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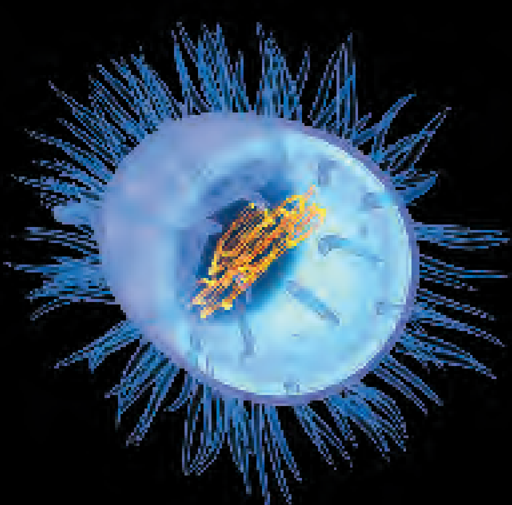

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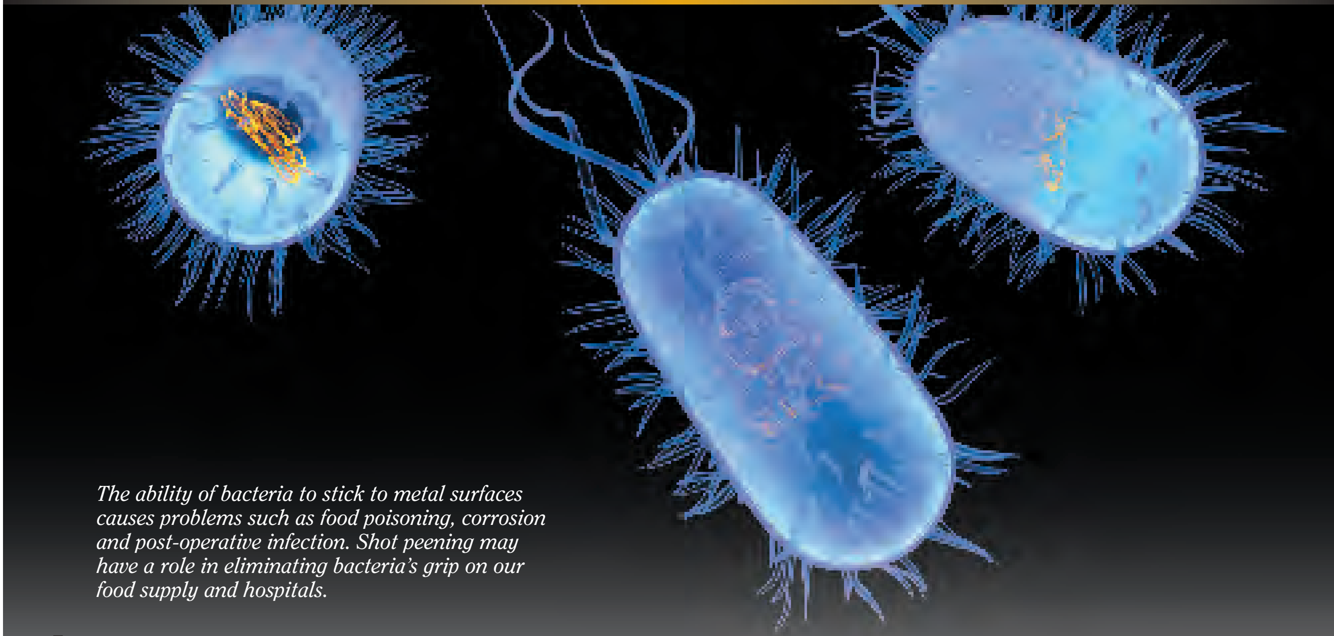

The ability of bacteria to stick to metal surfaces causes problems such as food poisoning, corrosion and post-operative infection. Shot peening may have a role in eliminating bacteria's grip on our food supply and hospitals.

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The Shot Peener

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The Shot Peener (ISSN 1069-2010), in print since 1986, is a quarterly publication from Electronics Incorporated with a circulation of over 5,000 subscribers 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 magazine. 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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The Shot Peener

Dedicated to raising the standard in shot peening & blast cleaning processes

Turning a Medical Crisis into a New Lease on Life

by Bryon Ater

There are probably hundreds of Shot Peener readers that have experienced something similar to my story. Your day starts out as it usually does. You go to the same job that you have taken for granted for many years and then something happens that changes the course of your life.

It happened to me. In January of 2001, I was running an overhaul facility for a major airline. I went into work one day and by the end of the day I was in the hospital. Six weeks after that I was unemployed.

While recovering from major surgery, I began to wonder who would want to hire me at this point in my life with my medical condition. What will happen to my family and me?

I had an idea about starting my own business but what would that be? I had been an automotive mechanic for years so I thought about that. I had worked as a mechanic for the Air Force and a national airline carrier so I thought about that. Then it came to me. I had been shot peening at my job with the airline for several years. I could use my experience in the aviation and automotive industry to educate on how shot peening could increase product life. That's where I headed.

I did a marketing study and began to develop BG&S Peening and Consulting LLC. What a great feeling to answer to no one but myself. It didn't take long to find out about the "Big Gorillas" that can get in the way. However, I proceeded to cut a niche into the road of progress.

I was making progress building the business and then all of a sudden I had to have major surgery again because of the same medical condition. I was down again. Who was going to run the business and was I going to lose everything that I had worked for? Those are some of the thoughts that went through my head while I was lying there in bed doing nothing. As I watched the hospital staff do their job cleaning the furniture and wiping down the rails on the beds and the floors, I asked a staff member what she was using to clean these areas. The young lady looked at me and said "a bacteria cleaner". As I lay there and watched her spray the cleaner on and then wipe it off, I remembered a TV program on diseases in the hospital. The program had acknowledged a number of cases where people have gotten sick as a result of being hospitalized. I started kicking around some ideas in my head related to shot peening.

Bryon Ater in his shot peening facility at BG&S Peening and Consulting.

While I recovered from surgery, I began pursuing the notion of using shot peening to help cure hospitals' bacteria problems and, at the same time, eliminate fatigue and stress corrosion problems. I consulted with Matco labs, a testing lab with which I worked, and the metallurgist on my company's advisory board to see if they thought this was a possibility. They shot me down. I was told that this could not be done because I would create more problems by shot peening than I would ever be able to cure—the shot peening process could trap bacteria in the metal.

I was determined to find a way to use shot peening to eliminate bacteria from living in the surface of metals. I decided to search for other companies that were looking for a solution to the same problem when I came across BIOSAFE™ INC. BIOSAFE manufactures a permanent antimicrobial that is used for a broad range of disease control. (An antimicrobial is a substance that kills or inhibits the growth of microbes such as bacteria, fungi, viruses, or parasites.) I shared my idea with Don Wagner, Vice President Business Development at BIOSAFE, only to discover that they were interested in applying their product onto metal surfaces. Their idea was to mix the antimicrobial into paint.

As the chart on the next page shows, BIOSAFE's antimicrobial is an extremely effective product on numerous surfaces, including stainless steel. An interesting aspect of the substance is that it causes the physical destruction of the bacteria's cell wall, thereby rendering it incapable of mutating into a "superbug". Superbug infections are practically immune to most antibiotics, making them tough to treat.

Don and I discussed the possibility of the benefits of shot peening metals with media treated with BIOSAFE antimicrobial. If we could deliver the antimicrobial to the metal through shot peening, would the treated surface retain the chemical and prevent bacteria growth? We performed tests combining his product with several different types of shot peening media. We processed the media with blue-tinted antimicrobial before placing it into the hopper. We shot peened three 1mil x 1mil squares each of Almen strips, aluminum and stainless steel at specified pressure, distance and time and then removed the samples. As evidenced by the residual blue tint, the antimicrobial adhered to the media and transferred to all three metal surfaces.

These tests were a career highlight for me and I felt great about this accomplishment. However, since the initial testing, we have returned to reality because this was only the first step. We know that we need to accomplish a great deal more. We are working on a list of self-imposed hurdles. As we have success with each hurdle, we know that there are great possibilities for this process. Despite all of today's advances in

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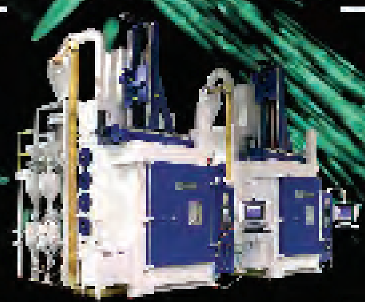

TURNING A MEDICAL CRISIS
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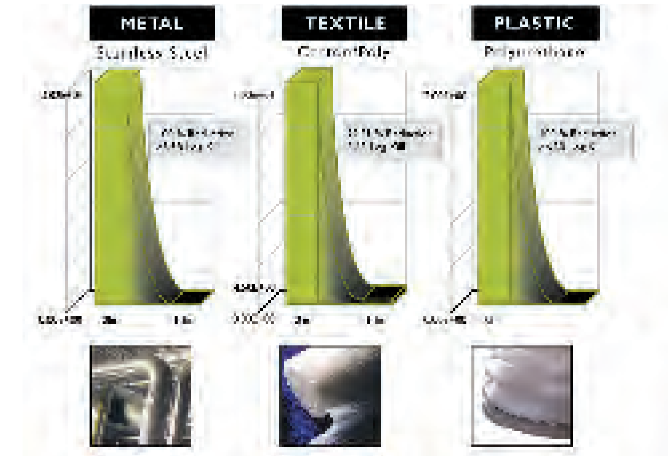

Test results from the application of BIOSAFE's antimicrobial on Escherichia coli (E. coli) infected metal, textile and plastic.

health care and food processing, we are more suspectible than ever to bacteria infections, as evidenced by recent coverage in the news of e.coli outbreaks in our food supply.

In health care, just a few prospects include cleaner, stronger metal surfaces throughout the hospital. Remember how I watched the hospital staff clean my hospital bed with a anti-bacteria spray? I've since learned that patients were more likely to be infected with drug-resistant germs when they stayed in a bed previously occupied by a patient infected with the germs. I'm glad I didn't know that at the time.

Since shot peening eliminates the porosity of metals, it can reduce the corrosion problem inherent in sterilizing surgical tools. Plus, embedding an antimicrobial into the tools would greatly reduce the infection risk from surgery. However, surgeons expect their surgical instruments to be extremely shiny—an education process would be necessary to get them to accept the dull finish of a shot peened knife.

One of the common problems in joint replacements is infections. The reason infections are such a significant problem is that bacteria cannot be easily eliminated from a joint replacement implant. Despite antibiotics and preventative treatments, patients with a joint replacement infection often will require removal of the implanted joint in order to cure the infection. A shot peened and antimicrobial-treated implant would be infection-resistant, lighter, stronger and more durable.

The food industry could be revolutionized by metals embedded with antimicrobial. Stainless steel meat hooks and the splash boards in meat processing plants are breeding grounds for bacteria and leave our food supply vulnerable to e.coli outbreaks.

We're very excited about the markets for this technology and BG&S has a patent pending for the application of the antimicrobial. We are in the process of applying for grants so that we can continue our research. We will also be partnering with the University of Pittsburgh to conduct more testing.

In the meantime, we continue to grow our conventional shot peening services at BG&S Peening and Consulting. We were approved by the FAA as a 145 repair station for shot peening. We just received ISO AS 9003 and are working on our Nadcap accreditation. BG&S Peening has obtained several government contracts and we are on the Hill AFB Landing gear commodity council. The company also train mechanics in shot peening and offers consulting and testing services from our Beaver Falls, Pennsylvania facilities. We have expanded our services to the automotive, medical, transportation, mining, defense and construction industries. Future plans of expansion will be in areas of composite repair and phosphate coating.

