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Machine Profiling: A Guide

One definition of *profile* is a graphical or other representation of information relating to particular characteristics of something, recorded in quantified form. For example, in medicine, a doctor will review the *blood profile* of a cancer patient.

Kumar Balan outlines a *machine profile* and how it can help many of us in the industry, from machine operators to OEMs, make a solid prognosis of a machine's ability to undergo a change based on its true capabilities and limitations.

Photograph caption:
Empire Abrasive Equipment used a fully developed machine profile to add a new feature to a successful machine design. The TT-36S with robotics is the result.

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Taking a Shot at Laser Cutting

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ZF TRW Utilizes Purdue Research Team for Residual Stress Study

ZF TRW gave a research team at Purdue the challenge of finding how much room the manufacturer has in their peening process to change parameters without negatively affecting the performance of their THP60 rack pistons.

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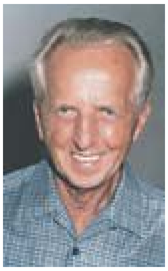
Shot Stream Generation

Our article by Dr. David Kirk concentrates on the differences between the shot stream generation of air- and wheel-blast machines and discusses possible new developments.



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Dave Barkley, EI Shot Peening Training Director and FAA Safety Team Member, brought shot peening and rotary-flap peening to aircraft enthusiasts at the 2016 EAA AirVenture this summer. Read about his presentation to recreational aircraft builders and mechanics on how shot peening can reduce fatigue cracking in custom-made aircraft parts.

EAA members and aviation enthusiasts totaling more than 550,000 from over 80 countries attend EAA AirVenture.

THE SHOT PEENER

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

Lesson Learned: The Value of a Machine Profile


JACK CHAMPAIGNE

KUMAR BALAN'S article on machine profiles reminded me of a related experience from several years ago. One of our larger customers was retrofitting an old wheel-type peening machine that had MagnaValves. I got a call from their service department asking for assistance because "our MagnaValves weren't working."

I started asking questions and decided to send a service engineer to get a better idea of what was happening. The first report I got back was discouraging. Chaos prevailed. Valves were flowing different flow rates and it was frustrating that all of the valves couldn't flow the same amount. It was time to implement a plan.

My strategy was to profile each MagnaValve on the machine, one at a time. It was necessary to determine the maximum flow rate at each expected motor speed and create a spreadsheet to capture the data. This data was then converted into graphs that very quickly, and convincingly, showed the machine just could not perform in an expanded capacity without changing 25 HP motors for 50 HP motors. My customer upgraded to 50 HP motors and the problem was solved.

I appreciated being involved with the incident because it has helped me with future service calls. If an obvious solution doesn't come to mind quickly, I suggest performing a machine profile to help determine the boundary conditions. It is easy to transfer the technique to air-type machines by requesting the maximum flow rate at selected air pressures.

I recommend you perform a machine profile if you want to peen a different component, flow a different media, retrofit a machine, etc. Once you have the machine profile, you can speak with authority on the machine's capabilities and limitations.

On a Different Note

I'm very pleased to share the work of the research team of Purdue University's Materials Engineering department in this issue of the magazine. This is partly because Purdue is my alma mater, but also because the resources at Purdue offer tremendous possibilities for the shot peening community. Most companies don't have in-house R&D departments and outsourcing research is difficult. Research venues like the Center for Surface Engineering and Enhancement at Purdue offer a viable alternative. Watch for more articles on this subject in upcoming issues of *The Shot Peener*. ●

THE SHOT PEENER

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Machine Profiling—A Guide

UNTIL A DECADE or so ago, the term "profile" was commonly used in reference to angles, channels and other formed sections. That's changed now! My know-it-all friend Google now informs me that the average internet user has created at least five "profiles" on social media. A profile presents a detailed and sometimes vivid description of oneself! What if we take this concept and apply it to our ever-evolving machines in the blast cleaning and shot peening world? Why, you may ask? Your machine was purchased for a specific application, but this will likely change over its life. Creating a machine profile will help us better understand its capabilities and, more importantly, its limitations. If your curious mind is questioning the legitimacy of this term in our industry, you're probably justified. It doesn't exist in a formal capacity, though one does come across highly organized users of equipment making attempts at creating a profile.

This discussion is an endeavor to do just that!

Defining the Machine Profile

Let's discuss some basics of the application, process and machine design in order to define a machine's profile. To keep our discussion in general terms, we will include blast cleaning and shot peening equipment, both with air- and wheel-type media propulsion systems.

The Application: The broad processes we commonly encounter in surface treatment (and pre-treatment) are blast cleaning and shot peening. In addition, processes such as descaling, grit blasting, etching and de-burring form minor variants of the main two processes. Therefore, the first classification could be in terms of its primary application from the above list.

Media Propulsion System: A vast majority of machines for the above applications utilize air- or wheel-type media propulsion systems. Wet blast systems need to be acknowledged, but since they aren't as widely used, we won't go into their specifics. Let's conclude that your system is either dry, in which case it's either a (centrifugal) wheelblast or airblast system, or it's a wet blast system.

Pressure blast nozzles mounted on a robotic arm provide travel path flexibility

Why is this important? Wheel or airblast systems are initially chosen based on the application they were meant to handle. Therefore, it's not always possible for a machine, wheel or air, to be adapted to a new application.

Airblast systems could further be segmented into suction- or pressure-style propulsion systems. Wheelblast systems, on the other hand, are almost always centrifugal systems driven by an electric motor. One could drill down further into wheel size, motor horsepower (HP), etc. (More on HP later.)

Why is this important? Suction systems are commonly used for applications that don't involve tenacious cleaning or high-intensity peening. Suction systems are also restricted in the size of steel abrasive they can propel. Therefore, the interchange between suction and pressure blast is not straightforward.

Machine Design: The main aspects when developing your machine profile include the type of media reclaim, work handling, blast delivery system (including robots, nozzle manipulators, etc.) and controls. Several other aspects of a machine could be used to enhance our profile, such as cabinet material, lining, and sound insulation. However, let us focus only on those that will help us analyze the machine's ability to adapt for a change in its application in the future.

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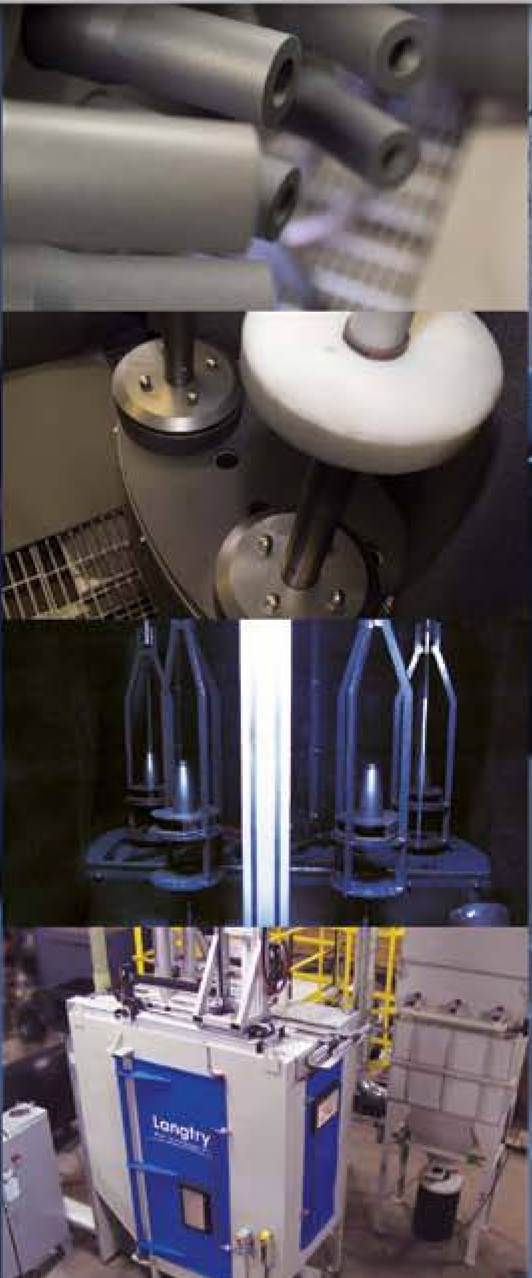

Type of Media Reclaim

The two main types of media reclaim are Vacuum and Mechanical. The choice depends on the type and quantity of media being conveyed and reclaimed. Wheel blast machines flow a significantly greater volume (as high as 10 times per wheel, depending on the wheel HP) of abrasive than airblast nozzles. Moreover, wheels almost always only propel ferrous abrasive. Therefore, given the higher flow rate and specific weight (steel shot = 280 lb./cu. ft. and glass bead/aluminum oxide between 100-125 lb./cu. ft.), mechanical style reclaim systems are more effective to convey blast media in wheelblast machines. Further, the size (capacity) of such reclaim systems are based on the total amount of abrasive propelled, since wheelblast machines could have a single or multiple wheels blasting simultaneously based on the work being processed and speed of operation. All wheelblast manufacturers designate different capacities of a mechanical reclaim system with their specific nomenclature. For example, a wheelblast machine with four (4) 16" diameter wheels driven by 40 HP motors might generate a total abrasive flow of over 2,500 lb. per minute. In order to convey this amount of abrasive, you might need a 12" diameter lower reclaim screw and a bucket elevator with a specific bucket capacity and casing size to elevate the abrasive. The profile of a machine with such a reclaim system will incorporate all these values.

Why is this important? If this machine, built with a reclaim system, is now tasked with a different part style that requires additional wheels, it may not work. If faced with a higher media flow, it will overload the system and likely trip the drive motors. On the other hand, if the media flow is significantly lower than the design value, it creates issues with the efficiency of the airwash separator when cleaning dust and fines from the abrasive stream. This is because the airwash separator relies on a full curtain of abrasive for efficient cleaning.

If your machine is now going to be used for a shot peening application, your media reclaim system may need to incorporate a vibratory size classifier in the mix.

Vacuum reclaim systems are in most airblast systems. They convey non-ferrous abrasives including glass bead, ceramic, aluminum oxide, and ferrous abrasives (typically small sizes and low flow rates). Vacuum reclaim systems are rated on their total volumetric conveying capacity (determined by the type and amount of abrasive). The main elements of a vacuum reclaim system are the media reclaim hose (different diameters and material), reclaimer or cyclone, and the exhaust fan that provides the suction power to move the abrasive through. Please note that an increase in volumetric capacity could affect the ability of the dust collector and exhaust fan to handle the new air volume.

Your airblast machine profile will need to specify these details in order to paint the complete picture.

Why is this important? Just like in our earlier discussion, if the total media flow rate or type changes due to the arrival of a new application, this may impact the reclaim system design thereby rendering the existing system ineffective. Your new application may require a larger size reclaimer and possibly a new dust collector with an increased capacity exhaust fan and motor. If, on the other hand, your machine is required to tackle a peening application from an earlier cleaning job, you'll need to introduce media classification as part of the reclaim system.

