

The Shot Peener

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Manufacturing for Performance Pursuing the motor sports industry

Plus

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- **Audits and Artisans** ▪ **Gear Peening**



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The Shot Peener



4 Motor sports manufacturers look for ways to improve vehicle performance, speed and safety.



6 Medical researchers are studying advanced surface treatments for orthopedic and restorative dentistry implants.



12 Shot peening engine components makes vehicles more fuel-efficient.

4 Manufacturing for Performance

Shot peening takes its place at the Society of Manufacturing Engineers motor sports conference and exhibit.

6 Hydroxyapatite Waterjet Treatment of Implants

Medical researchers from the University of Maryland Baltimore County are exploring the effects of abrasive waterjet peening with bioactive particles.

12 Air blasting and shot peening drive performance and fuel efficiency

Clemco has solutions for race car teams looking for better vehicle performance.

14 Of Audits and Artisans

According to an engineer that has developed and conducted shot peening artisan training and certification programs for the military and private industry, proper shot peening begins and ends with the people who perform the work.

18 Gear Peening: The Intense Story

Gear manufacturers get an important lesson in gear peening: Gear peening is a repeatable and controllable process.

24 Saturation Curve Analysis and Quality Control

A paper from our shot peening academic, Dr. David Kirk.

32 Recycled glass proves a hit with U.S. Army

Glass grit is created by crushing, cleaning, processing and grading recycled glass to produce a high quality blast media. It was the ideal solution to strip and clean U.S. military support equipment.

38 The Devil and the Surfaces

A brief look at the history of sandblasting and its place in surface finishing.

42 The Parting Shot

The Shot Peener (ISSN 1069-2010), in print since 1986, is a quarterly publication from Electronics Incorporated with a circulation of over 4500 readers worldwide. It is dedicated to raising the awareness and appreciation for the shot peening and abrasive blast cleaning industries.

Contributions to The Shot Peener are always welcome including the announcements of seminars, application notes, joint efforts, and press releases on new products and services. However, while it is our goal to include all newsworthy information in The Shot Peener, we are able to use these items only as space allows and we cannot guarantee their placement in the newsletter. Inclusion of articles in The Shot Peener does not indicate that The Shot Peener management endorses, recommends, or disapproves of the use of any particular commercial products or process, or that The Shot Peener endorses or concurs with the views expressed in articles contributed by our readers.

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Manufacturing for Performance

Manufacturing for Performance - what a powerful statement! It's the name the Society of Manufacturing Engineers (SME) has given to an annual Conference and Exhibit in Indianapolis. This event, focused on the motor sports industry, is held in January in the U.S.'s hub for racing activity. According to SME, their Indianapolis event brings high performance technologies and applications to designers and builders of motor sports vehicles and components. These manufacturing operations, which range from one-man machine shops to large race teams, are constantly looking for ways to improve vehicle performance, speed and safety.

Attendees will learn about state-of-the-art technologies that will improve their operations, including Rapid Manufacturing, Composites, Fabricating, High Speed Machining, Prototyping, Finishing & Coating, Shot Peening and many more.

The Shot Peener magazine had a booth at the first Manufacturing for Performance in January, 2006. Our staff was impressed with SME's organization and promotion of the event, its tremendous potential, and most of all, the concept of "Manufacturing for Performance". We met attendees and exhibitors from the race car industry, signed them up for subscriptions to *The Shot Peener*, and handed out copies of the magazine.

As Daryll McKinley points out in his article on page 14, "Audits and Artisans", shot peening has an identity crisis. Not within the industry; OEMs, job shops and suppliers are very secure in the knowledge that our surface-finishing technology advances manufacturing in aerospace, automotive, medical and energy. But outside of our world, if people have heard of shot peening at all, it's viewed as a primitive process or confused with blast cleaning. Our staff attends shows, like the SME Manufacturing for Performance, to be advocates for the shot peening process.

How much opportunity is in the motor sports industry for shot peening? The facts and figures from a recent newspaper article by the Associated Press on specialized degree programs in racing are enough to get anyone's motor rewiring.¹ Consider this:

Contribution to the economy

The motor sports industry, which employs more than 24,000 workers in North Carolina, has a \$5 billion economic impact on that state in 2003. Indiana has more than 1,000 companies in its motor sports sector. The Indiana Economic Development Corp. even has a director of motor sports development.

Motor sports programs in colleges and universities are growing

Dozens of colleges and universities are responding to the racing industry's growing popularity by creating motor sports programs designed to give students degrees in mechanics, engineering and management.

SME's support of the motor sports industry through linkages between manufacturing technologies such as design, advanced material usage, equipment and process knowledge will propel this industry and its people to new heights. We are pleased to have shot peening represented at Manufacturing for Performance as a surface treatment with tremendous benefits to design engineers.

—Rodney Grover
SME Motorsports Development

International Appeal

The first motor sports education programs began in the heart of NASCAR country, springing up in the Carolinas in the 1990s. Europe has a long tradition of motor sports education, in part due to the popularity of Formula One racing. Now, academic motor sports programs are cropping up in China, Malaysia and Singapore.

Motor sports school programs are unique

Many programs lack textbooks and instead rely on guest lectures and hands-on experience. Classes focus on sponsorships, management and marketing, as well as engineering and mechanics.

If your business has the proximity or resources to service the motor sports industry, are you getting your share of the business? Are your marketing materials education- and application-driven or just a recap of the technical benefits of your product? Is the identity of your company too closely linked to an old process or to a proven, controllable technology? (We know that shot peening will improve vehicle performance, speed and safety but we can't assume those outside our industry understand the benefits of a controlled shot peening process.) Teaching engineering students about shot peening is an exciting prospect. Can you offer your products for hands-on labs or teaching expertise to a college or university with a racing program? If you are already servicing the racing industry, think about submitting an article to a racing magazine. Believe us, we know that this isn't as easy as it sounds but the payoff can be huge. Kumar Balan, Product Engineer with Wheelabrator Group, has done a great job promoting gear peening with an educational article that was published in *Gear Product News*. (See the article on page 18 of this issue.)

SME believes product engineers are looking for high performance manufacturing technologies in motor sports and we believe it, too. We encourage you to seek avenues to get your products and services in front of motor sports designers and builders. ●



Manufacturing for Performance

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¹ Facts and figures source: South Bend Tribune, May 27, 2006.

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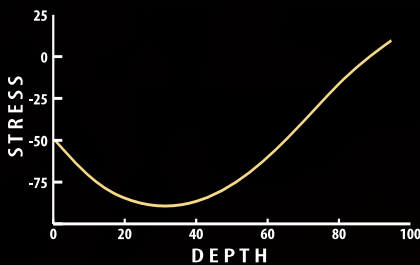


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Hydroxyapatite Waterjet Treatment of Implants

by A.E. Alade, W. Weber, B. Sadasivam, D. Arola (Department of Mechanical Engineering University of Maryland Baltimore County), P. Milidantri (Everest Metals)

Dr. Dwayne Arola, an Associate Professor in the Department of Mechanical Engineering at the University of Maryland Baltimore County, oversees the University's Advanced Manufacturing Lab.

"We are pleased to share this research with the readers of **The Shot Peener**. This project is one component of our research program that focuses on problems at the intersection of solid mechanics, materials and manufacturing. We address the effects from manufacturing processes on the mechanical properties and structural integrity of conventional, advanced engineering and biological materials. Part of the research activities within the Laboratory for Advanced Manufacturing Processes (LAMP) are focused on surface treatments, and their contribution to short- and long-term component performance, health, and safety issues. The Hydroxyapatite Waterjet Treatment of Implants study is part of our most recent efforts in the fields of orthopedics and restorative dentistry that have focused on the influence of existing treatment modalities on the mechanical behavior of implantable materials and their ability to promote life-long health. The laboratory is well equipped to investigate fundamental issues related to machining and material removal, and to solve research and development problems of industrial relevance. I welcome any comments or questions from the readers of your magazine."

—Dr. Dwayne Arola
darola@umbc.edu



Dr. Arola's Active Research:

- The Role of Fatigue Crack Growth in Dentin on Dental Restoration Failures, sponsored by the Whitaker Foundation
- Development of Apatite Jet Treatments for Human Enamel: A New Tool for General Dentistry, sponsored by the Technology Development Corporation (TEDCO) of Maryland
- CAREER: Aging, Tooth Fracture and the Success of Restorative Dentistry, sponsored by the National Science Foundation
- Research Experiences for Undergraduates (REU) Supplement, sponsored by National Science Foundation
- Refinement and Standardization of Test Methods for Characterization of Ceramics, sponsored by the National Institute of Standards and Technology

INTRODUCTION

Hydroxyapatite (HA) coatings are applied to the surface of dental and orthopaedic implants to enhance the development of a surface topography and surface chemistry that supports early osseointegration and mechanical interlock. Deposition of HA coatings is most often achieved via thermal plasma spray, which results in a porous coating of embedded HA particles. While porous coatings are considered essential for stable primary fixation, the fatigue strength of these coated devices is often less than that of the metal in wrought form [1]. Additional complications arise due to delamination and fracture of the coating from the substrate. The reduction in fatigue strength is attributed to stress concentrations posed by the porous surface topography and through microstructural changes that result from the deposition process. Abrasive Waterjet Peening (AWJ) is a newly developed method of surface treatment that has been proposed for orthopedic applications [2]. Studies on AWJ peening of metals have shown that the process is capable of introducing a surface texture that supports mechanical interlock, results in compressive residual stress and that particles can be impregnated within a substrate to provide the desired surface chemistry [3-5]. While promising, treatments had not been performed using HA particles. Based on the difference in hardness of HA with respect to other more common mineral and ceramic abrasives, the ability to impart residual stresses and surface characteristics favorable to orthopedic applications has remained unknown. Thus a small exploratory study was performed to confirm that the waterjet treatment with HA particles is feasible. The primary objectives of the investigation were to confirm that HA particles can be introduced within the treated surfaces and that an increase in fatigue strength can be achieved.