While I can't say that I'm grateful for my health problems that landed me in the hospital, I am grateful for my ability to see possibilities and have hope during difficult times. And if my experiences are key to the development of life-saving products (and an expanded market for shot peening!), I've been given a real gift indeed. ●

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Shot Peening… Getting It Right

by Dr. John Cammett

Reflections and Insights

Many readers know me as the guy who does the academic presentation on background and theory at the annual EI shot peening workshops. Indeed I have been doing this for more than fifteen years consecutively. If you consider that subject too abstract for your taste, please do not turn the page and avoid reading this article because you may think it is in the same vein. Instead, this is an appeal to consider the basic aspects of the shot peening process and the importance of doing it right. Lest I be judged overly sensitive or defensive about my workshop presentations, let me say that doing shot peening right is best served when the folks doing it understand the basics of how the process works and especially if they know why it is performed. Looking back over my forty-year professional career, I can claim to have been always interested in shot peening. This interest has held throughout, but is increasing even more now with passing time. The volume is increasing, yet has not yet passed or even reached full crescendo. I trust that the beat will go on for a long time to come. There is yet much to learn and I am well determined to continue the quest.

Through much of my career, I have been a failure analyst. My first experience in failure analysis was a very poignant one. It involved a fatigue failure of a helicopter rotor drive shaft. I hasten to add that this did not involve a military helicopter because it occurred long before my career with the U.S. Navy. While I was with Metcut in Cincinnati, a lawyer brought me the shaft to examine after it had already been examined by the National Transportation Safety Board (NTSB). The lawyer was seeking corroboration of findings by the NTSB metallurgist from examination of the failed component.

I had no disagreement that the failure mode was torsional fatigue. Further, there was no evidence of corrosion or other in-service degradation of the shaft. Also, there were no apparent manufacturing defects. This failure did not involve shot peening quality as an issue because the shaft had not been peened and peening was not called for in its manufacture or design. I claim no knowledge that the helicopter operation was always within its prescribed flight regime; however, my firm belief at that time and since was that the shaft should have been peened. Had it been peened, the helicopter pilot may well be still alive today. In other words, peening could have prevented the fatigue failure of the shaft and the resulting fatal crash.

This matter had personal significance because the pilot was a local physician and father of a high school friend and classmate of my younger daughter. I did not make the connection at the time of my involvement because of the time between the crash and my involvement. I was not called to testify in any legal action which presumably involved suit by the physician's heirs and estate against the helicopter designer and manufacturer. Had that occurred, I would have recused myself when I realized the personal connection. Please note that I am at liberty to discuss this matter because the legal issues of the incident have long since been settled.

Since that most unfortunate helicopter rotor shaft failure, I have examined more than a few aircraft component failures in which shot peening or lack thereof was an issue. I am not at liberty to divulge details, but fortunately I can say that none involved loss of life. Nonetheless, in all such cases, monetary losses were not trivial because aircraft, aircraft components and aircraft component systems are inherently very expensive. Failures of critical aircraft structural and engine components in flight can have disastrous consequences in terms of property loss and loss of life. Even failures on the ground can be very serious.

Let's not overlook the potential serious consequences of failures in ground vehicle components. Loss of use in a racing vehicle may involve great financial loss. Further, if failure occurs in a critical component at critical moments of operation, the consequences could be life-threatening to operators and passengers and result in total loss of the vehicle as well.

Components are not designed to fail, but are often designed to function for infinite life under presumed service conditions. In some cases, particularly in weight critical applications, components are designed only for a prescribed safe service life. In all cases, designers apply design rules and protocols conservatively to achieve desired service lives of components. Skilled designers of aerospace and automotive vehicles and components recognize that manufacturing methods, particularly surface finishing methods and treatments, are critical to performance and life.

Shot peening is one mechanical surface enhancing treatment that can add fatigue life or fatigue strength margin to a component. Peening can do this very reliably if it is performed with due diligence and control. Yet shot peening suffers from an image problem and is not generally popular with designers. Many reluctantly apply it, seeking some margin in fatigue resistance, but do not give it design credit as a fully-reliable benefit. As I see it, this image problem for shot peening stems from two sources:

(1) This process had humble origins and grew out of blast cleaning, a relatively unrefined and "dirty" process in the U.S. automotive industry, and
(2) Shot peening is conceptually very simple. Its analogy with blast cleaning has too often led to lack of process control in practice which in turn has led to variable, unreliable process results.

Peening is neither a cleaning process nor is it merely a matter of propelling spherical media, rather than grit, against the surface of a component. My point is that shot peening, when performed optimally and correctly with due diligence, will produce reliable component life benefits which can be fully accounted for and countenanced in component design and life management.

Basic Aspects of Peening:

Let's look at the basics of what it takes to do shot peening right. Beyond the peening equipment itself, shot peening, when boiled down to its most basic aspects, has three main

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variables: media, intensity and coverage. In the simplest terms, media is what we throw, intensity is how hard we throw and coverage is how much we throw. "Where" we throw may be considered a fourth basic aspect, involving both media stream aiming and part masking. Where we throw considerations will not be discussed as they are much less often problematic than the what, how hard and how much we throw aspects of the process.

The best peening practice involves achieving an optimum balance of these three basic aspects. Such achievement may be attained only by systematic experimentation and analysis. These are all too often not done. Instead, peening recipes are often derived from experience, not necessarily a bad thing, or from imitating what someone else did. The latter is not synonymous with experience and often leads to less than optimum results. While recognizing that there are interactions among the three basic aspects, let us consider each of these individually and in turn explore their importance to the peening process.

Media:

Shot peening media are, first and foremost, a critical aspect of good practice. After all, media particles are truly the "tools of the trade" and, as for all tools of craftsmen, they must be well-chosen and well-maintained to perform well. Choice of media for shot peening involves considerations for type and characteristics that are suitable and appropriate to the application.

Types of media include four general categories:

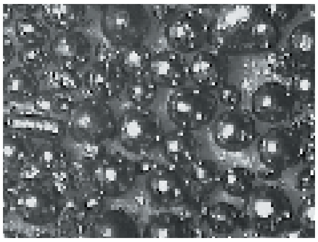
1. Cut wire media – The starting material for this is steel or stainless steel wire. The wire is cut into pieces of length equal to diameter and then, before use, the resulting cylindrical shape is made at least roughly spherical by a conditioning process that involves impingement against a hard surface.
2. Cast media (usually cast steel shot) – The majority of peening applications involve cast steel shot as the media. As the word cast implies, particles are made by solidification of molten liquid steel droplets. In earlier times, steel shot was used for munitions. It was made by pouring molten steel from a (shot) tower and breaking the molten metal into droplets by a stream of forced air. Free falling a sufficient distance through air allowed the droplets to take predominantly spherical shape and to solidify and become solid shot particles before reaching the ground at the bottom of the tower. Indeed this type of peening media, because of its historical roots, is the only type that can be truly called "shot" though we often refer to the other media types as shot also.
3. Ceramic bead media – This is an emerging and the newest media type for peening application. The most common ceramic bead material is zirconium oxide with a glassy-phase aluminum oxide binder. It is manufactured by compaction and sintering of the materials initially in powder form.
4. Glass bead media: - These media particles are also produced from the molten state. Interestingly, the major use of glass bead media is for reflectivity in paints used for highway and road surface markings. Glass beads are also used commonly in blast cleaning, but this is not to be confused with true peening.

My listing of media types above is in descending order of durability, particularly in regard to friability (i.e. ease of fracturing) because fractured media particles are detrimental to good peening. Rating the media types in order of durability is not a recommendation for use. Economics are another consideration. Media durability must be balanced against acquisition cost and whether or not media residue requires post-peening processing and of the processing cost.

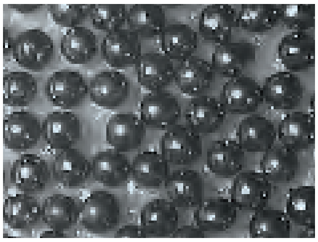
Other important criteria for media are size and size distribution, hardness, friability, shape, density and whether media residue left on parts after peening can be tolerated. These characteristics cannot be chosen either arbitrarily or independently because they may interact with each other and will have influences on the other basic aspects of peening—intensity and coverage.

For example, size and size distribution may affect friability since larger particles, particularly in cast steel media, will tend to fracture more readily than smaller particles. Choice of media size and media material density will affect the range of intensity that can be attained and, of course, smaller media will give more rapid coverage at the same mass flow rate than larger media. As with media size, higher hardness media of a given type and material is more friable than lower hardness media. Higher hardness media will also give greater intensity and somewhat more rapid coverage than softer media at the same peening conditions. Media shape is an important characteristic since fractured particles, misshaped particles or unconditioned cut wire with sharp edges or angular features will produce nonspherical impact dents or dimples. Finally, there is the matter of media residue on peened components. The most familiar example of this is ferrous contamination on aluminum components which must be removed post-peening due to rusting of the residue under moist service environmental conditions.

Notwithstanding all of the above, the best intentions and practice in media selection can be rendered ineffective if media isn't properly maintained. The left photogragh in Fig.1 is in-use cast steel media which was poorly maintained and the right photograph is well-maintained in-use media of the same type. The contrast between the two is dramatically obvious. In the right photograph, the spherical shot particles are about the same size. In the left photograph, we see widely disparate sizes of particles, misshaped particles, fractured particles and nonmedia contaminants. The well-maintained cast steel media has a better appearance than even new media which normally has misshaped particles to the extent allowed in applicable specifications. This brings into question the reason for specification requirements which allow more discrepant particles in used than in new media. If the only consequence of poor media maintenance were media with poor appearance, that would not be such a bad thing. Unfortunately, this is not the case. The truly bad consequences of poor media maintenance are inconsistency in peening results from dents of non-uniform size (confounding of intensity) and irregular shape as well as cushioning effects of dirt and nonmedia contaminants as they interfere with media impacts.



Poorly-maintained media



Well-maintained media

Fig.1

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SHOT PEENING… GETTING IT RIGHT
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We can avoid these undesirable effects by properly maintaining the media. An inline screen separator/classifier apparatus is very important. It is my opinion that one cannot claim to have a good peening process without one. An inline separator/ classifier consists of vibrating screens appropriately sized to allow passage of the proper size media and their return to the reservoir supply while letting fractured and sub-size media particles to pass through to a refuse container. As a practical matter, an inline separator will also remove a lot of nonmedia contamination as well as misshaped media particles, but removal of these can still more effectively be accomplished by an air wash device to remove low density contaminants and a spiral slide apparatus to remove misshaped (non-spherical) media.

Intensity:

The importance of selecting the best intensity for achieving a desired result of peening is illustrated in Fig.2. As easily seen from the data, an Almen intensity of 0.008A (in.) yielded greater fatigue life than peening either at lower or higher intensities. Usually the effect of intensity is not this marked, but there is generally a point reached with increasing intensity beyond which surface damage induced by peening begins to mitigate benefits attained by the induced subsurface compression. In other words, one can get too much of a good thing. Surface damage may take the form of micro laps or folds in soft materials to microcracking in hard materials. Such effects can be detected by metallographic sectioning and microscopic examination. Detection may also be possible via advanced nondestructive examination techniques which can also be employed to give intensity information. Such technology is not currently being applied to peening, but developments are occurring and may well find application in peening process control. As in the illustrated case, lower than optimum benefit may result when the peening intensity is too low. This may involve instances when intensity does not produce deep enough compression to overcome adverse residual stresses induced by prior processing or to overcome adverse applied stresses or stress gradients in service. These effects may be predicted and avoided through a judicious combination of residual stress measurement and finite element analysis based upon service loading.

