3-Communications MAS have agreed to open their doors to conference attendees. Site visits will be included in the registration fee.

Banquet
The conference banquet will feature a three-hour cruise in a Bateau-Mouche on the St. Lawrence river. The river cruise in an open excursion boat includes a gourmet dinner and jazz concert.

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rate variation is as represented in fig.4. This type of variation has a semi-circular shape.

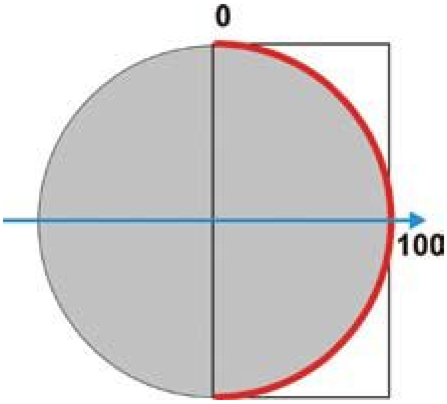

Fig.4. Variation of coverage for a uniform shot stream.

Commonly, however, the shot flow rate is not uniform—it is greater towards the center of the shot stream than it is on the outside limit. This gives an even greater variability than does a uniform shot stream.

Fig.5 indicates the variation of coverage for a non-uniform shot stream. The type of variation, shown in red, resembles a parabola rather than a semi-circle.

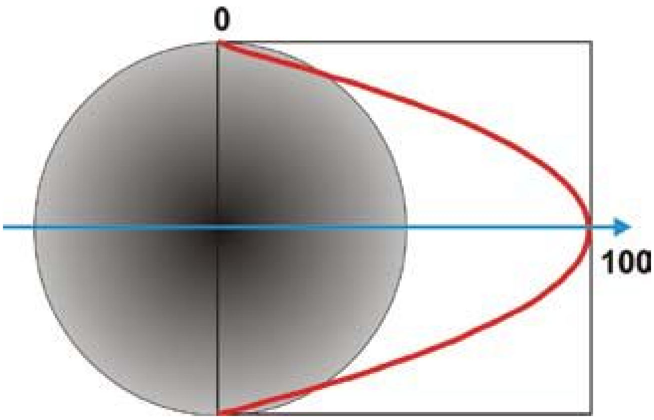

Fig.5. Variation of coverage for a non-uniform shot stream.

Figs.4 and 5 represent model situations where the edges of the shot streams are sharply defined. Real shot streams are not sharply defined—there is a "blurring" of the edges.

The variability of coverage is made worse if the shot stream is angled relative to the surface being peened. Fig.6 is a diagrammatic representation of this effect. When the stream is angled, the stream/surface area becomes elliptical. The rate of coverage is much greater at A than it is at B. A simple analogy is to shine a torch at an angle to a flat surface and observe the variation in brightness.

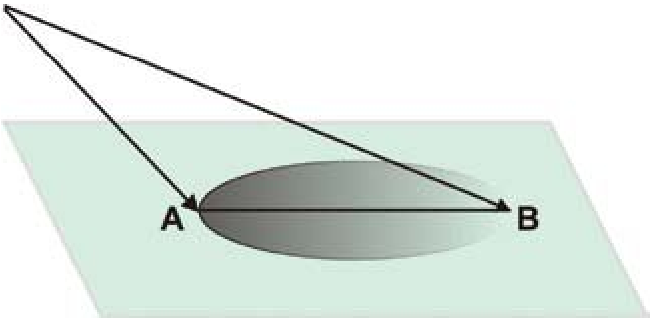

Fig.6. Effect of projected angle on coverage.

LINEAR MULTI-PASS COVERAGE GENERATION ON FLAT SURFACES

Fig.7 is a representation of the variation in coverage caused by overlapping of parallel linear passes. This "stripe effect" can only be observed directly on peened components if low coverage values have been applied. That is because we cannot normally distinguish between a "high degree of coverage" and a "very high degree of coverage." An established alternative for detecting coverage variation is to use a commercial fluorescent tracer.

Fig.7. "Stripe" effect of coverage induced by overlapping linear passes.

Quantitative analysis of coverage variation by overlapping passes has been described in a previous article (TSP, Summer, 2009). Figs. 8 and 9 are schematic depictions of zero and 50% overlap of linear passes.