MATERIALS AND METHODS

Commercially pure Titanium (cpTi) and a Titanium alloy (Ti6Al4V) were selected for the study based on their use in dental and orthopedic implants. The cpTi has a yield and ultimate tensile strength of 590 MPa and 660 MPa, respectively, while the Ti6Al4V has a yield and ultimate tensile strength of 1114 MPa and 1220 MPa, respectively. Each of the metals was obtained in wrought form as sheet (1.52 mm thickness) and circular rod (12.7 mm diameter). Rectangular specimens were sectioned from the sheet of both materials with dimensions of 18 mm x 127 mm. Fatigue specimens were prepared from the round stock of Ti6Al4V according to the standard RR Moore configuration with a 12.7 mm grip section and 6.35 mm gage section.

The surface treatments of all specimens were conducted using an OMAX Model 2652 abrasive waterjet. The machine is capable of discharging a mixture of water and abrasives at pressures within the range of 150-300 MPa. The nozzle assembly consisted of a 0.36 mm diameter sapphire orifice and a tungsten carbide mixing tube of 0.9 mm internal diameter and 89 mm length. A schematic of the peening process is shown in Figure 1 on page 8.

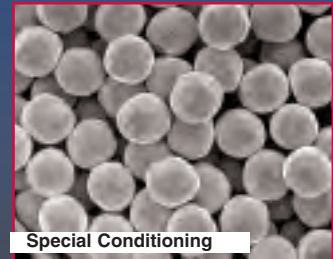
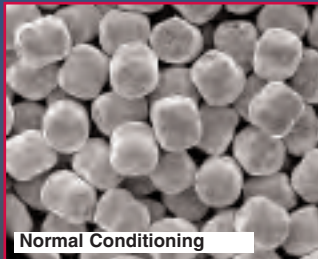
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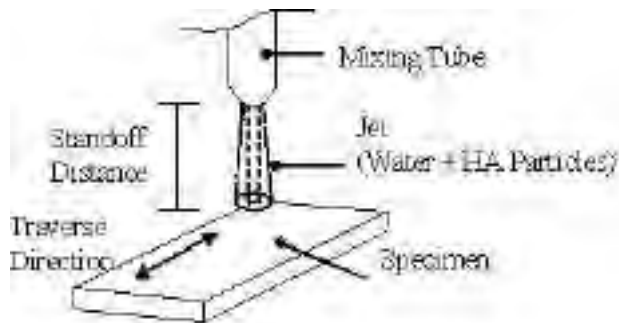


Figure 1 Process parameters for treatment

Surface treatments in the present study were conducted according to results of previous investigations on the treatment of Ti6Al4V and AISI 304 with either garnet or aluminum oxide particles [2, 4-6]. To maximize the HA concentration and magnitude of compressive residual stress the treatment pressure, standoff distance, particle flow rate and angle of incidence were held constant at 280 MPa, 220 mm, 0.3 kg/min and 90°, respectively. All treatments in the present study were performed using MCD apatitic abrasive particles (produced by "himed" of Old Bethpage, NY). The traverse speed was selected to achieve treatment intensities ranging from 0.01 to 0.05 sec/mm², which corresponds to surface traverse speeds of 0.5 m/min to 2.54 m/min; intensities of 0.01, 0.015, 0.02, 0.025, 0.03 and 0.05 sec/mm² were used.

Particles embedded within the treated surfaces were identified using a JEOL JSM-5600 scanning electron microscope (SEM). An accelerating voltage of 20 kV and working distance of 20 mm were used for all measurements. The particles were identified according to the surface chemistry, by the presence of calcium (Ca) and phosphorus (P) and the concentration of particles was determined according to a map of the chemistry over the surface area examined, which was achieved using Energy Dispersive X-Ray Analysis (EDXA). For each specimen the concentration of HA particles were quantified at two locations using a magnification of 200X.

The residual stress resulting from AWJ peening was estimated from the curvature imparted to the rectangular specimens, using a simple mechanics of materials approach. Details of the methods of evaluation are described in Reference [2]. The aforementioned approach provides a first-order estimate of the surface residual stress and a useful means for comparing residual stress over the range of treatment parameters. The subsurface residual stress distribution can be determined using the layer removal method [7] and is reserved for future study.

In addition to characterizing properties of the treated surfaces, the influence of HA treatments on the fatigue strength of Ti6Al4V was also studied. The R.R Moore fatigue specimens were treated using conditions that resulted in the maximum compressive residual stress in the rectangular specimens and consisted of a pressure, standoff distance, particle size range and treatment intensity of 280 MPa, 220mm, #40-#60 and 0.03 sec/mm² respectively.

Fatigue testing was conducted at room temperature under fully reversed fatigue ($R = -1$) using a standard R.R. Moore rotating bending machine [8]. The fatigue life distribution of the specimens was modeled according to the methodology followed in Reference [2]. Results of the model were used in estimating the apparent endurance strength of the

metals (at 1E07 cycles) and the contribution of HA treatment to the fatigue strength. Fracture surfaces of the specimens were examined using a Nikon SMZ 800 stereomicroscope and the SEM to identify additional features characterizing the source of failure.

RESULTS AND DISCUSSION

Surface treatment of the cpTi and Ti6Al4V specimens was conducted using identical conditions. In an evaluation of the treated surfaces with the SEM, hydroxyapatite particles were clearly evident. An example of particles in the surface of a specimen is shown in Figure 2(a). The concentration of Calcium and Phosphorus on the surface of the treated specimens was quantified using EDXA. An example grayscale map of the surface chemistry distribution on the surface of a treated specimen is shown in Figure 2(b). The surface area comprised of either Calcium (Ca) or Phosphorus (P) is highlighted in white, whereas the surface area corresponding to either Ti, Al or V are shown in black.

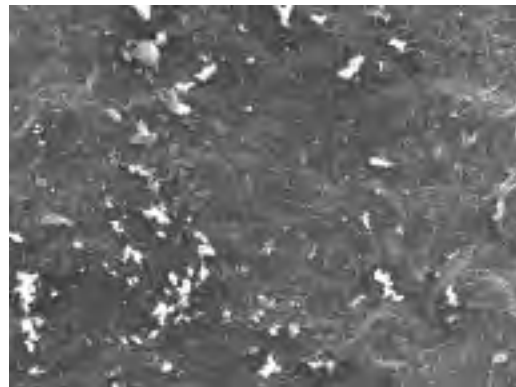


Figure 2a Embedded HA particles on the surface of a treated sample

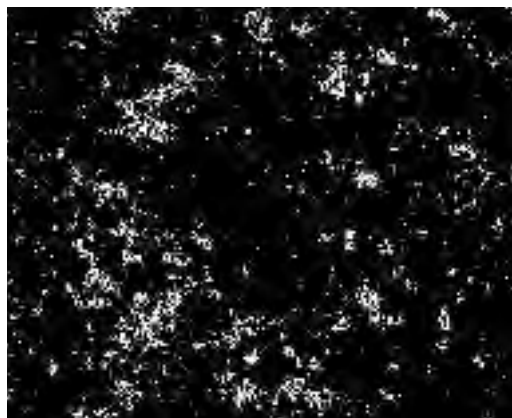



Figure 2b Grayscale map of the surface chemistry distribution (white = HA)

Residual stresses in the specimen were evaluated as a function of the percentage of embedded particles resulting from AWJ peening of Ti6Al4V and CP titanium and shown in Figure 3 on page 10. Despite an increase in average surface roughness (from 1 to nearly 6 μm), there was a marked increase in the fatigue life of Ti6Al4V when treated with HA. On a logarithmic scale, there was a 50 MPa increase in the stress amplitude required for failure in HA treated Ti6Al4V specimens. This fatigue life increase can be seen in Figure 4 (page 10).