Media hardness affects peening intensity. Harder media propelled at the same velocity as softer media will yield higher intensity based upon energy transfer considerations because lesser deformation of harder media upon impact means greater energy transfer to the Almen strip. Another factor influencing intensity is impingement angle whereas energy transferred varies as the trigonometric sine function of the angle. Nozzle standoff distance can also affect intensity when it increases to the point that air resistance measurably affects media velocity. Another factor influencing intensity in direct air pressure peening, though secondarily, is media flow rate. Leaner flow rates permit higher media velocity, hence higher intensity.

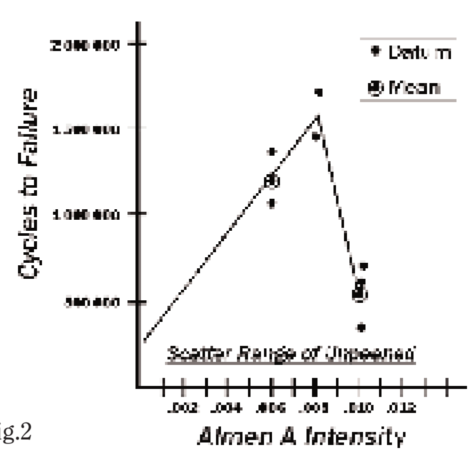

Fig.2

Finally, I must state the obvious regarding peening intensity because it is not recognized by all. All Almen intensities are arc heights, although special ones, but not all arc heights are intensities. Further, intensity can be determined only from an Almen saturation curve (arc height vs. exposure time or other time-based parameter) using multiple Almen strips (i.e. a minimum of four or five depending upon specification requirement). Almen intensity cannot be determined from a single Almen strip, and, indeed, one can easily be fooled when using one or two strips for intensity verification. Enough said on the subject of intensity!

Coverage:

From my experience in shot peening and shot peening training, I have reached two conclusions:

1. The concept of coverage, often confused with intensity, is the least understood and least appreciated aspect of peening, and
2. Most peening is performed with far too much coverage.

The former leads to misinterpretation of peening cycle times. The latter leads not only to the less than optimum benefit from peening, but also costs peening practitioners and component owners a lot of money. Peen Lean! Too much coverage may be hazardous to component health and to

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your pocketbook. Do I have your attention? Within limits on page space, I will not be able to fully develop my arguments, but I plan to do so in a future article.

Coverage up to 100% is defined as the percentage of impacted area on a component surface (i.e. the fraction of the surface area obliterated by peening dents expressed as a percentage). Beyond 100%, coverage is expressed as a multiple of the time to achieve 100% coverage. How does one determine the latter? The customary means for doing this is to peen a surface for increasing time and examine it at intervals via 10-30X magnifier until no undented areas are seen.

The really important point here is that coverage must be determined by observation of the component surface. Coverage is related to peening exposure time of the component. In general, this has absolutely no relationship to peening exposure time on Almen strips or to Almen strip saturation time. For any such relationship to exist, the component material must have the same hardness and plasticity characteristics as the Almen strip material, AISI 1070 steel. Peening specifications and methods that mathematically express component exposure time to Almen exposure or saturation time are fundamentally wrong. Coverage may be determined correctly only by observation on the component.For constant flow rate, the number of impacts in peening is linearly proportional to peening exposure time; however, coverage is not proportional. The reason is that impacts are random and each media particle does not necessarily strike a new site. Indeed, many of the sites are struck multiple times before full coverage is achieved. A plot of coverage percentage versus exposure time is a decelerating curve. In work on a medium hardness alloy steel performed by the author and Prevey, 80% coverage was attained in about 0.20 fractional time and 90% coverage in about 0.40 fractional time[1]. The residual stress distributions shown in Fig.3 indicated that the full residual stress benefit from peening was attained after 0.20 fractional time and did not change much from that point up to 400% coverage. Moreover, as shown by the S-N curves in Fig.4, the fatigue strength for 0.20T coverage was the same as for full coverage and was less for 300% coverage. The absolute differences in coverage time from 80% coverage to full coverage was more than three minutes and to 300% coverage was about 11 minutes. Similar results were obtained in work on nickel-base alloy

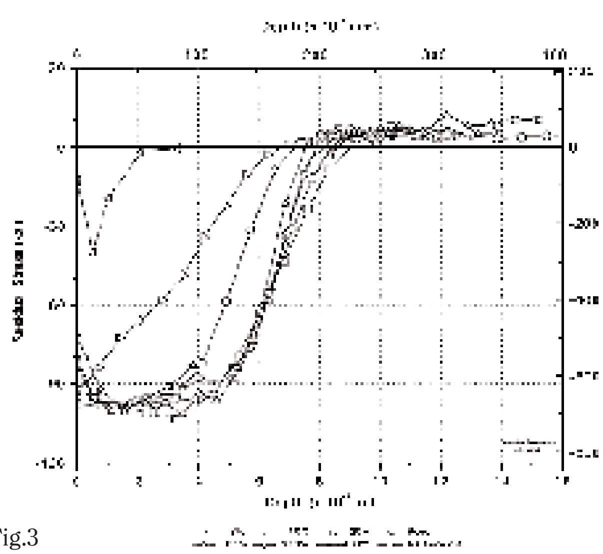

Fig.3

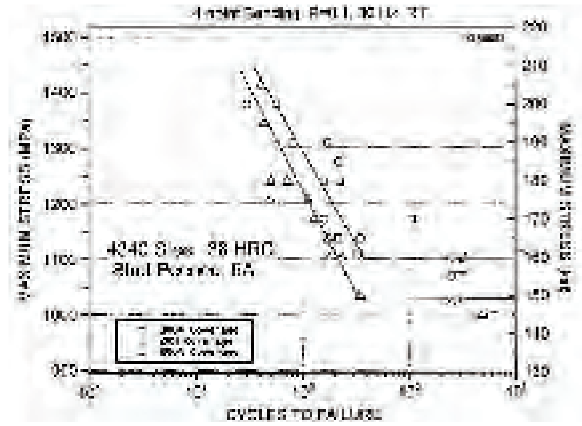

Fig.4

Inconel 718 by the author and Jayaraman[2]. A U.S. patent was recently granted based upon the referenced results.[3]

My presentation of these results doesn't mean that I'm pushing peening at coverage levels significantly less than full coverage, though it is possible with care and good process control in general and excellent flow control specifically. The associated cost benefit in reduction of cycle time in a production environment is obvious. For others, I recommend that full coverage or approximately so is all the coverage needed. Peening to coverage greater than 100% is not only a waste of time and money, it is also destructive of equipment and produces no benefit. It may also be detrimental to component quality and durability. I am planning a future article that will treat the subject in much greater detail. In the interim, I urge you to Peen Lean!

Summary:

Peening performed correctly with due heed for the basics will provide reliable benefits to components, mitigate risk of component failure and save money in doing so. Peen Lean! Do you need more argument than this? If you agree with me, then get on with things with my best wishes for your success. If you do not agree, then we need to talk. Call or email me; contact information is provided below.

References:

1) P. Prevey & J Cammett, ICSP8:
2) J. Cammett & N. Jayaraman, ICSP9
3) P. Prevey and J. Cammett, Patent US 7,159,425, B2, Jan 9, 2007.

John Cammett Dr. John Cammett, Materials Engineer/ Metals Branch Chief, recently retired after more than 15 years service with the U.S. Navy (Navair) in the In Service Support Center to the Fleet Readiness Center East, Cherry Point, North Carolina. His more than forty-year professional career has also included materials engineering and management positions at the General Electric Company, Evendale, Ohio; Metcut Research Associates Inc. and Lambda Research Inc, Cincinnati, Ohio. His areas of expertise at Cherry Point included analysis of aircraft component failures, aircraft mishap investigations, development of repair/rework process methods and technical support of depot manufacturing/r ework/repair operations, surface integrity investigations and metallurgical applications. A Registered Professional Engineer, Dr. Cammett is a fellow of ASTM, past Chairman of Committee E-9 on Fatigue, Life Member of ASM International and past chairman of the Cincinnati Chapter, also a member of the International Scientific Committee for Shot Peening and a conferee of the 2006 Shot Peener of the Year Award. In "retirement", Dr. Cammett is currently involved in training and consulting activities with Electronics Inc., Nadcap auditing plus other research and consulting activities in the private sector. Dr. Cammett may be contacted via cell phone at 1-910-382-5771 or email at pcammett@ec.rr.com.

Why Certify Test Sieves?

by Terry Reckart

As a significant player in the growing shot peening industry, you should be asking yourself a very straightforward question about your quality control process. The answer is becoming more pertinent each day.

Do I certify my test sieves and validate the performance of my shaking device?

If you do, keep up the good work. If you don't, here is why you should. If you are using your sieves to determine whether product, incoming material, media, etc., is good or bad based on the results obtained by sieving, then your sieves are instruments and must be in your instrument calibration program. Organizations that perform site audits such as Nadcap and FAA are becoming increasingly aware of the need to have sieves in the calibration program and are looking to insure that they are. Likewise, if your organization has an active management program such as ISO 9001-2000 or any of the various automotive or aerospace programs, then your sieves and shaking device(s) need to be part of your calibration program.

Do not be misled into thinking that your new sieve with its serialized "Certificate of Compliance" is calibrated, it is not. To be "calibrated" the instrument must have traceability back to a national standard such as NIST. To achieve this traceability, an additional cost per sieve is paid resulting in a "pedigree" for the individual sieve with traceability back to a national or international standard. When sieves are certified, they are done so to a standard. There are two major standards to which sieves are Verified/Calibrated. These standards are ASTM E-11 (USA) and ISO 3310-1 (International). Your individual instrument calibration program should recognize one of these standards as the governing document for the Verification/Calibration of your sieves. The use of one of these documents should be specified on any purchase order being placed for sieve certification with an outside firm.

Have you verified the performance of your sieve shaking device? Often overlooked but of vital importance for achieving valid, consistent sieving results are the operating parameters of the sieve shaking device used. Although there are no national standards governing the monitoring and adjustment of these parameters, each equipment manufacturer sets up the equipment to operate within a given set of parameter such as taps per minute, oscillations per minute, hammer height, amplitude, etc. You should determine what the manufacturer's operating parameters are for your given equipment and monitor your device in these areas. When it is noticed that the equipment is no longer within the manufacturer's parameters, the equipment should be overhauled or replaced.

In parting, please remember that the sieve that you tossed into the corner after the last time you used it is an instrument and should be treated as such. When the cloth becomes loose, replace the sieve. When the cloth separates from the frame or tears, don't try to repair it, replace the sieve. The lowly sieve is probably the least expensive instrument you have, but arguably one of the most important in your arsenal of instruments.

Terry Reckart is the president and founder of OSB LLC Sales & Consulting. During his career, he has served in the United States Navy, was employed by several major engineering firms as a Startup Engineer and has been self-employed as an independent technical writer. From 1995 until June 2005 he was the Quality & Technical Manager for a major sieve and wire cloth manufacturer where he pioneered the use of modern optical imaging devices to certify/calibrate test sieves. Today he is recognized as an authority on particle sizing using mechanical and optical measuring techniques. He has been a speaker at shot peening symposiums for many years providing his expertise in peening media analysis. You may contact Mr. Reckart by phone: 440-466-4102 or by email at osbllc@adelphia.net.

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The Marketing of Barkhausen Noise Analysis

by Michel Cardon

Twenty years ago, I read about a group of Finnish scientists who concentrated on an obscure phenomenon—Barkhausen Noise.

This phenomenon was unknown at that time, at least by those who could usefully apply it to their quality control problems. I was one of them, researching how shot peened parts could be controlled in production.