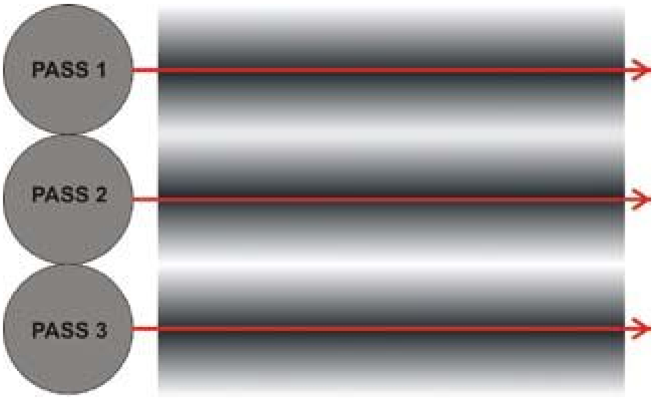

Fig.8. Coverage variation for zero overlapping linear passes.

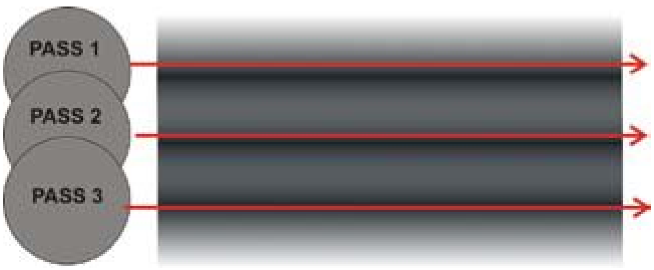

Fig.9. Coverage variation for 50% overlapping of linear passes.

COVERAGE VARIABILITY ILLUSTRATED USING PAINT SPRAY COMPARISON

An interesting parallel can be drawn between coverage variation in spray painting and in peening. Commercial spray painting is a multi-billion dollar industry that has therefore attracted huge research and development attention, especially for the automotive industry. At low paint coverages the variability is obvious. Current optimization techniques are based on employing ERBA (Electrostatic Rotating Bell Atomization). Paint enters a bell that is rotated at thousands of rpm in order to atomize it into tiny particles that are then ionized before being attracted to the component by potential differences of thousands of volts. The primary objective with spray painting is to achieve coverage within a required thickness range. A much simpler technique employs aerosol cans of paint.

Experiments using a simple aerosol paint spray can indicate procedures that are useful for highlighting shot peening coverage variations. These involved using a can of auto primer paint sprayed onto sheets of white A4 80 g paper from a distance of about 300 mm.

Fig.10 shows a very close similarity to the non-uniformity of shot stream coverage indicated in fig.5.

Fig.11 is a photograph of the author's attempt to simulate the situations shown in figs.8 and 9. This involved employing horizontal "strokes." The observed effect simulates a peening situation intermediate between those of figs. 8 and 9.

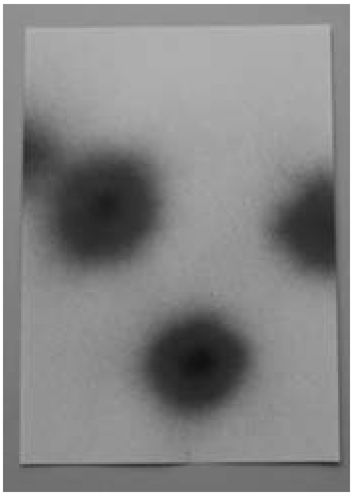

Fig.10. Static spray patterns showing coverage variation.

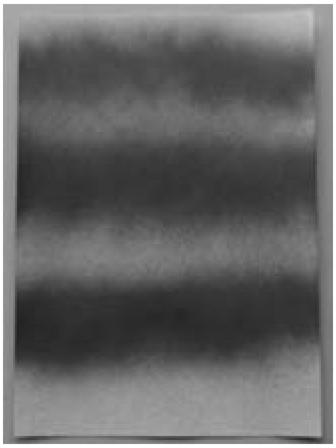

Fig.11. Paint spray patterns showing 'stripe' coverage variation.