CONCLUSIONS

A waterjet laden with hydroxyapatite (HA) particles was utilized in conducting surface treatments of commercially pure

Continued on page 10



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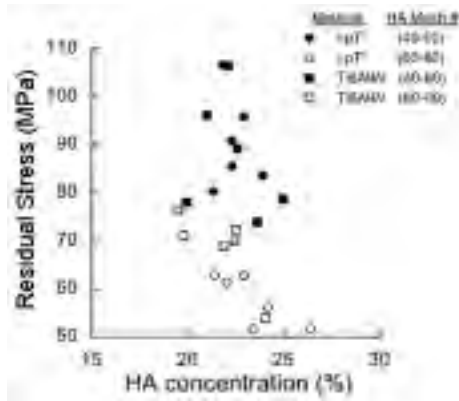


Figure 3 Relationship between the percentage of embedded particles and residual stress resulting from AWJ peening of Ti6Al4V and CP titanium

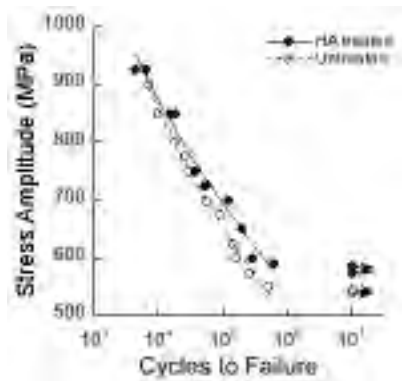


Figure 4 Stress life diagram for treated and untreated Ti6Al4V

titanium (cpTi) and a titanium alloy (Ti6Al4V). The concentration of HA and residual stress resulting from treatment of each metal were evaluated and the increase in fatigue strength of Ti6Al4V specimens subjected to the waterjet treatments was determined. Based on results of the investigation the following conclusions were drawn:

- HA particles were impregnated within the surface of the cpTi and Ti6Al4V targets and the surface concentration of HA ranged from 19 to 25% coverage. There was no apparent influence of the treatment intensity or particle size on the concentration of impregnated HA particles.
- Regardless of the process conditions, the surface treatment resulted in compressive residual stresses. In both the cpTi and Ti6Al4V the stress ranged from 50 to 110 MPa. Treatments conducted with the larger HA particles and treatment intensity resulted in the largest residual stress.
- Surface treatment of the Ti6Al4V with an intensity of 3 s/cm² resulted in a 10% increase in the fatigue strength with respect to the untreated metal. Results of the experimental evaluation suggest that further increase in fatigue strength can be achieved through an increase in the treatment intensity beyond that used in the present study.

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Industry news

New Products ■ New Companies ■ Awards
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Shockform Inc. signs exclusive agreement with Sonats S.A. to market Stressonic® Peening Technology in North America

Montreal, QC. ShockForm Inc. has signed an exclusive agreement with France's Sonats S.A. to do the marketing and sales of their Ultrasonic Peening Technology in North America.

Shockform Inc. will provide North American companies in the Aerospace, Energy, and Transportation sectors with technical and financial data to help them take advantage of the many benefits offered by the Stressonic® peening technology. Shockform Inc.'s president, Sylvain Forgues, stated "We are very pleased to have signed an agreement with Sonats S.A. We feel strongly that the lower peening costs and shorter cycle times offered by the Stressonic® technology will be very attractive to our customers. Our team of highly qualified specialists will work with clients to help them understand the technology and find the applications that will give them a competitive advantage."

Shockform Inc. provides sales and marketing services to small and medium companies with new and innovative technologies in the important field of structural fatigue life management. For further information, contact Sylvain Forgues at (514) 813-2533.

The Shot Peener Exhibits at SME's Manufacturing for Performance Conference

Mishawaka, Indiana. The Shot Peener magazine hosted a booth at the Society of Manufacturing Engineers' (SME) Manufacturing for Performance Conference and Exhibits. The event took place in January, 2006 in Indianapolis, Indiana, the U.S.'s hub for racing activity.

The Shot Peener staff worked as advocates of the shot peening process at the event by promoting shot peening as a way to improve vehicle performance, speed and safety to the designers and builders of motor sports vehicles and components.



Jack Champaigne (left), Editor of *The Shot Peener*, explains the benefits of the shot peening process to Benny Parsons (right), International Motor Sports Hall of Famer and former NASCAR champion. Jim Lorizz, Senior Technical Editor for SME, is in the middle. Mr. Parson delivered the keynote address at the *Manufacturing for Performance Conference*.

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Air blasting and shot peening drive performance and fuel efficiency

by Herb Tobben

Race car teams, car and truck owners alike are interested in performance. And with the high prices we are now paying for fuel, anyone who drives a motor vehicle wants to get the best mileage possible. In the most basic of terms, the internal combustion engine converts fuel into motion. Engines are made up of a number of critical components that work together to power the car. My job is to speak about air blasting and shot peening, and you guessed it...once again, they come to the rescue.

Shot peening, as of course you all know by now, is the cold working of a metal surface through massive bombardment of round particles to the surface. The purpose of shot peening is to put a uniform compressive layer into the surface to relieve the residual stress created during the manufacturing process. As each particle strikes the surface, it produces a round indentation. The edge of each indentation is raised slightly above the surface. The residual compressive layer may vary up to 0.062 inches below the surface.

So, you ask, how does shot peening make engines more fuel-efficient? Shot peening reduces friction, improves oil retention, and by improving fatigue life helps to minimize a vehicle's overall weight. Shot peening helps to improve performance, which in turn helps to conserve energy. Today's engines are seeing fuel-injection pressures of up to 30,000 psi compared with 900 psi a mere two decades ago. The reason for higher pressure is to use smaller amounts of fuel and help the engine to run more cleanly and efficiently. Shot peening the components that have to handle the very high pressures prolongs their service-life. They are otherwise susceptible to early fatigue failure that leads to cracking followed by breakage or complete failure.

The combustion cycle converts fuel into motion beginning with the intake stroke, in which the piston moves downward to allow the engine to take in air. Just a small amount of fuel is needed to mix with the air and when vaporized and compressed becomes energy. The very high injection pressures put repeated enormous stress on the components—the fuel injectors, nozzles, bodies and fuel pumps. Cylinders, pistons, valves and valve springs, the camshafts, crankshafts, and the connecting rods also see a lot of cycle loading.



Racecar engines are beginning to employ titanium valves for increased performance due to their light weight, durability, and heat resistance.

A certain enemy to fuel-efficiency is friction, and some friction loss in engines cannot be avoided and accounts for significant energy expenditure.

Components that contribute to friction loss, which can be shot peened, include the piston, valves and drive train gears. Beyond the benefits associated with shot peening, blasting plays another role in improving fuel economy. Numerous car makers are employing specialty coatings to increase wear resistance or reduce friction. The coatings have properties that reduce friction; they are hard and are being likened to carbide or titanium nitride. Their successful application relies upon proper surface preparation, among them grit blasting.

Over the years, I've seen many, many engine-related applications. Usually, they've involved shot peening or grit blasting. However, a recent project in the lab involved blasting titanium valves with a shot and grit mixture. The purpose of combining shot and grit media was to achieve a shot peened surface to improve fatigue life and at the same time create a surface profile for coating adhesion. For a competitive edge, race car teams are beginning to use titanium valves. While expensive, titanium is lightweight, durable, and

able to withstand high heat. It is commonly used in demanding aerospace applications.

As the racing technologies, component materials, and processes evolve and as race speeds, safety concerns, and costs increase, the applications for peening and blasting change accordingly. The constant remains that the objective of blasting and peening is to prolong life and to meet the needs of industry for quality, efficiency and economy. ●



Herb Tobben, the Sample Processing Manager of the Technical Services Department for Zero Cabinets and Zero Automation at Clemco Industries, creates solutions to customer problems. You may contact Herb at 1-636-239-8172 or htobben@clemcoindustries.com



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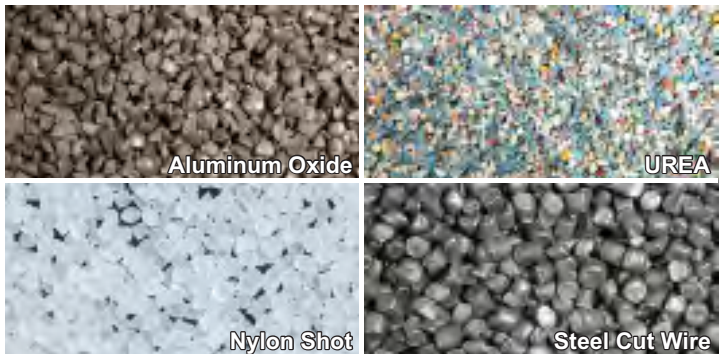
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Of Audits and Artisans

by Daryll McKinley

This past February, I had the opportunity to present a lecture on shot peening audits at the Electronics, Incorporated Asian Workshop in Singapore. It was a wonderful workshop held in a beautiful city and I relish the experience. In Jack Champaigne's Parting Shot column in the previous issue of the Shot Peener, Jack mentioned the Asian Workshop and my participation. Upon showing the column to a friend of mine, the friend asked, "That's cool, but what is shot peening?" This is not an unusual question as I typically hear it from the majority of my acquaintances outside of the shot peening world.

As I began to describe shot peening to him, he interjected with other questions like: "so, shot peening is like sand blasting?", "so, shot peening is a way of cleaning the surface of the part?", "so, are you buying lunch today, Mr. Singapore?" My singular answer to all of his questions was, "no." It's really not very easy to describe the process and benefits of shot peening without getting a bit technical and scribbling on a napkin. But I finally was able to quench his thirst for a simple understanding of shot peening by saying something along the lines of "shot peening is a surface treatment process for metallic components typically used in aerospace or automotive applications that experience fatigue stresses or stress corrosion cracking. Proper shot peening can and will significantly extend the life of parts in these service environments."

I recently took a quick survey and 100% of those questioned had not even heard of shot peening and were certainly not aware of its benefits (I asked my two kids). Along that line, I now have a few questions for you. Does the artisan in your shot peening shop really know what peening is? Does he understand the benefits gained by proper shot peening? Does he understand the necessity of performing proper shot peening? Does he know what is required of him to ensure that his peening process is correct and effective? Lastly, has he received proper training? (By proper training, I mean training with the correct content, good delivery, good reception, and ending with testing to ensure knowledge has been gained).