Between 1919, when Prof. Heinrich Barkhausen published his first work in a scientific magazine, and 1977, when Dr. Seppo Tiitto published results of his study relative to spectral damping of Barkhausen Noise, almost nothing happened related to this phenomenon.

Seppo Tiitto was lucky. He met a lovely blonde, Kirsti Mielityinen, at the Oulu University. They both worked on magnetic phenomenon. Happily enough for them, they appeared being of opposite polarities, so they got together, married and produced, beside a family, the first industrial quality testing system utilizing their knowledge of Barkhausen Noise.

While the main use of this instrument now is for the testing of grinding quality improvement, the initial instrument was made to test for tensile stresses appearing beyond the surface of cold rolling cylinders. When cylinders have been used for a long time, the effect of pressure in the mill, together with fatigue due to cycles of loading/unloading, can cause roll surface failures. This is extremely dangerous as large pieces from the cylinders' surface can detach and fly through the workshop.

The instrument developed by the Tiittos could detect variation in the stress condition of mill rolls without dismantling them and allow operators to stop and recondition the rolls before they became a real danger. Developed to scan a roll, they named their instrument Rollscan and it was marketed by Stresstech in Finland.

My experiences in introducing a new quality testing instrument

When I started to introduce these Barkhausen Noise Analysis (BNA) instruments, I found it was not always easy.

Most manufacturers believe their quality is very good. Introducing a new system to test for invisible or potential defects is sometimes received as a vexing proposal. As a production manager of a large automotive manufacturer put it, "Testing for quality would mean that we are not confident in our manufacturing procedure." However, this manufacturer became a regular BNA user in several of their production units.

As most Non-Destructive Testing methods (NDT), Barkhausen noise testing requires a calibration procedure. NDT is most often a relative, not absolute measurement method. Comparison with other NDTs or destructive testing calls for a comprehensive understanding of both methods and their limitations. A long, practical, daily industrial experience is a prime advantage to serve lab or production users.

Is this landing gear safe?

Selling this line of instruments sometimes called for nerves. As an example: A landing gears manufacturer asked for help. They used our Stresstech BNA instruments in production. They had an emergency: An Airbus was just back from Africa and

Barkhausen Noise Analysis

Barkhausen Noise Analysis (BNA) method, also referred to as the Magnetoelastic or the Micromagnetic method, is based on a concept of inductive measurement of a noise-like signal, generated when magnetic field is applied to a ferromagnetic sample. After a German scientist Professor Heinrich Barkhausen who explained the nature of this phenomenon already in 1919, this signal is called Barkhausen noise.

Barkhausen Noise - the Phenomenon

Ferromagnetic materials consist of small magnetic regions resembling individual bar magnets called domains. Each domain is magnetized along a certain crystallographic easy direction of magnetization. Domains are separated from one another by boundaries known as domain walls. AC magnetic fields will cause domain walls to move back and forth. In order for a domain wall to move, the domain on one side of the wall has to increase in size while the domain on the opposite side of the wall shrinks. The result is a change in the overall magnetization of the sample.

If a coil of conducting wire is placed near the sample while the domain wall moves, the resulting change in magnetization will induce an electrical pulse in the coil. The first electrical observations of domain wall motion were made by professor Heinrich Barkhausen in 1919. He proved that the magnetization process, which is characterized by the hysteresis curve, in fact is not continuous, but is made up of small, abrupt steps caused when the magnetic domains move under an applied magnetic field. When the electrical pulses produced by all domain movements are added together, a noise-like signal called Barkhausen noise is generated.

Barkhausen noise has a power spectrum starting from the magnetizing frequency and extending beyond 2 MHz in most materials. It is exponentially damped as a function of distance it has traveled inside the material. This is primarily due to the eddy current damping experienced by the propagating electromagnetic fields that Domain wall movements create. The extent of damping determines the depth from which information can be obtained (measurement depth). The main factors affecting this depth are

i) frequency range of the Barkhausen noise signal analyzed, and

ii) conductivity and permeability of the test material.

Measurement depths for practical applications vary between 0.01 and 1.5 mm.

Barkhausen Noise - the Properties

Two important material characteristics will affect the intensity of the Barkhausen noise signal. One is the presence and distribution of elastic stresses which will influence the way domains choose and lock into their easy direction of magnetization. This phenomenon of elastic properties interacting

Continued on page 20

Continued from page 18

because of very hard landing conditions, it was necessary to test for compressive residual stresses on gear main tubes. Compressive stresses, induced by shot peening, protect the high strength steel part against stress corrosion failure, but compressive strength can be relaxed by high temperature due to emergency braking or by excessive fatigue. The manufacturer needed to decide whether to let the Airbus leave with same landing gear, or change parts. The first option was faster and economical, but was it safe? The second option, to change parts, was safe, but long and costly.

With BNA, my crew found static electricity charges on the aircraft body. Their operator couldn't read stable measurement values. We grounded the BNA instrument and the landing tubes together with a piece of wire, and this eliminated the effect of static charges. When the instrument and gear tube where grounded together, measurements became stable. Gear was judged good for service, and customer's return-on-investment was excellent!

The case of the musical NDT instrument

Sometimes, BNA is quite surprising. In an aerospace hydraulic components factory, in the centre of France (Vierzon), we could hear faint music coming from our BNA instrument. The customer was not surprised…they were located a short distance from a powerful radio station, France Inter. They were used to hearing the radio station in every electrical component, from telephones to electric shavers!

Nomenclature can also have interesting consequences. People suffering from fatigue and stress would call us in response to our promotion of BNA— a product that tested for stress—in hopes we would have a remedy for them.

Sample testing mishaps

Suitability of a sample can also cause confusion. A ball bearing manufacturer had stress problems in rings. They wanted to compare analysis methods. So they merely cut a ring in two, and sent half to each supplier. Of course, after cutting the ring, its stress conditions had very little to do with original problem. Obviously, there is still a strong division between what is taught in scientific circles and the problems faced daily on the shop floor. Similar to the shot peening industry, continuous information from conferences, seminars, and dedicated magazines on NDT are surely excellent ways to fill this gap.

With the high demand for improved quality of mechanical components, fields of application for Barkhausen Noise and micromagnetic testing systems have grown to a highly used Non-Destructive Testing method for most steel part manufacturers worldwide.

Should you wish to learn more about BNA, may I suggest you look into ICBM conferences? For information on the upcoming International Conference on Barkhausen Noise and Micromagnetic Testing ICBM 6 in France, visit www.icbmconference.org.

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.

Barkhausen Noise Analysis con't.

with domain structure and magnetic properties of material is called a "magnetoelastic interaction". As a result of magnetoelastic interaction, in materials with positive magnetic anisotropy (iron, most steels and cobalt), compressive stresses will decrease the intensity of Barkhausen noise while tensile stresses increase it this fact can be exploited so that by measuring the intensity of Barkhausen noise the amount of residual stress can be determined. The measurement also defines the direction of principal stresses.

The other important material characteristic affecting Barkhausen noise is the micro-structure of the sample. This effect can be broadly described in terms of hardness: the noise intensity continuously decreases in microstructures characterized by increasing hardness. In this way, Barkhausen noise measurements provide information on the microstructural condition of the material.

Barkhausen Noise Analysis - the Applications

Many common surface treatments such as grinding, shot peening, carburizing and induction hardening involve some modification of both stress and microstructure and can be readily detected using the method. Various dynamic processes such as creep and fatigue similarly involve changes in stress and microstructure and can also be monitored with Barkhausen noise.

Practical applications of the magnetoelastic Barkhausen noise method can be broadly divided into three categories:

- Evaluation of residual stresses; provided microstructural variables can be reasonably controlled.
- Evaluation of microstructural changes; provided level of stress can be reasonably controlled.
- Testing of the following surface defects, processes and surface treatments that may involve changes in both stresses and microstructure:
  - Detection of grinding defects and grinding process control
  - Detecting surface defects through Cr-coating
  - Evaluation of shot-peening effect in steel
  - Measurement of residual surface stresses in steel mill rolls and steel sheet

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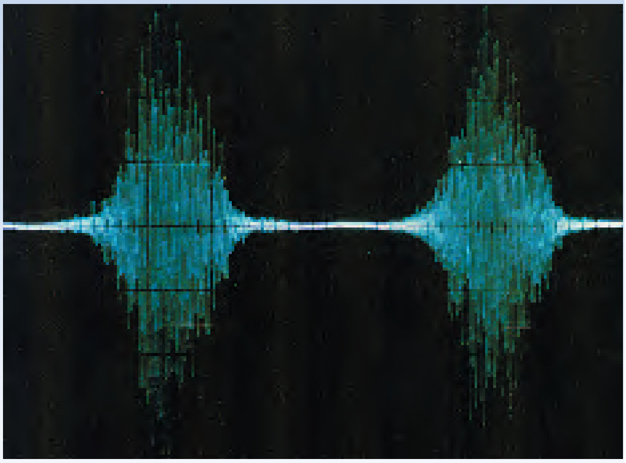

Oscilloscope image of the Barkhausen Noise measured with Rollscan instrument. (Image courtesy of Stresstech Group)

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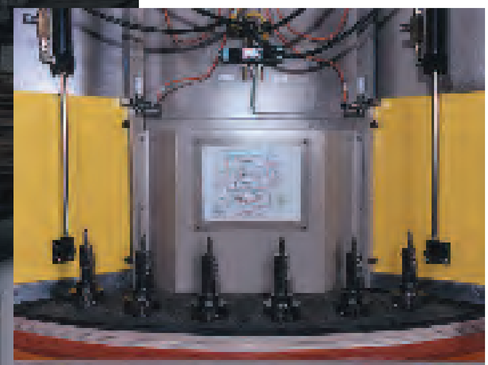

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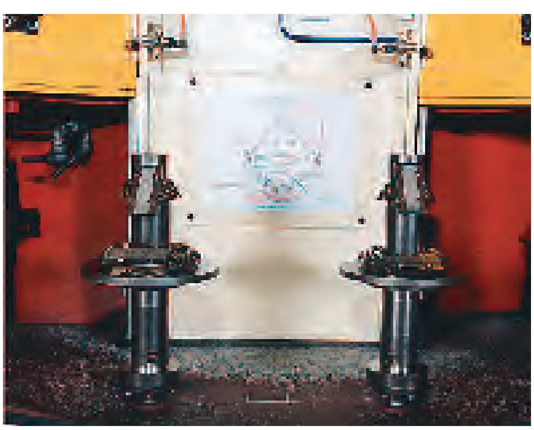

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Generation of Wheel-Blast Shot Velocity by David Kirk

INTRODUCTION
Shot velocity is of primary importance because it governs the kinetic energy of the impacting shot and hence the peening intensity. Wheel-blast shot acceleration is much more energy-efficient than air-blast shot acceleration – which accounts for its continued appeal. A variety of wheel types have evolved but the mechanics involved are generally similar. Normally, blades attached to a rotating wheel throw shot at components. Shot velocity is achieved in two stages: accelerator drum and throwing blades. Particles are fed into peripheral slots formed between the accelerator and a stationary control cage. Centrifugal force keeps the particles pressed into the slots as the accelerator drum rotates. At this stage the shot particles have the rotational velocity of the drum. When a slot reaches the outlet slot in the control cage some shot particles escape onto a throwing blade for the second stage of acceleration, see fig.1.