In our exercise to develop our machine profile, we have defined the broad classification of wheel or air, the type of media reclaim system, mechanical and vacuum, and recognized the specifics of both. Let's continue our exercise to another important classification—work handling.

Work Handling

From an equipment manufacturer's perspective, work handling arrangements are part and process dependent. A long part will necessitate a roller or belt conveyor whereas a rotary part will require a turntable. It's process dependent because a customer's plant layout might make it more practical to interface with a blast machine conveyor than, for example, an overhead monorail standard to a blast machine manufacturer. Customers operating at a smaller scale might adapt their layout to standard work handling arrangements offered by the equipment manufacturers.

The classic example is the ubiquitous tumblast- and table-style wheelblast machines. These "workhorses" in the blast cleaning and shot peening machine world are always purchased in their standard format and customer parts are "brought" to these machines rather than adapting them to existing plant layouts.

To enhance our developing profile, work handling arrangements could be segmented into rotary tables, roller and belt conveyors, overhead conveyors and derivatives of the same. The tables could be further segmented into a single rotary table turning continuously, with indexing motion or even interpolating, to present specific areas of the part to the nozzles or blast wheels. Main tables are classified simply by their diameter, and if available, by the number of satellite stations on top. Rotary tables could be fixed inside the blast cabinet, mounted on a swing arm or travel in and out of the cabinet on a work car, adding to further classification in your profile.

Inline conveyor systems are either roller- or belt-style with the former being more popular than the latter. Roller-style systems offer the benefit of processing the parts from the top and bottom surfaces simultaneously, accessing the lower portion of the part through the gap between consecutive rollers. The roller drives could move the part continuously (at variable speeds) or in an intermittent motion.

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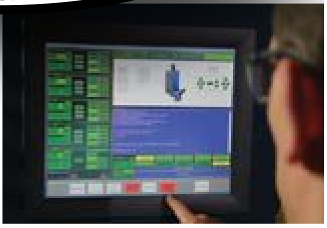

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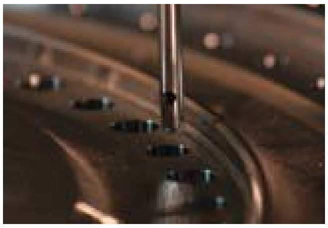

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Several other custom handling arrangements are also possible. However, it is impractical to incorporate all of them in our discussion here.

Why is this important? Since part styles dictate the handling arrangement, any change in that will directly affect the process. Consider this example. Your roller-style system is now required to handle new work, still along its length but with a shorter part length. The new length may not satisfy the requirement of resting on a minimum of three rollers for stability. Tables are usually very flexible, and as long as the work physically fits within the cabinet walls, the existing table could be adapted to different part styles.

Blast Delivery Systems

Blast delivery systems in a wheel machine are dependent on one component—the blast wheel. Most wheel blast machines incorporate a fixed wheel with the exception of an oscillating wheel pod or panel in special cases. The blast wheel is categorized by its size, connected drive motor HP, rotational speed in RPM and quantity in the machine. Wheels could also be direct or belt driven. For example, a 25EZ155 would denote a Wheelabrator 15.5" diameter wheel with 2.5" wide blades and belong to the popular EZEFIT family. In broad terms, it's common for users in the wheelblast world to refer to their machines by the number of wheels.

Why is this important? This definition is important because it determines the part style and size that can be processed in this machine. Further, the wheel power (HP) determines the abrasive flow rate and the speed at which a part can be cleaned or peened. In case of peening applications, the wheel speed and diameter determine the abrasive velocity and thereby the intensity. The former can be varied using an inverter, but the latter is usually fixed. Abrasive velocity has a direct impact on the intensity value, and is important to assess before committing the machine for a specific peening project.

The blast delivery system in an airblast system is a bit more involved. It's comprised of the blast nozzles and hoses—size, material and type, blast tank (pressure blast systems) capacity, quantity of outlets, nozzle holding arrangements, including nozzle manipulators, robots, or even manual systems. The blast nozzle is addressed by the size of its bore. As a common practice, the blast hose is about three times the length of the nozzle bore. Nozzle types could be straight bore or venturi- style. Some machines utilize nozzle lances when accessing bores, holes and slots, providing another differentiation to the family of nozzles.

Blast tanks are categorized on tank volumetric capacity (cubic feet), quantity of outlets (single or as many as 8 or 12) and intermittent duty (single chamber), or continuous duty (twin chamber). Some manufacturers have alternate blast tank designs that allow for one tank per nozzle in an attempt to maintain a higher degree of media delivery precision. This results in an airblast system carrying a description such as four (4) nozzle system with a 6.5 CFT single chamber blast tank with four (4) outlets.

The nozzle handling arrangements for an airblast machine create additional differentiation in our machine profile. Nozzle carriages are used for applications with relatively defined travel paths. Such carriages or manipulators are defined by their degrees of motion such as single axis, up to five axis of motion. Further, their definition is strengthened by the travel range of the individual axes, such as 18" stroke, 300-degree swing, etc. Robots have brought increased flexibility to our industry. With a standard six-axis robot, the machine capability is only limited by the programmer's imagination (and, of course, the physical size). Machines incorporate multiple robots to not only manipulate nozzles but also to position and present parts to fixed nozzles.

The profile of a shot peening machine, in addition to the basic features above, may also include closed-loop flow control valves and PID loops for blast tank pressure.

The final link in your machine profile is its control system. Most machines now have programmable features and their basic functions are coordinated through a PLC with a graphic HMI for operator control. Shot peening systems carry a more sophisticated version of controls with CNC for motion control of nozzles and computer controls for other features. These elements define the controls, with emphasis on the make of the PLC, CNC and servo drives.

Your machine profile is now complete to a degree that will help define its capabilities to a person familiar with this type of equipment.

Machine Profiles and Conversions

We started this discussion not only to define the machine profile, but also to understand its limitations when handling a part or application it wasn't originally designed for. However, our technical minds don't like to be limited by anything, and the innate response is to find a way to work around it. Let's find out if that is possible.

We have spent time discussing some of the possible issues in the "why is this important" sections. Let us now review the costs associated with a blast machine. Costs in a new machine are broken down into the following: Engineering (12-15%), material (25-30%), labor (25-30%) and the remainder in overheads, profits, etc. A simple modification requiring no new materials or structural modification does seem probable and even practical. Given the investment in labor and material, changes requiring either may not be that practical. You might even agree that learning the machine's limitation is as important as understanding its features! So, what are some

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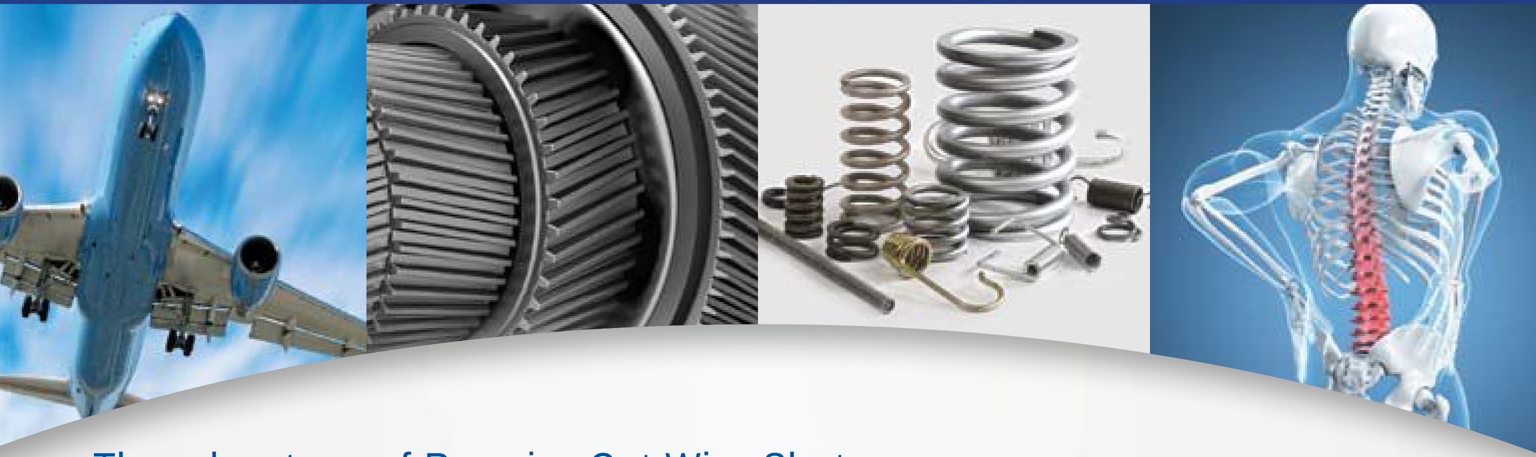

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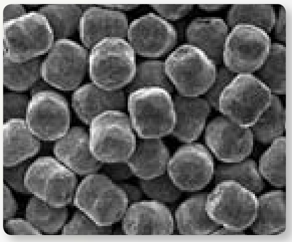

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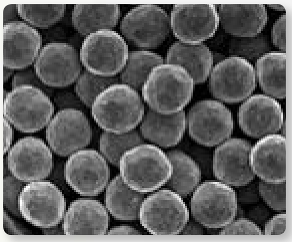

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of those conversions/modifications that might make sense. Below is a partial list:

- Addition of a new nozzle (if an extra outlet is available in the blast tank) and maintaining the total media flow by reducing media flow rate from the individual nozzles. Adding more suction guns is relatively easier since there is no blast tank in a suction system.
- Addition of a classifier in the media reclaim system and flow control valves at the blast tank outlet.
- Adding a nozzle carriage to an existing machine with fixed nozzles (as long as sufficient space is available inside the cabinet). Inclusion of a robot may not be as simple since cabinets are seldom designed with additional room to accommodate a robot as an after-thought and if located outside the cabinet, it will require extensive cabinet modifications for it to be able to reach inside the cabinet.
- Wheelblast machines can be adapted to different part styles as long as the physical size and orientation permit the same. Needless to mention, media type and size must be the same in order for this to be a successful conversion.

Theoretically, conversions do look good on paper. However, most customers considering conversions in our industry almost always find the cost of a new system to be not much more and opt for the latter.

OEMs can take advantage of a fully developed machine profile when deciding how to best add a new feature to a successful machine design. The following profile of an Empire machine demonstrates this.

Machine Profile of the Empire TT36-S

The TT-36 is an Indexing Turntable Machine with multiple satellites on top. This original design allows for fixed nozzles or those mounted on manipulators. Let's start developing the profile for this machine in a format discussed earlier.