You see, I believe that the shot peen artisan is the key element in the shot peening process. Certainly the media is an important aspect in peening, as is the peening machine, and the Almen gage, and the Almen fixtures, etc. But really, these are merely the tools used by the artisan to produce the desired peening effect. Proper shot peening begins and ends with the man who performs the work!

So, what gives you the assurance that your artisan is well prepared to perform his important job? Well, you could start by asking him a few questions. Ask him if he feels properly equipped to do his job. Ask him who certified him to be a shot peen artisan. Ask him what type of training he received and where did he receive it. Ask him about his periodic recertification. Ask him the difference between an A, C, and N Almen strip. Ask him if he can calculate 10% of a number. If you get nothing but blank stares or a steady stream of "I don't know", then you have a problem with your shot peening process.

My early days as a shot peening auditor and process monitor at an aircraft rework facility were very enlightening, and commenced the process of my hair turning grey. One day my boss walked into my office and said, "Daryll, I need for you to take over the shot peening processes". Of course, the first thing I did was grab my metallurgy textbooks and looked up

a definition of shot peening and commenced to train myself on the many aspects of the shot peening process.

After gaining a respectful confidence, I walked into the shot peening shops to gage the condition of the process. When I asked the artisans the questions I mentioned above, they either laughed at me or kept very quiet. Apparently, my predecessor had not closely monitored the peening process or the knowledge of the artisans. So, I started at square one and developed an artisan training and certification program. (Well, square one was shutting down the peening shop and taking a lot of heat from the shop supervisors). Back then, third-party training and certification sources were not available, so I developed and administered a curriculum with the following content:

- History of Peening
- How Peening Works
- Peening Benefits
- Peening Applications
- Peening Equipment
- Peening Media
- Almen Strips and Almen Gages
- Almen Fixtures
- Peening Intensity and Saturation
- Intensity Curve Generation and Interpretation
- Coverage and Inspection

The training consisted of several classroom lectures and shop demonstrations. Subsequent to the training, the certification process included written tests as well as practical tests, in which the artisan had to demonstrate his newly-acquired peening prowess in the peening shop. Pass/fail criteria were established and retesting limits were established. The certification process also included levels of certification, such as Level 1, Level 2, etc., which were based on cumulative peening experience and further in-depth testing.

After a period of intense training and testing, all of the shot peen artisans were trained, certified, and able to prove that they were properly performing their tasks. It was a long road, but one that had to be taken. The artisans found new respect for themselves and the work they were performing. They also received pay raises due to their efforts and their certifications.

Shot peening is one of a few metal treatment processes in which the end result cannot be measured or quantified to ensure that what was specified was actually accomplished on the part(s). Certainly the coverage can be inspected, but what of the intensity? If I were auditing a heat treat shop, I could easily check the furnace calibrations and test the hardness of the processed parts. If the measured hardness meets the part's specified hardness, then everyone is happy, especially the design engineer. The design engineer has performed calculations that tell him how strong (i.e., how hard) the part needs to be in order to perform its function without failing prematurely. Well, guess what? He has done the same thing for shot peened parts. He knows that in order to achieve the required life from the part, then the shot peening that he has specified must be done as specified, and without error. He realizes the criticality of shot peening and trusts that the peening shop performs its job properly. He trusts that certified, qualified artisans will be processing the part that he designed; the part that will end up in the user's trusting hands. *Continued on page 16*

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However, there currently is no "hardness" test or any other method of quantitatively determining if the part was peened with the correct shot stream intensity. To achieve high-quality shot peening, a high-quality process must be established and this process must be performed by a certified artisan.

So, now... don't you agree with me that the shot peen artisan is the key element in the peening process? It is the properly trained artisan who knows how to test an Almen strip for flatness prior to use. He also will know how to test the media for proper size, shape and consistency. If the peening equipment shuts down midstream in the peening of a part, he will know the corrective actions to take. It is the properly trained artisan who knows the shot stream intensity that has been established and is being applied to the part. He will create and control the needed documentation to attest that the parts that have been processed in his shop meet the specified design requirements.

If I were to walk into your shot peening shop today, I would first ask to speak to the artisans who perform the work. On my clipboard would be a list of various questions about the peening process. I would anticipate correct answers from your artisan for every one of my questions. You may have a very expensive computer-controlled peening booth, and some very pretty Almen gages. You may have the best available peening media and well-constructed peening fixtures. But it all has to come together when the shot stream hits the part. The peening artisan is the one who brings it all together — that's his job. And it's your job to ensure that he has been properly prepared to do his job.

If you have an in-house artisan training and certification program, then you are steps ahead in having a process that will survive the scrutiny of an auditor. If you don't, then establishing one should be of high priority. Smaller peening shops likely cannot support the time or expense of establishing a formal program for artisan training, certification, and recertification. There are third-party resources that can provide training, certification, pre-audit inspections, etc. for small shops as well as large ones. Regardless of the method you use to certify your artisan(s), the ultimate goal is an accurate, consistent peening process that meets the design requirements on each and every part that gets processed. Your customer is depending on it, and your auditor will be looking for it.

Happy Peening! ●



Daryll McKinley has a Bachelor's degree in mechanical engineering, a Master's degree in materials engineering, and he is a Registered Professional Engineer. During his career, he has developed and conducted shot peen artisan training and certification programs for the U.S. Navy, which were later adopted by private industry. During his employment with the Department of Defense, he conducted shop audits, authored

peening process specifications, and wrote equipment specifications.

Mr. McKinley's background includes mechanical design and testing, hardware failure analysis, aircraft accident investigation, materials processing, and corrosion control.

He has experience in the aerospace, automotive, military, and litigation fields. His past employers include the Department of Defense, General Dynamics, and a forensic consulting firm. Mr. McKinley now works as a consulting engineer performing failure analysis, mechanical design, and shot peening training.

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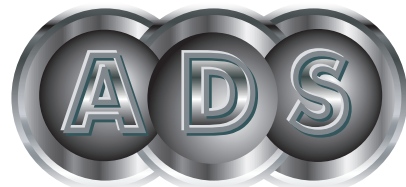
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Gear Peening: The Intense Story

by Kumar Balan



Automotive designers have traditionally relied on the advantages of shot peening of transmission parts to enhance their useful life. Commonly, shot peening machines are found post-heat treat and at the end of a production process for critical parts such as ring and pinion gear sets.

In peening circles, it is common knowledge that indentation of a metal surface by bombarding it with metal projectiles at high speed induces compressive stresses in the layer. With this as the basis of any shot peening application, it is not unusual to find any 'available' shot peening machine being put to active use topeen critical components. However, premature transmission failures and recalls are now prompting gear manufacturers to re-evaluate this seemingly simple process and develop it along the lines of an 'application based' approach for their peening needs.

Mechanism and Effects of Shot Peening

Impingement of metallic media (shot or cut wire) causes plastic deformation on the part surface. This extends the superficial layer creating compressive stresses underneath and providing a balance to the tensile stresses. This residual compressive stress delays the formation of fatigue cracks thereby increasing the useful life of a component.

Continuous impact of peening media on gear surfaces (after heat treatment) also transforms the residual austenite to martensite. This increases the hardness of the base material and induces compressive stresses.

With specific reference to gears, maximum shear stress appears at the root areas and in the transition radius. Increasing loads are experienced in the drive and coast faces. Therefore the focus of peening gears is on:

- Drive face
- Coast face
- Root areas

Finish requirements, namely intensity and coverage vary from one gear set to the other and are dependent on the final application. Whereas coverage is purely a visual check, intensity is a measure of deflection of a representative strip of spring steel (commonly called the Almen Strip).

Intensity Measurements

Part Verification Tools (PVT), such as the one shown here are designed to hold test strips in strategic locations. Test strips in these locations simulate areas of the part where intensity requirements and therefore measurements are critical.

Intensity ranges could be anywhere from 0.015 to 0.030 on the 'A' scale, depending on the application. Coverage requirements could range from 100% to 200%.

The above results can be achieved through a limited choice of peening techniques, each with its own distinct advantages over the other. These are:

- Using centrifugal blast wheels
- Using pressure blast nozzles
- Using hybrid machines (combinations of wheels and nozzles)

Media Propulsion Types

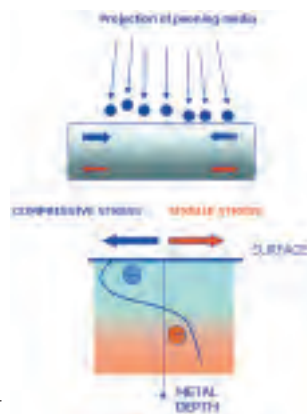
Centrifugal blast wheels certainly offer no comparison to any other media propulsion technique when productivity is in consideration. The media flow generated by a blast wheel covers a larger surface area than a blast nozzle. However, the limitation is usually set by the size of the gears being peened. In cases of smaller gears with narrow root areas, it may be required to employ multiple blast wheels positioned in strategic angles to achieve adequate coverage.

Alternatively, multiple direct pressure blast nozzles, each focusing on specific tooth areas, provide targeted blast coverage.

Both types of media propulsion systems are widely in use, though airblast peening systems are gaining popularity in relatively newer peening systems.

Process Variables

Though not very common, hybrid systems (combination of wheelblast and airblast propulsion systems) offer the benefits of higher productivity





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GEAR PEENING

Continued from page 18

with the wheel and 'touch-up' peening in required areas with in the same machine using a pressure blast nozzle.