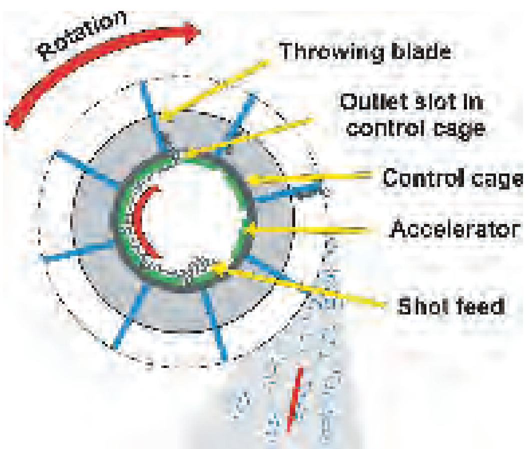

Fig.1 Wheel-blast system with 'open' throwing blades.

This article is an account of the mechanics involved in generating the final shot velocity. Equations are presented that allow estimates to be made of the thrown shot velocity, direction and angular range when leaving the wheel. These equations accommodate the variations in wheel speed and diameter, blade length, number of blades and control cage that occur with different wheel designs.

It is shown that the radial velocity is a large percentage of the tangential velocity. The ratio of radial/tangential velocity determines the direction of individual thrown shot particles.

ACCELERATOR DRUM
Shot particles trapped in a slot, immediately achieve the drum's peripheral velocity. They are then being acted upon by two forces: centrifugal and gravitational. The gravitational force, F_g, will vary from $+m.g$ to $–m.g$ (where m is the mass of the particle and g is gravitational acceleration) as the drum rotates. At the bottom of each rotation $+m.g$ is acting in an 'outwards' direction whereas at the top we have $–m.g$ (gravity is then pulling the particles in an 'inward' direction). The centrifugal force, F_C, is given by:

$$F_C = m.V_D^2/R \qquad (1)$$

where V_D is the tangential velocity of the drum and R is the distance of the slot from the axis of drum rotation.

The total outward force on a particle, F_{OUT}, is given by:

$$F_{OUT} = F_C + F_G \qquad (2)$$

The relative magnitudes of F_C and F_G are of obvious importance. If, for example, we have an accelerator drum of 100mm radius rotating at 50 r.p.s. then V_D is some $31.4 m.s^{-1}$. Using this value in equation (1) gives F_C as $9870\ m.s^{-1}$ so that (2) gives:

$$F_{OUT} = m(9870 \pm 9.8)ms^{-2} \qquad (3)$$

It follows from the value given in (3) that gravity is a negligible factor (0.1%) and can therefore be ignored for estimation purposes. Conversely, we must note that particles are being pressed against the control cage surface with an enormous centrifugal force. They are also being scraped along that surface at high speed. This combination of high force and high speed imposes very severe wear regimes on both particles and drum surface. Finally, when the particles reach an exit slot, they burst out with an acceleration about a thousand times that of normal gravity.

THROWING BLADE
When a shot-filled slot reaches the outlet slot of the static control cage some of the shot particles exit onto a throwing blade carried on a rotating drum. This 'cohort' of shot particles now immediately adopts the inner tangential velocity of the throwing blade.
The cohort of particles is now under immense centrifugal radial acceleration, forcing it along the blade. When the particles reach the tip of the blade they are flung off to form a shot stream. At the tip of the blade each particle being flung off will have two velocity components, V_T and V_R. These are vectors which combine to give the particle velocity, V_S, as illustrated in fig.2. V_R is the radial velocity induced by the centrifugal acceleration and V_T is the tangential velocity (which is equal to the rotational velocity of the blade tip).

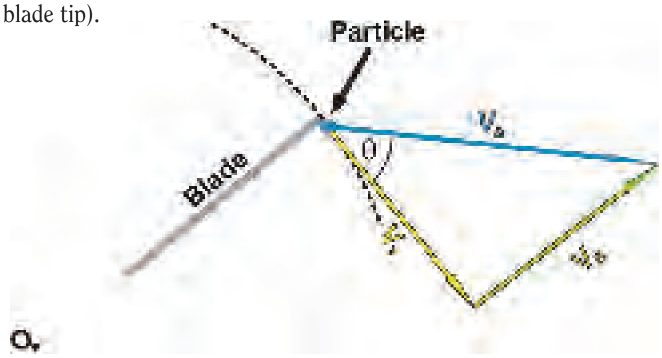

Fig.2 Individual particle leaving blade tip with vector-combined velocity, V_S.

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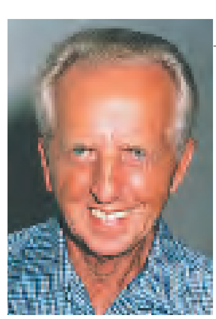

Dr. David Kirk, our "Shot Peening Academic", is a regular contributor to The Shot Peener. Since his retirement, Dr. Kirk has been an Honorary Research Fellow at Coventry University, U.K. and is now a member of their Faculty of Engineering and Computing. We greatly appreciate his contribution to our publication.


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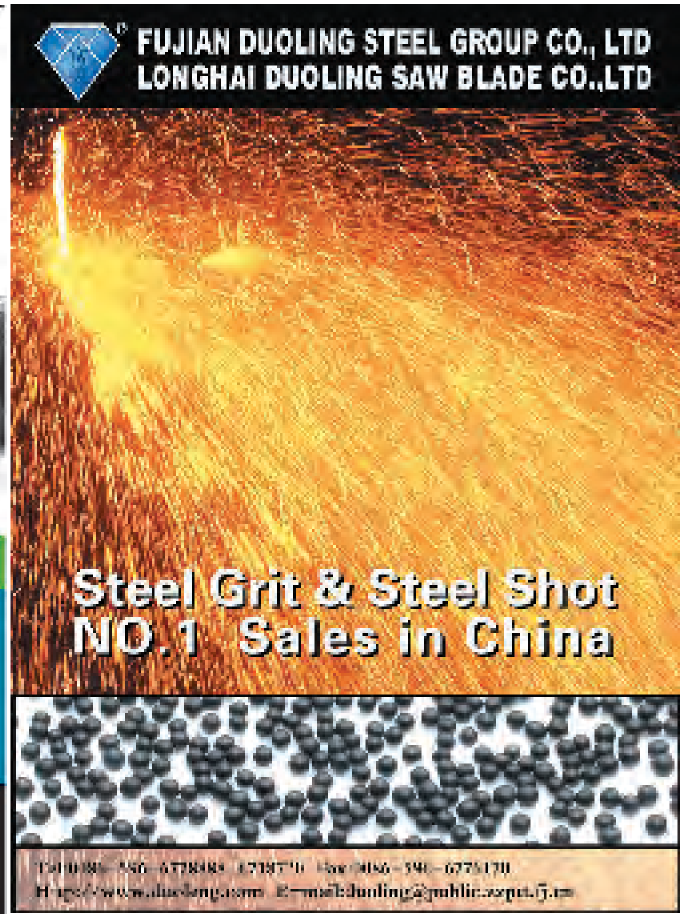
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Continued from page 24

The values of V_T and V_R determine both the velocity and movement direction, **θ**, of the thrown shot particles. Tangential velocity, V_T, is quite easy to estimate, whereas the radial velocity, V_R, requires the application of physical principles (and some simplifying assumptions).

TANGENTIAL VELOCITY COMPONENT, V_T.
Consider a single blade of length, **L**, rotating about an axis, **O**, such that the tip sweeps a radius, **R**, as shown in fig.3. The shot particle at the tip of the blade is being pushed by the blade with a velocity, V_T, as it leaves the blade. We can assume that the blade is rotating about the axis at a known, fixed, number of revolutions per second, N r.p.s. (= r.p.m./60). Now since velocity equals distance/time we know that in one 360° revolution the tip of the blade will have travelled a distance π.2R, the circumference of the circle. We multiply that circumference by the number of r.p.s., **N**, to give the required value of V_T as:

$$V_T = 2\pi.R.N \qquad (4)$$

As an example, if R = 0.250m and N = 50 r.p.s. then V_T = 78.5m.s^{-1}

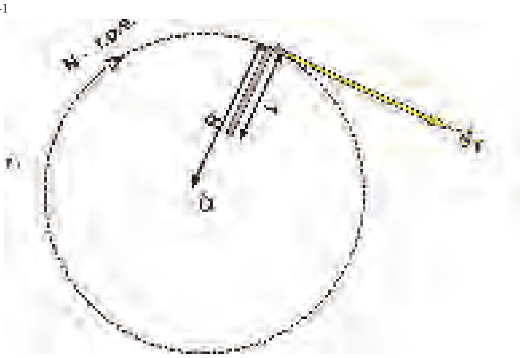

Fig.3 Generation of tangential velocity, V_T.

It is important to note that the tangential velocity, V_T, is constant for all of the particles thrown from the tip of a given 'open' blade rotating at a fixed rate.

RADIAL VELOCITY COMPONENT, V_R.
Shot particles emerging from the accelerator drum come into contact with a rotating blade at a point where it has a tangential velocity, V_A, see fig.4. Tangential velocity, v_x, at any distance, **x**, from a centre of rotation induces a centrifugal acceleration, a_x, given by the equation:

$$a_x = v_x^2/x \qquad (5)$$

where **x** is any notional distance from the centre of rotation, **O**.

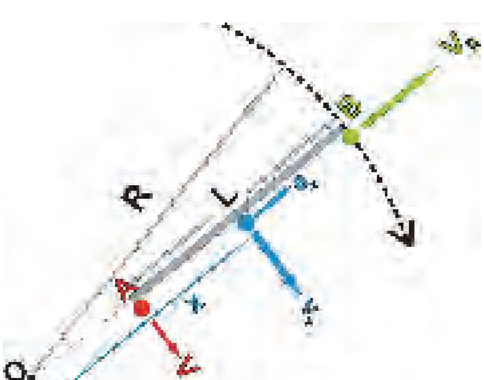

Fig.4 Velocities and acceleration of particle on blade AB.

This is the basic centrifuge principle. Note that lower case is conventionally used for values that vary, such as v_x, as opposed to upper case (capitals) for fixed values - such as V_A and V_R.

The acceleration of shot particles *along* the throwing blade will vary from $V_A^2/(R-L)$ at A to V_B^2/R at B. Estimation of the velocity of particles under *constant* acceleration is simple - as compared to when varying acceleration is involved. With variable acceleration we have to invoke integral calculus. Fortunately the calculus required is not difficult.

If we plot radial velocity, v, against radial velocity, v, from 0 to V_R, we have a straight line relationship. The triangular area under that straight line is $V_R^2/2$ (half the base times the perpendicular height). Expressing that in integral calculus notation we have that:

$$\int_0^{V_R} v.dv = V_R^2/2 \qquad (6)$$

Now **v.dv = dv(dx/dt) = (dv/dt).dx = a_x.dx**. We know that $a_x = v_x^2/x$ and that $v_x = 2\pi N.x$. Hence, **v.dv = a_x.dx =$(2\pi N)^2$.x.dx.** Equation (6) can therefore be re-written to give:

$$(2.\pi.N)^2 \int_{R-L}^{R} x.dx = V_R^2/2 \qquad (7)$$

The $(2\pi N)^2$ factor appears outside the integration symbol because it is a constant quantity. Integration of **x.dx** gives $x^2/2$ so that (7) yields the important relationship:

$$V_R^2 = (2\pi N)^2(2.R.L - L^2) \text{ or } \qquad (8)$$
$$V_R = 2\pi N(2.R.L - L^2)^{0.5}$$

Note that raising to the power of 0.5 is the same as taking the square root. For a given bladed wheel, **R** and **L** are fixed, known, quantities – for example 0.25m and 0.15m. Substituting those values into equation (8) gives that **V_R = 1.44.N.** V_R is a linear function of wheel rotation speed, N, for a given bladed wheel. For N = 20 r.p.s., R = 0.25m and L = 0.15m then V_R = 28.8 m.s^{-1}. When N is doubled to 40 r.p.s. V_R is doubled to 57.6m.s^{-1}. The corresponding values for V_T are 31.4 and 62.8 m.s^{-1} respectively.