Machine Model: TT36-S (S for Suction)
(The standard Empire TT-36P would denote Pressure blast)

Media Propulsion: Suction

Blast Delivery: Number of nozzles: Six (3/8" diameter with 3/16" diameter airjet)

Work Handling: Main table diameter: 36"

Satellite stations: 5/8" diameter x ¾" long keyed shaft, quantity: six (6), upgradable to twelve (12)

Nozzle manipulator (in a standard TT-36): single axis, stroke length: adjustable from 2 to 12", variable speed: 0.1 to 1.0 IPS

Maximum work envelope: 12" diameter x 18" high x 20 lb

Media reclaim system: 1200 CFM capacity, Ultrawear lined

Ventilation and dust collection: 1200 CFM cartridge

Controls: Allen Bradley Micrologix 1000 PLC with PanelView 300 HMI

The profile was used to develop an upgrade for this machine, allowing it to process more complicated profiles with added flexibility. The newly developed machine was designated TT36-SR—utilizing a robot instead of the conventional nozzle carriage.

The new machine profile matched the above with the inclusion of a Fanuc LR Mate 200i robot mounted outside and penetrating the cabinet from one of the sides. Another modification to the original design was to add a vibratory classifier to address the requirements of a peening application.

As discussed earlier, would the standard TT-36 render itself to an easy conversion to the robotic version? Given the space required to accommodate a robot, and to take advantage of its reach capabilities, the cabinet had to go through a slight expansion.

Summary

Part styles are constantly changing. The likelihood of utilizing a machine for a single part style is very low. Developing a machine profile helps you establish your baseline and define capabilities. It will help you market your services when spare machine time is available. Whether your machine functions in a job shop environment or large plant alongside other machines dedicated to specific parts, developing a profile will only help organize your cleaning or shot peening set-up. ●

The TT-36S with robotics has increased nozzle travel flexibility

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Taking a Shot at Laser Cutting

The following interview is reprinted with permission from TRUMPF Inc. The article originally appeared in the "TRUMPF Express" magazine of Spring 2016. The author is Susan Grohs and the photography was taken by Steve Adams of Steve Adams Photography.

Peening Technologies in East Hartford, Connecticut has reason to celebrate. Not only is this family company preparing for its 50th anniversary, it also just received its first patent. We sat down with company president Thomas Beach and his brother, vice president Walter Beach, to learn more about this small business with a big presence in the shot peening industry.

Can you provide a short history of your company?
Thomas: Our father founded the shot peening job shop segment of our company in 1966. Eventually, customers expressed an interest in buying the equipment we had designed so rather than lose business, we began to offer machines as well. While the job shop is still the larger segment of our business, both aspects have grown steadily over the years. We have grown to a workforce of approximately eighty employees, including our facility near Atlanta, Georgia. We established an operation there in 2003 at the request of a local customer who required job shop services in the South.

How is shot peening used across various industries?
Thomas: Shot peening is a finishing process used to make critical components stronger as well as to extend the life of less critical parts. Since it is relatively inexpensive compared to the cost of replacement or repair, it is an attractive solution for many industries. We commonly see aerospace, automotive, or power generation applications but also medical implants—for the patient, a longer-lasting implant is a real advantage. Other manufacturers are drawn to shot peening for reasons that have nothing to do with fatigue life. For example, shot peening is used to facilitate coating adhesion, such as nickel plating, or to produce a controlled and uniform look for architectural railings.

Walter: As technology advances, we see growing use in the automotive and aerospace sectors especially. In the past, it was simply understood that shot peening had a beneficial effect on materials. With computers, we are able to quantify this impact much more precisely. This enables engineers to work with thinner or different materials. This is a major attraction for automotive manufactures, for example, on a quest for lightweight designs. In addition, the parts are even less susceptible to fatigue failure.

What makes Peening Technologies unique?
Thomas: We make sophisticated automated equipment for shot peening and also supply shot peening as a job shop service. Our competitors typically do not offer both. Understanding both the machine and the process gives us a unique


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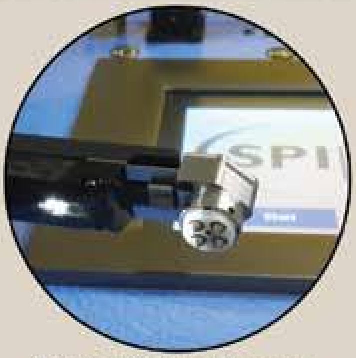
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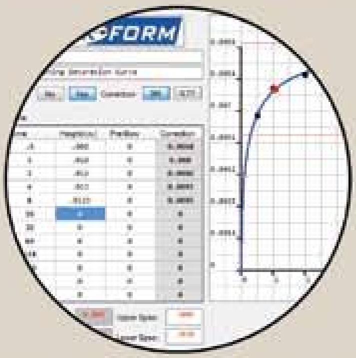
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understanding of our customers' needs and has enabled us to become a leader in shot peening technology and automation. When people think of shot peening, we want them to think of us.

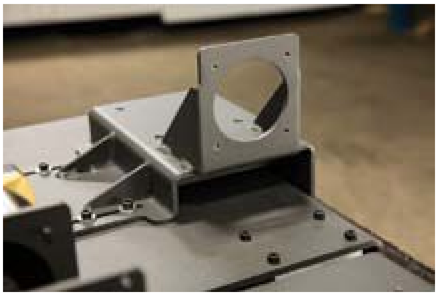
Walter: We also understand the numerous approvals and quality requirements that go along with shot peening. In addition to our FAA and EASA approvals, we are proud to be the first shot peening facility to earn Nadcap accreditation. From the specifications for the media we use, to testing processes and quality control, there is a lot to know and this is often a barrier to entry for others.

How has technology impacted growth of your business?
Thomas: Quality requirements in the industry became much more stringent just as shot peening technology began to evolve. For a small company, I think we have done well to take advantage of technologies as they become available. One of the most influential was the early adoption of 3D CAD modeling software. At the time it was an expensive proposition but it really paid dividends.

Walter: We initially invested in 3D software in 2000 as a means to transition the customer's 3D models into 2D process sheets. Although we took to the software pretty quickly, it took time for the new programming capabilities to change our process. Eventually we transformed what was once a crude process into something much more specific and refined.

Can you tell us more about the process of shot peening?
Walter: Shot peening is a surface enhancement process that works through the controlled application of media, usually steel, ceramics or glass. As the media strikes the metal part it creates a compressed layer in the material called a compressive stress. The compressive stress layer slows crack initiation or propagation through the part. While manufacturers typically only require this in key areas of the component, often the entire part or assembly is exposed to the media simply because it is faster and less costly than trying to protect it. At Peening Technologies, we process parts that range from those small enough to fit in your hand to parts that weigh thousands of pounds. Regardless of the size, a fixture must be developed to hold the part during processing. And that's where our patent comes in. (For more information about the shot peening process, visit our friends at www.shotpeener.com)

Your patent is titled: "Apparatus and Method for Quantifying Metal Surface Treatment." Can you describe it?
Thomas: In shot peening, every fixture is attached to industry-mandated Almen strip holders. What most people don't realize is that designing these fixtures is very labor intensive. On rare occasion, we might acquire a scrap part in advance, but typically we had to wait for the customer to send the part and then machine a solution. Simulations were either extremely crude or so over the top that no one could justify paying for them. We developed a way to use 3D software to generate a highly accurate simulation of the part with the holders. This method became our patent.



Why was this new method so important to your business?
Walter: The method enabled us to fabricate our tooling ahead of time and it is accurate to within a few thousands of an inch. Although there is certain testing required once the part is in hand, we are able to get to that point much faster while significantly reducing our costs.

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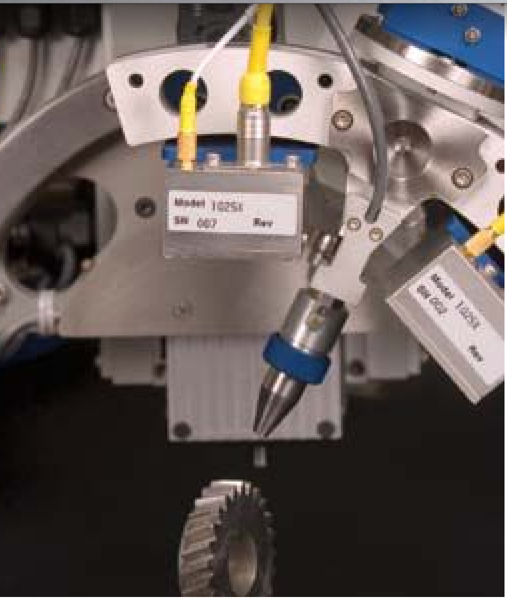

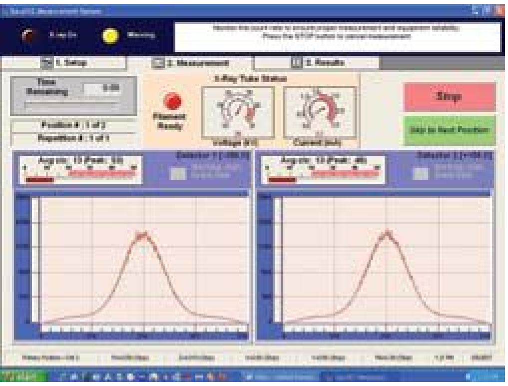

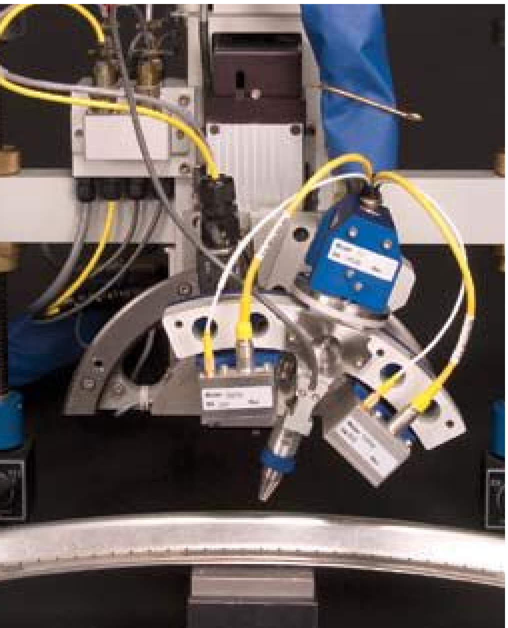

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Thomas: We developed the process out of necessity, really. The industry has an increasing need for shot peening and we take on increasingly complex work. We were struggling to find a way to shorten our development time. And we found one.

What led you to patent this process?
Thomas: It was actually a customer who encouraged us to seek out a patent. Shortly after we installed the TruLaser 1030, he was visiting our facility to witness and approve our process. He told us nobody else was doing anything like it and we should probably patent it. We thought he was most likely right and started the process. It took just over three years and was officially granted on June 23, 2015.