Regardless of the peening technique used, achieving the intensity targets in a repeatable and consistent fashion is the primary goal of any operation. It is therefore important to understand the critical variables that alter the final results in a peening process. They are:

Centrifugal Blast Wheel

Blast Wheel

Wheel HP

Wheel Speed

Blast Angle

- Wheel positioning
- Control Cage Movement

Direct Pressure Nozzle

Blast Nozzle

Nozzle Size

Blast Pressure

Blast Angle

- Nozzle Movement
- Multiple Nozzles

Each of the above process variables impacts the final result as follows:

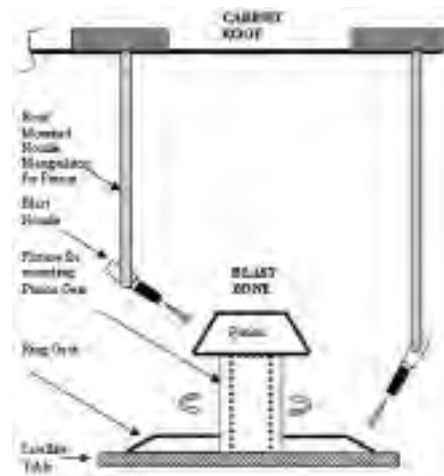
- The diameter of the blast wheel determines the tangential velocity of the projectile (blast media). Being in direct proportion, a 17.5" diameter wheel generates a greater velocity and therefore higher peening intensity than a 14" diameter wheel at the same speed.
- Horsepower of the wheel simply determines the amount of media propelled by the wheel.
- Wheel size works in conjunction with the wheel speed ($\pi \times D \times N$) to achieve the desired velocity and thereby the intensity. Wheelblast peening machines can be equipped with variable frequency drives to vary the wheel speed and therefore the velocity.
- Blast wheels are always mounted in a permanent and rigid location in the blast cabinet. However, blast pattern alterations, if required, are achievable by altering the control cage settings. The control cage location determines the exact point of blast media discharge from the blast wheel.

In a direct pressure nozzle system,

- The blast pressure is analogous to the wheel speed in a wheel type system. Higher blast pressures help achieve higher intensities. Blast pressure in a sophisticated gear peening system is usually monitored in a closed-loop feedback loop arrangement using a proportional regulator. Any deviation from the pre-set pressure value triggers an alarm to shut the machine down.
- The nozzle sizes determines the amount of media propelled on to the part. The target factor being relatively higher in a nozzle type system, all the energy dispensed through the blast media is directly applied towards achieving the required intensity.
- Blast nozzle movements are possible by mounting the nozzle(s) on multi-axes nozzle manipulators. These manipulators, with the assistance of servo drives and motion controllers, are capable of providing interpolated motion to the blast nozzle(s), which results in the blast nozzle following the part contour. Following the profile of a pinion or ring gear results in a consistent stand-off distance and thereby more repeatable results.

Note:

When peening a set of pinion and ring gears simultaneously, it is important that attention be given to the fact that tooth angles vary significantly within the set. Therefore, in a nozzle style system, it becomes important to rely on independent



nozzle settings in order to achieve desired results on the pinion and ring gears.

This is achieved using a dedicated nozzle carriage for the ring and pinion gears respectively. Other process variables affecting peening results include:

- Media Flow Rate
- Size of media
- Consistency of size
- Media flow rate is controlled using a commercially available flow control valve (MagnaValve – manufactured by Electronics Inc.). MagnaValves are provided at the feed side of the blast wheel or at the pressure vessel outlet in case of an airblast machine.
- Vibratory Classifier classifies the peening media into oversize, right and undersize/fines. A combination of two sieves ensures that a consistent size of peening media is available for every cycle.
- Size of steel shot (or cut wire) plays an important role in determining coverage and peening cycle time. As a rule, (a) smaller size of shot allows higher stress on immediate surfaces, (b) larger sized shot provides stress in material depths and (c) diameter of shot should be less than half the smallest radius in the part.

In summary

Gear peening systems have evolved over the past years. It is now possible to accord the same sophistication to peen gears in high volumes as is available to peen an aircraft landing gear. In both cases, the thrust is on repeatability and consistency of results.

Mechanical process variables in conjunction with sophisticated yet simple controls provide great flexibility in setting the process to achieve the desired peening effect on the part.

Contemporary automotive engineers are no longer restricted to using a traditional wheelblast machine or even just an airblast machine for their peening needs. Hybrid systems offer the benefits of both systems in an integrated platform designed to cater to specific needs. ●

Acknowledgement: Some data and illustrations in this article have been collected and assimilated due to the joint efforts of the several Wheelabrator group companies in Europe and North America.



Kumar Balan is a Product Engineer with Wheelabrator Group Equipment/Process Design & Specification Conformance. This article was originally published in *Gear Product News* and is reprinted with permission of the author. We commend Mr. Balan for advancing proper shot peening practices to the gear industry.

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Saturation Curve Analysis and Quality Control

by David Kirk

INTRODUCTION

Users specify the range of indentation ability of the shot streams to be used on their components. They are able to do this by virtue of the so-called "Saturation Intensity" which is a quantitative measure of shot stream indentation ability. The range is normally specified as upper and lower limits for the saturation intensity, which has to be obtained from a saturation curve. At various stages in shot peening we need to confirm that the specified indentation ability is being employed. These stages include the initial set-up of a job and subsequent verification intervals. The primary quality control application of saturation curve analysis is, therefore, the determination of saturation intensity values. A secondary application is to obtain an indication of the Almen strip indentation rate.

SATURATION CURVE SHAPE

Each shot particle that indents the surface of an Almen strip causes a minute plastic expansion of that surface. This expansion induces a corresponding tiny increment of convex curvature into the strip. Because a peened strip has received a very large number of indenting particles we get a measurable curvature – expressed as the deviation from original flatness and termed "Almen Arc Height". On initial exposure to a constant shot stream each shot particle can impose a similar increment of curvature. As a consequence the Almen arc height initially increases almost linearly with peening time. With further peening, the strip surface progressively work hardens so that the tiny increment of curvature attributable to each indenting particle is reduced. The rate of Almen height increase must therefore slow down. Eventually the incremental contributions become negligible. The slowing down and subsequent leveling-out are the reasons for the characteristic shape of Almen saturation curves.

Shot streams with different indenting ability will give different 'saturation curves'. With increase in shot velocity (and therefore of indenting ability) there is a corresponding increase in curve height, see fig.1. We should also note that the greater the shot flow the quicker will be the increase in arc height. That means that we can have different saturation curves without any difference in indentation ability.

Consider next the problem: "How can we assign to each saturation curve a quantity that uniquely defines the indenting ability expressed by that curve?" To solve that problem we need to find a particular point of the curve that defines the curve. The standard solution is the so-called "ten percent rule". This solution gives us: "The (first) point on the curve for which doubling the peening time increases the arc height by 10%". For every saturation

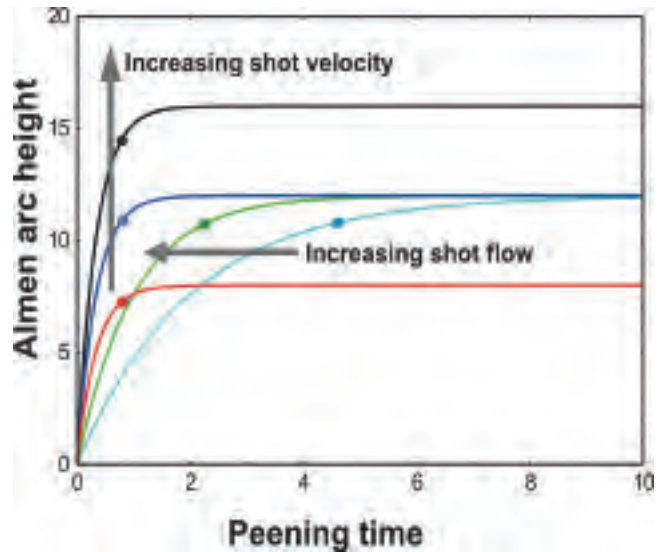


Fig.1 Effects of shot velocity and flow rate on position of 'saturation point'.

curve there is only one such point – shown as dots in fig.1. It should be emphasized that **the saturation point is not a data point**, it is a **derived point**. The saturation intensity is a defined high-curvature point of the saturation curve. There are alternative 'characteristic points'. Mathematically-minded readers will note that the curve's curvature at the 'saturation point' is close to the 'point of maximum curvature'. If we know the mathematical equation for the curve we can derive the point of maximum curvature by solving a relationship that includes the first and second derivatives of the curve's equation.

There are various specifications that detail the requirements for saturation curve measurements. All of these specify that several Almen strips must be exposed for different times to the same shot stream. The measured arc heights are then plotted against peening time. A curve must then be drawn so that the saturation intensity can be estimated. There are two alternatives: manual curve fitting and computer-based curve fitting. With the universal availability of computers and appropriate curve-fitting procedures the former technique should be 'consigned to history'.

SATURATION CURVE PREDICTION

One advantage of computerized curve-fitting is that the curve's equation has parameters that are directly related to saturation intensity and saturation time. Popular equations used for curve-fitting are 'two-parameter exponential' and 'two-parameter saturation growth'. These are:

$$h = a(1 - \exp(-b*t)) \quad (1)$$

$$\text{and } h = a*t/(b + t) \quad (2)$$

where **h** is arc height, **t** is peening time, **a** and **b** are the two parameters.