COMBINED SHOT VELOCITY, V_S, AND DIRECTION, θ.
The velocity for an individual particle, Vs, is obtained by combining the two contributing vectors V_T and V_R, as shown in fig.2. These vectors are at 90° to one another so that:

$$V_S^2 = V_T^2 + V_R^2 \qquad (9)$$

Using the values for V_T and V_R from equations (4) and (8) respectively, we obtain our second important relationship:

$$V_S^2 = (2\pi N)^2(R^2 + 2.R.L - L^2) \text{ or } \qquad (10)$$
$$V_S = (2\pi N)(R^2 + 2.R.L - L^2)^{0.5}$$

Equation (10) simplifies enormously for given bladed wheel values, R and L. Using, again, R = 0.25m and L = 0.15m, (10) becomes: **V_S = 2.13.N.**

The direction of V_S, θ, is obtained by knowing that:

$$\tan\theta = V_R/V_T \qquad (11)$$

Now, when $V_R = V_T$, tanθ =1, so that **θ = 45°**. *If* V_R is 0.87V_T then **tanθ = 0.87** so that **θ = 41°**. Finally *if* V_R= 0 then $V_S = V_T$ and **θ = 0°**.

EFFECTS OF BLADE/RADIUS ASPECT RATIO
The ratio of blade length, L, to wheel radius, R, can be termed the "blade/radius aspect ratio". Expressed as a percentage, commercial accelerator-fed machines have wheels with aspect

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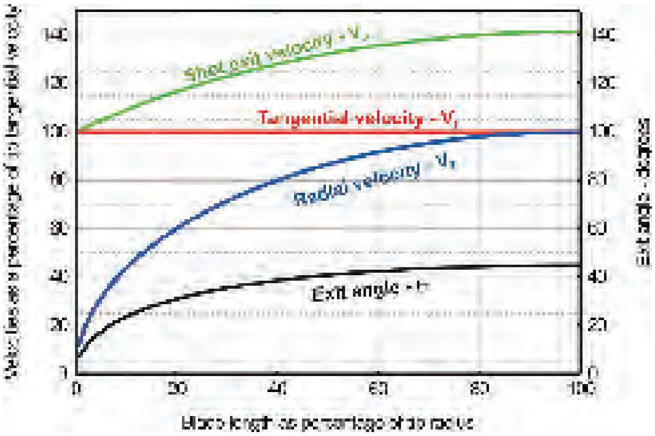

Fig.5 Effects of blade/radius ratio on induced velocities and exit angle.

ratios within a range of 30 to 70. The ratio for a particular machine/wheel affects both the shot's exit velocity, Vs, and the exit angle, θ. Fig.5 illustrates the effects of aspect ratio on shot velocity components and exit angle. The curves were derived by plotting equations (4), (8), (10) and (12) against aspect ratio. Within the aspect ratio range of 30 to 70 the thrown shot velocity is predicted to vary from about 123 to 138% of the tangential velocity. The corresponding exit angle range is from 36 to 44°.

COHORT MOVEMENT

The forgoing account is based on the movement of a single particle along a rotating, open-ended, blade. Cohorts of particles escaping out of the aperture of the control cage have group features that are important.

Cohort *mass* is a simple function of the number of blades, speed of wheel rotation and mass thrown per second. For example: an eight-bladed wheel rotating at 50 r.p.s. throws 400 cohorts per second. If we are throwing 120kg per minute that is 2 kg per second. Dividing 2000g equally between 400 cohorts gives 5g per cohort.

Cohort *number* depends on the shot size. S230 shot has an average mass of 1.48mg per particle. Dividing 5g by 1.48mg gives 3380 particles per cohort.

Cohort *volume* is mass/(density x 'packing factor'). For one solid piece volume is mass/density. A cohort of particles has a fraction of empty space between particles. For estimation purposes we can assume that the 'packing factor' is 0.5 (half solid, half space). Hence 5g of steel shot with a density of 7.86 x 10-3g/mm^3 would occupy a volume of 5/(7.86 x 10^{-3} x 0.5) = 1270 mm^{-3}(1.27cc).

These estimates of the mass, number and volume of each cohort allow us to envisage the scale of cohort movement from control cage to blade tip.

Our first problem is to get the cohort out of a slot and onto a blade. **The particles in the slot have very high tangential velocity but zero radial velocity.** Fig.6 is a schematic representation of the elements involved in cohort transfer. Only a fraction (shown blue) of the particles pressing in an accelerator slot will escape as it passes the exit slot. The remainder (shown yellow) will be carried past the exit slot to be subsequently 'topped up'. This remainder, being under enormous centrifugal acceleration, helps to push shot particles out of the slot. The cohort of particles that does escape is collected by the throwing blade. The collected particles are then subject to the radial acceleration described previously. It is also noteworthy that the time available for the cohort to exit is of the order of a thousandth of a second.

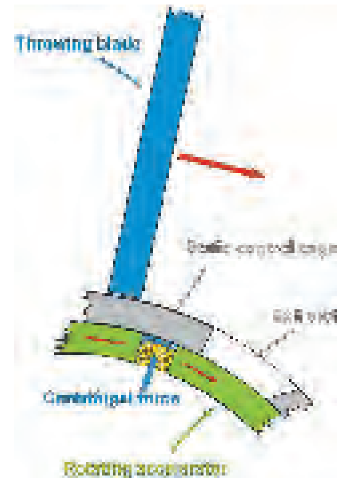

Fig.6 Elements involved in shot cohort transfer to throwing blade.

With an eight-slot, 200mm diameter, accelerator the slots will be of the order of 10mm wide by 50mm across. This *area* of 500mm^2 contains a cohort *volume* of the order of 1000mm^3. It follows that each cohort is about 2mm deep. S230 shot has a diameter of about 0.7mm so that an S230 cohort is a layer about three particles deep. This layer reaches the outlet slot just before the blade root - in order to give time for the escaping shot to exit onto the blade face. Synchronisation of slot, outlet and blade is vital for effective wheel blast operation.

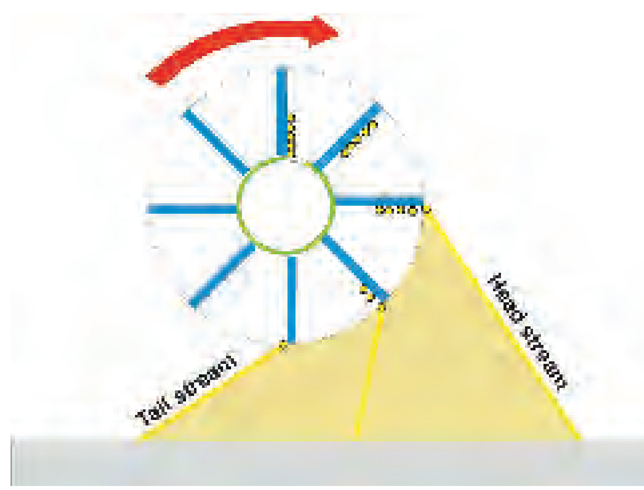

Fig.7 Schematic representation of shot cohort movement positions.

Fig.7 is a schematic representation of the several significant positions of a shot cohort. The shot particles exit onto the throwing blade at slightly different times. This means that there will be an initial cohort spread along, as well as across, the blade. A blade 50mm wide by 150mm long has an area of 7,500mm^2. It follows that a cohort of, say, 3,500 S230 shot particles will be present, on average, as a monolayer. The radial spread will increase as the cohort moves towards the blade tip. That is because centrifugal acceleration increases towards the blade tip - so that the leading particles are travelling faster than those at the rear. The time taken for the first particle to travel from the exit slot to the blade tip determines the position of the head stream and that for the last particle determines the position of the tail stream.

The time difference (between first and last thrown particles) determines the angular range over which the cohort is thrown for a given wheel speed.

Continued on page 30


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Continued from page 28

TIME FOR SHOT TRAVEL

The time, T, needed for an individual shot particle to travel the full length, L, of a blade is given by:

$$T = L / V_{AVR} \qquad (12)$$

where V_{AVR} is the average radial velocity.

Radial velocity, v_{RX}, varies with distance, x, along the blade according to the equation:

$$v_{RX} = 2\pi N[x^2 + 2x(R - L)]^{0.5} \qquad (13)$$

The average radial velocity, V_{AVR}, is obtained by integrating equation (13) over the length of the blade and then dividing that 'area' by L:

$$V_{AVR} = \frac{2\pi N}{L}\int_0^L [x^2 + 2x(R - L)]^{0.5} \qquad (14)$$

Substitution from equation (14) into equation (12) gives:

$$T = L^2 / [2\pi N \int_0^L [x^2 + 2x(R - L)]^{0.5} dx] \qquad (15)$$

If L = R. Equation (15) simplifies enormously when L = R to give T = 1/(πN). One revolution takes a time 1/N so that T is always 1/π of a revolution – about one-third. Referring to fig.7 that is equivalent to the first particle joining a blade at about 11 o'clock and being thrown off at 3 o'clock. If, for example, n = 50 r.p.s then T = 1s/50π or 0.0064s.

Generally L is substantially less than R, so that equation (15) has to be solved 'as is'. Two solution routes are available. The first route is to use a mathematical software program, such as Mathcad, which will solve the integral iteratively and do the necessary arithmetic automatically. The second route is to invoke the very complex integral calculus solution of the integral. Both routes give identical answers. T reduces progressively with decrease in blade length, L. T/N is the fraction of a revolution during which the leading particle travels along the blade and is independent of the wheel radius. Table 1 shows how T/N varies with blade aspect ratio, L/R. The highlighted 60% ratio is typical for commercial wheels with a corresponding one-sixth of a wheel revolution.

DISCUSSION

This account has concentrated on the two components of thrown shot velocity – tangential and radial velocities, V_T and V_R. The thrown shot velocity, V_S, will have a *minimum of* V_T and a *maximum of* $V_T.\sqrt{2}$. The maximum would require that $V_R = V_T$, which in turn requires that the throwing blades have the same radius as that of the wheel. The tangential velocity component is an easily-predictable, stable, factor whereas the radial velocity component depends upon the ratio of blade length to wheel radius and on other factors. Predicted times for shot to travel along the blades explain both the need for pre-positioning of the control cage exit slot and why there is an angular spread between the exiting of first and last particles in a given 'cohort'.

The equations presented for radial velocity and time for shot travel have assumed that *all* of the centrifugal acceleration is converted into shot movement. 100% conversion would require that there is no air resistance as particles travel along the blades and no particle/blade friction. Both air resistance and friction are present. The radial velocity component will, therefore, be somewhat lower than the theoretical prediction. Measurements of exit velocity and direction, together with analysis of manufacturers' data sheets, indicate that an empirical correction factor of 0.8 would reasonably accommodate air resistance and friction effects.

All of the radial velocity component will be lost if caging around the blades extends beyond the head stream position for an open wheel. That would also mean a substantial reduction in shot velocity and hence kinetic energy, $\frac{1}{2}mv^2$, for the corresponding fraction of the thrown shot particles.

It has been shown that the cohort of particles leaving an accelerator slot is only a few layers thick. The angular range over which particles leave the tip of a given blade depends largely on the time difference between the arrival at the blade base of the first and last particles of the cohort. That time difference is proportional to the length of the control cage exit slot. Before reaching the control cage exit the particles are being rotated against the control cage at high speed and with enormous force–leading to severe wear problems for shot, accelerator and cage.

The fact that centrifugal acceleration increases towards the blade tip means that particles are increasing their separation distance as they travel along the blade. That increases the validity of calculations based on the movement of individual particles.