Why was the addition of the TruLaser 1030 so important to your process?
Thomas: While we don't run the laser ever day, it has become a crucial and integral part of our process. When we purchased the TruLaser 1030 in 2012, it significantly changed the way we looked at fixtures. In the past, we would job shop the fabrication out. We have good vendors, but at such a low quantity our jobs could end up on the backburner. The nature of our business, however, is speed so we felt compelled to bring this step in-house. We originally looked to invest in a plasma cutting machine but after visiting TRUMPF, we realized all the additional benefits a laser cutting system could afford. We could cut faster and more accurately as well as design parts in new ways and with difficult contours. The laser machine enabled us to be much more efficient and creative.

Walter: With the addition of the TruLaser, fixtures were no longer an expensive proposition. We have thousands of parts and fixtures in our database. Unavoidably, they are subject to wear due to the nature of the process. The new fixtures are so fast and easy to reproduce that we no longer need to keep fixtures in stock. This saves space and makes it easier to get exactly what you need, when you need it.

Thomas: The TruLaser 1030 also enabled us to manufacture parts for our shot peening equipment in-house. It takes approximately three months to design the enclosures, motion units, and media delivery in a way that will suit the customer's manufacturing needs and the environment where the machine will be placed. While we still machine parts, when we can cut parts for the robotic units and the enclosure with the TruLaser 1030, the entire assembly becomes more economical to produce and we are able to pass these savings on to the customer.

Everything seems to be going so well at Peening Technologies. What is the most challenging part of your business?
Thomas: Since shot peening is often applied to high dollar parts, even a small job for us is often a big concern for the customer. We frequently provide additional support long after the part or equipment has been delivered. This takes time and resources, but we understand how important it is to make sure everything is precisely right in processing. With such a large customer base this is both a blessing and a curse, but also a responsibility we take on willingly. ●

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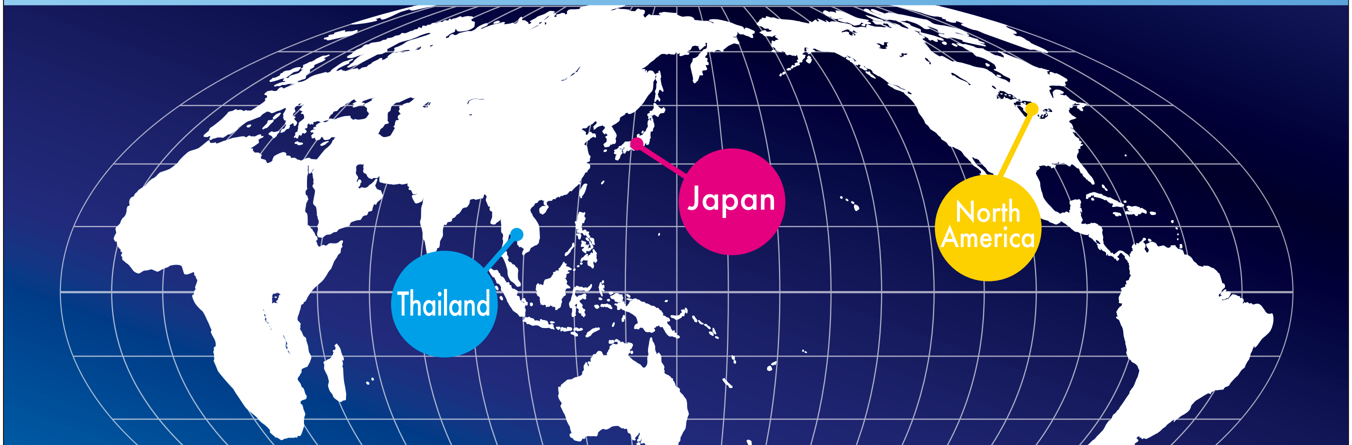

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ZF TRW Utilizes Purdue Research Team for Residual Stress Study

Student Researchers: Doug Blomeke, Cayley Dymond, Hojung Kim, Xiaomeng Zhang
Faculty Advisor: Dr. David Bahr • Industrial Sponsor: Mark Herter, Program Manager with ZF TRW

THE ZT TRW branch in Lafayette, Indiana produces power steering systems for the heavy-duty trucking industry. To meet performance and safety standards for their customers, ZF TRW uses shot peening to increase the fatigue life of their products. Mark Herter, Program Manager with ZF TRW, engaged the services of the research team with Purdue Materials Engineering to provide guidance on which parameters are the most important in the shot peening process and how modifying these parameters affects the microstructure, residual stress, and hardness.

Project Background

The research team set out to tell TRW how much room they have in their peening process to change parameters without negatively affecting the performance of their THP60 rack pistons. There are three concepts that are fundamental to this project: shot peening, residual stress, and fatigue.

Experimental Procedure

The picture of the as-received THP60 rack piston is shown to the right. The sample preparation procedure followed the ASTM standards. Synthetic chemotextile hard napless polishing cloth and glass-filled epoxy powder were used to improve edge retention. The etchant was nital which contained 2% nitric acid and 98% ethanol. Parts for the Design of Experiments were named with a two-number convention. The first number is the peening air pressure, and the second number is the percentage of the normal peening time that was used.

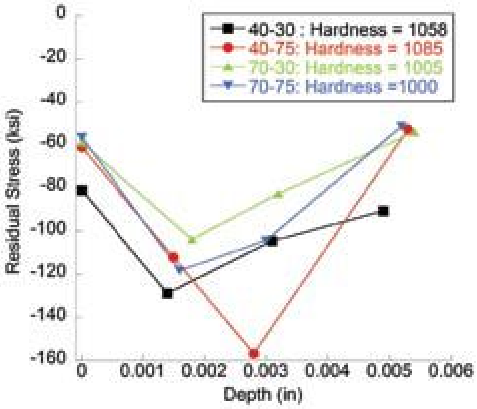
Residual Stress Measurement by X-Ray Diffraction (XRD)

To measure the residual stress at the surface of the parts from the current process, the team used the XRD Debye-Scherrer Ring method. The depth profiles were created for the other parts using the $\sin^2\psi$ method.

Since austenite had a different crystal structure from martensite and other phases of iron, the resulting diffraction pattern would be different. The amount of retained austenite could be estimated by comparing the intensities of diffraction peaks arising from each of the phases. In the absence of significant undissolved carbides and preferred orientation, there was a correlation between the intensity ratio and the volume fraction of retained austenite. Two standards (ASTM E975 and SAE SP-453) for austenite measurements were used. Both assumed that the material had a nearly random orientation and few carbides.

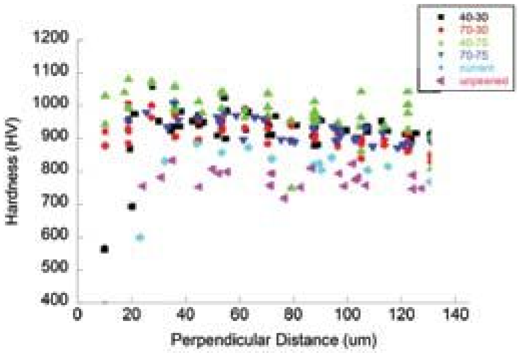
Result

Residual Stress



The residual stress profiles and the maximum hardness value and location for the four experimental samples. 40-75 shows the greatest residual stress at the deepest location along with the highest hardness value.

Hardness



Hardness values near the surface for the four experimental samples, the current process, and an unpeened region. The 40-75 sample showed the highest average hardness and the unpeened sample showed the lowest average.

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Presence of Cementite

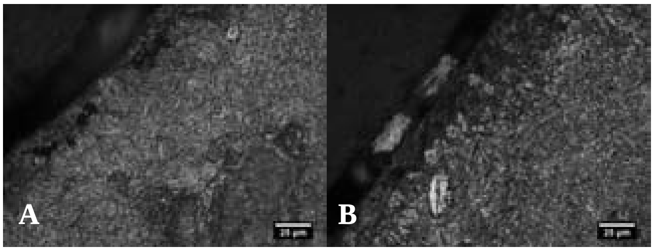


Image A shows the microstructure near the surface of the peened region for 40-30. Image B shows the same region for 40-75. All samples had microstructures comprised of tempered lath martensite. Small, semi-circular white areas reveal the presence of cementite, more heavily present in Image A than in Image B.

Cementite Volume Percentages

Current Unpeened	Current Peened	40-30	40-75	70-30	70-75
4.85	2.30	1.87	1.28	1.79	1.79

Surface Retained Austenite

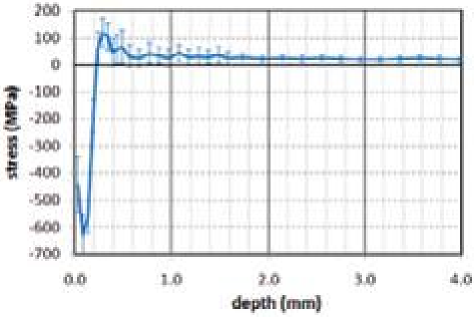
Three of the samples had similar levels of retained austenite, around 0.3 percent. The 40-30 sample had a higher level of retained austenite but was still relatively low at only 1.10 percent. This could cause a slight effect in the observed hardness and residual stress.

Retained Austenite Volume Percentages

40-30	40-75	70-30	70-75
1.10	0.27	0.25	0.33

Discussion

The figure below shows a typical residual stress depth profile for a shot peened metal. The maximum compressive stress is reached within 100 μm and then drops until a tensile residual stress is reached deeper in the part, a necessary force balance as the part is unmoving. Because we took measurements at four discrete depths, it is possible we did not accurately capture the peak compressive residual stress in each part.



Typical residual stress depth profile for a shot peened metal. Image is property of Los Alamos National Laboratory.

The 40-75 part had the largest compressive residual stress and the deepest maximum, but its third measurement was taken more shallowly than in any other sample. Because the other measurements align so closely, it seems likely that for the other three samples, the true peak compressive residual stress was missed as it occurred between the second and third measurement depths.

The 40-30 sample had the greatest compressive residual stress at the surface at roughly -80 ksi while the other three samples were all around -60 ksi. The 40-30 sample also had a much greater compressive residual stress deeper into the part. At 0.005 inches from the surface, the residual stress in the 40-30 sample was -91 ksi while the other three samples showed residual stresses at this depth of only about -52 ksi. The 70-30 sample exhibited lower residual stress readings in two locations than any other sample. Collectively, the results demonstrate that peening with a greater velocity induced less residual stress into the part.

Near the surface, the 40-75 sample showed slightly higher hardness values overall. The 40-75 sample exhibited the least cementite at 1.28%. Its retained austenite measurements were similar to both the 70-30 and the 70-75 samples. Hardness would be expected to be lower with more cementite and more retained austenite since these are softer phases. However, there is no correlation between retained austenite and hardness supported by the data. The unpeened tooth showed on average lower hardness values than all of the other samples, demonstrating that the shot peening process does affect hardness.

Conclusions

Peening at a lower velocity produced a deeper and greater residual stress field. These results showed it is possible to peen the part at too high a velocity, causing a negative effect on the imparted residual stress. The residual stress curves showed no peening time effect, indicating that the current process runs longer than is necessary to reach the saturation point where no additional benefit is achieved. All of the peened parts were harder than the unpeened parts, but all peened parts were not significantly different in hardness from each other.