For both equations the saturation intensity is a fixed proportion of parameter **a**, [9a/10 for equation (1) and 9a/11 for equation (2)]. Similarly the saturation time is a fixed proportion of parameter **b**, [2.303/b for equation (1) and 4.5*b for equation (2)]. Fig.2



Dr. David Kirk, our "Shot Peening Academic", is a regular contributor to *The Shot Peener*. Since his retirement, Dr. Kirk has been an Honorary Research Fellow at Coventry University, U.K. and is now a member of their Faculty of Engineering and Computing. We greatly appreciate his contribution to our publication.

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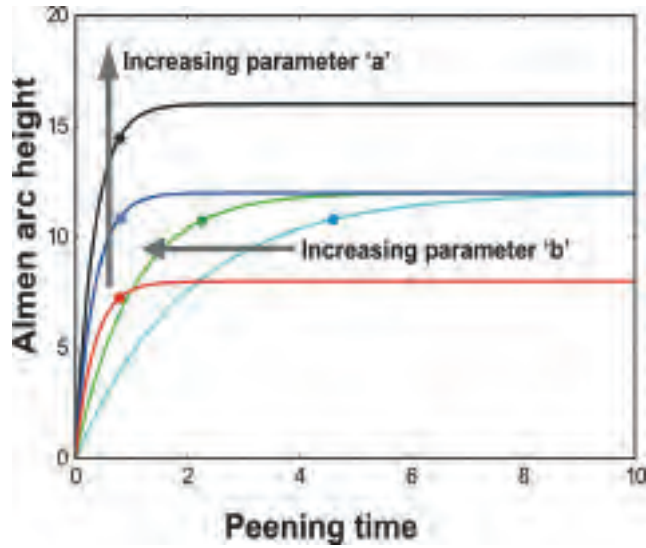


Fig.2 Effect of arc height and peening time on two-parameter exponential saturation curves.

illustrates these relationships for equation (1). The similarity with fig.1 is not coincidental!

The machine control settings that lead to every saturation curve produced by a particular peening shop should have been documented. Settings for a new job can therefore be based either directly on past records or on the superintendent's wealth of experience (or both). Armed with a knowledge of the equation parameters we can plot an expected saturation curve immediately. The case study shown in the next column illustrates the approach used by the author for his laboratory peening facility.

The primary factors that govern saturation curves, for a given shot charge, are shot velocity and shot stream flux. In this context, 'flux' is the number of shot particles crossing each unit area of the shot stream's cross-section. Shot velocity is controlled by varying either air pressure or wheel speed. Shot stream flux is varied by means of some type of feed valve – such as a Magna valve. There is, however, an inter-dependence of shot velocity and shot flux. That means that we cannot vary velocity and flux independently. There are several factors that contribute to the inter-dependence. The major factor is the efficiency of energy conversion. For an air-blast machine the compressed air is providing kinetic energy, some of which is translated into kinetic energy of the shot particles. The greater the shot flux, the lower is the air stream's efficiency in accelerating the shot particles. Complex physics are involved!

DATA POINT SELECTION

Data point selection for a saturation curve is very important, but is rarely mentioned in specifications. The primary objective is to determine the characteristic 'saturation point' to within reasonable confidence limits. It follows that the range of selected data points should straddle the expected saturation point without being too close together. This means that we should have some points at lower times than the saturation time and some at longer times. The most useful sequence of peening 'times' is generally found to be based on a 'geometric progression'. For example, the sequence of numbers 1, 2, 4, 8, 16 and 32 is a geometric progression where

Case Study: Attempt to produce an Almen Arc height of 0.015" using S110 steel shot.

The author's records are stored as Excel spreadsheets with separate sheets for each type and size of shot. For each shot type there are separate columns for air pressure, shot feed rate (with actual MagnaValve settings), gun-to-component distance, gun type (suction fed or direct fed), angle of impact, Almen strip type, test date, arc heights and times, saturation intensity, saturation time and fitted curve parameters. Complementary sheets detail the history of each shot charge in terms of origin, purchase date, sieve details, image analysis, etc. With only about a thousand saturation curves on record it was a simple task to use Excel's Data/Sort facility to highlight the several previous combinations of settings that yielded approximately 0.015" when using S110 steel shot. The recorded saturation curve parameter values were then fed into a Curve Solver computer program to produce a "reference curve". The combination of machine settings that gave that "reference curve" were then used to produce a new, current, saturation curve. This new curve was then plotted on the same graph as the reference curve. Fig.3 shows the outcome.

Current Curve

a	b	Sat.Int.	T
15.31	0.43	13.78	5.32

Reference Curve

a	b	Sat.Int.	T
16.49	0.32	14.84	7.20

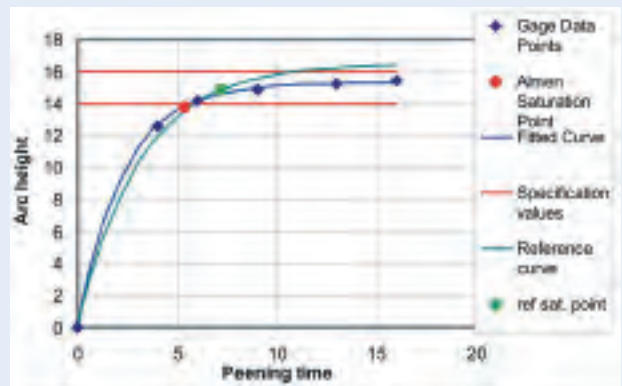


Fig.3. Comparison of reference and new saturation curves using Curve Solver 2EXP v3.00C.

For the situation represented in fig.3 there is a clear discrepancy between the two curves. The machine settings have produced a lower saturation intensity and shorter saturation time than was expected. By cross-checking with the complementary data it was found that the S110 shot charge had been in use for so long that its average diameter was substantially lower than when the reference curve was produced. That led to a lower intensity potential and a faster coverage rate. The problem was subsequently solved by clearing out the shot charge and replacing it with new shot.

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each number is double the preceding number. Such a sequence normally allows an efficient utilization of the limited number of data points.

Fig.4 illustrates a real situation where the choice of data points was not efficient. This situation occurred because a high shot stream flux was imposing a very high coverage in a single pass over the Almen strips. Computer-based curve-fitting yielded the indicated T and 2T arc heights. Typical error bars are shown for the four data points. It takes little imagination to appreciate that, given the error limits shown, the 'real' T value is anywhere between 0.1 and 1.0 strokes. We cannot, however, select fractions of a peening stroke! Stroke speeds can often be increased to yield the equivalent of stroke fractions. With fig.4, half and quarter stroke fractions would be far more effective than the three and four stroke points. It would be simplistic to argue that the shot feed rate should be reduced so that the saturation time becomes much longer. Shot feed rate reduction would mean that production rates would suffer badly.

COVERAGE

Saturation times are a useful guide to the rate at which components will receive specified coverage levels. For any given machine set-up, the coverage rate of the Almen strips is inversely proportional to the saturation time. Hence, the shorter the saturation time the higher will be the coverage rate. The coverage rate for a component will not be the same as that for Almen strips. That is because there is normally a difference between the indentation resistance (hardness) of the component and that of the Almen strip. The coverage rate for a component is therefore inversely proportional to both saturation time and component hardness. If the component is softer than the Almen strips then it will receive a higher coverage rate than will the strips. Conversely, if the component is harder than the Almen strip then the component's coverage rate will be lower than that for the strips.

T-TESTING

T-testing is an important feature of quality control. The objective is to check periodically that the shot stream's indentation ability is being maintained after the original set-up curve has been produced.

Single-strip T-testing is a straightforward test with the clearly-defined requirement that the measured arc height for a strip peened for a designated time, T, has to be between stated upper and lower limits. The test may require either one or more strips to be tested for one or more Almen block locations. If the test is to be effective then control has to be exercised over both shot stream flux and shot velocity. In practical terms we have to control both shot feed rate and air pressure/wheel speed.

The measured arc height on a single strip will rarely be precisely the same as that predicted from the full saturation curve test. That is because all measurements have unavoidable variability – which can be expressed as a standard deviation. Every Almen arc height measurement is a 'statistic' and collections of statistics are best treated using reliable, appropriate, statistical techniques. The commonest statistical parameter is the 'average' of a collection of values. A 'normal distribution' of values has two parameters: the average or mean, μ , and the standard deviation, σ , of the values. 'Confidence limits' are defined as the probability that a measurement will lie within those limits. Hence '95% confidence limits' would be plus and minus two standard deviations from the mean. '99.7% confidence limits' are plus and minus three standard

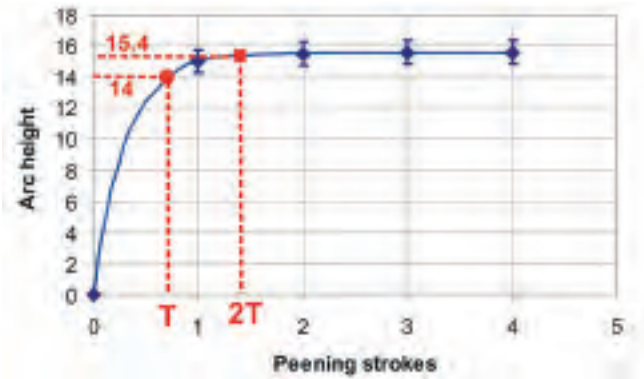


Fig.4 Almen saturation curve with data points beyond the saturation point.

deviations from the mean. Confidence limits will only be maintained for actual measurements if there is no change in mean arc height. Again that means that we must control both shot velocity and shot stream flux.