Table 1

Fraction of wheel revolution during single particle transfer along blade.

Blade aspect ratio, L/R - %	Revolution fraction, T/N
10	0.055
20	0.081
30	0.104
40	0.126
50	0.148
60	0.172
70	0.199
80	0.229
90	0.267
100	0.318 (=1/π)

2007 Shot Peener of the Year Nomination Form

Do you have a co-worker or work associate that deserves recognition as the 2007 Shot Peener of the Year? This is your chance to submit a nomination. Criteria for this award includes:

- Advancement of the understanding of shot peening through education, research or publication
- Development or advancement of a shot peening process, product or service that benefits the shot peening industry and society

Nominee Information

Name

Company or University

Telephone Number

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Reason your nominee deserves recognition as a Shot Peener of the Year:

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Nominations are due by Wednesday, August 1, 2007.
Nominations will be reviewed by The Shot Peener staff.

Mail or fax the form to:

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Shot Peening Control

The Curve Solver Program

Graphs Almen saturation curve and provides value of intensity

by Jack Champaigne

The introduction of the 10% rule in 1984 by the SAE was the first mathematical approach to determine intensity from the saturation curve. As I discussed in my article in the winter Shot Peener, the 10% rule helped undo the confusion created by earlier SAE documenation regarding saturation, coverage and intensity. However, plotting a saturation curve to meet the 10% rule is laborious and prone to inaccuracies. Thankfully, computer-based curve-fitting procedures are now almost universally available. They offer several advantages over manual procedures including speed and objectivity.

Electronics Inc. is pleased to be representing the Curve Solver program designed by Dr. David Kirk. This Curve Solver has several advantages over other products of its kind: It was developed by Dr. Kirk, one of the greatest researchers in the shot peening industry, it's available in 12 versions, it is very easy-to-use and comes with a comprehensive reference manual sent directly to users via email, and it is FREE!

The program is easy-to-use since it is based on the popular spreadsheet program "Excel" from Microsoft. A built-in feature, called "solver" is used to fit a smooth curve to the arc height data and then compute a value for intensity. The lower and upper peening tolerances can also be displayed in the graph as shown on page 36. Shown below are the available versions.

We didn't need proof that no one likes to plot saturation curves, but here is a telling statistic: We have received 603 requests for Dr. Kirk's Curve Solver. To get your free copy, go to www.shotpeener.com/learning/solver.htm.

SATURATION CURVE SOLVER PROGRAM SUITE

Program Type	Equation	Program No.	File Name
Standard	EXP2P	1	SC S1 S EXP2P vers.06.xlt
	2PF	2	SC S2 S 2PF vers.06.xlt
	EXP3P	3	SC S3 S EXP3P vers.06.xlt
Comparator	EXP2P	4	SC S4 C EXP2P vers.06.xlt
	2PF	5	SC S5 C 2PF vers.06.xlt
	EXP3P	6	SC S6 C EXP3P vers.06.xlt
Flapper - 3M	EXP2P	7	SC S7 FL3M EXP2P vers.06.xlt
	2PF	8	SC S8 FL3M 2PF vers.06.xlt
	EXP3P	9	SC S9 FL3M EXP3P vers.06.xlt
Flapper - BG	EXP2P	10	SC S10 FLBG EXP2P vers.06.xlt
	2PF	11	SC S11 FLBG 2PF vers.06.xlt
	EXP3P	12	SC S12 FLBG EXP3P vers.06.xlt

NOTES:

Program Type

- "Comparator" programs have the added feature of being able to superimpose another curve on a chart for comparison purposes.
- "Flapper" programs allow for automatic correction of measurements according to either the "3M" or "Boeing" recommended procedures.

Equation

- "EXP2P" is a two-parameter exponential equation,
- "2PF" is the French Specification two-parameter equation
- "EXP3P" is a three-parameter exponential equation.

File Name

- "SCS" is for Saturation Curve Solver, followed by the program number, program type and equation. "vers.06" identifies a specific version of a given program. This will change as new versions are produced (e.g. to "vers.07" in 2007).
- "xlt" is the 'file extension' which identifies the program as an Excel 'template'. When a template is used and then closed a template asks if you wish to "save". The usual procedure is to then save work as a "worksheet" with an 'xls' extension thus preserving the template unaltered for future use.

Continued on page 36

Industry News

New Products ▪ New Companies ▪ Awards ▪ Upcoming Events ▪ People in the News

Potters Industries Acquires Flex-O-Lite

Valley Forge, Pennsylvania. *Potters Industries, Inc., the international manufacturer of highway safety and engineered glass material products, announced today that it has acquired certain assets of Flex-O-Lite Inc., a leading manufacturer of highway safety marking spheres, metal finishing glass beads and high refractive index glass beads, from Jackson Products, Inc. Terms of the transaction were not disclosed. Potters is a wholly-owned subsidiary of PQ Corporation, the chemicals and engineered glass materials company.*

The combined company will offer products and services under both the Potters and Flex-O-Lite brands. "This acquisition is a real plus for Potters as it complements our strengths and will allow us to take our combined 150-plus years of industry expertise, innovation and quality products and direct that towards continued high quality service to our customers," said Scott Randolph, President of Potters Industries.

The ordering process for both companies will remain unchanged. Customers can call Potters Customer Service at 1-800-55-BEADS or Flex-O-Lite's Customer Service at 1- 800-325-9525.

About Flex-O-Lite

Flex-O-Lite has been a leading manufacturer of glass spheres used for a variety of reflective and industrial applications for over 65 years. Headquartered in St. Louis, Missouri, the company distributes its products to over 20 countries on six continents. Flex-O-Lite is a subsidiary of Jackson Products Inc., a worldwide leader in personal and work zone safety products and processes.

About PQ Corporation

PQ Corporation (www.pqcorp.com) is a leading producer of inorganic specialty chemicals and engineered glass materials. The Company conducts operations through two principal businesses: the Chemicals division, which develops, manufactures and sells silicate-based specialty chemicals, and the Potters division, which manufactures and sells highly engineered solid and hollow glass spheres. The Company's products are used in variety of applications in a diverse range of industrial, consumer and governmental end-markets. The Company operates 57 manufacturing sites in 19 countries on five continents and has one of the most comprehensive global manufacturing and distribution networks serving customers in the Company's end-markets.

ICSP 10 Abstract Deadline Approaches

Tokyo, Japan. *The 10th Annual Conference on Shot Peening will be held in Tokyo, Japan in September 2008. The deadline for Abstracts is July 31, 2007. For more information, please contact the conference office by:*

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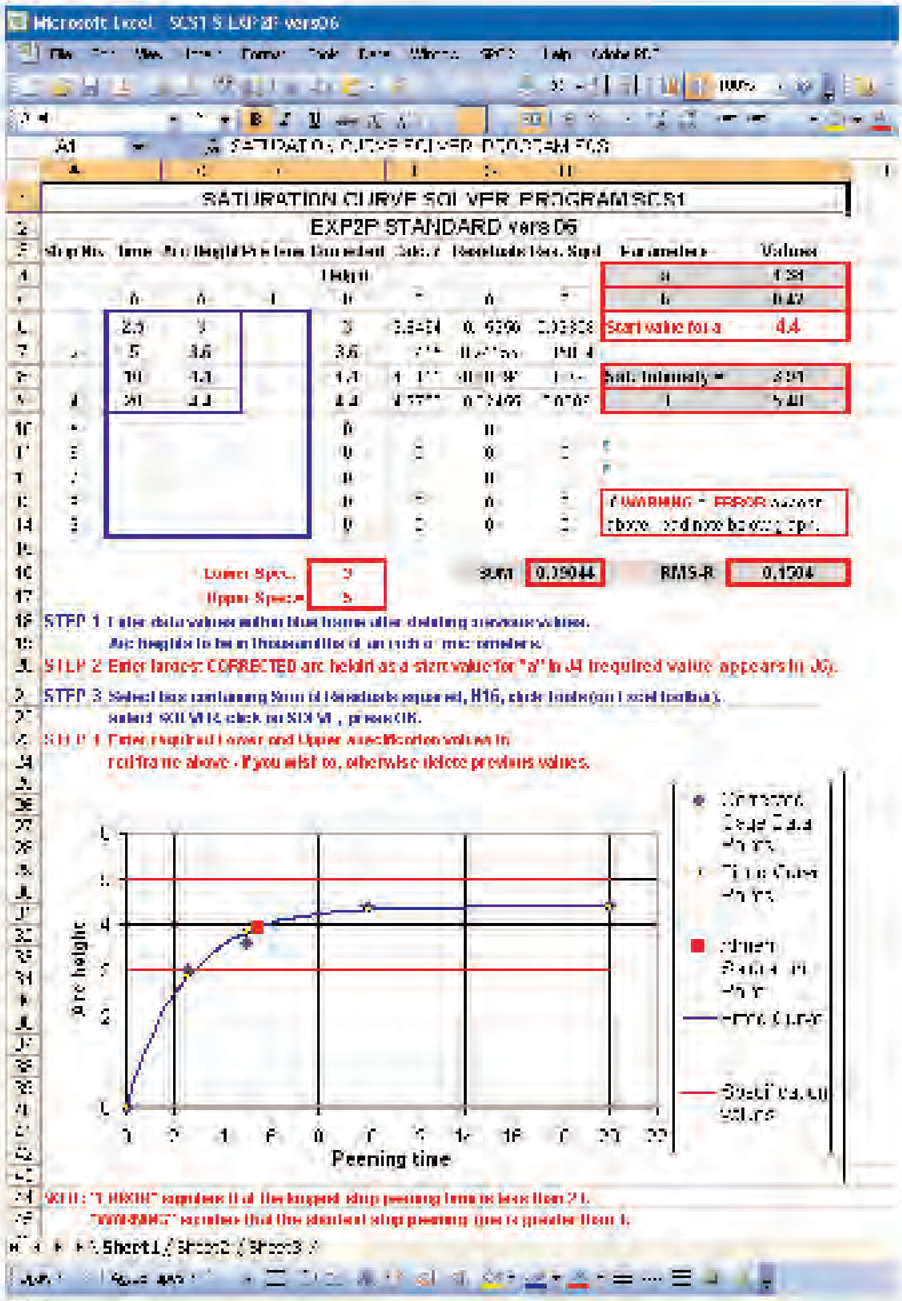


Dr. David Kirk joined Coventry University as a Senior Lecturer in Metallurgy in 1960 and rose to become Chairman of the School of Materials. Interest in residual stresses led to research into shot peening and his development of the Shot Peening Research Laboratory at Coventry University. He was Chairman of the Fifth International Conference on Shot Peening held at Oxford University in 1993, where he was elected as Chairman of the International Scientific Committee on Shot Peening. In 1996 he received their "Lifetime Achievement Award". Since his retirement, Dr. Kirk has been an Honorary Research Fellow at Coventry University and is a member of their Faculty of Engineering and Computing. He is a featured contributor to *The Shot Peener* and designer of the Curve Solver.

Jack Champaigne is Editor of *The Shot Peener* and President of Electronics Inc. (EI) Mr. Champaigne is an instructor for the EI shot peening workshops and on-site training programs. He also developed and oversees the online forums for the www.shotpeener.com web site.

Static Electricity is More Than a Nuisance to Blasting

by Herb Tobben

Though more noticeable during the dryer winter months, static build up is always an issue for blasting operations, at any time of the year. A few simple steps taken to control static electricity will produce a safer, more comfortable, and, of particular importance, more efficient blast operation.

Most of us will admit that we read the owner's manual that accompanies our new purchase only when we encounter a problem. So, worth noting here is the fact that every ZERO cabinet operation manual contains important information about the safe and efficient use of our equipment. Reading the manual and selecting the right media for your blast application are only the first steps to achieving an efficient operation.