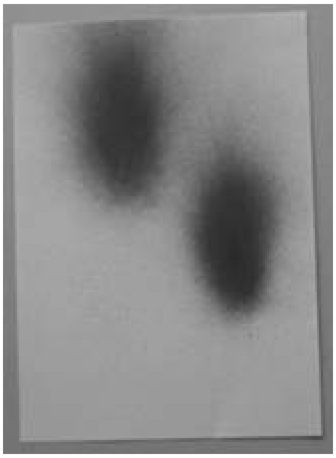

Fig.12. Angled spray paint patterns.

Fig.12 emulates the effects of angling a peening stream relative to a component's surface. The predicted shape and


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coverage variation are very similar to those given in fig.6. Finally, fig.13 illustrates the author's attempt to achieve uniform coverage by waving the spray over the surface. Uniformity was not achieved!

Fig.13. Random paint spray.

DETECTABILITY AND EFFECTS OF COVERAGE VARIABILITY

It is generally recognized that 98% is the maximum level of coverage that can be measured with any degree of accuracy. Variability of coverage levels below 98% can therefore be detected, but not for higher levels. It has also been suggested that 98% should be regarded as "Full Coverage."

The minimum level of coverage on a peened component that displays detectable variation is of critical importance. Assume, for example, that coverage with a single pass varies as shown in fig.14. The problem now is to estimate how many further passes would be needed to satisfy a client's specified coverage level. For the example shown, the minimum observed coverage level is 60%.

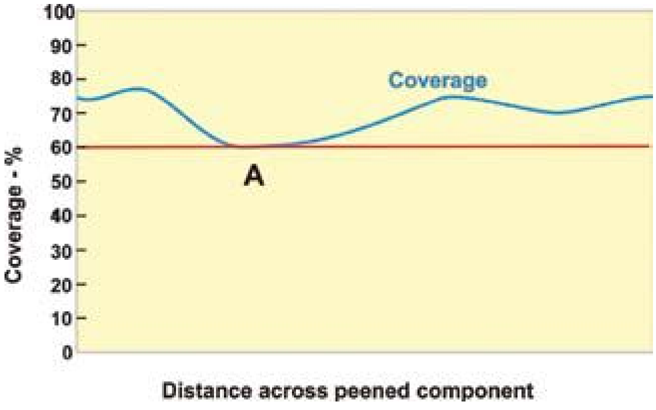

Fig.14. Representation of possible coverage variation across a peened component.

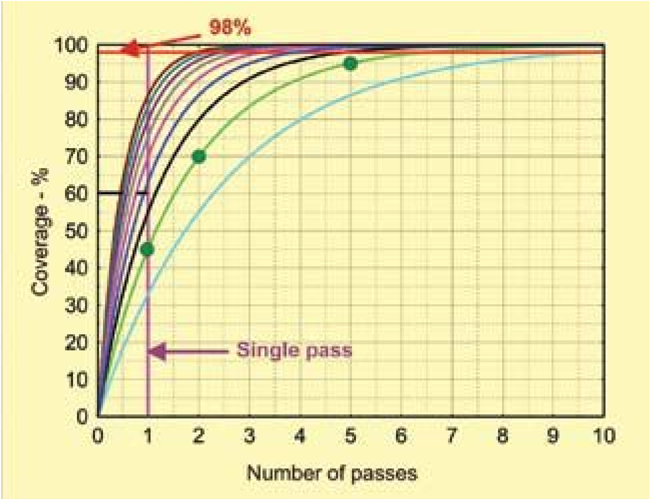

Fig.15. Prediction curves for estimating number of passes to achieve required coverage level.

It is neither practicable nor necessary to make enough quantitative measurements to replicate the complete curve of fig.14. In practice, peeners scan the surface using simple optical magnification. Experienced peeners can readily detect the "low point" region equivalent to A. Just one coverage measurement at, or near to, A is sufficient to estimate the required number of repeat passes. An experienced peener might say that "Four or five repeat passes will give 'full coverage' (98%) if one pass imposed a minimum of 60%." The basis of this judgement is illustrated by the coverage prediction curves shown in fig.15. The variation of coverage with amount of peening is well-established, having the exponential shape of the curves shown. For fig.15 several coverage/passes curves have been included, reflecting different peening rates.