Multi-block T-testing is more complicated than single-block T-testing. Some components require an array of several Almen blocks – in extreme cases more than twenty – for the set-up saturation intensity determination. Intermittent confirmation testing may then require single strips to be tested at the same time at all of the locations. That 'same time' cannot correspond to the saturation point 'time' for all of the test blocks. Each block will have yielded a different saturation 'time'. One reasonable way of handling the situation is to take the mean of the saturation times derived for all of the locations involved and require that the nearest integral 'time' be used - with compensating adjustments to the required arc height limits.

Two-strip T-testing is required by some users. This involves tests being carried out at two different peening times, T and 2T, with a requirement that the arc height at 2T will be less than 10% greater than that at T. The test is more rigorous and more complicated to analyze than single-strip T-test confirmation.

DISCUSSION

Every full Almen saturation curve is a confirmation test of a shot stream's required indentation ability and is therefore an essential part of quality control. The curve yields an internationally-accepted parameter, the so-called "saturation intensity", whose derivation is classically simple – using either manual or computerized curve-fitting procedures. Saturation intensity is a high-curvature point of the saturation curve – it is not a data point.

Continued on page 30

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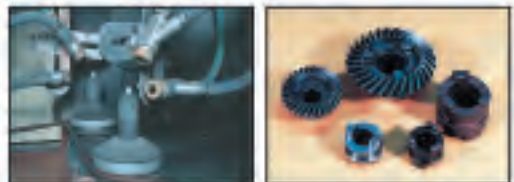
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Saturation time can be used as an indication of the shot stream's coverage rate. With computerized curve fitting procedures the derived saturation point is determined objectively and it is possible to quantitatively relate actual curves to those that would be anticipated.

The objective with T-testing is to confirm that the required saturation intensity is being maintained during a production run. It cannot, however, guarantee that this intensity is being maintained. That is because different saturation curves can intersect at the specified saturation point. Consider, for example, the situation illustrated by fig.5. A set-up saturation curve is shown, together with the corresponding saturation point, T_s . A second saturation curve is shown which could easily have arisen during a production run if the shot flow rate had been substantially reduced – hence inducing increased shot velocity (if air-blast is being employed). The second curve has the same Almen arc height at T_s as the set-up curve, but has a different saturation intensity, T_c . Hence, a confirmation T-test would not reveal that the saturation intensity had in fact substantially increased.

Two-strip T-testing is difficult to quantify reliably. It cannot be either as effective or as reliable as a full saturation curve. The use of full saturation curves should, therefore, be the preferred practice, especially for critical applications.

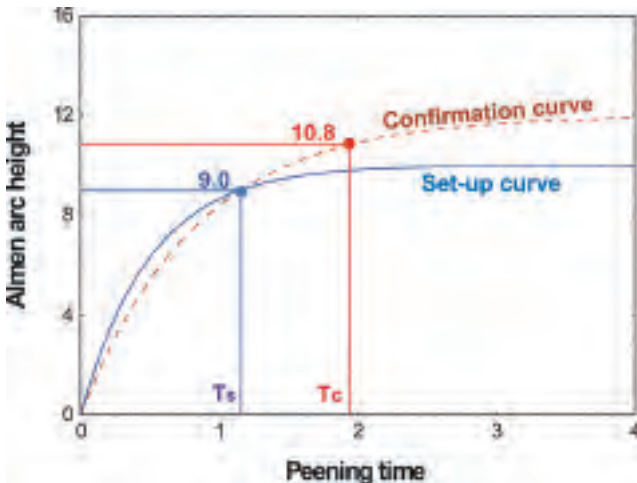
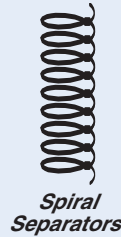


Fig.5 Identical arc heights obtained at T_s with different saturation intensities.

CONCLUSIONS

1. Saturation intensity is a reliable, primary, quality control parameter. It is a high-curvature point of the saturation curve – not a data point.
2. Computerized curve-fitting has substantial advantages relative to manual curve-fitting.
3. Single-strip T-testing for confirmation testing is useful provided that effective control is exercised over both shot flux and shot velocity.
4. Saturation curves can provide a useful indication of coverage if an appropriate allowance is made for the relative indentation resistance of Almen strip and component material.

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Recycled glass proves a hit with U.S. Army

The US Army Field Support Battalion Unit, based in Hythe, Southampton, is a US Army Centre of Excellence for the maintenance of land vehicles and watercraft. Military support equipment – including mobile cranes, generators, trailers and watercraft – is shipped in from war zones across the world to be completely stripped and cleaned before being released again into service.

As part of this maintenance process, drive engines and running gear are replaced and chassis are stripped to bare metal for repainting in the appropriate camouflage colour, depending on the intended destination of the vehicle. Many of the vehicles have suffered significant war damage so it is necessary to strip back all the paint to see what metal damage has been caused.

Until recently, the Unit had used copper slag as the blasting media for cleaning and surface preparation of the vehicles prior to painting. However, following the introduction of US HAZMAT regulations governing the use of hazardous materials, the Unit decided to investigate more environmentally friendly alternatives to the copper slag. It was also important to identify a suitable alternative without compromising on performance requirements or incurring additional costs.

Finding a suitable solution

Having heard about the previous success stories of recycled glass used as glass grit, the Unit decided to investigate its suitability for the army's vehicles and equipment and approached glass reprocessor Krysteline to undertake a trial of TruGrit, a 100% recycled glass grit abrasive.

Over the past three months, the Unit has switched to using recycled glass grit as its only blast media with impressive results. Currently, it uses three tonnes of medium grade (0.75 – 1.5mm) glass grit every week, at a pressure of 200 PSI. Two forms of equipment are used during the blasting process – a standard shot blasting system and a portable, lightweight, blasting gun which enables the paint to be stripped off layer by layer.

Achieving results

As well as offering significant environmental benefits, the glass grit results in a much cleaner and controlled cleaning process and environment. Colin Buchanan, Paint Supervisor and HAZMAT Officer, explains: "The Unit has been particularly impressed with the fact that significantly less dust is created during the blasting process, which had been a problem for us in the past. Any dust that is generated is easily controlled."

"Another benefit we have identified is that, in addition to complying with the new US HAZMAT regulations, the glass



grit can be disposed of in a number of ways, without presenting an environmental hazard. In terms of costs, the glass grit has proved to be more cost-effective than many of the other alternative materials we investigated."

"By sharing the results we have achieved in our maintenance projects here in the UK, we hope to encourage other army sites across the world to consider switching to glass grit. The benefits it offers in terms of cleanliness, ease of control, cost effectiveness and

environmental performance all add up to make glass grit an ideal product for shot blasting."

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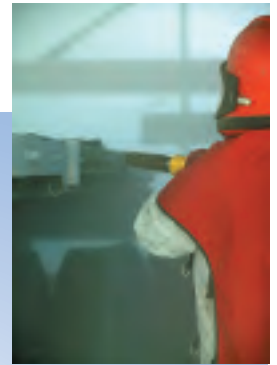
Key Facts

The United Kingdom WRAP (the Waste & Resources Action Programme) aims to develop stable, high value markets for recycled products and materials. It has identified the use of glass grit for shot blasting as a rapidly developing market and is currently funding trials of its use in the UK Ministry of Defence, Highways Agency, Marine and Network Rail applications.

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- Are created by crushing, cleaning, processing and grading recycled glass to produce a high quality blast media which can be used as a wet or dry abrasive.

"The benefits it offers in terms of cleanliness, ease of control, cost effectiveness and environmental performance all add up to make glass grit an ideal product for shot blasting."



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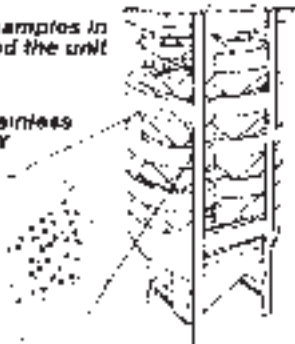
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The Devil and the Surfaces

by Michel Cardon

The eminent physicist, Wolfgang Pauli¹, used to say, “God made the bulk; the surface was invented by the devil.” Pauli explained that the diabolical characteristic of surfaces was due to the simple fact that a solid surface shares its border with the external world. Inside the solid, each atom is surrounded by other similar atoms. Surface atoms may interact either with other atoms from the same surface, or with atoms located just below or just above it, or with atoms located beyond it. Therefore, surface properties of a solid are quite different depending upon one’s location. As an example, surface atoms’ minimal energy spatial pattern is often quite different from internal atoms’ minimal energy spatial pattern. Surface structures are complex, and for a long time, every effort made to establish precise experimental and theoretical descriptions of these structures failed.

The surfaces of parts are the location for many phenomena between the material and its environment, where all physical and chemical interactions and exchanges take place. A part’s surface is quite often associated with a useful function—it might be absorbing, reflecting, supporting, insulating, conducting...

Because the processes used to manufacture, treat, protect, coat, or assemble part’s surfaces will determine the service life for the part, surface treatments have a tremendous importance in industry. Yet, partly because of historical reasons, they were, and sometimes still are, underestimated.

Origin of Sandblasting

Benjamin Chew Tilghman developed the first sandblasting machine. The accounting of how his concept for the process came about may be a myth, but the story is Tilghman, while serving as a General in the Army, observed how sand dust, when blown by wind, could etch window glass surfaces and leave a transparent image of the steel mesh that covered the windows. The story has basis in fact since Tilghman served as a General in the Civil War and was commander of a brigade in Florida.