Blasting, by definition, brings together elements that as a matter of course have materials flowing through pipes or hoses; the activity and conditions surrounding blasting generate static electricity. Dry air, essential to an efficient blasting operation, contributes to the build up of static electricity. The movement of blast media particles through hoses to the nozzle / gun, over the part being blasted, and in the recovery hose generates static electricity. Cyclone-type separators and media classifiers, where media and dust swirl over large surface area, normally generate a static charge. This charge must be continuously dissipated to prevent an accumulation of an electrostatic charge that can result in a spark. If not dissipated, in a manual blast operation, the static charge is released when the operator comes in contact with the cabinet, usually around the armhole or wherever the operator leans against the cabinet.

To keep static electricity from building to a dangerous level, which may cause a fire or an explosion, the cabinet must be connected to an earth ground. With all the components interconnected, all are at the same electrical potential.

Take care to do the job properly when grounding equipment. Connecting to a metal-frame building, water pipe or electrical conduit on the wall does not control static, as an electrical neutral-wire or third-wire ground may carry static current in certain locales. When grounding, clean and remove any paint and rust from the contact area for a good conductivity. It is prudent to consult the requirements of the National Electric Code and National Fire Protection Association Lightning Protection Code.

Ground from cabinet

Ground to earth

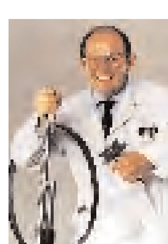
Static grounding cables must be low-resistance at or below 5 ohms of ground. For permanent installations, check the ground with an ohmmeter at least once a year. For temporary or portable installations, check the static ground at start up and again each time the equipment is moved.

To avoid getting 'zapped', even with a well-grounded cabinet, keep the part being blasted in contact with the metal grate or attach a ground clamp to the part to dissipate the charge created by the blast media exiting the nozzle and going over the part. And, not all rubber mats are created equal. If you stand on a rubber mat, make sure it is designed to dissipate static and is connected to earth ground. At the time of manufacture and assembly, all ZERO cabinets are fitted with air- and media-conveying hoses that contain a conductive material to reduce static; similarly flexible exhaust hose contains a spiral wire. The spiral wire serves two purposes. First, it keeps the hose from collapsing under vacuum, and second it helps dissipate static build-up in the hose when grounded at each end. The spiral wire is not a replacement for a ground wire to each component.

Sometimes, despite proper grounding throughout the blast equipment, a static charge can build due to the type and configuration of the part. And some parts, such as semi-conductors can be damaged by static electricity. Though overlooked by many people, clothing and the type of shoes worn by the operator can contribute to the problem. With sit-down style ergonomic cabinets, the operator may be isolated from the ground and therefore vulnerable to a static charge. Wearing conductive shoes and keeping a foot on the grounded cabinet will prevent the operator from becoming charged. Avoiding all nylon clothing is also a good idea, as nylon is an insulator.

From an operational standpoint, when static electricity is left unchecked in a manual or automated system, the static can cause media flow and separation problems. Media will cling to the cabinet walls, will hang up in the recovery hoses, and even cling to itself resulting in media flow problems. With a static charge, media may cling to the part, and negatively affect the media cleaning process as fines and broken particles will cling to the larger reusable particles.

Grounding is the key to reducing the risk of static shock and avoiding efficiency-robbing static build up throughout the blast system. Taking these extra steps makes working at the blast cabinet more comfortable for the operator and ensures the cabinet system functions at its optimum level of performance. ●



Got a question about shot peening, abrasive blasting, or sample processing? Clemco can help. Call **Herb Tobben** at 1-636-239-8172 or submit your request at online at www.clemcoindustries.com in the Contact Us section. Herb Tobben is Sample Processing Manager for the ZERO Automation product line at Clemco Industries Corp. He is a regular speaker at the Electronics Inc. Shot Peening Workshop.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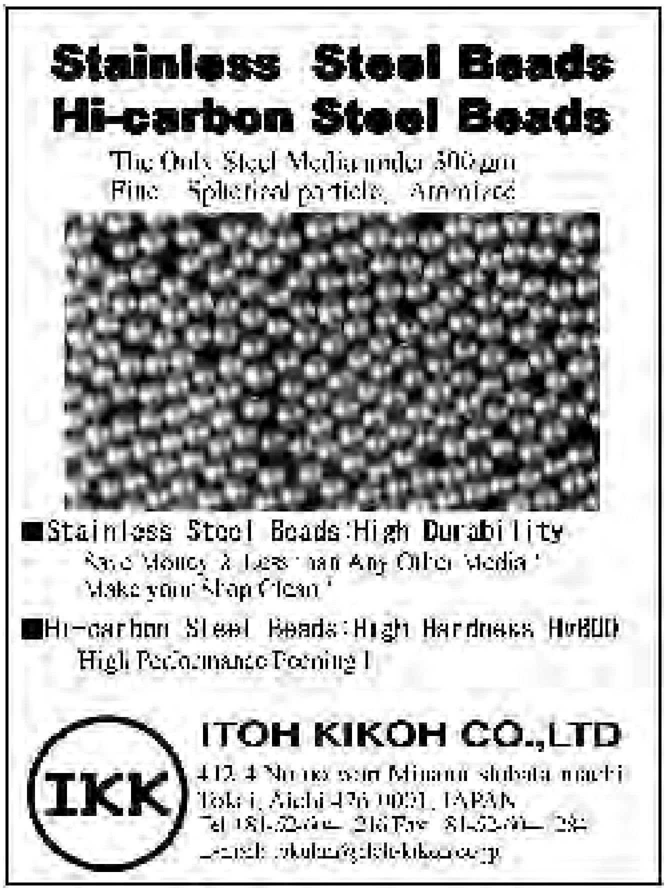

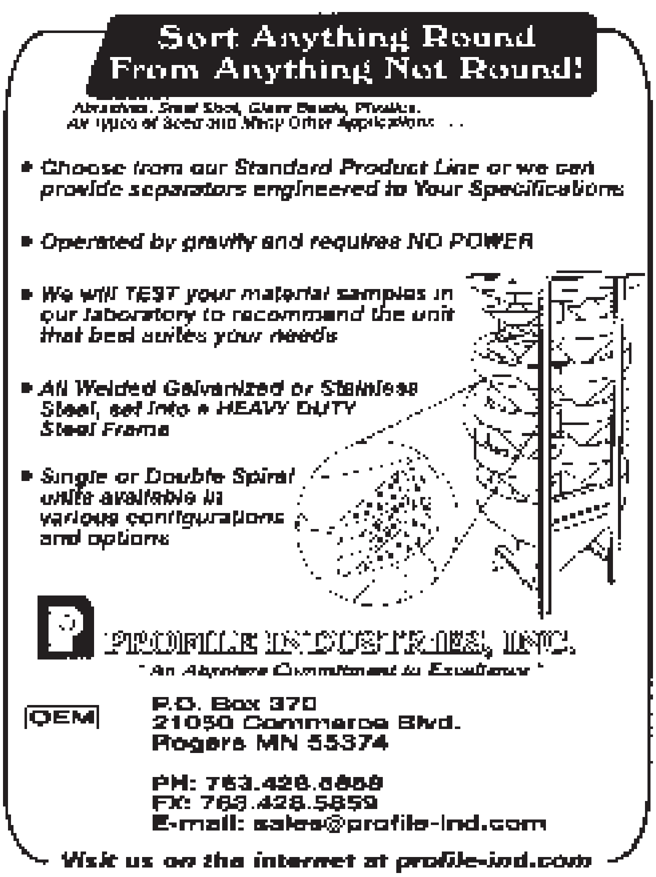

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Jack Champaigne

The best news in the industry is free!

For over 20 years, **The Shot Peener** has been dedicated to raising the awareness and appreciation for the shot peening and abrasive blast cleaning industries. Providing continuing education on industry trends, technology, environmental issues, applications and processes is what we strive for in every issue. The dissemination of free information in **The Shot Peener** and at our web site (www.shotpeener.com) has been the vehicle that has helped drive the growth of understanding of shot peening and blast cleaning processes.

We are the publisher of the magazine, but we aren't the only ones that donate time and resources to share information for the benefit of everyone. So many people have contributed articles over the years—we apologize in advance if we leave anyone out. Our most recent contributor list includes:

- Bryon Ater
- Bill Barker
- Nancy Cardillo
- Ken Decker
- Dave Eggleston
- Lloyd Hackel
- Robert Heaton
- Dr. David Kirk
- Jenny Kulikowsky
- Daryll McKinley
- David Neidig
- Terry Reckhart
- Milt Stevenson
- Dr. Katsuji Tosha
- Jean-Michel Duchazeaubeneix
- Kumar Balan
- Dr. John Cammett
- Michel Cardon
- Dan Dickey
- Axel Friese
- Jed Heastrup
- Ken I'Anson
- Jim Klomparens
- Tom Meacham
- Metal Improvement staff
- Scott Nelson
- Dan Spinner
- Herb Tobben
- Ron Wright

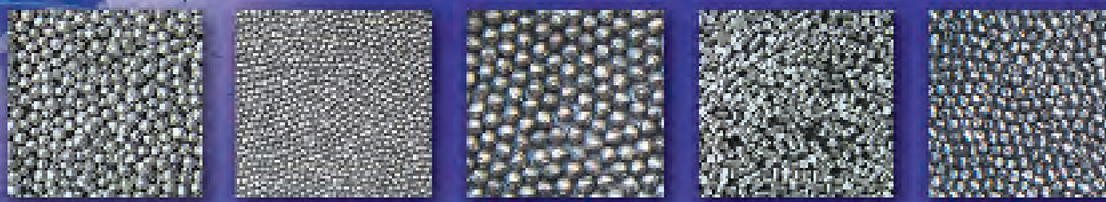
The Shot Peener always has been and always will be a FREE resource to everyone in the metal finishing industries!

The Shot Peener isn't the only free resource available to you. To date, over 600 copies of the Almen Strip Saturation Curve Solver Program have been downloaded at no charge from our web site. The program was developed and is continuously refined by Dr. David Kirk. In a conversation with Dr. Kirk, I asked him why he did not charge for the program and he said it was an "educational tool" that will help people further their understanding of intensity and saturation. Read more about Dr. Kirk's Curve Solver on page 34.

"The best news in the industry is free" has been the headline for our magazine's ad for years. It's a play on words—our goal is to promote what's **best** about our industry so that we can be a part of expanding the market for us all. Anyone in any field that picks up our magazine in your office, in your shop, or at a trade show, will be impressed with the breadth of services and significance of shot peening and blast cleaning to industry. In closing, I would like to thank all of our advertisers (see the directory on page 40) who help underwrite the publishing costs that allows us to continue to distribute the best news in the industry. Thank you to everyone that makes this possible!

大丰市大奇金属磨料有限公司

DAFENG DAQI METALGRINDING MATERIAL CO.,LTD



According to SAE J441 VDFI 8001 DIN8201 AMS 2431 MIL-S-13165C

Found in 1998 and now become the good manufacturer in the field of cut wire for shot peening and shot blasting:

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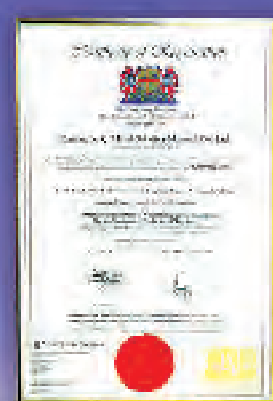
Stainless steel cut wire shot SUS304/302/430
Zinc cut wire shot
Copper cut wire shot
Aluminum cut wire shot



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