Use of the prediction curves can be illustrated by the following example: three dots are shown on the green curve in fig.15. The first dot corresponds to coverage of 45% having been imposed by one pass. The second dot corresponds to coverage of 70% being predicted after a second pass. The third dot corresponds to coverage of 95% being achieved if three passes are applied. For the example of 60% imposed by one pass prediction is not quite as easy, because it doesn't happen to correspond exactly with any particular curve—we must interpolate between nearest curves.

Prediction curves are the graphical equivalent of mathematical prediction programs. One such prediction program was described in TSP Summer 2012, where entering the measured value of coverage for one pass yielded predictions of coverage for multiple passes. Copies of that program are available from Electronics Inc. at www.shotpeener.com.

MINIMIZATION OF COVERAGE VARIABILITY

Coverage variability can, of course, be rendered undetectable.

This occurs, for example, if "300%" coverage has been specified. This requires that peening is applied for three times as long as is needed to reach "full coverage". With that amount of peening it would not be possible to detect any variation in coverage.

"Uniform coverage" of less than 98% can be defined as coverage that does not exhibit detectable variation. Experienced industrial shot peeners have far more knowledge than has the author on how to approach such uniformity for complex component shapes. The basic principles are, however, common to those required for uniform spray painting.

One novel technique that could prove useful in improving uniformity is to incorporate dithering. "Dither" comes from the Middle English verb "didderen," meaning "to tremble." Small vibrating motors were built into the mechanical computers used in World War II bombers and the induced vibration was called "dither." Small vibrating motors could be attached to a peening nozzle in order to induce two-dimensional dithering. Experiments with an aerosol paint spray and physical hand trembling revealed that a much more uniform coverage could be achieved than when using a firm hand.

Another suggestion that could be used for large, flat, components is to employ a highly rectangular nozzle. This concept springs from the fact that high-pressure patio cleaners can have either circular or rectangular water jet streams. Personal experience indicates that the highly rectangular jet induces a much more uniform cleaning action than does the circular water jet.

DISCUSSION

The main objective for this article was to try and raise awareness of coverage variability. This important topic has produced very little attention in published work. Simple geometrical factors show some coverage variability is unavoidable. Steps should therefore be taken to minimize its extent.

There are very few occasions when coverage variation can be encouraged. One could be for concave fillets where maximum coverage may be required at the center of the fillet if this is the most highly stressed region.

Non-uniform peening can have an effect on measured peening intensity values. Almen strip deflection increases with the amount of peening (and hence the coverage) that has been applied. The more a moving shot stream is offset from the centerline of the strip the lower will be the average resulting coverage. This will, however, only be significant for small-diameter shot streams.

The paint spray analogy that has been included can be an economical way of making newcomers to shot peening aware of coverage variability.

The suggestions made of ways of reducing coverage variability are speculative. Progress requires, however, that new techniques evolve.

The Parts Are the Wrong Temperature!

I HAVE MANY STORIES and one of my favorites is a fascinating lesson in listening. Several years ago, while touring a customer's facility, I kept overhearing telephone conversations that seemed to be related. One of my customer's customers was upset because the belt for their bucket elevator had to be replaced for the second time. The machine was supposedly fitted with a high-temperature conveyor belt and suddenly it was going down. The scramble was on to review the sales orders and shipping papers. The paperwork proved that, in fact, a high-temperature bucket conveyor belt was on the machine. A little later I overheard two employees talking about the crazy thing the operator had reported. The machine operator said the parts were not coming out of the machine at the right temperature. That's when I thought "I'm staying around for a while. This is getting really interesting."

My customer's staff quickly figured out the problem and shared their findings with me.

So. What was happening? The machine had been operating for some time very successfully. Then a new media supplier approached the purchasing agent, offering longer life media. Since the company was consuming a large amount of media each month, this sounded promising so the purchasing agent bought the alternate brand. He was going to save the company a lot of money. Dreams of receiving the company "Hero Badge" danced in his mind. His daydream, however, didn't materialize in the real world.

After adding new media into the machine, the maintenance person noticed he had to readjust the belt on the bucket elevator. Not just once, but frequently. He also reported the media hopper seemed to be a lot hotter than usual. The operator then reported to the maintenance person that the parts were not as hot when coming out of the machine. Have you already figured out what was going on?