"The research finding most interesting to us was regardless of the peening time, we had roughly the same surface residual stress. This is of course something we are going to explore further in the near future when we review the processes and make upgrades in the THP60 rack piston production line. The shot peening operation has not created bottlenecks for us, but longer cycle times are harder on the equipment and could lead to more down time," said Mr. Herter. ●

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ACADEMIC STUDY
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Shot Stream Generation

INTRODUCTION

Air-blast shot streams consist of a mixture of fast-flowing air and entrained shot particles carried along by the flow of air. Generating an air-blast shot stream embraces two main problems: firstly producing a fast-flowing stream of air of appropriate velocity and secondly introducing the shot particles into this fast-flowing stream (see schematic fig.1).

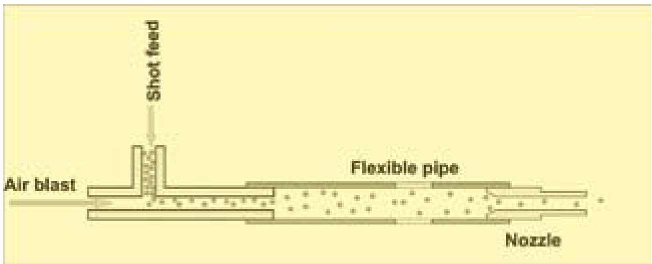

Fig.1. Direct-feed air-blast shot stream generation.

With wheel-blast shot streams, shot particles travel along rotating metal blades until they are flung off at their ends. Air travels with the particles and has a similar velocity at the blade tips. Fig.2 illustrates the essential features of a wheel-blast shot stream.

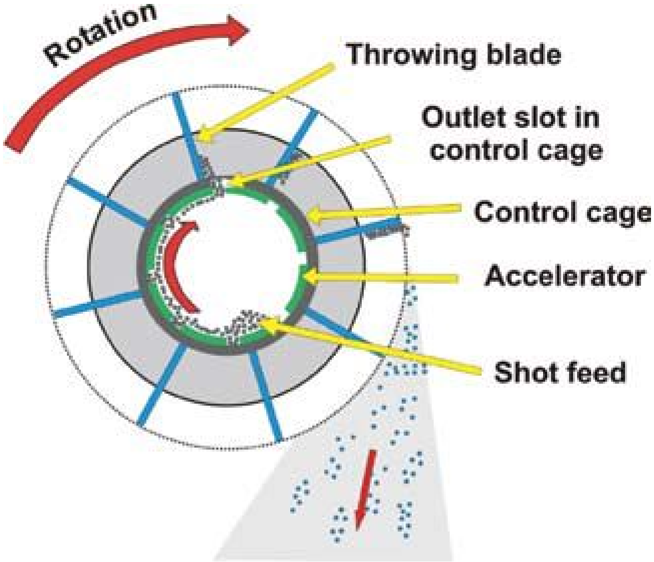

Fig.2. Essential features of a wheel-blast shot stream.

Generating a conventional wheel-blast shot stream embraces several problems: feeding shot into the center of the wheel, accelerating the shot until it reaches the outlet of the control cage and controlling the wheel velocity.

The theory and mechanics of generating air and wheel-blast shot velocities have been described in previous *Shot Peener* magazine articles, refs.1 and 2. Relevant concepts are included in this article. One major addition is a consideration of what happens to air flow after it leaves the nozzle.

Air- and wheel-blast machines generally operate with widely different shot flow rates. Each has its own advantages and disadvantages. Apart from the introduction of flapper peening, there appears to have been no significant developments in shot stream generation in the last half century. This article concentrates on the variables of the two major processes and discusses possible new developments. Important equations are included but it is emphasized that no mathematical expertise is required to employ them.

AIR-BLAST SHOT STREAM GENERATION

Air, being compressible, allows us to control the velocity of the shot particles that are entrained in the air stream emerging from the nozzle. The most important variable is the pressure of the air in the nozzle. Increasing the air pressure in the nozzle increases its density, as illustrated in fig.3.

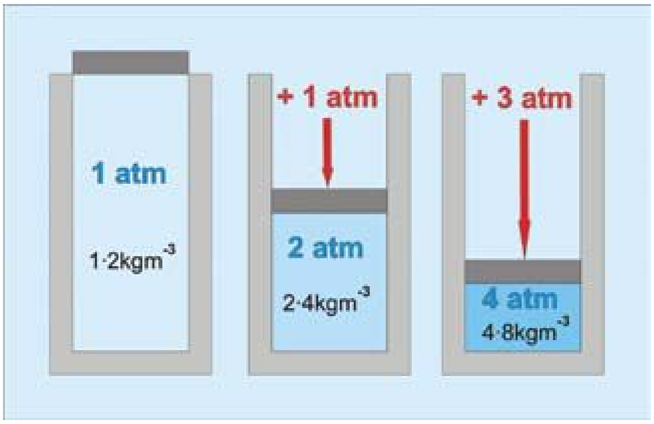

Fig.3. Increase of air density with applied pressure.

Nozzle Air Velocity

An important principle is that:

The maximum velocity of air in any form of pipe is the speed of sound in air.

The change of nozzle air velocity with nozzle air pressure

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is illustrated in fig.4. If the air pressure in the nozzle is one atmosphere (the same as outside the nozzle) then there can be no significant movement of air. As we gradually increase the air pressure in the nozzle it flows with increasing velocity. When the nozzle air pressure reaches two atmospheres the velocity suddenly reaches a limit—the speed of sound in air. Any further increase of nozzle air pressure will not increase the air velocity in the nozzle! What does happen is that the air travelling at this limited velocity becomes denser as the pressure increases.

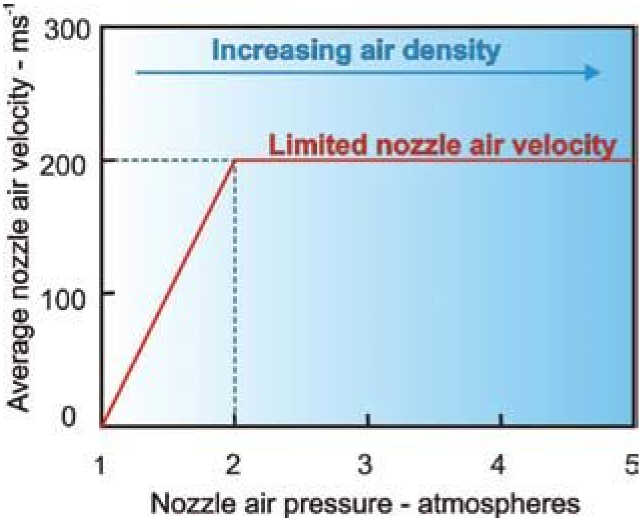

Fig.4. Effect of nozzle air density on nozzle air velocity.

It should be noted that the limited nozzle air velocity is on the centerline of the nozzle and velocity is a minimum (virtually zero) at the wall of the nozzle, as shown schematically in fig.5. Air velocity prediction is straightforward for the commonly used straight nozzles. Venturi-shaped nozzles are more complicated.

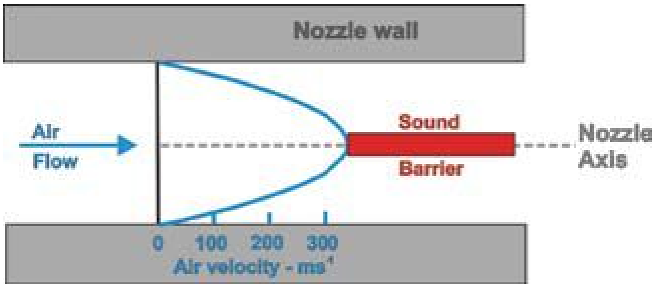

Fig.5. Distribution of air velocity in nozzle.

Along the centerline of the nozzle, air flow is limited to the speed of sound. Air flow away from the centerline is, however, retarded by friction at the nozzle wall. Hence, between the nozzle wall and the centerline there is a variation of velocity. The average air velocity within the nozzle is some two-thirds of the speed of sound. As pointed out in a previous article (ref.1) this has been found to be fixed at about 210 ms^{-1} for most commercial nozzles.

Nozzle Shot Velocity

As we introduce solid shot particles into a fast-flowing air stream the particles are forced to accelerate. The mechanics of this acceleration have been described previously (ref.1). Before introducing the relevant equations for this acceleration, consider the following simple qualitative analogy.

Trapped in a Pipe

Imagine being trapped in a large-diameter underground pipe. If there was no air flowing down the pipe we would feel no force from the air. On the other hand, if the air was flowing at, say, 10 meters per second, we would definitely feel a force but it would not sweep us off our feet. If water was flowing along the pipe at the same velocity we would certainly feel a much larger force—enough to knock us off our feet. That is because water has a much greater density than air. The greater the density the greater the force exerted. If the air pressure was increased without increasing its velocity, we would feel a larger force because the air has become denser. Doubling the air pressure would, however, also mean that the air velocity at the center of an open-ended pipe would have to be at the speed of sound. That high-velocity air would fling us along the pipe at an increasing velocity.

The velocity of shot emerging from a straight nozzle can be estimated using equation (1) from ref.1:

$$\mathbf{v_S = (1{\cdot}5.C_D.\rho_A.s/\pi.d.\rho_S)^{0.5}\,(v_a - v_S)} \qquad (1)$$

where $\mathbf{v_S}$ = average shot velocity, $\mathbf{C_D}$ is the "drag coefficient" (a dimensionless number that depends upon the shape of the object and for a smooth sphere $\mathbf{C_D}$ = 0.5), $\boldsymbol{\rho_A}$ = density of air in the nozzle, **s** = distance that the shot particle travels as it is being accelerated, **d** = average shot diameter, $\boldsymbol{\rho_S}$ = density of the shot and $\mathbf{v_a}$ = average air velocity in the nozzle.

Equation (8) may look a bit off-putting but we do not need to be a mathematician to employ it. The simplest approach is to set up an Excel spreadsheet that includes a formula that is a re-arranged form of equation (8). Table 1 shows how the estimated shot velocity (cell C11) is evaluated using the following (in Excel format):

=C9*((1.5*C3*C5*C4*C8)/(C6*C7))^0.5(1+((1.5*C3*C5*C4*C8)/(C6*C7))^0.5)

With an Excel spreadsheet, it is a simple task to enter specific values for the variables. Changing a variable gives an instant insight of its significance. (The author is very willing to email a copy of the spreadsheet. Please send the request to

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dr.d.kirk@btinternet.com.) For the example shown in Table 1, the density for steel shot has been entered.

Table 1. Specimen estimation of nozzle-induced average shot velocity using Excel.