What is indisputable is that Tilghman is credited with inventing a sand blast apparatus in 1871. He produced the first equipment to replace acid etching used for glass engraving, much “à la mode” at that time for mirrors and for bars, café and hotel windows. Another important use was for engraving tombstones, instead of costly hand-chiselling. This became very popular in a new country where settlers wished to mark their place with a name and brief biography engraved on a tombstone.

Industrial uses came quickly; for instance, the booming market for steel ships required an efficient process to remove

rust and prepare the steel for painting. In H. J. Plaster’s article on Tilghman², he writes about many other applications for Tilghman’s invention as listed in the **National Cyclopaedia of American Biography** including the “removal of scale from forgings and castings; labeling bottles used by chemists and druggists; scouring the outside of bank safes; smoothing armor plates of warships; removing dirt from brick and stone buildings; cleaning tubes, tanks and boilers; refacing wheels of emery and corundum; granulating celluloid films for cameras; perfecting the joints in reservoirs, boilers and tanks; preparing steel rails and girders for welding; exposing cracks in the teeth of milling machines and for taking off the layers of paint successively laid on a ship.”

Many other developments are now familiar to a majority of our readers. However, it is often considered that “shot peening” is the “noble” part of surface treatment, while to others, surface treatment using angular abrasive are of secondary importance. I always try to fight against this pre-cast idea.

A short story to illustrate my point: My company supplied one of the very first CNC blast machine to process ballistic missiles bodies to a precise degree of finish using white alox (aluminum oxide). I later showed this machine to a prospective user at the initial customer site. It was operated by a bright young man. He was playing with the keyboard and push buttons, looking frequently at the CNC CRT display. At my departure, I thanked the workshop manager for the visit and told him, “Seems you have a good machine operator.” The answer was “Shhhh! He can’t read!”

Explanation: The machine operation was understood as “sandblasting”. Because of local union regulations, our customer’s employees couldn’t be offered the job of a “sandblaster”. Therefore, the shop manager picked up his phone, called the staff management department and said, “Hi! Send me a sandblaster!” But the young man was only a temporary jobber: He was bright, quick and memorized controls, etc., but couldn’t read. This magnificent machine, tailor-made to a strict specification, used like this...

In all probability, sandblasting has a lesser reputation from its early days when it was a dangerous profession. Sand is made of silica (Silicon Dioxide, SiO₂). When used as an abrasive for blasting, it breaks into fine particles. When inhaled, these particles can cause a lethal lung disease, “Silicosis”, also known as the Coal Miners disease. Even with primitive helmets and external ventilation, dust inhalation was inevitable. If you were in a British shipyard in the early 1900s, one could read under the poster: “Join the Navy and see the world”. A chalked warning reads “Become a sandblaster, and see the next”.

So a sandblaster in the early 1900s might have agreed that surfaces were invented by the devil! However, given the complexity of surface physics and the demand today in so many industries for blast cleaning, all surface treatments are deserving of our respect. ●

¹Wolfgang Pauli. Born in 1900 in Vienna, Pauli was a U.S. and Swiss physicist. Pauli helped to lay the foundations of the quantum theory of fields. He was awarded the Lorentz Medal in 1930 and the Nobel Prize in Physics 1945 for the discovery of the Exclusion Principle, also called the Pauli Principle.

²A Tribute to Benjamin Chew Tilghman by H.J. Plaster is available for download at www.shotpeener.com.



Michel Cardon is retired from the vacu-blast industry and resides in Paris, France. During his career, he was the manager of the vacu-blast department of his family business, Satem. He formed Matrasur which was later purchased and became Wheelabrator. Some of his career highlights include being a guest of the U.S. Capitol in 1982 and a meeting with Jacques Chirac.

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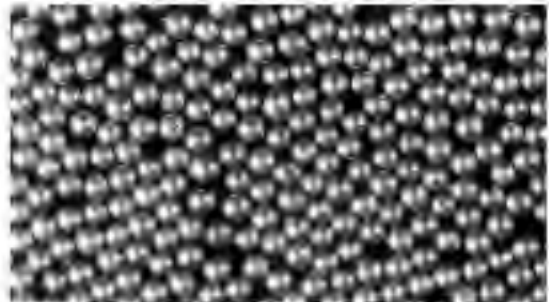


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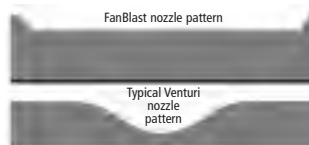
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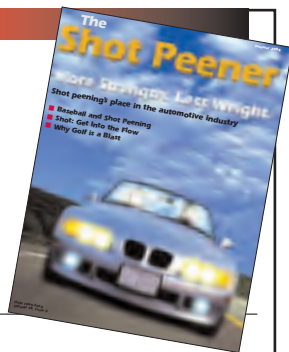
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Electronics Inc. www.electronics-inc.com	11, 17, 21, 34, 35, 44
Empire Abrasive Equipment Company www.empire-airblast.com	37, 39
Engineered Abrasives www.engineeredabrasives.com	22, 23
Equipos de Abrasion para Metales	25
Ervin Industries www.ervinindustries.com	33
Flex-O-Lite..... www.flexolite.com	37
Gear Technology www.geartechnology.com	36
Innovative Peening Systems www.innovativepeening.com	25
Itoh Kikoh Co., Ltd..... www.itoh-kikoh.co.jp	39
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Saint-Gobain Zirpro www.zirpro.com	9
Sam Young Industrial Company, LTD.....	30, 41
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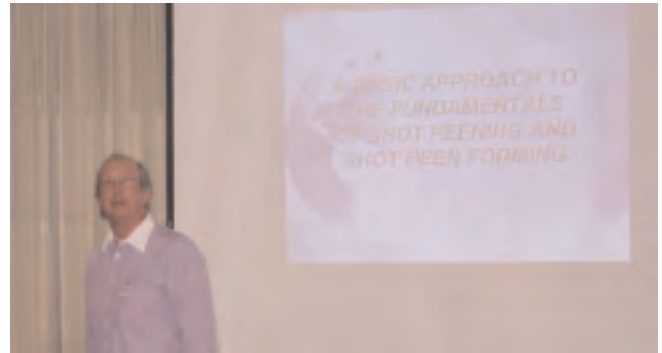
Performance Engineering

In auto racing, a split second can be the difference between the winner's circle or being towed back to the garage wondering what improvements can be made to make the difference in the next race. This year's Indianapolis 500 Auto Race had the second closest margin of victory in the race's prestigious history. Sam Hornish Jr. won the race in 3.10.58.7590 hours, just 0.0635 seconds in front of second place finisher, Marco Andretti. With a track temperature of 100 degrees F (38 degrees C) and average speed of 157.085 MPH (252.8 km) the race cars were pushed to endurance limits. The competition keeps teams feverishly looking for the technology to improve their edge on the track under extreme conditions. Auto racing teams and car owners are often pioneers to innovations in making autos "faster, stronger, and lighter". Often, the result is these improvements find their way into the automobiles we drive everyday in the streets around the world.

The Society of Manufacturing Engineers recognized a need to bring "technology that wins races" to the growing industry of motor sports (See Industry News, p.10). Shot peening delivers state-of-the-art technology to the auto sport industry worldwide, and is an integral part to the motor sports industry. From connecting rods and piston skirts, to springs and gears, racing teams are turning to experts in shot peening from original equipment manufacturers (see Herb Tobben's article, p.12), media suppliers, and service providers, such as job shops and consultants. The end goal — improve the performance of their cars, whether for strength, safety, or even gas mileage. If a critical part breaks or the car's performance is sub-par, the driver is at a disadvantage or worse—the car may not finish the race. Five cars at Indianapolis didn't finish due to mechanical failures.

Auto racing is only one industry that has recognized the importance of performance engineering. For decades, the aerospace industry has recognized the value of controlling and improving technologies, including shot peening. With the average age of humans rising worldwide, and the baby boomers coming of age, the demand for and life of medical implants (orthopedic and dental) has also increased dramatically. As a result, the implant industry has also turned to technologies to improve implant performance, not only in strength but also in tissue adhesion. Dr. Dwayne Arola's article on Hydroxyapatite Waterjet Treatment of Implants (p.6), is an example of the resources and energy put into developing performance technologies.

At the International Shot Peening and Blast Cleaning Workshop in Montreal in May, David Cook gave a terrific class on Peen Forming of Wing Skins. The class was not only informative but gave a clear endorsement for the need and future of Shot Peening as a technology today and going forward. We were so impressed with David's enthusiasm that we ask him to give the



David Cook led a class on peen forming of wing skins at the EI Montreal Shot Peening Workshop. He will be the keynote speaker at the Indianapolis workshop this fall.

keynote address at the U.S. Shot Peening Workshop in Indianapolis October 31 through November 2. Coincidentally, David and his wife are heavily involved in Formula One car racing and are developing a race course in Texas.

Additionally, Drazen Galovic kicked off the Montreal workshop with a wonderful endorsement for the need for training and continuing education in the industry. I would like to again thank him and all the other presenters, exhibitors and students for making the event a success. We will be back next year in Montreal due to the response of all involved. If you missed Montreal, join us in Indianapolis. We will have a large exhibit area and 30 plus speakers with four classrooms going at a time! ●



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