When regular hardness media was substituted for the original high-hardness media, the shot peening process was changed. The high-hardness media made the proper "dents" in the component. This denting creates friction and heats

the component. Life is good. Substitute regular hardness shot and what happens? This softer media, upon hitting the component, doesn't make the same size dent. In fact, the media, being too soft, changes its shape instead of changing the surface of the component.

Oops. Changing the shape of media causes friction and friction causes heat. So now we know why the media hopper is hotter than usual. Now we can understand why the elevator belt was stressed. But what about the comments from the machine operator? He was correct. The parts were not coming out of the machine at the right temperature. The heat generated from the collision of the new media and component now shifted from the component to the media and the shot-peened components were cooler.

What Did I Learn about Listening?

1. The operator understands his machine, like a mother understands her babies. One of the best resources for troubleshooting a process problem is the machine operator. Listen to what he has to say.

2. You can learn the most useful things while eavesdropping.

The moral of the story: Ask purchasing to request approval before changing media vendors or products. This particular change affected the entire shot peening process and cost the company money due to downtime.

Craig Wallbank | Technical and Training Center Manager | Winoa USA Inc.

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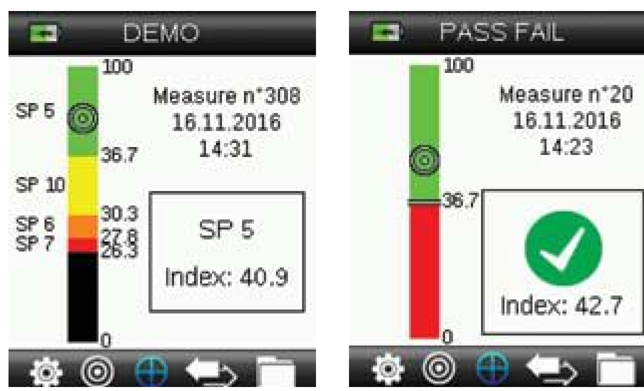
WA Clean is 7.8" x 4.7" (20 cm x 12 cm) in size and weighs only .5 lb (300 g). It can be used with or without a magnetic skirt.

Main Features and Benefits

- Easy-to-use handheld device—7.8 inch x 4.7 inch (20 cm x 12 cm) in size and weighs only 1/2 lb (300 g)
- Quick measurements: Less than two seconds per analysis
- Can be used in total darkness
- Potential to reduce re-blasting and over-blasting
- Magnetic skirt fits on curved surfaces such as pipes and windmills towers (can be purchased without the magnetic skirt when avoidance of the transfer of contamination, soluble salts, or chlorides is necessary)
- Cleanliness measurement or PASS/FAIL working modes
- Easy-to-use interface—downloads to spreadsheets
- PC transfer via USB and no software to install
- Internal storage is able to record up to 20 different references for multiple substrates



The WA Clean has two working modes: Cleanliness measurement (left) or PASS/FAIL (right).

How It Works

An array of color is beamed to the surface of the substrate. As the incident beam hits the surface, certain spectrums of color are absorbed and at the same time reflected off the surface. It is this reflected light that is measured by the "eye" of the device and converted to a unique cleanliness level index from 0 to 100.

Using these index figures, we now tell the machine what it is looking at using standard industry SSPC VIS 1 (ISO 8501-1) reference photographs. For example, if we know the surface to be SP10/NACE2 (Sa2.5) the index value is 65, the minimum value for that degree of cleanliness has been achieved. As we approach SP5 (Sa3), the index will be higher, say 80. Using these two values, the 65 is the minimum value for SP10 (Sa2.5) and the 80 is the maximum value before we transfer the surface to an SP5 (Sa3). As with the visual reference photographs, prior to any measurement, we also need to tell the WA Clean the starting rust grade, A/B/C/D.

The working principle of WA Clean is color spectrometry. The coordinates obtained are converted to a unique cleanliness level index from 0 to 100.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How do we do this? Again, using the industry standard reference photographs, we can consider that the rust grade is X. Taking a selected number of measurements we can find the average surface rust coloration to have an index of 10, for example. For any value below this figure, the device will read “NB” (non-blasted). For a more accurate measurement, the WA Clean indexes can be set to any of the levels of current cleanliness grade: SP7 / SP6 / SP10 / SP5 (Sa1 / Sa2 / Sa2.5 / Sa3). NACE 1/2/3/4 can also be used.