1	B	C	D
2	**Parameter**	**Value**	**Units**
3	Cd	0.5	none
4	Normal Air Density	1.2	kgm^{-3}
5	Air Pressure	9	atm
6	Shot Density	7860	kgm^{-3}
7	Shot Diameter	0.25	mm
8	Nozzle Length	50	mm
9	Average Air Velocity	200	ms^{-1}
10			
11	**Shot Velocity**	**48.6**	**ms^{-1}**

Post-Nozzle Air Flow

Air is a compressible fluid. When compressed air emerges from a nozzle it must almost immediately expand to atmospheric pressure. Fig.6 illustrates, schematically the sideways air velocity, **V_S**, as well as the forwards air velocity, **V_F**, which are present as a consequence of this expansion. The figure corresponds to a nozzle pressure of 4 atm. which, on expansion, doubles the diameter of the air stream.

The basic problem when investigating air flow is that it is invisible. In other industries, air flow is commonly studied by introducing smoke into the air stream. One important region is very close to the nozzle exit. The model shown in fig.7 is of a cylinder of plastic foam that has been partly inserted into a transparent tube. The foam, being compressible, simulates the expansion of compressed air as it exits the tube (the shape at A being equivalent to the dotted lines shown in fig.6). Lines, C, tangential to the foam, have been added to the photograph in order to indicate the conical direction of air flow.

The conical shape of the air stream is maintained until it exceeds the distance used for shot peening—thereafter the air billows out.

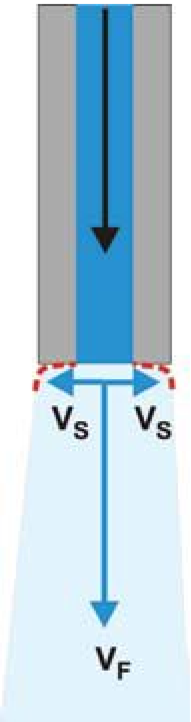

Fig.6. Schematic representation of air flow leaving a nozzle.

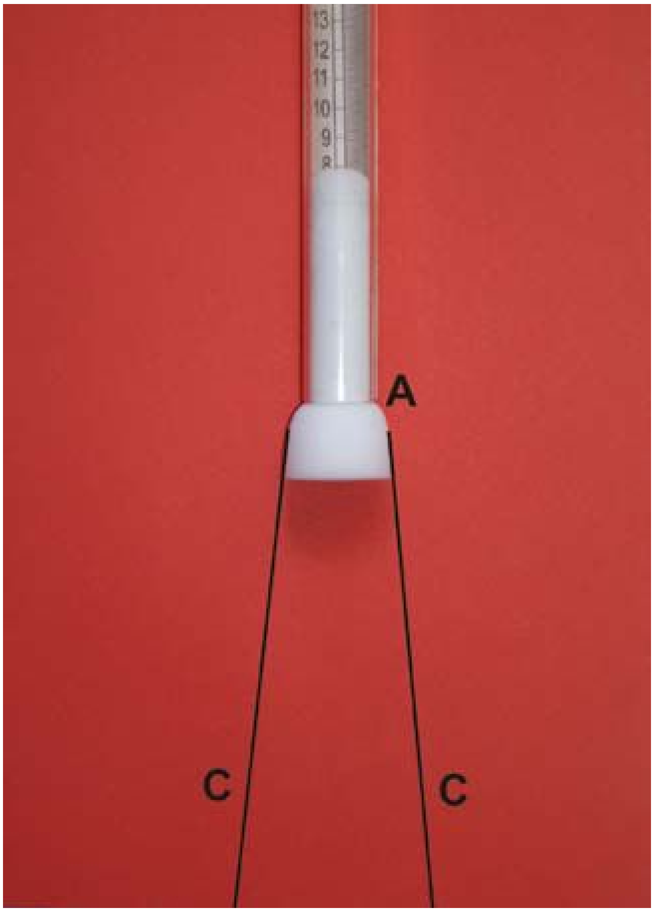

Fig.7. Model of expansion of a compressible substance on leaving a tube.

Post-Nozzle Shot Flow

The flow of shot leaving nozzles has already been studied directly using high-speed cameras and indirectly by examining dents on plates inserted into the shot stream. One important question is: "Why does the shot stream have a conical shape when projected from a cylindrical nozzle?" The answer lies in the effect of the sideways air velocity, **V_S**, shown in fig.6. **V_S** increases with distance from the centerline of the nozzle. Sideways motion of the air stream pushes entrained shot slightly sideways, generating the conical shape.

When shot emerges from the nozzle, it is travelling slower than the air stream. This causes the shot speed to further increase until the air is flowing at the same speed as the shot. As a consequence we have a "sweet spot" of maximum shot velocity. Previous studies have shown that the peening intensity value is a maximum at this sweet spot distance from the nozzle (commonly about 250 mm). After this distance the air velocity becomes less than that of the shot and slows down the shot.

WHEEL-BLAST SHOT STREAM GENERATION

Wheel-blast shot stream generation has been analyzed in a previous TSP paper, ref.2. Particles are pushed along fast-rotating blades by centrifugal force. When each particle

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leaves the tip of the blades it has a combination of radial velocity, $\mathbf{V_R}$, and tangential velocity, $\mathbf{V_T}$, as shown in fig.8. The combination of these two velocities gives the actual shot velocity, $\mathbf{V_S}$.

It has been shown (ref.2) that the velocity of shot as it leaves the blade tip, $\mathbf{V_S}$, is a simple function of wheel speed, **N**, blade length, **L**, and wheel radius, **R**. These factors are shown in fig.9. The corresponding equation for estimating $\mathbf{V_S}$ is:

$$\mathbf{V_S = 2*\pi*N(R^2 + 2*R*L - L^2)^{0.5}} \qquad (2)$$

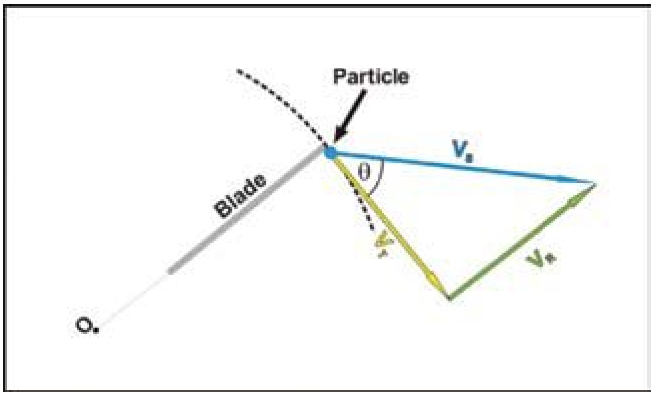

Fig.8. Shot velocity as a combination of radial and tangential velocities.

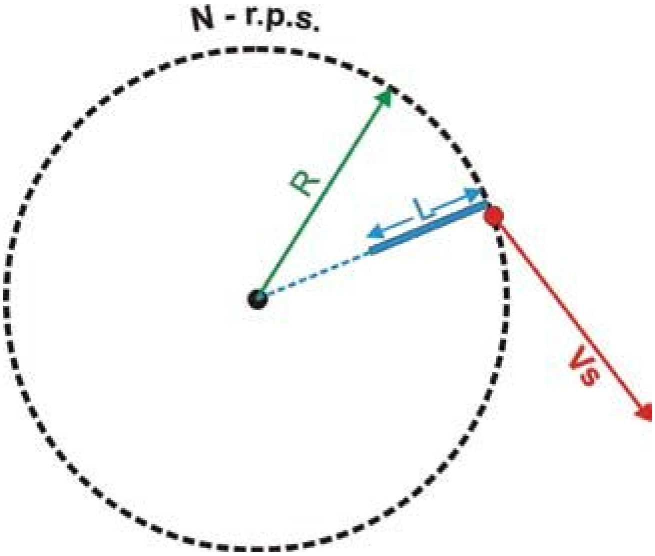

Fig.9. Wheel-blast variables contributing to thrown shot velocity.

Equation (2) can be used in several ways:

Example 1 Calculating thrown shot speed, V_S.

Assume that the wheel is rotating at 50 r.p.s. so that N = $50s^{-1}$, R = 0.2 m and L = 0.1 m. Substituting these values into equation (2) gives that:

$$\mathbf{V_S = 2*\pi*50(0.2^2 + 2*0.2*0.1 - 0.1^2)^{0.5}\ \text{so that}}$$
$$\mathbf{V_S = 83ms^{-1}}$$

Example 2 Calculating effect of different blade lengths

If, for example, the blade length in the previous example was only 0.05m we have that:

$$\mathbf{V_S = 2*\pi*50(0.2^2 + 2*0.2*0.05 - 0.05^2)^{0.5}\ \text{so that}}$$
$$\mathbf{V_S = 75ms^{-1}}$$

The difference between the shot velocities for these two examples may seem small but we have to remember that the kinetic energy of a shot particle is proportional to the square of its velocity. Particles traveling at $83ms^{-1}$ have 22.5% greater kinetic energy than if they were travelling at $75ms^{-1}$. The speed of sound limits the maximum radial velocity of the wheel's blades.

ALTERNATIVE SHOT STREAM GENERATION

Conventional shot stream generation appears to be mainly restricted to two methods—air-blast and wheel-blast. Both methods accelerate shot particles in manners that can be likened to a jet-ski and a paddle steamer respectively. "Thinking outside the box" seems to be an appropriate way of exploring alternative methods. Two possible alternatives are outlined in this section.

Direct Air Compression

Air compression normally involves an indirect procedure. Air is compressed into a ballast tank from which it is fed via hoses to shot peening cabinets. One thought is that a small individual compressor could be directly attached to each peening nozzle. Fig.10 is a schematic representation of such an arrangement.

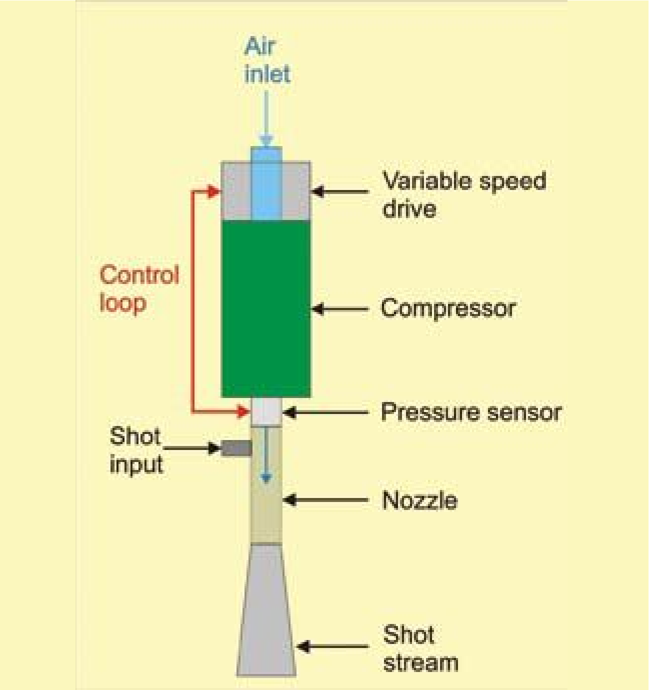

Fig.10. Direct drive air compression system.