Not only can we use the cleanliness values interface, the device can be used in PASS / FAIL mode. Again, for example, if our minimum specification calls for a surface to be no lower than SP10, we can calibrate the WA Clean to that required index. Should the reading be lower than the given value it will tell us the part is in FAIL. The discretion of the user or quality department can then determine if the substrate is subject to additional blasting.

Field Tested and Approved

The WA Clean was developed through the time and involvement of pilot customers—mainly pipe coating facilities. A large Russian manufacturer and coater of steel pipe for the gas industry using FBE (Fusion Bonded Epoxy) tested the WA Clean and wrote the following in their Quality Control procedures:

- “*Very happy with the tool, find it very useful, especially at night time or when not enough light.*”
- “*All people very happy with it, even the head of the shop wants to help with certification.*”
- “*We managed to solve disagreement with inspectors thanks to WA Clean.*”

For more information on the WA Clean in North America, please contact: Craig Wallbank at Office Phone: (936) 253 5301, Cell phone: (281) 853-5463, Email: craig.wallbank@wabrasives.com or Charlie Gorman at Office Phone: (936) 253-5302, Cell Phone: (915) 526-5180, Email: charlie.gorman@wabrasives.com.

In Europe and Asia, visit wabrasives.com for contact information.

The WA Clean is ideal for pipe coating, rail and steel plate.

The 13th International Conference on Shot Peening

Hotel Delta Montreal
475, President-Kennedy Avenue
Montreal, H3a 1j7 Canada
September 18-21, 2017

Aims and Scope

Prof. Martin Lévesque
Conference Chairperson

The purpose of this conference is to foster exchanges between academic and industrial scientists on processes inducing beneficial residual stresses, as well as their effects, with an emphasis on traditional shot peening. While this is not an exhaustive list, processes like deep rolling, laser peening, ultrasonic peening, cavitation peening, flapper peening and needle peening fit within the conference’s scope. In addition, fundamental or applied aspects, modeling, experimental methods, fatigue life, forming and industrial applications will be addressed.

Keynote Speakers

- Dr. Nihad Ben Salah, Safran Research Center
- Professor Yukui Gao, Tongji University
- Professor Michael Hill, University of California
- Mario Guagliano, Politecnico di Milano

Presentations

The organizing committee anticipates at least 75 high quality talks (18 minutes + 7 minutes question and answer period). Poster sessions might also be arranged based on the number of proposal and the available time slots.

Proceedings

The conference papers will be compiled into a proceedings booklet.

Student Presentation Awards

Students (undergraduate, graduate and post-doctoral fellows) are encouraged to present their works at the conference. A jury will evaluate oral presentations made by students and will distribute three “best presentation awards” during the banquet.

Exhibition

An exhibition of commercial products related to the conference topics will held parallel to the conference.

Registration

Early registration begins May 30, 2017.

Additional Information

Website: www.polymtl.ca/icsp13/en
Conference Chairman: Professor Martin Lévesque at martin.levesque@polymtl.ca


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Is This the Largest 3D Metal Piece Ever Made?

RESEARCHERS AT CRANFIELD UNIVERSITY have unveiled what they believe is the biggest metal 3D part ever made in one piece, using Cranfield's Wire + Arc Additive Manufacture (WAAM) process.

The six-metre long, 300-kg, double-sided spar is made from aerospace-grade aluminium on Cranfield's new 10-metre metal printer. Cranfield's researchers are already upgrading it to make it suitable for production of titanium parts with the addition of a local shielding device which the University has also developed.

The 3D printing, also known as additive manufacture (AM), enables the production of metal parts at significantly reduced time and cost when compared to existing methods. Virtually any shape can be created and it enables an increase in design freedom by using the process of adding successive layers of material in different shapes. Traditional machining techniques mostly rely on the removal of material through cutting or drilling, thereby creating more wastage and at higher cost.

WAAM is the most suitable candidate AM process for the manufacture of large structural components, especially for the aerospace sector, but also for the oil and gas, automotive, marine and energy industries.

Professor Stewart Williams, Head of Cranfield's Additive Manufacture programme, said: "Hundreds of millions of pounds are spent on medium to large-scale components by the aerospace industry each year. There is great potential for significant cost savings in terms of waste and production efficiency if we can transform the way these parts are manufactured."