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A direct drive system would obviate the need for conventional flexible hoses. The variable speed drive would operate in conjunction with a pressure sensor to provide closed-loop control.

Screw Shot Propulsion

The "paddle steamer" analogy of wheel-blast propulsion sparks a thought that the more efficient screw propulsion principle could be invoked. Screw propulsion is widely used to move both liquids and solids at ordinary speeds and air at high speeds. Literature searches by the author have failed, however, to reveal any high-speed applications for solids. That does not mean that they are not possible. Fig.11 represents, schematically, a combination of compressed air and "Archimedean" propulsion. The screw could be either integral with an outer cylinder or spinning inside a static cylinder. The combination could provide a system intermediate between high-precision low-volume air blast and low-precision wheel-blast generation.

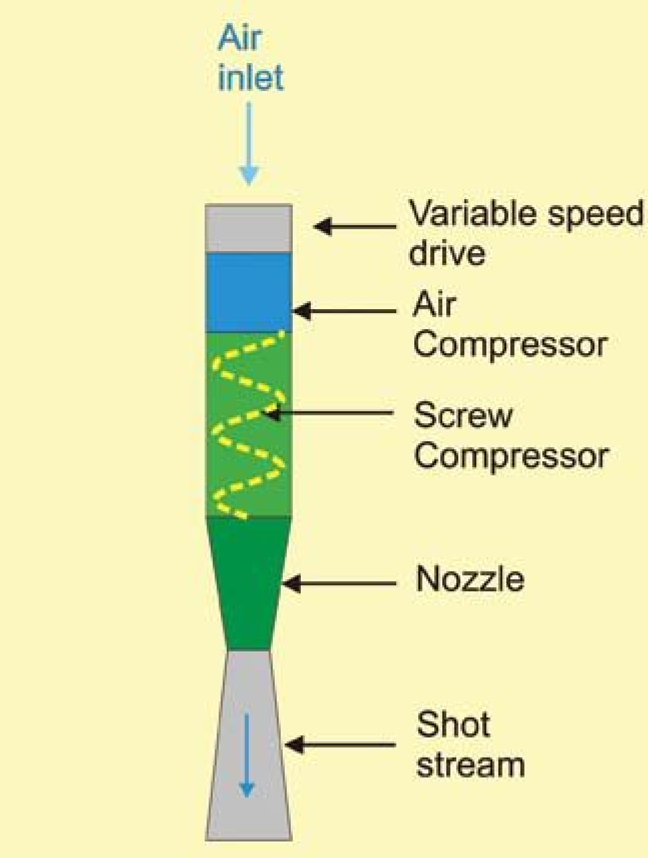

Fig.11. Schematic representation of combined air/screw shot stream generation.

DISCUSSION

Shot peening is wholly dependent on quantities. Individual parameters, such as coverage and peening intensity, are readily appreciated. Peening control depends, however, on the combined effects of several parameters. These combined effects can be expressed either as graphs or as equations or both. In this article the effects of individual parameters on shot stream generation have been highlighted. The beauty of programs such as Excel is that no mathematical skills are needed to examine the effects of changes in parameter values. We simply substitute different values, press "Enter" and observe the change in, say, shot velocity.

Progress in peening technology requires changes, minor or major, in the techniques that we employ. Perhaps the greatest barrier to progress is the all too familiar attitude of "We have always done it this way and it works. Why should we change?" Profitable changes will only occur if we make the effort to be innovative. The two examples given in this article are intended to be indicative of areas where changes could be effected. ●

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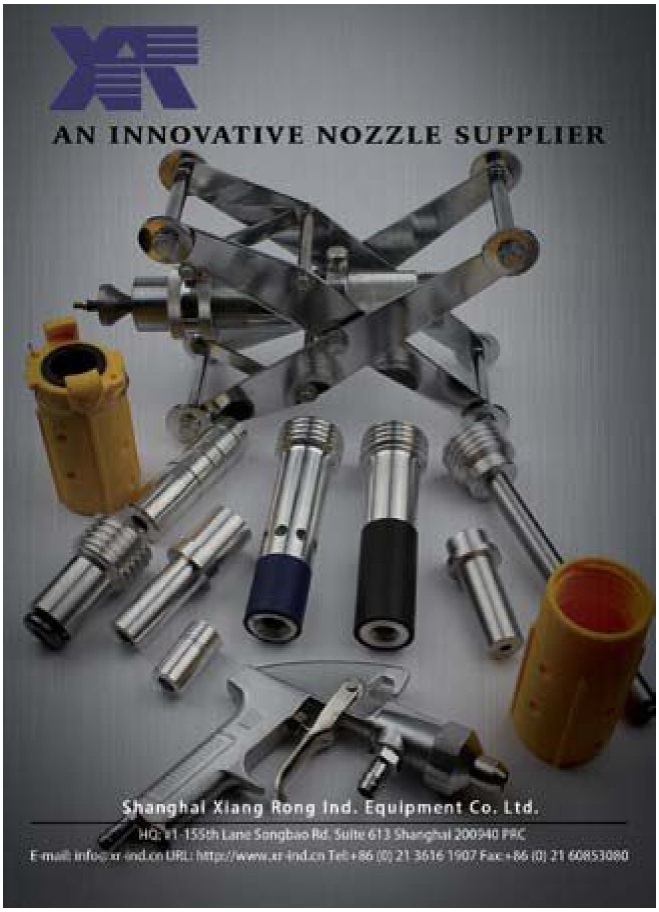
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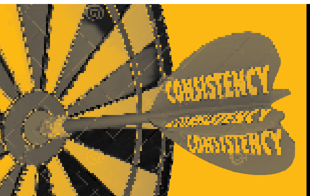

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MECHANICAL PRE-STRESSING TREATMENTS using shot peening are widely used in automobile, aeronautic and biomedical industries to improve mechanical parts and structures. These cold-working processes use spherical media called shot, and introduce surface compressive residual stresses that are found to enhance the fatigue resistance of intermediate- and high-strength metals and alloys. They protect the structure from fracture as fatigue cracks propagates mostly from surfaces during operation. The gain in strength and fatigue life observed after such a treatment can be spectacular while offering the advantage of being relatively easy to perform technically.

It is, therefore, not surprising that major companies working in very different areas have now turned their attention to such process/applications and to the control of the operating conditions in order to optimize coverage or to achieve targeted surface properties.

Nevertheless, in order to make additional progress and bring the technology to the next level, there is need to understand how shot behaves inside the peening chamber, and how the operating parameters (shot density, velocity, chamber geometry) will affect the shot impact on pieces and parts. Although the measurements of steel sphere velocities and angles can be relatively straightforward, not much is known on the way these behave collectively. The situation becomes even worse for the case of ultrasonic shot peening in which the spheres are propelled by an ultrasonic vibrating wall (a sonotrode), and bounce around in a blind peening chamber.

It is, therefore, widely believed that a direct visualization of the shot from hard sphere simulations could provide an interesting added value to the problem posed, while also saving R&D money used for cumbersome measurements of sphere bouncing, chaining methods relating the operating conditions to materials properties, validity assessments, post-treatment analysis, etc. In fact, because most of these aspects can be hardly reconciled, most of the design of peening chambers and the choice of process parameters remain empirical to a large extent, making it costly, time consuming and partially optimized, especially when complex industrial parts are to be considered.

In this respect, a promising solution is provided by the software SHOTVISUAL which is capable of stimulating a large number of shot peening possibilities for complex parts in industrial conditions while keeping the computation time to a minimum.

An event-driven molecular algorithm is used to model the behavior of an assembly of spheres, inspired by the statistical physics treatment of vibrated granular gases. A finite number of hard spheres (the shot) is driven by a velocity stream or by a vibrating boundary sonotrode (for the case of ultrasonic shot peening) and contained within defined boundaries. Such event-driven simulations allow studying all sorts of industrial conditions, including for parts that have complex geometries, defined by a finite element mesh (FEM), made of triangular elements.

One, thus, has the possibility to conduct efficient 3D simulations in short computing times, achieving in certain situations a 1:1 ratio between effective peening time and the simulation time. The realistic operating process parameters such as shot diameter and density, velocity stream of the blaster, amplitude and frequency of the ultrasonic sonotrode, as well as the process duration are read and act as input data for the event driven simulation.

The use of an OpenGL C++ library permits a direct 3D visualization (optional) that renders the individual trajectories of the spheres and meshes during the simulation. Using the software, one can now eventually correct process parameters by visualizing how the shot impacts the parts. Once the operating conditions are roughly optimized, impact related data are saved for each FEM meshed triangle: coordinates, impact time and velocity, impact angle. Such data can afterwards be used for a second refinement of the operating conditions, and provide now quantitative relationships between the process control parameters and the various impact properties, including surface coverage which is constrained by international standards (SAE J2277). Let us now consider two examples of the SHOTVISUAL software in the following.

Figure 1 on page 38 shows a typical impact distribution of an aluminium sample obtained from SHOTVISUAL in a cylindrical peening chamber geometry. The software permits

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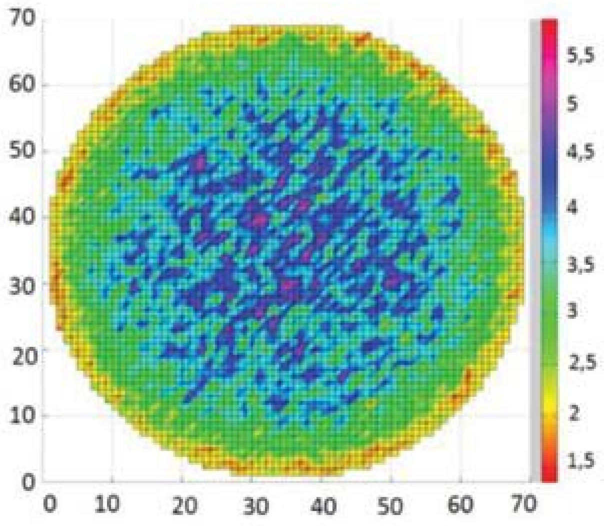

Figure 1: Impact velocity field (in m/s) for an ultrasonic shot (20 kHz) peened aluminium sample. Chamber diameter 70 mm, height 45 mm, Shot diameter 3 mm. Shot quantity 20 g.

the detection of the effect of the operating conditions on the surface coverage and the impact velocities. Here, one realizes that the coverage is not homogeneous and further analysis indicates that the heterogeneity is essentially driven by inelastic collisions with the side-walls that lead to partial adsorption characterized by weakly moving steel spheres close to the sample. An appropriate change in the operating conditions (for example, an increase of the amplitude) reveals that this flaw can be cured, whereas alternative solutions that may be seen as obvious, for example, an increase of the shot density, turn out to be counterproductive. In fact, a larger number of colliding spheres increases locally the shot density and produces an inelastic collapse of the colliding spheres, which results in an enhanced heterogeneity of the treatment.

The second example is provided in Figure 2 and will also serve us to provide a short survey of the software SHOTVISUAL. A first step consists in reading the CAD triangular mesh representing the part, e.g., an aluminum spur gear. All relevant surfaces in direct contact with the spheres are selected and grouped according to their nature (part, chamber, sonotrode) and their material characteristics that permit to define corresponding collision restitution coefficients. A library of velocity dependent restitution coefficients for various materials (Ti, Ni, Al,…) is used for this purpose.

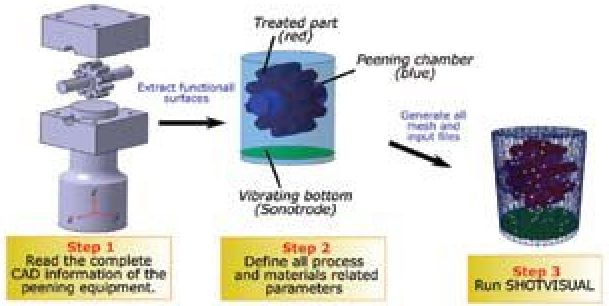

Figure 2: Schematics of the SHOTVISUAL simulation.

Once the various required mesh and input files are generated, the simulation can begin. The C++ library OPCODE then constructs an Aligned Axis Bounding Box (AABB) based collision tree for each of the colliding possibilities (shot, walls, sample, eventually sonotrode) and the program conducts fast sphere-mesh collision detection queries in order to rebuild the trajectories with time of each of the shot spheres.

The user can choose between two versions. A first one uses real-time visualization that is more demanding in computation time and is mainly to be used for exploratory phases. The second version without any visual feedback (console mode) can be used for the simulation of long treatment times.

Specifically, a simulation of five (5) seconds of treatment (500 spheres) for this case study, when ran in single CPU mode on a simple laptop PC (Intel® CoreTM i7 CPU, at 1.73 GHz), took 30 seconds and 7.5 minutes to complete in "Console_ mode" and in "visualization mode" respectively. Ultimately, the dynamics of the shot and the impact properties can be

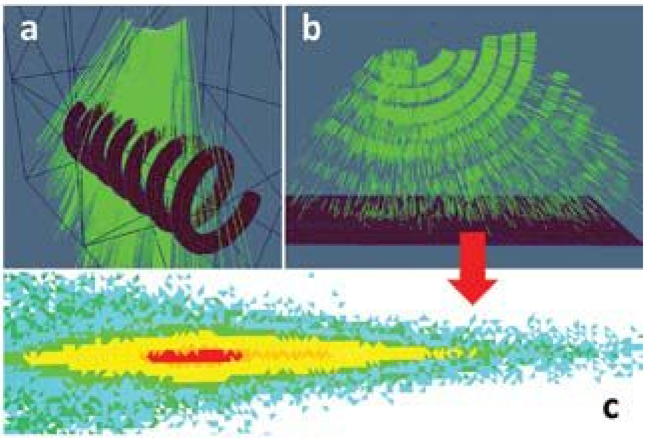

Figure 3: Air blasted shot peening on a steel spring (a) and on a moving plate from a rotating turbine (b). The latter leads to a characterization of the impact distribution (c), and it is found that the heterogeneous coverage results from the spread in output velocity and angle from the turbine.

Series of simulations permit to correct this flaw and to optimize the process by adapting both the plate velocity and the angular velocity of the shotblasting turbine.

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visualized on various industrial parts—springs, gears, plates, etc.—that have been subjected to a surface treatment (Figure 3).

Taken together, these new and exciting developments clearly open the possibility to fully control the shot peening process, blasted or ultrasonic, while also offering the possibility to obtain easily targeted surface treatments without numerous labor hours. This furthermore reduces the need to spend time and money in routine experimentation and analysis. ●

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For More Information

If you have question or a query about shot visualization and surface treatment optimization, the software SHOTVISUAL can help. Please visit www.shotvisual.com or send an email to Emmanuel Guyot (Emmanuel.guyot@utt.fr). The workgroup SHOTVISUAL also provides:

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SHOTVISUAL results from a joint collaboration between Paris Sorbonne Universités—UPMC, France (Matthieu Micoulaut, matthieu.micoulaut@upmc.fr) and Université de Technologie de Troyes, France (Emmanuel Guyot and Emmanuelle Rouhaud, Emmanuelle.rouhaud@utt.fr). All developers are involved in the modeling of surface treatment processes and their connection with mechanical properties of materials.

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EI Shot Peening Training at AirVenture

DAVE BARKLEY, Electronics Inc. Shot Peening Training Director and FAA Safety Team Member, was asked to speak at the 2016 EAA AirVenture. EAA stands for Experimental Aircraft Association and the organization describes itself as "a community of passionate aviation enthusiasts that promotes and supports recreational flying."

AirVenture is an annual summer convention at Wittman Regional Airport in Oshkosh, Wisconsin. Deemed the "World's Greatest Aviation Celebration," warbirds, vintage planes, homebuilts and ultralights are on display at the event that attracts over 500,000 aircraft enthusiasts. In addition to displays and air shows, the FAA conducts training along with EAA's forums and demonstrations. And that's where Dave came in. He gave a presentation to recreational aircraft builders and mechanics on how shot peening can reduce fatigue cracking of custom-made aircraft parts.

"Two aspects of shot peening especially interested my audience," said Dave. "First, they wanted to know why shot peening should be done after corrosion removal, even if the part hadn't been shot peened before. They were also interested in rotary-flap peening because it's a viable way for a small shop to shot peen."

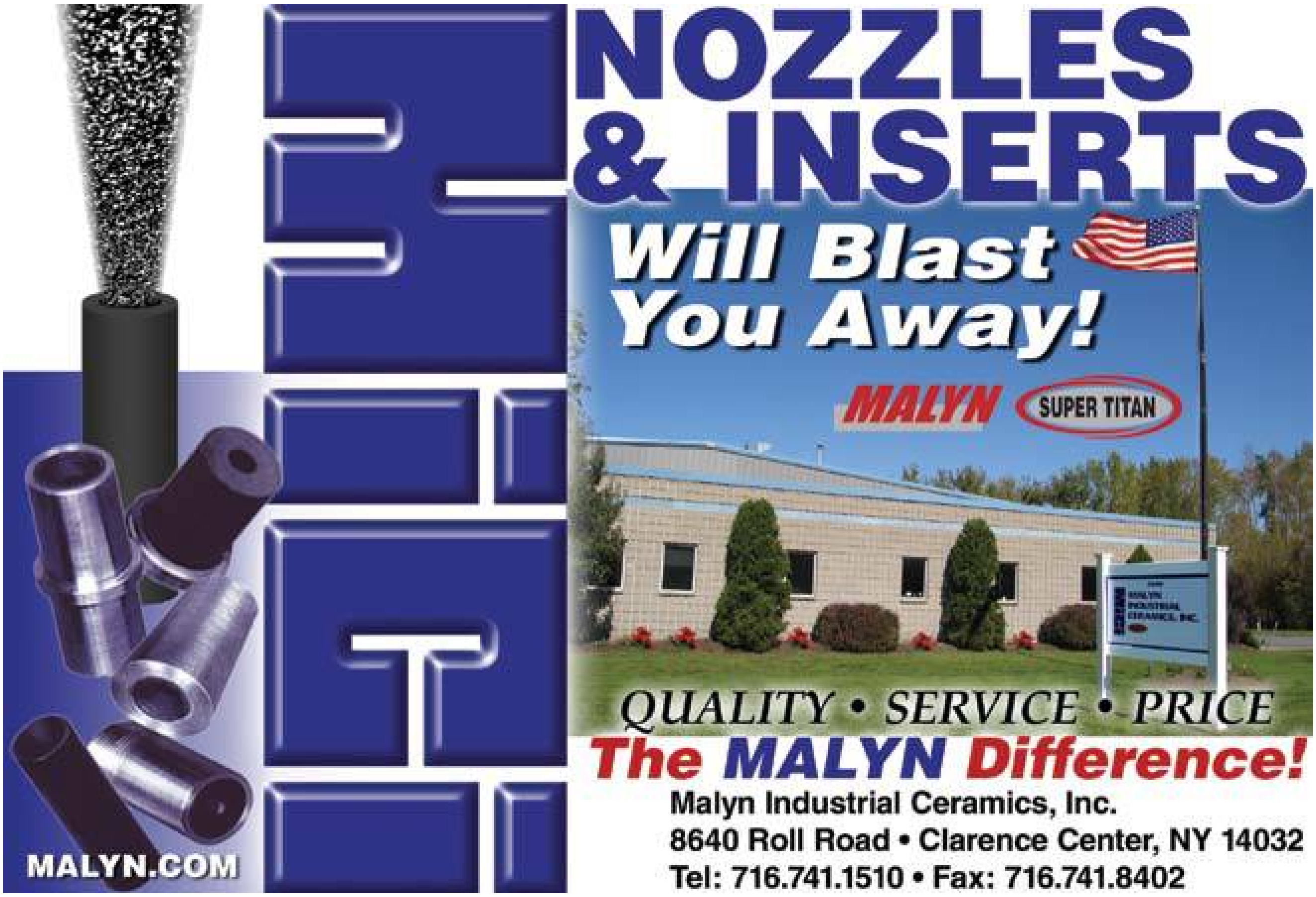
Shot peening was new to most of the participants and Dave predicts some will explore it further. "One gentleman stayed after the presentation and took notes while I explained concepts like saturation curves. He said he plans to bring shot peening into his shop and will attend the US workshop in Indianapolis this fall," added Dave.

Dave's presentation at AirVenture was not his first meeting with the EAA. He made a presentation to EAA Chapter 790 in Lake in the Hills, Illinois earlier this year. The following comments are from Mike Perkins, EAA Technical Counselor and Flight Advisor.

"Dave's presentation to our EAA group was eye-opening because fatigue failures are always on the mind of amateur-aircraft builders and kit-plane manufacturers—turbulence, landing-cycles, and engine vibration take their toll. Strength is not an issue because when a part is new, it's adequate with a good margin. Rather, it's an issue of durability—how does it hold up against vibration and load-flexing. But little has been done in the kit-plane world to solve cracking problems in parts that are highly stressed. Instead, the durability answer most often is to simply compensate by over-designing, which quickly leads to weight problems or a need to over-inspect and learn what to fix from failure statistics.

We learned from Dave that the durability of a part can be maintained better over the aircraft's lifetime by shot peening, and he showed us with a practical demonstration on-the-spot of how it can be done—peening equipment, parts, microscope, and all." ●

The Lockheed C-5 Galaxy military transport, among the largest aircraft in the world, was one of the thousands of aircraft on display at AirVenture.



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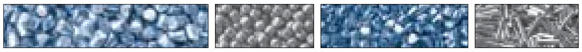

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