He continued, "This demonstration clearly shows the potential of the WAAM process with this newly-acquired machine for changing future manufacturing processes."

The huge spar was designed by Cranfield MSc students to test the capability of the new WAAM machine and to assess the challenges of building a structure of such size with all the necessary steps in the manufacture of real aerospace components of similar dimensions. The team estimate that WAAM can enable substantial cost savings, as much as 70% compared to the traditional machine-from-solid approach, as well as large lead time reduction—from well over a year to just a few weeks.

The University leads the WAAMMat consortium, which comprises 20 industry partners and 13 further universities, targeting the maturation and commercial exploitation of the WAAM process. Cranfield's team comprises 30 people and a portfolio of 70 projects.

Recent research has proved the possibility of achieving even better mechanical properties compared to the equivalent wrought alloys, and the team is supporting the qualification programmes of large aerospace original equipment manufacturers (OEMs) to enable a more sustainable future for aviation.


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Shouwen YU | President of International Congress on Fracture | www.icf14.org

14th International Conference on Fracture

Rhodes, Greece • June 18-23, 2017

THE 14TH INTERNATIONAL CONFERENCE ON FRACTURE (ICF14) will be held on the island of Rhodes, Greece, June, 18-23, 2017. ICF14 is organized by Chair Professor Dr. Emmanuel Gdoutos and a working team with the International Congress on Fracture (ICF). ICF14 will be a forum of university, industry and government interaction and exchange of ideas in an area of scientific and technological importance.

ICF sends the very warmest welcome to our global community of scientists, technologists, engineers and others working in the very diverse and wide-ranging field of fracture. ICF was founded in 1969 at ICF2 in Brighton, England, by Founder President Professor Takeo Yokobori with origins at ICF1 in Sendai, Japan in 1965.

The International Congress on Fracture (ICF) is today the premier international body for the promotion of industrial, experimental and theoretical research, education and worldwide cooperation among scientists and engineers concerned with the mechanics and mechanisms of fracture, fatigue and safer design of materials, components, structures, and systems. The objectives of the Congress are:

- foster research in the mechanics and phenomena of fracture, fatigue, and strength of materials for development of materials which are more failure resistant than the conventional materials
- develop design and assessment methods of components, structures and systems with structural integrity
- promote international co-operation among scientists and engineers in the field
- integrate the many disciplines involved in such research and to provide means whereby results of such efforts may be publicly communicated.

Fracture, fatigue and the integrity of materials and structures are of critical significance in the development of civilization, and lay the foundation for the improvements in different arenas of science and technology. We have made much progress, including standard methods that have been established for characterizing fracture properties of materials, fracture mechanics-based reliability assessments of structural integrity have been embedded into industrial design and defects assessments in practice. This has spurred activity in structural health monitoring and materials development.

While these major accomplishments have improved the reliability of our infrastructure in power-generation, transportation, engineering systems, mining, earthquake engineering, etc., researchers in the field are now tackling many new problems from bio-medicine to geophysics, from nano/atomic to macro scales, from physical to holistic and system modeling, from basic science to applied engineering.

The International Congress on Fracture devotes itself to promoting communication and cooperation among the researchers in fracture all around the world and the quadrennial International Conferences on Fracture play a significant role. The ICF14 team has endeavored for years to make this conference a successful continuation of the honored tradition and, at the same time, to create a dynamic and innovative conference which stretches the boundaries of the exciting disciplines for the new era.

We can see that ICF14 covers almost all active research fields in the fracture fields and aims at probing into the role of fracture in the most advanced academic developments. We appreciate the endeavor of the ICF14 in providing us a wonderful platform for exchange and collaboration, and I am sure that the conference will offer all delegates a wealth of information and many opportunities for discussions.

In 776 B.C., Greece initiated the Olympic Games. We will meet on the historic island in Greece in June, 2017. Like the slogan of 2008 Olympic Game said, “One World, One Dream!” In today’s fracture community, we shall try our best to realize a brilliant dream. Let us continue the quest for new heights in this fascinating and diverse field. Let us embrace the 14th ICF in Rhodes, Greece with new research results. Seeing you at the beautiful and historic island of Rhodes in June 2017.